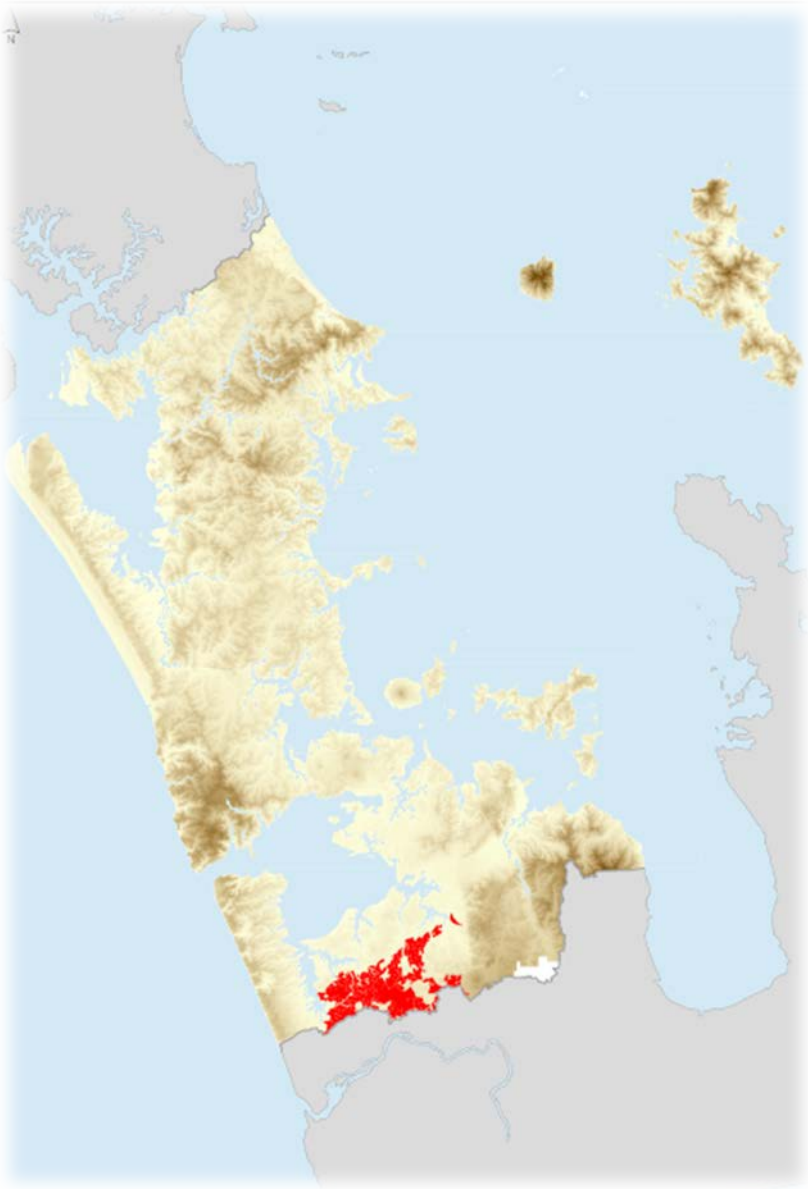
Soil Information Inventory:

Patumahoe and related soils

October 2018 Soil Information Inventory 16



RIMU Research and Evaluation Unit

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Soil Information Inventory 16:

Patumahoe and related soils

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Auckland Council
Soil Information Inventory, SII 16

ISBN 978-1-98-858922-0 (Print)
ISBN 978-1-98-858923-7 (PDF)

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Position: Manager, Environmental Monitoring, Research and Evaluation (RIMU)

Date: 1 October 2018

Recommended citation

Martindale, M., D Hicks and P Singleton (2018). Soil information inventory: Patumahoe and related soils. Auckland Council soil information inventory, SII 16

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be understood or used without referring to background information which is dispersed across old maps, publications, or unpublished reports.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

Patumahoe and related soils on thick weathered volcanic ash are depicted by DSIR's oldest published maps south of Auckland (1:253,840) as a single series i.e. soil with distinct profile and parent material, divided into two types i.e. with different textures or other characteristics:

82	Patumahoe clay loam
82a	Patumahoe sandy clay loam

On a map of intermediate age covering part of Franklin district (1:63,360) the soils are separated into four series:

Ph	Patumahoe clay loam, deep phase
PhR	Patumahoe clay loam, rolling phase
PhS	Patumahoe clay loam, shallow phase
Pk	Pukehohe clay loam
Hv	Helvetia clay loam
Mu	Mauku silt loam

The soils do not appear on a recent map of Manukau City (1:25,000), where volcanic ash is a thin veneer mapped as different series (see Soil Information Inventory for Karaka and related soils).

On the DSIR's published soil maps of North Auckland (1:100,000), similar soils are depicted as a single series within an undifferentiated complex (C1a) that includes unrelated series. The soils are labelled as:

HV	Hobsonville clay loam (within C1a complex)

Sourced from:
Soil maps of Helensville-Waitakere area; Whangaparaoa-Auckland area
NZ Soil Bureau maps 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*

3 Online maps

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

82	Patumahoe family, sibling 2
82a	No family or sibling assigned
Ph, PhR, PhS	Patumahoe family, sibling 2
Pk	Patumahoe family, sibling 3
Hv	Awad family, sibling 11
Mu	Mauku family, sibling 2
HV	No family or sibling 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, any published map polygon labelled as Ph etc. contains more than one soil type. On farm-scale soil maps (1:5,000 - 1: 10,000) south of Auckland they are labelled as:

Pk	Pukekohe clay loam
Mus	Mauku sandy loam
Mu	Mauku silt loam
Phs	Patumahoe sandy clay loam
Ph	Patumahoe clay loam
Hv	Helvetia clay loam

No farm-scale maps have been prepared within the published map polygons labelled C1a (Hobsonville complex) areas north of Auckland. When locating sites for soil sampling here, the Hobsonville series has been differentiated as:

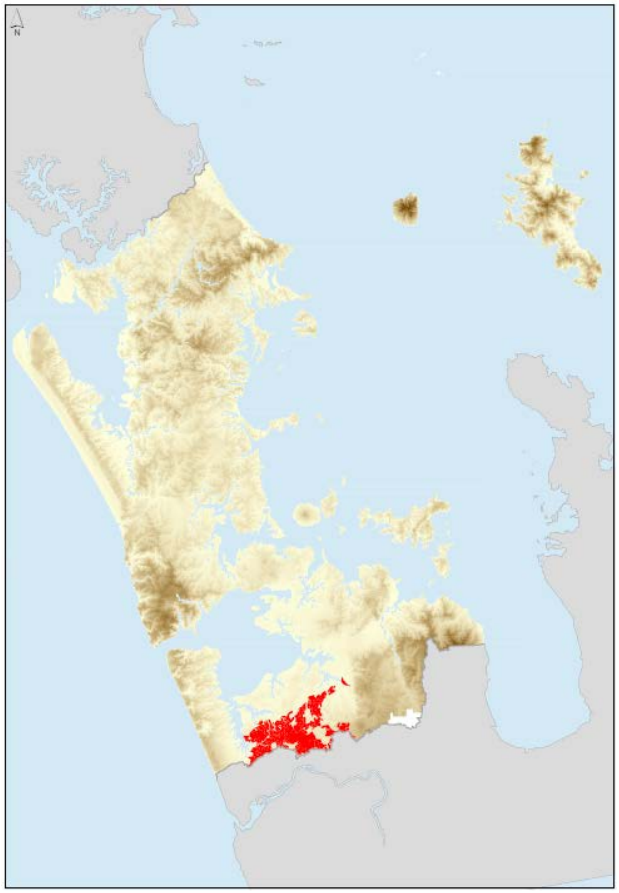
Hbs	Hobsonville sandy clay loam
Hb	Hobsonville clay loam
Hbm	Hobsonville clay loam (mottled subsoil)

Local series names have been retained on Auckland Council's farm-scale maps for continuity with published nomenclature, though the Hobsonville label has been changed to avoid confusion with Helvetia.

