HAWKE'S BAY
REGIONAL COUNCIL

Soil Quality in the Hawke's Bay 2011

Extensive Pasture

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Soil Quality in Hawke's Bay 2011: Extensive Pasture

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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 the Hawke's Bay region as part of their obligations under the State of the Environment (SoE) reporting. HBRC reviewed their soil monitoring programme in 2006 (Pearson & Reid, 2006). This provided a framework to selection process for sites to represent Hawkes Bay based on land form, soil order, soil types and land use. It also prioritized the soil quality indicators.

In 2009 the National Land Monitoring Forum (NLMF) produced robust guidelines from which councils can produce nationally consistent land monitoring procedures and reporting. This report examines soil quality of extensive pastoral land use in the Hawke's Bay. Soil quality is assessed in accordance with the recommendations of Pearson and Reid (2006) and the NLMF guidelines.

Extensive pastoral land use can be defined as land under low producing exotic grassland. The land has been modified by development of a pastoral system and establishment of exotic grass cover, often ryegrass. However it is distinguished from high producing pasture by lower inputs of fertiliser and little pasture improvement. Stocking rates are low and stock types (sheep, beef and deer) have a low management input. It should be noted that beef finishing and intensive beef production is not included in the extensive pastoral group.

Sampling for soil quality monitoring was delayed for 2011 due to an exceptionally wet autumn. During this period the Hawke's Bay and in particular the Eastern (coastward) Hawke's Bay experienced extensive land movement on rolling and steep country. Flooding and deposition occurred in some low lying areas. Land that is most vulnerable to slipping or inundation is typically managed extensively and so many sites visited in this sampling round had been affected by land movement.

Nineteen sites were sampled from extensive pastoral properties used for dry stock throughout Hawkes Bay. Results from the analysis of soil from each site enabled the following conclusions to be made:

- In general soil quality in the Hawke's Bay extensive pasture sites is good, although some care should be taken in interpretation of the results since sampled areas excluded sites of recent mass movement and likely future instability.
- Extensive pasture sites are expected to have low C, N and fertility status compared to other land uses (cropping, intensive pasture) and so changes over time are likely to be more important than a point in time review.
- Compared to previous soil physical condition of sampled soils the extensive pasture soils sampled in this round were within the target range for soil physical parameters. This is most likely due to lower instance of animal and machine tracking on extensive pasture sites.
- A high number of sites had P status outside of the target range. This indicates that low P status may be wide spread in the Hawke's Bay.
- Low P status should be addressed to avoid "knock-on" effects due to poor pasture cover and resulting risk of further loss of shallow soil (NB this does not address issues due to deeper failure of hillslopes).

Recommended actions coming from this report include:

- Further information and assistance to farmers is needed to maintain hill country soil cover.

- 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.
- Land managers and advisors, including fertilizer representatives, may require information regarding the management of P on hill country soils. Specifically, the adoption of P forms best suited to soil type and land slope, and application regimes designed to optimise P use.
- 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.
- Comparison of soil quality under different land uses with the same soil type is recommended.

2 INTRODUCTION

2.1 Purpose

The purpose of this report is to provide Hawkes 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 State of the Environment document. The data is collected from representative extensive pastoralism properties in the region and compared to interpretative frameworks developed by an expert panel and compared to data collected from previous sampling. These comparisons will help to identify changes and provide general statements on the regions soil condition.

2.2 Background

The HBRC is developing a database of soil condition from different land uses representative of the Hawkes Bay region. This database began with the "500 Soils Project" cofounded 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.

The HBRC reviewed their soil monitoring programme in 2006 (Pearson & Reid, 2006). This provided a framework to selection process for sites to represent Hawkes Bay based on land form, soil order, soil types and land use. It also prioritized the soil quality indicators. Previously sampled land uses were divided into intensive cropping, dairying and bull beef land use. The current report focuses solely on extensive pastoralism and is compared to data identified for bull beef properties in the 2007 report.

The Land Monitoring Forum that took place in 2009 produced robust guidelines from which councils can produce nationally consistent land monitoring procedures and reporting. This report examines soil quality of extensive pastoral land use in the Hawke's Bay. Soil quality is assessed in accordance with the recommendations of Pearson and Reid (2006) and the NLMF guidelines.

2.3 Scope

The scope of this report is to describe soils used for extensive pastoralism in the Hawkes Bay region.

- Section 3: Methods used to collect data.
- Section 4: Results from data collected with brief written interpretation.
- Section 5: Discussion
- Section 6: Conclusion
- Section 7: Recommendations

3 SOIL QUALITY AND LAND USE

3.1 Soil Quality Monitoring in the Hawke's Bay

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 (2009) for the measurement and interpretation of soil quality. In addition, previous reports into soil quality in the Hawke's Bay have been reviewed and referenced through this report.

3.2 Land Use Definition

Extensive pasture land use has not been categorised as a land use group in previous sampling periods. The adoption of extensive pasture as a land use is in line with the NLMF guidelines which group pastoral land stocked with sheep/beef and deer as extensive pastoralism. The land use categories are defined so that they can be aggregated back to the New Zealand Land Cover Database.

Extensive pastoral land use can be defined as land under low producing exotic grassland. The land has been modified by development of a pastoral system and establishment of exotic grass cover, often ryegrass. However it is distinguished from high producing pasture by lower inputs of fertiliser and little pasture improvement. Stocking rates are low and stock types (sheep, beef and deer) have a low management input. It should be noted that beef finishing and intensive beef production is not included in the extensive pastoral group.

3.3 Soil Quality Indicators

Much investigation has been undertaken into the measurement of soil quality. In line with the recommendations of the Pearson and Reid (2006) the adopted indicators for the 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 or soil acidity;
- Olsen P;
- Total C and N;
- Potentially mineralisable N;
- Bulk density;
- Macroporosity; and
- Aggregate stability (not analysed in this study).

Priority Two: 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 Three: Extra Measurements

- Exchangeable cations and cation exchange capacity;
- Heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni);
- DDT; and
- Hot water extractable C.

3.4 Trace Element & 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 heavy metals it is recommended to pursue further investigation (Chapter 5: NLMF, 2009). Organochlorines 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.

Particular attention will be given to cadmium, fluorine and uranium that are known to accumulate in the soil when superphosphate has been applied. Use of a range of zinc containing products such as in antibiotics and fungicides are also common practice on pastoral farms, particularly facial excema preventative remedies (Kim & Taylor, 2009).

3.5 Historical State of Hawke's Bay Soils

The key concerns of Hawke's Bay soils that emerged from previous sampling were the physical conditions. Low macroporosity occurred under bull beef and dairy farming, with bull beef farms in particular falling below the target range in the 2007 sampling (Sparling & Stevens). Poor aggregate stability occurred in all land uses and soils, with many falling below the target range. This is consistent with half the sites in New Zealand used for dairying and nearly a third of drystock sites which have been described in the New Zealand Soil Health Report Card (NZSHRC) with compacted soils (MOE, 2010). The NZSHRC also states the organic reserves are above target ranges on a quarter of dairy and drystock sites, however in the Hawke's Bay organic reserves of cropping soils are often low not high. Fertility is below the target range for many drystock sites in New Zealand(MOE, 2010), and is also of concern on some Hawke' Bay soils. Low phosphorus levels have occurred and but also excess nitrogen.

The key objectives for soil quality monitoring is to determine if the soils are improving or declining over time and if the current state is good or bad. Hawke's Bay soils natural characteristics vary with the seven different soil orders sampled that have both high and low natural nutrient levels and both high and low macroporosity between them. Fertility can be managed and therefore low or excess levels sampled can be adjusted. The stability is more difficult but again careful farm management can minimize the impact of compaction although the Pallic and Brown soils that occupy half of the sites sampled have a naturally moderate to low macroporosity. Pallic soils can have a weak structure that is easily damaged.

Extensive pastoralism monitored for this report is best compared to soils used for bull beef production that were monitored in the 2007 report. Drystock typically farmed on extensive pastoralism would normally cater for sheep and or beef. Sheep farms sampled in this report may have the advantage of less compaction with smaller animals but more likely related to farm management.

The 2007 soil quality report (Sparling & Stevenson) highlighted distinct differences between land use for cropping, bull beef and dairy farming. Loss of organic matter was the key concern of cropped soil by comparison to low macroporosity in bull beef and dairy farmed soils.

4 METHODOLOGY

4.1 Site Selection

The method for site selection follows the recommendation of NLMF (2009). The selection of sites follows the recommendation of Pearson and Reid (2006). The report identified that extensive pastoral land use occurred on 8 soil orders across the Hawke's Bay Region (Table 1). A total of 22 soil types were considered to be representative of extensive pasture in the region.

In order to determine locations for the establishment of soil quality monitoring sites HBRC utilized existing soil and land use maps of the region. Overlays of land use and soil type were applied to property boundaries. Sites that were visited in the 2007 study (Sparling, 2007) were given preference where detail for relocating those sites was known. The 2007 study sampled site land use were not identified as extensive pasture, however, site land use identified as Bull Beef were taken as equivalent to extensive pasture.

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

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 monitoring site establishment.

4.2 Establishment of a Monitoring Site

Monitoring sites were established in accordance with NLMF (2009) procedures and Section 5.2 of Pearson and Reid (2006). In brief, the site was located 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. GPS co-ordinates were taken at 0 m, 25 m and 50 m. Soil pits were excavated at approximately 0 m, 25 m and 50 m along the transect. Soil was described to a depth of not less than 50 cm for all three 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 was delayed for 2011 due to an exceptionally wet autumn. During this period the Hawke's Bay and in particular the Eastern (coastward) Hawke's Bay experienced extensive land movement on rolling and steep country. Flooding and deposition occurred in some low lying areas.

Land that is most vulnerable to slipping or inundation is typically managed extensively and so many sites visited in this sampling round had been affected by land movement. The procedure for establishment of sites requires that areas subject to movement are considered atypical

and avoided. In order to meet this requirement transects were typically located in the most stable landforms. There is potential that these are not the most representative profile of some of the soil types. It is noted that this may cause overestimation of some parameters, most likely those associated with organic matter accumulation. However these landforms are likely to be able to be revisited more easily over time.

4.4 Sampling and Analysis

Soil sampling and analyses followed the guidelines prepared by the National Land Monitoring Forum (NLMF) (2009). The draft guidelines of this forum were the basis for sampling and analysis in 2007, however the assumption made for the 2007 report was that procedures followed the protocols established by the 500 Soils Project (Hill et al., 2003). These protocols formed the basis for the NLMF guidelines. A summary of the procedure is as follows.

4.4.1 Sampling for Soil Physical Indicators

An intact core of approximate dimensions 100 mm ∅ x 75 mm L was taken from three locations at each transect. The sampling locations corresponded to the soil pits at 0 m, 25 m and 50 m.

4.4.2 Sampling for Soil Chemical and Microbiological Indicators

A foot corer of dimensions 20 mm ∅ x 100 mm L was used to obtain one soil core every approximately 2 m along the transect. The cores were combined to provide a composite sample for analysis.

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

4.4.3 Sample Handling and Transport

Sealed samples were packed in chilly bins where necessary and transferred to a storage fridge if not conveyed immediately to a laboratory for analysis. Intact cores 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 were sent to Hill Laboratories in Hamilton.

4.4.1 Sample Analysis

As indicated above samples were sent to Hill Laboratories for chemical analyses, being:

- 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: As, Cd, Cr, Cu, Ni, Pb, Zn, Hg;
- Organochlorine pesticide screen;
- Total uranium (Ur); and
- Total fluoride (Fl^-).

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; and
- Available water capacity (AWC).

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. Percent carbon and nitrogen was multiplied by 10 and the bulk density to change units from percentage to mg/cm^3.

5 RESULTS

5.1 Soils & Sites

Nineteen sites were sampled from extensive pastoral properties used for dry stock throughout Hawkes Bay. Table 1 lists the soil types at each sample site and the soil order/group to which they belong. Two properties had two sample sites because of two different soil types, 13 & 14, 17 & 18.

Of the 8 soil orders chosen to represent the region only organic soils are not represented in this analysis. While initially the Poukawa soil was identified as an Organic Soil used for extensive pastoralism it was noted that most of the area of Poukawa soil is managed as cropping soil and was therefore not considered to be representative of extensive pasture. The order listed is that identified for the soil type by Pearson & Reid (2006). The observed properties conform to the descriptions of Pohlen *et al.* (1947). The different allocated soil order identifies recent soils for Ruahine and Awamate. Differences of the allocated soil order also occurred in the 2007 monitoring report of soil quality (Sparling & Stevenson, 2008).

Table 1: Soil Quality Monitoring Sites

Site No	Soil Type	Order
1	Te Apiti	Pallic
2	Okawa	Gley
3	Mokapeka	Brown
4	Atua	Pallic
5	Crownthorpe	Pallic
6	Waipawa	Pallic
7	Matamau	Brown
8	Hastings	Gley
9	Matapiro	Pallic
10	Ruahine	Brown
11	Gisborne	Pumice
12	Taupo	Pumice
13	Hangaroa	Pumice
14	Awamate	Gley
15	Mahoenui	Pallic
16	Tiniroto	Pumice
17	Takapau	Allophanic
18	Gwavas	Brown
19	Te Onepu	Mellanic

Soil profile and site descriptions are provided in Appendix A. Soil chemistry, physical data, heavy metal levels and agrichemical contaminants are shown in Tables 2 to 5 below. Analysis results as received from the analysing laboratories are given in Appendix C.

