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Mana Kai Rangahau

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A regional soil quality monitoring program for the Hawke's Bay

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A report prepared for
Hawke's Bay Regional Council

Copy 1 of 6

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Contents

1 Executive summary

Regional councils and the Ministry for the Environment have a legislative and administrative responsibility to monitor and report on the state of the environment in their respective regions.

Hawke's Bay Regional Council (HBRC) approached Crop & Food Research to assist with the development of a soil quality monitoring program to address their state-of-environment monitoring needs, in particular to:

- define a generic framework for site selection
- identify suitable monitoring sites
- select soil quality indicators.

In choosing sites for soil monitoring, representative soils on representative land forms must be chosen to best summarise the soil resources of the Hawke's Bay region. The range of land uses that occur on those soils and land forms must also be represented. This information, supplied by HBRC, provides a 4-step hierarchical framework for choosing sampling sites. Those 4 levels are: land form, the most common soil order on these land forms, the most common soil types within each order, and the different land uses on each soil type.

Monitoring sites that reflect the soil types and meet the land use criteria identified are then established.

Indicators of soil quality are then determined. These can be classified as priority 1 (the minimum data set, which includes soil pH or acidity, Olsen P, total C & N, potentially mineralisable N, bulk density, macro-porosity and aggregate stability); priority 2 (visual assessments that do not require laboratory testing), and priority 3 (extra measurements).

The process of collecting samples along a 50 m transect is described as well as the necessary laboratory tests and equipment required for field testing.

2 Introduction

Regional councils and the Ministry for the Environment have a legislative and administrative responsibility to monitor and report on the state of the environment in their respective regions. The Government's objectives for the State of the Environment monitoring and reporting are:

- to systematically report on the state of New Zealand's environmental assets
- to systematically measure the performance of its environmental policies and legislation
- to better prioritise policy and improve decision making relating to the environment.

State of the Environment monitoring and reporting measures and monitors human activities and their effects on the environment using **environmental performance indicators**. The soil quality indicators chosen by the National Land Monitoring Forum have been trialled, in partnership with regional councils and science providers, through a number of projects and monitoring programs over the last 7 years.

A list of abbreviations used in this document is given in Table 1.

Table 1: Abbreviations used in this document.

Abbreviation	Meaning
AMN	Anaerobically mineralisable nitrogen, same as Pot Min N
ARL	Analytical Research Laboratories
EDTA	Ethylene diamine tetra acetic acid
GPS	Global positioning system
HB	Hawke's Bay
HBRC	Hawke's Bay Regional Council
LMI	Land management index
LRI	Land resource inventory
LUC	Land use capability class
MDS	Minimum data set
MFE	Ministry for the Environment
NLMF	Nation Land Monitoring Forum
Pot Min N	Potentially mineralisable nitrogen (same as AMN)
SQM	Soil quality monitoring

3 Aim of soil quality monitoring program

By implementing a soil quality monitoring program, the key aims of the Hawke's Bay Regional Council (HBRC) are to monitor soil quality in Hawke's Bay to determine:

- if it is improving or declining over time
- if the current state of the soil resource is good or bad.

Hawke's Bay Regional Council approached Crop & Food Research to assist with the development of a soil quality monitoring program to address their State of the Environment monitoring needs, in particular to:

- define a generic framework for site selection
- identify suitable monitoring sites
- select soil quality indicators.

The National Land Monitoring Forum's draft *Soil Quality Monitoring Protocol* will be used in the first instance as a basis for program design. Our assistance in this program has been funded by Envirolink. More information on this fund can be found at www.frst.govt.nz/research/envirolink.cfm

4 Framework for site selection

In choosing sites for soil monitoring, we need to choose representative soils on representative land forms to best summarise the soil resources of the Hawke's Bay region. The range of land uses that occur on those soils and land forms will also be represented. This information, supplied by HBRC, gives us a 4-step hierarchical framework for choosing sampling sites. Those 4 levels are:

- land form (subdivided further by geological/geomorphological variation to give a more robust starting point to understand which soils we are interested in);
- the most common soil order on these land forms;
- the most common soil types within each order (here we identify 'icon' soils that the council wants to understand more about in relation to SQM);
- the different land uses on each soil type (here we categorise land uses applicable to each soil to further develop knowledge on current/future state).

4.1 Land form

We based information on land forms in Hawke's Bay on the Land Resource Inventory (LRI). This classifies land in terms of rock type, soil type, slope angle, erosion type and vegetation cover. The slope angle commonly corresponds to the Land Use Capability (LUC) system, which divides land into 8 classes based on how versatile the land is for sustainable production. We developed 3 land form classes based on slope angle and LUC classes. These are defined in Table 2.

Table 2: Land forms are based on slope angle and LUC class.

Slope angle (degrees)	LUC class	Land form	% of land area
0° – 3°	1	Flat	
4° - 7°	2 to 5	Rolling	
8° – 15°			
16° – 20°			
21° – 25°	6 to 8	Steep	
26° – 35°			
> 35°			

4.2 Soil order and soil type

Of the 15 soil orders in the New Zealand soil classification system (Hewitt), 10 are understood to be present in Hawke's Bay and we have chosen to implement SQM on 8. Each soil type in Hawke's Bay has been classified by this system. Within these soil orders, we have identified the soil types that require SQM. This correlates with the Council's need to understand pressure/response issues on soils on certain land forms such as terraces or rolling mudstone hills. For each soil order, soil types were selected using the following criteria:

- **variability -** how variable the land forms and soil types are within a soil order. Soil orders with many very different land forms and soil types are likely to have more monitoring sites. For SQM it is possible to target monitoring on to some 'named' soils, with the knowledge that some soils listed under that order will have similar characteristics and therefore have similar SQM outcomes under similar pressure;
- **vulnerability of the soil**. For example, the Okawa soil was included because although it covers only a relatively small area, it is easily compacted by high stocking rates;

- **pressure**. The type of land uses present on these soils and the foreseeable changes in land use. For example, podzol soils in national forests are under very little pressure and were therefore dropped from the sampling set;
- **area**. Finally, we made minor adjustments based the area of each soil order/type. Critically this was not just on the basis of the % area of the region – some soil types were included to 'even out' the spatial distribution of the sites so that there were no obvious large geographic holes.

The 8 soil orders we have selected are outlined in Table 4, along with the area (%) they cover within Hawke's Bay. A map showing their distribution is given in Appendix I. The soil types selected within each soil order are listed in Table 4, along with justification for their inclusion as a monitored soil. The distribution of these soils in the Hawke's Bay region is shown in Appendix II. **Together these 25 soils represent around 41% of the Hawke's Bay LRI land area**. It is worth noting that the soil areas are taken from the Hawke's Bay LRI map, which covers a slightly larger area (1.848 m ha) than of the HBRC (1.4 m ha). The number and percentage of sampling sites on the various land forms and soil orders are shown in Table 3.

Table 3: Distribution of monitoring sites by soil order and land form.

	Sites on each soil order or land form	
	Number	%
Pumice	16	17
Allophanic	6	7
Organic	5	5
Gley	17	18
Mellanic	8	9
Brown	12	13
Recent	12	13
Pallic	16	17
Flat	45	49
Rolling	21	23
Steep	26	28

Table 4: Soil types selected for soil quality monitoring program.

Soil order and (% area)	Land form	Soil type	Area (ha x 1000)	Justification
Pumice (26.6%)	Flat	Taupo	93.6	Represents Taupo pumice formation soil type. Large area in mid and northern HB, increasing land use pressure
	Rolling	Gisborne	42.0	Represents soils with deep tephric content. Large area in northern HB, multiple land use
	Steep	Kaweka	92.8	Represents pumice layers on greywacke hill country. Large area in mid HB
		Hangaroa	30.1	Represents tephric material on Tertiary hill country. Sister soils include Tutira, Waihua, and Tuai hill soils. Large area in northern HB
Allophanic (2.7%)	Flat	Takapau	37.1	Multiple land use, vulnerable to wind erosion
Organic (0.4%)	Flat	Poukawa	5.8	Multiple land use, small area but vulnerable to wind erosion and change under drainage
Gley (2.4%)	Flat	Hastings	14.9	Multiple land uses, high pressure
		Awamate	7.3	Increasing pressure, only cropping soil in Northern HB
		Okawa	7.8	Most common loess gley soil, vulnerable to compaction
		Pukehou	0.3	Mudstone gley soil, vulnerable to compaction
Melanic (0.3%)	Rolling	Te Aute	0.6	Sandy loam in Central HB
		Te Onepu	1.8	Clay loam, common in Central HB

Soil order and (% area)	Land form	Soil type	Area (ha x 1000)	Justification
Brown (27.9%)	Rolling	Matamau	29.1	Large area in rolling hills below ranges in central and southern HB
	Steep	Ruahine	48.0	Large area of ranges above Matamau soils in central and southern HB
		Mokapeka	9.5	Represents sandstone hill country pastoral soil
		Gwavas	9.1	Represents marine gravel hill country soil
Recent (15.4%)	Flat	Twyford	6.4	Common light textured recent soil, multiple land uses, high pressure
		Pakowhai	1.9	Common heavy textured recent soil, multiple land uses, high pressure
Pallic (19.4 %)	Rolling	Matapiro	104.0	Large area, typical pallic soil of loess origin on rolling land forms
		Atua	58.5	Typical pallic soil of mudstone origin on rolling land forms
		Wanstead	41.6	Bentonitic parent material vulnerable to earth flow
	Steep	Crownthorpe	37.1	Typical pallic soil of loess origin on steep land forms
		Mahoenui	76.1	Typical of steep mudstone county in northern HB. Includes Moumaki and Taihape soils
		Te Apiti	6.3	Typical of steep mudstone county in central HB
		Waipawa	2.4	Typical pallic soil of argillite origin on steep land forms

4.3 Land use

The following land use categories have been selected for monitoring. A selection of land uses will be monitored on each soil type. The more versatile soils tend to have a greater range of land uses.

