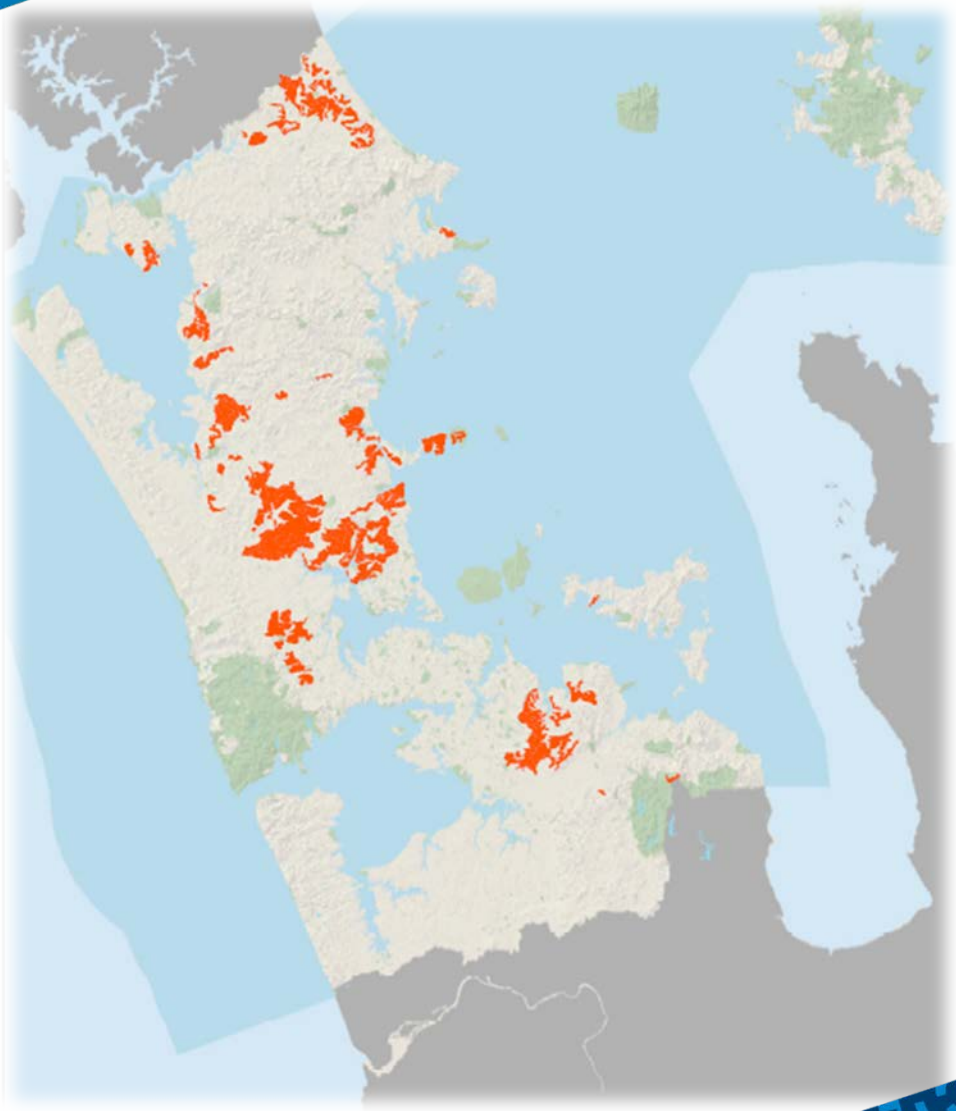
Soil Information Inventory:

Mahurangi and related soils

October 2018 Soil Information Inventory 8



RIMU Research and Evaluation Unit

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Soil Information Inventory 8:

Mahurangi 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be understood or used without referring to background information which is dispersed across old maps, publications, or unpublished reports.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 sandstone deeply weathered to clay are depicted as three separate series i.e. soils with distinct profiles and parent materials.

MV, MVH	Mahurangi fine sandy loam
HKf, HKfH	Hukerenui fine sandy loam
WKf	Wharekohe fine sandy loam

The Mahurangi label appears on map polygons singly, or combined with less weathered soils from sandstone e.g.

MV+ WR	Whangaripo clay loam
MV + WA	Warkworth clay loam
MV + DV	Dome Valley clay (rare)

In Northland two related soils (Otaika fine gravelly loam and Oturu fine sandy loam) appear on maps, singly or in combination with other soils weathered from sandstone (not listed here because they are not mapped in the Auckland region).

