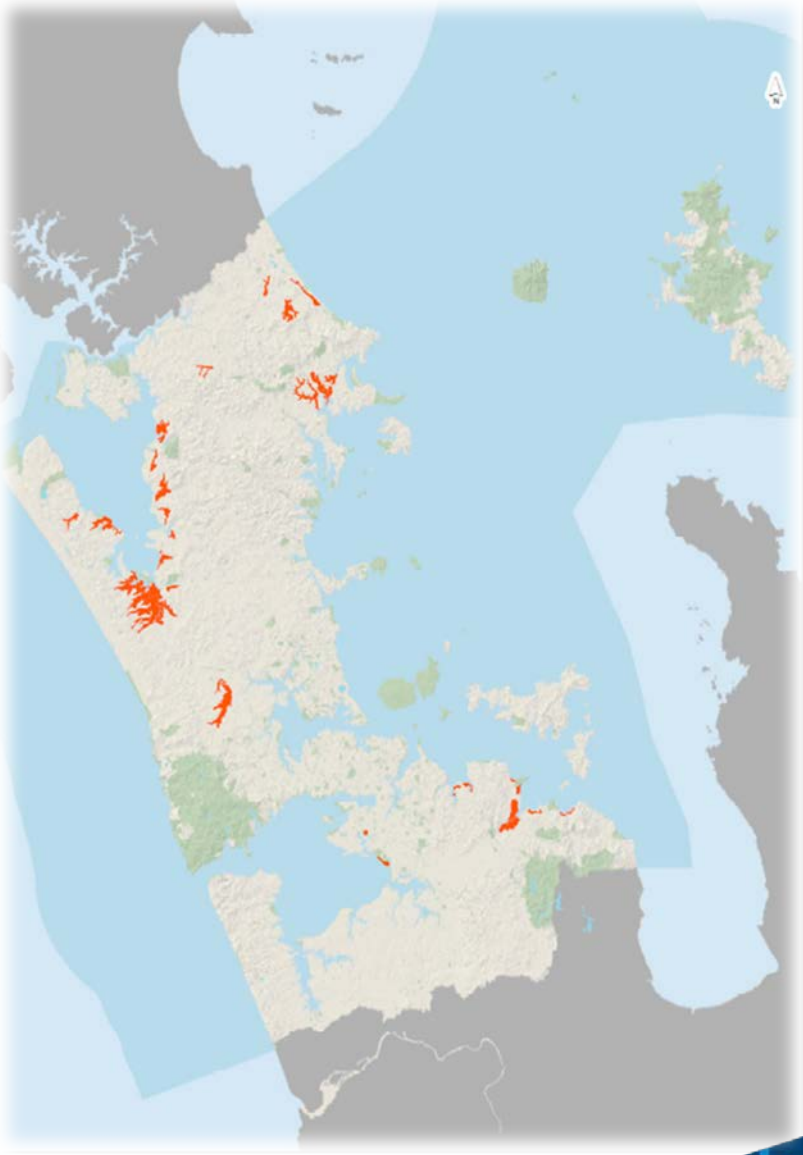
Soil Information Inventory:

Kaipara and related soils

October 2018 Soil Information Inventory 5



RIMU Research and Evaluation Unit

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Soil Information Inventory 5:

Kaipara and related soils

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Auckland Council
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1 Introduction

With Auckland's expected growth from 1.7 to 2.0 million people in the next 30 years (The Auckland Plan 2050) and a goal to double New Zealand's agricultural exports by 2025 (Ministry for Primary Industries), an understanding of Auckland's soil resources is essential for planning urban growth, and sustaining if not expanding rural production, while managing the impacts of both on our region's environment.

Existing information on Auckland's soils is difficult to assess and interpret. Electronic versions of soil maps are available on research institute websites. Some have been uploaded into Auckland Council's geographic information system (GIS, GeoMaps) for use by council staff and for public viewing. However, the GIS maps and their attached attribute lists cannot be understood or used without referring to background information which is dispersed across old maps, publications, or unpublished reports. Many of these documents are now hard to find.

Auckland Council has undertaken to compile old information for the region's main soils into single documents called soil information inventories (SIIs). These may be viewed on Knowledge Auckland, www.knowledgeauckland.org.nz council's research and technical publications website, downloaded and printed. It is expected that there will be gaps in each inventory. The gaps will be filled as new information becomes available. Each inventory is a repository for information old and new and will be a "living document".

