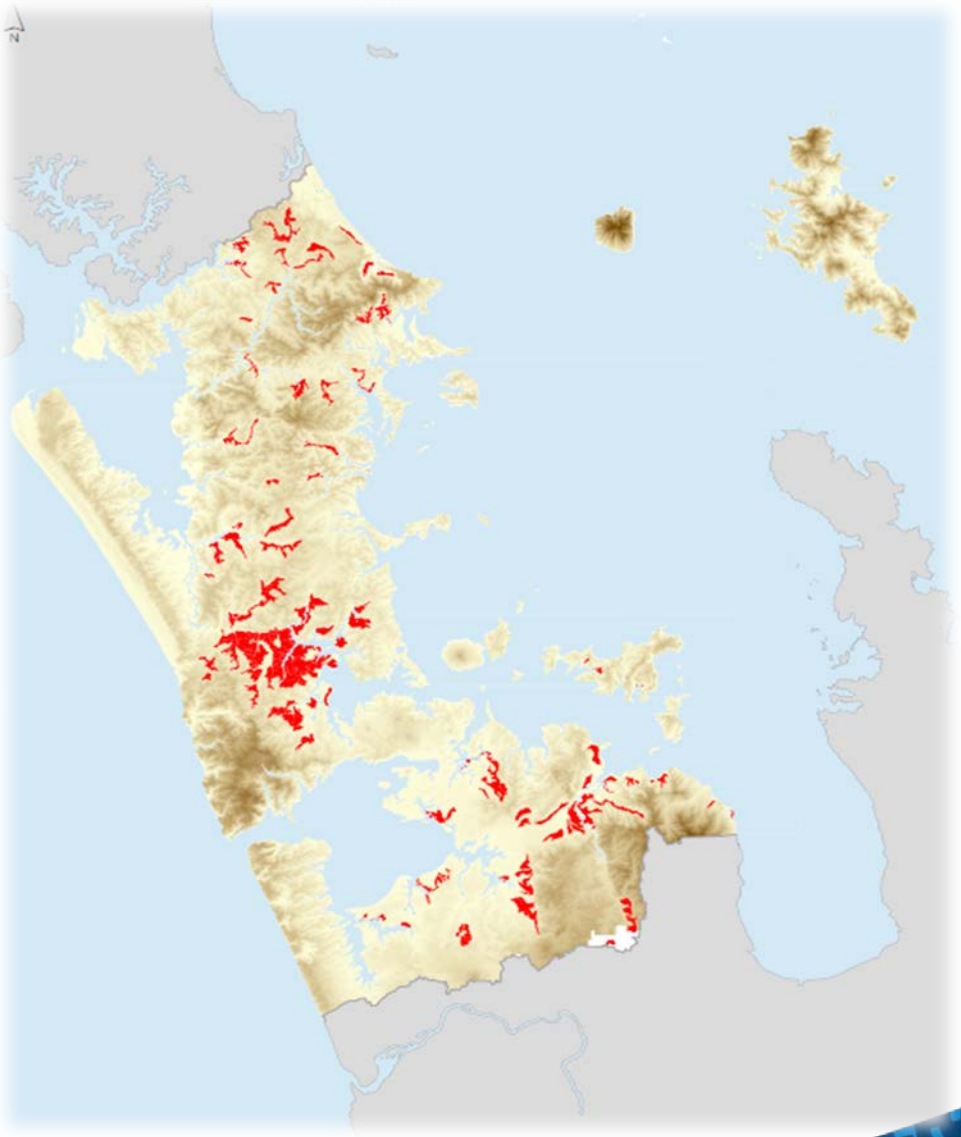
Soil Information Inventory:

Manurewa, Whareora and related soils

October 2018 Soil Information Inventory 9



RIMU Research and Evaluation Unit

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Soil Information Inventory 9:

Manurewa, Whareora and related soils

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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be understood or used without referring to background information which is dispersed across old maps, publications, or unpublished reports.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 oldest published maps of South Auckland (1:253,840), soils on old stream alluvium are depicted as two series i.e. soils with distinct profiles and parent materials: Manurewa and Clevedon. The maps differentiate another three locally: Whareora, Waipuna and Topehaehae. All the soils are also recorded as part of two complexes i.e. associated with (but undifferentiated from) other unrelated soils. Labels that appear on the maps are:

34b, 34bH	Manurewa silt loam
98d	Clevedon silt loam
34d	Whareora loam and clay loam (rare)
40a	Waipuna clay and clay loam (rare)
98	Topehaehae silt loam and clay loam (rare)
73a	Koheroa complex
73b	Torehape complex

A map of intermediate age covering part of Franklin district (1:63,360) differentiates just one of the above series with an alphabetic label:

Cl	Clevedon silt loam

A recent map of Manukau city (1:20,000) separates the soils into mapping units that contain spatially associated types i.e. soils with differences in texture or other characteristics, assigning alphanumeric labels:

ACB1-11	Manurewa silt loam and clay loam
ACC1-4, 7-9, 12, 14	Clevedon silt loam and clay loam, or Clevedon complexed with ash soils
BCB1	Whareora clay loam and Waipuna clay
BCB2	Kara clay
BCB3,4,5	Whareora and Waipuna complexed with younger alluvial soils
BCC1-3	Clevedon clay loam complexed with other soils
BD1-2	Kara clay complexed with other soils
CD1	Kara clay

On DSIR's published soil maps of North Auckland (1:100,000), similar old alluvial soils are mapped either as three series (Whareora, Waipuna, Kara), or within three complexes:

WOa	Whareora sand
WO	Whareora clay loam
WU	Waipuna clay
KRe	Kara clay
C1	Waitemata complex
C1A	Hobsonville complex
C4A	Dairy Flat complex

The Kara series also appears on maps north of Auckland as other types: Kara sandy loam (KRa), Kara silt loam (KR), and Kara peaty silt loam (KRy). These three are so different that they will be described by a separate soil information inventory (yet to be prepared).

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 map

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

34b, 34bH, 98d	No family or sibling name assigned
34d, 40a, 98	No family or sibling name assigned
73a, 73b	No family or sibling name assigned
Cl	Awad family, sibling 11
ACB1	Porchester family, sibling 8
ACB2	Temuka family, sibling 12
ACB3, 9	Flaxmere family, sibling 74
ACB4, 10, 11	Clinton family, sibling 2
ACB5	Temuka family, sibling 10
ACB6,7,8	Porchester family, sibling 8 complexed with other soils
ACC1,9, BCC1	Airfield family, sibling 3
ACC2	Oronoko family, sibling 18
ACC3, 4	Kimp family, sibling 1
ACC7	Flaxmere family, sibling 91
ACC8	Temuka family, sibling 70
ACC12, BCC3	Temuka family, sibling 53
ACC14	Airfield family, sibling 3, complexed with other soils
BCB1	Whangaripo family, sibling 1
BCB2	Porchester family, sibling 1
BCB3,5	Flaxmere family, sibling 88
BCB4	Clinton family, sibling 2
BD1	Whangaripo family, sibling 3
BD2	Whangaripo family, sibling 3 and Clinton family, sibling 2
CD1	Whangaripo family, sibling 3
WO	Airfield family, sibling 5
WU	No family or sibling name assigned
KRe	No family or sibling name assigned

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

When investigated in the field by local soil mappers south of Auckland, any published map polygon labelled 34b, Cl, ACB etc. is differentiated into a limited number of soil types i.e. series divided according to texture or other characteristics. On farm-scale soil maps (1:5,000 - 1: 10,000) the Manurewa and Clevedon series are labelled as:

Mai	Manurewa silt loam
Ma	Manurewa silty clay loam
Cl	Clevedon clay loam (mottled)
Clg	Clevedon clay (gleyed)

Where published maps include similar soils within polygons labelled as Karaka, Koheroa or Torehape complex, they are differentiated and labelled as one or other of the above when re-mapping at farm scale. Areas in Manukau where recent medium-scale maps give the soils alphanumeric labels are now mostly urban. On the few farm-scale maps prepared here, or when identifying and sampling soils within urban limits, old alluvial soils are assigned the same names and labels as above.

North of Auckland, any published map polygon labelled WOa, WO, WU or KRe turns out to have all four types spatially associated within it. On farm-scale maps they are differentiated and labelled as:

Woa	Whareora sandy loam
Wo	Whareora sandy clay loam
Wu	Waipuna clay loam
Kre	Kara clay (gleyed)

In areas labelled as complexes (C1, C1a, and C4) on the maps, few farm-scale maps have been prepared because most such areas are now either urbanised or in lifestyle blocks close to city limits. When old alluvial soils are encountered within polygons labelled as complexes, and when soil sampling close to the city, they are labelled as above.