1. Permanent pasture (grazing where land is seldom disturbed)
    a) intensive including dairy
    b) extensive
2. Permanent crop (horticultural crop where land is seldom disturbed)
    a) orchard
    b) vineyard
3. Temporary crop (horticultural crop where the land is regularly disturbed)
    a) continual (e.g. market gardening)
    b) seasonal (e.g. summer crop, winter grass)
    c) rotational (e.g. summer crop every 2nd or 3rd year - includes fodder crops)
4. Exotic forestry (tree crops, seldom disturbed)
5. Native (undisturbed)

The land uses that can be monitored on each soil type are outlined in Table 5.

Table 5: Land uses studied under each soil type.

Soil order	Land form	Soil type	1a. Int pasture	1b. Ext pasture	2a. Orch*	2b. Viney*	3a. Cont crop	3b. Seas crop	3c. Rot crop	4. Forest	5. Native	**Total**
Pumice	Flat	Taupo	1	1					1	1	1	**5**
	Rolling	Gisborne	1	1					1	1	1	**5**
	Steep	Kaweka								1	1	**2**
		Hangaroa	1	1						1	1	**4**
Allophanic	Flat	Takapau	1	1		2		1	1			**6**
Organic	Flat	Poukawa	1	1			1	1	1			**5**
Gley	Flat	Hastings	1	1	2		1	1	1			**7**
		Awamate	1	1				1				**3**
		Okawa	1	1					1			**3**
		Pukehou	1	1				1	1			**4**
Melanic	Rolling	Te Aute	1	1					1	1		**4**
		Te Onepu	1	1					1	1		**4**
Brown	Rolling	Matamau	1	1						1	1	**4**
	Steep	Ruahine		1						1	1	**3**
		Mokapeka		1						1	1	**3**
		Gwavas		1						1		**2**
Recent	Flat	Twyford	1		2			1	1			**5**
		Pakowhai	1	1	2		1	1	1			**7**
Pallic	Rolling	Matapiro	1	1								**2**
		Atua	1	1								**2**
		Wanstead										
	Steep	Crownthorpe		1						1		**2**
		Mahoenui	1	1						1	1	**4**
		Te Apiti	1	1						1	1	**4**
		Waipawa		1						1		**2**
TOTAL			**18**	**22**	**6**	**2**	**3**	**7**	**11**	**14**	**9**	**92**

In = intensive; Ext = extensive; Orch = orchard; Viney = vineyard; Cont crop = continuous cropping; Seas crop = seasonal cropping; Rot. Crop = rotational cropping; Forest = exotic forest; Native = native forests.

*Note: The inter-row and tree/vine line are sampled separately on orchards and vineyards, so each site counts as 2.

5 Monitoring sites

5.1 Deciding on monitoring sites

Properties that fit the soil type and land use criteria outlined above need to be identified. The land use description form in Appendix III should be used as a guide for collecting background information for each potential monitoring site[1]. The following questions are outlined in the form but deserve reiteration here as they are particularly important in terms of deciding if the monitoring site is suitable.

- Does the farmer keep land management records? If not, it will be difficult to associate changes in soil quality indicators with changes in land management.[2]
- How long has the site been in the current land use? If the land use at the site site has recently changed, it is likely that the soil will be changing as a result. This will make it difficult to compare soil quality between land uses.
- Type and location of any unusual areas (e.g. old fire sites, erosion scars, farm or stock tracks) must be noted so monitoring transects avoid atypical areas.
- Are there any immediate plans to change land use, particularly to a land use not covered in this program (e.g. residential, glasshouse), or other development plans (e.g. major earthworks for landscaping purposes)? If so, it is unlikely the site will be suitable for long-term monitoring.

While there is an inherent risk that land use can change at many of the selected sites, the above questions will help to minimise the risk that changes will compromise how representative the monitoring programme is over the longer term. Giving preference to sampling properties with Farm Plans may be a useful way to minimise this risk.

5.2 Establishing monitoring sites

Monitoring sites are 50 m transects within a paddock from which all soil samples are collected. The transect should be at least 10 m from any obstruction or disturbed area such as tracks, fence lines, shelter belts, stock camps, water troughs, streams, drainage ditches and buildings. The transect should be on a visually uniform and representative part of the area to be sampled.

[1] That appendix is very similar to the one presented in the NLMF National Land monitoring guidelines, but it contains some additional questions that will be very helpful for HBRC staff

[2] If the site is considered essential for other reasons, then it may be necessary to help the farmer set up a recording system. However, even if farmers agree to this and change their ways so good records are kept, there will always be some doubt on how to interpret the baseline soil measurements with regard to soil management history.

As the transect is the basis for all sampling, we need to ensure that:

- the soil type present is the one required
- the soil type is consistent along the transect.

Therefore, the soil type at each monitoring site should be confirmed by a pedologist in conjunction with HBRC staff. A profile description (soil horizon notation, colour, depth, texture, etc.) should be made to at least 50 cm, also identifying the potential rooting depth and nature and depth of any limiting horizons. The soil profile should be assessed in the middle of the transect, and checked at either end of that transect. If the soil changes dramatically along the transect or is not the soil type required, then another transect should be selected.

The same transect will be used for all future sampling so the location of the transect must be accurately recorded to enable its relocation for future sampling. Ideally the start and end of the transect should be defined by GPS co-ordinates. Alternatively, or additionally, the location can be sketched on to a detailed aerial photo (at least 1:10 000) or a sketch map drawn to show the location relative to landmarks such as fences, trees and tracks.

For orchards and vineyards (permanent row crops) it is most easy to run the transect along a row (see also Section 7.1.4).

5.3 Existing potential monitoring sites

Through a variety of projects, Crop & Food Research has conducted a range of soil quality measurements on farms in the region. It may be possible to use some of the same properties for the sites outlined in Table 5. A complete list of sites, along with the measurements conducted at each site, is provided in Appendix IV.

6 Soil quality indicators

6.1 Priority 1 measurements

The **minimum data set (MDS)** suggested by the National Land Monitoring Forum (NLMF) contains the following soil indicators.

1. **Soil pH or soil acidity.** Most plants and soil animals have an optimum pH range for growth. Indigenous species are generally tolerant of acid conditions but introduced pasture and crop species require a more alkaline soil. Some heavy metals may become soluble and bioavailable at low pH.
2. **Olsen P**. Phosphorus (P) is an essential nutrient for plants and animals. Plants get their P from phosphates in soil. Many soils in New Zealand have low available phosphorus, and P needs to be added to soils used for agricultural purposes. Depletion of nutrients shows that soils are being `mined' and, if so, current land use may require maintenance applications of fertiliser .

3. **Total C & N.** Total carbon (C) is a measure of organic matter content. Organic matter helps soils retain moisture and nutrients, and gives good soil structure for water movement and root growth. Nitrogen (N) is an essential nutrient for plants and animals. Most N in soil is in organic matter and total N gives a measure of those reserves. The ratio of C to N can indicate the type of organic matter returned to the soil.

4. Potentially mineralisable N. Not all the organic matter N can be used by plants. Soil organisms change the N to forms plants can use. Potentially mineralisable N gives a measure of how much organic N is available to the plants, and the activity of the organisms.

5. Bulk density is a measure of soil compaction. Compacted soils will not allow water or air to penetrate, do not drain easily, restrict root growth and can have adverse effects on plant growth. Compact soils increase the potential of run-off and nutrient losses to surface waters.

6. Macro-porosity is a measure of soil aeration. Macro-pores (30 to 3000 µm) are important for air penetration into soil, and are the first pores to collapse when soil is compacted. This test includes particle density and soil moisture content at -10 kPa. Total porosity can also be calculated using particle density and bulk density. Macro-pores are the larger pores that are the main route by which air enters soil.

7. Aggregate stability is a measure of how resistant soil crumbs (2-4 mm diameter) are to breakage. Stable soils will resist compaction, slaking, and crusting of seed beds.

For measures 1 to 4, one composite sample is collected per site. For the remaining measures, 3 individual samples are collected per monitoring site. Full details on sample collection are given in Section 7.

6.2 Extra measurements – priority 2

Priority 2 measurements are visual assessments of the soil and do not require any laboratory testing. We recommend that the visual soil assessment[3] is conducted at all sites at the same locations as measures 5-7 (i.e. 3 locations on each monitoring transect). Additional visual assessments that should be conducted include:

- % bare ground in 1 m^2 area
- % area of crusted soil and thickness of that crust
- % area of damaged soil surface (e.g. by stock treading or vehicle tracks), and depth of damage
- thickness of organic matter thatch if present.

Full details of these additional measurements are given in Appendix V.

[3] Shepherd TG 2000. Visual soil assessment Volume 1. Field guide for cropping and pastoral grazing on flat to rolling country. Horizons.mw & Landcare Research, Palmerston North. 84 p.
Shepherd TG, Jansses HJ 2000. Visual soil assessment. Volume 3. Field guide for hill country land uses. Horizons.mw & Landcare Research, Palmerston North. 48 p.

6.3 Extra measurements – priority 3

Some additional chemical soil tests can be added to the sample collected for pH, Olsen P, total C & N, and potentially mineralisable N. These are outlined in Table 6. These measurements may be conducted less frequently than the MDS.