Their intent is to:

- ease access to soil information
- enable better understanding of the soils' properties
- enhance public awareness about the location of productive or problematical soils
- improve awareness of the soils' potential and limitations, amongst consultants and planners
- help council staff provide better advice, and make more informed decisions.

Our role has been document compilers, not authors. We have selected information which appears useful for landowners, farm, forest, environmental or planning consultants, and the council staff who deal with them. While we regard the selected information as reliable, responsibility for accuracy of contents rests with the organisations which originally collected and published the maps or documents which we cite. Auckland Council makes the information available on the Knowledge Auckland website with this understanding.

Acknowledgments are due principally to old soil surveyors of the DSIR's Soil Bureau, who collected most of the information reproduced here, notably Charles Sutherland, Charles Wright, Norman Taylor, Edward Cox, and Gary Orbell.

Assistance from Mandy Holt (cross-section), Tyana Rowe-Kurene, Tony Edhouse and Linda Wallis (document editing and layout), Fiona Curran-Cournane (internal publication referee) and Malcolm McLeod (external publication referee) is also acknowledged.

Michael Martindale, Douglas Hicks and Peter Singleton
June 2016, October 2018

2 Published maps

On DSIR's published soil maps of North Auckland (1:100,000), soils on young estuarine alluvium - elevated above present-day tide level - are depicted as two separate series i.e. soils with distinct profiles and parent materials. They are divided into four types i.e. soils with differences in texture or other characteristics:

KPy	Kaipara peaty clay loam
KP	Kaipara clay loam and clay
YUy	Waipu peaty silt loam and peaty clay
YU	Waipu clay

though there is a problem with identity of Waipu soil on some of these areas (see Farm-scale maps).

On DSIR's oldest maps of South Auckland, similar soils are depicted as two series divided into five types:

101	Kaipara clay
101a	Kaipara peaty clay loam and peaty loam
103	Hauraki clay
103a	Hauraki peaty clay
103b	Hauraki peaty loam

No similar soils appear on a map of intermediate age covering part of Franklin district (1:63,360). A more recent map of Manukau city (1:20,000) separates young estuary soils into two mapping units which contain spatially associated soil types. They are assigned alphanumeric labels:

AAB1	Hauraki clay
AAB3	Hauraki peaty clay

Sourced from:
Soil maps of Maungaturoto-Kaipara area; Mangawhai-Warkworth area;
Helensville-Waitakere area; Whangaparaoa-Auckland area;
NZ Soil Bureau maps 189, 190, 220, 221
Soil map of the North Island, sheets 2 and 3 (Auckland and Waikato);
NZ Soil Bureau maps 11/2, 11/3
Soil map of part Franklin county;
NZ Soil Bureau map 149/1
Soil map of Manukau City;
NZ Soil Bureau map unpublished

3 Online maps

Landcare Research's online soil map (S-map, 1:50,000) re-names and re-labels the soils as follows:

KPy	Invermay family, un-numbered sibling
KP	Invermay family, sibling 1
YUy	Waipl family, sibling 1a
YU	Temuka family, sibling 68
101,101a	No family name or sibling number assigned
103,103a, 103b	No family name or sibling number assigned
AAB1	Temuka family, sibling 55 and Invermay family, sibling 2
AAB3	Temuka family, sibling 11

Reasons for the basis of S-map can be found in the S-map database manual. The names and numbers were assigned by computer-matching local soil properties with different soils in other parts of the country.

Sourced from S-map Online – Home http://smap.landcareresearch.co.nz/home

4 Farm-scale maps

North of Auckland, any published map polygon labelled as Kaipara series (KPy, KP) turns out to be a mosaic of Kaipara plus other soil types when investigated in the field by local soil mappers, On farm-scale soil maps (1:5,000 - 1:10,000) the Kaipara soils are labelled as:

Kpy	Kaipara peaty clay loam
Kp	Kaipara clay loam and clay

Polygons labelled Waipu series (YUy, YU) if on estuarine terraces, turn out to have a proportion of old weathered Waipu soil (a series mapped on the east coast of Northland), interspersed with patches of younger soil, equivalent to Kaipara series on the west coast. Few of these polygons have yet been re-mapped at farm scale, as one or other series (see Soil Information Inventory for Clevedon and related soils). Polygons labelled YU etc. if on stream terraces (inland valleys), turn out a mosaic of Waipuna clay with Kara clay, silt loam or sandy loam. The published map labels here appear to be typographic errors i.e. YU instead of WU.