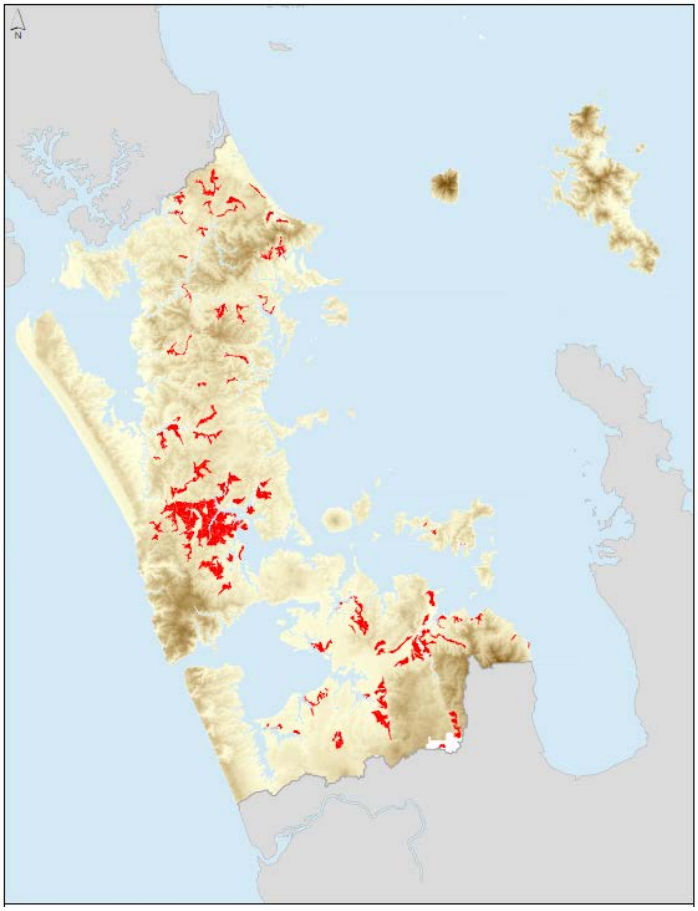
Local series names for Manurewa, Whareora and related soils have been retained on Auckland Council's farm-scale maps for continuity with published nomenclature. A local mapper (DLH) considers they could be regarded as the same series, north and south of Auckland.

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

As narrow strips within the former Franklin district, near (but above) streams draining towards the Manukau Harbour (west) or Wairoa, Whitford and Tamaki estuaries (east). As broader strips and patches within the former Rodney district, also near (but above) streams draining towards the Waitemata and Kaipara harbours, or towards the Mahurangi and other east coast estuaries. Locally alongside streams on the larger Hauraki Gulf islands, Waiheke and Great Barrier.

Because they occur as narrow strips or small patches, the Whareora, Manurewa and related soils are spatially associated with other soils that are quite different (see heading **On what landform** for an explanation). For this reason, they are recorded as part of soil complexes instead of mapped separately, in many places on the published maps.



Location of Whareroa, Manurewa, and related soils

Whareora, Manurewa and related soils are mapped on 27,000 hectares (6% of Auckland region). About 8600 hectares (32% 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

Manurewa, Whareora and related soils occur on high flood-free terraces above present-day stream level. The same soils are present on medium-level terraces though where close to streams, they are buried beneath a thin layer of recent soil, forming in young alluvium deposited by infrequent large floods (see Soil Information Inventory for Whangamaire and Whakapara soils). The soils have formed from old stream alluvium (part of the Tauranga Group sediments deposited between 1.8 million and 0.1 million years ago). Their clay content has increased through protracted weathering, though they contain residual silt and sand.