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

Patumahoe clay loam occupies much of central Franklin district, from west of Bombay to east of Waiuku, and north of Pukekohe to south of Tuakau. Related soils - Pukekohe clay loam, Helvetia clay loam, Mauku silt loam and Mauku sandy loam - appear on small parts within the broad area mapped as Patumahoe clay loam. Another related soil - Hobsonville clay loam – is present west of the upper Waitemata harbour.



Location of Patumahoe and related soils

Patumahoe and related soils are mapped on 17,800 hectares, 3% of Auckland region. About 11,400 ha (60% of the area mapped) are in agricultural use (estimated from overlay of Agribase 2010 on Fundamental Soils Layer)
http://intermaps.arc.govt/AucklandCouncilViewer/

Pukekohe clay loam (on hillslope) grades to Patumahoe clay loam (on undulating ash-mantled lava flows) in the middle distance. *Photo: A Thompson*

5.1 On what landform

Patumahoe and related soils are found on undulating to rolling terrain with a thick mantle of weathered rhyolitic airfall ash (Hamilton Ash), over old basaltic lava flows (Franklin Basalt).

Distinctive layers of volcanic ash, which make up the Hamilton Ash Formation, on basalt. *Photo: P Singleton*

Where Hamilton Ash is thin (usually on other geological formations dissected into steeper terrain), published soil maps differentiate other related soils: Hamilton, Bombay, Ararimu, Hunua, Matakawau and Red Hill clay loams. These will be discussed in a separate soil information inventory because greater slope, also subsoil formed from diverse parent materials, have a bearing on their management.

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

5.2 How they differ from other soils

Patumahoe clay loam is easily cultivable and retains its structure, so can be continuously cropped for vegetables. Its surface becomes sticky when wet, making wheeled vehicles and towed machinery slip, though aggregates well as it dries. Provided it is kept moist, the clay subsoil is slow-draining enough to retain irrigation water in the root zone. If allowed to dry, cracks develop enabling rapid drainage (and loss of soluble nutrients) towards groundwater. Hobsonville clay loam has similar properties.

Pukekohe clay loam has the same good properties for cultivation and vegetable growing as Patumahoe, with extra advantages. Its gritty subsoil is free-draining. Its easy, even slopes allow long cultivation passes. They are mostly north-facing and elevated, so almost frost-free.

Helvetia clay loam does not have quite as good properties for vegetable growing or pasture grazing as Patumahoe clay loam. Its position in hollows on undulating ground, is where water drains towards and down through the soil, so silt and clay particles accumulate here reducing subsoil permeability. After rain, water ponds in the topsoil for several days, preventing passage of machinery, and causing pasture to pug if grazed. Nonetheless the soil aggregates quickly as it dries, so has good structure for crop and pasture growth.
Mauku silty and sandy loams, like Pukekohe clay loam, have the extra advantages of free-draining topsoil and upper subsoil. However, they also have some disadvantages for cultivation. Their undulating contour, combined with coarser texture, creates greater risk of topsoil movement and rilling during rainstorms. They are also at risk of windblow if a gale occurs when exposed soil is dry. These limitations cease to be a problem once crop cover establishes, or if the soil stays in pasture.

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

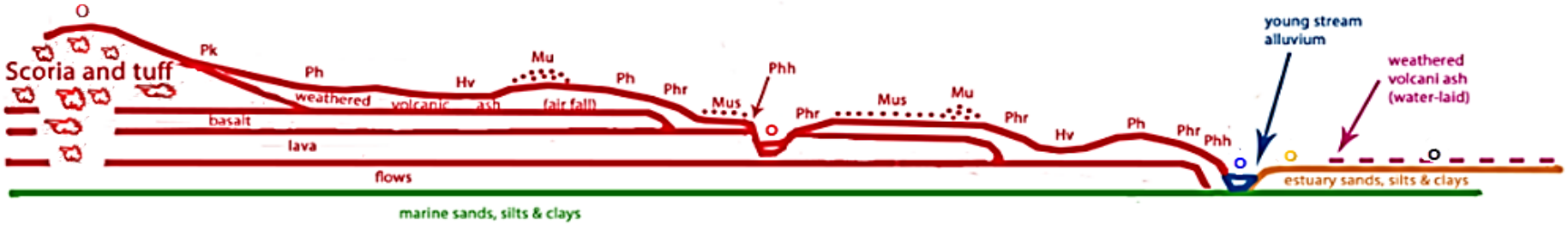
Pasture landscape on Patumahoe soils. *Photo: P Singleton*

