

Soil Information Inventory:

Clevedon, Waipu, and related soils

October 2018

Soil Information Inventory 4





Soil Information Inventory 4: Clevedon, Waipu, and related soils

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Auckland Council

Soil Information Inventory, SII 4

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Table of contents

1	Introduction	6
2	Published maps.....	7
3	Online maps	9
4	Farm-scale maps.....	10
5	Where the soils occur.....	11
5.1	On what landform.....	12
5.2	How they differ from other soils.....	13
6	Classifications	14
7	Soil profile descriptions	16
8	Properties of typical profile	20
8.1	Chemical.....	20
8.2	Physical.....	21
8.3	Irrigation and drainage	22
8.4	Topsoil properties under different uses.....	23
8.5	Land use capability	23
9	Past and present land uses.....	25
10	Information about soil management.....	27

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be understood or used without referring to background information which is dispersed across old maps, publications, or unpublished reports.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

Soils on weathered estuarine alluvium around and south of Auckland are mostly ash-mantled (refer to Soil Information Inventory for Karaka and related soils). Where ash cover has been stripped by stream erosion, narrow strips of soil are depicted by DSIR's oldest maps (1: 253,840), also on a map of intermediate age covering part of Franklin district (1: 63,360), as two 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:

34c, Th Te Hihi sandy clay or clay loam

98d, Cl Clevedon silt or clay loam

A recent map of Manukau city (1:20,000) separates Clevedon silt or clay loam on estuarine terraces into six mapping units that contain spatially associated soil types, assigning alphanumeric labels:

ACC5 Clevedon silt or clay loam

ACC6 Clevedon silt or clay loam

ACC10 Clevedon complexed with Orere clay loam and Un-named

ACC11 Clevedon complexed with Torehape silt loam and Un-named

ACC13 Clevedon complexed with Un-named and Karaka silty or sandy loam

ACC15 Clevedon complexed with Whareora sandy clay loam or Waipuna clay loam

ACC1-4, 7-9, 12 and 14 correspond with Clevedon silt or clay loam on stream alluvium. These mapping units contain soils similar to Manurewa silt loam (and possibly should be re-named as such), so are described in the Soil Information Inventory for Manurewa, Whareora and related soils.

North of Auckland, soils on weathered estuarine alluvium occur as small dissected terraces close to tidal creeks. DSIR's published soil maps (1:100,000) do not separate them from the soils on adjacent estuarine flats which are slightly elevated above present-day tide level (see Soil Information Inventory for Kaipara and related soils). Identification as separate series is needed when mapping at larger-scale (see Farm-scale maps).

Soil Information Inventory 4: Clevedon, Waipu, and related soils

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:

34c, Th	Ahuriri family, sibling 3
98d, Cl	Awad family, sibling 11
ACC5	Invermay family, sibling 1
ACC6	Eureka family, sibling 2
ACC10	Guys family, sibling 2, Flaxmere family, sibling 91, Invermay family, sibling 1
ACC11	Otara family, sibling 7, Flaxmere family, sibling 91, Invermay family, sibling 1
ACC13	Eureka family, sibling 2, Temuka family, sibling 53, Smal family, sibling 13
ACC15	Eureka family, sibling 2, Whangaripo family, sibling 1

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 (KP) or Waipu (YU) series turns out to be a mosaic of young soil on estuary alluvium plus small areas of older soil when investigated in the field by local soil mappers. On farm-scale soil maps (1: 5,000 - 1: 10,000) near the Kaipara harbour, the older soil is labelled as:

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

The DSIR's type profile descriptions support extending the Kaipara series name to soil on young estuarine alluvium along both coasts (see Soil Information Inventory for Kaipara and related soils); and applying the Waipu series name to areas of weathered soil on old estuarine alluvium.

South of Auckland, limited field investigation of published map polygons labelled Th or Cl has been undertaken by local mappers. When identifying soil for sampling, labels are attached as follows:

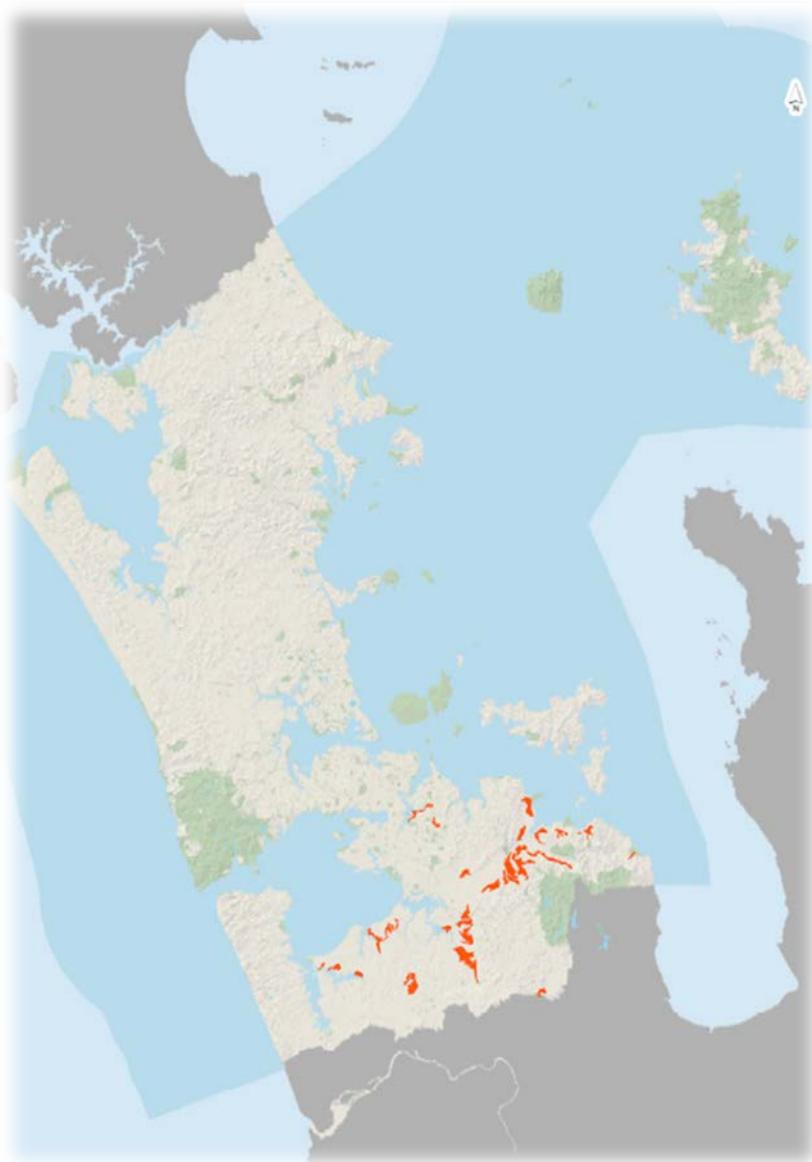
Th	Te Hihi sandy clay loam
Thm	Te Hihi sandy clay loam (mottled)
Thg	Te Hihi sandy clay (gleyed)
Cl	Clevedon silt loam
Clm	Clevedon clay loam (mottled)
Clg	Clevedon clay (gleyed)

Local series names for Clevedon 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

On elevated, flat-topped but steep-sided terraces alongside and upstream of Kaipara harbour estuaries. On stream gully sides cut through similar terraces that are ash-mantled, next to estuaries of the Manukau and Waitemata harbours. On narrow terrace remnants flanking east coast estuaries from Mangawhai to Okura; also, the Tamaki, Whitford and Wairoa estuaries. In similar positions on the east coast of Great Barrier island around estuaries at Whangapoua and Claris.



Location of Clevedon and related soils

Clevedon and related soils are mapped on 4,700 hectares (1% of Auckland region). About 2,700 hectares (57% of the area mapped) are in agricultural use (estimated from overlay of Agribase 2010 on Fundamental Soils Layer).

<http://intermaps.arc.govt/AucklandCouncilViewer/>



Clevedon, Waipu and related soils occur on flat terraces and side slopes, well above Takahiwai or Kaipara soil alongside tidal estuaries. *Photo: D Hicks*

5.1 On what landform

Clevedon, Waipu, and related soils occur on elevated, flat-topped but steep-sided terraces of old (weathered) estuarine alluvium above present-day tidemark. Part of the Tauranga Group sediments, the alluvium is its second-youngest estuarine formation ranging in age from 130,000 years old (shorelines about 5 metres above present-day) through 80,000 (estuary flats exposed at start of the last Ice Age as sea level dropped).

Climax forest dominated by kauri grew on these sites for many thousands of years during the Ice Age. As subsoil became too impermeable for tree roots, the forest was replaced by gumland scrub. There are few remnants of the original forest or shrub cover, now largely replaced by pasture.