The Hukerenui and Wharekohe labels, widespread in Northland, appear on just a few map polygons in North Auckland; either singly or combined with Mahurangi series or with each other e.g.

MV + HKf
MV + WKf (rare)
HKf + WKf

DSIR's oldest published maps of South Auckland (1:253,840) do not differentiate similar soils on sandstone, nor does a map of intermediate age covering part of Franklin district (1:63,360). A recent map of Manukau city (1:20,000) indicates their presence within map units that contain spatially associated soil types i.e. soils with different textures or other characteristics. They are assigned alphanumeric labels:

CE1	Brookby (Warkworth-Hukerenui-Mahurangi) complex
CE3	Brookby (Hukerenui) silty or sandy loam
DE3	Brookby (Hukerenui-Mahurangi) complex

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 Manukau City, NZ Soil Bureau map

3 Online maps

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

MV	Mahurangi family, siblings 2a and 2b, N372 family, sibling 6a, Perth family, sibling 3a
HKf	No family name or sibling number
WKf	No family name or sibling number
CE1	Baton family sibling 14, complex with Bushc family sibling 20 and Eureka family sibling 19
CE3	Baton family sibling 14, complex with Whangaripo family sibling 2
DE3	Baton family sibling 14, complex with Eureka family sibling 19 and Bushc family sibling 20

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 MV, HKf or WKf turns out to be a mosaic of the three when investigated in the field by local soil mappers. All three can be differentiated into distinct types i.e. soils with different textures or other characteristics, when mapping at farm scale. These correspond with two situations:

- Parts of the polygon where the soil has weathered from parent rock or

- Parts where it has weathered from re-deposited material, usually colluvium (slopewash deposit).

On farm-scale soil maps (1:5,000 - 1:10,000) the types are labelled as:

Mv	Mahurangi clay loam
Mvc	Mahurangi fine sandy loam (colluvial variant)
Hkf	Hukerenui fine sandy loam
Hkfg	Hukerenui fine sandy loam with iron nodules (colluvial variant)
Wkf	Wharekohe sandy loam
Wkfp	Wharekohe fine sandy loam with iron pan (colluvial variant)

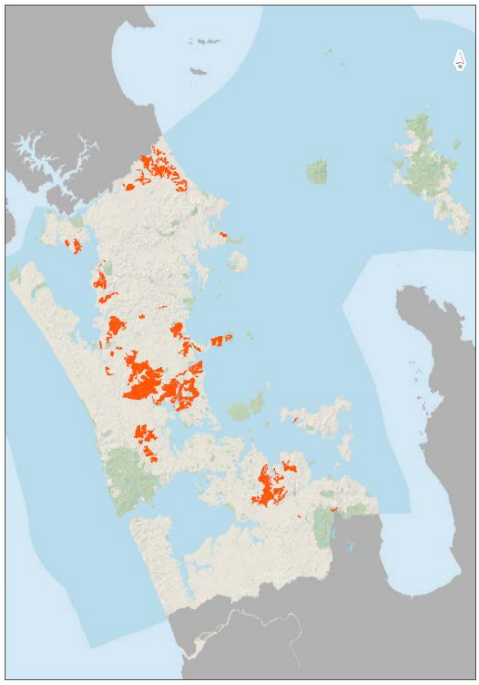
Published map polygons where MV etc. appears as part of a compound label e.g. WR + MV, generally turn out to contain extensive areas of Mahurangi series as a mosaic with the other named soil. Patches of related soil i.e. Hukerenui or Wharekohe series may be present within the areas separable as Mahurangi, though are rarely large enough to differentiate on a farm-scale map.

Published map polygons labelled solely as associated soils i.e. WR, WA, DV, usually contain small areas of Waikare, Hukerenui and Wharekohe series. Where large enough to differentiate at farm scale, these are separated and labelled as above.

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

Throughout eastern parts of the Auckland region, from its northern boundary at Te Hana through the urban area to the southern boundary at Ararimu.



Location of Mahurangi and related soils

Mahurangi and related soils are mapped on 28,200 hectares (5% of Auckland region). About 15,400 hectares (55% of the area mapped) are in productive use, divided between dairy or drystock pasture and forest plantation (estimated from overlay of Agribase 2010 on Fundamental Soils Layer). *http://intermaps.arc.govt/AucklandCouncilViewer/*

5.1 On what landform

Mahurangi and related soils are extensive on rolling to moderate hillslopes where clay regolith is weathered from Waitemata Group marine sediments (inter-bedded siltstone, sandstone and tuffaceous sandstone). They occur in different slope positions (see photo) where past vegetation differences have strongly influenced soil development.