6 Classifications

NZ genetic (NZG):	Brown granular loam
NZ soil (NZSC):	Typic orthic granular or allophanic orthic granular *http://soils.landcareresearch.co.nz/contents/SoilNames_NZSoilClassification_SoilOrders.aspx*
Soil Taxonomy (USDA):	Typic haplohumult or typic kandiudult *http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051544.pdf*
World Soils (FAO):	Ferralsol or oxisol *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.

Cross section showing Patumahoe and related soils' position in landscape



On weathered volcanic ash (airfall):

Pk	Pukekohe clay loam	- upper slopes with thin ash
Ph	Patumahoe clay loam	- undulating slopes
Phr	Patumahoe clay loam (rolling phase)	- rolling slopes
Phh	Patumahoe clay loam (hill phase)	- moderate slopes
Hv	Helvetia clay loam	- depressions in undulating slopes
Mu	Mauku silt loam	- low mounds on undulating slopes
Mus	Mauku sandy loam	- terraces on undulating slopes

On underlying rocks or overlying sediments:

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

Patumahoe clay loam *Photo: F. Curran-Cournane*

The DSIR's type profile description is:

Patumahoe clay loam

Horizon	Depth (cm)	Description
Ap	0-20	Very dark greyish brown (10YR 3/2) clay loam; friable; strongly developed medium polyhedral structure; distinct boundary.
Bw(f)	20-70	Yellowish brown to strong brown (10YR 5/6 - 7.5 YR 5/8) clay loam; friable; moderately developed medium blocky structure breaking to very fine subrounded polyhedral structure; few faint yellowish red mottles; diffuse boundary.
2Bw(f)	on	Yellowish red to strong brown (5YR 5/6 – 7.5 YR 5/8) clay loam; non-sticky; slightly firm peds; weakly developed medium blocky structure easily breaking to very fine subrounded polyhedral structure; many distinct and faint reddish mottles.

Patumahoe clay loam occurs on gently undulating and easy rolling slopes, where Hamilton Ash beds thickly mantle lava flows sloping away from eruption vents. The A horizon is present under forest and pasture. In cropped fields it has been thoroughly incorporated

into the upper B horizon. In places, Patumahoe soil contains enough sand for its A and B horizons to be described as sandy clay loam.

Pukekohe clay loam *Photo: F. Curran-Cournane*

The type profile description is:

Pukekohe clay loam

Horizon	Depth (cm)	Description
Ap	0-20	Dark reddish brown (5 YR 3/2) gritty clay loam; friable; weakly developed medium polyhedral structure crushing to very fine subrounded polyhedral structure; distinct boundary.
Bw(f)	20-66	Yellowish brown to brown (10YR 5/6 – 7.5YR 5/4) clay loam; medium packing; strongly developed medium blocky structure crushing easily to fine subrounded polyhedral structure; few thin clay skins; few faint diffuse reddish mottles; diffuse boundary.
2Bw	on	Strong brown (7.5YR 5/8) clay loam; medium packing; moderately developed medium blocky structure crushing easily to fine subrounded polyhedral structure.

Pukekohe clay loam is restricted to easy rolling and rolling slopes, on the Hamilton Ash bed-mantled basaltic cone of Pukekohe Hill. Its diagnostic feature is increasing incidence of grit and lapilli, moving from A through B to lower B horizons. Within cropped fields the A horizon has been incorporated into the upper B.

