Soils of the Waimea Plains: Part 3 Brightwater District

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INTRODUCTION

The Waimea Plains lie at the eastern margin of the Moutere Depression, an area of relatively low lying land between the uplifted east and west Nelson Ranges. Of recent Geological origin, the Waimea Plains has been formed through deposition of alluvial sediments in a valley system that has been excavated in the Moutere Gravel Formation by the Wai-iti and Wairoa Rivers, which join and flow northwards into Tasman Bay. Covering around 7,500 ha but with the effective area now continually reducing through urban development, the Waimea Plains is a highly important resource for the economy of Nelson as it provides the basis for an appreciable portion of the horticultural production of the Province. Its economic value is enhanced in that the soils of the Waimea Plains comprise a significant portion of the more versatile land and soils that are found within the Nelson Province.

The soils of the Waimea Plains were first described in a report published in 1966 (Soils and Agriculture of the Waimea Plains, *Chittenden, Hodgson and Dodson 196)*. Both the soil map at a scale of 1:126,720 (two miles to the inch) and the accompanying report are generalised and provide only a broad picture of the existing soil pattern and the soil properties. Given the inherent soil variations found on fluvial and floodplain surfaces, that report provides little indication of significant soil differences at a scale useful for individual farm management or land-use planning purposes. An even less detailed picture of the soils of the Waimea Plains was given in the General Survey of the Soils of South Island (scale 1:250,000 *Soil Bureau Staff 1968).*

The present soil survey around the Brightwater district covers approximately 1000 ha and is a continuation of recent (2011/2012) more detailed soil mapping in the Appleby district to the north and the Waimea West district (2012-2013) to the west. The survey area covers land from the confluence of the Wai-iti and Wairoa Rivers to Spring Grove in the Wai-iti river system and from the confluence of the Wai-iti and Wairoa Rivers to entrance of the Wairoa Gorge in the Wairoa River system.

SURVEY METHODS

Field investigations were carried out over 58 days between October 2013 and July 2014. Black and white 1938 aerial photographs were used to assist with identification of landform units and determining changes in river flow patterns, prior to the construction of the existing stopbank system. These as well as grey scale LIDAR maps were useful for looking at micro-topographic variations, which are largely concealed in the modern satellite images where the landscape features are to a large part concealed by tree crop or vine-land types of vegetation.

Soil observations were made mainly from auger borings, up to 1 metre depth where possible, along transect lines that in most cases were short due to the constraints imposed by individual property sizes and long term row crops. Additional observations were made from soil profile pits excavated to around 1 metre where possible as well as from exposures in a few sections. The auger observations provided the basis for assessments of soil depth to gravel, soil horizon formation, soil texture and soil drainage characteristics while the observations from the pits and sections allowed soil structure, soil strength, plant root distribution and nature of underlying materials to be assessed. A total of 1070 observations were made, 1020 from auger inspections and 50 from soil profile pits and sections.

The soil description criteria used are those described in the Soil Description Handbook *(Milne et al. 1995),* which gives the official description standards for description of New Zealand soils. Additional and updated criteria are given in *Clayden and Webb (1994)* and *Webb and Lilburne (2011*). Field soil data were electronically recorded and included a digital image for the soil at each observation site. Each observation site was located and recorded using GPS and marked on 1:4000 colour photo field sheets onto which soil boundaries were plotted. The field sheets had contours at half-meter intervals and these were useful in assisting with the plotting of the soil boundaries. Soil boundaries were later transferred onto a photogrammetric base for final map compilation by TDC staff. The field data for each soil that was recognised were analysed in respect of the variation in properties for each of the recognized soil types (horizon sequences and thicknesses, colour, texture, drainage, soil depth, stoniness etc.) and the information was used in determining the properties for each soil as well as the variability within the map units. The soil versatility ratings (Table 2) are derived from assessments of a range of soil and land attributes as prescribed by *Webb and Wilson (1995)* and as used by *Agriculture New Zealand (1994)* in the Classification assessment for Productive Land in the Tasman District.

THE SOIL LANDSCAPE ENVIRONMENT

At the northern end of the survey area a short distance North of Brightwater, the land surface has been influenced by the combined effect of both the Wai-iti and the Wairoa Rivers as the floodplain and low terrace systems of the two merge. However, to the south and the east of Brightwater where the two rivers have diverged, there are differences between the two river systems in terms of their sediment deposition history, landscape formation and associated soil patterns.

The terraces associated the Wairoa River comprise a number of surfaces, the highest at the entrance to the Wairoa Gorge is about 52m above sea level. This surface, which forms the distinctive stony plain that extends from Richmond to the Wairoa River may date from the maximum of the of the last glacial period (18-28,000 yrs B.P) when there was an abundant supply of coarse sediment from the denuded Richmond

Range to the east. The deposits, termed the Hope Gravel Formation (Johnston 1982), have older sediments the base (circa 49,000 yrs) and in the lower layers comprises clay-bound gravel. A section of this material was observed in a gravel excavation pit on a property on River Terrace Road (Baigent property) where the exposure revealed several metres of dense brownish clay-bound basal gravels, overlain by pale brown, weakly clay enriched and less cohesive gravel (Fig 1).

Figure 1. Brown clay-bound gravel overlain by pale brown weakly cohesive gravel.

Below the main Waimea Plains terrace surface, three separate terrace levels are recognised. Near the Wairoa River gorge entrance, two surfaces are approximately 5 and 10 metres respectively below the upper terrace level with the height differences diminishing down river. These surfaces are commonly very stony or bouldery and are very uneven with distinct old river channel features. These terrace levels probably represent degradation surfaces, associated with short term late glacial climate fluctuations *(Barrell et al. 2013)* when the Wairoa River was carrying a much reduced sediment level but when water flows were still high, The stony nature of the soils and the uneven channelised surfaces are indicative of a high-energy river system. The lower most level embraces the recent terraces and surfaces of the river floodplain system formed within the Appleby Gravel Formation, (*Johnston 1982*) that has developed during post-glacial or Holocene time.