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

Near Te Arai, Mahurangi clay loam and fine sandy loam underlie seasonally wet lower slopes. Hukerenui fine sandy loam is on planar upper slopes, capped by Wharekohe fine sandy loam on undulating broad ridges *Photo: D. Hicks*

5.2 How they differ from other soils

Mahurangi and related soils are underlain by a layer of clay which has weathered from the same marine sedimentary rocks as are exposed on hillslopes. These ridges and footslopes are the most stable parts of the landscape, so there has been sufficient time for clay illuviation to occur in upper subsoil; also for a layer of fine silty sand to form on top of the clay i.e. for podsols to develop. Under generations of kauri forest, nutrients are leached from the topmost clay, while percolating soil water washes the clay itself downwards through soil pores and cracks, depositing it in the upper subsoil. Initially a sandy topsoil develops over a clay-rich upper subsoil which seals once wet. This is mapped as Mahurangi clay loam or fine sandy loam. With time, a distinct eluvial (leached) horizon of sand or silt develops between topsoil and subsoil. This is Hukerenui fine sandy loam. Finally, the eluvial horizon compacts into a pan, parts of which may cement. The end-stage is mapped as Wharekohe fine sandy loam.

Sourced from:
Wilson, A.D. and Cox, J.E., Soils of Rodney County, Unpublished report, Soil Bureau DSIR
Molloy, L., 1987, Soils in the New Zealand Landscape, New Zealand Society of Soil Science

6 Classifications

NZ genetic (NZG):	Yellow-brown earth, podzolised yellow-brown earth, or podzol
NZ soil (NZSC):	Perch-gley albic ultic, mottled densipan ultic, perch-gley densipan ultic *http://soils.landcareresearch.co.nz/contents/SoilNames_NZSoilClassification_SoilOrders.aspx*
Soil Taxonomy (USDA):	Aquic, aeric or typic albaquult *http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051544.pdf*
World Soils (FAO):	Cambisol or podsol *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.

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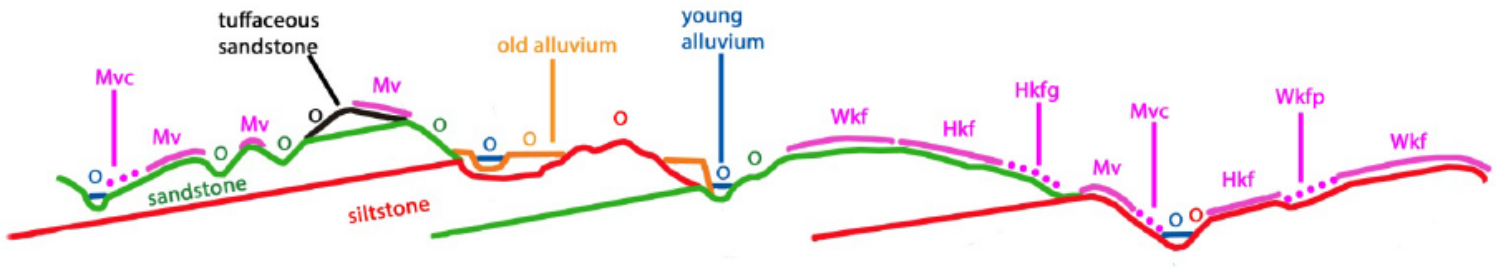
Cross section showing Mahurangi and related soils' position in the landscape



<u>On broad ridges and stable upper slopes:</u>

Mv Mahurangi clay loam

Hkf Hukerenui fine sandy loam

Wkf Wharekohe fine sandy loam

<u>On slope hollows and stable footslopes:</u>

Mvc Mahurangi fine sandy loam

Hkfg Hukerenui fine sandy loam with iron nodules

Wkfp Wharekohe fine sandy loam with iron pan

O, O, O, O, O Other soils (refer to relevant soil information inventory)

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

7 Soil profile descriptions

DSIR's unpublished type profiles for Mahurangi soils were labelled Waikare clay, sandy clay and fine sandy loam (YKs) at time of field survey (1937-1952). They were re-labelled as a separate series with a new name when maps were eventually published (1978-1982).