Table 6: Priority 3 measurements. Except for the active carbon test, the prices quoted assume that the samples are already air-dried and sieved. Drying and sieving will usually add $20-25 +GST per sample. However, that charge will not be made if measurements are requested from the same laboratory that does the MDS chemical analyses, or if you ask that laboratory to return the portion of the samples they did not use so that you can resend them off to another laboratory for further analysis.

Test	Approx. cost excl GST	Importance and purpose
Basic test	$20 above existing soil pH and Olsen P	Includes soil pH, Olsen P, exchangeable cations, volume weight and cation exchange capacity (CEC). Used for determining fertiliser requirements for pastures and crops. CEC is related to clay content and organic matter, and therefore can act as a check of soil type
Cd	$20	Heavy metal found in phosphate fertilisers, environmental contamination
Heavy metal suite (As, Cd, Cr, Pb, Hg, Ni)	$78.50	Full suite of heavy metals, environmental contamination
EDTA Cu	$20	Copper frequently used in horticultural production, high levels affect soil microbial activity, environmental contamination
DDT	$75	Environmental contamination
Active carbon (hot water extractable)	$40-$45	Includes much of the C found in soil micro-organisms that play an important role in building soil structure and releasing plant available nutrients. Ratio of active to total carbon indicates the relative activity of soil micro-organisms

7 Collecting samples

7.1 Field samples – how to collect MDS

At each monitoring site, samples are collected along a 50 m transect. As described in Section 5 (Monitoring sites), this is a permanently marked transect that will be used for all future monitoring. The samples collected in the field for the minimum data set fall into 3 categories and 3 sampling methods.

7.1.1 Chemical properties

Chemical properties (soil pH, Olsen P, total C & N, mineralisable N). These are collected using a 10 cm long soil corer, every 2 m along the 50 m transect line. All 25 cores are placed in a clean, robust and well labelled plastic bag, chilled during storage and submitted to the lab as soon as possible. Note that the sampling depth suggested by the NLMF is not the

depth typically used for pastoral (7.5 cm) or horticultural (15 cm) land uses. A soil core sampler for this depth is probably not readily available, but a 15 cm one can easily be shortened. A soil core sampler costs around $50 and is available from most soil testing laboratories.

7.1.2 Bulk density and macro-porosity

Three bulk density and macro-porosity cores are collected at 15 m intervals along the transect line. The same soil core is used for both tests, so only 3 cores need to be collected per site. The samples are tested by Landcare Research in Hamilton and the test includes:

- bulk density,
- macro-porosity,
- particle density,
- total porosity (a calculation from bulk density and particle density), and
- moisture content at 2 tensions, 5 and 10 kPa.

Landcare will also supply the rings and ring covers for the sampling free of charge, as well as the padded shipping containers. The cores are tested intact so it is vital that they reach the laboratory in an undisturbed state. HBRC will need to supply some equipment, such as a spade, knife and plastic bags.

Landcare offers full training in the field method of collecting cores for bulk density and macro-porosity. A training session with a Landcare staff member for 2–3 days, visiting a number of monitoring sites, will cost around $1200 per day excl. GST plus a vehicle/mileage charge. This could be funded by the Envirolink program.[4]

7.1.3 Aggregate stability

Three samples are collected at 15 m intervals along the transect line, next to the samples for bulk density and macro-porosity. Using a spade, dig out a 10 cm deep square of soil and place in an ice-cream container. Avoid smearing or compressing the soil. The samples should be chilled and sent to the laboratory for sample preparation as soon as possible.

7.1.4 Sampling issues for specific land uses

The areas under vines or trees in vineyards and orchards respectively are very different to those in the inter-row. These areas should be sampled separately for all tests. The easiest method for permanent row crops is to run the 50 m monitoring transect along a row. Samples for plant line and inter-row are collected from parallel transects down the row. Given the short

[4] If the sites have already been identified and described pedologically then Landcare would send a technician to provide the training. However, Landcare has told us that the usual process is that when first time samples are taken they would send a pedologist to describe the soil, take the samples and train the council staff in the sampling process. Taking this approach typically they can get through 3• 5 sites a day, if there is little travel time between sites. Such a process could have advantages for HBRC, but the number of sites required means that the costs would be out of the range of the Envirolink program.

distance between the 2 transects, it is not necessary to establish the transects separately (see Section 5.2).

7.2 Lab tests

7.2.1 Chemical tests for MDS

The chemical properties of the soil (i.e. soil pH, Olsen P, total C & N, and potentially mineralisable N) can be measured by any commercial soil sampling laboratory. The cheapest option is either Hill Labs or ARL at a price of around $50 per sample. Full quotes for each lab are given in Appendix VI. One sample is collected per monitoring site.

7.2.2 Bulk density and macro-porosity for MDS

Bulk density, macro-porosity, particle density and moisture content at 5 and 10 kPa are measured on each sample by Landcare Research in Hamilton (John Claydon on 07 858 3700 or email claydonj@landcareresearch.co.nz). It is vital these are delivered as undisturbed cores. Landcare provides the sample rings, ring covers and shipping container as part of the cost of $50 per sample. Three samples are collected per monitoring site. Further details on these tests are provided in Appendix VII.

7.2.3 Aggregate stability for MDS

Aggregate stability is measured by Crop & Food Research at Lincoln (contact Glyn Francis on 03 325 6400 or email francisg@crop.cri.nz). Three samples are collected per monitoring site. Samples cost $50 each plus a sample preparation charge of $20 per sample. It is possible to undertake the sample preparation yourselves by sieving moist soil to collect aggregates of 2–4 mm in size. The aggregates are slowly air-dried on a tray at 25°C for 4–7 days, then carefully re-sieved over 2 mm. Soil aggregates of 2–4 mm in diameter are stored in robust pottles. The laboratory at Crop & Food Research requires at least 100 g of soil. Sieves can be sourced from Biolab and further details can be found in Appendix VIII. The costs associated with undertaking all the tests for the minimum data set are summarised in Table 7.

Table 7: Summary of costs associated with sampling for the minimum data set.

Soil quality indicator	Tested by	No. samples per mon. site	Cost per sample (excl GST)
1. Soil pH		1	
2. Olsen P		1	$50
3. Total C & N		1	
4. Pot min N		1	
5. Bulk density	Landcare Research	3	$50
6. Macroporosity	Landcare Research	3	
7. Aggregate stability	CFR Lincoln	3	$70
Total cost per monitoring site			**$410**

All costs include sample preparation, and $20 per sample can be saved from the aggregate stability cost by preparing the samples. This would bring the total cost per site down to $350 (excluding GST).

7.2.4 *Priority 3 measurements*

These additional measurements are made on the existing chemical samples collected for the minimum data set, so there is no additional field sampling required. Most of the priority 3 measurements can be conducted by the commercial soil testing laboratory selected to test the other chemical properties.

The exception is the active C test, which is tested by Crop & Food Research, Lincoln (contact Glyn Francis, ph 03 325 6400 or email francisg@crop.cri.nz). The active C test is conducted on fresh soil samples, so the soil chemical sample needs to be subsampled before it is submitted to the commercial testing laboratory. To subsample, put all the soil into a clean bucket, breaking up the cores as much as possible. Mix the soil well, then grab several small handfuls of soil at random, mixing the soil between each hand grab. A minimum of 200 g of soil is required. Place into a well-labelled, clean, plastic bag, tie up, and keep chilled before sending to Crop & Food Research, Lincoln, as soon as possible.