South of Auckland published map polygons labelled 101, AAB1 etc. are young estuary soils correctly identified as Kaipara series or Hauraki series (its Firth of Thames equivalent). In event of future mapping or sampling at farm scale, a local mapper (DLH) recommends using labels and names that correspond to equivalent North Auckland series, as follows:

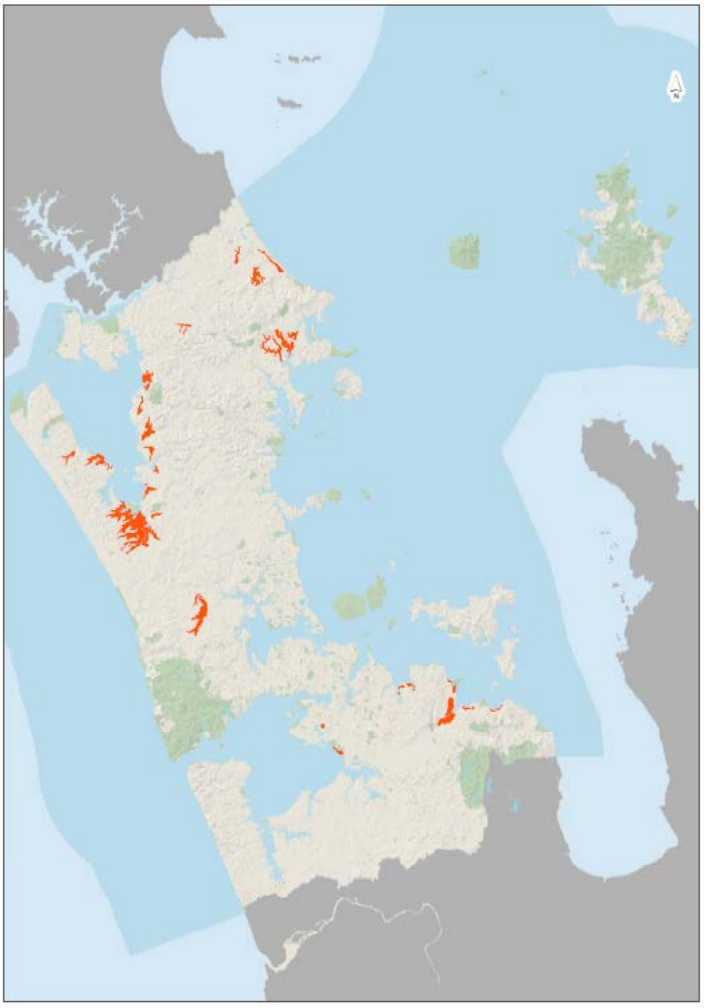
Hay	Hauraki (Kaipara) peaty clay loam
Ha	Hauraki (Kaipara) clay loam and clay

Local series names for Kaipara and related soils have been retained on Auckland Council's farm-scale maps for continuity with published nomenclature.

Sourced from 1995-2015 farm-scale maps and soil notes prepared for private landowners, Auckland Regional Council or Auckland Council

5 Where the soils occur

Extensively alongside Kaipara Harbour estuaries. As thin strips next to estuaries of the Manukau and Waitemata harbours. As discontinuous patches beside east coast estuaries from Mangawhai to Okura; also, the Tamaki, Whitford and Wairoa estuaries.