To the southwest of Brightwater, the river terrace system associated with the Wai-iti River is more subdued and there is little evidence of higher terraces related to the Hope Gravel Formation or soils forming within deposits of that formation. Transport and deposition of sediment and associated fan and terrace construction has clearly been more vigorous in the Wairoa River than in the Wai-iti River system. The effectiveness of the fluvial processes between the two rivers is reflected in the present day river flow data with the Wairoa River having a recorded peak flow of 1466 cum/sec while the recorded maximum flow of the Wai-iti River is 397 cum/sec (TDC flow data).

SOILS OF THE BRIGHTWATER DISTRICT

In this section, the soils of the Brightwater district are described in relation to the landscape position that they occupy as outlined in Table 1. The soils on the lower terrace surfaces are the youngest with weakly developed soil profiles, while the soils on the higher and older elevation surfaces have more strongly developed soil profiles with weathering to greater depths. Most of the soils within the survey area are classed as shallow to moderately deep (Table 2) with deep soils being of somewhat limited extent. The proportion of soils classed as stony within the Wairoa River system is higher than in the Wai-iti River system and this is probably a reflection of the past significantly higher energy status of the Wairoa River.

Included with the soil descriptions are percentages of depth classes and stoniness classes for each soil family (shallow, moderately deep, deep, slightly stony, stony and very stony) as recorded from the auger observations. These provide a guide to the variation that might be encountered within the individual areas that are separated on the accompanying soil map.

Table 1
Soils of the Brightwater District

Recent River Floodplain and lowest Terraces		
Well drained soils	Wai-iti soils	Wa, Wamd, Wash, Wast
Older River Overflow and Low Terrace Surfaces		
Well drained shallow soils	Redwood soils	Rd, Rdmd, Rdsh, Rdst
Well drained moderately deep soils	Motupiko soils	Mk, Mksh, Mkst
Well drained deep soils	Waimea soils	Wm, Wmmd, Wmsh
Moderately well drained soils	Cotterell soils	Ct
Recent stream alluvium		
Well drained	Eves soils	Ev
Higher Terraces		
Well drained soils	Brightwater soils	Bg
	Ranzau soils	Rz, Rzvst, Rzsh, Rzmd
Older fan surfaces		
Well drained	Wantwood soils	Wt
Imperfectly drained soils	Lee soils	Le
Disturbed soils		
Well drained	Anthropic	An

Soil name and map symbol;   Wai-iti soils (Wa, Wamd, Wash, Wast)

Concept and overview

Wai-iti soils occur on the floodplain surfaces and lowest terrace levels and overflow channels of the Wai-iti River and Wairoa Rivers. Some of the surfaces on which Wai-iti soils occur were river flood channels up until the 1930's before management of the river systems took place. Occupying 276 ha, Wai-iti soils are now largely protected from occasional flooding by the stopbank system, which was constructed in the late 1950's and early 1960's.

Relationship to previously named soils

Wai-iti soils were not identified in the earlier surveys (Chittenden et al. 1966) although were included within the Waimea soil family, without being separated on the soil map. In the 2011/12 survey of the Redwood Valley-Appleby portion of the Waimea Plains (Campbell unpublished) Wai-iti soils were separated as the recent well drained soils on the floodplain and lowest surfaces of the Waimea River.

Landform origin and history

The floodplains of the Wai-iti and Wairoa Rivers have formed after river entrenchment following the period of Post Glacial warming. Prior to the stopbank construction and flood protection work carried out by the Nelson Catchment Board in the 1950's and 1960's inundation and changes in river channels commonly occurred. A flood resulting from a severe storm in April 1957 probably covered most of the area that is mapped here as Wai-iti soils. Buried soils were found in more than 20% of the observations of Wai-iti soils and are indicative of the past flooding and river depositional activity. The stopbank system was constructed for a 1 in 50 year flood return period and could be expected to be breached during more severe storms predicted with global climate change.

Key features and physical properties

Wai-iti soils are weakly developed with a brown to dark brown sandy loam A horizon that averages 13cm thick, although in 35% of the observations, there is little colour differentiation between the surface and subsurface materials. Where present, the buried A horizon averages 18cm thick. Subsoil colours vary, with dark yellowish brown to olive brown colours in deeper silty textured material and olive colours where the soil material is coarse textured. Wai-iti soils are weakly structured, have textures that vary from sandy loam (60%) to silt loam (40%) and range in depth from shallow and stony to deep (>100cm).

Identified variants

Wai-iti soils vary considerably over short distances because of the flood-channelled nature of the land surfaces. The mapped variants in Wai-iti soils include Wai-iti moderately deep (Wamd 45-100cm depth to gravel), Wai-iti shallow (Wash <45cm to gravel) and Wai-iti stony (Wast where the percentage of stones in the surface horizon exceeds 5%.) Deep Wai-iti soils were found in 11% of the recorded observations, moderately deep soils in 30%

of the observations and shallow soils in 57% of the observations. In 35% of observations for Wai-iti soils, the soils were classed as stony with 15% classed as slightly stony (<5%) and 15% classed as very stony (>35%).

Associated and similar soils

Eves soils, formed from stream alluvium derived from local sources have similar properties to Wai-iti soils. In some lower lying swales and old stream channels where soil drainage is impeded, moderately well drained and imperfectly drained soils (Appleby 3%) are present.

Versatility and land use rating

Wai-iti moderately deep and deep soils have a moderate to high versatility (1.9 Table 2) while the shallow and stony soils have a moderate to low versatility owing to stoniness (bouldery in places), somewhat excessive drainage, and lower available water capacity. Both the moderately deep and deep soils and also the shallow and stony soils are however used successfully for horticultural crops despite the risk of flooding in extreme weather events. These soils are included in class B of the Tasman District Council system for land management.