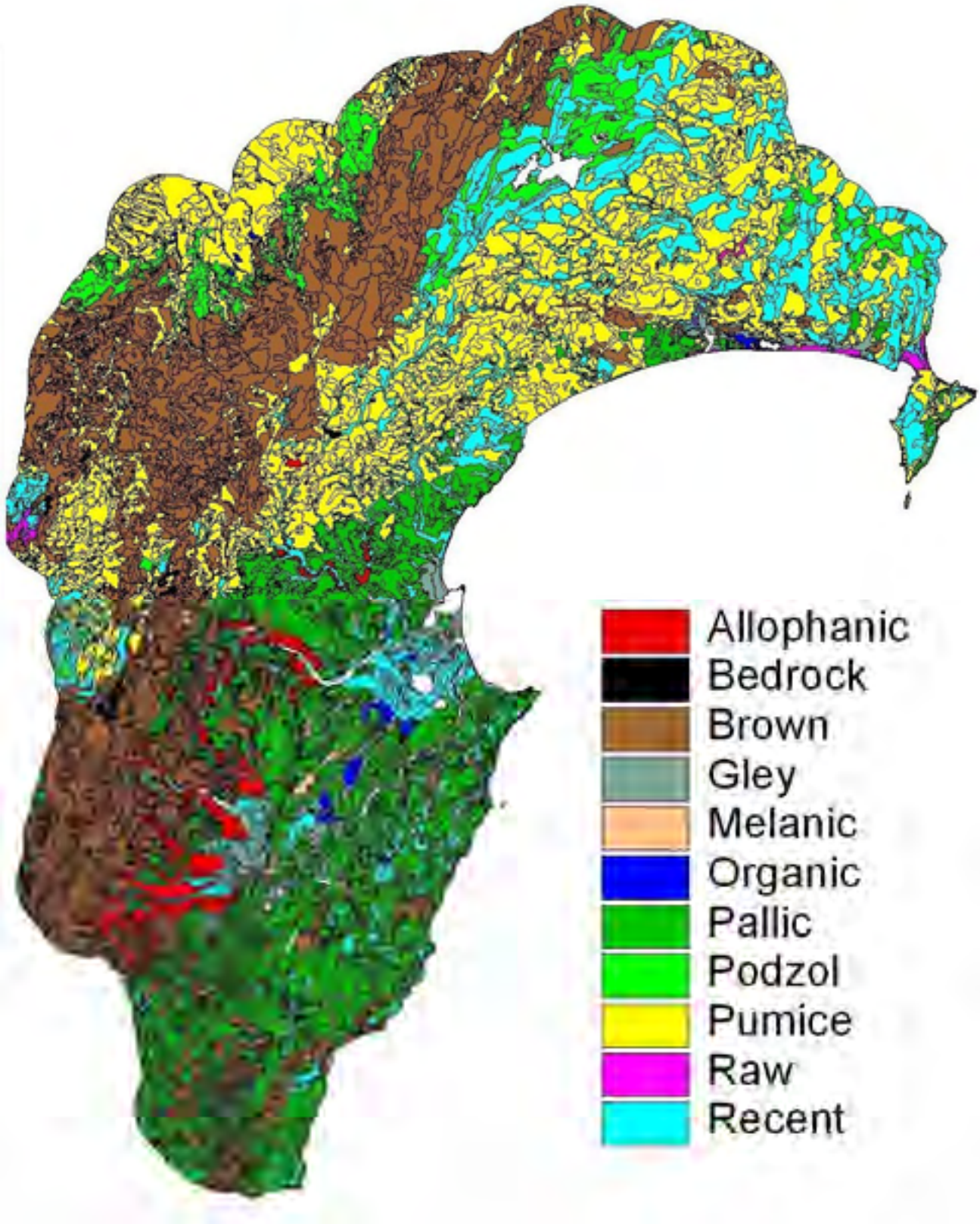
8 *Summary of equipment required*

- You will need to get a 100 mm soil corer made up as this sampling depth is not the standard used for either pasture (75 mm) or cropping/horticulture (150 mm). The tread-in style corers are the easiest to use. We suggest you purchase a 150 mm corer and have it modified by an engineering company.

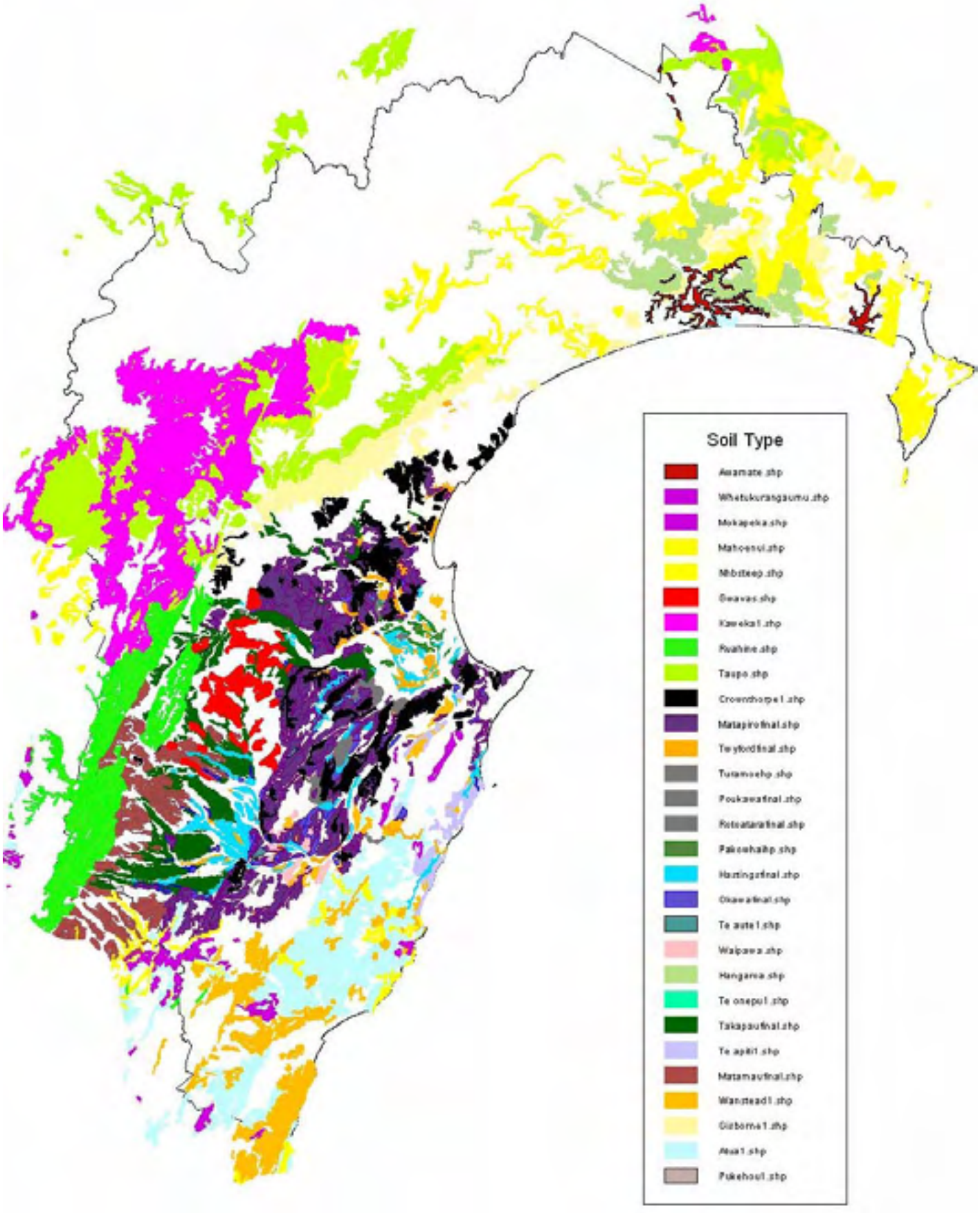
- Start collecting ice-cream containers for the aggregate stability samples.
- In order to save $20 per sample for aggregate stability preparation, purchase Endicott test sieves of 2 and 4 mm mesh size at a cost of around $400 for both (source through Biolab Scientific, ph 0800 833 966, see Appendix VIII). The method of sample preparation is outlined in Section 7.1. You will also need to think about ways of drying samples. There is a drying room at Crop & Food Research, Lawn Rd, that you can hire (contact Jeff Reid, ph 06 870 0109, email reidj@crop.cri.nz).
- The bulk density and macro-porosity equipment is supplied by Landcare Research as part of the charge for the test.

Appendices

Appendix I Soil orders in Hawke's Bay



Appendix II Soil types to be monitored in Hawke's Bay



Appendix III Contact and Land Use Description Check Sheet

Site number …….. **Sample number ……..**

Sampled by……... **Date**……

Location …….
(Accompanied by map/photo/sketch plan plus summary sheet)

Landowner

Occupier - Yes/No (if No, is occupier manager/sharemilker/lessee)
Is landowner contact person? Yes/No

Landowner name……...…….….

Property address……..……...…..

……..

Landowner postal address…….……....……....

……

Landowner phone/fax/e-mail
…….…….

……...……

Occupier

Is occupier contact person? Yes/No

Occupier name…….……

Address
(residential/postal)…….……

…….……...……

Occupier
phone/fax/email……

…….……

Contact person

Name……..…….……

Position……

Address
(residential/postal)…….…….……..

…….…….……

Contact
phone/fax/email…….

……

Current Land Use Details

Do you keep comprehensive land management records? Yes / No

Present Land Use……

Description of management type/approach……

……

……

Duration of present land use……..…….

Previous land use ……..…….

Vegetation Cover- dominant…….…….

Secondary/sub-dominant……..…..…….

Crop/Stock type……...……

Crop/Stocking rates……..……..……

Age of crop/pasture...……

Irrigation yes/no Annual depth applied (mm) …….

Effluent application yes/no Type, frequency, rate etc. Include nutrient content if known

……

……

Crop rotation sequence/Grazing system ……..……...

……..…

……..……...

……

……..……...

Artificial drainage yes/no Drainage type……..

Frequency of cultivation…….

Current annual fertiliser regime/application rates……..

……

……..…..…..……..…..

……..……..…

Date, type and rate of fertiliser last applied to sample paddock.……...

……

..……..

Fertiliser History - past 5 years (if different from above)……..

……

……

……

……

Broad-scale chemical applications past 5 years…….

……

……

……..……..…

……..….

Other management information……..

……

……

Land Use History

Approximate time cleared from native bush…….

……

Sequence of land uses with approx. dates (or best guess) including fertiliser history (if known).

……

……

……

When was this land last cultivated? ……

……

Describe type and location of **unusual areas of paddock** (e.g old fire sites, former fence lines, stock camp sites, farm and stock tracks). Also please draw location on paddock map

……

……

……

……

……

……

Are you planning to develop or change the land use in this paddock? Describe. ……

……

……

……

Appendix IV Existing potential monitoring sites

MfE Project 1997–2000

Soil quality variables were measured in a range of seasonal cropped paddocks (tomatoes, sweet corn and maize) in Hawke's Bay. In each paddock, 4 plots (15 m x 15 m) were established and the following measurements at 2 sampling depths (0-15 cm and 15-30 cm) conducted in each plot.

- Basic nutrient test
- Potentially mineralisable N
- Microbial biomass carbon (similar test to Active Carbon)
- Total C & N
- Bulk density
- Particle density (to determine total porosity)
- Aggregate stability
- Earthworm populations

The exact location of paddocks, and plots within each paddock can be obtained from Crop & Food Research. The sites are listed in the following table.