Location of Kaipara and related soils

Kaipara and related soils are mapped on 7900 hectares (2% of Auckland region's area). About 5400 hectares (68% of the area mapped) are in agricultural use (estimated from overlay of Agribase 2010 on Fundamental Soils Layer). *http://intermaps.arc.govt/AucklandCouncilViewer/*

5.1 On what landform

Kaipara and related soils underlie low flats – formerly swampy, now drained – adjacent to but slightly above tidal estuaries *Photo: D. Hicks*

Kaipara and related soils develop on low flats underlain by young estuarine alluvium. Part of the Tauranga Group sediments, the alluvium is its youngest estuarine formation, formed since post-Ice Age sea level peaked about 5000 years ago at positions landward of the present-day shoreline. Rapid accretion of estuary sediment, aided by flood deposits of sand, silt and clay washed down tidal creeks, has raised the flats slightly above present-day tidemark, so they are no longer inundated by the highest (king) tides or storm surges. There has been sufficient time for distinct topsoil to form, above subsoil that is mainly clay though interspersed by silt, sand and shell layers. Natural vegetation ranges from forest tolerant of damp sites (kahikatea) through swampy scrub (manuka, cabbage tree) to swamp (raupo, flax, sedge, rush) where water table is at the surface. Clearance, drainage and cultivation have transformed what was once a diverse landscape into pasture and exotic tree shelterbelts, with few remnants of the original cover.

Sourced from:
Edbrooke, S. W., 2001, Geology of the Auckland Area, Institute of Geological and Nuclear Sciences 1: 250,000 map 3 and accompanying bulletin
Molloy, L., 1987, Soils in the New Zealand Landscape, New Zealand Society of Soil Science

5.2 How they differ from other soils

Kaipara soils on young estuarine alluvium differ from the Takahiwai soils on raw estuarine alluvium in just three respects:

- Presence of a distinct topsoil,
- Some weathering of subsoil clay,
- Salt and sulphur compounds have leached from the subsoil, enabling it to develop structure.

Sourced from:

Wilson, A.D. and Cox, J.E., Soils of Rodney County, Unpublished report, Soil Bureau DSIR

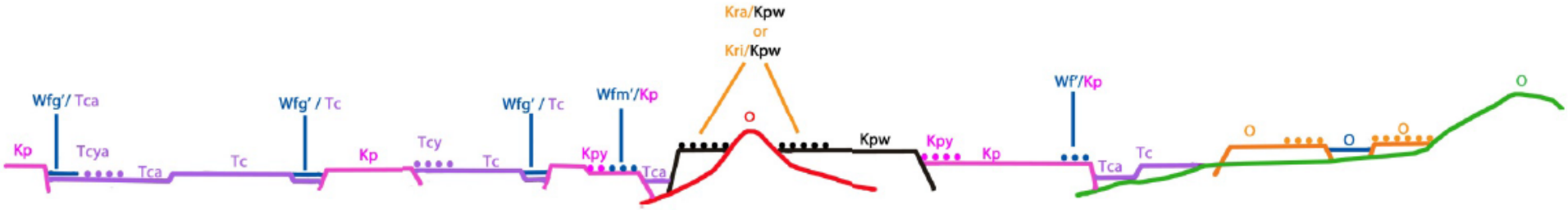
Rijkse, W. C., 1978, Soil Groups of New Zealand Part 3: Gley Soils, New Zealand Society of Soil Science

6 Classifications

NZ genetic (NZG):	Northern gley soil
NZ soil (NZSC):	Gley recent or orthic gley *http://soils.landcareresearch.co.nz/contents/SoilNames_NZSoilClassification_SoilOrders.aspx*
Soil Taxonomy (USDA):	Haplaquept *http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051544.pdf*
World Soils (FAO):	Gleysol *http://www.fao.org/3/a-i3794e.pdf*

DSIR replaced the NZ genetic classification dating from 1930s with the NZ soil classification in 1990s. DSIR's soil scientists considered that Soil Taxonomy did not work well in New Zealand, nor did World Soils. Soil Taxonomy and World Soils remain internationally accepted classifications.

Cross section showing Kaipara and related soils' position in the landscape



On fresh estuary alluvium:

Tca Takahiwai sandy clay
Tcya Takahiwai peaty sandy clay
Tc Takahiwai clay
Tcy Takahiwai peaty clay

On young estuary alluvium:

Kp Kaipara clay or clay loam
Kpy Kaipara peaty clay loam

On old estuary alluvium

Kpw Kaipara clay or clay loam (weathered)

Wfg'/Tc etc Whakapara sandy or silty clay (shallow) over Takahiwai soils

Wf'/Kp } Whakapara sandy silt loam or silty clay
Wfm'/Kp } loam (shallow) over Kaipara soils

Kra'/Kpw } Kara sandy loam or silt loam (shallow) over
Kri'/Kpw } Kaipara clay or clay loam (weathered)

On stream alluvium:

O, O Other soils

On clay weathered from rock:

O, O Other soils

Soil type labels on the cross-section are sourced from Auckland Council's farm-scale maps

7 Soil profile descriptions

Kaipara clay with incipient topsoil *Photo: D Hicks*

DSIR's type profile was prepared at a site on Ruawai Flats next to the north Kaipara. It is labelled as Kaipara clay and clay loam.