Terrace surfaces vary from flat (0-3 degrees) through undulating (4 - 7 degrees) to rolling (8 - 15 degrees). Flat parts of the high terraces have different soil formed in a mantle of volcanic ash (see Soil Information Inventory for Karaka and Otao soils). Manurewa, Whareora and related soils typically occur on the sloping parts of high terraces where ash has been stripped by sheetwash (overland runoff), or on medium-level terraces that are ash-free, or on distinct edges (scarps) cut by streams and gullies. Here moderate (21-30 degree) to steep (31-49 degree) slopes drop to floodways (stream flats) that have deep layers of recent soil on young alluvium.
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

Whareora sandy clay loam on slow-draining terrace (right) is interspersed with Waipuna clay loam on imperfectly draining hollows (scattered rushes) and young Whakapara soil (raised flood berm) *Photo: D Hicks*

5.2 How they differ from other soils

Key features of the old alluvial soils are well-developed topsoil (often deep) with sandy clay loam or clay loam texture, over clay subsoil that has poor structure (blocky in summer, massive in winter). They are perceived by farmers as good soils for pasture, capable of occasional cultivation for grain or fodder crops, though winter wetness (caused by subsoil structure) increasingly limits grazing, moving from the slow-draining Whareora and Manurewa, through the imperfectly draining Waipuna and Manurewa, to the impeded Kara and Clevedon.

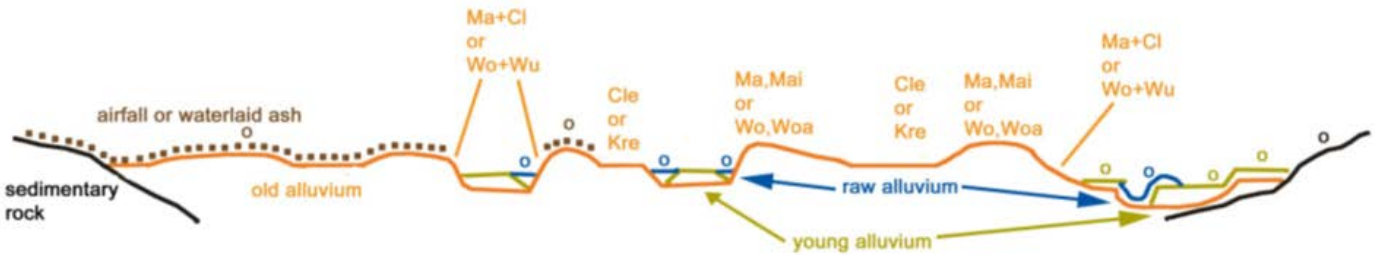
Sourced from: Wilson, A.D. and Cox, J.E., Soils of Rodney County, Unpublished report, Soil Bureau DSIR
Orbell, G., 1977, Soils of part Franklin County, Report 33, Soil Bureau DSIR
Purdie, B. et al 1982, Manukau Soil Survey, District Office Report Hv5, Soil Bureau, DSIR

6 Classifications

NZ genetic (NZG):	Northern yellow-brown earth or gley soil
NZ soil (NZSC):	Mottled orthic brown, typic or mottled yellow ultic; acid orthic gley *http://soils.landcareresearch.co.nz/contents/SoilNames_NZSoilClassification_SoilOrders.aspx*
Soil Taxonomy (USDA):	Aeric or typic ochraquult *http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051544.pdf*
World Soils (FAO):	Fluvisol or 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 Manurewa, Whareora, and related soils' position in the landscape



South Auckland

On old alluvium:

Mai	Manurewa silt loam
Ma	Manurewa silt clay loam
Cl	Clevedon clay loam
Cle	Clevedon clay

North Auckland

On old alluvium:

Woa	Whareora sandy loam
Wo	Whareora sandy clay loam
Wu	Waipuna clay loam
Kre	Kara clay

On young alluvium, raw alluvium, waterlaid or airfall ash:

o, o, o Other soils

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

7 Soil profile descriptions

http://en.wikipedia.org/wiki/Soil_horizon

Manurewa silt loam *Photo: F. Curran-Cournane*

Manurewa silt loam is briefly described in Soil Bureau Bulletin 5 (General Survey of the Soils of North Island) as:

Manurewa silt loam

Horizon	Depth (cm)	Description
A	0-6	Grey silt loam
Bw(f)	6-10	Yellow mottled silt loam
Bw	on	Yellow-brown silty clay

A local soil mapper (DLH) has observed greater textural variation in soils mapped as Manurewa at farm scale. Topsoil texture varies from silty to silty clay loam; subsoil from silty clay to clay. There does not appear to be a type profile for the heavier silty clay loam type within Manurewa series.

Whareora sandy clay loam *Photo: D Hicks*

No DSIR type profile has been located for the equivalent soil north of Auckland, Whareora sandy loam or sandy clay loam. There is a brief description in Soil Bureau Bulletin 5 (General Survey of the Soils of North Island).