Horizon	Depth	Description
A	0-14cm	brown to dark brown (10YR 4/3) silt silt loam; weakly developed fine polyhedral structure; weak soil strength; compact; friable; many fine roots
BC	14-37cm	dark yellowish brown (10YR 4/4) silt loam; weakly developed fine blocky structure; weak soil strength; compact; very friable; many fine roots
b A	37-46cm	dark yellowish brown (10YR 3/4) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; few fine roots
b BC	46-55cm+	dark yellowish brown (10YR 4/4) sandy loam; apedal; 50% fine to coarse stones, compact

Soil name and map symbol; Redwood soils (Rd, Rdmd, Rdsh, Rdst)

Concept and overview

Redwood soils occur mainly on the low terrace surfaces of the Wairoa River and cover 145 ha. They are formed on surfaces that lie above the present flood plain and a little below the main valley floor level. Redwood soils have a gently undulating topography with a subdued channelised surface resulting from former overflows during flood conditions. The soils are weakly developed with a shallow weathering depth (<45cm to unaltered subsoil), a mainly sandy loam texture and a shallow depth to gravelly sediments, commonly about 40cm.

Relationship to previously named soils

Redwood soils were not mapped in the earlier survey of the soils of Waimea County (*Chittenden et al. 1966)* and were probably included with Waimea sandy loam. They were mapped in the 2011/12 and 2012/13 surveys of the Redwood Valley-Appleby and Waimea West parts of the Waimea Plains (Campbell unpublished).

Landform origin and history

Redwood soils are formed from Appleby Gravel Formation deposits circa 4120± 60 BP. (*Johnston 1982)* but the surface materials and soils may be relatively recent as the soil weathering depth is shallow (generally <45cm) and buried soils are occasionally present. There have probably been intermittent climate related cycles of aggradation and degradation in the river systems through the Holocene warming period with Redwood soils representing a relatively recent fluctuation in the river flow pattern.

Key features and physical properties

Redwood soils are well drained, predominantly shallow soils (52%), with a dark brown or brown to dark brown A horizon of about 20cm overlying a dark yellowish brown B or BC horizon of less than 25cm passing into a olive to light olive brown C horizon. Topsoil texture is predominantly silt loam or sandy loam and the subsoil texture sandy loam or silt loam passing into sandy gravel with increasing depth. The average depth to gravel was found to be 27cm but 42% of the soils were stony to the surface with 15% slightly stony (1-5%), 25% moderately stony (6-35%).

Identified variants

The main variants identified were Redwood moderately deep soils (Rdmd 25%) and Redwood deep (Rd 23%).

Associated and similar soils

Redwood soils are associated with Wai-iti soils, which occur on the lower most floodplain surfaces. Some of the soils shallow within the Eves mapping unit have similar properties to Redwood soils.

Soil versatility and Landuse

Redwood soils have a moderate to high versatility (average 1.9 Table 2) and are in places used for market garden crops. Where the soils are very stony or bouldery, the versatility is moderate to low but the soils here are largely used for viticulture. The main restrictions are the shallow depth to gravel and soil stoniness with consequent lower available moisture storage but this limitation is overcome with irrigation. The surface stoniness provides a limitation to the range of horticultural crops that can be grown but allows the soils to be worked throughout the year. Redwood shallow, moderately deep and deep soils are included in class B of the Tasman District Council Classification system for productive land.

Horizon	Depth	Description
A	0-18cm	dark brown (10YR 3/3) sandy silt loam; moderately developed fine polyhedral structure; very weak soil strength; compact; friable; common fine roots
B	18-40cm	dark yellowish brown (10YR3/4-10YR4/4) sandy loam; weakly developed medium polyhedral structure; weak soil strength; compact; very friable; common fine roots
BC	40-43cm	dark yellowish brown (10YR 4/4) sand; apedal; 30% fine to coarse stones; loose; few fine roots
C	43-60cm	olive (5Y 4/3) sand; 70% fine to very coarse stones; few fine roots

Soil name and map symbol; Motupiko soils (Mk, Mksh, Mkst)

Concept and overview

Motupiko soils occur within the Wai-iti River system and cover 126 ha.
They are present to the southwest of Brightwater on a low terrace surface that lies between 1-2m above the existing floodplain system. The land surface is broad and gently undulating but with occasional stony riser undulations on the former floodplain surface. In places, the surface is crossed by shallow channels formed during previous river overflows and also by stream drainage channels that originate from foothills to the east. Motupiko soils are derived from predominantly Moutere Gravel alluvium, are well drained and moderately deep soils with soil weathering profiles that typically pass into unweathered sandy or gravelly material below 75cm.

Relationship to previously named soils

Motupiko soils were earlier mapped in the survey of the soils of Waimea County (*Chittenden et al. 1966*) as soils formed from Moutere Gravels, greywacke, argillite and sandstone with silt loam to sandy loam textures and overlying gravel. In the 2012/2013 Waimea West Survey, they were mapped on the lower terraces of the main river systems that drain the Moutere Hills.

Landform origin and history

Motupiko soils are formed from the Appleby Gravel Formation sediments *(Johnston 1982)* that were deposited in the Post Glacial period. The distribution of Motupiko soils across the valley floor indicates a period of widespread sediment accumulation before later entrenchment of minor stream channels into the terrace surface.

Key features and physical properties

Motupiko soils are well drained with dark yellowish brown to dark brown silt loam or sandy loam A horizon (average 21cm thickness) a dark yellowish brown silt loam or sandy loam textured B horizon (average 29cm thickness), passing into a yellowish brown to light olive brown sandy loam textured BC horizon. In approximately 30% of the observations, the soils were stony with very stony soils recorded in 5% of the observations.

Identified variants

The main variation for Motupiko soils was in respect of soil depth, moderately deep to deep soils occurring in 35% of the observations, deep soils in 20% of the observations and 45% shallow soils with the depth to gravel at approximately 25cm. In some lower lying areas where the soils are deep, subsoil mottles may be present and patches of Cotterell soils present.

Associated and similar soils

Motupiko soils are associated with moderately well drained Cotterell soils, which occur in some lower lying areas and in shallow drainage channels where soil drainage is restricted. Waimea soils have similarities to Motupiko soils but are typically deeper and somewhat finer textured.

Soil versatility and landuse

Motupiko soils have a moderate to high versatility (1.5 Table 2) and in a few places are utilised for vineyards and tree crops and for horticultural nursery use. The chief limitations are their low nutrient status, slight winter limitations for trafficability and workability and stoniness in some places. They are included in class B of the Tasman District Council Classification system for productive land.