Table 2: Soil chemical characteristics of Hawke's Bay sites sampled in 2011

Site	Soil Type	pH	CEC	Total Carbon	Total Nitrogen	C/N	Olsen P	Base Saturation	Mineral-isable N	Potassium	Calcium	Magnesium	Sodium
			me/100 g	mg/cm^3	mg/cm$_3$	ratio	mg/L	%	µg/cm^3	Exchangeable cations me/100g			
01-11-10cm	Te Apiti	5.8	35	76.2	7.17	10.7	21	74	446	1.04	21.8	2.59	0.23
02-11-10cm	Okawa	5.6	13	37.0	3.58	10.4	11	49	186	0.28	4.6	1.45	0.26
03-11-10cm	Mokapeka	5.6	16	48.8	4.27	11.6	6	45	138	0.37	5.4	1.05	0.12
04-11-10cm	Atua	5.4	15	41.1	4.00	10.1	15	40	129	0.51	4.1	1.25	0.12
05-11-10cm	Crownthorpe	5.7	18	45.9	4.73	9.9	29	65	143	0.81	9.4	1.28	0.15
06-11-10cm	Waipawa	5.5	19	55.6	4.94	11.2	10	54	127	0.41	8.1	1.8	0.14
07-11-10cm	Matamau	5.6	21	59.4	5.61	10.5	30	53	326	0.68	9.0	1.55	0.13
08-11-10cm	Hastings	6.6	24	62.7	6.61	9.6	42	87	178	1.29	17.9	1.57	0.08
09-11-10cm	Matapiro	6.0	26	57.8	5.78	10.0	23	71	314	0.86	13.6	3.77	0.56
10-11-10cm	Ruahine	5.9	31	76.8	7.36	10.4	27	52	255	1.12	12.4	2.31	0.2
11-11-10cm	Gisborne	6.0	21	54.8	4.73	11.5	5	46	104	0.23	8.4	0.77	0.13
12-11-10cm	Taupo	5.7	26	55.4	4.85	11.4	6	28	135	0.51	5.6	1.01	0.23
13-11-10cm	Hangaroa	5.6	16	42.2	3.87	11.0	6	31	114	0.42	3.2	1.13	0.2
14-11-10cm	Awamate	5.9	14	24.5	2.97	8.1	27	67	157	0.47	7.1	1.63	0.12
15-11-10cm	Mahoenui	5.6	18	36.6	3.66	9.9	13	42	156	0..35	5.3	1.70	0.38
16-11-10cm	Tiniroto	5.5	16	38.2	3.63	10.5	15	37	110	0.45	4.6	0.77	0.17
17-11-10cm	Takapau	6.0	18	48.3	5.06	9.6	13	60	105	0.24	9.5	0.99	0.21
18-11-10cm	Gwavas	5.9	19	48.8	4.76	10.2	22	62	139	0.71	9.7	1.43	0.08
19-11-10cm	TeOnepu	6.6	31	71.8	7.76	9.3	42	100	262	1.83	27.8	1.72	0.11

Table 3: Soil chemical characteristics of Hawke's Bay sites sampled in 2011(units utilised for target range)

Site	Soil Type	pH	CEC	Total Carbon	Total Nitrogen	C/N	Olsen P	Base Saturation	Mineral-isable N	Potassium	Calcium	Magnesium	Sodium
			me/100 g	%	%	ratio	mg/L	%	µg/cm^3	Exchangeable cations me/100g			
01-11-10cm	Te Apiti	5.8	35	6.8	0.64	10.7	21	74	**446**	1.04	21.8	2.59	0.23
02-11-10cm	Okawa	5.6	13	3.3	0.32	10.4	**11**	49	186	0.28	4.6	1.45	0.26
03-11-10cm	Mokapeka	5.6	16	4	0.35	11.6	**6**	45	138	0.37	5.4	1.05	0.12
04-11-10cm	Atua	5.4	15	3.7	0.36	10.1	15	40	129	0.51	4.1	1.25	0.12
05-11-10cm	Crownthorpe	5.7	18	3.4	0.35	9.9	29	65	143	0.81	9.4	1.28	0.15
06-11-10cm	Waipawa	5.5	19	5.4	0.48	11.2	**10**	54	127	0.41	8.1	1.8	0.14
07-11-10cm	Matamau	5.6	21	5.4	0.51	10.5	30	53	**326**	0.68	9.0	1.55	0.13
08-11-10cm	Hastings	6.6	24	5.6	0.59	9.6	42	87	178	1.29	17.9	1.57	0.08
09-11-10cm	Matapiro	6.0	26	4.9	0.49	10.0	23	71	**314**	0.86	13.6	3.77	0.56
10-11-10cm	Ruahine	5.9	31	9.6	**0.92**	10.4	27	52	**255**	1.12	12.4	2.31	0.2
11-11-10cm	Gisborne	6.0	21	7.3	0.63	11.5	**5**	46	104	0.23	8.4	0.77	0.13
12-11-10cm	Taupo	5.7	26	8.8	**0.77**	11.4	**6**	28	135	0.51	5.6	1.01	0.23
13-11-10cm	Hangaroa	5.6	16	4.8	0.44	11.0	**6**	31	114	0.42	3.2	1.13	0.2
14-11-10cm	Awamate	5.9	14	**1.9**	**0.23**	8.1	27	67	157	0.47	7.1	1.63	0.12
15-11-10cm	Mahoenui	5.6	18	3.7	0.37	9.9	**13**	42	156	0..35	5.3	1.70	0.38
16-11-10cm	Tiniroto	5.5	16	3.9	0.37	10.5	15	37	110	0.45	4.6	0.77	0.17
17-11-10cm	Takapau	6.0	18	4.2	0.44	9.6	**13**	60	105	0.24	9.5	0.99	0.21
18-11-10cm	Gwavas	5.9	19	4.1	0.40	10.2	22	62	139	0.71	9.7	1.43	0.08
19-11-10cm	TeOnepu	6.6	31	7.4	**0.80**	9.3	42	100	**262**	1.83	27.8	1.72	0.11

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

Table 4: Soil physical characteristics of Hawke's Bay sites sampled in 2011

Site	Soil Type	Dry bulk density	Particle density	Porosity	Macro-porosity	Field capacity	AWC
		(g/ cm^3)	(g/cm^3)	(%)	(%)	(%)	(%)
01-11-10cm	Te Apiti	1.12	2.52	56	7	49	20
02-11-10cm	Okawa	1.12	2.49	55	11	44	26
03-11-10cm	Mokapeka	1.20	2.53	53	16	36	23
04-11-10cm	Atua	1.11	2.51	56	17	38	22
05-11-10cm	Crownthorpe	1.35	2.57	48	11	36	17
06-11-10cm	Waipawa	1.03	2.50	59	19	40	17
07-11-10cm	Matamau	1.10	2.50	56	11	45	24
08-11-10cm	Hastings	1.12	2.51	55	15	40	21
09-11-10cm	Matapiro	1.18	2.52	53	7	46	22
10-11-10cm	Ruahine	0.80	2.40	67	19	48	24
11-11-10cm	Gisborne	0.75	2.31	68	20	48	32
12-11-10cm	Taupo	**0.63**	2.22	72	22	49	34
13-11-10cm	Hangaroa	0.88	2.36	63	20	43	29
14-11-10cm	Awamate	1.29	2.63	51	**5**	46	26
15-11-10cm	Mahoenui	0.99	2.45	60	16	44	30
16-11-10cm	Tiniroto	0.98	2.36	59	12	46	32
17-11-10cm	Takapau	1.15	2.51	54	15	39	23
18-11-10cm	Gwavas	1.19	2.54	53	19	34	21
19-11-10cm	TeOnepu	0.97	2.46	60	14	47	25

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

Table 5: Heavy metal levels of Hawke's Bay sites sampled in 2011

Site	Soil Type	Individual Tests		Heavy metals , screen As, Cd, Cr, Cu, Ni, Pb, Zn, Hg							
		Total Recoverable Uranium	Fluoride	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
01-11-10cm	Te Apiti	0.96	390	2	0.27	11	11	7.6	<0.10	8	51
02-11-10cm	Okawa	0.76	260	<2	0.11	7	4	7.4	<0.10	4	34
03-11-10cm	Mokapeka	0.45	196	<2	0.10	9	3	6.1	<0.10	4	41
04-11-10cm	Atua	0.57	240	2	0.21	8	4	8.2	<0.10	4	32
05-11-10cm	Crownthorpe	0.76	270	3	0.30	13	20	9.9	<0.10	9	48
06-11-10cm	Waipawa	0.63	240	2	0.32	6	7	5.3	<0.10	5	45
07-11-10cm	Matamau	0.73	260	2	0.27	10	9	7.5	<0.10	5	46
08-11-10cm	Hastings	0.8	300	2	0.46	12	14	8.9	<0.10	10	65
09-11-10cm	Matapiro	1.2	300	<2	0.35	11	9	9.1	<0.10	10	71
10-11-10cm	Ruahine	1.53	500	<2	0.59	12	20	6.8	<0.10	6	69
11-11-10cm	Gisborne	0.94	400	<2	0.53	7	5	5.4	<0.10	3	36
12-11-10cm	Taupo	0.66	360	<2	0.43	4	5	3.9	<0.10	2	25
13-11-10cm	Hangaroa	0.43	270	<2	0.10	5	3	5.8	<0.10	4	27
14-11-10cm	Awamate	1.02	340	2	0.15	15	7	8.8	<0.10	11	52
15-11-10cm	Mahoenui	0.8	340	<2	0.23	7	4	6.0	<0.10	5	36
16-11-10cm	Tiniroto	0.73	350	<2	0.32	5	4	5.1	<0.10	4	33
17-11-10cm	Takapau	0.97	310	2	0.34	14	9	9	<0.10	7	71
18-11-10cm	Gwavas	0.77	240	3	0.26	14	10	8.2	<0.10	6	48
19-11-10cm	TeOnepu	0.71	240	4	0.69	17	16	14.4	0.12	6	63

5.2 Priority One Indicators

The results from the soils analysed have been compared to the interpretative frameworks developed by expert panels (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.

5.2.1 Soil pH

Soil pH results are shown in Figure 1. All the sampled soils were within the target range for soil pH. Two soils were near to the high limit corresponding to a Hastings soil (Site 8) and a Te Onepu Soil (Site 19). A high pH is expected for the Te Onepu soil as a result of the limestone stone parent material and likely elevated carbonate concentration in the soil. The Hastings soil was present in a catchment draining from limestone hills and so can be expected to have elevated carbonate concentrations also.

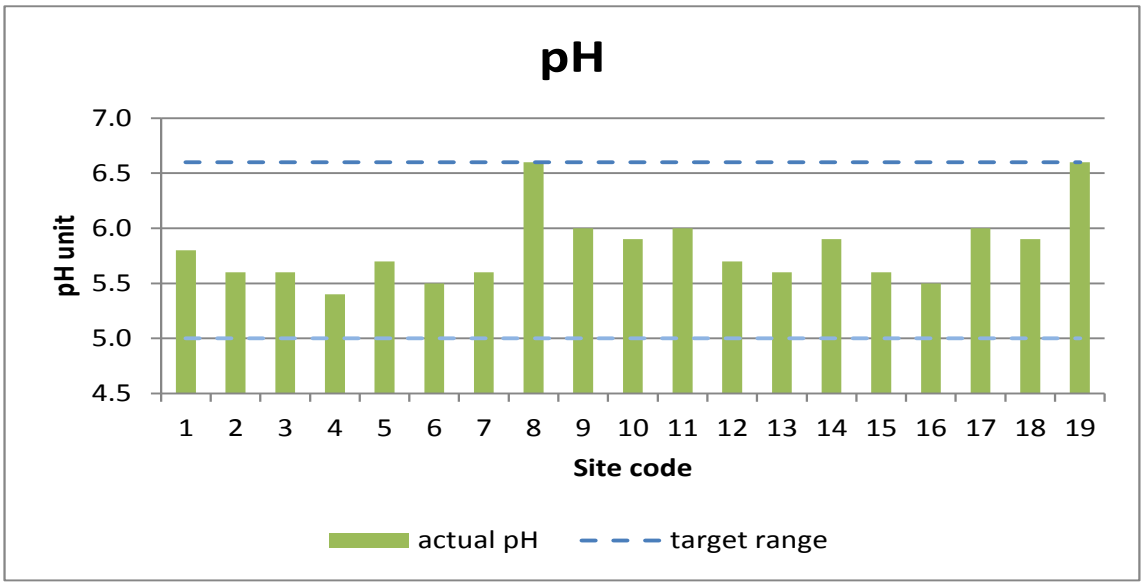

Figure 1: Soil pH for Hawke's Bay sites sampled in 2011

5.2.2 Total Carbon

The range recorded of total C (%w/w) is 1.9 to 9.6. For comparative purposes the results have been expressed on a weight per volume basis (mg/cm^3). Figure 2 shows the results that range from 24.5 to 76.8 mg/cm^3. Utilising the 2009 framework the Awamate soil (Site 14) is very depleted and below the critical limit, potentially due to "dilution" by low carbon sediment after recent flooding. All other sites are above the critical limit with the majority in the normal range.

In general, extensive pasture land use is expected to slowly accumulate carbon due to the low incidence of disturbance under this land use. Reduction in carbon concentration is most likely to be due to soil loss or sediment deposition.

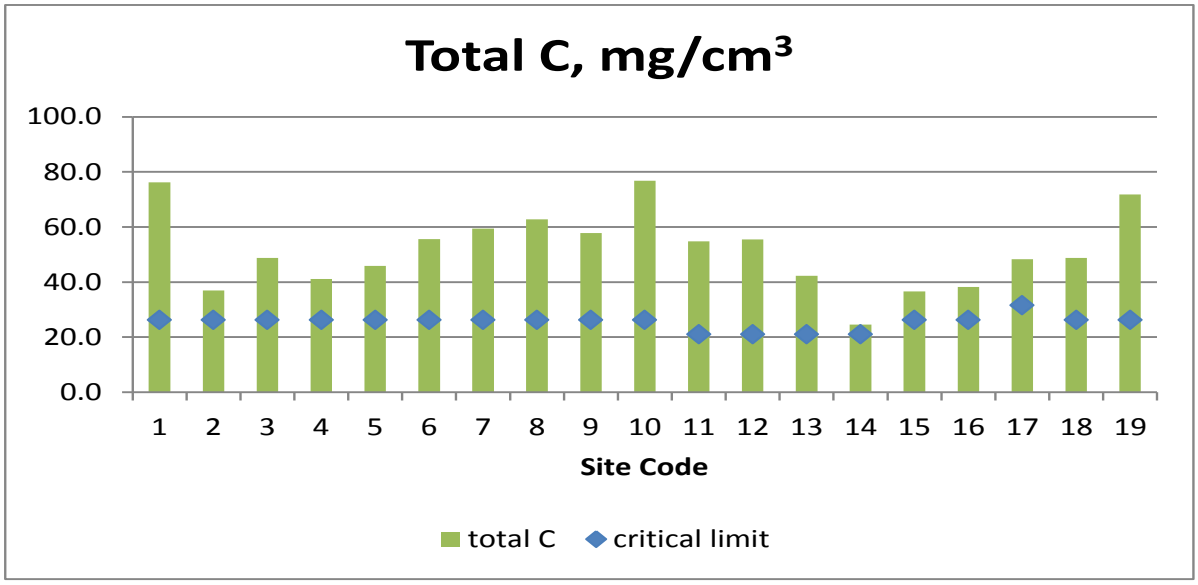

Figure 2: Total C for Hawke's Bay sites sampled in 2011

5.2.3 Total Nitrogen

There was a wide range of total N between sites from very depleted through to high. In general the trend for total N follows the total C observed. There is no clear trend based on soil order and it is likely that the total N status of the soils is related to land management practices such as fertilisation history, pasture development and tillage. Sites having total N towards the low end of the target range include the Awamate soil (Site 14) for reasons as outlined for total C. Figure 3 shows total N for the sites measured.