Kaipara clay

Horizon	Depth (cm)	Description
Ap	0-10	Very dark grey (10YR 3/1) clay; moderately developed fine and very fine subangular polyhedral structure; hard when dry; abundant fine roots; sharp wavy boundary.
Crg	10-17	Greyish brown (2.5Y 5/2) clay; common yellowish red (5YR 5/6-5/8) mottles along root channels; very firm packing; massive structure in place, upper part of prisms or fissuring 7 to 10 cm apart, with a slightly rounded cap; faces of the fissures are coated with very dark grey material from the A horizon; many extremely fine pores; abundant fine roots; diffuse boundary.

Horizon	Depth (cm)	Description
Crcg	17-38	Greyish brown (2.5Y 5/2) clay; common rust coloured and grey coatings along root channels; massive in place breaking to weakly developed fine and medium polyhedral structure; very firm; common brownish yellow - reddish yellow - dark reddish brown soft spherical iron concretions; many fine roots.
Crjg1	38-97	Greyish brown (2.5Y 5/2) clay; common strong brown tubular rust coloured mottles along root channels some with a pale yellow material; faces of fissures have a thin reddish brown coating and dark grey staining; massive structure breaking to clods; extremely firm; high packing in place; sticky; numerous fine roots; diffuse boundary.
Crjg2	on	Blue grey clay; few strong brown tubular mottles, generally with a yellowish-red lining and a brittle outer rust coloured coating, the surface of which is furred with a pale yellow soft material, few prominent reddish-brown mottles; fissures have dark red (2.5YR 3/6) coating of organic material; firm; massive in place breaking to weakly developed medium polyhedral structure; many fine grass roots.

A local soil mapper (DLH) considers the profile is a description of Kaipara clay, as found in drained swamps. It is very different from the most widespread soil type, Kaipara clay loam, on seasonally wet flats (formerly swampy scrub or kahikatea forest) which have been in pasture many years.

Kaipara clay loam *Photo: D Hicks*

A provisional profile description is:

Kaipara clay loam

Horizon	Depth (cm)	Description
A	0-15 cm	Dark grey clay loam; earthy; subangular polyhedral and firm when dry; friable when moist; sharp boundary.
Cgg	15-40 cm	Mottled yellow and grey clay; massive structure, blocky to prismatic and hard when dry; sticky when moist; topsoil penetrates down vertical fissures in upper half of horizon; diffuse boundary.
Crg	40+ cm	Grey clay; massive and sticky (always moist to wet); rust coloured mottles may be present in upper half.

Kaipara peaty clay loam *Photo: N Watson*

There is no DSIR type profile description. A local soil mapper (DLH) considers it is not a widespread type, but is present as small pockets interspersed with Kaipara clay loam.

A provisional profile description is:
Kaipara peaty clay loam

Horizon	Depth (cm)	Description
A	0-30 cm	Black clay loam (where drained) or peaty clay loam (where not); earthy structure and friable consistence (where drained), or massive (where undrained); common fibrous sedge/rush/grass roots (where undrained); sharp boundary.
Cgg	30-60 cm	Mottled yellow and grey clay (if drained); massive structure and sticky when moist, blocky to prismatic structure and hard when dry; or gleyed grey clay (if not drained); few fibrous roots throughout horizon; rust coloured mottles may be present along root channels; diffuse boundary.
Crg	60+cm	Grey clay; massive and sticky (always moist to wet).

Sourced from:
Sutherland C.F., Cox, J.E., various dates, Type profile descriptions for North Auckland Soil Survey, Unpublished documents, Soil Bureau, DSIR

8 Properties of typical profile

Properties of typical profiles are best indicated by laboratory analyses for the type profile. i.e. site where Kaipara series was first defined and described. Data for any other site will vary from the type profile, though not greatly.