Horizon	Depth	Description
A	0-19cm	dark yellowish brown (10YR 3/3) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; many fine roots
AB	19-27cm	dark brown (10YR 4/4) and yellowish brown (10YR 5/6) silt loam; moderately developed fine polyhedral and weak medium blocky structure; compact; slightly firm soil strength; friable; common fine roots
Bw	27-50cm	yellowish brown (10YR 5/6) silt loam; weakly developed medium blocky structure; firm soil strength; compact; brittle failure; 2% fine stones; few fine roots
BC	50-78cm	dark yellowish brown (10YR 4/6) sandy silt loam; weakly developed medium blocky structure; firm soil strength; compact; brittle failure; 2% fine stones; few fine roots
C	70-80cm+	light olive brown (2.5Y 5/6) sandy loam; apedal; 5% fine and medium stones; very firm; dense

Soil name and map symbol; Waimea soils (Wm, Wmmd, Wmsh)

Concept and overview

Waimea soils cover 139 ha and occur in a small area near Brightwater and on the low terraces on the north side of the Wairoa River where they are more extensive. They are formed on a relatively even and little dissected surface that lies about 1-2m above the Waimea River floodplain and which forms the uppermost surface of the low terrace system. Waimea soils are predominantly deep soils with heavy silt loam to clay loam subsoils textures passing into coarser texture or gravel at greater depth. In a few areas they are shallow to moderately deep.

Relationship to previously named soils

In the survey of the soils of Waimea County *(Chittenden et al. 1966)* all of the soils on the lower valley floor surfaces were mapped as Waimea soils In the 2011/12 survey of the Redwood Valley-Appleby area and in the 2012/13 survey of the Waimea West district (Campbell unpublished) Waimea soils are restricted to the deeper and heavier textured soils on the older recent fluvial surfaces of the Waimea Plains while the soils earlier mapped as Waimea silt loam and sandy loam were separated as Wai-iti and Redwood soils.

Landform origin and history

Waimea soils are formed on the Appleby Gravel Formation *(Johnston 1982)* with deposition occurring in the Holocene, judged by the C^{14} dates of 4120$\pm$ 60 and 4620 $\pm$ 140 years B.P from samples at Waimea West. The relatively wide occurrence of Waimea soils over a more or less uniform surface suggests a period of benign deposition dominated by widespread accumulation of silty to clayey, rather than sandy gravelly sediments..

Key features and physical properties

Waimea soils have an A horizon that is dark brown and averages 23.5cm thick with moderately developed structure and silt loam or heavy silt loam texture. The B horizon is dark yellowish brown clay loam to silt loam with an average thickness of 40cm overlying a BC horizon (average thickness 30cm) with silt loam to clay loam texture. A few mottles are sometimes present below about 80cm.

Identified variants

Shallow soils (Wmsh) sometimes with stones to the surface, occur in a few places (11% of observations) generally associated with an older river channel system. Moderately deep soils (Wmmd) were found in 35% of the observations with the soil depth to gravel averaging 65cm. In some places near the edge of a terrace, a thin layer of more recently deposited sediment (Redwood soil sedimentation event) overlies the Waimea soil.

Associated and similar soils

Motupiko deep soils are similar to Waimea soils but the former have sandy loam rather than clay loam subsoil textures and are predominantly moderately deep. The Motupiko soil family is restricted to those soils derived predominantly from Moutere Gravel materials. Cotterell soils occur with Waimea soils where subsoil drainage is impeded.

Soil versatility and landuse

Waimea soils have a moderate to high versatility for use, (1.5 Table 2) their main limitations being somewhat slow permeability along with seasonally restricted workability and trafficability due to their heavier texture and slower drainage. In the present survey area, they are used mainly for viticulture with some horticulture (Kiwifruit). Waimea soils are included in Class B of the Tasman District Council Classification system for land management.

Horizon	Depth	Description
A	0-20cm	brown to dark brown (10YR 4/3) heavy silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; many fine roots
AB	20-25cm	brown to dark brown and dark yellowish brown (10YR 4/3+ 4/6) clay loam; moderately developed fine polyhedral and medium blocky structure; weak soil strength; compact; friable; common fine roots
B	25-60cm	dark yellowish brown (10YR 4/6) clay loam; moderately developed medium blocky structure; compact; brittle failure; few fine roots
BC	60-60cm+	dark yellowish brown (10YR 4/6) heavy silt loam; weakly developed medium blocky structure; slightly firm soil strength; compact; brittle failure

Soil name and map symbol; Cotterell soils (Ct)

Concept and overview

Cotterell soils cover 20 ha and occur in scattered areas mainly on lower lying land and old drainage channels on the lower terrace system of the Wai-iti and Wairoa Rivers. They are moderately well drained soils with subsurface wetness resulting from slow subsoil permeability and low-lying topography. They are characterised by diffuse or distinct patterns of reddish and grey coloured mottles usually below 50cm depth. Some small areas of soils with impeded drainage on higher terraces are included with Cotterell soils.

Relationship to previously named soils

Soils on the floodplain and terraces with a drainage impediment were not separated in the earlier survey of the soils of Waimea County *(Chittenden et al.1966)* but were separated in the earlier 2011/12 and 2012/13 surveys of western part of the Waimea Plains (Campbell unpublished).

Landform origin and history

The lower terrace surfaces of the Wai-iti and Wairoa Rivers are relatively young and were constructed in Post Glacial Late Holocene time during a period of active river sedimentation during which the Appleby Gravel Formation was formed post 4120- 4620 yrs BP judged by ^{14}C obtained from within buried sediments at 7.6m at Waimea West *(Johnston 1982).* The broad floodplain surface was crossed by shallow braided channels and depressions a with Cotterell soils occurring in some of these lower lying areas.

Key features and physical properties

Cotterell soils have deep to moderately deep profiles with a brown to dark brown silt loam textured A horizon (average thickness 22cm) overlying a dark yellowish brown to olive brown silt loam textured B horizon (average 29 cm thick) which in turn overlies distinctly mottled sandy loam to clay loam with variable mottle colours ranging from light grey to yellowish red or reddish brown. With increasing depth, textures are commonly sandier while soil colour is olive to olive grey. Cotterell soils are predominantly deep, (51% of observations >100cm), with moderately deep soils (45-100cm to gravel) at an average depth of 54cm. Cotterell soils are predominantly moderately well drained (67% of observations) with the remainder imperfectly drained.