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

Soils on weathered estuarine alluvium differ from the soils on young estuarine alluvium in several respects:

Over tens of thousands of years, subsoil has weathered to clay, silty clay or sandy clay,

On the most weathered sites, clay has washed out of the lower topsoil leaving behind a silty or sandy eluvial horizon,

Washed-down clay has almost sealed the upper subsoil creating an illuvial perch-gley layer.

In these respects, the soils closely resemble soil on weathered stream alluvium (Kara series). If more field investigation is undertaken, the Te Hihi and Clevedon series, plus weathered variants of Kaipara and Waipu series, could possibly be merged with Kara.

Sourced from:

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

Orbell, G., 1977 Soils of part Franklin County, Report 33, Soil Bureau DSIR

6 Classifications

NZ genetic (NZG): northern gley soil or podzol

NZ soil (NZSC): orthic gley, perch-gley ultic or densipan ultic

http://soils.landcareresearch.co.nz/contents/SoilNames_NZSoilClassification_SoilOrders.aspx

Soil Taxonomy (USDA): ochraqult

http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051544.pdf

World Soils (FAO): gleysol or podsol

<http://www.fao.org/3/a-i3794e.pdf>

DSIR replaced the New Zealand genetic classification dating from 1930s with the New Zealand 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.

7 Soil profile descriptions

Topsoil (Ap)



Subsoil (Bt)

Te Hihi sandy clay loam *Photo: D Hicks*

DSIR's type profile description is:

Te Hihi sandy clay loam

Horizon	Depth (cm)	Description
Ap	0-15	Dark greyish brown sandy clay loam; friable; moderate fine and medium polyhedral structure; indistinct boundary.
Bt	15-61	Brownish yellow clay loam; friable to firm; strong medium blocky structure; few thin clay coatings; indistinct boundary.
Ctr	on	Pale grey clay or sandy clay; firm; moderate medium blocky structure; few thin clay coatings.

On "easy rolling and rolling gully sides cut in 12 to 24 m terrace ... moderately well drained, dries out in summer, lies fairly wet in winter".

Soil Information Inventory 4: Clevedon, Waipu, and related soils

Topsoil (Ag)



Subsoil (Bgg)

Parent material (Crg)

Clevedon clay loam *Photo: D. Hicks*

DSIR appears not to have prepared a type profile for Clevedon clay loam on old estuary terraces. A related profile from the Franklin soil survey is:

Clevedon silt loam (flood deposit over Clevedon clay loam)

Horizon	Depth (cm)	Description
Ag	0-15	Dark grey silt loam; friable; strongly developed medium polyhedral structure; few grey mottles; diffuse boundary.
Bgg	15-45	Pale brownish grey silt loam; firm; weakly developed medium prismatic structure; many grey and yellowish red medium mottles; diffuse boundary.
Crg	on	Grey clay loam; firm; strongly developed medium and coarse prismatic structure; many yellowish red medium mottles.

On “flat stream floodplains” that are “poorly drained” with “infrequent flooding” on “weakly argillised mixed alluvium”.

Soil Information Inventory 4: Clevedon, Waipu, and related soils

There are no DSIR series names or type profiles for similar soils north of Auckland. Published maps include them with Kaipara clay or Waipu clay, but at farm scale they are differentiated on high terraces adjacent to estuarine flats. A local mapper (DLH) has prepared provisional profile descriptions:



Topsoil (A)

Lower topsoil (A/Bg)

Subsoil (Bgg)

Kaipara clay (weathered) *Photo: D Hicks*

Kaipara clay (weathered)

Horizon	Depth (cm)	Description
A	0-10	Dark grey clay loam; low packing and friable consistence when moist; polyhedral structure and firm when dry; sharp boundary.
A/Bg	10-20	Mottled yellow-grey clay; massive structure and sticky consistence when moist, blocky to prismatic structure and hard when dry; dark grey clay loam topsoil penetrating fissures throughout horizon; diffuse boundary.
Bgg	20-70+	Mottled yellow-grey clay or gleyed grey clay; massive and sticky (always moist to wet); rust coloured mottles may be present in the upper 20 cm.

Soil Information Inventory 4: Clevedon, Waipu, and related soils

Topsoil (A)



Lower Topsoil (E)

Kara sandy loam over Kaipara clay (weathered) *Photo: D Hicks*

Kara silty or sandy loam over Kaipara clay (weathered)

Horizon	Depth (cm)	Description
A	0-20	Dark grey silty or sandy clay loam; low packing and friable consistence when moist; microfine single grained and loose when dry; diffuse boundary.
E	20-40	Pale grey silt or sand; microfine single grained and loose when moist, massive and hard (but non-indurated) when dry; sharp boundary.
Bgg	40-47	Mottled yellow and grey clay; sticky when moist; blocky to prismatic structure and hard when dry; or gleyed grey clay (if not drained); massive and sticky; rust mottles may be present along root channels; diffuse boundary.
Crg	47-97+	Grey clay; massive and sticky (always moist to wet).