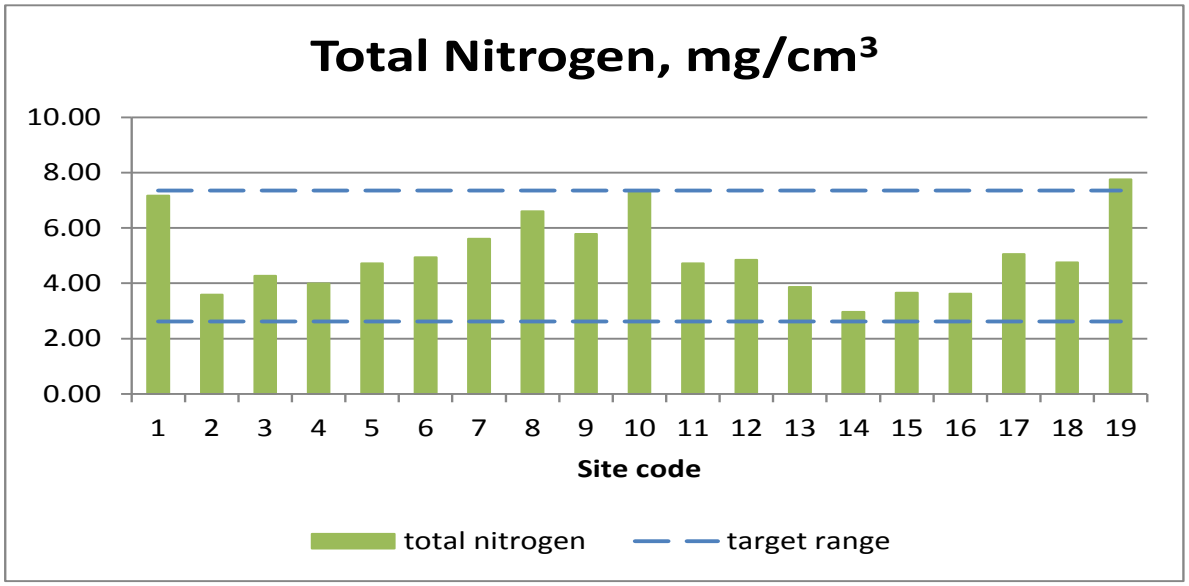

Figure 3: Total N for Hawke's Bay sites sampled in 2011

5.2.4 Anaerobically Mineralisable Nitrogen

The concentration of anaerobically mineralisable N (AmN) is a function of the C:N ratio. Some caution is advised in the interpretation of these results due to some concern for sample storage which may have caused elevated AmN. Figure 4 shows the AmN results. In general soils sampled were within the target range for AmN. Five sites had high AmN which is an indicator

of nitrate leaching risk. Sites at the low end of the range may be at risk of limiting the potential for plant growth.

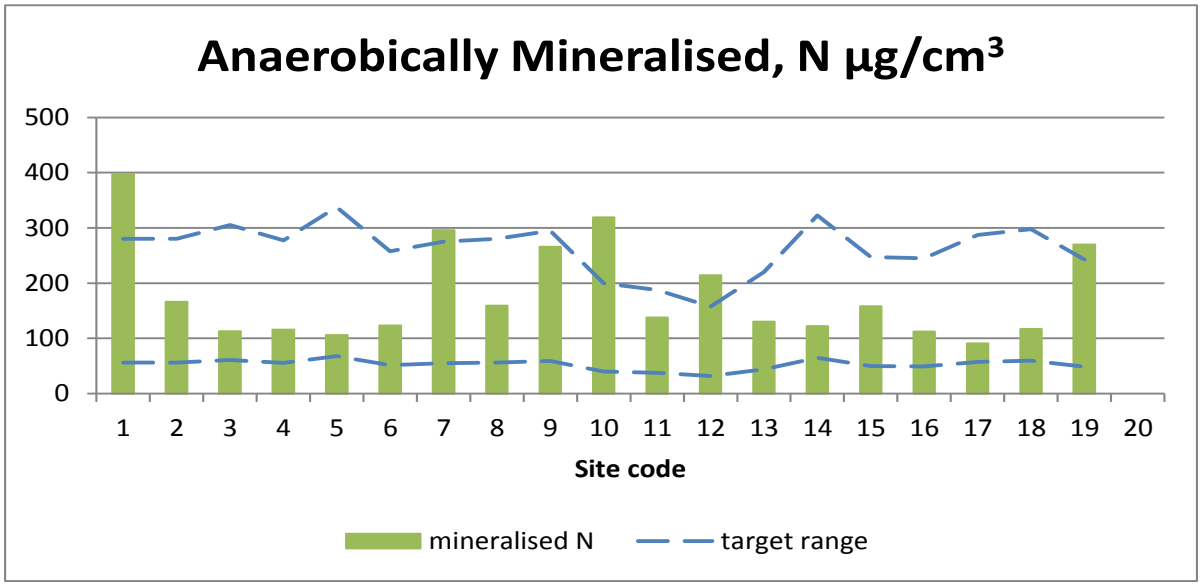

Figure 4: Mineralisable N content (µg/cm3) of Hawke's Bay soils sampled

5.2.5 Olsen Phosphorus

Ten sites showed very low levels from the Olsen P test, therefore operating below potential growth rate for the pasture and at or outside the target range. Levels are comparable to 2007 however 4 sites are below any recorded in 2007. Figure 5 gives the Olsen P results.

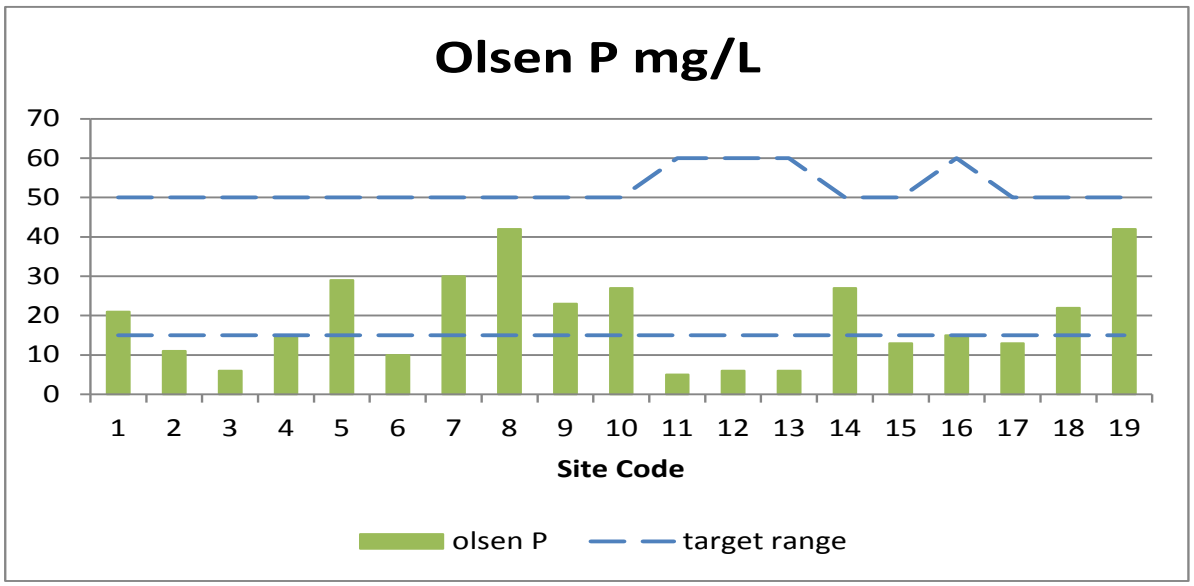

Figure 5: Olsen P content (mg/L) of Hawke's Bay soils sampled

5.2.6 Carbon : Nitrogen Ratio

The C/N ratio is consistent with the Total C and N measures. The Awamate soil (Site 14) is low by comparison to all other sites which range between 9.3 to 11.6. Below 9 is considered too low to store N in organic forms meaning that N may be limiting to pasture growth. Figure 6 gives the C/N ratio for each site.

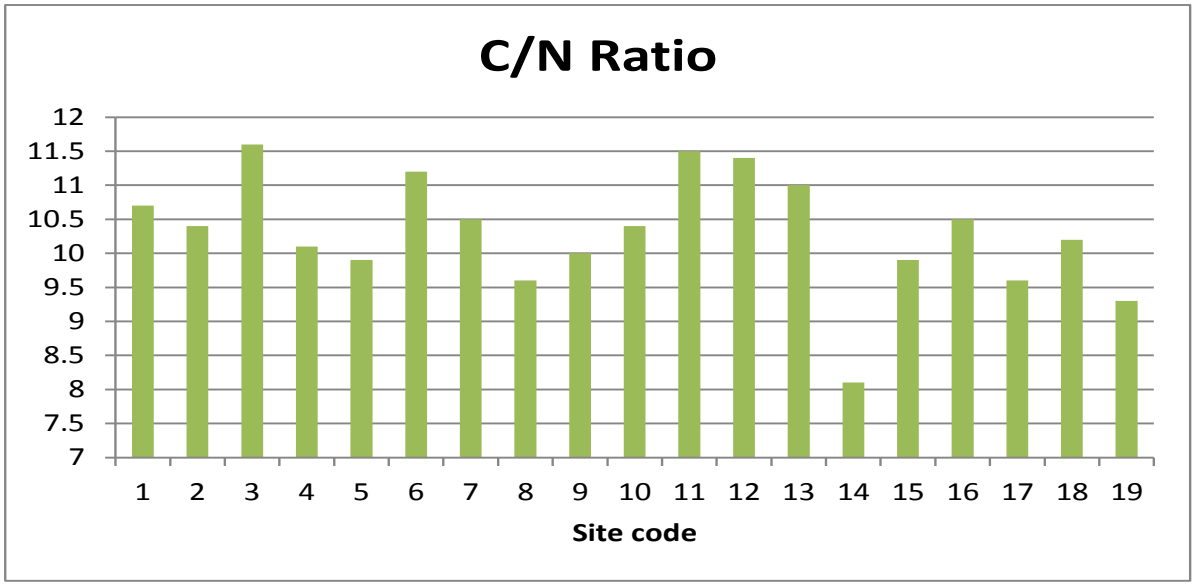

Figure 6: C/N ratio of Hawke's Bay soils sampled

5.2.7 Dry Bulk Density

All sites sat within the target range except a pumice soil with very low bulk density. Therefore no soil sampled should impede root growth from reduced aeration and drainage. Figure 7 shows the bulk density results. The Taupo soil (Site 12) with very low bulk density is at risk of increased water and nutrient loss. These results are generally consistent with 2007 results that indicated only one site showing signs of compaction outside the target range.

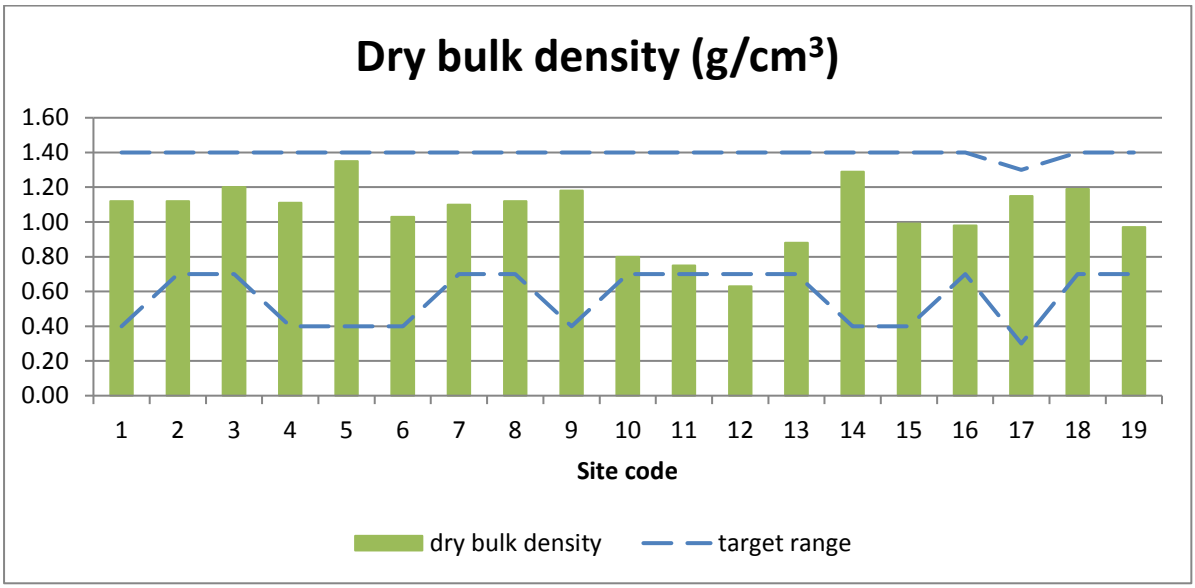

Figure 7: Dry bulk density (g/cm³) of Hawkes Bay soils sampled

5.2.8 Macroporosity

Figure 8 shows macroporosity for the sampled soils. All sites except site 14 indicate macroporosity inside the target range that will contribute to adequate aeration and plant growth. Consistent with other data, site 14 macroporosity is very low. 2011 results contrast with 2007 that found most beef sites were below the target range.

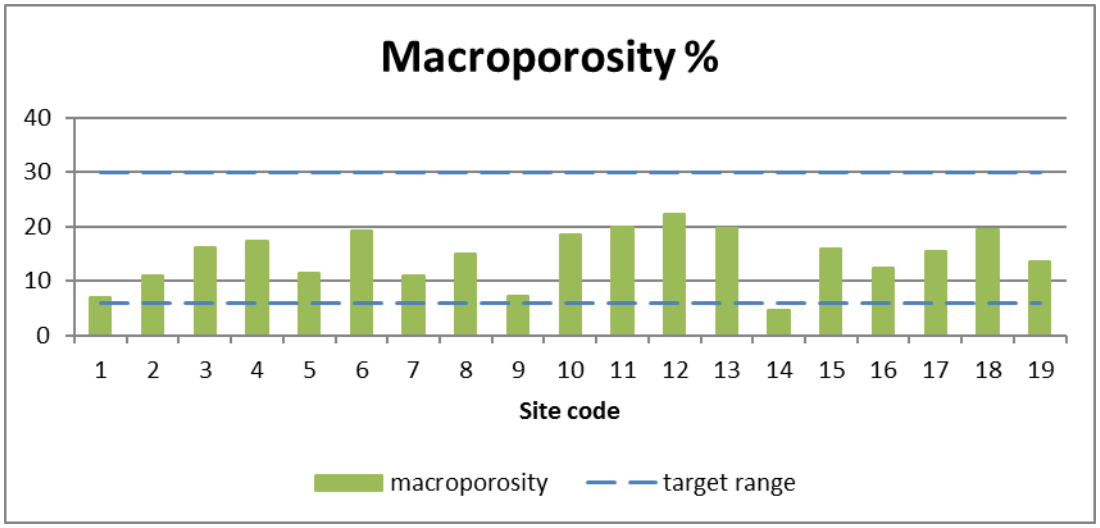

Figure 8: Macroporosity % of Hawkes Bay soils sampled

5.3 Priority Two Indicators

Where determined, results of the visual soil assessment (Shepard, 2000) are detailed in the soil descriptions given in Appendix A.