Identified variants

Apart from differences in drainage (moderately well drained and imperfectly drained; which are not mapped separately) variation in Cotterell soils is mainly due to soil depth variation with 35% of observations recorded as moderately deep soils, 51% as deep and 13% as shallow.

Associated and similar soils

Cotterell soils occur within the same landform units as Waimea, Motupiko and Redwood soils but typically in lower lying channels or backslopes where drainage is impeded.

Soil versatility and landuse rating

Cotterell soils have a moderate to low versatility and moderate limitations for use (2.3 Table 2). The main limitation is drainage and slow permeability in the lower soil horizons but periodic waterlogging and soil wetness restrict trafficability and workability. Where Cotterell soils occur in former overflow channels, their use is limited by topography. Cotterell soils are included in Class C of the Tasman District Council Classification system for productive land.

Horizon	Depth	Description
A	0-22cm	brown to dark brown (10YR 4/3) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; many fine roots
AB	22-29cm;	brown to dark brown and light olive brown (10YR 4/3+2.5Y 5/4) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; many fine roots
B	29-44cm	light olive brown to dark yellowish brown (2.5Y 5/4-10YR 4/4) silt loam; moderately developed fine polyhedral and blocky structure; weak soil strength; compact; friable; common fine roots
B(g)	44-70cm	light olive brown (2.5Y 5/4) silt loam; 20% strong brown (7.5YR 5/8) and 45% light brownish grey (2,5Y 6/2) medium mottles; moderately developed medium blocky structure; slightly firm soil strength; compact; brittle failure; few fine roots
BCg	70-100cm	light olive grey (80%, 5Y6/2) and yellowish (10%, 5YR 5/8) fine to medium mottled silt loam; apedal; slightly firm soil strength; compact; brittle failure

Soil name and map symbol Eves soils (Ev)

Concept and overview

Eves soils cover 21 ha and are mapped to the southwest of Brightwater within the Wai-iti catchment system. They are the soils that are formed on the sediments deposited by small secondary streams that have developed on the low terrace Wai-iti River system. These ephemeral streams are low flow watercourses that carry local storm runoff waters and their sediments are locally derived and variable. Channel alignments to improve drainage have minimised the effects of periodic flooding and reduced sediment deposition.

Relationship to previously named soils

Eves soils were not identified in the survey of the soils of Waimea County *(Chittenden et al. 1966).* They were mapped in the 2011/12 and the 2012/13 surveys of the western part of the Waimea Plains (Campbell unpublished) with small areas of poorly drained soils associated with Eves soils being separated as Mahana soils.

Landform origin and history

Deposition of the sediments that constitute the main valley floor between Spring Grove and Brightwater (Appleby Gravel, *Johnston 1982*) took place in the Post Glacial Holocene period as a broad depositional event. Subsequently, runoff waters from adjacent higher ground were concentrated in low lying areas on the valley floor and aided by periodic storm events, established a channel system along which sediments and water have moved. These channels have a developed a minor system of terraces that record changes in the flow and sediment deposition of these incipient streams.

Key features and properties

Eves soils are predominantly shallow to moderately deep soils that have silt loam to sandy loam A horizons of varied colour (dark yellowish brown, brown or dark brown, average thickness 17cm) overlying dark yellowish brown to olive brown sandy loam or silt loam B or BC horizons with weakly developed soil structure. In 40% of the observations, a buried A horizon was present recording recent flood and depositional activity within the stream system. Subsoil mottles indicative of impeded drainage are present in several areas.

Identified variants

Stony soils (moderately stony) were found in 33% of the observations, Shallow soils (including the stony soils) were found in 45% of the observations and moderately deep soils in 42% of observations. Moderately well drained and imperfectly drained soils were noted in 20% of the observations.

Associated and similar soils

Eves soils are similar to Wai-iti soils, both being formed from recent alluvial deposits and having weak soil development with periodic flooding.

Soil versatility and landuse

Eves soils have a moderate to low versatility (2.1 Table 2). The main limitations are susceptibility to flooding and low nutrient status, while topography (narrow channels and associated channel and terrace scarps makes intensive use impractical in most places. They are used along with adjacent soils predominantly for grazing. They are included in Class D of the Tasman District Council Classification for productive land.

Horizon	Depth	Description
A	0-10cm	dark yellowish brown (10YR 3/4) sandy loam; weakly developed fine polyhedral structure; very weak soil strength; compact; very friable; abundant roots
BC	10-30cm	dark yellowish brown (10YR 4/4) sandy loam; weakly developed fine polyhedral structure; weak soil strength; friable; common fine roots
C1	30-46cm	dark yellowish brown to olive brown (10YR 4/4-2.5Y 4/4) sandy loam; apedal; weak soil strength; compact; friable; common fine roots
C2	46-62cm	olive brown (2.5Y 4/4) sand; apedal; very weak soil strength; compact; very friable; few fine roots
C2	62-75cm+	olive brown (2.5Y 4/4) sand; apedal; loose; 30% medium to coarse stones

Soil name and map symbol; Brightwater soils (Bg)

Concept and overview

Brightwater soils cover 99 ha and occur chiefly on the south side of the Wairoa River and also in a small area on the north side of the Wairoa River near the entrance to the Wairoa Gorge. They occur on a terrace that is intermediate between the uppermost surface on which Ranzau soils occur and the lower terrace system with Waimea soils. Brightwater soils are predominantly shallow and stony soils with a weathering depth that extends to about 60cm.

Relationship to previously named soils

In the survey of the soils of Waimea County *(Chittenden et al. 1966)* all of stony and shallow soils on the elevated terraces related to the Wairoa River were mapped as Ranzau soils. In the present survey, the soils on the lower level of the older terrace sequence with less deeply weathered profiles are separated from the more deeply weathered Ranzau soils on the uppermost terrace levels.