Sourced from:

Orbell, G.E., 1977, Soils of part Franklin County, Soil Bureau Report 33, DSIR

Hicks, D. 2011-2015 Field notes (unpublished)

8 Properties of typical profile

The properties of typical profiles are best indicated by laboratory analyses for the type profiles i.e. sites where Te Hihi, Clevedon and Kaipara (weathered) or Waipu series were defined and described. Data for any other site on either soil will vary from the type profile, though not greatly.

8.1 Chemical

<http://soils.tfrec.wsu.edu/mq/chemical.htm>

Incomplete chemical analyses for Te Hihi and Clevedon soils appear in the online version of National Soils Database (NSD). The following data are sourced from old Soil Bureau laboratory records in Orbell 1973:

Te Hihi sandy clay loam

Property	Topsoil	Subsoil	Units
Acidity	5.3-6.3	4.9-5.1	pH
Total carbon	5.7	0.9-1.1	%
Total nitrogen	0.5	0.07-0.08	%
Available phosphorus	43	4	mg %
P retention	29	30-35	%
Available sulphur		-	%
Cation exchange capacity	18.6	8.6-9.5	me%
Base saturation	66	17-21	%
Calcium	8.5	1.0-1.3	me%
Magnesium	2.2	0.3-0.3	me%
Potassium	1.0	<0.1	me%
Sodium	0.5	0.2	me%

Sourced from laboratory analysis SB08270, DSIR Soil Bureau

Soil Information Inventory 4: Clevedon, Waipu, and related soils

Clevedon silt loam (flood deposit over Clevedon clay loam)

Property	Topsoil	Subsoil	Units
Acidity	5.6	-	pH
Total carbon	3.8	-	%
Total nitrogen	0.29	-	%
Available phosphorus	0.004	-	mg %
P retention	-	-	%
Available sulphur	-	-	%
Cation exchange capacity	13.6	-	me%
Base saturation	30	-	%
Calcium	2.8	-	me%
Magnesium	1.4	-	me%
Potassium	-	-	me%
Sodium	-	-	me%

Sourced from laboratory analysis SB01234, DSIR Soil Bureau

Kaipara (weathered) or Waipu clay

There are no chemical analyses for weathered variants of Kaipara or Waipu clay in the online version of National Soils Database, nor do any appear in old Soil Bureau publications.

8.2 Physical

<http://soils.tfrec.wsu.edu/mq/chemical.htm>

The following estimates are sourced from the Fundamental Soils Layer (FSL) plus relevant S-map factsheets:

Te Hihi sandy clay loam

Property	Topsoil	Subsoil	Units
Stones	0-4	-	%
Sand	-	-	%
Silt	-	-	%
Clay	-	-	%
Dry bulk density	-	-	g/cm ³
Total porosity	-	-	%
Macroporosity	5.0-9.9	-	%

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

Soil Information Inventory 4: Clevedon, Waipu, and related soils

Clevedon silt loam (flood deposit over Clevedon clay loam)

Property	Topsoil	Subsoil	Units
Stones	0-4	-	%
Sand	-	-	%
Silt	-	-	%
Clay	-	-	%
Dry bulk density	-	-	g/cm ³
Total porosity	-	-	%
Macroporosity	5.0-9.9	-	%

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

Kaipara (weathered) or Waipu clay

There are no physical analyses for weathered variants of Kaipara or Waipu clay in the online version of National Soils Database, nor do any appear in old Soil Bureau publications.

8.3 Irrigation and drainage

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

The following estimates are sourced from the Fundamental Soils Layer (FSL) plus relevant S-map factsheets:

Te Hihi sandy clay loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	% w/w
Plant-available water	50-99	-	mm
Depth to slowly permeable layer	-	0.45-1.19	m
Perm. at slowly permeable layer	-	<4	mm/hr

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

Soil Information Inventory 4: Clevedon, Waipu, and related soils

Clevedon silt loam (flood deposit over Clevedon clay loam)

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	% w/w
Plant-available water	0-24	-	mm
Depth to slowly permeable layer	-	0.66-1.49	m
Perm. at slowly permeable layer	-	<4	mm/hr

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

Kaipara (weathered) or Waipu clay

There are no soil moisture analyses for weathered variants of Kaipara or Waipu clay in the online version of National Soils Database, nor do any appear in old Soil Bureau publications.