MF104 describes Waikare clay, sandy clay and fine sandy loam as "formed from strongly and deeply weathered massive sandstones ... mudstones ... red grits .. belonging to the Waitemata Beds ... and some pumice alluvium". It contains four type profiles described as, (a) brown clay on "soft crumbly red grits", (b) light brown sandy clay on "soft crumbly sandstone", (c) grey mottled clay on "soft crumbly mudstone" and (d) fine sandy loam on "pumice alluvium". All four are re-named on DSIR's published soil map as Mahurangi fine sandy loam (despite a note in the type profile saying that the fine sandy loam type occupies "very small areas within the YKs" label.

Profiles (a) to (c) are common within published map polygons labelled MV, and resemble each other except for differences in colour and texture which may relate to parent material of the weathered clay. Profile (c) is modal (most widespread):

Mahurangi clay loam *Photo: D Hicks*

Waikare grey mottled clay (c) = Mahurangi clay loam

Horizon	Depth (cm)	Description
Ah	0-7	Dark grey (10YR 4/1) clay; sticky when wet; firm; high packing; strongly developed medium subangular blocky structure; abundant scrub roots.
Bw(g)	7-20	Light brownish grey (2.5Y 6/2) clay; many prominent medium and fine, dark rusty brown mottles; very coarse prismatic structure breaking to strongly developed coarse blocky structure; prominent; dark grey brown humus staining on the faces of the prisms and faces of the blocky aggregates; sticky when wet; abundant scrub roots; diffuse boundary.
Br	20-60	Light brownish grey (2.5Y 6/2) clay; common distinct medium and fine rusty brown mottles; very coarse prismatic structure breaking to strongly developed coarse blocky; distinct humus staining on the faces of the prisms and on some of the faces of the blocky aggregates; sticky when wet; very high packing; contains many scrub roots; diffuse boundary.
C(g)	on	Light grey (2.5Y 7/2) clay; many prominent fine and medium reddish rusty brown mottles; strongly developed blocky structure; sticky when wet; high to very high packing; common scrub roots.

A local soil mapper (DLH) notes that the A horizon usually contains a little white silica sand dispersed through clay; and develops nutty to crumbly structure under pasture. The C horizon varies from grey through mottled grey and yellow, to brown with pink or red mottles (as described for profile a), and rarely white with red-brown mottles (as described for profile b).

Profile (d) resembles Mahurangi fine sandy loam, as mapped at farm scale where sheetwash (erosion of soil by overland runoff) has deposited colluvium in slope hollows or on footslopes. However, it differs in some respects:

Mahurangi fine sandy loam (colluvial variant) *Photo: D. Hicks*

Waikare fine sandy loam (d) = Mahurangi fine sandy loam (colluvial variant)

Horizon	Depth (cm)	Description
Ap	0-10	Dark grey (10YR 4/1) fine sandy loam; friable; massive but with traces of very weakly developed very fine subangular blocky structure; contains numerous grass roots; sharp boundary.
Ed	10-30	White (10YR 8/1) very fine silica sand; massive; slightly humus stained; weakly to strongly indurated; sharp boundary.
Bfm1	30-37	Dark brown iron and humus pan; strongly indurated; thinly laminated.
Bfm2	37-39	Brown; iron pan; weakly indurated; thinly laminated;
C(g)	on	Light yellowish brown (10YR 6/4) clay; many prominent medium dark reddish brown and grey mottles; very coarse prismatic structure breaking down to a strongly developed medium blocky structure; very high packing.

A local soil mapper (DLH) notes that the A2 horizon of Mahurangi fine sandy loam is compact (never cemented). A Bfm iron pan is rarely present; the B horizon is usually Bw(g) and Br as described for Mahurangi clay loam. Profile (d) is more likely Wharekohe fine sandy loam with pan (see below).

DSIR's mappers describe Waikare sandy clay/Mahurangi fine sandy loam as formed from "superimposed pumice alluvium" i.e. water-sorted volcanic ash. However, their type profile description contains no evidence to support that interpretation. When observing colluvial

variant in the field, pumice is not visible, nor are the ferromagnesian sand grains that characterise ash. The white layer is as likely to be silica sand or silt that accumulated as an E (leached) horizon upslope, prior to its being deposited downslope by sheetwash.

