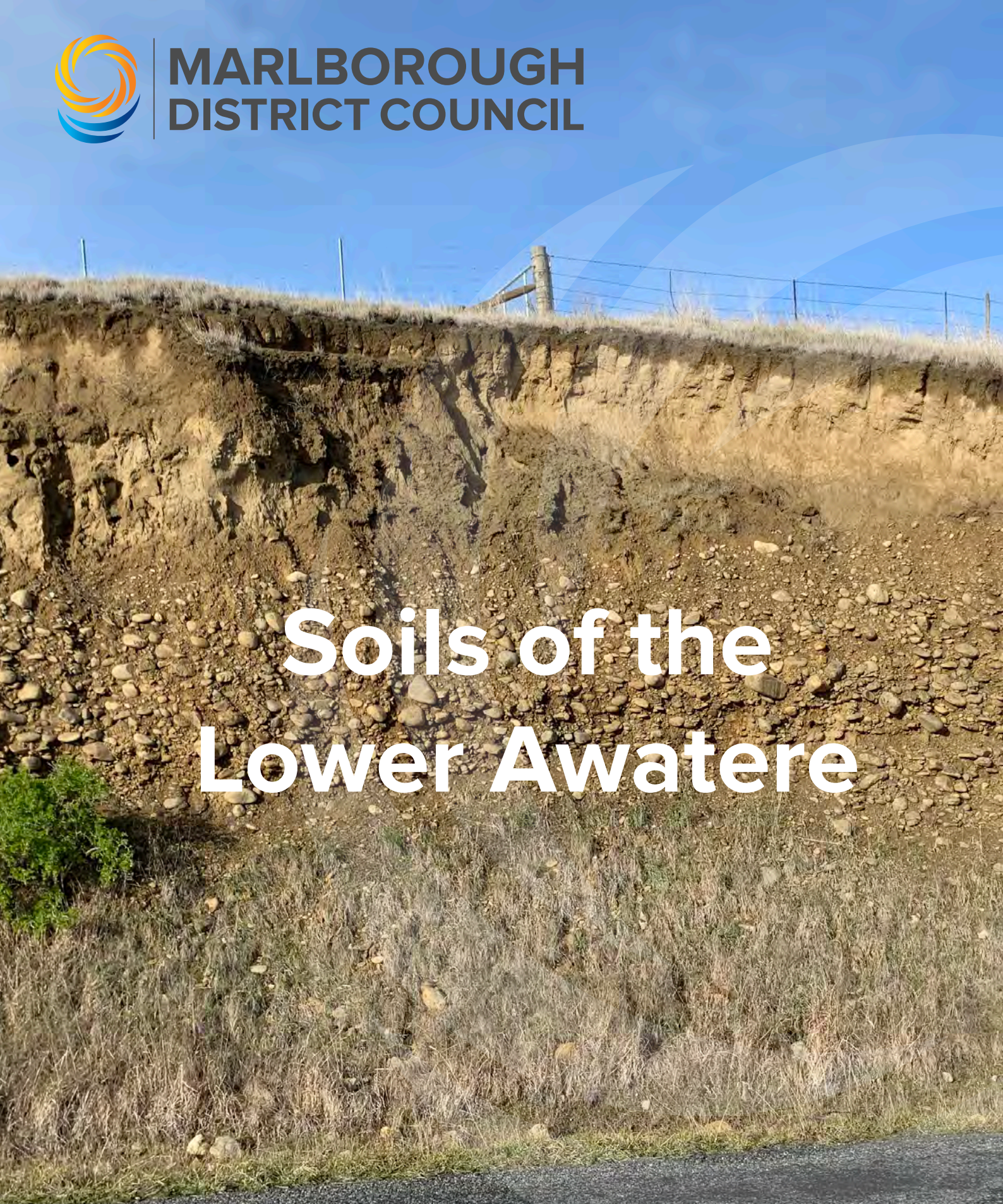
MARLBOROUGH DISTRICT COUNCIL



Soils of the Lower Awatere

Technical Report No: 20-001
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ISSN 1179-819X (Online)

ISBN 978-1-927159-92-7 (Online)

File Reference/Record No: E355-004-008-13/Record No: 20111863

July 2020

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Acknowledgements:

The Marlborough District Council wish to thank the landowners for providing access to their properties to allow soils to be sampled. This report would not be possible without the earlier field and lab work by Soil Bureau staff and Dr Iain Campbell's storage of that field and analytical data over the past 32 years.

Executive Summary

The soils that occur on 9500 ha of terrace lands in the Lower Awatere Valley, Marlborough, are described in this report, which is an accompaniment to the soil map for Awatere Valley of the Manaaki Whenua Landcare Research on-line S-Map series and the soil map of the Marlborough District Council web site. This report captures data that was acquired during a field survey undertaken by New Zealand Soil Bureau staff of the Department of Scientific and Industrial Research in the mid 1970's.

The soil distribution pattern over the survey area is largely fragmented because the Lower Awatere Valley is within an active tectonic environment and ongoing river downcutting has resulted in numerous discontinuous terrace surfaces. Approximately 75% of the soils in the mapped area are formed from river alluvium of which about 45% are shallow and stony. On the south side of the Awatere River, loess of variable thickness covers the higher elevation river terraces and the soils on this material occupy 25% of the surveyed area.

Twenty seven soil families are identified within the surveyed area. They differ widely in respect of their age and development status, their depth and stoniness, soil textures, physical properties, drainage attributes and also the parent materials from which they are formed. Soil chemical, physical and mineralogical properties for a range of the soils are given in the accompanying appendices.

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Soils of the Lower Awatere Valley

1. Introduction

Awatere Valley is one of four significant river valley systems that provide drainage for the Marlborough region. Located about 15 km to the south of Blenheim (Figure 1), the Awatere Valley lies along a northeast/southwest axis and is part of the north-eastern South Island complex structural fault system dividing the Pacific and Australian tectonic plates (Little & Jones, 1998; Spörli, 1980). The valley extends inland for 110 km with a catchment area of about 1620 km^2. The Awatere Valley lies predominantly within a mountainous zone, bounded by ranges on the north and western margins, where peaks are mostly between 1600-1800 m altitude and by the Inland Kaikoura Mountains on the southern side where the altitude reaches 2885 m.

Figure 1: Marlborough with the location of the Awatere Valley study area outlined in orange. State Highway One in red.

Over most of its length the valley floor is narrow and flanked by intermittent terraces. Inland, the valley floor is largely made up of discontinuous terrace surfaces which, together with low rainfall and severe winters, largely preclude intensive forms of farming. Around 35 km from the coast however, the valley floor widens, the terrace system is semi-continuous and well developed. With a more amenable climate this area is suited for intensive land use.

In 1974, the Ministry of Works and Development, the New Zealand Government Department, previously responsible for New Zealand infrastructure projects, proposed a border dyke irrigation scheme for the terrace lands of lower Awatere Valley, east of State Highway 1. In 1975, a soil survey of this area was undertaken by soil scientists from the New Zealand Soil Bureau Division of the Department of Scientific and Industrial Research to assess the suitability of the soils for the proposed irrigation scheme. The survey was subsequently extended to cover the terrace lands of the Lower Awatere Valley with a focus on flat to undulating land to about 32 km inland from the coast and field work was completed in 1978. A late decision to have the soil map published on a colour photogrammetric map necessitated the survey area being flown with colour photography and this led to a considerable delay in finalising the base map

and drafting the soil map. Compilation of the survey was subsequently abandoned with the disestablishment of the New Zealand Soil Bureau in 1988 and the Department of Scientific and Industrial Research in 1992. The field work notes, and analytical data gathered during the survey were preserved by the Dr Iain Campbell and by Landcare Research in the hope that funding could be found to publish a full map and soils report.

In 2007, Landcare Research, the successor organisation that took over soil science work previously undertaken by the New Zealand Soil Bureau, compiled the soil map from the original draft soil maps (Campbell unpublished, 2007) at 1:25,000 scale and on a Land Information New Zealand (LINZ) topographic base map. The soil map and information about the soils within the survey area are currently available through the Manaaki Whenua Landcare Research on-line S-Map series (https://smap.landcareresearch.co.nz/) and the Marlborough District Council web site (https://maps.marlborough.govt.nz/smartmaps).

This report describing the soils of Lower Awatere Valley is an accompaniment to that soil map. It has been compiled for the Marlborough District Council by Dr Campbell from the field data that was gathered prior to 1978. This report endeavours to provide sufficient information to landowners to enable more efficient management of their soils and to provide confidence that the mapped soils are well described.

2. Soil Survey Methods

The field work was carried out intermittently between 1975 and 1978, in part due to the prevailing soil and weather conditions. With low rainfall in the area and frequent drying winds, observations using soil augers were only practical within a small window of time each year, generally July-October when soil moisture conditions were favourable for deep auger soil inspections. Part way through the survey, a small non self-propelled drainage digger became available and greatly assisted the detailed examination of soils in deep profile pits and for later soil sampling.

Soil observations were made along numerous traverse lines, usually aligned between the river and the foothills which formed the boundary of the survey area. During the course of the survey more than 3200 auger observations were made along with 316 detailed soil profile pit examinations (observation frequency 1 per 2.7 ha). Soil auger observations typically recorded soil horizons and soil colours, soil texture, surface stoniness, the presence of mottles and depth to gravel. The soil pit descriptions recorded similar properties but with more detailed assessment of soil horizons, soil structure, soil consistence, mottle patterns, plant root distribution and soil stoniness. The detailed soil descriptions were recorded on cards with a standardised format to aid consistency of assessments. Auger observations were recorded in notebooks with data then transferred onto 1:4500 scale aerial photo field sheets and 1:15,840 scale NZ Mosaic map sheets. Soil boundaries were later redrawn with the assistance of air photo interpretation onto 1:15,000 scale photogrammetric transparencies.

At the conclusion of the field mapping, soils were sampled at 20 sites to provide characterising data for the range of soils within the survey area. The criteria for field description was based on the manual for New Zealand soil descriptions (Taylor & Pohlen, 1962), with some modifications to allow for more precise soil groupings. For this report, some of the soil data have been re-assessed using updated criteria which are now the New Zealand standards for soil profile descriptions. (Milne, Clayden, Singleton, & Wilson, 1995). Photographs of landscapes and soil profiles photographs accompanying the soil descriptions are recent images (2019) taken by the author specifically for this report.

3. Topography of the Survey Area

The area covered by the soil survey is approximately 9,497 ha (excluding river bed and terrace scarps) of the lower terrace lands of the Awatere River Valley, extending from the river mouth inland to a locality known as Woodman's Bend upstream from the confluence with the Medway river. The main topographic feature of the valley floor is a prominent terrace surface (Figure 2), referred to as the Starborough Terrace Set by Eden (1989). At the coast, this surface is approximately 35 m above river and sea level. Near Woodman's Bend the Starborough Terraces are 260 m above sea level and 52 m above river level giving a slope angle of 24 minutes or 7 metres per km.

Figure 2: Awatere Valley terraces viewed from Seaview Hill northwest over the Awatere River road and rail bridges. The foreground and middle-distance upper terrace surface are the dominant Last Glaciation aged landscape feature of the valley floor known as the Starborough Terrace set.

Throughout the length of the survey area, the Awatere River is incised into the terraced landscape, commonly with steep scarps separating the various terrace levels (Figure 3). These form six distinct terraces or sets of terraces known as the Starborough, Downs, Upton and Clifford Terrace Sets as well as the Muritai and Sherborne terraces, in order of increasing age (Eden, 1989). These terraces have formed due to sustained tectonic uplift and resultant down-cutting of the river through uplifted material (Figure 9). Periods of aggradation (accumulation of alluvium in the river) have also occurred which has contributed to the formation of the terraces. Aggradation has most likely occurred during cold climatic periods when increases in rainfall has led to increased erosion from high ground and deposition of that eroded material in the river valley (Eden, 1989).

The uppermost Starborough 1 Terrace surface is not continuous and is more extensive on the south side of the valley. There are several less distinctive surfaces than the Starborough 1 surface at lower elevations (Figure 3). These are designated Starborough 2-9, by Eden (1989) and tend to become progressively less continuous as terrace elevation and height above the river increase up-valley. The lowest surface (Starborough 9) is formed by the river flood plain and lies about 2-3 m above river level. The ground surface of the Starborough Terraces vary from smooth and planar to slightly undulating, sometimes with minor degradation terrace steps. The topographic variation results from ongoing river down-cutting, possibly associated with continuing tectonic activity and also to river flow channels formed at the time of alluvial deposition.