Whareora loam and clay loam

Horizon	Depth (cm)	Description
A	0-9	Dark brown loam
Bw(g)	-	Yellow brown clay loam flecked with grey
C	on	-

A local soil mapper's (DLH's) provisional description is:

Whareora sandy clay loam

Horizon	Depth (cm)	Description
Ap	0-20	Dark grey sandy clay loam; friable to firm; crumbly structure when moist, nutty when dry, grading to
A/B	20-32	Yellow-brown loamy clay; friable to firm; crumbly structure when moist; polyhedral when dry; diffuse boundary.
Bw(f)	32-57	Yellow-brown loamy clay with faint mottles; firm to hard; massive structure when moist, polyhedral to blocky when dry; diffuse boundary.
C(g)	57+	Mottled grey and yellow loamy clay; firm to hard; massive structure when moist, blocky if dry.

Clevedon clay loam *Photo: D Hicks*

DSIR's published type profile for young alluvial soil mapped as part of Clevedon series is labelled as silt loam:

Clevedon silt loam

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

Clevedon series is described by DSIR's mappers as being on "flat stream floodplains" that are "poorly drained" with "infrequent flooding" on "weakly argillised mixed alluvium". However, the type profile is atypical. Most of the published map polygons labelled 98d, Cl or ACC have clay loam topsoil with clay subsoil beneath.

Amongst the DSIR's unpublished type profile descriptions, there are three for the equivalent soil north of Auckland, Waipuna clay loam. The one that corresponds best with what's observable in map polygons labelled WU is:

Waipuna clay loam *Photo: D Hicks*

Waipuna clay loam

Horizon	Depth (cm)	Description
A	0-4	Greyish brown (10YR 5/2) clay; very firm; moderately developed, coarse and medium polyhedral structure; sharp irregular boundary.
A/B(g)	4-9	Light grey (10YR 7/1) clay; abundant very pale brown to yellowish brown (10YR7/3 - 5/4 - 5/8) mottes and common dark reddish-brown iron coatings along some of the root channels; very firm packing; weakly to moderately developed coarse polyhedral structure; dark grey staining on the faces of the coarse structure; contains many fine dark grey subrounded casts; abundant scrub roots; diffuse boundary.
Bw(g)	9-22	Light brownish grey (10YR 6/2) clay; abundant, distinct mottles of pale brown to brownish yellow (10YR 6/3 - 6/6) and common dark reddish-brown iron flecks mostly along some of the root channels; very firm packing; moderately developed coarse polyhedral structure; grey staining on the faces of many of the aggregates; common subrounded casts; many scrub roots; diffuse boundary.
Bgg	22-32	Very pale brown (10YR 7/3) clay; with abundant, distinct mottles of light brown grey - pale brown - brownish yellow (10YR 6/2 - 6/3 - 6/6) with a stronger greying on the faces of many of the aggregates; common yellowish red (5YR 5/6) iron flecks, mostly as thin coatings along some of the root channels; firm; strongly developed coarse and medium polyhedral structure, breaking to fine polyhedral structure; containing many of the fine roots; diffuse boundary.

Horizon	Depth (cm)	Description
R	on	White (10YR8/1) clay; stronger greying on the faces of the aggregates; common prominent, fine, yellowish red and dark reddish-brown coatings of iron on the faces of some of the aggregates and along old root channels; medium packing; moderately developed medium and fine polyhedral structure; many fine roots.

Sourced from:
Orbell, G.E., 1977, Soils of part Franklin County, Report 33, DSIR Soil Bureau
Sutherland C.F., Cox, J.E. various dates, Type profile descriptions for North Auckland Soil Survey, Unpublished documents, DSIR Soil Bureau

8 Properties of typical profile

These are best indicated by analysis results for the type profiles i.e. sites where Manurewa, Whareora and related soils were defined and described. Data for other sites will vary somewhat, particularly where different types within the series are found.