DSIR's type profiles for Hukerenui fine sandy loam are also unpublished. They are described as "formed from the thinly superimposed watersorted pumice alluvium ... on former sandy clay gumlands ... under former kauri forests". Two type profiles are given; profile (b) is modal (most widespread):

Hukerenui fine sandy loam *Photo: D Hicks*

Hukerenui fine sandy loam (b)

Horizon	Depth (cm)	Description
Ap	0-15	Dark grey (10YR 4/1) fine sandy loam; friable; massive; contains some very fine subrounded polyhedral structure; few fragments of kauri gum and abundant grass roots; diffuse boundary.
E	15-30	Brown to dark grey (humus stained) (7.5YR 5/2 - 10YR 4/1) fine sandy loam; massive; medium packing; very weakly indurated; abundant grass roots; sharp boundary.
Bfm	30-33	Greyish brown (2.5Y 5/2); weakly developed iron humus pan with distinct flecks and iron staining of brownish yellow and reddish brown on the structural faces and with black coatings of humus; weakly indurated, brittle, massive in place, but when disturbed breaks into a fine blocky structure; many fine roots clustered on the surface of the pan and only a few fine roots penetrating the pan; sharp boundary.
C	on	Sandy clay

Profile (a) resembles Hukerenui fine sandy loam (colluvial variant) as mapped at farm scale:

Hukerenui fine sandy loam with iron nodules *Photo: D Hicks*

A local soil mapper (DLH) comments that the Hukerenui colluvial variant typically has E horizons thickened by silica sand from downslope sheetwash; a common occurrence under sparse gumland scrub (also during pasture conversion). The weak Bfm iron pan is not always present; uncemented iron oxide nodules are as common. Both features appear associated with groundwater seepage through footslopes.

Hukerenui fine sandy laom (a) = with iron nodules (colluvial variant)

Horizon	Depth (cm)	Description
Ap	0-13	Dark grey (10YR 4/1) fine sandy loam; friable; massive in place breaking to weakly developed fine and very fine subangular polyhedral structure; contains some fine worm casts and abundant grass roots; diffuse boundary.
E1	13-23	Light grey-grey (10YR 7/1 - 6/1) fine sandy loam; friable; low packing; massive structure, with some intermingling of the upper horizon; abundant grass roots; diffuse boundary.
E2	23-36	Grey-light brownish grey (10YR6/1 - 6/2) fine sandy loam; with a very dark brown staining (humus), and a faint distinct fine yellowish brown mottling; friable; very weakly indurated; massive structure, abundant grass roots; sharp wavy boundary.

Horizon	Depth (cm)	Description
Bfm	36-40	Dark reddish brown-brownish yellow (5YR3/4 - 7.5YR 6/8) weakly indurated shattered laminated iron pan with medium plates and many fine grass roots clustered between them, when disturbed these plates break into very thin plates; sharp boundary.
Bw(f)	40-60	Brownish yellow (10YR 6/6) sandy clay; very firm; moderately developed coarse polyhedral structure; yellowish red thin coatings of iron along the old root channels and few grass roots; the upper 5 to 7 cm of this horizon is inclined to be platy; diffuse boundary.
Bg	on	Light grey to brownish yellow (10YR 7/1 - 6/3 - 6/6) sticky sandy clay; common distinct fine iron flecking and a strong greying along some of the root channels; high packing; strongly developed subangular polyhedral structure; few fine grass roots.

Wharekohe fine sandy loam *Photo: D Hicks*

DSIR's type profiles were located in Omahuta Forest, Northland, on "deeply weathered banded sandstone" interspersed with larger areas of "soft blue grey calcareous mudstone". They were originally labelled as a silt loam with pan (Wkfp), then re-labelled as a fine sandy loam with pan. There are three type profiles; (1) silt loam, (2) silt loam with sandy clay subsoil, (3) fine sandy loam.

The third is close to Wkf as mapped in North Auckland:

Horizon	Depth (cm)	Description
Ah	0-8	Dark grey fine sandy loam; friable; massive; abundant scrub roots; sharp boundary.
E	8-11	White fine sandy clay loam; friable soft weakly cemented silica pan; contains numerous scrub roots.
Ed	11-33	White strongly cemented massive siliceous pan almost indurated in places, generally more cemented in the lower part of the horizon; few fine scrub roots; sharp boundary.
Bw(f)(h)	33-56	Light yellowish brown clay; many distinct, medium and fine grey and yellowish red mottles; sticky, very firm; high packing; strongly developed medium and coarse subangular polyhedral and moderately developed prismatic structure with dark humus staining along the faces of the prisms; diffuse boundary.
Bw(f)	on	Yellowish brown clay; many distinct, fine and medium, yellowish red and some grey mottles; sticky; firm; moderately developed medium subangular polyhedral structure breaking to fine and very fine subangular polyhedral.