Figure 3: Multiple terrace levels of the Awatere River system. The surface with the power pylon (left of picture) and foreground is the Starborough 2 surface with the surfaces below representing stages in river down cutting.

In numerous places, fans ranging in size from around 2 ha to 300 ha, along with companion tributary streams spill onto and, in places, are dissected into, the Starborough terraces and older surfaces (Figures Figure 2, 5 and 6). The fans and associated sediments formed subsequent to the major aggradation and degradation events that gave rise to the upper Starborough Terraces. The larger fans must have developed in times when stream flows and rainfalls were greatly in excess of those observed today. Areas of wet land with impeded drainage occur on lower lying ground around the fan toe slopes.

Some of the streams have their own terrace systems, these having formed through subsequent stream downcutting. Drainage channels associated with the fan systems are for the most part very shallow (for example Starborough Creek and Richmond Brook) and in places meander along the upper Starborough Terrace surface for a considerable distance before crossing the terrace and joining the Awatere River (Figure 4). The lower reaches of Richmond Brook stream are incised 20 m into the surrounding terrace land but its upper reaches and also the channels of the other streams are incised <2 m below the surrounding landscapes.

In several places above the highest Starborough Terrace surface, remnants of an older and previously more extensive terrace is found (Downs Terrace Set, Eden (1989), Figure 6) while remnants of even older terraces (Upton, Clifford, Muritai, Sherbourne Sets) are found at higher elevations, elsewhere in the lower valley (Eden, 1989). The Downs surface is undulating and rolling, partly dissected and in places is also covered with younger alluvial sediments derived from tributary streams and detritus from adjacent hill slopes. Towards the west of the survey area, terraces are deeply dissected (about 45 m in the Upton Brook Stream system) and judged by the soil pattern this dissection may have taken place about the beginning of the Post Glacial period commencing about 12k years ago.

The Awatere fault has had an obvious influence on the terrace landscape with terrace surfaces ruptured in places resulting in discordant topography and interrupted natural drainage systems (Figure 7).

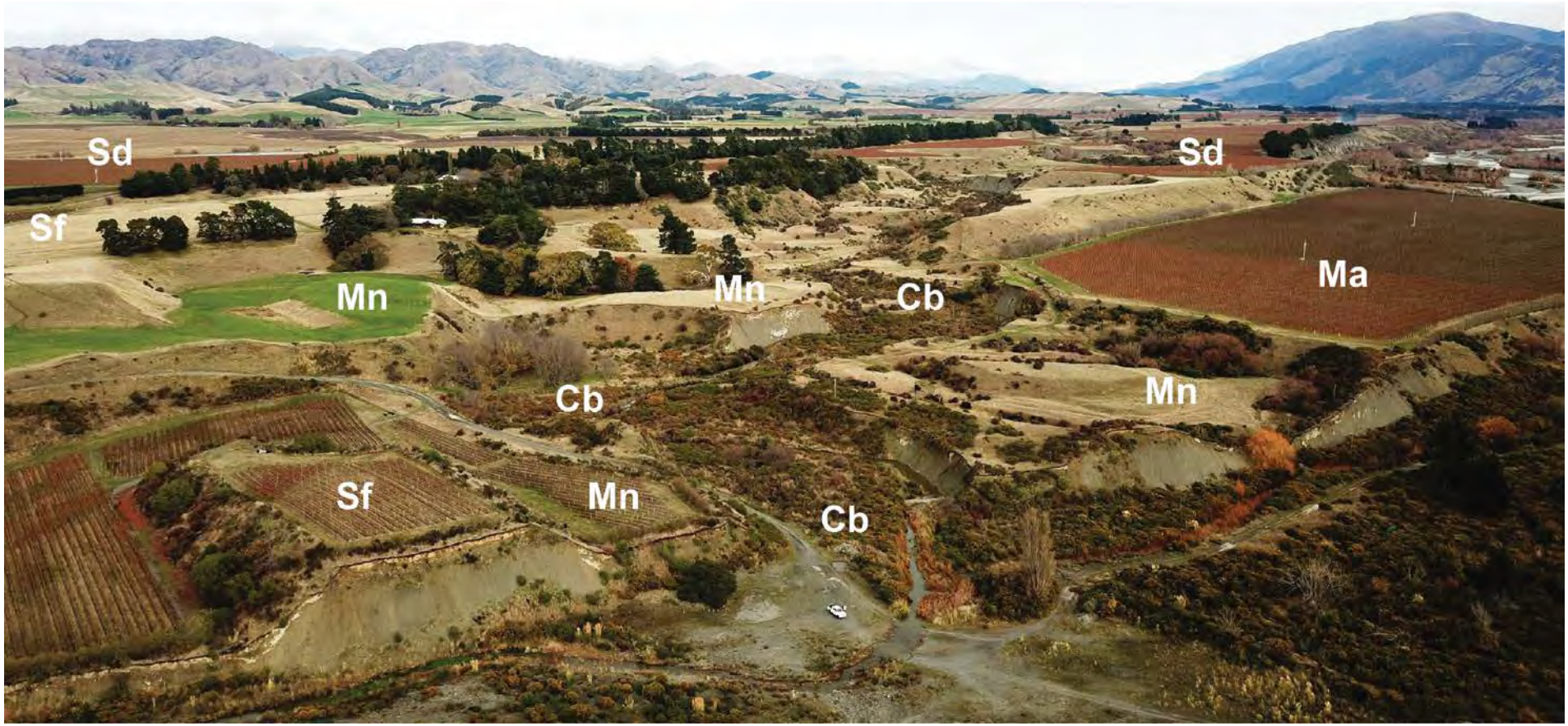

Figure 4: Richmond Brook, with its headwaters in the southern foothills has dissected the valley terrace land and is incised about 20 m, with stream lowering keeping pace with ongoing Awatere River down-cutting. The convoluted channel has numerous old cut-off meanders at different levels that indicate four or five intervals of stream incision. The result is a highly complex stream-valley soil pattern identified mainly as the older Stafford, younger Castlebrae soils and deeper Marathon soils.

Sf-Stafford, Sd- Seddon, Mn- Marathon, Cb-Castlebrae, Ma- Muratai

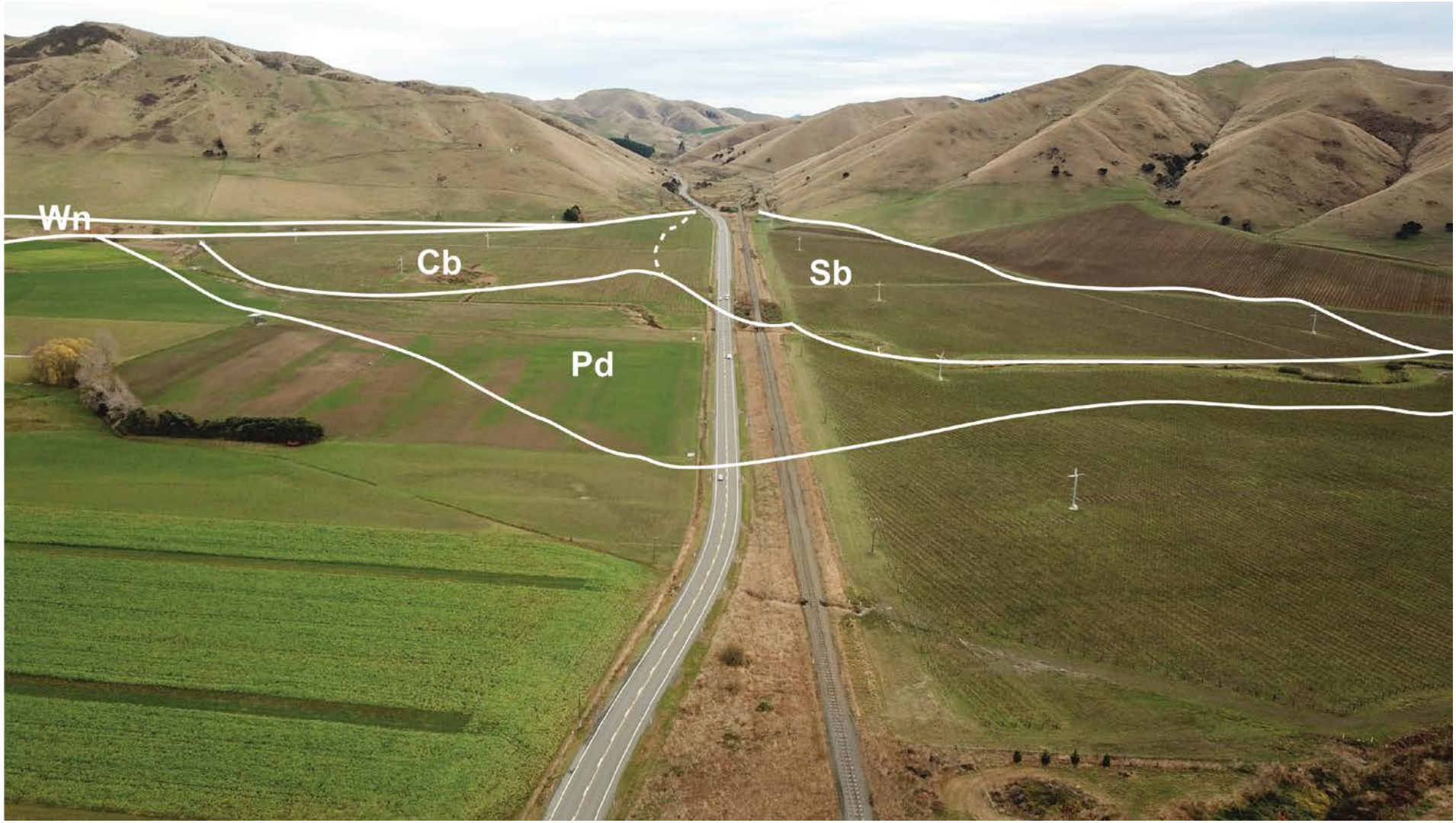

Figure 5: : The fan (70 ha) at the mouth of the valley leading to Dashwood Pass was constructed by sediment flows subsequent to the formation of the Upper Starborough Terrace surface and may represent a climatic period of more intense rainfall. There is a mixture of younger and older soils (Castlebrae, Starborough) on the upper fan surface and imperfectly to poorly drained Wainui soils in lower lying toe slope areas.
Wn- Wainui, Cb- Castlebrae, Sb- Starborough, Pd- Pinedale

Figure 6: Starborough 1 Terrace surface with Seddon soils (Sd) in the foreground. The undulating older Downs Terrace surface with Sedgemere soils (Sm) in the middle distance.