Landform origin and history

Brightwater soils are formed on sediments of the Hope Gravel Formation *(Johnston 1982),* which are described as outwash gravels from cold periods during various glacial episodes. Subsequent to the period of extensive gravel aggradation that formed the main surface of the Waimea Plains, river downcutting resulted in the formation of several degradational terrace surfaces with Brightwater soils probably being of Late Otiran age.

Key features and physical properties

Brightwater soils are predominantly shallow with an average depth to gravel of less than 25cm. The A horizon, about 23cm thick is dark brown to very dark brown and generally stony (57% of observations). The B horizon (average 22cm thick) is dark yellowish brown stony silt loam and overlies a BC horizon of olive coloured stony sandy loam, passing into unweathered stony gravel.

Identified variants

Brightwater shallow soils (<45cm to gravel) were found in 76% of the observations and Brightwater moderately deep soils (45-100cm to gravel in 23% of the observations, the average depth to gravel being 58cm. Very stony soils (>35% stones in the surface horizon) were found in 12% of the recorded observations.

Associated and similar soils

Brightwater soils are similar to Ranzau soils in respect of their stoniness and depth to gravel but they have shallower weathering profiles while the stones present are commonly coarser than those in Ranzau soils. Brightwater soils are similar to the Ikamatua soils in the Golden Bay region in respect of stoniness, weathering depth and position in the landscape.

Soil versatility and landuse

Brightwater soils have a moderate to low versatility for use (2.1 Table 2) their main limitations being their stoniness, medium to low available water capacity and a moderate rooting depth that is restricted by the subsoil gravels. They are used mainly for viticulture within the present survey area with a few small areas in the past used for orchards. They are included in Class C of the Tasman District Council Classification system for land management.

Horizon	Depth	Description
A	0-22cm	very dark brown (10YR 3/2) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; 25% fine and medium stones; common fine and medium roots
AB	22-25cm	very dark brown (10YR 3/2) and dark yellowish brown (10YR 4/6) silt loam; weakly developed fine polyhedral structure; weak soil strength; compact; friable; 15% fine and medium stones; few fine and medium roots
B	26-50cm	dark yellowish brown (10YR 4/6) sandy loam; weakly developed fine polyhedral structure; compact; friable; 55% fine to very coarse stones; few medium roots
BC	50-55cm	dark yellowish brown (10YR 4/4) sand; weakly developed fine polyhedral structure; compact very friable; 60% fine to very coarse stones; few medium roots
C	55-75cm+	olive brown to dark yellowish brown (2.5Y 4/4-10YR 4/4) sand; apedal; loose; 65% fine to coarse stones

Soil name and map symbol; Ranzau soils (Rz, Rzsh, Rzvst, Rzmd)

Concept and overview

Ranzau soils occupy 136 ha and occur the high terrace surfaces that are present to the south and east of the Wairoa River. They are almost everywhere stony, having formed on the extensive gravels derived from the Richmond Range to the east and deposited as the Wairoa River exited the Wairoa Gorge. They are moderately weathered soils with a soil weathering depth (about 80cm+) consistent with an origin dating from Late Glacial time. .

Relationship to previously named soils

Ranzau soils were previously mapped in the survey of the soils of Waimea County *(Chittenden et al. 1966)* with Ranzau stony clay loam on the main surface of the Waimea plain and Ranzau gravelly silt loam on the smaller separate fan surfaces along the foot hills from Hope through to Stoke.

Landform origin and history

Ranzau soils are formed on sediments of the Hope Gravel Formation *(Johnston 1982),* which are described as outwash gravels from cold periods during various glacial episodes during Late Otirian time *(Barrell et al. 2013).* These sediments are from a range of rock types including greywacke, argillite, sandstone, limestone and ultrabasic rocks. The absence of significant erosional detritus from adjacent hilly land on the terrace surfaces suggests an age of late, rather than early Otiran time. Following the period of extensive gravel aggradation that formed the main surface of the Waimea Plains, river downcutting resulted in the formation of several degradational surfaces, the two main levels being about 5-6m apart near Wairoa Gorge and separated by a distinct scarp. As there is little difference in weathering on these two terrace levels, the soils on both surfaces are mapped as Ranzau soils.

Key features and physical properties

Ranzau soils are predominantly stony and shallow with an average depth to gravel of 22cm. The A horizon, about 25cm thick is dark brown to dark yellowish brown stony silt loam to sandy loam and overlies a deep dark yellowish brown stony silt loam to sandy loam horizon, passing into yellowish brown to light olive brown stony sandy loam below about 70cm.

Identified variants

Ranzau soils are predominantly shallow soils (83% of observations <45cm to gravel) while moderately deep soils with an average thickness of 55cm to gravel were noted in 17% of the observations. Of the shallow stony soils 30% were found to be very stony (>35% surface stones) and in some places bouldery.

Associated and similar soils

Brightwater soils are similar to Ranzau soils in respect of their stoniness and depth to gravel but they have shallower weathering profiles. Where a prominent terrace scarp is present separating the various terrace levels, the slopes may be steep to moderately steep, however, soils on these sloping areas have not been separated but are included within the Ranzau family.

Soil versatility and landuse

Ranzau soils have a moderate to high versatility for use (1.8 Table 2) their main limitations being their stoniness, medium to low available water capacity and a moderate rooting depth that is restricted by the subsoil gravels. Within the present survey area, they are mainly under pastoral use but where they are shallow to moderately deep, they are used for plant nursery crops. Ranzau soils are included in class A of the Tasman District Council Classification system for land management.

Horizon	Depth	Description
A	0-23cm	very dark greyish brown (10YR 3/3) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; 3% fine and medium stones; few fine roots
Bw1	23-50cm	yellowish brown to dark yellowish brown (10YR 4/6-5/6) silt loam; moderately developed fine polyhedral structure; compact; friable; 40% fine and medium stones; few fine roots
Bw2	50-70cm	yellowish brown (10YR 4/6) sandy loam; very weakly developed fine polyhedral structure; compact; friable; 55% fine to coarse stones; few fine roots
BC	70-100cm	light olive brown (2.5Y 5/6) sand; apedal loose; 65% fine to very coarse stones

Soil name and map symbol; Wantwood (Wt)

Concept and overview

Wantwood soils cover 8 ha and occur in a small area in the southwest part of the survey area. They are formed on a gently sloping surface from colluvial fan deposits that are derived from erosion of calcareous sandstone and siltstone rocks from the steep slopes of the adjacent Mt Heslington area. The soils are predominantly deep, well drained and fine textured, although have 5-10% of fine weathered siltstone fragments that give the soil a gritty consistence.