8.1 Chemical

http://soils.tfrec.wsu.edu/mg/chemical.htm

An incomplete chemical analysis appears in the online version of National Soils Database (NSD). The following data are sourced from Soil Bureau Bulletin 5:

Kaipara clay

Property	Topsoil	Subsoil	Units
Acidity	5.2	5.7	pH
Total carbon	22.2	-	%
Total nitrogen	1.48	-	%
Available phosphorus	0.028	0.015	mg %
P retention	-	-	%
Available sulphur	-	-	%
Cation exchange capacity	68.8	38.1	me %
Base saturation	37	62	%
Calcium	14.1	10.3	me %
Magnesium	9.8	12.7	me %
Potassium	-	-	me %
Sodium	-	-	me %

Sourced from laboratory analysis SB1430, DSIR Soil Bureau

Kaipara peaty clay loam

Property	Topsoil	Subsoil	Units
Acidity	6.8	-	pH
Total carbon	16.9	-	%
Total nitrogen	1.21	-	%
Available phosphorus	0.015	-	mg %
P retention	-	-	%
Available sulphur	-	-	%
Cation exchange capacity	83.8	-	me %
Base saturation	98	-	%

Property	Topsoil	Subsoil	Units
Calcium	70.0	-	me %
Magnesium	10.0		me %
Potassium	-	-	me %
Sodium	-	-	me %

Sourced from laboratory analysis SB1431, DSIR Soil Bureau

8.2 Physical

http://soils.tfrec.wsu.edu/mg/chemical.htm

There are no physical analyses for Kaipara or Hauraki soils in the online version of National Soils Database (NSD). The following estimates are sourced from the Fundamental Soils Layer (FSL) plus the relevant S-map factsheet:

Kaipara clay

Property	Topsoil	Subsoil	Units
Stones	-	0-4	%
Sand	-	-	%
Silt	-	-	%
Clay	-	-	%
Dry bulk density	-	-	g/cm³
Total porosity	-	-	%
Macroporosity	5.0-7.4	-	%

Sourced from FSL table; Landcare Research

Kaipara peaty clay loam

Property	Topsoil	Subsoil	Units
Stones	-	0-4	%
Sand	-	-	%
Silt	-	-	%
Clay	-	-	%
Dry bulk density	-	-	g/cm³
Total porosity	-	-	%
Macroporosity	10.0-14.9	-	%

Sourced from FSL table and S-map factsheet; Landcare Research

8.3 Irrigation and drainage

http://irrigationefficiency.co.nz/assets/Uploads/Farmers-Guide.pdf

No soil moisture analyses appear in the online version of NSD. The following estimates are sourced from FSL plus the relevant S-map factsheet:

Kaipara clay

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	% w/w
Plant-available water	50-74	-	mm
Depth to slowly permeable layer	-	0-0.89	m
Perm. at slowly permeable layer	-	<4	mm/hr

Sourced from FSL table and S-map factsheet; Landcare Research

Kaipara peaty clay loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	% w/w
Plant-available water	50-74	-	mm
Depth to slowly permeable layer	-	0-0.89	m
Perm. at slowly permeable layer	-	<4	mm/hr

Sourced from FSL table and S-map factsheet, Landcare Research

8.4 Topsoil properties under different uses

Local management practices affect the properties of soil, so the history of land use needs to be considered. For many Auckland soils, an indication is provided by soil test results collected by Auckland Council from sites known to have been under the same use long-term. These sites are being re-sampled at five to ten-year intervals to detect any trends. Kaipara and related soils have been sampled at two sites in the Auckland region, corresponding to the main land uses which are dairy and drystock pasture. A control site in wetland has yet to be established.