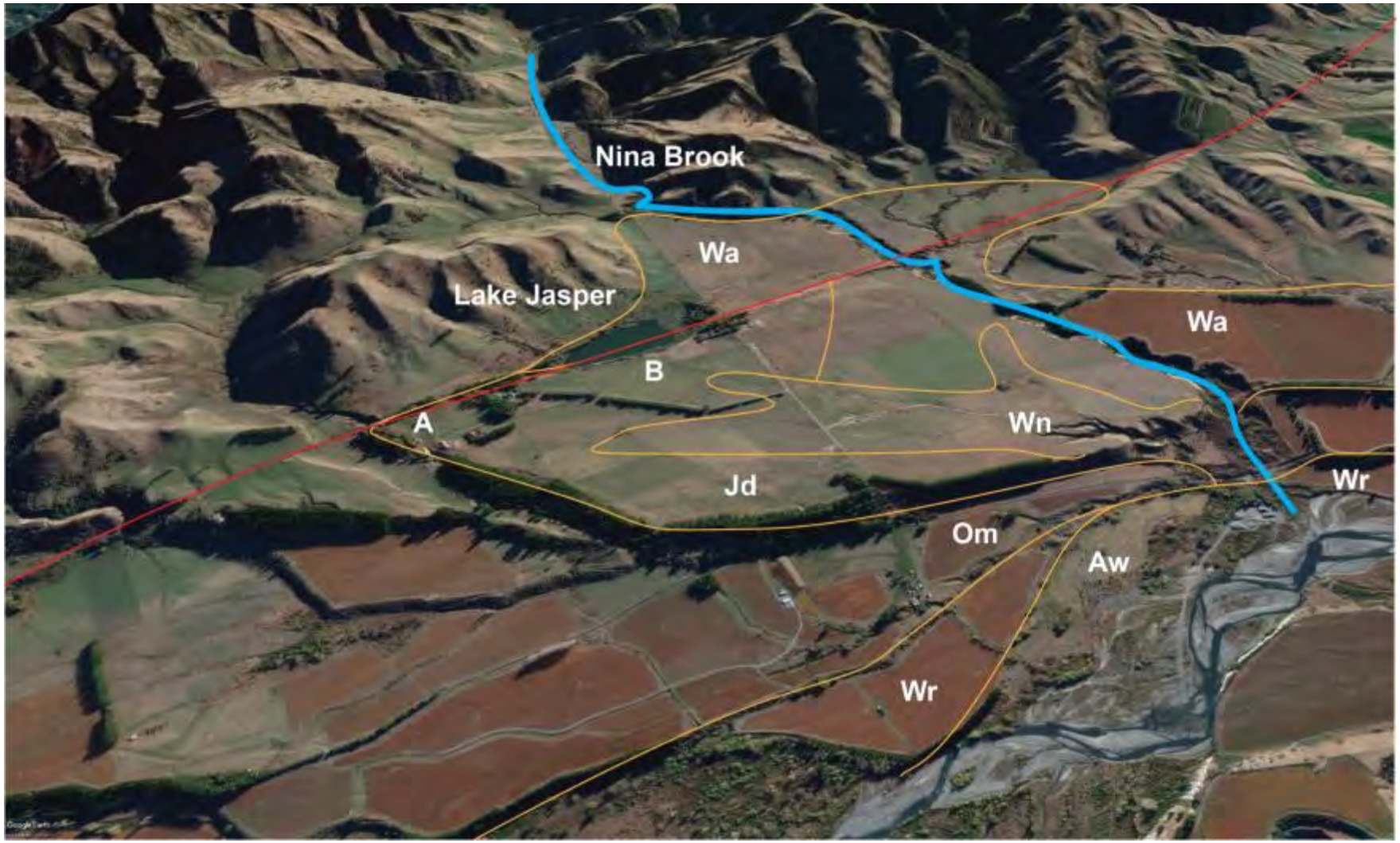

Figure 7: Tributary streams from side valley catchments (Nina Brook) have constructed fans over Late Last Glaciation (and older) terrace gravels with stony Warwick soils (Wa) on the fan surface. The red line marks the position of the Awatere Fault with a terrace edge offset of approximately 30 m at A. Lake Jasper (B) has formed on the northern boundary of the fault. Wainui soils (Wn) occur with impeded drainage. Jordan soils (Jd) are on an older surface (Downs Terrace). The younger lower terrace surfaces have Awatere (Aw), Wairau (Wr) and Omaka (Om) soils.

4. Soil Materials and Age of the Surface Deposits

In the survey area, terrace soils are formed predominantly from river alluvium and loess deposits. Locally derived alluvium and poorly sorted fluvial slope deposits (colluvium) provide parent material on tributary stream and fan surfaces. The river alluvium and terrace surfaces range in age from Late Last Glaciation (< 25k yrs BP - Vandergoes et al. (2013) on the upper Starborough 1 Terrace and become progressively younger at lower elevations (Holocene to Recent, <12k-<1K). On the Starborough Terrace 2 surface, the alluvium is mostly stony sandy gravel (Figure 8) with clasts ranging up to 50 cm and largely un-weathered.

The soil weathering depth is within the range of 80-100 cm which is comparable with weathering on alluvial gravels elsewhere in New Zealand that were derived from massive aggradations following the maximum of the Last Glaciation. The gravelly alluvium is up to 6 m thick (Figure 9) and rests on Tertiary sedimentary rocks of the Awatere Group (Roberts & Wilson, 1992). In the survey area, these are mainly mudstones and sandstones and can be widely seen in the exposures in the steep slopes that border the Awatere River. The Upper Starborough Terrace alluvium deposits are less extensive than similar aged alluvial gravels found in many other South Island valleys. This is probably because glacial activity within the Awatere catchment in the Late Quaternary was restricted to a few mountain glaciers on the northern slopes of the Inland Kaikoura Range thus limiting the supply of cold climate detritus into the fluvial system. Similar stony and often more bouldery alluvium (with boulders up to 70 cm) occurs on all the lower terraces, perhaps a reflection of climatic fluctuations after the cold climate maximum as well as tectonic changes within the region. Locally, the lower terrace gravels (Starborough 1-9) may be capped with a variable thickness of fine textured alluvium and sometimes loess on the higher terraces.

Figure 8:Starborough Terrace 2 surface with very stony and bouldery alluvium and Dashwood soils.

Figure 9: Steep slopes with exposures of Awatere Group Tertiary Starborough Formation (TSF) sedimentary rock bordering much of the river. Starborough 1 Terrace gravel (ST1) is overlain by 3-4 m of loess with later dissection (center/left) leaving thinner gravel and loess deposits. Here, river down cutting of around 60 m has taken place since deposition of the Starborough 1 Terrace gravels.

The river alluvium comprises predominantly Torlesse Supergroup rock (greywacke with a dominantly quartz/feldspar mineralogical composition) derived from the indurated sedimentary greywacke rocks to the west. There are some additions of Tertiary Starborough Formation sedimentary rock material (Roberts & Wilson, 1992) in the gravel fines derived from eroded river channel exposures. There is also a component of igneous material derived from volcanic rocks from within the Torlesse Supergroup (Baker, Gamble, & Graham, 1994; Challis, 1960; Grapes, Lamb, & Adams, 1992). Igneous material occurs within the Awatere catchment rocks as intrusions and dyke swarms and has a wide range of basic mineralogical compositions. This composition is reflected in the mineralogy of the sand fraction of the Dashwood soil (Appendix 3) which shows the presence of minerals such as Oligoclase Apatite, Hornblende, Augite, Olivine, Magnetite and Garnet, commonly found in volcanic rocks.

Subsequent to the deposition of Starborough Terrace 1 gravels, small streams with their headwaters in hills on the north and south sides of Awatere Valley deposited alluvium onto the Starborough and Downs Terrace surfaces, forming stream channels with alluvial sediments, minor terrace systems and in places alluvial fans (Figure 10). The soil materials for these ancillary deposits are derived from the adjacent hills and comprise greywacke, reworked older gravels, Tertiary sediments, loess, and in a few places, detritus of volcanic origin that has eroded from hillside materials. Judging by the areal extent of some of these fan deposits (Figure 5, 7, 10 and 11), it is likely that they may have accumulated in response to a period of extreme rainfalls, perhaps as global climate changed with the transition from the cool Late Pleistocene conditions to warmer Post Glacial Holocene conditions. The alluvial sediments of the ancillary streams mostly do not have the coarse bouldery characteristic of the Awatere River sediments but comprise gravels of smaller sizes generally with a silty matrix consistent with less active sedimentary conditions.

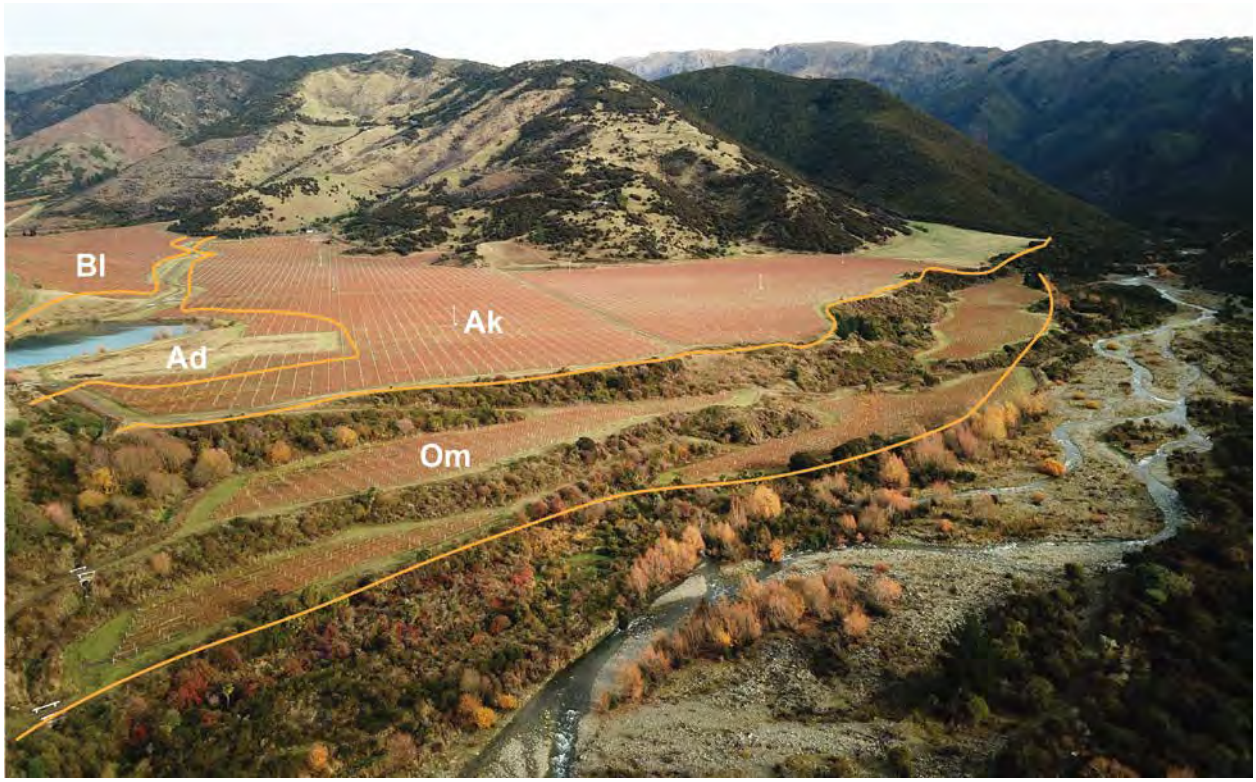

Figure 10: Black Birch stream. Note the minor stream terraces formed alongside the stream. Omaka (Om) and small areas of Wairau soils have formed on the minor terraces. Altimarlock (Ak), Awadale (Ad) and Blairch (Bl) soils have formed in the upper fan surface in igneous materials derived from the Black Birch range in the background.

Figure 11: A shallow stream channel, part of the Richmond Brook drainage system, crossing the undulating Downs Terrace surface. The soils are variable and include Castlebrae and Starborough soils near the stream and Ugbrooke soils further away. Sedgemere soils are on the undulating land in the middle distance.

Figure 12: Terrace scarp on the south side of the Awatere River. Seddon soils to the left of the picture, Seaview soils to the right formed in Downs Terrace Loess deposits on top of the terrace. Note the undulating surface on the top terrace.

Resting on the upper Starborough and higher Downs Terrace surfaces is an extensive overlay of loess principally on the south side of the valley (Figure 12). These air-fall materials were deposited over a long period of time in the Last Glaciation, starting prior to the Last Glacial Maximum (33.0-26.5k BP, Clark et al. (2009) and continuing until the Holocene (<12k BP) and even into recent time. The dating of the loess deposits is assisted by the presence of volcanic glass. This is most likely Kawakawa/Oruanui Tephra from Taupo (age 25.3ka BP, Vandergoes et al. (2013)) and occurs over a wide part of northern South Island (Campbell, 1986). The loess was probably derived largely from aggrading or degrading stony Awatere riverbed surfaces. Seasonal thawing during cold climate times resulted in massive floods of turgid waters that left deposits of silts and sands on the flood plain surface when water flows diminished. At times of low river flows in winter months, intense cold katabatic winds disseminated the residual surface fines over the adjacent land surfaces. Small dust clouds can sometimes be observed today in the Awatere Riverbed so some loess is still accumulating.