Helvetia clay loam *Photo: D Hicks*

The type profile description is:

Helvetia clay loam

Horizon	Depth (cm)	Description
Apc	0-25	Dark brown clay loam; friable; moderately developed fine polyhedral structure; many black concretions; indistinct boundary.
B(f)c	25-43	Brownish yellow clay; sticky and plastic when wet, firm when dry; massive structure; many strong brown mottles; many black concretions; distinct boundary.
Bg	on	Pale brownish grey clay; sticky and plastic when wet; firm when dry; moderately developed coarse prismatic structure; abundant strong brown and red mottles.

Helvetia clay loam is a gley soil from strongly argillised Hamilton Ash beds occurring in depressions closely associated with Patumahoe soils to which they grade with improving drainage.

Mauku sandy loam *Photo: D Hicks*

The type profile description is:

Mauku silt loam

Horizon	Depth (cm)	Description
Ap	0-23	Dark yellowish-brown silt loam; friable; weakly developed fine polyhedral structure crushing easily to strongly developed extremely fine polyhedral structure; diffuse boundary.
Bw	23-41	Strong brown silt loam; friable; weakly developed fine polyhedral structure crushing easily to very fine polyhedral structure; distinct boundary.
b A	on	Buried A horizon (generally Patumahoe clay loam)

Mauku silt loam appears on dune-like mounds ... well drained to somewhat excessively drained, from reworked volcanic ash. A buried A horizon is not discernible everywhere; a Patumahoe B horizon appears more common. A sandy phase is also widespread: (provisional profile description by D. Hicks)

Mauku sandy loam

Horizon	Depth (cm)	Description
A	10-35	Dark brown sandy loam; friable; subrounded polyhedral structure; diffuse boundary.
B	20-25	Pale brown sandy loam; friable to loose; single grain structure; diffuse boundary.
b A	on	Yellowish brown to brown clay loam; firm; blocky structure when dry crushing to very fine polyhedral structure when moist.

Mauku sandy loam's A and B horizons appear to be water-sorted volcanic ash, typically on terraces close to streams, though also on footslopes over a buried Patumahoe B horizon.

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

8 Properties of typical profile

Properties of typical profiles are best indicated by laboratory analyses for the type profile i.e. site where Patumahoe clay loam was defined and described. Data for other sites will vary somewhat, particularly where different types within the series are found. Properties of the related soils may differ from those reported below.

8.1 Chemical

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

An incomplete chemical analysis appears in the online version of National Soils Database (NSD). The following data are sourced from an old Soil Bureau laboratory record.

Property	Topsoil	Subsoil	Units
Acidity	6.0-7.0	5.0- 5.6	pH
Total carbon	3.3-5.0	3.3- 5.0	%
Total nitrogen	0.29-0.45	0.29-0.45	%
Available phosphorus	74-76	10-14	mg %
P retention	64-66	83-100	%
Available sulphur	19-26	338-1152	ug/g
Cation exchange capacity	20.0-20.9	16.0- 22.7	me %
Base saturation	59-100	12-48	%
Calcium	10.5-25.0	0.4-6.7	me %
Magnesium	0.7-1.5	0.4-1.0	me %
Potassium	0.2-0.8	0.1-0.1	me %
Sodium	0.3-0.4	0.3-1.7	me %

Sourced from laboratory analysis SB09578, DSIR Soil Bureau

8.2 Physical

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/nj/home/?cid=nrcs141p2)018993

An incomplete physical analysis appears in the online version of National Soils Database (NSD). The following data are sourced from an old Soil Bureau laboratory record, plus data cited in scientific papers:

Sourced from laboratory analysis SBT135, DSIR Soil Bureau, S-map factsheet, Landcare Research

Property	Topsoil	Subsoil	Units
Stones	0-1	0	%
Sand	5- 6	0-2	%
Silt	26-27	9-4	%
Clay	67	83-91	%
Dry bulk density	0.92-1.00	0.78-?	g/cm³
Total porosity	7- 60	No data	%
Macroporosity	4-21	No data	%

Sourced from laboratory analysis SB09578, DSIR Soil Bureau, plus Gradwell and Arlidge 1971, Barratt 1971

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 data are sourced from the old laboratory record for a similar soil in Soil Bureau Bulletin 26 (Soils of New Zealand), plus estimates from a relevant S-map factsheet.