8.1 Chemical

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

Manurewa silt loam

Property	Topsoil	Subsoil	Units
Acidity	5.6-6.0	5.2-6.5	pH
Total carbon	2.6-5.5	0.7-1.5	%
Total nitrogen	0.25-0.55	0.07-0.13	%
Available phosphorus	14-90	2-3	mg %
P retention	26-30	37-41	%
Available sulphur	-	-	mg %
Cation exchange capacity	15.4-22.7	10.5-12.3	me %
Base saturation	77-90	19-70	%
Calcium	10.5-17.4	1.4-6.7	me %
Magnesium	1.2-2.5	0.6-1.1	me %
Potassium	0.1-0.3	<0.1	me %
Sodium	0.1-0.3	0.1-0.2	me %

Sourced from laboratory analysis SB08433, DSIR Soil Bureau

Whareora sandy clay loam

Property	Topsoil	Subsoil	Units
Acidity	5.6	5.2	pH
Total carbon	4.9	-	%
Total nitrogen	0.4	-	%
Available phosphorus	0.009	0.003	%
P retention	-	-	%
Available sulphur	-	-	%
Cation exchange capacity	25.4	16.4	me %
Base saturation	34	17	%
Calcium	5.3	1.5	me %
Magnesium	3.0	1.2	me %
Potassium	-	-	me %
Sodium	-	-	me %

Sourced from laboratory analysis SB01136, DSIR Soil Bureau

Clevedon clay loam

Property	Topsoil	Subsoil	Units
Acidity	5.6	5.2	pH
Total carbon	3.8	-	%
Total nitrogen	0.29	-	%
Available phosphorus	0.004	0.003	%
P retention	-	-	%
Available sulphur	-	-	%
Cation exchange capacity	13.6	16.4	me %
Base saturation	30	17	%
Calcium	2.8	1.5	me %
Magnesium	1.4	1.2	me %
Potassium	-	-	me %
Sodium	-	-	me %

Sourced from laboratory analysis SB01234, DSIR Soil Bureau

Waipuna clay loam

There are no chemical analyses for Waipuna clay loam in the online version of NSD; nor are there any in Soil Bureau Bulletin 5.

8.2 Physical

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/nj/home/?cid=nrcs141p2_018993

No physical analyses for any of the soils appear in the online version of NSD. Soil physical data are not tabulated in Soil Bureau Bulletin 5. The following estimates are sourced from the Fundamental Soils Layer (FSL) plus relevant S-map factsheets.

Manurewa silt loam

Property	Topsoil	Subsoil	Units
Stones	0-4	-	%
Sand	-	-	%
Silt	-	-	%
Clay	-	-	%
Dry bulk density	-	-	g/cm³
Total porosity	-	-	%
Macroporosity	5.0-9.9	-	%

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

Clevedon clay loam

Property	Topsoil	Subsoil	Units
Stones	0-4		
Sand	-	-	%
Silt	-	-	%
Clay	-	-	%
Dry bulk density	-	-	g/cm³
Total porosity	-	-	%
Macroporosity	5.0-9.9	-	%

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

Whareora sandy clay loam

Property	Topsoil	Subsoil	Units
Stones	0	0	%
Sand	1-5	1-5	%
Silt	79-61	59-45	%
Clay	20-34	40-50	%
Dry bulk density	1.09	1.26	g/cm³
Total porosity	-	-	%
Macroporosity	5.0-14.9	-	%

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

Waipuna clay loam

Property	Topsoil	Subsoil	Units
Stones	0	0	%
Sand	1-5	1-5	%
Silt	59-45	59-45	%
Clay	40-50	40-50	%
Dry bulk density	0.87	1.01	g/cm³
Total porosity	-	-	%
Macroporosity	?	-	%

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 analysis appears in the online version of National Soils Database (NSD). The following estimates are sourced from FSL plus relevant S-map factsheets.

Manurewa silt loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	% v/v
Plant-available water	75-250	-	mm
Depth to slowly permeable layer	-	0.90-1.19	m
Perm. at slowly permeable layer	-	<4	mm/hr

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

Clevedon clay loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	% v/v
Plant-available water	0-24	-	mm
Depth to slowly permeable layer	-	0.60-1.49	m
Perm. at slowly permeable layer	-	<4	mm/hr

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

Whareora sandy clay loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	%v/v
Plant-available water	49	30	mm
Depth to slowly permeable layer	-	>1	m
Perm. at slowly permeable layer	-	4-72	mm/hr

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

Waipuna clay loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	%v/v
Plant-available water	61	58	mm
Depth to slowly permeable layer	-	0.1-0.2	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. Seven sites are located on Whareora and related soils north of Auckland.