The loess deposits are widespread on surfaces on the south side of the river but minimal on the north side. The depth of these beds varies depending on age of the terraces. Starborough Terraces 3-9 have a covering of up to 1.5 metres. The older Starborough 1 and 2 terraces may have deposits as deep as 4 metres but are commonly 2-3 metres deep. The Downs and Upton Terraces can be more variable with 2-3 metres deposited over most of these surfaces but with depths of up to 10m in places. The oldest terraces (Clifford and Muratai) have the deepest loess deposits of between 9 to <20m in depth (Eden, 1989). The loess varies in texture across the survey area and in the thinner deposits is commonly underlain by a 10-20 cm sandy layer on top of the underlying gravel. The loess deposits generally become finer textured with increasing distance from the river with the sand fraction decreasing and the silt and the clay content increasing. (Table 1).

During the accumulation of aeolian material, dunes were formed in a few places on the terrace surfaces. The mineralogical composition of the sand fraction for the soils from loess (Appendix 3) is broadly similar to that for the Dashwood soil from alluvium, having essentially come from the same source. However, there are some mineral species present in the loess that are commonly found in metamorphic rocks and this could indicate that there have been accretions of aeolian material from the Wairau River system, where schist rocks are present and extensive loess deposits are also found.

Table 1: Particle size values (profile averages) for soils formed from loess. The younger loess materials and those nearest the Awatere River have higher sand and lower clay proportions. The higher clay and fine clay percentages in Sedgemere and Jordan soils are a reflection of greater soil age and weathering.

	Seddon	Seaview	Sedgemere	Jordan
Sand %	18	12.7	10.8	8
Silt %	54	55.8	54	52
Clay %	28	31	33	39

5. Climate

The climate for Awatere Valley is similar to that for much of eastern Marlborough with small differences in the overall pattern a consequence of topographic influences within the region. A detailed appraisal of the climate and weather of the region, (including assessments of rainfall intensities and variability, air and ground frosts, growing and heating degree days etc.) was given by Chappell (2016) as deduced from data from a number of permanent recording stations. The climate is classed as warm and temperate with a moderate supply of moisture and with average temperature of 10.8°C and average annual rainfall of 657 mm (Cfb or temperate oceanic climate, according to the Koppen-Geiger climate classification).

The general rainfall pattern for eastern Marlborough is shown in Figure 13. Rainfall is lowest in the coastal area on the south side of Awatere River and increases inland and on the north side of Awatere River due to the rain shadow effect of the northern hills. Rainfall is typically greatest in the months of July/August with least in February (Figure 14). The rainfall totals and distribution result in a soil moisture deficit in the months of January to April, a period of soil moisture recharge between the months of April and June, a period of soil moisture surplus between June and October and a period of soil moisture utilisation between October and January.

The period of soil moisture surplus from June to October is of significance for Seddon, Seaview, Sedgemere and Jordan soils which are formed from loess and to a lesser extent, Broadbridge soils (imperfectly drained on loamy alluvium). These soils have, to varying degrees, a hard pan or fragic soil horizon at around 70-100 cm depth which formed during the Last Glaciation cold climate conditions. This hard pan restricts the downward movement of water and during the months of water surplus, these soils become saturated at times of heavier rainfall events. Anaerobic conditions during periods of saturation in the subsoil horizons result in the distinctive mottle patterns that are present in these soils. The intensity of the grey and ocherous mottle colours is generally a reflection of the degree and extent of anaerobic conditions and soil wetness. Surface water ponding can sometimes be observed on Sedgemere soils in the months of September and October.

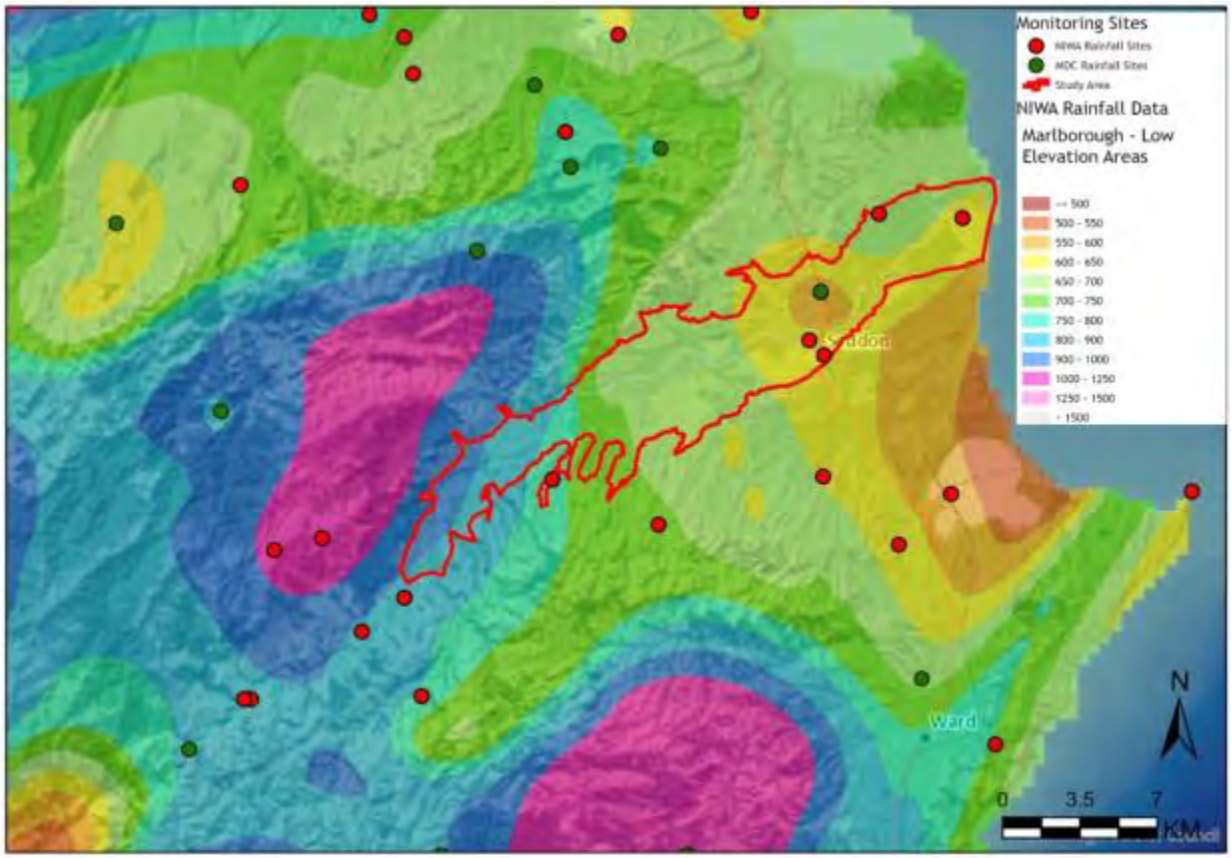

Figure 13: Rainfall isohyets for eastern Marlborough with the locations of Marlborough District Council and NIWA weather recording stations shown. An interactive version of this map can be found at: https://maps.marlborough.govt.nz/smartmaps. Look for Annual Rainfall Maps.

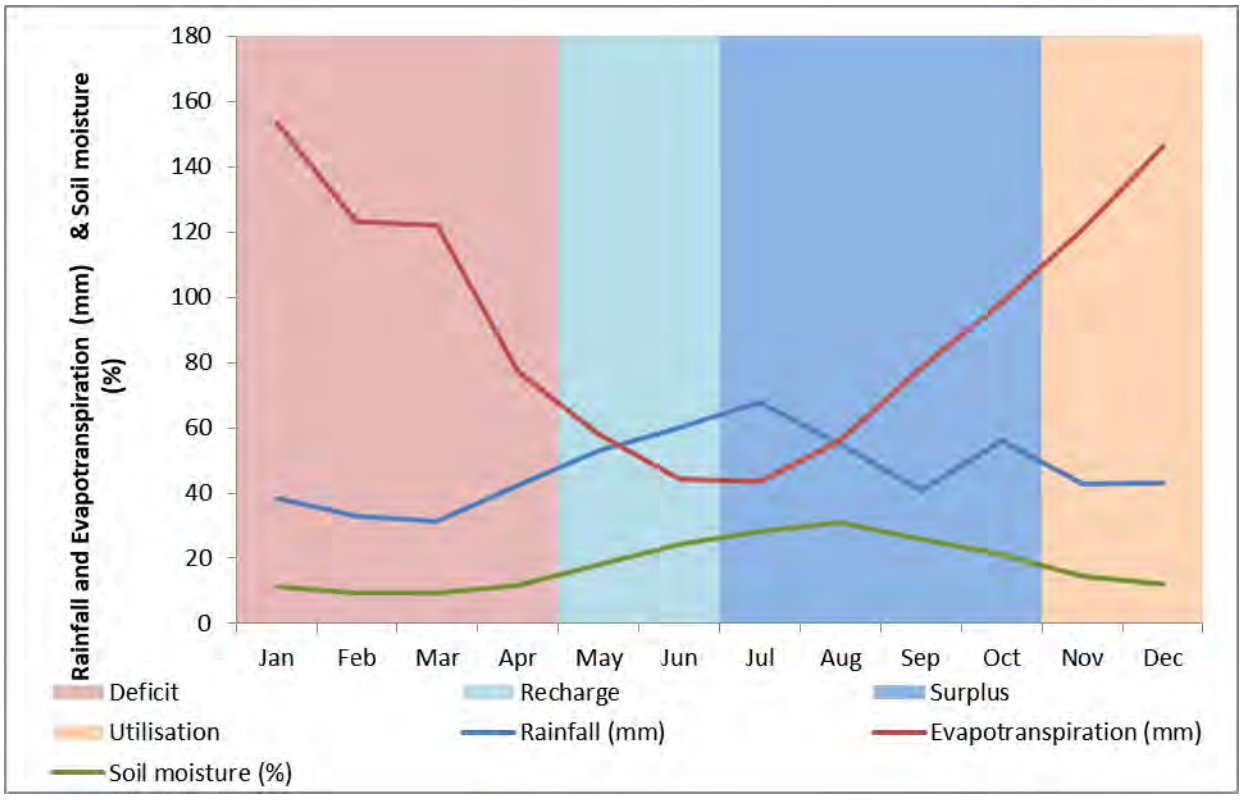

Figure 14: Rainfall, evapotranspiration and soil moisture for the Dashwood Weather station, Awatere Valley.

6. Distribution Pattern of the Soils

The distribution of the soil forming factors outlined above (parent materials, topography, climate) has dictated the locations and occurrences of the various soils described in this report. Further soil development has occurred through landscape dissection, soil moisture and sediment accumulation processes.

The location of where the lower Awatere Valley soils occur within the landscape is shown in Figure 15 and 16. For the purposes of this report, the soils are described within four terrace groups, low, intermediate, high and dissected. In general terms, low terraces correspond to Starborough 3-9 terraces, intermediate to Starborough 1-2, Downs and Upton, and high to Sherborne and Muratai. Dissected terraces occur on all terrace types. However the reader is cautioned against correlating these descriptors too closely as the low, intermediate, high and dissected classification does not correspond exactly to named terraces in some locations.

The soils of the lower terraces display features consistent with strong river flows at the time of deposition. The spatial distribution of alluvial material depends on the energy of the fluvial environment in which the sediments were deposited. High-energy environments such as channels of braided rivers can carry and therefore deposit relatively large particles (cobbles to boulders). Lower-energy fluvial environments such as found in Awatere Valley side streams will deposit finer-textured alluvium. Different components of the stream channel vary in their ability to carry and deposit sediment, and as the river or stream migrates across the landscape . These variations in water flow create soil features such as uneven ground surfaces with raised bouldery patches, sediments that include large boulders, high degree of variability soil profiles and relic river channels that can later fill with fine sediments or loess (Boettinger, 2005).

Soil age and degree of weathering increases with elevation and increasing surface age however, where side-stream sediments have been deposited on the broad terrace surfaces, younger less-weathered soils are found. The movement of water within these fan and stream drainage systems contributes to complexities in the soil pattern. Within these drainage systems, water from tributary streams can flow along low angle meandering pathways and saturate the surrounding area. In addition, intermittent flows from small fans on adjacent sloping land have associated impeded drainage areas at the bottom or toe slope position of the fan. These features give rise to areas of soils with impeded drainage properties.

The soils described in this report are discussed in order of their landform relationship as set out in Figure 15 and Table 2, beginning with the youngest soil (Awatere) on the lower-most land surface and progressing to the oldest soil (Jordan) on the higher land surface. A summary of the environmental setting and characteristics for each soil is given in Appendix 1. Results of chemical and physical analyses from the soil sampling that was undertaken in 1977 are given in Appendix 2. Sand mineral assemblages present in a selection of soils are given in Appendix 3.