5.4 Priority Three Indicators

5.4.1 Organochlorine Pesticides

For most sites all measured organochlorine pesticides were below detectable limits. Of the measured organoclorine pesticides only DDT or it's metabolites (DDD, DDE) were measured. DDT/DDD/DDE was detected in soils at 5 sites, being:

- Site 7, Matamau series (0.581 mg/kg);
- Site 10, Ruahine series (0.027 mg/kg);
- Site 11, Gisborne series (0.020 mg/kg);
- Site 16, Tiniroto series (0.252 mg/kg); and
- Site 18, Gwavas series (0.019 mg/kg)].

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.

No sites exceeded the soil quality guideline adopted for agricultural soils. Presence of DDT is likely to be due to the coating of grass seed for protection against grass grub at pasture establishment prior to the 1970s. The value measured at Site 7 is close to the guideline value and further investigation may be warranted.

5.4.2 Trace Elements

Measured levels of As, Cd, Cr, Cu, Pb, Hg, Ni and Zn were below levels corresponding to risk to environmental or human health. Cd was considered to be the contaminant of most concern due its presence in phosphate rock used for superphosphate production. While Cd was detected in all samples the levels were below soil limits.

5.4.3 Fluoride

All measured values for fluoride were within the expected range for NZ soils (200-500 mg/kg, FLRC, 2009). As with P and Cd results this is likely to reflect low rates of phosphate fertiliser addition or loss of topsoil due to slipping.

5.4.4 Uranium

Measured U varied from 0.43 to 1.53 with the pattern of elevated values generally following the other indicators. This suggests that variance in U is likely to associated with the soil fertility as modified by land management. In general, levels are low and below the proposed Canadian soil limit of 23 mg/kg. Further information is required to determine a New Zealand limit (Taylor *et al.*, 2007).

5.5 Overall Soil Quality

The results from the soils analysed have been compared to the interpretative frameworks developed by expert panels (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.

Five sites met all soil quality targets, 10 met all but one target seven of which was insufficient phosphorus levels. Three sites had two targets unmet and one property site 14 had three targets unsatisfied.

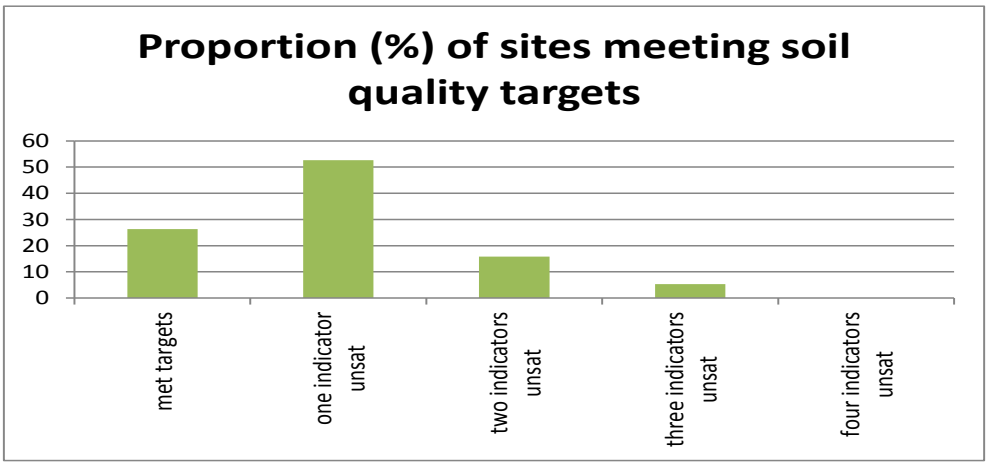

Figure 8: Proportion of Hawkes Bay soils not meeting soil quality targets for 7 quality indicators

As depicted in Figure 9 the main reason for sites failing one target was low phosphorus levels (52%). 26% of sites did not meet the mineralisable nitrogen target level. For beef properties analysed in 2007 two properties out of 10 met all targets, 4 had two unsatisfied and four had 3 targets unsatisfied. The main reason for unsatisfactory levels was for low macroporosity, whereas only 20% had Olsen P below target levels.

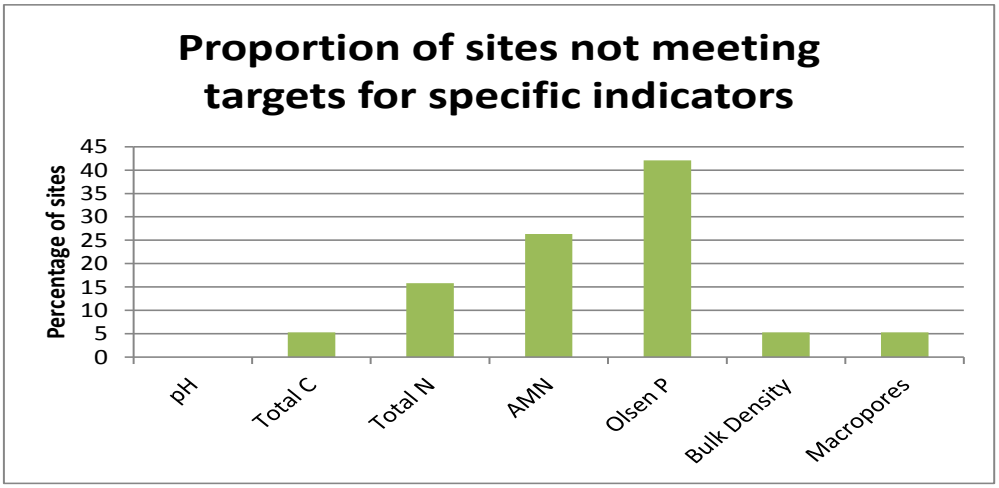

Figure 9: Proportion of Hawke's Bay soils not meeting suggested targets for specific soil quality indicators

5.6 Changes in Soil Quality Over Time

No sites previously sampled were sampled for the current data set. This is due to the extensive pastoral land use not previously being identified as a land use group. In addition, for the land use equivalent to extensive pasture, being bull beef, the details for relocating the sites were not available.

It is still considered appropriate to compare previously sampled bull beef sites in general with the current dataset. It should be noted that datasets prior to 2007 may not be directly comparable as described by Sparling and Stevenson (2008) which states:

> *"The current and archive data may not be directly comparable for all measured characteristics because analytical methods may have differed from those used previously. Two earlier sites had been sampled for the Crop and Food SQM project to a 15 cm depth, rather than the 10 cm depth of the 500 Soils protocol, which also causes problems when trying to compare soil characteristics that are strongly stratified with depth (i.e. properties that can be more or less concentrated in the surface soil). The depth of 10 cm is adequate for most non-tilled soils and is consistent with the IPCC recommendations for estimating C storage in surface soils."*

Some general observations regarding change over time in the soil quality observed for extensive pastoral land use can be made.

- pH is stable and within the target range;
- Total C was, in general, higher in 2011. The higher total C observed in 2011 is likely to be influenced by the choice of sampling location, whereby recent mass movement was avoided;
- Total N is similar for all sampling events when changes in sampling depth is considered;
- Olsen P has increased from 2007 results but is similar to earlier results. While Olsen P is typically low, it is relatively stable;
- A small increase in the mean value for anaerobically mineralisable N was seen, however it is considered to be within the bounds of experimental error and not significant; and
- Other measured parameters were not previously reported.

Data produced from the sites were generally similar between the two time periods. One or two sites fell outside of the target range for all measurements except pH which stayed within the target range. The main concern that arose for bull beef in 2007 was a large percentage of properties with low macroporosity indicating soil compaction whereas in 2011 this was only a concern for one property. However the concern in 2011 was low Olsen P values.

No targets have been specified and no data from previous years for comparative purposes is available for the following data collected: Porosity, particle density, field capacity, AWC and all heavy metal tests.

6 DISCUSSION

In previous soil quality monitoring for pasture soils the primary concern identified was low macroporosity, indicating soil compaction was occurring under pastoral land uses. The current dataset suggests that macroporosity is within the target range for all except one site. The Awamate soil which did not meet target macroporosity was subject to flooding and silt deposition within three months prior to sampling. This is likely to have influenced the soil macroporosity in the upper 10 cm and so the low macroporosity result is not considered to be a direct result of the land use at the site. In general the macroporosity of extensive pasture soils monitored was acceptable although at the low end of the scale. Further monitoring over time is warranted.

The current dataset represents land management practices, in particular stock types, which vary from the previously sampled bull beef sites. Both the different stock types including sheep and deer, and the low stocking rates and machine trafficking seen result in lower risk of soil compaction. It is considered that the broader application of the term extensive pasture to include farming regimes other than bull beef will assist to highlight differences in macroporosity due to higher stocking of heavier animals on marginal land, in particular in comparison to intensively managed sites which are to be sampled in the next 1-2 years.

The Olsen P status of the extensive pastoral sites monitored is the indicator of most concern for the current dataset. With over 40 % of sites falling below the target range for Olsen P. The range of soils which returned low Olsen P values span a number of soil groups including Pumice, Pallic, Gley and Brown. The soil groups represented include typically high P retaining soils (Pumice and Brown) and low P retaining soils (Pallic and Gley).

Olsen P is taken as a measure of the labile (plant available) P pool. For high P retention soils it is expected that P applied as fertiliser or other amendments will sorb to the soil, protecting it from loss of P as soluble phosphate. As a result P is typically higher in these soils where a history of fertiliser applications has occurred. If, however a significant time since P application has passed or a low rate of P is applied the P becomes occluded, meaning that it is no longer readily available. In this situation low Olsen P results may be returned. In soils with a low P retention the applied P is not strongly sorbed to the soil and is at risk of being lost predominantly via run-off. Again, this may result in low Olsen P measured.

For the sampled Hawke's Bay extensive pasture soils a further consideration for the low P status is the degree of soil loss that has occurred on the hill country which predominantly represents the land use, in particular, over the three months prior to sampling. Low P status may be an indicator of loss of the soil A horizon which is likely to contain the highest concentration of applied P. The soil Olsen P can be increased by the application of phosphate fertilisers or other P containing soil amendments.

A number of soil types sampled in the extensive pasture land use are known to be also under other land uses within the region. The collation of data from multiple land uses would enable a valuable comparison of soil quality under different land uses.

7 CONCLUSIONS

- In general soil quality in the Hawke's Bay extensive pasture sites is good, although some care should be taken in interpretation of the results since sampled areas excluded sites of recent mass movement and likely future instability.
- Extensive pasture sites are expected to have low C, N and fertility status compared to other land uses (cropping, intensive pasture) and so changes over time are likely to be more important than a point in time review.
- Compared to previous soil physical condition of sampled soils the extensive pasture soils sampled in this round were within the target range for soil physical parameters. This is most likely due to lower instance of animal and machine tracking on extensive pasture sites.
- A high number of sites had P status outside of the target range. This indicates that low P status may be wide spread in the Hawke's Bay.
- Low P status should be addressed to avoid "knock-on" effects due to poor pasture cover and resulting risk of further loss of shallow soil (NB this does not address issues due to deeper failure of hillslopes).

8 RECOMMENDATIONS

- Further information and assistance to farmers is needed to maintain hill country soil cover.
- 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.
- Land managers and advisors, including fertilizer representatives, may require information regarding the management of P on hill country soils. Specifically, the adoption of P forms best suited to soil type and land slope, and application regimes designed to optimise P use.
- 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.
- Comparison of soil quality under different land uses with the same soil type is recommended.

9 REFERENCES

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10 APPENDICES

Appendix A: Soil Descriptions

Appendix A: Soil Descriptions

Soil	Te Apiti clay
Transect length and direction	50 m, SW
Classification	Pallic
Land use	Extensive pasture
Date sampled	20/06/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture, extensive recent slipping
Slope degrees	20+
Landform	Steeply rolling, midslope concave.
Annual rain (mm)	
Elevation (m)	
Parent material	Mudstone
Drainage	Imperfect
Topsoil depth (cm)	24
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-24	Dark greyish brown (10YR 4/2) clay loam; moderately sticky; moderately plastic; moderately pedal fine nut and crumb structure; common fine roots; diffuse boundary.
Bw	24-36	Light yellowish brown (10YR 6/4) loamy clay; moderately sticky; moderately plastic; moderately pedal fine nut and crumb structure, common fine roots diffuse boundary.
Bg	36-46	Light brownish grey (10YR 6/2) clay; common fine ocherous mottles; very sticky; very plastic; moderately pedal fine nut and crumb structure; indistinct boundary.
Btg	46-90+	Light brownish grey (10YR 6/2) clay; very sticky; very plastic; massive breaking to platey.

Soil	Okawa heavy loam
Transect length and direction	50 m
Classification	Gley
Land use	Extensive pasture
Date sampled	20/06/2011
Land use history	
Present vegetation	Pasture
Slope degrees	0-4°
Landform	Elevated floodplain
Annual rain (mm)	
Elevation (m)	92
Parent material	Loess and Alluvium
Drainage	Poor
Topsoil depth (cm)	20
Limiting horizon	Fragipan
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-20	Very dark greyish brown (10YR 3/2) clay loam; moderately pedal medium polyhedral structure; moderately sticky; moderately plastic; slightly firm soil strength; moderate penetration resistance; friable; common fine roots; distinct boundary
Bg	20-37	Pinkish grey (5YR 6/2) clay loam with common medium dark brown (7YR 3/4) mottles; weakly pedal; moderately sticky; moderately plastic; weak soil strength; low penetration resistance; deformable; common fine roots; distinct boundary.
Btg	37-53	Light reddish brown (5YR 6/3) clay with many medium dark brown (7YR 3/4) mottles; apedal massive; moderately sticky; moderately plastic; very firm soil strength; high penetration resistance; deformable; indistinct boundary.
Bxg	53-84+	Reddish brown (5YR 5/3) clay with many medium dark brown (7YR 3/4) mottles; apedal massive; moderately sticky; moderately plastic; very firm soil strength; very high penetration resistance; deformable

Soil	Mokapeka sandy loam
Transect length and direction	50 m WSW
Classification	Brown
Land use	Extensive pasture
Date sampled	20/06/2011
Land use history	Extensive pasture
Present vegetation	Pasture
Slope degrees	15-25°
Landform	Rolling hill, midslope
Annual rain (mm)	
Elevation (m)	
Parent material	Sandstone
Drainage	Well drained
Topsoil depth (cm)	26
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-26	Dark brown (10YR 3/3) sandy loam; non sticky; non plastic; weakly pedal fine nut and crumb structure; many fine roots; friable; distinct diffuse boundary.
Bw1	26-53	Light yellowish brown (10YR 6/4) sandy loam; non sticky; non plastic; apedal earthy; common fine roots; friable; indistinct boundary.
Bw2	53-80+	Brownish yellow (10YR 6/6) loamy sand; non sticky; non plastic; apedal earthy; friable; few fine roots.