Land use:		**Natural cover**	**Pasture**				**Orchard**	
Types:		**Bush**	**Life style**	**Organic**	**Drystock**	**Dairy**	**Conv.**	**Organic**
Sample Number:		**00/21**	**00/14**	**00/15**	**98/22**	**98/25**	**98/08**	**00/20**
Acidity	pH	5.7	6.0	6.4	6.1	5.3	6.4	5.9
Total carbon	%	5.5	5.8	5.4	5.1	3.8	6.1	5.8
Total nitrogen	%	0.3	0.5	0.4	0.4	0.3	0.4	0.5
Available nitrogen	ug/ cm^3	130	222	207	37	40	67	239
Available phosphorus	ug/cm^3	38	7	14	37	112	100	46
Cation exchange capacity	cmol/cm^3	18.3	19.6	21.7	17.7	14.3	21.4	20.9
Base saturation	%	18.3	19.6	21.7	17.7	14.3	21.4	20.9
Calcium	cmol/ cm^3	9.9	17.5	17.0	12.0	4.7	14.2	16.2
Magnesium	cmol/ cm^3	2.8	1.4	1.2	1.3	1.2	2.5	1.8
Potassium	cmol/ cm^3	0.7	0.3	0.4	0.7	0.8	0.9	0.7
Sodium	cmol/ cm^3	0.4	0.2	0.2	0.1	0.1	0.1	0.3
Bulk density	t/ m^3	1.05	1.00	0.98	0.94	1.00	1.03	1.05
Particle density	t/ m^3	2.49	2.46	2.43	2.48	2.49	2.41	2.49
Aggregate stability	mm mwd	2.51	2.56	2.59	1.40	1.25	2.66	2.55
Total porosity	%	58.1	59.4	59.7	62.2	59.7	57.2	57.8
Macroporosity	%	10.3	8.9	7.5	21.5	21.9	8.3	8.6
Total available water	%	17.8	24.0	27.3	20.8	19.8	28.1	20.1
Readily available water	%	6.8	8.4	9.4	8.4	5.9	9.6	6.8

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

Soil Quality for Horticultural Sites in the Auckland Region 2013, 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
Sandy or silty loam on terraces	2s,2e5	2p	Free to slow draining	Fruit trees and vines, regular grain and fodder crops, intensive grazing
Silty clay or clay loam on terraces	3s3, 3s5	3p	Slow to imperfectly draining	Fruit trees and vines, rotational grain and fodder crops, intensive grazing
Clay on terraces	4w4b,3w4	3p+w, 4p+w	Impeded, seasonally wet	Occasional fodder crops, intensive grazing
Rolling terrace edges	3e2, 3e7, 4e, 4e7	3p+t, 4p+t	Risk of topsoil loss if cultivated	Occasional grain and fodder crops, intensive grazing
Stable scarp or gully	-	5b + g	Slight bank collapse/gully risk	Summer-autumn grazing, riparian vegetation to stabilize banks

Landform	NZLRI	Farm	Main limitation	Sustainable uses
Unsuitable scarp or gully	-	6b	Moderate bank collapse/gully risk	Drought grazing, riparian vegetation to stabilize banks
Unstable scarp or gully	-	7b	Severe bank collapse/gully risk	Riparian vegetation to stabilize banks

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

Manurewa, Whareora, and related old alluvial soils do not appear to have been favoured by the Maori inhabitants of Tamaki-makau-rau, who clearly preferred volcanic soils for their cultivations. Nevertheless, old alluvial soils were amongst the first cleared for farming around outskirts of Auckland during the early days of settlement 1840s onwards, because of their easy contour and flood-free situation.

While each colonist's farm would have had a vegetable garden and orchard, commercial vegetable growing, and fruit production never developed on the soils except between Henderson and Kumeu, where they occur as a mosaic with other soils favoured by fruit-growers. In this district Dalmatian immigrants focused on pockets of volcanic Otao loam, when buying land for small market gardens, orchards and vineyards, though it was not uncommon for their plantings to extend onto the better-textured alluvial soils such as Whareora, and in places onto Waipuna. Many were swallowed up by suburban housing after the 1940s, but some persist beyond the city outskirts. Since the 1970s several sub-tropical fruits such as kiwifruit, persimmon and feijoa have been planted on Whareora or Waipuna soil farther north in Rodney. While the orchards are not numerous they have persisted, so appear commercially viable.