Many of the soil map units described below include occurrences of other soils that may be present within the map unit. Where the soil patterns are complex, it is not possible to accurately assess (or map) the proportions of differing soils which may be included within the map unit. By convention, the first named soil within a double map unit symbol is considered to be the one of greatest extent, so the areas given do not indicate the exact extent of that particular soil.

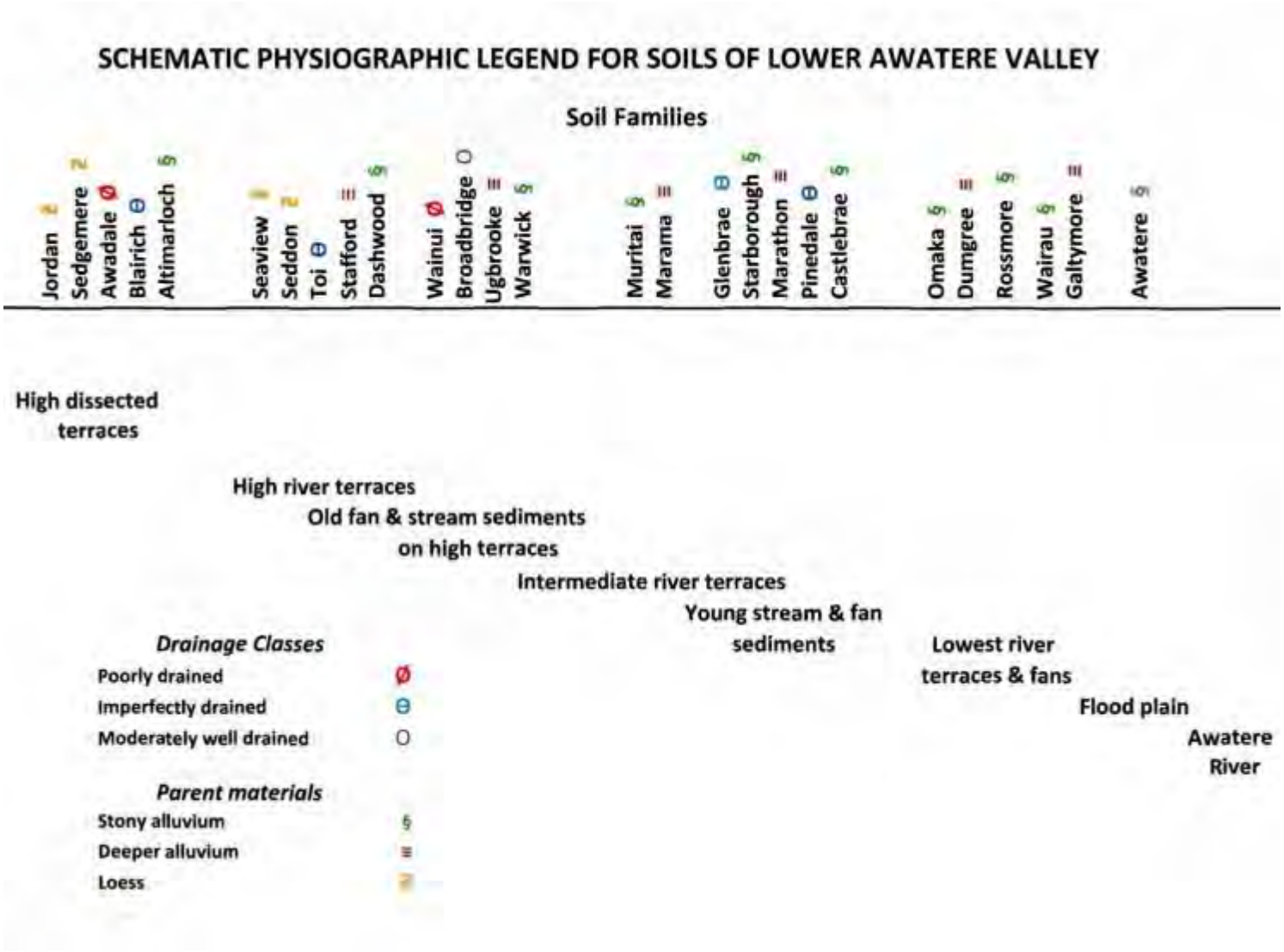

Figure 15: Landscape relationships for Lower Awatere valley soils.

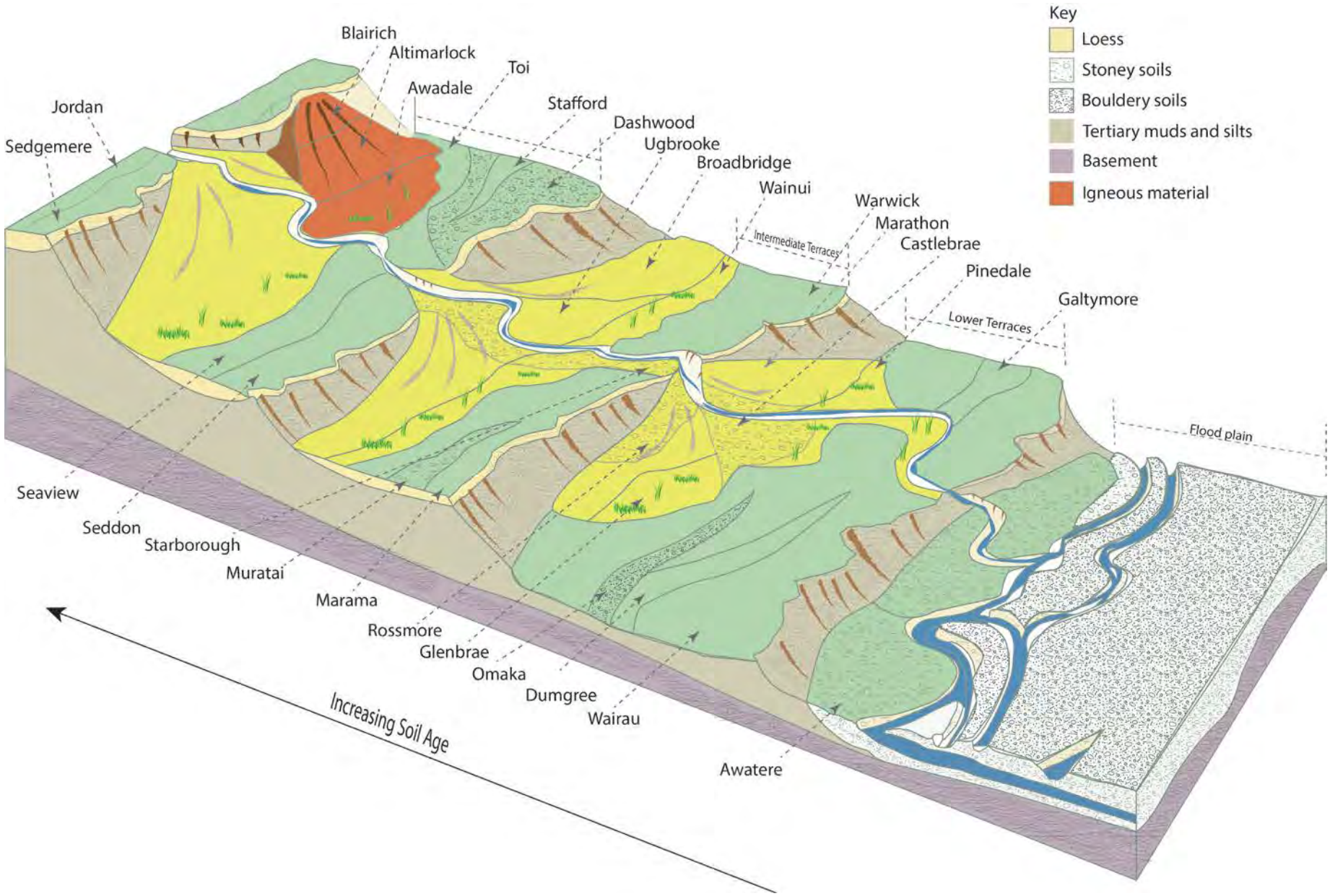

Figure 16: Graphical representation of the landscape locations of Lower Awatere Valley soils.

Table 2: Soils of Lower Awatere Valley, arranged by landscape position and soil drainage class.

Landform	Parent Material	Drainage	Soil Family name	Symbol	NZ Soil classification
Soils on the river floodplain	Coarse greywacke alluvium	Well drained	Awatere soils	Aw	RFT
Soils on the low river terraces	Coarse greywacke alluvium Loamy greywacke alluvium	Well drained	Wairau	Wr	RFW
			Galtymore	Gm	RFW
Soils on low stream terrace and fan sediments	Stony greywacke alluvium	Well drained	Castlebrae	Cb	RFT
	Loamy greywacke alluvium	Imperfectly drained	Pinedale	Pd	GRT
	Stony igneous alluvium	Well drained	Rossmore	Rm	RFT
Soils on the intermediate river terraces	Coarse greywacke alluvium	Well drained	Omaka	Om	ROW
			Muritai	Mt	PIT
	Loamy greywacke alluvium		Dumgree	Dg	ROW
			Marama	Ma	PIT
Soils on Intermediate stream and fan sediments	Stony greywacke alluvium	Well drained	Starborough	Sb	RFW
	Loamy greywacke alluvium		Marathon	Mn	RFW
	Loamy greywacke alluvium	Imperfectly to poorly drained	Glenbrae	Gb	GOT
Soils on the high river terraces	Stony greywacke alluvium	Well drained	Dashwood	Dw	PIT
	Stony greywacke alluvium		Stafford	Sf	PIT
	Mod. deep loamy alluvium over stony alluvium	Imperfectly to poorly drained	Toi	To	GOT
	Young loess over gravel or old loess	Moderately well drained to well drained	Seddon	Sd	PLM
			Seaview	Sv	PXJ
Soils on high tributary stream terraces and fans	Coarse greywacke alluvium	Well drained	Warwick	Wa	PIT
	Loamy greywacke alluvium		Ugbrooke	Ug	PJT
		Moderately well drained	Broadbridge	Bb	PPJ
		Poorly drained	Wainui	Wn	GOC
	Stony igneous alluvium	Well drained	Altimarlock	Ak	EMT
		Imperfectly drained	Blairich	Bj	EMM
		Poorly drained	Awadale	Ad	GOT
Soils on dissected high terraces	Old loess	Imperfectly to moderately well drained	Sedgemere	Sm	PXJN
			Jordan	Jd	PUJ

7. Soil Descriptions

The representative soil descriptions given in the following pages are from records made at the time that the field work was undertaken. The soil profile photographs accompanying these descriptions are recent images from different sites and while they are not an exact match with the accompanying descriptions, they illustrate the essential features for the soil family.

7.1. Flood Plain Soils

7.1.1. Awatere soils

Map symbol: Aw1bG

Area: 201 ha; 27 auger observations plus 7 pit descriptions

Reference

Awatere soils were not identified as a separate family in earlier surveys within the region and the name was introduced in this survey to include the raw to very weakly developed and predominantly well drained soils on the river flood plain surfaces. They were previously included with Wairau and Upper Wairau gravelly sand and Wairau sandy loam in an earlier 1:250 000 scale survey of the soils of Awatere, Kaikoura and Marlborough Counties by Gibbs and Beggs (1953). In the 1:250,000 scale General Survey of the soils of South Island (Soil Bureau Staff, 1968) they are included with Waimakariri Set.

Distribution, environment and soil materials

Awatere soils are mapped at 38 locations ranging from 2-21 ha in size on land up to about 3 m above river level on the floodplain surface of Awatere River. Being in an unstable sedimentary environment, their present day distribution differs from that shown at the time of the soil mapping, with the river meandering during flood flows removing some areas and creating new ones. They occur over an elevation range of between 5-210 m above sea level and within a rainfall range of about 630-850 mm. The soil parent material is very recent river alluvium from greywacke with some additions of igneous and tertiary sedimentary rock materials

Characteristics and distinguishing features

Awatere soils as mapped are a complex unit with a wide range profile depths, textures and stoniness. They are distinguished by a very weakly developed profile form (A/C horizons only) typically with a thin to moderately thick (or sometimes non-existent) A horizon overlying a structureless sandy textured C horizon subsoil with negligible oxidation through weathering. Surface stones or boulders are common and the thickness of sandy material over stony gravel is variable. Profiles with silt loam texture occur in places.