Soil	Atua silt loam
Transect length and direction	50 m, NE
Classification	Pallic
Land use	Extensive pasture
Date sampled	21/06/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	12
Landform	Rolling, planar midslope
Annual rain (mm)	
Elevation (m)	
Parent material	Mudstone
Drainage	Imperfect
Topsoil depth (cm)	20
Limiting horizon	Argillic horizon at 90 cm
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-20	Dark brown (10YR 3/3) silt loam; non sticky; non plastic; weak penetration resistance; moderately pedal medium nut structure; many fine live roots; distinct wavy boundary.
Bg	20-50	Pale olive (5Y 6/4) clay loam; with common strong brown (7.5YR 5/8) mottles; moderate penetration resistance; slightly sticky; slightly plastic; weakly pedal; weakly developed fine nut structure; clay coatings; few fine live roots; diffuse wavy boundary.
Btg	50-90+	Pale olive (5Y 6/4) silty clay; with many strong brown (7.5YR 5/8) mottles; firm penetration resistance; moderately sticky; moderately plastic; moderately firm soil strength; moderately developed medium nut structure; common fine live roots; diffuse wavy boundary.

Soil	Crownthorpe complex
Transect length and direction	50 m, NE
Classification	Brown
Land use	Extensive pasture
Date sampled	21/06/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	25
Landform	Steep planar midslope
Annual rain (mm)	
Elevation (m)	
Parent material	Mudstone
Drainage	Well drained
Topsoil depth (cm)	20
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-20	Dark brown (10YR 3/3) silt loam; non sticky; non plastic; some fine roots; firm penetration resistance; indistinct boundary.
Bw	20-50	Dark yellowish brown (10YR 4/4) silt loam; slightly sticky; slightly plastic; few fine roots; weak penetration resistance; indistinct boundary.
Bw2	50-65+	Reddish brown (2.5YR 5/4) silty clay loam; slightly sticky; moderately plastic; no roots; moderate penetration resistance.

Soil	Waipawa silt loam
Transect length and direction	50 m, SE
Classification	Pallic
Land use	Extensive pasture
Date sampled	28/06/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	15-20
Landform	Strongly rolling, convex midslope
Annual rain (mm)	
Elevation (m)	
Parent material	Mudstone (papa)
Drainage	Imperfectly drained
Topsoil depth (cm)	27
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-27	Dark greyish brown (10YR 4/2); moderately strong pedality; coarse nut structure; many fine roots; firm penetration resistance; distinct diffuse boundary.
Bw	27-50	Reddish brown (2.5YR 5/4); moderately pedal nut and crumb; common fine roots; firm penetration resistance; indistinct boundary.
Bt	50-90	Light yellowish brown (10YR 6/4); strongly pedal nut structure; many sub-angular papa gravel; firm penetration resistance; matrix iron coatings; indistinct boundary.
Btg	90-120+	Light yellowish brown (10YR 6/4) with many ocherous (10YR 6/4) mottles; apedal massive; clay coatings; few sub-angular gravel; moderate penetration resistance.

Soil	Matamau silt loam
Transect length and direction	50 m, SW
Classification	Brown
Land use	Extensive pasture
Date sampled	28/06/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	8
Landform	Low rolling, planar midslope
Annual rain (mm)	
Elevation (m)	
Parent material	Mudstone, loess
Drainage	Poorly drained
Topsoil depth (cm)	30
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-30	Dark greyish brown (10YR 4/2) silt loam; weak penetration resistance; strongly developed very fine nut structure; abundant very fine live roots; dry; indistinct boundary.
Bw	30-46	Yellowish brown (10YR 5/4) silty clay loam; weak penetration resistance; strongly developed medium nut structure; many very fine live roots; dry; diffuse boundary.
Bt	46-95+	Light reddish brown (2.5YR 7/3) clay loam with many strong brown (7.5YR 5/6) mottles; moderate penetration resistance; moderately sticky; moderately plastic; massive breaking to blocky.

Soil	Hastings loam
Transect length and direction	50 m
Classification	Gley
Land use	Extensive pasture
Date sampled	28/06/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	0-3
Landform	Terrace
Annual rain (mm)	
Elevation (m)	
Parent material	Alluvium
Drainage	Imperfectly drained
Topsoil depth (cm)	30
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-30	Very dark grey (10YR 3/1) silty clay loam; moderate penetration resistance; weakly pedal nut structure; many fine roots; diffuse boundary.
Bw	30-70	Pale brown (10YR 6/3) silty clay loam; moderate penetration resistance; slightly sticky; slightly plastic; weakly pedal, nut and crumb structure; common fine roots; indistinct boundary.
Bg	70-90+	greyish brown (2.5Y 5/2) silty clay; firm penetration resistance; apedal massive breaking to fine nut and crumb structure; slightly sticky; slightly plastic; no roots.

Soil	Matapiro silt loam
Transect length and direction	50 m
Classification	Pallic
Land use	Extensive pasture
Date sampled	04/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	12
Landform	Low rolling hills, concave midslope.
Annual rain (mm)	
Elevation (m)	
Parent material	Loess
Drainage	Imperfectly drained
Topsoil depth (cm)	20
Limiting horizon	Fragipan at 60 cm
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-20	Very dark greyish brown (10YR 3/2) silt loam; friable soil strength; moderately developed fine polyhedral peds; slightly plastic, moderate penetration resistance, many fine and very fine roots; distinct diffuse boundary.
Bw	20-30	Very dark grey (10YR 3/1) silt loam; friable soil strength; massive breaking to moderately developed fine nut structure; many fine roots; distinct boundary.
Bt	30-60+	Yellowish brown (10YR 5/6) clay; with light grey (5Y 7/1) and reddish yellow (7.5YR 7/6) mottles; very sticky, very plastic; firm penetration resistance, few fine roots, massive structure.

Soil	Ruahine silt loam
Transect length and direction	50 m, NW
Classification	Brown
Land use	Extensive pasture
Date sampled	04/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	0-5
Landform	Crest of dissected plain
Annual rain (mm)	
Elevation (m)	
Parent material	Greywacke
Drainage	Well drained
Topsoil depth (cm)	20
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-20	Dark brown (10YR 3/3) silt loam; moderately firm penetration resistance; friable medium nut and crumb structure; many fine roots; distinct boundary
Bw1	20-60	Dark yellowish brown (10YR 4/6) silt loam; moderate penetration resistance; strongly developed medium nut structure; common roots; diffuse boundary
Bw2	60-80+	Brownish yellow (10YR 6/6) silt loam; moderate penetration resistance; strongly developed medium nut structure; few roots;

Soil	Gisborne sandy loam
Transect length and direction	50 m
Classification	Pumice
Land use	Extensive pasture
Date sampled	18/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	8
Landform	Rolling, midslope planar.
Annual rain (mm)	1100
Elevation (m)	
Parent material	Taupo pumice
Drainage	Well drained
Topsoil depth (cm)	25
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-25	Very dark grayish brown (10YR 3/2) sandy loam, many fine roots, firm penetration resistance, fine polyhedral peds, friable smooth distinct boundary.
Bw1	25-32	Yellowish brown (10YR 5/8) loamy sand, massive single grain, poorly graded sub-angular sand, many fine roots, weak penetration resistance, smooth indistinct boundary.
Bw2	32-40	Dark yellowish brown (10YR 4/4) sand, massive single grain, poorly graded sub-angular sand, common fine roots, weak penetration resistance, smooth indistinct boundary.
Bw3	40-58	Dark yellowish brown (10YR 4/4) fine sand, massive single grain, poorly graded sub-angular sand, no roots, weak penetration resistance, smooth indistinct boundary.
C	58-100+	Brown (10YR 4/3) fine sand.

Soil	Taupo sandy silt
Transect length and direction	50 m, SE
Classification	Pumice
Land use	Extensive pasture
Date sampled	18/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	15
Landform	Rolling concave midslope
Annual rain (mm)	
Elevation (m)	
Parent material	Taupo pumice
Drainage	Well drained
Topsoil depth (cm)	20-30
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-15	Black (10YR 2/1) sandy loam, fine charcoal, fine polyhedral peds, friable, many fine and very fine roots, indistinct smooth boundary.
Ap2	15-25	Black (10YR 1/1) sandy loam, many fine charcoal (land clearance), apedal earthy, friable, many fine roots, distinct smooth boundary.
Bw1	25-31	Very pale brown (7.5YR 7/3) coarse sand, common fine roots, apedal single grain.
Bw2	31-40	Light reddish brown (2.5YR 6/3) silty sand, common fine roots, apedal single grain.
Bw3	40-100+	Light brownish grey (2.5Y 6/2) sandy silt, few fine roots, apedal earthy.

Soil	Hangaroa
Transect length and direction	50 m, N
Classification	Pumice
Land use	Extensive pasture
Date sampled	18/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	10
Landform	Moderately steep, lower slope.
Annual rain (mm)	
Elevation (m)	
Parent material	Taupo pumice overlying mudstone (papa)
Drainage	Imperfectly drained
Topsoil depth (cm)	25
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-25	Dark brown () Silt loam; moderate penetration resistance; moderately pedal nut and crumb structure; friable; distinct boundary.
Bw	25-46	Orange brown () sandy loam; many fine pumice; moderate penetration resistance; moderately pedal nut and crumb structure; friable; indistinct boundary.
BC	46-70	Pale grey () clayey silt with common orange mottles; moderate penetration resistance; slightly sticky; slightly plastic; moderately pedal blocky breaking to nut and crumb structure.

Soil	Awamate
Transect length and direction	50 m
Classification	Gley
Land use	Extensive pasture
Date sampled	19/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture, recently flooded
Slope degrees	0-3
Landform	Floodplain in narrow valley (200-500 m wide)
Annual rain (mm)	
Elevation (m)	
Parent material	Mudstone
Drainage	Poorly drained
Topsoil depth (cm)	Indistinct topsoil
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Bw	0-33	Yellowish brown (10YR 5/4) loamy silt; slightly sticky; slightly plastic; common fine roots; apedal massive; distinct boundary.
Bg	33-90+	Light reddish brown (2.5Y 6/3) clayey silt; slightly sticky; slighty plastic; few fine roots; common strong brown mottles; apedal massive.

Soil	Mahoenui
Transect length and direction	50 m, SE
Classification	Pallic
Land use	Extensive pasture
Date sampled	19/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture, mature poplars, blackberry.
Slope degrees	15-25
Landform	Steep, concave midslope.
Annual rain (mm)	
Elevation (m)	
Parent material	Mudstone
Drainage	Moderately drained
Topsoil depth (cm)	30
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap1	0-30	Brown (10YR 4/3) loamy silt; many roots; weakly pedal fine nut and crumb structure; colluvial material; distinct boundary.
Ap2	30-64	Yellowish brown (10YR 5/4) silt; few roots; firm soil strength; weakly pedal fine nut and crumb structure; distinct diffuse boundary.
Bw1	64-80	Light brownish grey (10YR 6/2) clayey silt; few roots; firm soil strength; weak coarse blocky structure; indistinct boundary.
BC	80-110+	Light brownish grey (10YR 6/2) silty clay loam; few roots; common angular gravel (papa).

Soil	Tiniroto
Transect length and direction	50 m, W
Classification	Pumice
Land use	Extensive pasture
Date sampled	19/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	5-8
Landform	Outwash toe slope
Annual rain (mm)	
Elevation (m)	
Parent material	Pumiceous tephra
Drainage	Well drained
Topsoil depth (cm)	20
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-20	Black (10YR 2/1) sandy loam; weakly pedal fine nut and crumb structure; non sticky; non plastic; weak penetration resistance; distinct boundary.
Bw	20-49	Yellowish brown (10YR 5/6) loamy sand; apedal massive breaking to single grain; non sticky; non plastic; weak penetration resistance; distinct boundary.
BC	49-82+	Very pale brown (10YR 8/2) silty sand; common fine to coarse Mn nodules; apedal single grain; non sticky; non plastic; weak penetration resistance.

Soil	Takapau silt loam
Transect length and direction	50 m
Classification	Allophanic
Land use	Extensive pasture
Date sampled	21/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	0-3
Landform	Elevated terrace
Annual rain (mm)	
Elevation (m)	
Parent material	Tephra over greywacke alluvium
Drainage	Well drained
Topsoil depth (cm)	18
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
A	0-18	Very dark brown (10YR 2/2) sandy loam, apedal earthy, friable, very slightly sticky, many fine and very fine roots, distinct wavy boundary.
Bw1	18-28	Dark yellowish brown (10YR 4/4) fine loamy sand, slightly sticky, weakly pedal, fine polyhedral peds, common fine roots, smooth indistinct boundary.
Bw2	28-44	Yellowish brown (10YR 5/4) loamy sand, common fine roots, smooth indistinct boundary.
C	44-150+	Rounded gravel in sandy matrix (10YR 5/4).

Soil	Gwavas sandy loam
Transect length and direction	50 m, N to NE
Classification	Brown
Land use	Extensive pasture
Date sampled	21/07/2011
Land use history	Extensive pasture
Present vegetation	Ryegrass pasture
Slope degrees	15
Landform	Rolling, concave midslope
Annual rain (mm)	
Elevation (m)	
Parent material	Greywacke
Drainage	Moderately drained
Topsoil depth (cm)	26
Limiting horizon	
Sampled by	KB/BL

Horizon	Depth (cm)	Description
A	0-26	Very dark grayish brown (10YR 3/2) sandy loam
Bw	26-47	Dark yellowish brown (10YR 4/4) loamy silt, many common 20-200 mm gravel (10YR 6/6)sub-rounded to sub-angular, some highly weathered, weak penetration resistance, common fine and very fine roots.
BC	47-70+	Dark yellowish brown (10YR 4/4) loamy gravel 5-20 mm, common fine roots, weak penetration resistance.