Site no.	Site name	Location	Soil series
T9701	Harbour Board Far	Poraiti	Ahuriri
T9702	Harbour Board Near	Poraiti	Ahuriri
T9703	Cox	Brookfield Rd	Pakowhai
T9704	Grainger	Erickson Rd	Meeanee
T9705	Gyde	Goulter Rd	Mangateretere
T9706	Tucker	Richmond Rd	Mangateretere
T9707	Allen	Richmond Rd	Mangateretere
T9708	Agnew	Lawn Rd	Mangateretere
T9709	Grandmas	Lawn Rd	Mangateretere
T9710	Harrison	Tukituki Rd	Hastings
T9711	Taylor	Tennants Rd	Hastings

Site no.	Site name	Location	Soil series
T9712	Mahoney	Evenden Rd	Kaiapo
T9713	Wallace	Evans Rd	Te Awa
T9714	Curtis	Twyford Rd	Hastings
T9715	Burns House	Hills Rd	Hastings
T9716	Burns Bottom	Hills Rd	Hastings
T9717	Woodbury	Rosser Rd	Te Awa
T9718	Thelwell	Maraekakaho Rd	Not sure
T9719	Hearst	Railway Rd SH 2	Twyford
T9720	Dearney	St Georges Rd	Karamu
T9801	Mission	McLeod Rd	Farndon
T9802	Sherilyn	Eriksen Rd	Meanee
T9803	Moore (back)	Tannery Rd	Farndon
T9804	Jones	Parkhill Rd	Waipukerau
T9805	Jones-nolime	Parkhill Rd	Waipukerau
T9806	Couper Nth	Brookfield Rd	Farndon
T9807	Hantler	Tukituki Rd	Hastings
T9808	Center Flat	Ohiti Rd	
T9809	Chook Farm	Twyford Rd	Hastings
T9810	40 Acres	Ohiti Rd	
T9811	Percival Rd	Percival Rd	Kaiapo
T9812	Rosser	Rosser Rd	Te Awa
T9813	White	Swamp Rd	Moteo
T9814	Ludemann	Swamp Rd	Pakowhai
T9815	Carrington	Twyford Rd	Hastings
T9816	Ortons	Thompson Rd	Mangateretere

Site no.	Site name	Location	Soil series
T9817	Mulligan	Lawn Rd	Mangateretere
T9818	Nottingley	Nottingley Rd	Karamu
T9819	Parkinson	Omaranui Rd	Omaranui
T9820	Racecourse	Southland Rd	Karamu
S9801	Hantler	Tukituki Rd	Hastings
S9802	Harrison Far	Tukituki Rd	Hastings
S9803	Tylees	Te Mata-Mangateretere Rd	Mangateretere
S9804	Tuckers	Richmond Rd	Mangateretere
S9805	Cornes	Korokipo Rd	Poporangi
S9806	Good	Korokipo Rd	Pakowhai
S9813	Hills 1st Paddock	Waiharere Rd	Awamate
S9814	Hills Shed Paddock	Waiharere Rd	Awamate
S9815	Kaiwhenua organic	Ngatarawa Rd	Te Awa
S9817	Glazebrooks	Valley Rd	Havelock
S9818	Averill	Wenley Rd	
S9819	Grants	Maraekakaho	Te Awa
S9820	Holmes	Maraekakaho	Te Awa
M9805	Ahuriri	Turfrey Rd	Ahuriri
M9806	Mission	McLeod Rd, Awatoto	Meanee
M9807	Wallace	Evans Rd	Te Awa
M9808	Grandmas	Lawn Rd	Mangateretere
M9809	Kenny Rd	Kenny Rd	Meanee
M9810	Paxies	Tannery Rd	Meanee
M9811	Brookfields Rd	Brookfields Rd	Farndon
M9818	Harbour Board	Lagoon Farm	Ahuriri

Site no.	Site name	Location	Soil series
S9901	Graingers	Eriksen Rd	Meeanee
S9902	Pilcher	Lawn Rd	Mangateretere
S9903	Hill	Percival Rd	Kaipo
S9905	Nichol Rd	Nichol Rd	Te Awa
S9906	Grants	Maraekakaho Rd	Pakipaki
S9908	Edwards	Ahuriri Farm	Ahuriri
S9909	Brownriggs	Te Aute Trust Rd	Peat
S9910	Hawkins	Te Aute Trust Rd	Peat
S9911	Pattersons	Clive	Pakowhai
S9919	Brookfield	Brookfield Rd	Pakowhai
S9920	Nottingly	Nottingley Rd	Karamu
S9921	Chook Farm	Twyford Rd	Hastings
M9903	Carringtons	Twyford Rd	Hastings
M9904	Coxes West	Brookfield Rd	Pakowhai
M9905	Grassmere	Meeanee	Farndon
M9906	Otenes	Ruahapia Rd	Pakowhai

MfE Orchard 2001–03

A range of commercial orchards were tested for soil quality indicators in 2001. Within a selected block on each orchard, the following soil measurements were conducted in both the tree line and the inter-row (0-15 cm).

- Basic nutrient test
- Potentially mineralisable N
- Total C & N
- Microbial biomass carbon
- Active carbon
- Earthworm populations
- Water infiltration

- Bulk density
- Particle density (to calculate total porosity)
- Copper

The exact location of each sampling location can be obtained from Crop & Food Research. The sites sampled are listed below.

Site No.	Site name	Grower	Soil series
1	Ruby Glen	Doug McPhail	Farndon
2	Waimea	Kas Fairey	Farndon
3	Waites	Stu Covell	Farndon
4	Dooney	Peter Dooney	Farndon
5	Vesty	Mark Vesty	Twyford
6	Brannigan IFP	Kerry Brannigan	Pakipaki
7	Brannigan Organic	Kerry Brannigan	Pakipaki
8	Young	Peter Young	Hastings
9	Ranui	Brian Rich	Te Awa
10	Ngatahi old queens	Brian Grapes	Omarunui
11	Ngatahi young peaches	Brian Grapes	Omarunui
12	CA Wake	Gary Wake	Kaiapo
13	Cropwell	Norm Millar	Twyford
14	Vogelaar young pears	Paul Vogelarr	Pakipaki
15	Vogelaar Plady	Paul Vogelarr	Twyford
16	Rangitane Gala	Glenn Soeberg	Omarunui
17	Rangitane Fuji	Glenn Soeberg	Pakowhai
18	Whyte	Edward White	Mangateretere
19	CA Dames	Jos Dames	Mangateretere
20	Chambers	Tom Chambers	Hastings

Site No.	Site name	Grower	Soil series
21	Falls Peaches	John Falls	Twyford
22	Falls Pears	John Falls	Kaiapo
33	R+G Partnership	Karl Mathys and Gisela Ahlborn	Poporangi
34	Waima	Mark Ericksen	Pakowhai
35	Craig Wilson	Craig Wilson	Flaxmere
36	Mike Simcox	Mike Simcox	Flaxmere
37	Fernhill Young fruit	Todd Blackman	Esk
38	Fernhill 5 Yr old	Todd Blackman	Hastings
39	Grant Pears	Campbell Grant	Pakowhai
40	Grant Braeburn	Campbell Grant	Moteo
41	Morangi A3	Ru Collin	Turamoe
42	Morangi Gravel middle	Ru Collin	Omarunui
43	Mountain View	Ru Collin	Turamoe

Focus vineyard 2006

We have identified 2 common soil types used for grape production. As part of the Hawke's Bay Focus Vineyard project, we shall be sampling vineyards of different ages on each soil type. The following soil measurements (0-15 cm) will be taken from both the vine line and the inter-row

- Basic soil test
- Soil bulk density
- Total C & N
- Aggregate stability
- Aggregate size
- Active carbon
- Penetration resistance (0-15 cm and 15-25 cm)

The sampling will commence shortly (autumn 2006). Blocks within the following properties have been identified.

Property no.	Vineyard	Contact	Vineyard age (years)	Soil type
1	Bullnose	Larry Morgan	>12	Ngatarawa
2	Bullnose	Larry Morgan	>12	Ngatarawa
3	Bullnose	Larry Morgan	>12	Ngatarawa
4	Bullnose	Larry Morgan	>12	Ngatarawa
5	Prospect	Chris Howell	6-12	Ngatarawa
6	Prospect	Chris Howell	6-12	Ngatarawa
7	Prospect	Chris Howell	6-12	Ngatarawa
8	Prospect	Chris Howell	6-12	Ngatarawa
9	Crossroads	Brent Stone	<6	Ngatarawa
10	Prospect	Chris Howell	<6	Ngatarawa
11	Bullnose	Larry Morgan	<6	Ngatarawa
12	Isosceles	Larry Morgan	<6	Ngatarawa
13	Ngatarawa	Peter ?	>12	Takapau
14	Ngatarawa	Peter ?	>12	Takapau
15	Bullnose	Larry Morgan	>12	Takapau
16	Bullnose	Larry Morgan	>12	Takapau
17	Keesing	Paul Keesing	6-12	Takapau
18	Kemblefield	Chris Kemble	6-12	Takapau
19	Matthews	Richard Matthews	6-12	Takapau
20	Prospect	Chris Howell	6-12	Takapau
21	Crossroads	Brent Stone	<6	Takapau
22	Kemblefield	Chris Kemble	<6	Takapau
23	Bullnose	Larry Morgan	<6	Takapau
24	Prospect	Chris Howell	<6	Takapau
25	Keesing	Paul Keesing	pasture >12	Takapau
26	Kemblefield	Chris Kemble	pasture >12	Takapau

Land management index project (LMI)

This project, funded by Sustainable Farming Fund, will develop a soil quality prediction tool based on historic paddock management practices. The approach has been to sample a range of land uses on selected soil types and gather a paddock management information. The measurements being conducted are:

- Total C & N (0-15 and 15-30 cm)
- Bulk density (0-15 cm)
- Aggregate stability (0-15 cm)
- Olsen P and pH (0-15 cm)
- Active carbon (0-15 cm)
- Aggregate size (0-5 cm)
- Penetration resistance (0-15 and 15-25)

There are 3 sampling locations in each paddock, although the 15-30 cm soil sample for total C & N is combined across all 3 sampling locations. The sites sampled for this project are listed below. Not all paddocks have been finalised for this year (HB0506 sites).