Range of profile features, variation and distinctions

A horizon colour varies from brown (10YR 5/3) to olive (5Y 4/3). Profile textures vary between sand, sandy loam and silt loam, and depth to gravel from stony surface to 75 cm depth.

Castlebrae soils are similar in respect of soil profile development but occur on recent stream sediments, away from the Awatere River and on higher terrace surfaces where stream or fan alluvium has accumulated and they commonly have stones throughout the soil profile.

Analytical features (SB9373 Appendix 2)

This soil is very weakly leached and un-weathered, as suggested by the very low Tamm's extractable Fe values. The organic carbon values are very low, while very high values for H_2SO_4 P values and the low organic P values express the lack of weathering and youth-full nature of the soil. Bases are low and BS% values are very high. Clay content is low and is an expression of the absence of soil weathering and reflects the recent sedimentary environment of the soil material.

Representative profile: Awatere loamy sand (Aw1bG)

Horizon	Depth	Description
A	0-8 cm	dark greyish brown (2.5Y 4/2 loamy sand, weakly developed fine polyhedral structure, weak soil strength, loose, very friable, many fine roots
C1	8-28 cm	olive (5Y4/3) sand, apedal, very friable, loose, few fine roots
C2	28-52 cm	olive grey (5Y 4/2) sand, apedal, loose, few fine roots
C3	52-70 cm	olive grey (5Y 4/2) stony sand, apedal, loose, few fine roots

7.2. Low River Terraces and Fan soils

7.2.1. Galtymore soils

Map symbols: Gm1sG, Gm0sG

Area: 120 ha; 53 auger observations plus 6 pit descriptions

Reference

Soils on the low terrace surfaces of the Wairau, Awatere and other river valleys were mapped by Gibbs and Beggs (1953) as Wairau gravelly sand and Wairau sandy loam where the soils were deeper. They were included with Waimakariri Set in the General Survey of Soils of South Island (Soil Bureau Staff, 1968). In this survey, soils with profiles >45 cm to gravel are separated from Wairau soils as Galtymore soils.

Distribution environment and soil materials

Galtymore soils were mapped in 21 locations in areas from between 1-21 ha. They occur on the lowest river terrace up to about 8 m above the flood plain (Awatere soils) surface. They are found along the length of the river between 7-175 m altitude and over a rainfall range of about 630-825 mm. The soil parent material is recent river alluvium from greywacke with some addition of igneous and tertiary sedimentary rock. No recent buried soils were observed in this mapping unit indicating that the surface is essentially above flood level. Land surfaces are predominantly even but with minor ridge and swale micro-topography due to the old river flow patterns.

Characteristics and distinguishing features

Galtymore soils are moderately deep (Gm1sG 45 - 90 cm over gravel) and deep (Gm0sG >90 cm over gravel) with soil texture predominantly sandy loam in upper horizons and becoming sandier with increasing depth. Soil horizon development is weak (A/(B)/C) with the B horizon exhibiting only slight oxidation with olive brown to light brown colouration to a soil depth of around 45 cm and olive colours below.

Range of profile features, variation and distinctions

Textures in A horizons range from sandy loam to fine sandy loam and in B and C horizons from silt loam to sand. A horizon colours vary between brown (10YR 4/3) and dark greyish brown (10YR 3/2) while B horizon colour ranges between olive (2.5Y 4/4) and brown (10YR 4/3). The mean depth to gravel for Galtymore moderately deep soils was 55 cm and for Galtymore deep sandy loam 91 cm.

Wairau soils have a similar degree of soil development to Galtymore soils but are shallow soils, often stony throughout and in places with surface boulders and can occur with or grade into Galtymore soils.

Analytical features

No analyses were undertaken for Galtymore soils, but the chemical properties can be expected to be similar to those found in the Wairau soils.

Representative profile: Galtymore sandy loam (Gm0sG)

Horizon	Depth	Description
A	0-20 cm	very dark greyish brown (10YR 3/2) sandy loam, weakly developed fine polyhedral structure, compact, friable, many fine roots
(B)	20-38 cm	olive brown (2.5Y 4/4) sandy loam, weakly developed fine polyhedral structure, compact, very friable, many fine roots
C	38-100 cm	olive (5Y 4/3 sandy loam, apedal, loose, few fine roots

7.2.2. Wairau soils

Map symbol: Wr4sG^B, Wr3sG, Wr2sG

Area: 355 ha; 110 auger observations plus 8 pit descriptions

Reference

Wairau soils were first mapped in a survey of Wairau Valley, east of Renwick by Harris and Birrell (1939) and included Upper Wairau sandy loam, meadow phase and shallow phase on low terrace surfaces that were frequently flooded. Wairau gravelly sand and Wairau sandy loam were also mapped in Awatere Valley by (Gibbs & Beggs, 1953). They were included with the Waimakariri Set in the General Survey of Soils of South Island (Soil Bureau Staff, 1968). The three units separated in this survey are:

- Wairau very stony bouldery gravel (>70% stones, Wr4sG^B),
- Wairau stony sandy loam (35-70% stones, Wr3sG) and
- Wairau shallow sandy loam (<45 cm to stony gravel, Wr2sG).

Distribution, environment and soil materials

Wairau soils are mapped in 50 locations in areas from around 1 to 80 ha. They occur on the lowest terrace surface of the Awatere River and also Black Birch Stream and lie within the elevation range of 7-200 m above sea level and within the annual rainfall range of 630-850 mm. The soil parent material is predominantly recent very stony or bouldery river alluvium from greywacke with some addition of igneous and tertiary sedimentary rock. Greater quantities of igneous material were noted in the Black Birch Stream sediments which directly drain greywacke terrain that contain volcanic rock intrusions. The land surface is commonly uneven with a shallow ridge and swale micro-topography resulting from former river flow patterns.

Characteristics and distinguishing features

Wairau soils are young soils with weakly developed features typically with an A/(B)/C profile form. Soil weathering is confined to weak oxidation to a depth usually <50 cm with (B) or B horizon colour brown to olive brown (10YR 4/3-2.5Y 4/4). Coarse material is predominant in most profiles reaching 70% and ranges from small sizes through to boulders with bouldery material abundant in places. Soil structure development is weak and sandy textures dominate the fine fraction.

Range of profile features, variation and distinctions

The A horizon thickness ranged between 15 and 31 cm with colour between greyish and brown, depending on organic matter content, soil textures varied between sand and fine sandy loam and the mean thickness of fine material over gravel was 24 cm (range 15-42 cm). Changes between Wairau shallow, stony and bouldery soils can occur over very short distances due to river flow patterns on the land surface. Galtymore soils are present in places where the depth of fine material over gravel exceeds 45 cm. Castlebrae soils have similar weathering profiles to Wairau soils but have silty textures and coarse stones are generally absent.

Analytical features (SB9372 Appendix 2)

Wairau soils have low organic C and N values, high phosphorous and base saturation values, and medium to low exchangeable bases, commensurate with its weakly weathered and weakly leached status. The youthfulness of the soil is further indicated by the high sand and low clay content shown in the fine fraction analyses.

Representative profile: Wairau shallow loamy sand (Wr2sG)

Horizon	Depth	Description
A	0-31 cm	greyish brown to very dark greyish brown (10YR 4/2-3/2) loamy sand, weakly developed fine polyhedral structure, compact, very friable, few stones, abundant fine roots
B	31-57 cm	brown to olive brown (10YR 4/3-2.5Y 4/4) sand, weakly developed fine polyhedral structure, very friable, abundant stones and boulders, many fine roots
C	37-80 cm+	bouldery gravel, apedal, loose

7.2.3. Rossmore soils

Map symbol: Rm3sG

Area: 8.5 ha; 6 auger observations plus 1 pit description

Reference

Rossmore soils have not been previously identified or mapped. Although small in area, these soils are separated because of their distinctive characteristics, having been formed from recently deposited reworked volcanic materials. The nearest relationship is with Middlehurst soils (Gibbs & Beggs, 1953; Soil Bureau Staff, 1968) which are soils within the Awatere district (but outside the survey area) that are formed on in-situ volcanic materials including marine basalt, flows and tuffs.

Distribution, environment and soil materials

Rossmore soils occur in 3 small areas (<1-4.5 ha) on a low river terrace surface of the Awatere River, about 2 km Southwest of Black Birch Stream. They are formed on small fan deposits of recently deposited igneous materials that originated from erosion of volcanic rock dyke intrusions in greywacke found within hill side gullies that are dissected into adjacent steeply sloping valley sides. The small fans are at an altitude of between 180-200 m and lie at the base of a steep escarpment, above which is an old terrace remnant (80 m above, Downs or Upton Terraces, Eden, 1989) with more extensive deposits of reworked volcanic materials. Periodic erosion on the steeper valley hill sides transported debris down gullies to be deposited on the fan surfaces formed on the lower Awatere terraces.

Characteristics and distinguishing features

Rossmore soils are distinguished by reddish brown colours throughout the profile, somewhat typical for soils from volcanic materials, but soil horizon development is not well advanced with an A/(B)/C profile form and a shallow soil weathering depth while stony material is dominant within the profile. Layers of buried former soils were observed and are indicative of periodic accumulations of sediments onto the fan surfaces.

Range of profile features, variation and distinctions

While Rossmore soils are predominantly stony, the texture of the fine fraction varies from silt loam to sand. The coarse fraction is mainly fine to medium stones but boulders may be present. Altimarlock soils occur nearby and are also formed from reworked volcanic material but they occur on a higher and older land surface (Figure 15), are more weathered with finer texture and fewer stones in the profile.

Analytical features

There are no chemical or analytical data available for this soil, but the soil chemistry can be expected to have similarities with Altimarlock soils (Appendix 2).

Representative profile: Rossmore stony sandy loam (Rm3sG)

Horizon	Depth	Description
A	0-24 cm	dark reddish brown (5YR 3/2) stony fine sandy loam, weakly developed fine polyhedral structure, weak soil strength, loose, abundant small and medium partly weathered igneous stones, many fine roots
B	24-45 cm	dark reddish brown (5YR 3/4) stony sandy loam, weakly developed fine polyhedral structure, weak soil strength, loose, many fine and few coarse stones, many fine roots
C	24-45 cm	dark reddish brown to dark brown (5YR 3/3 7.5YR 3/2) sandy gravel, apedal, loose, abundant small to large stones, many fine roots
bB	67-100 cm	reddish brown (5YR 4/3) sandy loam, weakly developed fine polyhedral structure, weak soil strength, compact, abundant fine to coarse stones, few fine roots

7.2.4. Dumgree soils

Map symbols: Dg1sG, Dg0sG

Area: 195 ha; 99 auger observations plus 11 pit descriptions

Reference

Dumgree soils have not been previously separated but were included within the Omaka and Upper Wairau sandy loam map units in the initial survey by Gibbs and Beggs (1953). They were included with Eyre-Paparua Set in the General Survey of Soils of South Island (Soil Bureau Staff, 1968). They are mapped here as moderately deep (Dg1sG) to deep sandy loam to silt loam soils (Dg0sG). They occur together with Omaka soils on the uppermost low terrace of the Awatere River. They are separated from Omaka soils which are stony and shallow.

Distribution, environment and soil materials

Dumgree soils have been mapped in 17 locations in areas from 1-26 ha, between 10-210 m above sea level and within the mean rainfall range of 625-825 mm. They occur in irregular shaped areas that relate to river flow and depositional processes of the Awatere River. The ground surface is commonly uneven with a ridge and swale topography (1-1.5 m) resulting from flow channelling when the surface was the former flood plain. The soil material is fine textured Awatere River alluvium over bouldery gravel that is derived predominantly from greywacke rocks with some additions of igneous materials and Tertiary sedimentary rocks.

Characteristics and distinguishing features

Dumgree soils are well drained, moderately deep and deep with sandy loam to silt loam textures and weakly to moderately weathered soils (profile form A/B/BC/C) indicative of a relatively youthful age. The B horizon depth is seldom >60 cm. Dumgree moderately deep and Dumgree deep soils have similar physical characteristics, apart from the depth to gravel.