Elsewhere the old alluvial soils stayed in permanent pasture, except for pockets that had better structure for cultivation and drainage (Manurewa silt loam, Whareora sandy loam. Here grain and fodder crops were grown in rotation with pasture on small dairy and drystock farms up till the 1920s-1930s, mainly to feed livestock and draught animals on-farm. Since the 1940s it has become unusual to see a crop on Manurewa or Whareora soil except when pasture is renewed.

On these, as well as on old alluvial soils with poorer structure/drainage - Waipuna, Clevedon and Kara soils - small dairy farms would have been the predominant land use as much for Auckland's town milk supply as for export, up till the 1940s. Drystock farms would have been a secondary land use. The number of commercial livestock farms has dropped in recent decades, partly through amalgamation into larger farms; even more because of demand for lifestyle block subdivisions within commuting distance of Auckland. Such subdivision has been a common fate of farms when elderly owners retire. The lifestyle blocks are either lightly grazed by drystock or planted with hobby orchards and similar.

Commercial woodlots and tree plantations are not a feature of the landscape on old alluvial soils, because much better returns can be obtained from dairying or drystock fattening. However, they are a treed landscape in the sense that shelter and amenity plantings are a feature of the farms and lifestyle blocks.

As Auckland expanded beyond the Tamaki isthmus after 1945, new suburbs sprang up on former farmland. The Whareora and related soils, being easy-contour and flood-free, were easy to subdivide. Perhaps the only soil issue that relates to urban use is the perch-gley layer in Clevedon or Kara clay. Unless good open or subsoil drainage is installed, any houses on Clevedon or Kara clay are likely to have a perched water table around their foundations through winter and spring; also standing water on their lawns in wet weather.
Sources: D Hicks pers. obs.

10.1 Typical fruit, crop, and pasture yields

Fruit	**Yield**	**Units**
Apples	?	t/ha
Kiwifruit	?	t/ha
Citrus	?	t/ha
Grapes	?	t/ha
*Source: grower advice?*Crop	Yield	Units
Maize	Up to 12	t/ha
Forage brassica	Up to 4	t/ha

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

Pasture	**Yield**	**Units**
Improved pasture (dairy)	10.6-13.0	t dm/ha/yr
Improved pasture (drystock)	7.0-10.6	t dm/ha/yr
Semi-improved pasture	6.0-8.2	t dm/ha/yr
Un-improved pasture	5.0-6.0	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

Manurewa, Whareora and related soils are not as versatile as better-structured soils derived from volcanic ash (such as Karaka or Otao series). Nonetheless their extent, easy access and contour enable small-scale vegetable and fruit growing on the types that have coarser topsoil texture (silty or sandy clay loam) and better structure (crumbly to granular); also enabling farmers to grow grain or fodder crops rotationally with pasture. The same features make these types productive parts of dairy and drystock fattening farms.

Key management issues that may arise, relate more to the types that have finer topsoil texture (clay loam or clay) and poor structure (blocky when dry, massive when wet). Here the issues are:

- Adequate fertilizer to replace crop and grass uptake
- Maintaining soil structure under cultivation
- Pasture loss through pugging on the silty clay and clay loams
- Draining the wet soils
- Disposing dairy effluent onto land safely
- Topsoil moving downslope on rolling terrace edges
- Nutrient loss and faecal contaminants in surface runoff

So how the soils are managed impacts on water quality and sediment entry, as well as on farm production. Tips for managing soil structure and nutrients, for controlling erosion, and for applying irrigation water or effluent, are contained in:

- *High terraces with old alluvial soil* *Soil Information Sheet 4, Auckland Council*
- *Code of Practice for Nutrient Management* *Fertiliser Association* *http://www.fertiliser.org.nz/site/code_of_practice/default.aspx*
- *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*
- *Drainage construction and maintenance:* *TP10, Auckland Regional Council*
- *Poplars* *Soil Conservation Leaflet, Auckland Regional Council*
- *Willows* *Soil Conservation Leaflet, Auckland Regional Council*
- *Streamside planting guide* *Auckland Council*
- *Riparian zone management: strategy guideline and planting guide* *TP148, Auckland Regional Council*
- *Willows* *Soil Conservation Leaflet, 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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