LMI code	Name	Paddock ID	Land use	Soil series
HB0304 - 01	Paul Muir	3	Sheep/Beef	Matapiro
HB0304 - 02	Paul Muir	4	Sheep/Beef	Matapiro
HB0304 - 03	Maurice Gray	38 MP	Sheep/Beef	Waipawa
HB0304 - 04	Maurice Gray	39 HP	Sheep/Beef	Waipawa
HB0304 - 05	Kevin Davidson	38	Dairy	Takapau
HB0304 - 06	Kevin Davidson	11	Dairy	Takapau
HB0304 - 07	Jamie Gunson	3	Techno	Mangatahi
HB0304 - 08	Jamie Gunson	12	Techno	Mangatahi
HB0304 - 09	Jamie Gunson	14	Techno	Mangatahi
HB0304 - 10	Jamie Gunson	back	Sheep/Beef	Tikokino
HB0304 - 11	Angus Mabin		Techno	Taniwha
HB0304 - 12	Angus Mabin		Techno	Taniwha
HB0304 - 13	Angus Mabin		Techno	Taniwha

LMI code	Name	Paddock ID	Land use	Soil series
HB0304 - 14	Angus Mabin		Techno	Taniwha
HB0304 - 15	Angus Mabin		Techno	Matapiro
HB0304 - 16	Kevin Davidson	5	Dairy	Takapau
HB0304 - 17	Simon Beamish	4	Techno	Takapau
HB0304 - 18	Beamish	10	Techno	Takapau
HB0304 - 19	Craig Wellington	Next to road	Techno	Poporangi
HB0304 - 20	Craig Wellington	Next to road	Techno	Ngatarawa
HB0304 - 21	Craig Wellington	Along main drive way	Sheep/Beef	Ngatarawa
HB0304 - 22	Dean Nikora	63	Dairy	Takapau
HB0304 - 23	Dean Nikora	62	Dairy	Takapau
HB0304 - 24	Dean Nikora	58	Dairy	Takapau
HB0304 - 25	Dean Nikora	57	Dairy	Takapau
HB0304 - 26	Dean Nikora	Runoff	Sheep/Beef	Takapau
HB0304 - 27	Dean Nikora	9	Dairy	Takapau
HB0304 - 28	Dean Nikora	35	Dairy	Takapau
HB0304 - 29	Dean Nikora	68	Dairy	Takapau
HB0304 - 30	Dean Nikora	57	Dairy	Okawa
HB0304 - 31	Bruce Worsnop	18	Sheep/Beef	Matamau
HB0304 - 32	Bruce Worsnop	11	Sheep/Beef	Kopua
HB0304 - 33	Bruce Worsnop	35	Sheep/Beef	Takapau/Tikokino
HB0304 - 34	Michael Pallesen	6	Dairy	Tikokino
HB0304 - 35	Michael Pallesen	5	Dairy	Tikokino
HB0304 - 36	Terry Walters	Slopes	Techno	Makaretu
HB0304 - 37	Terry Walters	Hill tops	Techno	Matamau
HB0304 - 38	Terry Walters	Hill tops	Techno	Matamau

LMI code	Name	Paddock ID	Land use	Soil series
HB0304 - 39	John Hudson		Techno	Takapau
HB0304 - 40	Michael Pallesen	11b	Dairy	Takapau
HB0304 - 41	John Hudson		Techno	Takapau
HB0304 - 42	John Hudson		Techno	Takapau
HB0405 - 01	Mark Apatu	Carrington	Seas crop	Hastings
HB0405 - 02	Mark Apatu	Racecourse cult	Seas crop	Hastings
HB0405 - 03	Mark Apatu	Wings	Seas crop	Hastings
HB0405 - 04	Greg Wilson	Clover	Rotat crop	Hastings
HB0405 - 05	Greg Wilson	Bottom side	Rotat crop	Hastings
HB0405 - 06	Greg Wilson	No. 3	Rotat crop	Hastings
HB0405 - 07	Ron Curtis	Curtis	Exten past	Hastings
HB0405 - 08	Greg Wilson	Lane	Inten past	Hastings
HB0405 - 09	Greg Wilson	Macro	Intensive pasture	Hastings
HB0405 - 10	Mike Glazebrook	Plantation	Seas crop	Poporangi
HB0405 - 11	Mike Glazebrook	Gasgoinge	Seas crop	Poporangi
HB0405 - 12	Mike Glazebrook	Airstrip	Seas crop	Poporangi
HB0405 - 13	Craig Wellington	Washpool Little McRae	Rotat crop	Poporangi
HB0405 - 14	Craig Wellington	Washpool Big McRae	Rotat crop	Poporangi
HB0405 - 15	Craig Wellington	Washpool Storkbill	Rotat crop	Ngatarawa
HB0405 - 16	Gerald Burns	Burns house	Seas crop	Hastings
HB0405 - 17	Gerald Burns	Burns end	Seas crop	Hastings
HB0405 - 18	Gerald Burns	Burns Cfarm	Seas crop	Hastings
HB0405 - 19	Gerald Burns	CFarm plot 2	Seas crop	Hastings
HB0405 - 20	Gerald Burns	CFarm plot 4	Seas crop	Hastings

LMI code	Name	Paddock ID	Land use	Soil series
HB0405 - 21	Gerald Burns	CFarm plot 5	Seas crop	Hastings
HB0405 - 22	Gerald Burns	CFarm plot 6	Seas crop	Hastings
HB0405 - 23	Gerald Burns	CFarm plot 11	Seas crop	Hastings
HB0405 - 24	Gerald Burns	CFarm plot 12	Seas crop	Hastings
HB0405 - 25	Gerald Burns	CFarm plot 14	Seas crop	Hastings
HB0405 - 26	Gerald Burns	CFarm plot 15	Seas crop	Hastings
HB0405 - 27	Mark Apatu	Otenes plot 1	Seas crop	Pakowhai
HB0405 - 28	Mark Apatu	Otenes plot 4	Seas crop	Pakowhai
HB0405 - 29	Mark Apatu	Otenes plot 5	Seas crop	Pakowhai
HB0405 - 30	Mark Apatu	Otenes plot 6	Seas crop	Pakowhai
HB0405 - 31	Mark Apatu	Otenes plot 11	Seas crop	Pakowhai
HB0405 - 32	Mark Apatu	Otenes plot 12	Seas crop	Pakowhai
HB0405 - 33	Mark Apatu	Otenes plot 14	Seas crop	Pakowhai
HB0405 - 34	Mark Apatu	Otenes plot 15	Seas crop	Pakowhai
HB0405 - 35	McDonald	Chesterhope Big Paddock	Exten past	Pakowhai
HB0405 - 36	McDonald	Chesterhope Stud Paddock	Exten past	Pakowhai
HB0405 - 37	McDonald	Chesterhope 2nd Paddock	Exten past	Pakowhai
HB0405 - 38	Mark Apatu	Racecourse ST, tilled	Seas crop	Hastings
HB0405 - 39	Mark Apatu	Racecourse ST, untilled	Seas crop	Hastings
HB0405 - 40	Hugh Ritchie	Drumpeel orig cult	Seas crop	Hastings
HB0405 - 41	Hugh Ritchie	Drumpeel orig reduced till	Seas crop	Hastings
HB0405 - 42	Hugh Ritchie	Drumpeel pump cult	Seas crop	Hastings

LMI code	Name	Paddock ID	Land use	Soil series
HB0405 - 43	Hugh Ritchie	Drumpeel pump ST, tilled	Seas crop	Hastings
HB0405 - 44	Hugh Ritchie	Drumpeel pump ST, untilled	Seas crop	Hastings
HB0405 - 45	Hugh Ritchie	Anderson cultivated	Seas crop	Turamoe
HB0405 - 46	Hugh Ritchie	Anderson ST, tilled	Seas crop	Turamoe
HB0405 - 47	Hugh Ritchie	Anderson ST, untilled	Seas crop	Turamoe
HB0405 - 48	John Duncan	Duncan cult	Rotat crop	Turamoe
HB0405 - 49	John Duncan	Duncan ST	Rotat crop	Turamoe
HB0405 - 50	Dennis McKenzie	McKenzie cult	Seas crop	Turamoe
HB0405 - 51	Dennis McKenzie	McKenzie ST, tilled	Seas crop	Turamoe
HB0405 - 52	Dennis McKenzie	McKenzie ST, untilled	Seas crop	Turamoe
HB0405 - 53	Andy Raikes	Raikes cult	Rotat crop	Turamoe
HB0405 - 54	Andy Raikes	Raikes ST, tilled	Rotat crop	Turamoe
HB0405 - 55	Andy Raikes	Raikes ST, untilled	Rotat crop	Turamoe
HB0405 - 56	Rhod McIntyre	Water Wheel	Exten past	Turamoe
HB0405 - 57	Rhod McIntyre	Blueberry	Exten past	Turamoe
HB0405 - 58	Rhod McIntyre	Holding	Exten past	Turamoe
HB0405 - 59	Greg Wilson	Gums	Intensive pasture	Hastings
HB0506 - 01	Mark Apatu	Mowatts	Seas crop	Hastings
HB0506 - 02	Donald Fraser	Lane 3B	Rotat crop	Poporangi
HB0506 - 03	Tony Jefferd	Pivot 1	Seas crop (ST)	Poporangi
HB0506 - 04	Simon Godden	Ashcot Pdk 18	Rotat crop	Poporangi
HB0506 - 05	Robin Hilson	Next to woolshed	Exten past	Poporangi
HB0506 - 06	Tony Jefferd	Small sheep 2	Exten past	Poporangi
HB0506 - 07	Tony Jefferd	Small sheep 1	Exten past	Poporangi