Land Use		Natural Cover	Pasture	
Type:		**Wetland**	**Drystock**	**Dairy**
Sample number-		**-**	**00/12**	**00/11**
Acidity	pH	-	5.5	5.9
Total carbon	%	-	6.6	6.7
Total nitrogen	%	-	0.56	0.54
Available nitrogen	µg/ cm^3	-	210	264
Available phosphorus	µg/ cm^3	-	35	72
Cation exchange capacity	cmol/cm^3	-	32.8	36.2
Base saturation	%	-	77	87
Calcium	cmol/ cm^3	-	16.5	25.9
Magnesium	cmol/ cm^3	-	3.7	4.2
Potassium	cmol/ cm^3	-	0.6	1.5
Sodium	cmol/ cm^3	-	0.6	0.4
Bulk density	t/ m^3	-	0.84	1.02
Particle density	t/ m^3	-	2.46	2.41
Aggregate stability	mm mwd	-	2.57	2.46
Total porosity	%	-	65.9	58.5
Macroporosity	%	-	10.4	3.7
Total available water	%	-	26.1	20.2
Readily available water	%	-	7.4	6.3

Sourced from Sparling, G. et al, various dates, 500 Soils Project, Landcare Research Reports to Auckland Council

and

Soil Quality of Dairy Sites in the Auckland Region in 2009, *Soil Quality of Drystock Sites in the Auckland Region in 2010*

9 Land use capability

Land use capability is a classification of land according to properties that determine its capacity for sustained primary production. Classes 1 to 4 are arable, classes 5 to 8 non-arable. Class 1 is versatile i.e. capable of many uses, with negligible limitations to any use. Class 8 is land with extreme limitations that preclude productive use.
http://www.landcareresearch.co.nz/publications/books/luc

Three factors - geology, soil and slope - are considered when assigning land use capability classes. Another two - erosion and vegetation - may be recorded but rarely affect the decision. On regional-scale maps, notably the 1: 50,000 New Zealand Land Resource Inventory (NZLRI), limitations to use are indicated by four subclasses, c (climate), w (wetness), s (soil) or e (erosion). Unit numbers (1, 1b etc.) are used as labels for areas of land (map polygons) with the same geology, soil and slope, which are considered to have similar productive potential and management needs. General descriptions of productive potential and management needs are attached to NZLRI unit numbers.

NZLRI sub-classes and unit numbers were used for farm-scale land use capability maps (1:5,000 - 1: 10,000) prepared by Auckland Regional Authority or Auckland Regional Council between 1979 and 2010. On farm-scale soil maps prepared for Auckland Council since 2011, the four sub-classes are now replaced by twenty specific limitations. NZLRI unit numbers and their attached general descriptions are replaced by farm-specific tables.

Landform	NZLRI	Farm	Main limitation	Sustainable uses
Well-drained clay flats	2w2,2w3b	2w	Water table occasionally in subsoil, winter-spring	Continuous cropping, intensive dairy or drystock grazing
Imperfectly draining clay flats	3w2,3w2b, 3w3b	3w	Water table fluctuates in winter-spring	Rotational cropping, intensive dairy or drystock grazing
Seasonally wet clay flats	4w2b,4w3b	4w	Water table in subsoil through winter-spring	Occasional cropping, intensive dairy or drystock grazing
Semi-drained swamp	-	5f	Occasional flooding, water table near surface, winter-spring	Summer –autumn grazing; wetland restoration as sediment traps and nutrient filters
Seasonal swamp	6w1	6f	Frequent flooding, water table at surface through winter-spring	Emergency grazing in summer drought, ecological restoration as wetlands
Permanent swamp	7w1	7f	Water table at surface year-round	Conservation as wetlands

Sourced from: Harmsworth, G.R. 1996, Land use capability classification of the Northland region, Publication 9, Landcare Research; Anonymous 1979, NZLRI Waikato region land use capability extended legend, Water and Soil Division, MWD; Jessen, M.R. 1984, Additions to NZLRI Waikato Region land use capability extended legend, Water and Soil Division, MWD; Hicks, D. and Vujcich, V. 2017, Farm-scale land use capability classification for Auckland. Auckland Council Technical Report TR2017/016.

10 Past and present land uses

Kaipara and related soils were cultivated by early Maori. In places, taro may have extended onto Kaipara peaty clay loam or peaty silt loam. On better-draining Kaipara clay loam, there appears to have been small-scale growing of kumara. Flax would also have been harvested in quantity from natural stands on wet Kaipara clay in swamps.

For many years Kaipara clay loam and clay (where drained) have been significant soils for commercial kumara growing in Northland, particularly at Ruawai on the northern Kaipara. Commercial growing seems never to have developed around the southern Kaipara. Here European colonists preferred to establish pasture on the drained swamps. Dairy farming was facilitated by good water transport from tidal creeks to a factory (established 1900s) beside the railhead at Helensville. Although dairy farming has always been the main land use on these soils, beef cattle breeding/fattening farms are interspersed.