Soil	Te Onepu clay loam
Transect length and direction	50 m; NE
Classification	Melanic
Land use	Extensive pasture
Date sampled	21/07/2011
Land use history	Extensive pasture, drystock, certified organic
Present vegetation	Pasture
Slope degrees	1-3
Landform	Planar, below crest, depositional surface
Annual rain (mm)	Around 1000 mm
Elevation (m)	
Parent material	Limestone
Drainage	Moderately well drained
Topsoil depth (cm)	22 cm
Limiting horizon	R – limestone at 60 cm
Sampled by	KB/BL

Horizon	Depth (cm)	Description
Ap	0-22	Black (10YR 2/1) loam, fine polyhedral nut and crumb structure, common fine roots, indistinct smooth boundary.
Bw1	22-37	Dark yellowish brown (10YR 3/4) clayey silt, weakly pedal polyhedral nut and crumb, many worm casts, few roots, firm, slightly sticky, plastic,, indistinct smooth boundary.
Bw2	37-60	Dark yellowish brown (10YR 4/6) clayey silt, firm, plastic, no roots.
R	60+	Slightly altered limestone

Appendix B: Analytical Results

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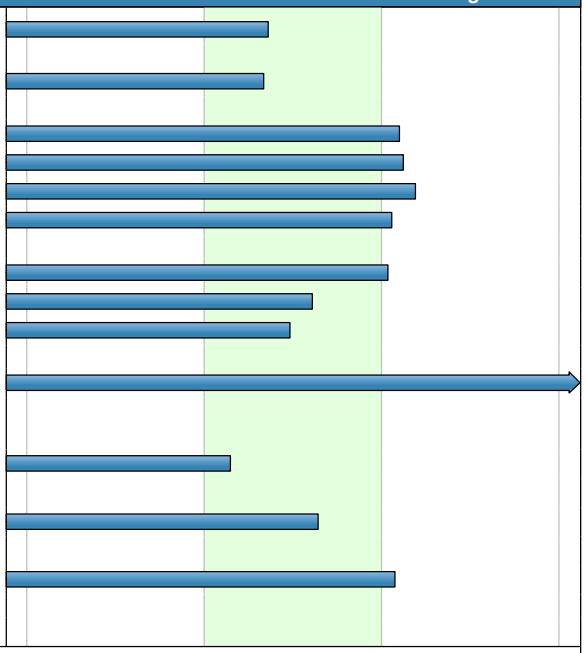
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	917835 shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	28-Jul-2011
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 09 Agri 04/07/11 04-Jul-2011 **Lab Number:** 917835.1
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.0	5.8 - 6.3
Olsen Phosphorus	mg/L	23	20 - 30
Potassium	me/100g	0.86	0.50 - 0.80
Calcium	me/100g	13.6	6.0 - 12.0
Magnesium	me/100g	3.77	1.00 - 3.00
Sodium	me/100g	0.56	0.20 - 0.50
CEC	me/100g	26	12 - 25
Total Base Saturation	%	71	50 - 85
Volume Weight	g/mL	0.79	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	316	100 - 150
Anaerobically Mineralisable N*	µg/g	266	
Organic Matter*	%	8.5	7.0 - 17.0
Total Carbon	%	4.9	
Total Nitrogen	%	0.49	0.30 - 0.60
C/N Ratio*		10.0	
Anaerobically Mineralisable N/Total N Ratio*	%	5.4	3.0 - 5.0
Soil Sample Depth*	mm	0-100	
Base Saturation %		K 3.3	Ca 52 Mg 14.3 Na 2.1
MAF Units		K 14	Ca 13 Mg 67 Na 20



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.

Analyst's Comments

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 level above should be divided by two.

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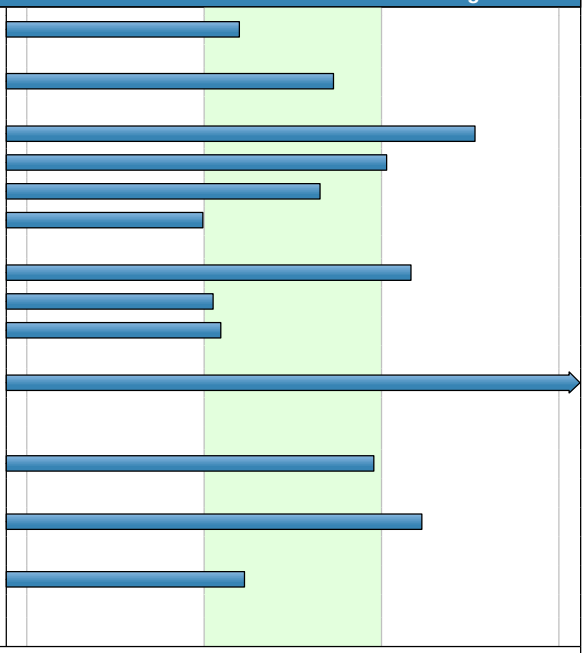
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 10 Agri 04/07/11 04-Jul-2011 **Lab Number:** 917835.2
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.9	5.8 - 6.3
Olsen Phosphorus	mg/L	27	20 - 30
Potassium	me/100g	1.12	0.50 - 0.80
Calcium	me/100g	12.4	6.0 - 12.0
Magnesium	me/100g	2.31	1.00 - 3.00
Sodium	me/100g	0.20	0.20 - 0.50
CEC	me/100g	31	12 - 25
Total Base Saturation	%	52	50 - 85
Volume Weight	g/mL	0.64	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	304	100 - 150
Anaerobically Mineralisable N*	µg/g	319	
Organic Matter*	%	16.6	7.0 - 17.0
Total Carbon	%	9.6	
Total Nitrogen	%	0.92	0.30 - 0.60
C/N Ratio*		10.4	
Anaerobically Mineralisable N/Total N Ratio*	%	3.5	3.0 - 5.0
Soil Sample Depth*	mm	0-100	
Base Saturation %		K 3.6	Ca 40 Mg 7.5 Na 0.6
MAF Units		K 15	Ca 10 Mg 33 Na 6



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.

Analyst's Comments

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 level above should be divided by two.

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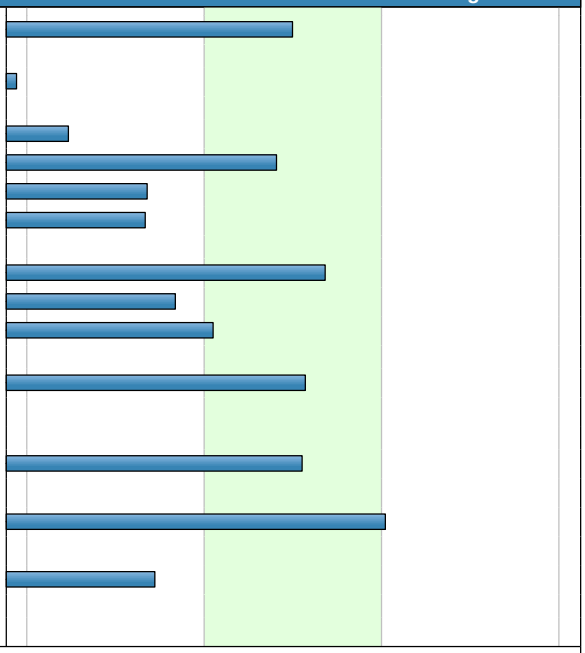
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 11 Agri 18/07/11 18-Jul-2011 **Lab Number:** 917835.3
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.0	5.8 - 6.3
Olsen Phosphorus	mg/L	5	20 - 30
Potassium	me/100g	0.23	0.50 - 0.80
Calcium	me/100g	8.4	6.0 - 12.0
Magnesium	me/100g	0.77	1.00 - 3.00
Sodium	me/100g	0.13	0.20 - 0.50
CEC	me/100g	21	12 - 25
Total Base Saturation	%	46	50 - 85
Volume Weight	g/mL	0.62	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	129	100 - 150
Anaerobically Mineralisable N*	µg/g	138	
Organic Matter*	%	12.5	7.0 - 17.0
Total Carbon	%	7.3	
Total Nitrogen	%	0.63	0.30 - 0.60
C/N Ratio*		11.5	
Anaerobically Mineralisable N/Total N Ratio*	%	2.2	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 1.1	Ca 40	Mg 3.7	Na 0.6
MAF Units	K 3	Ca 7	Mg 11	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.

Analyst's Comments

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 level above should be divided by two.

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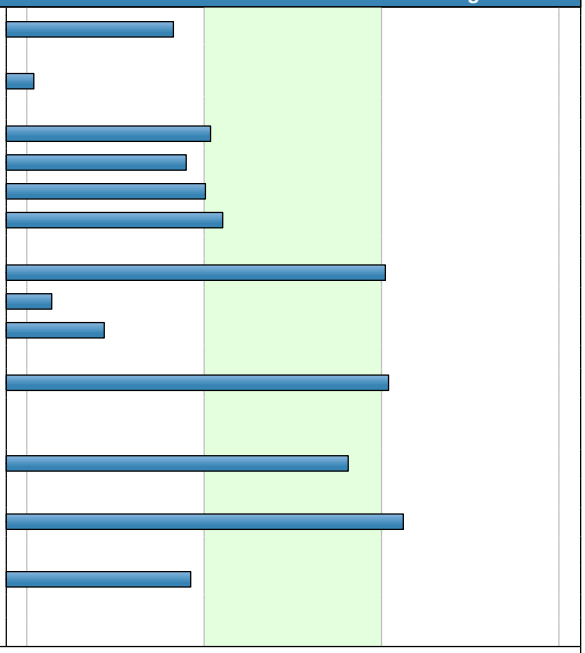
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 12 Agri 18/07/11 18-Jul-2011 **Lab Number:** 917835.4
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.7	5.8 - 6.3
Olsen Phosphorus	mg/L	6	20 - 30
Potassium	me/100g	0.51	0.50 - 0.80
Calcium	me/100g	5.6	6.0 - 12.0
Magnesium	me/100g	1.01	1.00 - 3.00
Sodium	me/100g	0.23	0.20 - 0.50
CEC	me/100g	26	12 - 25
Total Base Saturation	%	28	50 - 85
Volume Weight	g/mL	0.49	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	156	100 - 150
Anaerobically Mineralisable N*	µg/g	214	
Organic Matter*	%	15.1	7.0 - 17.0
Total Carbon	%	8.8	
Total Nitrogen	%	0.77	0.30 - 0.60
C/N Ratio*		11.4	
Anaerobically Mineralisable N/Total N Ratio*	%	2.8	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 2.0	Ca 22	Mg 3.9	Na 0.9
MAF Units	K 5	Ca 3	Mg 11	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.

Analyst's Comments

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 level above should be divided by two.

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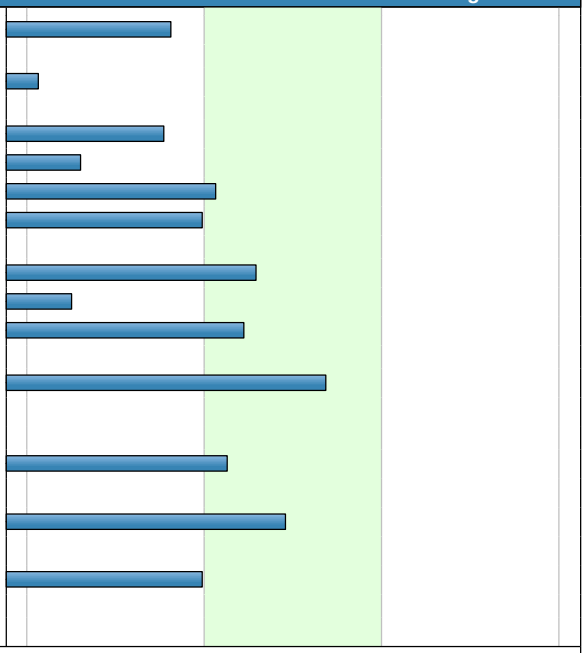
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 13 Agri 18/07/11 18-Jul-2011 **Lab Number:** 917835.5
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.6	5.8 - 6.3
Olsen Phosphorus	mg/L	6	20 - 30
Potassium	me/100g	0.42	0.50 - 0.80
Calcium	me/100g	3.2	6.0 - 12.0
Magnesium	me/100g	1.13	1.00 - 3.00
Sodium	me/100g	0.20	0.20 - 0.50
CEC	me/100g	16	12 - 25
Total Base Saturation	%	31	50 - 85
Volume Weight	g/mL	0.69	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	134	100 - 150
Anaerobically Mineralisable N*	µg/g	130	
Organic Matter*	%	8.3	7.0 - 17.0
Total Carbon	%	4.8	
Total Nitrogen	%	0.44	0.30 - 0.60
C/N Ratio*		11.0	
Anaerobically Mineralisable N/Total N Ratio*	%	3.0	3.0 - 5.0
Soil Sample Depth*	mm	0-100	
Base Saturation %		K 2.7 Ca 20 Mg 7.2 Na 1.2	
MAF Units		K 6 Ca 3 Mg 18 Na 6	



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.

Analyst's Comments

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 level above should be divided by two.

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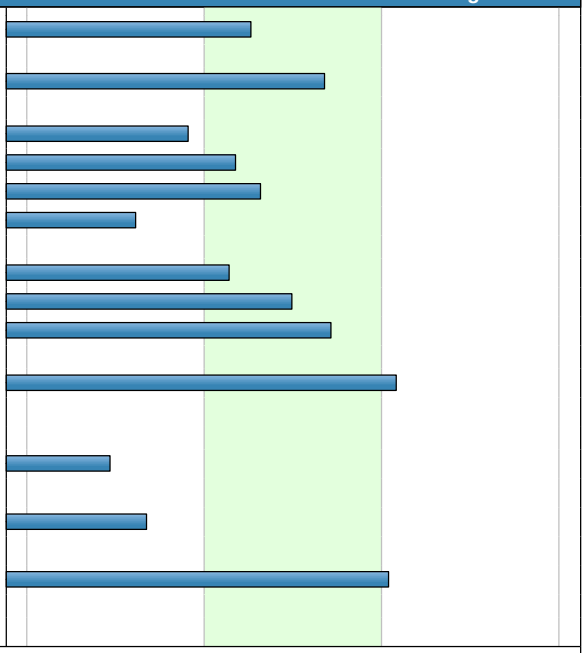
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	28-Jul-2011
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 14 Agri 19/07/11 19-Jul-2011 **Lab Number:** 917835.6
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.9	5.8 - 6.3
Olsen Phosphorus	mg/L	27	20 - 30
Potassium	me/100g	0.47	0.50 - 0.80
Calcium	me/100g	7.1	6.0 - 12.0
Magnesium	me/100g	1.63	1.00 - 3.00
Sodium	me/100g	0.12	0.20 - 0.50
CEC	me/100g	14	12 - 25
Total Base Saturation	%	67	50 - 85
Volume Weight	g/mL	0.89	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	163	100 - 150
Anaerobically Mineralisable N*	µg/g	122	
Organic Matter*	%	3.3	7.0 - 17.0
Total Carbon	%	1.9	
Total Nitrogen	%	0.23	0.30 - 0.60
C/N Ratio*		8.1	
Anaerobically Mineralisable N/Total N Ratio*	%	5.2	3.0 - 5.0
Soil Sample Depth*	mm	0-100	
Base Saturation %		K 3.4	Ca 51	Mg 11.8	Na 0.9
MAF Units		K 9	Ca 8	Mg 33	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.