LMI code	Name	Paddock ID	Land use	Soil series
HB0506 - 08	Donald Fraser	Lane 3A	Rotat crop	Takapau
HB0506 - 09	Tony Jefferd	Pivot 2	Seas crop (ST)	Takapau
HB0506 - 10	Simon Godden	Ashcot Pdk 18	Rotat crop	Takapau
HB0506 - 11	Mike Palleson	4	Dairy	Tikokino
HB0506 - 12	?	?	Dairy	Tikokino
HB0506 - 13	Mike Palleson	6	Dairy	Tikokino
HB0506 - 14	Dean Nikora	?	Dairy	Tikokino
HB0506 - 15	Dean Nikora	20	Dairy	Takapau
HB0506 - 16	Mike Palleson	29 - back only	Dairy	Okawa
HB0506 - 17	Dean Nikora	4	Dairy	Okawa
HB0506 - 18	?	?	Dairy	Okawa
HB0506 - 19	Simon Godden	20 - front half bounding Burnside Rd	Dairy	Takapau
HB0506 - 20	Ian Waldrom	?	Exten past	Matapiro
HB0506 - 21	?	?	Techno	Mangatahi
HB0506 - 22	?	?	Techno	Mangatahi
HB0506 - 23	?	?	Techno	Okawa
HB0506 - 24	?	?	Techno	Okawa
HB0506 - 25	?	?	Techno	Okawa

Appendix V Additional visual soil assessments

1. Area of bare ground (%) not covered by living vegetation or dead residue (before raking away residue). Visual guide.
2. Area of crusted soil (%) and **estimate thickness** (Figure 1).
3. Area of damaged soil surface (%), e.g. by stock treading or vehicles, and depth of damage (Figure 2).
4. Inspect slice of soil for organic thatch build up (Figures 3 and 4). Measure thickness. If soil recently ploughed, thatch may be buried at depth. Record depth and thickness as best you can (it won't be easy).

Figure 1: Crusting.

Figure 2: Surface damage.

Figure 3: Organic thatch.

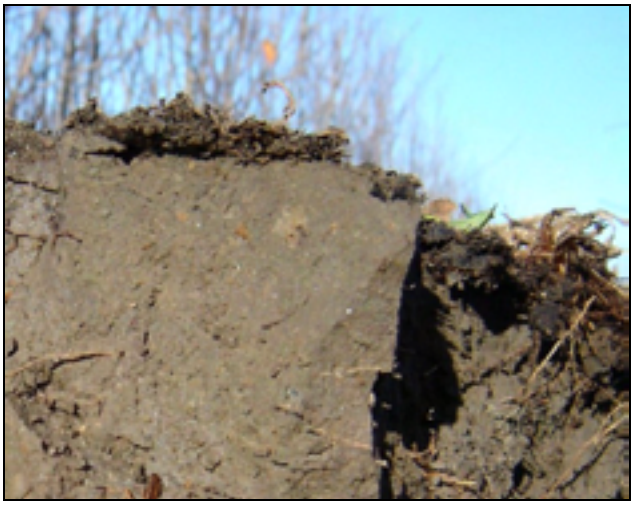
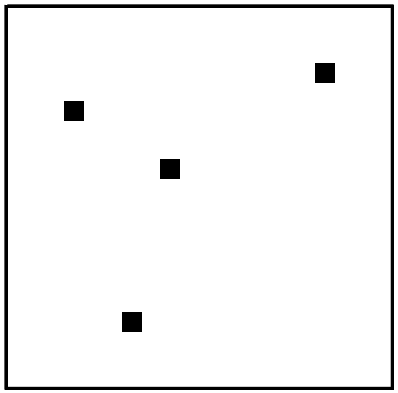


Figure 4: Organic thatch.

Visual guide to percent areas

1%



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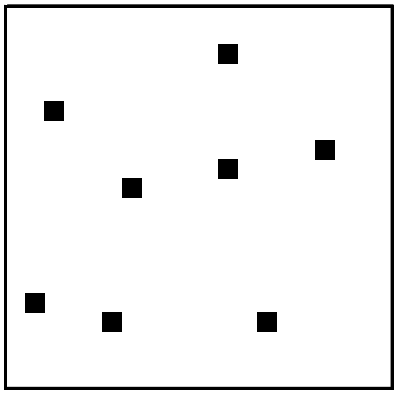

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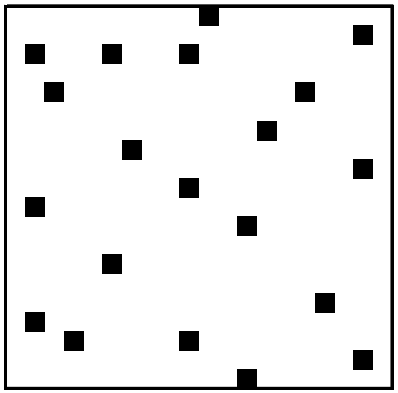

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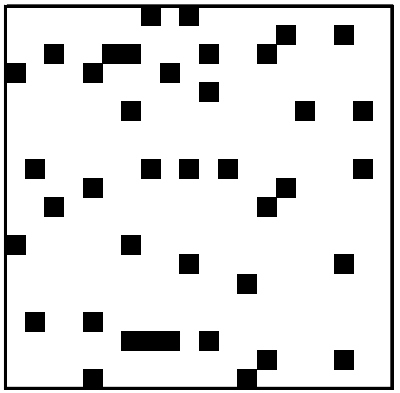

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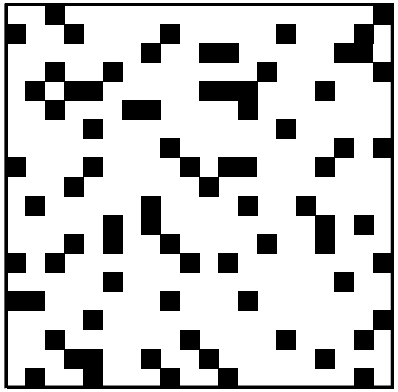

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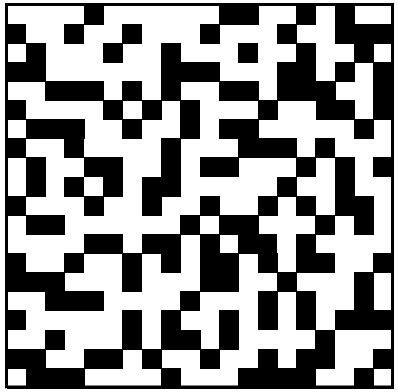

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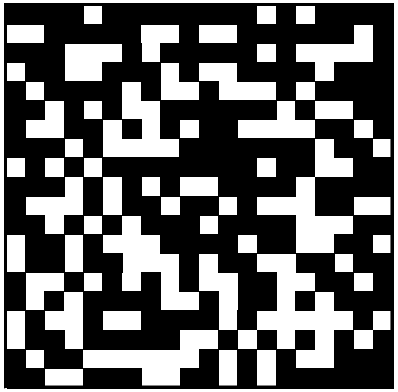

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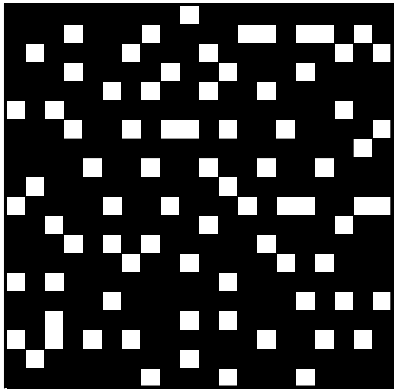


Appendix VI Laboratory quotes for pH, Olsen P, total C & N and Potentially mineralisable N

Hill Laboratories

Quote No - 19271

Client Name: Hawkes Bay Regional Council Napier
Contact Name: Hawkes Bay Regional Council
Charge To: Hawkes Bay Regional Council
Fax No: 06 835 2601

Date: 09/05/2006
From: Mrs P M Calvert
Client Ref: Soil Quality Monitoring

We are pleased to be able to quote for your analytical requirements

R J Hill Laboratories Quote - No 19271 Page 1

Detail Line	List Price	Quote Price	Qty	Line Total	Bottles Rqrd

Notes:

NZLABS

New Zealand Laboratory Services Limited
[illegible]
Phone (07) [illegible]
Freephone [illegible]
Fax (07) [illegible]

[illegible]

[illegible]

[illegible]

Thank you for requesting a quote from **New Zealand Laboratory Services** for analysis of [illegible]

LABORATORY: SOIL

Tests	Retail Price	Discount Price
[illegible]	$ 8.30	$ 7.47
pH	$ 8.30	$ 7.47
Total Nitrogen	$ 10.50	[illegible]
Total Carbon	$ 18.37	$ 16.53
Mineralisable Nitrogen	$ 23.00	[illegible]
Sample Preparation	$ 10.50	$ 9.45
Total	$ 83.97	$ 75.57

Please Note:

[illegible]

[illegible]

Technical Sales Representative

6 April 2006

Attention Andrea Pearson
Crop and Food Research
Lawn Road
HASTINGS

Dear Andrea

Re: Pricing for the provision of soil analytical services to the Hawkes Bay Regional Council for their State of the Environment Monitoring Program.

Thank you for the opportunity to register our interest and quote for the work detailed in your recent email.