Range of profile features, variation and distinctions

The A horizon thickness averaged 24 cm with B horizon thickness between 12-25 cm. A Horizon colours were dark grey-brown while the B horizons were dark brown coloured. Unweathered C horizon material was present between 60-80 cm. The soils have weakly to moderately developed structure, consistent with a youthful age. The average depth to gravel for Dumgree moderately deep soils was 63 cm and for Dumgree deep soils, 98 cm.

Within the Dg1sG and Dg0sG map units, Dumgree soils grade over short distances into moderately stony, stony or bouldery Omaka soils which were found to be present in 20% of the observations. In a few places such as channel hollows, (7% of observations) subsoil textures were heavy silt loam to clay loam and subsoil mottles indicative of impeded drainage were present. Dumgree soils have formed in river alluvium and have resemblances to Castlebrae soils which have formed in finer textured stream alluvium.

Analytical features (SB9374 Appendix 2)

Values for carbon, nitrogen and cation exchange capacity are low in the sampled soil, values for exchangeable cations are in the medium range while values for phosphorous and base saturation are very high. These chemical characteristics are a reflection of the weakly weathered nature of the soil.

Representative profile: Dumgree fine sandy loam (Dg0sG)

Horizon	Depth	Description
A	0-24 cm	very dark greyish brown (10YR 3/2) fine sandy loam to silt loam, moderately developed fine polyhedral structure, weak soil strength, compact, friable, many fine roots
Bw	23-39 cm	brown to dark brown (10YR 4/3 silt loam, moderately developed fine blocky and polyhedral structure, weak soil strength, friable, many fine roots
BC	39-59 cm	olive brown (2.5Y 4/4) silt loam, weakly developed fine blocky and polyhedral structure, weak soil strength, compact, friable, few fine roots
C	59-84+	olive brown to light olive brown (2.5Y 4/4-5/4) fine sandy loam, apedal, compact, slightly firm, few fine roots

7.2.5. Omaka soils

Map symbol: Om4sG^B, Om3sG, Om2sG

Area: 427 ha; 170 auger observations plus 13 pit descriptions

Reference

Omaka soils were first mapped by Harris and Birrell (1939) for the weakly to moderately developed soils adjacent to the Omaka River in Wairau Valley. They were shown as being much more extensive in Wairau Valley in the 1:250,000 survey by Gibbs and Beggs (1953)and were also mapped with Wairau soils on the younger terrace sets in Awatere Valley in that same survey. The 1:250,000 survey of the soils of South Island (Soil Bureau Staff, 1968) showed these low terrace soils as belonging to the Eyre-Paparua Set. Omaka soils mapped in this survey are comparable with the concepts of the earlier surveys and the deeper soils are here separated as Dumgree soils. The three units separated are:

- Omaka bouldery sandy loam (Om4sG^B),
- Omaka stony sandy loam (Om3sG) and
- Omaka shallow sandy loam (Om2sG).

Distribution, environment and soil materials

Omaka soils are mapped in 35 locations in areas from about 1.5 ha to 50 ha and occur on the uppermost surface of the low terrace system. They are characterised by predominantly bouldery river gravel sediments with an uneven ground surface, sometimes with raised lenticular bouldery patches caused by old river-flow channelling. The bouldery nature of the sediments and the ground surface features suggest strong river flows at the time of deposition, perhaps <5k years ago, judged by the degree of soil weathering. Omaka soils occur from near the coast to the inland margin of the survey area, predominantly on the north side of Awatere River between 20-215 m above sea level and within a rainfall range of 675-850 mm. Near the coast, the surface on which Omaka soils are formed is about 6 m above river level and near Woodman's bend, 17 m above river level.

Characteristics and distinguishing features

Omaka soils are classed as well drained but rapid loss of water from the soil due to the bouldery/sandy texture renders the soil drainage somewhat excessive. Omaka bouldery sandy loam has many surface boulders, Omaka stony sandy loam may be stony to the surface or have a thin cover of fines over stony gravel. Omaka shallow sandy loam has a deeper cover of sandy loam or slightly stony sandy loam with stony gravel within 45 cm from the surface. In some places, surface boulders have been removed and the soils resemble Omaka shallow sandy loam.

Omaka soils are weakly weathered (profile form A/B/BC/C) with a dark brown to dark yellowish brown coloured B horizon and olive coloured and unweathered C horizon bouldery gravels within approximately 60 cm of the surface. Soil structure is weakly developed. For Omaka bouldery soils, the fine fraction texture was mainly sandy.

Range of profile features, variation and distinctions

The mean depth to gravel for Omaka stony soils was 25cm with a similar depth for Omaka shallow sandy loam (range 10-45 cm). Within the Omaka soil map units, changes in stoniness occur over short distances and deeper soils (Dumgree soils) were found within the Omaka mapping units in 28% of the observations so these units are quite variable. Omaka and Wairau soils have similar textural characteristics but the Wairau soils are younger and have less developed profiles. Castlebrae soils show a similar degree of profile development to Omaka soils but Castlebrae soils are somewhat less bouldery and have a higher clay content due to their formation from finer textured stream alluvium.

Analytical features

No chemical analyses were carried out for this soil but its analytical properties would be expected to have similarities those for the Dumgree soil with which it is closely related.

Representative profile: Omaka shallow sandy loam (Om2sG)

Horizon	Depth	Description
A	0-24 cm	very dark greyish brown (10YR 3/2 sandy loam, weakly developed fine blocky and polyhedral structure, weak soil strength, compact, friable, few greywacke stones, many fine roots
(B)	20-35 cm	dark yellowish brown (10YR 4/4) coarse sandy loam, weakly developed fine polyhedral structure, weak soil strength, compact, friable, few greywacke stones, many fine roots
(B)C	35-55 cm	dark yellowish brown (10YR 4/4) loamy sand, very weakly developed fine polyhedral structure, loose, very friable, abundant coarse stones, few fine roots
C	55-80 cm+	olive brown (2.5Y 4/4) coarse sand, apedal, loose, abundant medium and coarse greywacke stones, few fine roots

7.3. Young Stream and Fan Soils

7.3.1. Castlebrae Soils

Map symbols: Cb3sG, Cb3sU, Cb2sG, Cb2sU

Area: 580 ha; 92 auger observations plus 11 pit descriptions

Reference

Castlebrae soils have not been previously mapped or distinguished and they are separated here from Awatere River alluvial soils because of the different landforms and sedimentary environment in which they are found. Areas of Castlebrae soils in previous soil surveys were included within the Dashwood, Seddon and Sedgemere mapping units (Gibbs & Beggs, 1953). The units separated are:

- Castlebrae stony sandy loam (Cb3sG),
- Castlebrae stony sandy loam undulating phase (Cb3sU) on sloping ground,
- Castlebrae shallow sandy loam (Cb2sG) and
- Castlebrae shallow sandy loam undulating phase (Cb2sU) on sloping ground.

Distribution, environment and soil materials

Castlebrae soils are mapped in 22 locations in areas ranging from 1-50 ha. They occur in smallish areas on young active parts of sloping fan surfaces (<7°) where recent sediments have accumulated on foot slopes at the mouths of gullies or valleys. They are also mapped in larger elongated areas on the recent stream channel alluvial surfaces along Stafford Creek, Starborough Creek and Richmond Brook. These streams have formed winding channels with complex stream meander patterns and highly variable topography (Fig 4). As a result, the soil distribution as mapped is a simplification of a highly complex soil pattern.

Castlebrae soils occur between 60-220 m above sea level and within the rainfall range of 700-800 mm. The soil materials are alluvial stream sediments, predominantly sandy but sometimes silty and commonly stony although stone sizes are consistently smaller than Awatere river gravels. The soil materials are derived primarily from erosion of surface materials within local gullies and hill slopes.

Characteristics and distinguishing features

Castlebrae soils have weakly developed soil profiles (A/B or A/BC/C) with little alteration within the B/BC horizon. Depth to gravel seldom extends to > 50 cm. Soils may be stony to the surface or stone free to 45 cm depth with predominantly sandy loam or sometimes silt loam textures. On fan surfaces with slopes >4° Castlebrae undulating soils are separated. Soils with buried horizons of former soils are commonly found and reflect the dynamic character of the stream and fan landforms.

Range of profile features, variation and distinctions

Considerable soil variation was noted within the Castlebrae mapping units due to the variable nature of the sedimentary environment. The average A horizon thickness was 24 cm with the B horizon average thickness at 23 cm. Unweathered sandy gravel is found below. The average depth to gravel for Castlebrae shallow sandy loam was 34 cm. Silt loam textured profiles were found in places and also some deeper soils where fine textured alluvium was present.

In some toe slope locations where Castlebrae soils merge with Pinedale soils, mottles may be present in the subsoil. The overall profile morphology is similar to that for Wairau soils on river alluvium and flooding periodically occurs in stream channels with deposition of fresh alluvium in places. Castlebrae soils occur in conjunction with Starborough soils (stony and well drained), Pinedale and Glenbrae soils (moderately deep/deep and imperfectly or poorly drained). The latter two occur on older surfaces within the stream and fan land systems.

Analytical features (SB9381 Appendix 2)

The chemical data for the Castlebrae soil profile is broadly similar to that for the Wairau soil. Slightly lower base saturation and phosphorous values and slightly higher values for cation exchange, total bases and

extractable Fe may be a reflection of the origin of the soil materials from local hills and pre-weathering of the soil materials. Likewise, the higher clay content shown in the particle size analyses is probably due to the different source of the alluvial materials.

Representative profile: Castlebrae stony sandy loam (Cb3sG)

Horizon	Depth	Description
A	0-28 cm	dark greyish brown (10YR 3/2) sandy loam, moderately developed fine polyhedral structure, weak soil strength, compact, friable, many medium greywacke stones, many fine roots
BC	28-58 cm	light olive brown (2.5Y 5/4) stony sand, very weakly developed fine polyhedral structure, very weak soil strength, very friable, abundant non weathered medium greywacke stones, many fine roots
C	58- 90 cm+	light olive brown (2.5Y 4/4) stony sand, apedal, loose, abundant medium and large greywacke stones, many fine roots

7.3.2. Pinedale Soils

Map symbols: Pd0zG

Area: 73 ha; 40 auger observations plus 5 pit descriptions

Reference

Pinedale soils were not identified as a separate family in previous surveys (Gibbs & Beggs, 1953; Soil Bureau Staff, 1968). At the generalised mapping scales of 1:250,000 of these surveys, they were included within the Dashwood and Omaka map units. They are imperfectly to poorly drained soils occurring in conjunction with Castlebrae soils on fan toe slopes or associated drainage channels. The single unit separated here is Pinedale silt loam (Pd0zG).

Distribution, environment and soil materials

Pinedale soils are mapped in 10 locations in areas from 2-11 ha, between 10-180 m above sea level and within the rainfall range of 650-825 mm. They occur in low lying areas at the base of recent fan surfaces where drainage is impeded and also along associated poorly drained discharge channels. They are formed from fine textured stream sediments that are commonly layered due to intermittent stream flows and sediment discharges. The soil parent material is derived from erosion products from adjacent hills and gullies, mainly greywacke, conglomerate and loess. Flooding along stream channels and on low lying ground commonly occurs during significant rainstorms and can lead to deposition of additional material.

Characteristics and distinguishing features

Pinedale soils are deep imperfectly to poorly drained soils with a shallow to moderate weathering depth but with a profile form (A/Bg/Cg) that is quite varied due to differences in drainage conditions and sedimentary processes. Topsoils are dark grey and sometimes overlie several layers of mottled buried topsoil, on light brownish weakly structured subsoil with mottles that increase in abundance down the profile indicating periodic waterlogging. Textures are variable but mainly silt loam to clay loam.

Range of profile features, variation and distinctions

The soil depth for Pinedale soils is variable with 45% recorded as deep (average depth to gravel 95 cm), 30% moderately deep (45-90cm) and 25% shallow (20-45cm) and stony. The A horizon is predominantly silt loam texture but heavier textures (silt loam to clay loam) were recorded in 40% of the observations. A horizon thickness was between 4-24 cm. Subsoil texture is predominantly clayey with 20% of observations noted as silt loam to sandy loam. The mottle pattern is extremely varied, depending on soil wetness with bluish colours in places but as the drainage impediment lessens and mottles disappear, Pinedale soils merge with Castlebrae soils.