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. Te Hihi, Clevedon, Kaipara (weathered) or Waipu estuarine soils have not yet been sampled; nor are there yet any soil quality monitoring sites on weathered fluvial soils with similar properties (Kara series).

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

<http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/technicalpublications/Documents/tr2013019landandsoilmonitoringprogramme2013.pdf>

8.5 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

Soil Information Inventory 4: Clevedon, Waipu, and related soils

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
Imperfectly draining clay loam	Incl in 3w2,3w2b, 3w3b	3p+w	Subsoil structure moderately limits cultivation	Rotational fodder crops, intensive dairy or drystock grazing
Seasonally wet clay	Incl in 4w2b,4w3b	4p+w	Subsoil structure and winter wetness severely limit cultivation	Occasional fodder crops, intensive dairy or drystock grazing
Silty or sandy eluvial layer over clay	Incl in 4w2b,4w3b	3p, 4p	Subsoil structure severely limits cultivation	Occasional fodder crops, intensive dairy or drystock grazing
Terrace edges, stable	-	5b+g	Slight slip and gully risk	Dairy or drystock, grazing woodlots
Terrace edges, unstable	-	6b+g	Moderate slip and gully risk	Drystock, grazing, woodlots

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.

9 Past and present land uses

Clevedon, Waipu and related soils do not appear to have been widely cultivated by Maori, who doubtless preferred adjacent soils with better properties for crop growth: sandy peats and peaty sands for taro; clay loams (where well-drained) or volcanic loams for kumara.

European colonists quickly recognised that the soils' structure did not favour root development under fruit trees and vines, nor cultivation for crops. They were able to grow pasture, though found it difficult to graze heavy stock when soils turned wet at onset of winter. A mix of drystock (sheep and beef cattle fattening) together with dairy farms established; dairy where the soils could be grazed in conjunction with adjacent better-draining soils (ash-mantled or on higher footslopes) through winter and spring. Livestock grazing has remained the main productive use up till the present day.

Timber trees are planted as small farm woodlots or for shelter. Growth rates vary, doubtless in response to subsoil conditions. Commercial forest plantations have never established, probably because dairy or drystock farming is a higher-value use of the land.

Since the 1970s, some of the farms have been cut up into lifestyle blocks, particularly where they are on outskirts of the city, from Clarks Beach through Karaka to Whitford and Clevedon. As yet there has been little urban subdivision of the soils (small old estuary terraces within city limits excepted), though this could change as satellite towns are established. If so, stormwater drainage, and foundations that can withstand seasonal shrinking and swelling of subsoil, will be needed.

Sourced from:

Morris, N. (1965), Early Days in Franklin. The Franklin County Council, The Pukekohe Borough Council, The Tuakau Borough Council, The Waiuku Borough Council.

9.1 Typical crop, pasture and tree plantation yields

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

Source: local growers

Pasture	Yield	Units
Improved pasture (dairy)	12.1	t dm/ha/yr
Improved pasture (drystock)	11.8	t dm/ha/yr
Semi-improved pasture	9.4	t dm/ha/yr
Un-improved pasture	5.9	t dm/ha/yr

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

Timber	Yield	Units
Radiata pine (clearwood regime)	?	t/ha
Radiata pine (unpruned pulpwood)	?	t/ha
Macrocarpa cypress (woodlot)	?	t/ha
Eucalypt (woodlot)	?	t/ha
Acacia (woodlot)	?	t/ha

Source: FRI trials cited on SCION website; various papers in NZ Journal of Forestry and NZ Farm Forestry

10 Information about soil management

Clevedon, Waipu and related soils' versatility is limited by their estuarine origin (heavy clay subsoil), together with age (protracted weathering, leaching and clay translocation down the profile). They can be cultivated for a limited range of fodder crops. If drained and fertilised, they become reasonable soils for pasture growth in autumn and spring, though summer yield can be limited by dry topsoil, while winter yield is limited by saturation and pugging.

Soil 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:

- *High terraces with old alluvial soil* *Soil Information Sheet 4, Auckland Council*
- *Code of Practice for Nutrient Management* *Fertiliser Association*
[\(Code of Practice for Nutrient Management\)](#)
- *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*
- *Streamside planting guide* *Auckland Council*

Soil Information Inventory 4: Clevedon, Waipu, and related soils

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