Analyst's Comments

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 level above should be divided by two.

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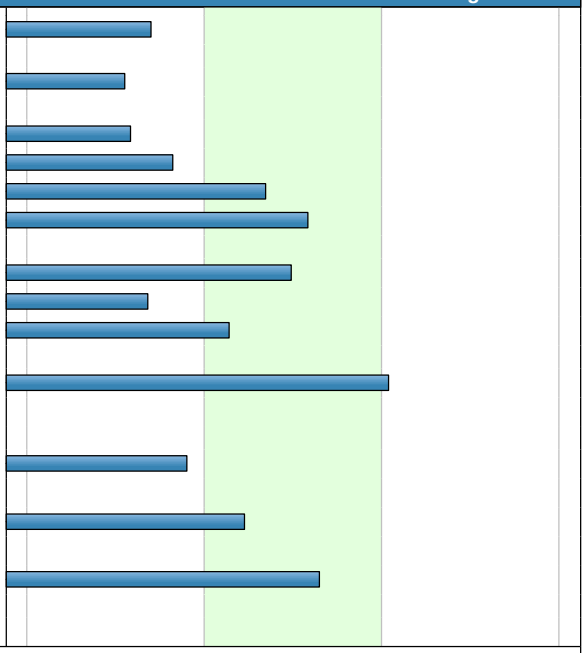
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	917835 shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	28-Jul-2011
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 15 Agri 19/07/11 19-Jul-2011 **Lab Number:** 917835.7
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.6	5.8 - 6.3
Olsen Phosphorus	mg/L	13	20 - 30
Potassium	me/100g	0.35	0.50 - 0.80
Calcium	me/100g	5.3	6.0 - 12.0
Magnesium	me/100g	1.70	1.00 - 3.00
Sodium	me/100g	0.38	0.20 - 0.50
CEC	me/100g	18	12 - 25
Total Base Saturation	%	42	50 - 85
Volume Weight	g/mL	0.66	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	156	100 - 150
Anaerobically Mineralisable N*	µg/g	158	
Organic Matter*	%	6.3	7.0 - 17.0
Total Carbon	%	3.7	
Total Nitrogen	%	0.37	0.30 - 0.60
C/N Ratio*		9.9	
Anaerobically Mineralisable N/Total N Ratio*	%	4.3	3.0 - 5.0
Soil Sample Depth*	mm	0-100	
Base Saturation %		K 1.9 Ca 29 Mg 9.2 Na 2.0	
MAF Units		K 5 Ca 4 Mg 25 Na 11	



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.

Analyst's Comments

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 level above should be divided by two.

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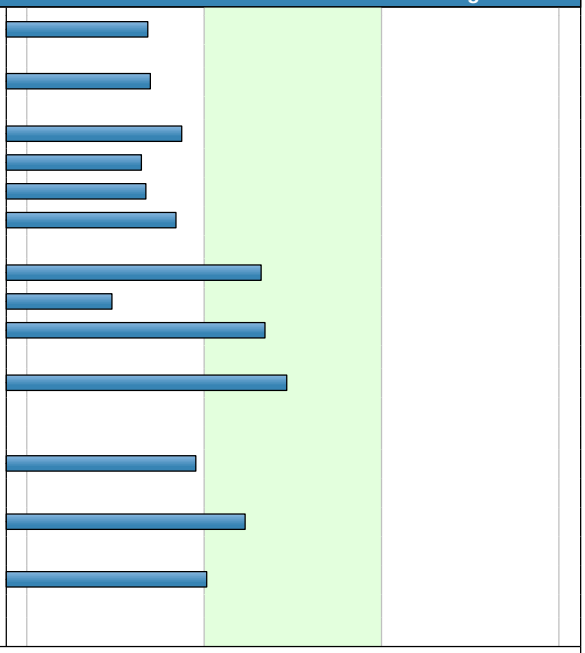
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	917835 shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	28-Jul-2011
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 16 Agri 19/07/11 19-Jul-2011 **Lab Number:** 917835.8
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.5	5.8 - 6.3
Olsen Phosphorus	mg/L	15	20 - 30
Potassium	me/100g	0.45	0.50 - 0.80
Calcium	me/100g	4.6	6.0 - 12.0
Magnesium	me/100g	0.77	1.00 - 3.00
Sodium	me/100g	0.17	0.20 - 0.50
CEC	me/100g	16	12 - 25
Total Base Saturation	%	37	50 - 85
Volume Weight	g/mL	0.74	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	123	100 - 150
Anaerobically Mineralisable N*	µg/g	112	
Organic Matter*	%	6.7	7.0 - 17.0
Total Carbon	%	3.9	
Total Nitrogen	%	0.37	0.30 - 0.60
C/N Ratio*		10.5	
Anaerobically Mineralisable N/Total N Ratio*	%	3.0	3.0 - 5.0
Soil Sample Depth*	mm	0-100	
Base Saturation %		K 2.8	Ca 28 Mg 4.8 Na 1.0
MAF Units		K 7	Ca 4 Mg 13 Na 6



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.

Analyst's Comments

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 level above should be divided by two.

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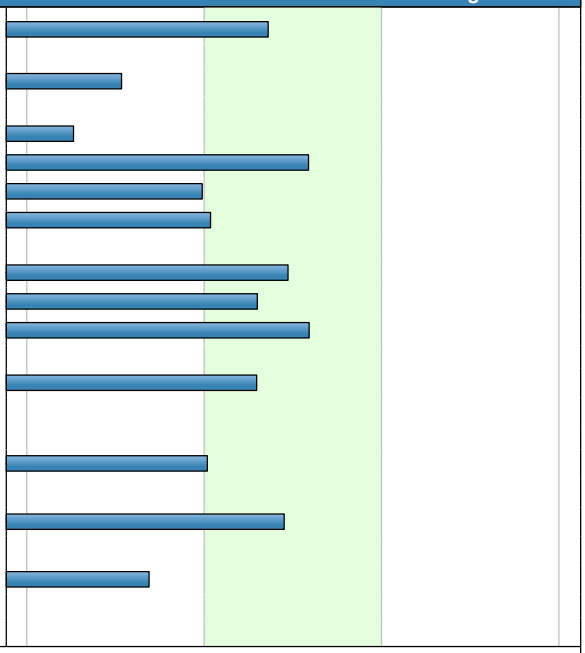
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	917835 shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	28-Jul-2011
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 17 Agri 21/07/11 21-Jul-2011 **Lab Number:** 917835.9
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.0	5.8 - 6.3
Olsen Phosphorus	mg/L	13	20 - 30
Potassium	me/100g	0.24	0.50 - 0.80
Calcium	me/100g	9.5	6.0 - 12.0
Magnesium	me/100g	0.99	1.00 - 3.00
Sodium	me/100g	0.21	0.20 - 0.50
CEC	me/100g	18	12 - 25
Total Base Saturation	%	60	50 - 85
Volume Weight	g/mL	0.84	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	115	100 - 150
Anaerobically Mineralisable N*	µg/g	91	
Organic Matter*	%	7.2	7.0 - 17.0
Total Carbon	%	4.2	
Total Nitrogen	%	0.44	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 1.3	Ca 53 Mg 5.5 Na 1.2
MAF Units		K 4	Ca 10 Mg 19 Na 8



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.

Analyst's Comments

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 level above should be divided by two.

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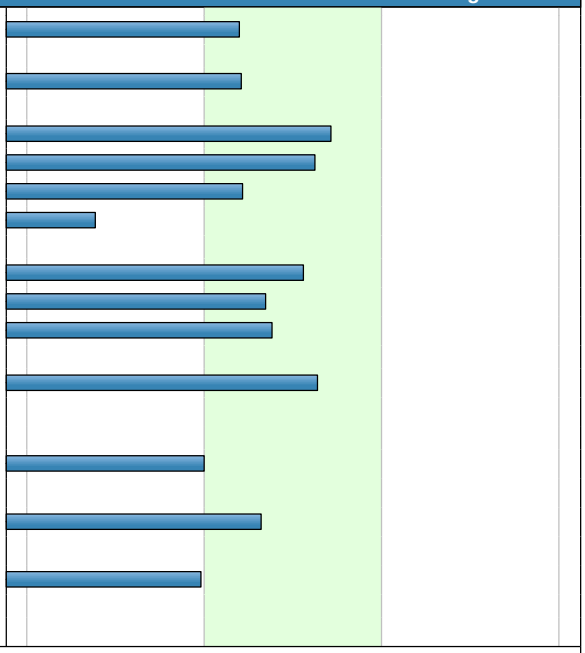
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	917835 shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	28-Jul-2011
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 18 Agri 21/07/11 21-Jul-2011 **Lab Number:** 917835.10
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.9	5.8 - 6.3
Olsen Phosphorus	mg/L	22	20 - 30
Potassium	me/100g	0.71	0.50 - 0.80
Calcium	me/100g	9.7	6.0 - 12.0
Magnesium	me/100g	1.43	1.00 - 3.00
Sodium	me/100g	0.08	0.20 - 0.50
CEC	me/100g	19	12 - 25
Total Base Saturation	%	62	50 - 85
Volume Weight	g/mL	0.75	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	132	100 - 150
Anaerobically Mineralisable N*	µg/g	117	
Organic Matter*	%	7.0	7.0 - 17.0
Total Carbon	%	4.1	
Total Nitrogen	%	0.40	0.30 - 0.60
C/N Ratio*		10.2	
Anaerobically Mineralisable N/Total N Ratio*	%	2.9	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 3.7	Ca 51	Mg 7.4	Na 0.4
MAF Units	K 11	Ca 9	Mg 24	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.

Analyst's Comments

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 level above should be divided by two.

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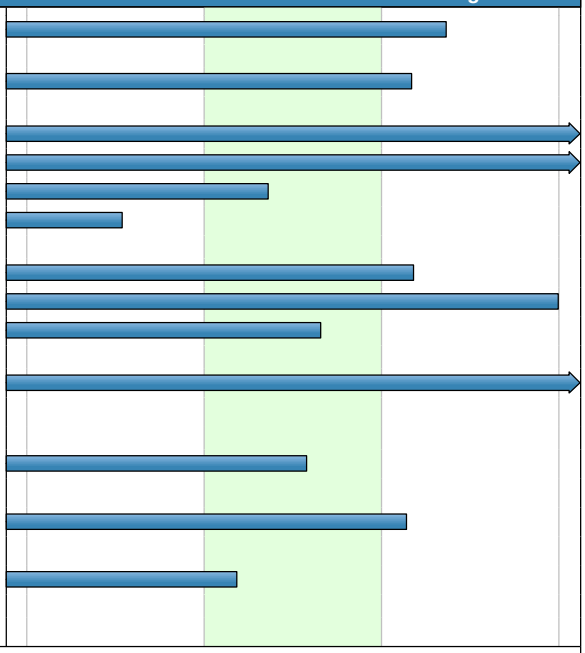
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	917835 shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	28-Jul-2011
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: Site 19 Agri 21/07/11 21-Jul-2011 **Lab Number:** 917835.11
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	1.83	0.50 - 0.80
Calcium	me/100g	27.8	6.0 - 12.0
Magnesium	me/100g	1.72	1.00 - 3.00
Sodium	me/100g	0.11	0.20 - 0.50
CEC	me/100g	31	12 - 25
Total Base Saturation	%	100	50 - 85
Volume Weight	g/mL	0.86	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	350	100 - 150
Anaerobically Mineralisable N*	µg/g	270	
Organic Matter*	%	12.8	7.0 - 17.0
Total Carbon	%	7.4	
Total Nitrogen	%	0.80	0.30 - 0.60
C/N Ratio*		9.3	
Anaerobically Mineralisable N/Total N Ratio*	%	3.4	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.8	Ca 88	Mg 5.5	Na 0.3
MAF Units	K 32	Ca 30	Mg 33	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.

Analyst's Comments

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ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	917835 shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	28-Jul-2011
		Date Reported:	08-Aug-2011
		Quote No:	45047
		Order No:	
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

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	Samples
Sample Registration*	Samples were registered according to instructions received.	-	1-11
Soil Prep (Dry & Grind)*	Air dried at 35 - 40°C overnight (residual moisture typically 4%) and crushed to pass through a 2mm screen.	-	1-11
pH	1:2 (v/v) soil:water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-11
Olsen Phosphorus	Olsen extraction followed by Molybdenum Blue colorimetry.	1 mg/L	1-11
Potassium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-11
Calcium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-11
Magnesium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-11
Sodium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	2 MAF units	1-11
Available Nitrogen	Anaerobic incubation followed by extraction using 2M KCl followed by Berthelot colorimetry. (Calculation based on 15cm depth sample).	1 mg/L	1-11
Anaerobically Mineralisable N*	As for Available Nitrogen but reported as µg/g.	5 µg/g	1-11
Organic Matter*	Organic Matter is 1.72 x Total Carbon.	0.2 %	1-11
Total Carbon	Dumas combustion.	0.1 %	1-11
Total Nitrogen	Dumas combustion.	0.04 %	1-11
Potassium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.01 me/100g	1-11
Calcium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.5 me/100g	1-11
Magnesium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.04 me/100g	1-11
Sodium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.05 me/100g	1-11
Potassium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.1 %BS	1-11
Calcium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 %BS	1-11
Magnesium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.2 %BS	1-11
Sodium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.1 %BS	1-11
CEC	Summation of extractable cations (K, Ca, Mg, Na) and extractable acidity.	2 me/100g	1-11
Total Base Saturation	Calculated from Extractable Cations and Cation Exchange Capacity.	5 %	1-11
Volume Weight	The weight/volume ratio of dried, ground soil.	0.01 g/mL	1-11

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.