Property	Topsoil	Subsoil	Units
Field capacity	31-42	41-51	% w/w
Wilting point	20-22	38-48	% w/w
Plant-available water	13-18	1-3	% v/v
Plant-available water	40	35	mm
Depth to slowly permeable layer	-	0.8	m
Perm. at slowly permeable layer	-	<4	mm/hr

Sourced from laboratory analysis SB07684, DSIR Soil Bureau, 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 Patumahoe and related 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.

Land use:		**Natural cover**	**Pasture**				**Market Garden**		**Orchard**
Types:		**Bush**	**Life style**	**Organic**	**Dry stock**	**Dairy**	**Conventional**	**Organic**	**Conventional**
Sample Number:		**1997/3**	**1995/2**	**2000/7**	**1998/4**	**1997/4**	**1995/1**	**2000/8**	**1998/3**
Acidity	pH	5.3	6.3	6.1	5.9	6.9	7.2	6.4	6.3
Total carbon	%	7.5	6.1	8.1	6.5	6.9	2.1	5.6	5.8
Total nitrogen	%	0.5	0.6	0.7	0.6	0.7	0.2	0.5	0.5
Available nitrogen	ug/ cm^3	112	130	227	113	256	113	120	39
Available phosphorus	ug/cm^3	3	12	10	12	55	192	15	39
Cation exchange capacity	cmol/cm^3	33.2	25.8	29.5	23.7	34.5	23.0	22.2	27.1
Base saturation	%	47	62	73	59	81	100	90	72
Calcium	cmol/ cm^3	10.4	13.0	14.4	11.7	21.8	19.0	14.0	16.0
Magnesium	cmol/ cm^3	3.8	1.7	2.1	1.5	2.9	2.4	1.4	2.0
Potassium	cmol/ cm^3	1.0	1.1	1.4	0.4	2.8	2.1	0.1	1.5
Sodium	cmol/ cm^3	0.5	0.3	0.3	0.3	0.3	0.1	0.2	0.2
Bulk density	t/ m^3	0.82	0.82	0.84	0.92	0.95	0.96	0.83	7
Particle density	t/ m^3	2.46	2.41	2.44	2.48	2.43	2.60	2.65	2.68
Aggregate stability	mm mwd	-	-	2.73	2.74	-	-	2.48	2.64
Total porosity	%	66.8	63.9	65.5	63	61	63	66	61
Macroporosity	%	19.2	9.5	12.3	13	8	30	25	20
Total available water	%	16.9	24.9	24.2	19	21	7	16	14
Readily available water	%	5.9	6.7	6.9	7	5	3	6	5

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 1:50,000 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
Flat	1w1	1c	Absent or negligible	Vegetable, grain and fodder crops, tree and vine crops
Undulating	2e1	2c	Slight sheetwash risk if cropped	Vegetable, grain and fodder crops, tree and vine crops
Rolling	3e2	3c+t	Moderate sheetwash risk if cropped	Rotational vegetable, grain and fodder crops, tree and vine crops, improved pasture
Strongly rolling	4e4	4c+t	Severe sheetwash risk if cropped	Occasional grain and fodder crops, tree and vine crops, improved pasture
Moderate	6e11	5c+s	Slight gully risk under pasture	Tree and vine crops, improved pasture, woodlots
Steep	6e11	6c+g	Moderate gully risk under pasture	Improved pasture, 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.