A local mapper (DLH) observes that Wharekohe fine sandy loam (with or without pan) is locally present in Auckland's landscape. It typically occurs as large patches on upper slopes or ridges. Diagnostic features are an E horizon which alternates from loose to indurated (or even silicified) over a short distance, over a compact upper B(x) which is stained by humus and contains iron oxide lamella but has not formed a distinct humus pan or iron pan.

Wharekohe fine sandy loam with pan (Wkfp) appears on the published soil maps of North Auckland in few map polygons, but is present at farm scale within polygons labelled Mahurangi (Mv) or Hukerenui (HKf) fine sandy loam. DSIR's type profile MF132 originally labelled fine sandy loam with pan, then hand-annotated as sandy loam with pan, seems the closest description:

Wharekohe (fine) sandy loam with pan = with iron pan (colluvial variant)

Horizon	Depth (cm)	Description
Ap	0-5	Dark grey (10YR 4/1) fine sandy loam; friable; weakly developed fine and very fine subangular polyhedral structure with fine and very fine worm casts; abundant grass roots; diffuse boundary.
E1	5-30	Grey (10YR 5/1-6/1) fine sandy loam; friable; massive in place, weakly developed fine and very fine subangular polyhedral structure; abundant grass roots; diffuse boundary.
E3	30-40	Light brownish grey (10YR 6/2) fine sandy loam; friable; massive (silica) in place with weakly developing fine and very fine subangular

Horizon	Depth (cm)	Description
		polyhedral structure; along some of the root channels there is a yellowish red coating; abundant grass roots; indistinct smooth boundary.
Ec	40-45	Light brownish grey (10YR 6/2) fine sandy loam; friable; massive (silica) in place with very weakly developed fine and very fine subangular polyhedral structure; many small hard and soft reddish brown to dark reddish brown spherical and angular iron concretions abundant fine grass roots layered along the surface of the horizontally laminated iron pan below; sharp boundary.
Bfm	45-77	Very pale brown to yellow brown (10YR 7/4 - 7/6) thinly laminated iron pan (plates 5mm); very hard, brittle, strongly indurated; many fine grass roots layered between the plates in the upper 2 cm of the horizon, no roots below.
CR(f)	on	Light yellowish brown (2.5Y 6/4) sandy clay; many fine faint mottles; very firm and very high packing; massive laminated structure; contains some small pieces of soft sandstone.

A local mapper (DLH) observes that Wharekohe fine sandy loam with iron pan is not widespread in Auckland's landscape. It typically occurs as small patches in hollows or on footslopes. Diagnostic features are A and E1 horizons often thicker than described (possibly an artefact of deposition by sheetwash), weakly cemented, over a hard but brittle iron pan.

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

These are best indicated by analysis results for the type profiles i.e. sites where Mahurangi, Hukerenui or Wharekohe series 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

An incomplete chemical analysis appears in the online version of National Soils Database (NSD). For Hukerenui and Wharekohe soils, the following data are sourced from Soil Bureau Bulletin 5. For Mahurangi soil, estimates are sourced from the Fundamental Soils Layer (FSL) plus a relevant S-map factsheet.

Mahurangi clay (or fine sandy) loam

Property	Topsoil	Subsoil	Units
Acidity	5.5 - 6.4	5.5 - 6.4	pH
Total carbon	4.0 - 9.9	-	%
Total nitrogen	-	-	%
Available phosphorus	-	-	mg %
P retention	0 - 29	-	%
Available sulphur	-	-	%
Cation exchange capacity	0 – 24.9	0 – 24.9	me%
Base saturation	-	-	%
Calcium	-	-	me%
Magnesium	-	-	me%
Potassium	-	-	me%
Sodium	0 - < 0.1	0 - < 0.1	me%

Sourced from FSL and S-map factsheet, Landcare Research

Hukerenui fine sandy loam

Property	Topsoil	Subsoil	Units
Acidity	5.6	5.3	pH
Total carbon	4.0	-	%
Total nitrogen	0.18	-	%
Available phosphorus	0.002	0.002	mg %
P retention	-	-	%
Available sulphur	-	-	%
Cation exchange	15.5	10.7	me%

Property	Topsoil	Subsoil	Units
capacity			
Base saturation	26	24	%
Calcium	2.4	1.2	me%
Magnesium	1.6	2.0	me%
Potassium	-	-	me%
Sodium	-	-	me%