Relationship to previously named soils

In the survey of the soils of Waimea County *(Chittenden et al. 1966),* soils that were derived from calcareous shale and sandstone rocks outcropping on the lower slopes of the hills on the western side of the Richmond Range were separated as Heslington soils on the steep slopes and Wantwood soils on the undulating to rolling land of the lowermost slopes. The soils on associated small fans were included with Wantwood soils. The soils mapped in the present survey as Wantwood are consistent with those mapped previously.

Landform origin and history

Wantwood soils in the present survey are formed on low angle fan deposits derived from the north-facing slopes of Mt Heslington. These sediments overlie the Late Otirian Uh2 surface *(Johnston 1982)* on which Ranzau soils are formed and are thus younger in age than that surface. They probably represent sediments that were eroded from Mt Heslington during a late glacial, cool climate episode.

Key features and physical properties

Wantwood soils are well drained and have an A horizon that averages 24.5cm thick, with dark brown to dark brown colour and silt loam texture. The B horizon is around 65cm thick with yellowish brown colour and a silt loam texture and passes into slightly gravelly silt loam. Fine stones (<5mm) are common within the soil profile sometimes forming indistinct layering.

Identified variants

Shallow soil with a stony subsoil was identified in an area on the uppermost part of the fan surface while subsoil mottles may be present on the lower slopes where Wantwood soils grade into Lee soils.

Associated and similar soils

Wantwood soils are associated with Lee soils, which occur on the lowest lying toe slope surface of the fan and where the soils are imperfectly drained. Wantwood soils resemble Waimea soils in respect of their depth and colour but differ in having fine gravelly material present with a different lithology.

Soil versatility and landuse

Wantwood soils have a moderate to high versatility (1.2 Table 2) and there are few significant limitations for intensive use. They are currently used for nursery cropping and in the past have been used for intensive field cropping. They are included in class B of the Tasman District Council Classification system for land management.

Horizon	Depth	Description
A	0-28cm	very dark greyish brown (10YR 3/2) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; very friable; 10% fine stones; common fine roots
AB	28-32cm	very dark greyish brown and yellowish brown (10YR 3/2 + 10YR 5/6) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; 10% fine stones; few fine roots
B	32-70cm	yellowish brown (10YR 5/6) silt loam; moderately developed fine polyhedral and medium blocky structure; slightly firm soil strength; compact; friable; 10% fine stones; few fine roots
BC	70-100+	yellowish brown (10YR 5/8) silt loam; weakly developed fine polyhedral and medium blocky structure; slightly firm soil strength; compact; brittle failure; 20% fine stones

Soil name and map symbol; Lee (Le)

Concept and overview

Lee soils cover 16 ha and occur in a small area in the southwest part of the survey area near Heslington Road. They are formed at the foot of a gently sloping fan on fine textured colluvial fan deposits that are derived from erosion of calcareous sandstone and siltstone rocks from the steep slopes of the adjacent Mt Heslington. The soils are moderately deep to deep and imperfectly to moderately well drained. Fine siltstone fragments may be present giving the soil a gritty consistence.

Relationship to previously named soils

In the survey of the soils of Waimea County *(Chittenden et al. 1966),* soils that were derived from calcareous shale and sandstone rocks outcropping on the lower slopes of the hills on the western side of the Richmond Range were separated as Heslington soils on the steep slopes and Wantwood soils on the undulating to rolling land of the lowermost slopes. The soils on associated small fans were included with Wantwood soils but no associated soils with impeded drainage were separated.

Landform origin and history

Lee soils in the present survey are formed on the lower surface of a low angle fan, the deposits having been derived from the north-facing slopes of Mt Heslington. These sediments overlie the Late Otirian Uh2 surface *(Johnston 1982)* on which Ranzau soils are formed and are thus younger in age than that surface. Their impeded drainage is a result of water accumulation from higher ground through the fan sediments with slow transmission through the soil due to heavy textures.

Key features and physical properties

Lee soils are imperfectly drained to moderately well drained with a dark brown A horizon (average 24cm thick). The upper B horizon is sometimes brownish yellow or yellowish brown before passing into a strongly mottled horizon with a wide variety of colours from light greys to strong brown and reddish brown. The soil texture is predominantly clay loam and fine weathered stones (up to 10%) may be present. A watertable may be present at around 90cm depth.

Identified variants

Lee soils profiles vary in depth from moderately deep (average 77cm to gravel) to deep (>100cm). Moderately well drained soils were observed in 45% of the observations and imperfectly drained soils in 55% of the observations. Lee soils grade into Wantwood soils as the soil drainage conditions improve.

Associated and similar soils

Lee soils are associated with Wantwood soils, which occur on higher parts of the fan surface. Lee soils have similarities with Cotterell soils but the later are typically moderately well drained and have silty rather than clayey textures.

Soil versatility and landuse

Lee soils have a moderate to low versatility (2.6 Table 2) with some significant limitations for intensive use. Where they are moderately well drained, they are used in conjunction with Wantwood soils for nursery crops but elsewhere their use is pastoral. Lee soils are included in class D of the Tasman District Council Classification system for land management.