Wendy Homewood
Quality Assurance Officer - Agriculture Division

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ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	910845	SPv1
Contact:	B Lynch	**Date Registered:**	02-Jul-2011	
	C/- Hawkes Bay Regional Council	**Date Reported:**	15-Aug-2011	
	Private Bag 6006	**Quote No:**	45046	
	NAPIER 4142	**Order No:**		
		Client Reference:	01 Metals	
		Submitted By:	B Lynch	

Sample Type: Soil

Sample Name:		01 Metals 20-Jun-2011	02 Metals 20-Jun-2011	03 Metals 20-Jun-2011	04 Metals 21-Jun-2011	05 Metals 21-Jun-2011
Lab Number:		910845.1	910845.2	910845.3	910845.4	910845.5
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.96	0.76	0.45	0.57	0.76
Fluoride*	mg/kg dry wt	390	260	196	240	270
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	2	< 2	< 2	2	3
Total Recoverable Cadmium	mg/kg dry wt	0.27	0.11	0.10	0.21	0.30
Total Recoverable Chromium	mg/kg dry wt	11	7	9	8	13
Total Recoverable Copper	mg/kg dry wt	11	4	3	4	20
Total Recoverable Lead	mg/kg dry wt	7.6	7.4	6.1	8.2	9.9
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	8	4	4	4	9
Total Recoverable Zinc	mg/kg dry wt	51	34	41	32	48
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	< 0.010	< 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 Type: Soil						
Sample Name:		01 Metals 20-Jun-2011	02 Metals 20-Jun-2011	03 Metals 20-Jun-2011	04 Metals 21-Jun-2011	05 Metals 21-Jun-2011
Lab Number:		910845.1	910845.2	910845.3	910845.4	910845.5
Sample Name:		06 Metals 28-Jun-2011	07 Metals 28-Jun-2011	08 Metals 28-Jun-2011	09 Metals 04-Jul-2011	10 Metals 04-Jul-2011
Lab Number:		910845.6	910845.7	910845.8	910845.9	910845.10
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.63	0.73	0.80	1.20	1.53
Fluoride*	mg/kg dry wt	240	260	300	300	500
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	2	2	2	< 2	< 2
Total Recoverable Cadmium	mg/kg dry wt	0.32	0.27	0.46	0.35	0.59
Total Recoverable Chromium	mg/kg dry wt	6	10	12	11	12
Total Recoverable Copper	mg/kg dry wt	7	9	14	9	20
Total Recoverable Lead	mg/kg dry wt	5.3	7.5	8.9	9.1	6.8
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	5	10	10	6
Total Recoverable Zinc	mg/kg dry wt	45	46	65	71	69
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	0.012	< 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	< 0.010	0.46	< 0.010	< 0.010	0.027
2,4'-DDT	mg/kg dry wt	< 0.010	0.017	< 0.010	< 0.010	< 0.010
4,4'-DDT	mg/kg dry wt	< 0.010	0.104	< 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:		11 Metals 18-Jul-2011	12 Metals 18-Jul-2011	13 Metals 18-Jul-2011	14 Metals 19-Jul-2011	15 Metals 19-Jul-2011
Lab Number:		910845.11	910845.12	910845.13	910845.14	910845.15
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.94	0.66	0.43	1.02	0.80
Fluoride*	mg/kg dry wt	400	360	270	340	340
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	< 2	< 2	< 2	2	< 2
Total Recoverable Cadmium	mg/kg dry wt	0.53	0.43	0.10	0.15	0.23
Total Recoverable Chromium	mg/kg dry wt	7	4	5	15	7
Total Recoverable Copper	mg/kg dry wt	5	5	3	7	4
Total Recoverable Lead	mg/kg dry wt	5.4	3.9	5.8	8.8	6.0
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	3	2	4	11	5

Sample Type: Soil						
Sample Name:		11 Metals 18-Jul-2011	12 Metals 18-Jul-2011	13 Metals 18-Jul-2011	14 Metals 19-Jul-2011	15 Metals 19-Jul-2011
Lab Number:		910845.11	910845.12	910845.13	910845.14	910845.15
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Zinc	mg/kg dry wt	36	25	27	52	36
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	0.020	< 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:		16 Metals 19-Jul-2011	17 Metals 21-Jul-2011	18 Metals 21-Jul-2011	19 Metals 21-Jul-2011	
Lab Number:		910845.16	910845.17	910845.18	910845.19	
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.73	0.97	0.77	0.71	-
Fluoride*	mg/kg dry wt	350	310	240	240	-
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	< 2	2	3	4	-
Total Recoverable Cadmium	mg/kg dry wt	0.32	0.34	0.26	0.69	-
Total Recoverable Chromium	mg/kg dry wt	5	14	14	17	-
Total Recoverable Copper	mg/kg dry wt	4	9	10	16	-
Total Recoverable Lead	mg/kg dry wt	5.1	9.0	8.2	14.4	-
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	0.12	-
Total Recoverable Nickel	mg/kg dry wt	4	7	6	6	-
Total Recoverable Zinc	mg/kg dry wt	33	71	48	63	-
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
alpha-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
beta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
delta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
cis-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
trans-Chlordane	mg/kg dry wt	< 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	-
2,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
4,4'-DDD	mg/kg dry wt	0.012	< 0.010	< 0.010	< 0.010	-

Sample Type: Soil						
Sample Name:		16 Metals 19-Jul-2011	17 Metals 21-Jul-2011	18 Metals 21-Jul-2011	19 Metals 21-Jul-2011	
Lab Number:		910845.16	910845.17	910845.18	910845.19	
Organochlorine Pesticides Screening in Soil						
2,4'-DDE	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
4,4'-DDE	mg/kg dry wt	0.161	< 0.010	0.019	< 0.010	-
2,4'-DDT	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
4,4'-DDT	mg/kg dry wt	0.080	< 0.010	< 0.010	< 0.010	-
Dieldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Endosulfan I	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Endosulfan II	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Endosulfan sulphate	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Endrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Endrin Aldehyde	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Endrin ketone	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Heptachlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Heptachlor epoxide	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Hexachlorobenzene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	-
Methoxychlor	mg/kg dry wt	< 0.010	< 0.010	< 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**	**Samples**
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%.	-	1-19
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-19
Organochlorine Pesticides Screening in Soil	Sonication extraction, SPE cleanup, dual column GC-ECD analysis (modified US EPA 8082).. Tested on dried sample	-	1-19
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-19
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	1-19
Total Fluoride in solids*	Alkaline fusion of sample. Ion selective electrode determination. Methods of Soil Analysis 2nd Edition, Pt2, 26-4.3.3.	10 mg/kg dry wt	1-19

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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Soil Physics Laboratory Analytical Report

Job Number: PJ10022
Customer: Hawke's Bay Regional Council
Barry Lynch

Date Received: 27/07/2011
Date Reported: 31/08/2011

Core No.	Site name	Sample ID	Particle density	Dry bulk density	Porosity	Macro-porosity	Field capacity	AWC
			(g/cm^3)	(g/ cm^3)	(%)	(%)	(%)	(%)
771	1A	PP11-0012	2.50	1.02	59	11	47	20
872	1B	PP11-0013	2.48	1.09	56	4	51	20
733	1C	PP11-0014	2.59	1.24	52	4	48	19
815	2A	PP11-0015	2.47	1.09	56	8	45	29
800	2B	PP11-0016	2.49	1.13	55	9	44	27
817	2C	PP11-0017	2.49	1.15	54	9	43	23
977	3A	PP11-0018	2.56	1.25	51	12	36	22
709	3B	PP11-0019	2.52	1.16	54	12	38	24
833	3C	PP11-0020	2.52	1.19	53	13	36	21
911	4A	PP11-0021	2.49	1.07	57	12	42	23
883	4B	PP11-0022	2.53	1.15	55	16	36	22
923	4C	PP11-0023	2.51	1.12	55	17	37	21
983	5A	PP11-0024	2.58	1.44	44	7	36	15
894	5B	PP11-0025	2.56	1.31	49	9	38	19
721	5C	PP11-0026	2.58	1.30	49	14	34	17
836	6A	PP11-0027	2.50	1.03	59	16	41	19
797	6B	PP11-0028	2.51	1.05	58	18	39	20
980	6C	PP11-0029	2.48	1.00	60	18	40	13
890	7A	PP11-0030	2.52	1.17	54	11	41	22
876	7B	PP11-0031	2.48	1.04	58	10	45	24
993	7C	PP11-0032	2.49	1.11	56	6	48	28
938	8A	PP11-0033	2.51	1.13	55	12	40	20
766	8B	PP11-0034	2.50	1.10	56	12	42	22
936	8C	PP11-0035	2.52	1.13	55	13	39	21
818	9A	PP11-0036	2.55	1.18	54	4	48	23
880	9B	PP11-0037	2.49	1.16	53	5	47	23
820	9C	PP11-0038	2.53	1.20	52	8	42	21

Note: all sampled by client.
AWC = Available–water capacity

John Dando, Soil Physics Laboratory Manager

Job Number: PJ 10022

Date Reported: 31/08/2011

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Core No.	Site name	Sample ID	Particle density	Dry bulk density	Porosity	Macro-porosity	Field capacity	AWC
			(g/cm^3)	(g/ cm^3)	(%)	(%)	(%)	(%)
706	10A	PP11-0039	2.44	0.86	65	16	44	24
942	10B	PP11-0040	2.38	0.77	68	16	49	24
908	10C	PP11-0041	2.38	0.76	68	14	51	24
895	11A	PP11-0042	2.38	0.81	66	17	46	30
955	11B	PP11-0043	2.25	0.70	69	11	49	35
837	11C	PP11-0044	2.29	0.73	68	16	48	31
877	12A	PP11-0045	2.22	0.63	72	19	46	30
878	12B	PP11-0046	2.22	0.61	73	14	54	39
939	12C	PP11-0047	2.23	0.65	71	17	48	34
960	13A	PP11-0048	2.29	0.80	65	16	44	30
886	13B	PP11-0049	2.39	0.95	61	16	38	26
931	13C	PP11-0050	2.39	0.89	63	13	47	30
879	14A	PP11-0051	2.64	1.34	49	4	44	27
787	14B	PP11-0052	2.63	1.23	53	3	49	30
863	14C	PP11-0053	2.63	1.31	50	3	45	21
823	15A	PP11-0054	2.46	0.94	62	16	43	30
807	15B	PP11-0055	2.43	1.01	58	10	46	30
827	15C	PP11-0056	2.44	1.01	59	13	42	29
822	16A	PP11-0057	2.34	0.93	60	10	45	31
712	16B	PP11-0058	2.37	0.99	58	9	45	31
935	16C	PP11-0059	2.38	1.03	57	6	49	34
941	17A	PP11-0060	2.51	1.15	54	12	40	24
831	17B	PP11-0061	2.50	1.12	55	14	38	23
940	17C	PP11-0062	2.51	1.17	53	12	38	23
860	18A	PP11-0063	2.57	1.30	50	13	32	20
714	18B	PP11-0064	2.53	1.10	57	17	36	21
920	18C	PP11-0065	2.53	1.17	54	16	35	21
885	19A	PP11-0066	2.47	0.96	61	10	48	27
862	19B	PP11-0067	2.51	1.10	56	9	44	22
811	19C	PP11-0068	2.39	0.86	64	12	47	26

Job Number: PJ 10022

Date Reported: 31/08/2011

Landcare Research
Manaaki Whenua

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
771	1A	PP11-0012	46	48	47	27	47	49	47	27
872	1B	PP11-0013	47	48	47	29	51	53	51	31
733	1C	PP11-0014	35	39	38	23	44	48	48	28
815	2A	PP11-0015	45	43	41	15	50	47	45	16
800	2B	PP11-0016	41	41	39	15	46	46	44	17
817	2C	PP11-0017	41	39	37	17	47	45	43	20
977	3A	PP11-0018	29	32	29	11	36	39	36	13
709	3B	PP11-0019	33	36	33	12	38	42	38	14
833	3C	PP11-0020	29	33	30	12	35	39	36	14
911	4A	PP11-0021	38	42	39	18	41	45	42	19
883	4B	PP11-0022	30	34	31	12	34	38	36	14
923	4C	PP11-0023	31	35	33	14	34	39	37	16
983	5A	PP11-0024	22	26	25	15	31	38	36	22
894	5B	PP11-0025	27	30	29	15	35	40	38	20
721	5C	PP11-0026	25	27	26	12	32	36	34	16
836	6A	PP11-0027	41	42	40	22	42	43	41	22
797	6B	PP11-0028	36	39	37	18	38	41	39	19
980	6C	PP11-0029	35	41	40	27	35	41	40	27
890	7A	PP11-0030	36	37	35	17	42	43	41	19
876	7B	PP11-0031	47	46	44	21	49	48	45	22
993	7C	PP11-0032	44	45	44	19	48	50	48	20
938	8A	PP11-0033	35	38	36	18	39	43	40	20
766	8B	PP11-0034	38	40	38	18	41	44	42	20
936	8C	PP11-0035	33	37	34	16	38	42	39	18
818	9A	PP11-0036	43	42	41	22	50	50	48	25
880	9B	PP11-0037	42	42	40	21	49	49	47	24
820	9C	PP11-0038	36	37	35	18	43	44	42	21

Job Number: PJ 10022

Date Reported: 31/08/2011

Landcare Research
Manaaki Whenua

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
706	10A	PP11-0039	50	56	52	24	43	49	44	20
942	10B	PP11-0040	64	67	63	33	49	52	49	25
908	10C	PP11-0041	67	72	68	36	51	54	51	28
895	11A	PP11-0042	57	61	56	20	46	49	46	16
955	11B	PP11-0043	67	81	70	21	48	57	49	15
837	11C	PP11-0044	65	71	66	24	48	52	48	17
877	12A	PP11-0045	70	84	73	25	44	53	46	16
878	12B	PP11-0046	88	96	89	25	54	58	54	15
939	12C	PP11-0047	73	83	73	21	47	54	48	14
960	13A	PP11-0048	55	61	55	17	44	49	44	14
886	13B	PP11-0049	37	47	40	12	35	45	38	12
931	13C	PP11-0050	50	56	53	20	44	50	47	18
879	14A	PP11-0051	33	34	33	13	44	46	44	17
787	14B	PP11-0052	39	41	40	15	48	50	49	19
863	14C	PP11-0053	34	35	35	19	44	47	45	24
823	15A	PP11-0054	46	49	46	14	43	46	43	13
807	15B	PP11-0055	46	48	45	16	46	49	46	16
827	15C	PP11-0056	44	45	42	13	44	46	42	13
822	16A	PP11-0057	50	54	48	15	47	50	45	14
712	16B	PP11-0058	47	50	46	15	46	49	45	14
935	16C	PP11-0059	49	50	47	14	51	51	49	15
941	17A	PP11-0060	34	37	35	14	39	42	40	16
831	17B	PP11-0061	33	37	34	14	37	41	38	16
940	17C	PP11-0062	33	36	33	13	38	42	38	15
860	18A	PP11-0063	22	28	25	9	29	37	32	12
714	18B	PP11-0064	28	36	32	13	31	40	36	14
920	18C	PP11-0065	27	32	30	12	32	38	35	14
885	19A	PP11-0066	49	54	51	22	47	51	48	22
862	19B	PP11-0067	37	42	40	21	41	47	44	23
811	19C	PP11-0068	50	60	55	24	43	52	47	21

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