Sourced from laboratory analysis SB01136, DSIR Soil Bureau

Wharekohe fine sandy loam

Property	Topsoil	Subsoil	Units
Acidity	4.5	4.7	pH
Total carbon	3.5	0.5	%
Total nitrogen	0.13	0.02	%
Available phosphorus	0.001	0.002	mg %
P retention	-	-	%
Available sulphur	-	-	%
Cation exchange capacity	6.6	1.5	me%
Base saturation	42	26	%
Calcium	2.4	0.8	me%
Magnesium	0.8	0.0	me%
Potassium	-	-	me%
Sodium	-	-	me%

Sourced from laboratory analysis SB03039, DSIR Soil Bureau

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

No physical analysis appears in the online version of National Soils Database (NSD). The following estimates are sourced from the Fundamental Soils Layer (FSL) plus relevant S-map factsheets:

Mahurangi clay (or fine sandy) loam

Property	Topsoil	Subsoil	Units
Stones	0	0	%
Sand	15-25	1-10	%
Silt	65-65	34-35	%
Clay	20-10	65-55	%
Dry bulk density	1.09	1.42	g/cm³
Total porosity	-	-	%
Macroporosity	7.5-14.9	-	%

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

Hukerenui fine sandy loam

Property	Topsoil	Subsoil	Units
Stones	0-4	-	%
Sand	-	-	%
Silt	-	-	%
Clay	-	-	%
Dry bulk density	-	-	g/cm³
Total porosity	-	-	%
Macroporosity	7.5-25	-	%

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

Wharekohe fine sandy loam

Property	Topsoil	Subsoil	Units
Stones	0-4	-	%
Sand	-	-	%
Silt	-	-	%
Clay	-	-	%
Dry bulk density	-	-	g/cm³
Total porosity	-	-	%
Macroporosity	10-25	-	%

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.

Mahurangi clay (or fine sandy) loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	% w/w
Plant-available water	95	30	mm
Depth to slowly permeable layer	-	0.35-0.45	m
Perm. at slowly permeable layer	-	<4	mm/hr

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

Hukerenui fine sandy loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	% w/w
Wilting point	-	-	% w/w
Plant-available water	-	-	% w/w
Plant-available water	25-38	-	mm
Depth to slowly permeable layer	-	0.90-1.49	m
Perm. at slowly permeable layer	-	<4	mm/hr

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

Wharekohe fine sandy loam

Property	Topsoil	Subsoil	Units
Field capacity	-	-	%
Wilting point	-	-	%
Plant-available water	-	-	%
Plant-available water	75-250	-	%
Depth to slowly permeable layer	-	0-0.89	g/cm³
Perm. at slowly permeable layer	-	<4	%
Field capacity	-	-	%

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 taken into account. 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. Mahurangi and related soils have not yet been sampled. Sites on Waikare soil (refer to Soil Information Inventory for Waikare and related soils) provide the closest soil quality data. Mahurangi and related soils may be expected to have lower nutrient status (more leached), though better topsoil structure (sandier). Their subsoil structure remains equally poor (perch gley layer or uncemented eluvial horizon or cemented pan).

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

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
Footslopes with perch-gley layer, iron nodules or iron pan	4w4 or incl in 4w7	4p+w	Poor structure + perch-gley layer causes seasonal wetness	Occasional fodder crops, improved pasture
Footslopes with uncemented silica pan	4s4 or incl in 4e3	4p	Pan difficult to cultivate	Occasional fodder crops, improved pasture
Mid-slopes with perch-gley layer or uncemented silica pan	4e12 or incl in 4e3	4p+t	Poor structure or pan difficult to cultivate + risk of topsoil loss	Occasional fodder crops, improved pasture, woodlots
Any slope position with cemented silica pan	6s5 or not def.	5p	Pan precludes cultivation	Semi-improved pasture

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

Mahurangi and related soils were not cultivated by Maori. Polynesian immigrants would have quickly discovered that root crops such as kumara or taro did not thrive on infertile soils which were saturated in winter but bone-dry in summer. European settlers found out the hard way that if these soils were cleared from scrub and sown to grass, neither pasture nor stock thrive. They quickly reverted to manuka scrub, or exotic shrubby weeds such as gorse, brush wattle and tobacco tree. For a hundred years, the chief use of the soils was as gum-diggings. The quantity and value of kauri gum extracted were such as to render them productive in an economic sense.