10 Past and present land uses

Root crops, principally kumara, were grown for hundreds of years on Patumahoe soils during Maori settlement, though perhaps not extensively, as much of the landscape remained in heavy bush until cleared by European settlers 1850s onwards. After initial experimentation at mixed farming – grain crops rotated with pasture – farmers started to grow potato and onion crops in the 1890s on the warm north-facing slopes of Pukekohe Hill. Vegetable growing expanded downslope onto Patumahoe soils 1900s onwards. A feature of expansion was the role played by Chinese and Indian immigrants. The area under vegetable crops peaked in the 1970s. About 5,000 hectares of Patumahoe clay loam and related soils are now in continuous cultivation for vegetable crops. This area accounts for about 25% of New Zealand's vegetable production; a decline from 30% in the 1980s. Rather than expand production onto the balance of Patumahoe soil in pasture, large-scale growers now lease land in the Waikato or Northland. This appears to be a response to the high cost of leasing or buying land locally, rather than any problems with soil-borne disease or decline in soil structure.

Pukekohe soils are known for vegetable growing *Photo: P Singleton*

A small fraction is planted in orchards. Kiwifruit is presently the main orchard crop, though citrus and pipfruit were grown historically in the Franklin district.
Patumahoe and related soils have been used for dairying since the 1890s. Some 6,000 hectares are in improved pasture i.e. dominated by rye grass, clover, or other high yielding species. Dairy farms outnumber drystock, but the number of both has been dropping in recent decades; not because livestock grazing is uneconomic, but 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 balance, 2,500 hectares, is land within Pukekohe town boundary (not all of this is in urban use).

Sourced from:
Hunt, D. (1959), Market Gardening in Metropolitan Auckland, New Zealand Geographer 15: 130-155.
Shing, P.M. (1977), Locational and structural changes of market gardening in Pukekohe-Bombay-Patumahoe Unpublished MA thesis, University of Auckland.
Hicks,D. (2006), A review of scientific information relating to the sustainability of current land use practices on cultivated land in the Franklin district of Auckland. Technical Publication 2006/319, Auckland Regional Council.

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

Vegetable	Yield	Units
Onion	Up to 55	t/ha
Potatoe	Up to 50	t/ha
Cabbage	Up to 30	t/ha
Lettuce	Up to 55	t/ha

Source: grower advice cited in Molloy, L. 1988, Soils in the New Zealand Landscape, N.Z. Society of Soil Science.

Crop	Yield	Units
Maize	Up to 25	t dm/ha/yr
Oats	7.4	t dm/ha/yr
Sorghum	3.0	t dm/ha/yr
Phacelia	3.3	t dm/ha/yr
Forage brassica	3.6	t/ha

Source: Williams, P.H. et al 1999, Year two results from the cover crop and nitrate leaching experiments in the Franklin Sustainability Project, Cropinfo Report 564, Crop and Food Research

Pasture	Yield	Units
Improved pasture (dairy)	13.7	t dm/ha/yr
Improved pasture (drystock)	12.9	t dm/ha/yr
Semi-improved pasture	10.9	t dm/ha/yr
Un-improved pasture	6.5	t dm/ha/yr

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

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11 Information about soil management

Patumahoe and related soils are versatile i.e. can sustain many uses including intensive food production. Key issues that arise are adequate fertilization to replace crop uptake; minimizing groundwater contamination by fertilizer (principally nitrogen) or pesticide residue; maintaining the soils' excellent structure for cultivation; coping with topsoil movement downslope through cultivated fields and into drains.

In these respects, the soils have similar management needs to other soils on old rhyolitic ash beds that extend north from the Waikato into the Auckland region. Tips for managing soil structure and nutrients, for controlling erosion, and for applying irrigation water or effluent, are contained in:

- *Fine-textured soils on young volcanic rocks Soil Information Sheet 10, Auckland Council*
- *Code of Practice for Nutrient Management Fertiliser Association* *http://www.fertiliser.org.nz/site/code_of_practice/default.aspx*
- *Erosion and Sediment Control Guidelines for Vegetable Production Horticulture NZ* *http://www.hortnz.co.nz/assets/Uploads/Auckland-Waikato-ES-Control-Guidelines-1-1.pdf*
- *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*
- *Riparian zone management: strategy guideline and planting guide TP148, Auckland Regional Council*

There has been considerable investigation of current and alternative land use practices on Patumahoe and related soils. Findings are summarised in:

- *A review of scientific information relating to the sustainability of current land use practices on cultivated land in the Franklin district of Auckland Technical Report TP319 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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