Contract growing of fodder maize is widespread, as well as growing for feed on-farm. Maize is grown for two or three years, then rotated with pasture, or sown as a single crop in course of pasture renewal. Other grain or fodder crops are uncommon, because the soils have a reputation for poor structure and low permeability - factors which restrict their cultivation “window” to short periods in early spring or late autumn (when neither too wet nor too dry).

Fruit-bearing trees can grow on Kaipara and related soils once drained, but do not thrive. High winter water table impedes root penetration, and may depress yield. Timber trees grow sizeable in farm shelter belts and woodlots, through shallow-rooted trees are prone to topple in westerly gales that sweep across the flats.

Sourced from:
Ryburn, W.R., 1999, Tall Spars, Steamers and Gum: A History of the Kaipara from Early European Settlement, 1854-1947. Kaipara Publications
And D. Hicks personal observations

10.1 Typical vegetable, crop, and pasture and tree plantation yields

Vegetable	Yield	Units
Kumara	?	t/ha
Potato	?	t/ha

Source: Ruawai growers

Crop	Yield	Units
Maize	?	t/ha
Sorghum	?	t/ha
Forage brassica	?	t/ha

Source: local growers

Pasture	Yield	Units
Improved pasture (dairy)	14.3	t dm/ha/yr
Improved pasture (drystock)	10.8	t dm/ha/yr
Semi-improved pasture	8.6	t dm/ha/yr
Un-improved pasture	5.8	t dm/ha/yr

Source: MAF and Dexcel trials cited in Lincoln Farm Technical Manual 2008; various papers in NZ Journal of Agricultural Research

11 Information about soil management

The estuarine origin of Kaipara and related soils gives their topsoil and subsoil characteristics that, even after drainage, render them not as versatile as soils on stream floodplains (which have textures and structures more suited to cultivation). Nonetheless the Kaipara soils can be cultivated for a limited range of root vegetables and fodder crops. Sufficient time has elapsed for them to lose the residual salinity, acid sulphate weathering, and lack of structure that characterise raw estuarine soils (Takahiwai). Topsoil is usually deep, with good structure when moist though cloddy when wet and hard when dry. So, it can be cropped if cultivated during short "windows" in spring or autumn, but seed strike and crop yield may be poor at other times. Subsoil generally has low permeability above a fluctuating water table. Provided they are effectively drained, the soils sustain good pasture with consistent high dry matter yield. After drainage, the water table is low enough for shelter trees and woodlots to grow well, though wind-throw can become a problem for big old trees.

So, management issues that arise are:

- Crop growth depressed by compaction if cultivated when too wet,
- Seed strike depressed by poor tilth if cultivated when dry,
- Pasture yield depressed by pugging if grazed when too wet,
- Pasture yield depressed by limited root penetration into hard subsoil structure when dry,
- Sediment entry into, nutrient loss towards, and faecal contamination of, drains.

Given their low-lying position in the landscape and extensive drain networks, how these soils are managed impacts on water quality of estuaries as well as on farm production. Tips for cultivation, grazing management, and improving soil structure, also for controlling sediment, nutrient and faecal matter losses, are contained in:

- *Low flats with estuarine soil* *Soil Information Sheet 3, Auckland Council*
- *Code of Practice for Nutrient Management* *Fertiliser Association* *http://www.fertiliser.org.nz/site/code_of_practice/default.aspx*
- *Drainage construction and maintenance:* *TP10, Auckland Regional Council*
- *A guide to managing farm dairy effluent (Auckland)* *Dairy NZ* *http://www.dairynz.co.nz/media/880785/auckland_guide_to_managing_farm_dairy_effluent.pdf*

- *Soil structural breakdown and compaction in New Zealand soils*
  Technical paper 95/5, MAF Policy
  http://maxa.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/land-management/soil-structure/soilcomp.htm

- *Riparian zone management: strategy guideline and planting guide TP148, Auckland Regional Council*

Find out more: phone 09 301 0101, email rimu@aucklandcouncil.govt.nz or visit aucklandcouncil.govt.nz **and knowledgeauckland.org.nz**

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