By the 1940s most gumfields had been exhausted, left a wilderness of holes and spoil-heaps covered by reverting scrub. Advent of machinery for scrub clearance, drainage and cultivation, together with scientific understanding of what fertilisers were needed to establish pasture, initiated a spurt of land development that extended over forty years till the mid-1980s. When the soils were heavily fertilised fodder crops such as chou, turnips, and even maize, could be sown and grown as part of the initial pasture mix. Improved ryegrass-clover pasture were subsequently sustained by heavy fertilisation and liming. Open or subsoil drains, plus deep-ripping to break up compact perch-gley layers and pans, reduced winter wetness. Heavy stocking and dunging helped build up organic matter, which washed down into the infertile silica layer between topsoil and subsoil.

Most areas of Mahurangi and related soils have now been productive pasture for between 70 and 30 years. They equally support dairy and drystock fattening farms. Crops are grown for supplementary feed just when pasture is renewed.

There are local instances where the sandy-textured Hukerenui and Wharekohe soils are planted in drought-tolerant tree and vine crops, and even vegetables (if irrigated). However these developments have entailed substantial initial expenditure, and will require ongoing heavy fertilisation to maintain yield. So it would be premature to regard intensive food production as sustainable.

Farm woodlots and shelterbelts are a common feature of the developed farm landscape. Commercial forest plantations planted on some former gumfields 1920s-1940s, notably Riverhead Forest, are now into a third rotation of pines. Foresters recognise the ongoing management of these soils as somewhat problematical. Fertilisation of the second and third rotations is usually needed, to correct nutrient deficiencies and maintain growth form. Trees tend to be shallow-rooted, so are subject to windthrow by gales.

Little of the Mahurangi and related soils' area now remains in natural cover. Many farms retain patches of gumland vegetation on corners cut off by streams or swamps, which the owners regard as too intractable to develop. Extensive gumland can still be seen on some

larger areas of crown land - now DOC reserve - or land in customary Maori title, which for one reason or another was not developed 1940s-1980s. Although disturbed by gum-digging and fires for a hundred years beforehand, vegetation has had some seventy years to recover. It is now recognised as a distinct ecosystem - opportunistic scrub and wetland plants which co-exist on infertile, seasonally wet and dry sites - providing habitat for several rare plant and animal species.

Sourced from:
Smallfield, P.W., 1969, The grasslands revolution in New Zealand, Hodder and Stoughton
Anonymous, 1974, Land Development in North Auckland, Department of Lands and Survey

10.1 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)	9.7-11.4	t dm/ha/yr
Improved pasture (drystock)	8.0-10.6	t dm/ha/yr
Semi-improved pasture	6.3-7.0	t dm/ha/yr
Un-improved pasture	4.6-5.0	t dm/ha/yr

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

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

11 Information about soil management

Mahurangi and related soils are not versatile, though can be made productive if developed into pasture or planted with timber trees. Small-scale horticultural development of the sandy-textured Hukerenui and Wharekohe soils - olive groves, vineyards, and even market gardens - is possible, though to maintain commercial yields, requires ongoing inputs which may prove unsustainable. The old soils' key features – poor subsoil structure which is difficult to alter, rapid leaching of nutrients down and out the profile, topsoil's seasonal alternation between winter-spring saturation and summer-autumn water deficit – necessitate somewhat more careful management than younger, and more tractable soils.

Management issues that may arise are:

- Adequately fertilising to replace crop, grass and tree uptake
- Opening drains through perch-gley layers and pans
- Deep-ripping perch-gley layers and pans
- Sustaining crop and grass growth through dry summers
- Maintaining dense sward (particularly on slopes) to avoid topsoil loss in runoff
- Avoiding pugging (particularly on footslopes and ridges) in winter and spring
- Scheduling irrigation/effluent spraying so as to minimise nutrient loss towards, and faecal contamination of, drains
- Installing farm and forest tracks that don't rill or gully
- Establishing temporary ground cover between forest harvest and re-planting

Tips for improving fertility and structure, for minimising stock impact on structure, also for controlling sediment, nutrient and faecal matter losses to runoff, are contained in:

- *Gumland soils* *Soil Information Sheet 11, Auckland Council*

- *Code of Practice for Nutrient Management* *Fertiliser Association*
  http://www.fertiliser.org.nz/site/code_of_practice/default.aspx

- *Streamside planting guide* *Auckland Council*

- *Native forest restoration guide* *Auckland Council*

- *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

- *Drainage construction and maintenance:* *TP10, Auckland Regional Council*
  (AC Technical publications and research)

- *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*
- *Forest harvest guidelines* *TP223, Auckland Regional Council*
- *Control of soil erosion in farmland* *Technical Paper 95/4, MAF Policy* *http://maxa.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/land-management/erosion-risks/*

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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