Quotation

Based on the receipt of between 50 and 60 soil samples* for the test parameters pH, Olsen P, Total Carbon and Nitrogen and Anaerobically Mineralisable Nitrogen (AMN), I am able to offer the following quotation**:

Quotation: $47.65 per sample plus GST

* Samples of field moist soils received at the laboratory.

** There is a further discount of 1.25 - 1.5% if paying by direct credit or direct debit respectively.

Methodology

- pH is determined by combination pH electrode and automated pH robot. Results are expressed as pH units to one decimal place.

- Olsen P is determined colorimetrically using a Flow Injection Analyser based on the phosphate, molybdate heteropoly blue chromophore. Results are expressed as Olsen P on a weight per volume basis (µg/mL)

- Total Carbon and Total Nitrogen are simultaneously determined by the combustometric method using a LECO CNS 2000 instrument. Carbon dioxide measurement is by Infra Red analyser and the nitrogen dioxide is by Thermal Conductivity Detection. Results are expressed on a percent weight for weight basis (%w/w)

- AMN is determined as accumulated ammoniacal nitrogen from the anaerobic incubation of soil over a 7 day incubation period. Analysis of the ammonium moiety is via Flow Injection Analysis using the Bertholot reaction. Results are expressed as kg N /ha. This can be converted to µg N /g or µg N /mL of soil.

- EDTA Trace Elements are by EDTA extraction followed by filtration and analysis of the filtrate by Inductively Coupled Plasma Optical Emission Spectrophotometry (ICP-OES). Results are expressed as µg /g

- Heavy metals are analysed as the Total Acid Recoverable concentration of the element after digestion with hydrochloric acid and nitric acid. Final analysis of the diluted digest is via ICP-OES. Results are expressed as µg /g

IANZ Accreditation and Quality Assurance

ARL has current IANZ accreditation status for each of the tests in the suite covered by the quotation. We also participate in two Inter-laboratory Collaborative Programs covering the test parameters; they are the New Zealand Soil Labs Program and the Australasian Soil and Plant Analytical Council (ASPAC) Program. We also have strict internal quality control systems based on predetermined accept/reject criteria for internally generated quality control check samples.

Turn Around Times

All tests, bar the AMN are reported 4 days from the receipt of samples. The AMN, with its 7 day incubation time, will take 10 days. An interim report of analysis is available for the parameters, pH, Olsen P, Total Carbon and Nitrogen.

Sample Retention

Under normal circumstances we retain samples for 3 months prior to disposal. In special circumstances this period can be extended by arrangement or the soils can be returned to you for long term storage if you wish.

Confidentiality

Results will be accorded due confidentiality and will not be communicated or otherwise disseminated without written permission from the customer.

Further Quotation
You have also asked that we submit a further quotation to cover the following test parameters.

Option 1: Basic test, Total C/N, AMN.
Option 2 : Heavy metal suite (As, Cd, Cr, Pb, Hg, Ni)
Option 3 : Cd only
Option 3: EDTA Cu
Option 4: DDT

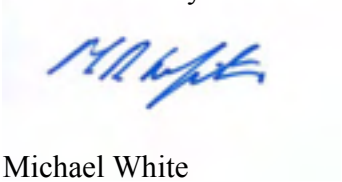
I offer the following quotations: Again these are subject to a further discount of 1.25 - 1.5% if paying by direct credit or direct debit respectively.

Option 1: $60.80 + GST per sample
Option 2 : $66.72 +GST per sample
Option 3 : $17.00 +GST per sample
Option 3: $17.00 +GST per sample
Option 4: $??? +GST *** per sample

*** This will be a subcontracted test.

We are very keen to provide the analytical service and trust that I have provided the necessary information, if not please do not hesitate to ring me.

Yours faithfully



Michael White

Manager
For Analytical Research Laboratories Limited

Analytical Research Laboratories Limited
890 Waitangi Road, Awatoto,
PO BOX 989 Napier, New Zealand, Phone +64-6-8359222

Standard prices for Analytical Research Laboratories (ARL)

TESTS AND TEST SUITES	OPTIONS	SHAREHOLDER	RETAIL
Basic Soil Analysis		$34.00	$40.00
Standard Soil Analysis		$42.50	$50.00
Standard Soil + Organic Sulphur		$51.00	$60.00
Sustainability Analysis		$352.19	$414.34
Mineral-N. (Deep Nitrogen Test)		$36.13	$42.50
pH		Please refer to ARL if individual analytes are required.	
Olsen Soluble P			
Calcium MAF			
Magnesium MAF			
Potassium MAF			
Sodium MAF			
Sulphate-S			
Ext.Org. Sulphur			
Lab Bulk Density (Dry wt/vol)			
CEC			
Base Saturation			
P Retention (ASC)		$9.78	$11.50
Reserve Potassium (TBK)		$21.25	$25.00
Anaerobically Mineralisable N.(AMN)		$9.78	$11.50
Soluble Salts (GH)		$9.78	$11.50
Hot Water Soluble B		$12.75	$15.00
Resin P		$12.75	$15.00
Org. Matter or Org. Carbon		$12.75	$15.00
Exch. Al		$12.75	$15.00
EDTA Co Mn Fe Cu Zn		$17.00	$20.00
Basic Mehlich 3 (P,Mn, Zn, Cu, Fe, B, Al)		$17.00	$20.00
Complete Mehlich 3 (P,K,Ca,Mg,Na,Mn,Zn,Cu,Fe,B,Al,Co)		$25.50	$30.00
Total N or Total C		$17.00	$20.00
C/N Ratio		$21.25	$25.00
Chloride		$9.78	$11.50
Reserve Mg		$12.75	$15.00
Ammoniacal-N		$9.78	$11.50
Nitrate-N		$9.78	$11.50
Heavy Metal suite (As,Cd,Cr,Pb,Hg,Ni)		$66.73	$78.50
Total Elemental Analysis per analyte		$17.00	$20.00
Soil Sample Preparation *		$6.38	$7.50
Moisture		$9.78	$11.50
Macroporosity - Subcontracted		-	-
True Bulk Density - Subcontracted		-	-
Total DDT - Subcontracted		$75.00	$75.00
Acidic Herbicide - Subcontracted		$330.00	$330.00
Multiresidue - Subcontracted		$240.00	$240.00

Appendix VII Bulk density and macro-porosity

Bulk density and macro-porosity are measured on cores of 75 mm long and 100 mm diameter. The core liners (rings) are pressed into the soil then dug out of the soil with a spade and trimmed with a knife. It is vital that the cores are kept intact and not damaged. Core liner covers are placed over each end of the core liner, then wrapped in Gladwrap™ and labelled. Samples are packed into a padded crate for transport to the laboratory. Samples should be sent to the laboratory as soon as possible, and stored at 3-5°C until dispatched. Full field training for collecting these samples is available from Landcare Research.

At the lab, the cores are tested for **bulk density, particle density,** and **volumetric water content at -5 and -10 kPa**, from which macro-porosity can be calculated. The NLMF decided that a tension of -10 kPa would be used to calculate macro-porosity, which corresponds to a pore size of around 30 µm. Other organisations routinely use -5 kPa tensions to calculate macro-porosity, and care should be taken to make sure the desired tension is used. Macro-porosity is calculated using the following equations.

Macro Porosity (%) = Total Porosity - (Volumetric water content at -10 kPa)

Total Porosity (%) = (1 - (Bulk density / Particle density)) x 100

Appendix VIII Endecotts test sieves

Quotation B50932

May 3, 2006

Crop & Food Research (Hastings)
RD 2, 265 Lawn Road
HASTINGS

Attention: Ms Andrea Pearson

Fax: (06) 870-0750
Email: pearsona@crop.cri.nz

Dear Andrea,

Thank you for your enquiry re Endecotts sieves.

As discussed, please find enclosed information detailing the Endecotts sieve range.

Below are prices for the sieves as discussed.

Thank you for your enquiry and please do not hesitate to call me on 0800248222.

Kind regards,

Alan Russell
Product Specialist
Analytical & Industrial Technologies

A Division of Biolab (NZ) Ltd.
Freephone: 0800 248 222
Fax: +64 (0) 9 980 6788
DDI: +64 (0) 9 980 6753
Email: alanr@nzl.biolabgroup.com
Web: www.biolabgroup.com

QUOTATION **B50932**	Customer No.: **6393** Date of Quotation : 3 May 2006 Expiry Date : 5 May 2006 Your Reference: SIEVES

FROM: ENDECOTT, UK

Item: EDC200BIW2.00 EA Qty: 1 **$180.00**
Sieve 200mm dia brass BS410/ISO3310 wire mesh aperture 2.00mm full height
Availability: Ex Stk

Item: EDC200BIW4.00 EA Qty: 1 **$230.00**
Sieve 200mm dia brass BS410/ISO3310 wire mesh aperture 4.00mm full height
Availability: 5-7 wks

TERMS & CONDITION OF SALE, and ITEM CLAUSES

TERMS	This quotation is subject to our standard Terms and Conditions of Sale, copy attached.
PRICES	**Prices quoted exclude GST** and are nett ex warehouse unless otherwise stated.
DELIVERY TIME	Delivery time quoted is subject to confirmation at time of receipt of your order. Items quoted ex stock are available subject to prior sale
ORDER	Should you wish to place an order as a result of this quotation**, please state the relevant quote number** to ensure you get the quoted prices.
INDENT	Goods ordered on indent for your order are not returnable for credit unless it is Biolab's error, or if the product is defective.
EXCHANGE RATE	This quotation is in NZ$, and is based on the exchange rate ruling today. Any significant variation in exchange rate will be for your account. Rates as applicable are listed below:-
One NZD =	0.3425 GBP For Items ; EDC200BIW2.00, EDC200BIW4.00