Horizon	Depth	Description
A	0-24cm	very dark greyish brown (10YR 3/2) clay loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; <2% fine stones; common fine roots;
AB	24-30cm	very dark greyish brown and pale brown (10YR 3/2+10YR 6/3) clay loam; moderately developed fine polyhedral and blocky structure; weak soil strength; compact; <2% fine stones; few fine roots
Bg1	30-40cm	pale brown (10YR 6/3) heavy silt loam; 5% yellowish red (5YR 5/6) fine distinct mottles; weakly developed medium blocky structure; weak soil strength; compact; brittle failure; <2% fine stones; few fine roots
Bg2	40-80cm	pale brown (10YR 6/3) sandy clay loam; 40% yellowish red (5YR 5/6) fine and medium distinct mottles; few rusty concretions; weakly developed medium blocky structure; weak soil strength; compact; brittle failure
BC(g)	80-90cm+	brown to dark brown (7.5YR 4/4) silt loam; 30% yellowish red (5YR 5/8) and 20% light brownish grey (2.5Y 6/2) distinct mottles; apedal; dense; water at 80cm

Soil name and map symbol Anthrophic (An)

Concept and overview

Anthropic soils cover 7 ha occurring chiefly in an area near the confluence of the Wai-iti and the Wairoa Rivers. Anthropic soils are soils that have been made by the truncation of natural soil by earth-moving machinery or by truncation and reinstatement after removal of subsoil material, commonly gravel. Anthropic soils are more widely distributed than is usually portrayed on soil maps, as the process of truncation and or reinstatement on a small scale is common on many farm properties, with terrace edges and small channels often being smoothed or infilled to facilitate land management. The Anthropic soils shown in this survey have been formed by gravel extraction for aggregate with soil and land restoration to a degree that agricultural use can be continued.

Relationship to previously named soils

No anthropic soils have been specifically mapped in earlier soil survey of Waimea County *(Chittenden et al. 1966).* Prior to their disturbance, they were considered to belong to the Waimea soil type (Waimea silt and sandy loam and Waimea gravelly loam) and Ranzau stony clay loam.

Landform origin and history

The anthropic soils shown in the present survey were originally Wai-iti or Redwood soils on the low terrace and floodplain system of the Wai-iti and Waimea River, although a small area near the entrance to the Wairoa Gorge was originally Brightwater soils.

Key features and physical properties

The anthropic soils are predominantly shallow with an indistinct, moderately stony, structureless sandy loam or silt loam textured surface horizon overlying similar, slightly lighter coloured moderately stony sandy loam. Underlying material is gravelly and variable, in places includes foreign substances such as clayey gravel, concrete clasts and a variety of organics which have been introduced for infilling. There is little evidence yet of reformation of an A horizon following their reinstatement.

Associated and similar soils

The soils most similar to the anthropic soils are the Wai-iti soils, which are formed on the most recently, deposited sediments of the Waimea River and which display little soil development.

Soil versatility and Landuse

The Anthropic soils have low to moderate versatility (2.3 Table 2) and moderate limitations for intensive use. The limitations include moderate available water capacity, stoniness, restricted rooting depth, low nutrients and increased flood risk due to ground level lowering. The soil disturbance due to its removal and replacement has resulted in a loss of soil structure and soil horizons, in particular, an A horizon with its associated nutrient pool and has probably diminished the soil moisture storage capacity and increased the soil moisture infiltration rate.

SOIL VERSATILITY ASSESSMENT

The purpose of land evaluation is to rate the quality of the land and soils within an area to provide an objective basis for land use decisions. In the past, Land Use Capability (*or LUC NWASCO 1979)* has been used with assessments made within an eight category system. However, the criteria used in this system are poorly defined and a limited number of attributes were used in the LUC assessments.

Molloy (1988) advanced the concept of using soil versatility as a means of rating arable land and proposed ten specific soil criteria to distinguish soils and land within specific classes. A highly versatile soil is one that is capable of growing a wide range of crops suited to its particular climate while on a soil with low versatility, the range of uses are restricted due to unfavourable soil properties. A similar approach while using different parameters was utilised by *Agriculture New Zealand (1994)* in a Classification System For Productive Land In The Tasman District with the soils of the region being assigned within an eight-class system similar to that of the LUC. scheme.

A comprehensive system proposed by *Webb and Wilson (1995)* for the evaluation of land included a set of parameters with critical values used to define class limits for suitability/versatility. They included topography, potential rooting depth, effective rooting depth, soil penetration resistance, profile available water, soil wetness, topsoil strength, stoniness, soil nutrient content, erosion severity and flood return interval. Climatic factors were also included for consideration when making regional assessments. Relative ratings are derived through ranking the various qualities in relation to one another in order to determine the suitability/versatility ratings. Accurate ratings however require physical laboratory measurements for some of the qualities.

REFERENCES

Agriculture New Zealand 1994. Classification System for Productive Land in the Tasman District. Agriculture New Zealand, Richmond.

Barrell, DJA, Almond, PC, Vandergoes, MJ, Lowe, DJ, Newnham, RM. 2013. A composite pollen-based stratotype for inter-regional evaluation of climatic events in New Zealand over the past 30,000 years (NZ-INTIMATE project). Quaternary Science Reviews 74 August p4-20.

Chittenden, ET, Hodgson, L, Dodson, KJ. 1996. Soils and Agriculture of Waimea County Bulletin 50. New Zealand Department of Scientific and Industrial Research.

Clayden, B, Webb TH. 1994. Criteria for defining the soilform – the fourth category of the New Zealand soil classification. Landcare Research Science Series 3. Manaaki Whenua Press. Lincoln, Canterbury, 36p.

Johnston, MR 1982. Part sheet N27-Richmond. Geological Map of New Zealand 1:50 000. Map (1 sheet) and notes (32p). Wellington, NZ Department of Scientific and Industrial Research.

Milne, JDG, Clayden B, Singleton PL, Wilson AD. 1995. Soil Description Handbook. Manaaki Whenua Press Lincoln, Canterbury, New Zealand.

*Molloy L. 1988***.** Soils in the New Zealand Landscape; Soils in the New Zealand Landscape; Living Mantle. Mallinson Rendel Publishers Ltd. Wellington New Zealand. 239p.

National Water and Soil Conservation Organisation (NWASCO) 1975-1979. New Zealand Worksheets: 1:63 360. Wellington, National Water and Soil Conservation Organisation.

Soil Bureau Staff 1968. General Survey of the Soils of South Island, New Zealand. NZ Soil Bureau Bulletin 27. NZ Department of Scientific and Industrial Research.

Webb, TH, Lilburne, LR. 2011. Criteria for defining the soil family and soil sibling the fourth and fifth categories of the New Zealand Soil Classification Landcare Research Science Series 3. Manaaki Whenua Press. Lincoln, Canterbury, 38p.