Analytical features

There are no soil chemical or physical analyses for Pinedale soils but they could be expected to have similarities with Wainui soils.

Representative profile: Pinedale silt loam (Pd0zG)

Horizon	Depth	Description
A	0-24 cm	very dark grey (10YR 3/1) silt loam, moderately developed fine polyhedral structure, weak soil strength, compact, friable, few coarse and fine roots
AB(g)	24-40 cm	very dark grey (10YR 3/1) and light yellowish brown (10YR 3/1) heavy silt loam, weakly developed fine polyhedral structure, weak soil strength, compact, friable, few fine light olive brown (2.5Y 5/6) mottles, few coarse and fine roots
BCg	40-75 cm	light yellowish brown to light olive brown (2.5Y 6/4-5/4) silty clay loam, weakly developed fine blocky structure, slightly firm soil strength, compact, friable, many olive grey (5Y 5/2) and light olive brown (2.5Y 5/6) mottles, few coarse roots
Cg	75-95 cm+	pale olive to olive (5Y 6/3-5/3) silty clay loam, moderately developed medium blocky structure, slightly firm soil strength, compact, brittle failure, abundant olive grey (5Y 5/2) and light olive brown (2.5Y 5/6) mottles, few coarse roots

7.3.3. Marathon Soils

Map symbols: Mn1zG, Mn1zU, Mn0zG

Area: 68 ha; 56 auger observations plus 7 pit descriptions

Reference

Marathon soils have not been previously mapped. They are identified in this survey as the moderately deep soils (Mn1zG, Mn1zU) and deep soils (Mn0zG) with weakly to moderately developed weathering profiles that occur on older fan and stream deposits. Marathon soils have accumulated mainly on the higher terrace surfaces. They occur within the Dashwood, Omaka and Seddon soil units of the earlier 1:250,000 surveys of Gibbs and Beggs (1953) and Soil Bureau Staff (1968).

Distribution, environment and soil materials

Marathon soils are mapped in 10 locations, mainly on the north side of Awatere River, in areas of between 2 and 13 ha. In places they occur as complexes with Castlebrae (Cb3sG + Mn0zG), Starborough (Sb3zU, Sb2zU, Sb2zG) and Glenbrae soils (Gb1zG) over larger areas. They are formed on gently undulating and occasionally undulating surfaces within an elevation range of between 40-200 m above sea level and within the annual rainfall range of 630-780 mm. The soil parent material, derived from erosion of greywacke, conglomerates and loess from local gullies, is silty to sandy textured stream alluvium, generally with few stones. This is deposited on the sloping surfaces of some small fans and on the upper terraced surfaces of small stream channels.

Characteristics and distinguishing features

Marathon soils are mostly deep and well drained soils with a moderately deep weathering depth (profile form A/B/BC/C). They have silt loam textures in upper horizons passing into sandy loams with increasing depth, there are few stones and soil structure is weakly developed. The topsoils are dark brown with an average thickness of 24 cm. Subsoils are typically yellowish brown to around 70 cm depth then pass into lightly weathered olive brown, very friable to loose, sandy gravel sediment. The average depth to gravel for Marathon deep soils (Mn0zG) was 103 cm with 54 cm for Marathon moderately deep soils (Mn1zG, Mn1zU).

Range of profile features, variation and distinctions

Marathon soils are mainly moderately deep soils with deep profiles in some places. A few stones are at times present in the upper horizons. Starborough soils which occur within the same landform units have a weathering form that is similar to Marathon soils, but they differ in that they are shallow soils with stones through the entire profile. Textures in A and B horizon range from silt loam and heavy silt loam to clay loam with differences resulting from variations in stream sediment deposition. A few subsoil mottles (moderately well drained class) were found to occur in 30% of the observations and mainly in the deeper soils. Where subsoil mottling intensifies, the soils merge with Glenbrae soils which are imperfectly drained and are found within the same landscape unit.

Analytical features

There are no soil chemical or physical analyses for Marathon soils but chemical properties can be expected to be similar to those of Starborough soils with which they are closely allied.

Representative profile: Marathon moderately deep silt loam (Mn1zG, Mn1zU)

Horizon	Depth	Description
A	0-24 cm	very dark greyish brown (10YR 3/2) silt loam, moderately developed fine polyhedral structure, weak soil strength, compact, friable, few small stones, many roots
Bw1	24-40 cm	yellowish brown (10YR 5/4) silt loam, weakly developed fine blocky and polyhedral structure, weak soil strength, compact, few fine stones, many fine roots
Bw2	40-67 cm	yellowish brown (10YR 5/4) to light olive brown (2.5Y 5/4) silt loam, weakly developed medium blocky structure friable, compact, few fine stones, few roots
BC	67-94 cm	light olive brown (2.5Y 5/4) fine sandy loam, weakly developed fine blocky structure, friable, compact, many fine and medium non weathered stones, few fine roots

7.3.4. Starborough Soils

Map symbols: SB3sG, SB3sU, SB3zG, SB3zU, SB2sG, SB2zU

Area: 267 ha; 110 auger observations plus 17 pit descriptions

Reference

Starborough soils have not previously been mapped. In this survey they are separated as the shallow and stony soils formed on fan surface sediments that have accumulated on terrace surfaces. In the earlier 1:250,000) surveys of Gibbs and Beggs (1953); Soil Bureau Staff (1968). Starborough soils are within the Dashwood, Seddon and Omaka sets.

Distribution, environment and soil materials

Starborough soils are mapped at 29 locations in areas of between 3.5 and 27 ha. The family includes:

- Starborough stony sandy loam (Sb3sG), stony silt loam (Sb3zG), on gently undulating land
- Starborough stony sandy loam on sloping land (Sb3sU),
- Starborough shallow silt loam (Sb2zG)
- Starborough shallow sandy loam on gently sloping (Sb2sG), and undulating (Sb2sU) land.

Starborough soils occur mainly on the north side of Awatere River associated with side stream fluvial systems such as Stafford and Dashwood Creeks, where low angle fan sediments have been deposited on the high river terrace surface (Figure 4). They are also found in several smaller areas on stream and fan deposits (Figure 5) that have been discharged from small valley-side gullies onto the terrace surfaces. Starborough soils occur within the altitude range of 60-250 m above sea level and within the mean annual rainfall range of 700-825 mm.

The soil materials for Starborough soils are predominantly sandy and silty gravels that commonly have alternating sand or stone layers resulting from stream depositional processes. The gravel material comprises predominantly small and medium stone sizes in contrast to the coarse stone sizes of the Awatere River gravels. The soil materials are derived locally from erosion of greywacke, conglomerates and loess cover deposits on nearby hills and have higher amounts of silt and sand fractions within the gravels than is found in the Awatere river sediments.

Characteristics and distinguishing features

Starborough soils are well drained, weakly to moderately weathered shallow and stony soils (profile form A/B/BC/C). The A horizon colours range from black to dark yellowish brown and thickness between 18 - 23 cm deep (average 22 cm thick). B horizon thickness averages 37 cm (range 20-66 cm) with yellowish brown to olive brown colours. B horizon oxidation depth extending to 50 cm. The lower B horizons have olive brown colours passing into a C horizon of dark greyish brown gravel or sand. The texture of the fine material is sandy loam with stones present in most horizons. The mean depth to gravel for the shallow soils is 29 cm (range 29-40 cm) with stones present in variable amounts in the upper horizons. The Starborough stony soils have moderately stony (15-35%) to very stony (>35%) A horizons. These soils have weakly developed structure and friable consistence.

Range of profile features, variation and distinctions

Soil horizon thickness, stoniness, textures and soil depth vary considerably due to inconsistent sediment deposition conditions on the fan and stream surfaces. Stony soils are more common on the upper parts of the fan surfaces with the finer textured silt loam Starborough soils on lower slopes.. As soil stoniness diminishes and the depth to gravel increases, Starborough soils merge into Marathon soils. In lower lying places where the subsoils have some mottles, Starborough soils merge with Glenbrae soils.

Analytical features (SB938 Appendix 2)

Starborough soils are moderately acid and have low organic C and N values, high phosphorous and base saturation values, and medium to low exchangeable bases in the surface soil horizon but with markedly lower values in the deeper horizons consistent with its weakly weathered and weakly leached status.

Representative profile: Starborough shallow fine sandy loam (SB2sG, SB2zU)

Horizon	Depth	Description
A	0-23 cm	dark yellowish brown (10YR 4/4) fine sandy loam, weakly developed fine polyhedral structure, weak soil strength, compact, very friable, few small and medium stones, many fine roots
AB	23-30 cm	very dark brown (10YR 2/2) and light olive brown (2.5Y 5/4) fine sandy loam, weakly developed fine polyhedral structure, compact, friable, very stony, many fine roots
Bw	30-62 cm	olive brown (2.5Y 4/4) sandy loam, weakly developed fine blocky structure, compact, very stony, many fine roots
C	62-120 cm+	light yellowish brown (2.5Y 6/4) coarse sand, apedal, loose, few fine roots, abundant stones

7.3.5. Glenbrae soils

Map symbols: Gb0zG, Gb1zG

Area: 102 ha; 52 auger observations plus 10 pit descriptions

Reference

Glenbrae soils have not been previously identified. This survey identifies Glenbrae soils as the imperfectly to poorly drained soils that occur on recent fan deposit sediments on the intermediate and lower terrace surfaces. In the 1:250,000 survey of Gibbs & Beggs (1953) they were included within the Dashwood and Omaka soil map units and within the Dashwood and Hororata sets in the New Zealand 4 mile to the inch soil survey (Soil Bureau Staff, 1968).

Distribution, environment and soil materials

Glenbrae soils are mapped in 16 places on the north side of the Awatere River in areas ranging from about 1 ha to 14 ha. The family includes Glenbrae moderately deep silt loam (Gb1zG, 45-90 cm to gravel) and Glenbrae silt loam (Gb0zG, >90 cm to gravel). They are imperfectly to poorly drained soils and occur in low lying positions at foot slope positions where local streams have deposited sediments at the lowermost parts of fans on the intermediate and lower terrace surfaces. The patches of Glenbrae soils mostly have irregular shapes because the colluvial fan sediments have in part infilled old river channel depressions formed by Awatere River flows when the terrace surfaces were formed. Glenbrae soils occur between 40-240 m above sea level and within the mean annual rainfall range of 650-750 mm. The soil material is mostly non stony or slightly stony, silty to clayey textured alluvium derived from local greywacke, conglomerate and loess materials from valley side surfaces and sometimes has Awatere bouldery gravel at the base of the soil profile.

Characteristics and distinguishing features

Glenbrae soils are predominantly moderately deep and deep soils with a very dark grey or dark greyish brown silt loam texture. The lower horizons are moderately to strongly gleyed, firm and massive with weakly developed blocky structures, are strongly mottled and have heavy silt loam or clay loam textures. The underlying C horizons have light grey colours with some reddish mottles and are stony in Glenbrae moderately deep soils and sandy to clayey textured in the deep Glenbrae soils. The soil profile form (A/B(g)/Bg/Cr) is indicative of significant soil wetness with the subsoil colour pattern dominated by the distinctive grey and reddish brown mottles. Surface water was observed in lower lying areas on numerous occasions.

Range of profile features, variation and distinctions

The A horizon thickness varied between 16-27 cm (average 21 cm) while textural variation included clay loams and sandy loams (30%). The mean depth to gravel for the Glenbrae moderately deep soil was 64 cm (range 60-72 cm) but there are some shallow soils present (20%). Subsoil textures also vary ranging between sandy loam and clay loam. The soil mottle colour patterns are highly variable in respect of the proportions of grey and reddish mottles that are present and is largely dependant on the degree of site wetness and local drainage conditions. At a few excessively wet sites, the topsoils were noted to be peaty. Pinedale soils have similarities with Glenbrae soils but have less well developed soil profiles and are not as intensively gleyed. A possible correlation for Glenbrae soils is with Fairhall soils meadow phase, mapped on part of the Wairau Plains by Harris and Birrell (1939).

Analytical features

There are no analyses for Glenbrae soils but their chemical and physical properties would be expected to be similar to those of Wainui soils.

Representative profile: Glenbrae moderately deep silt loam (Gb1zG)

Horizon	Depth	Description
A	0-20 cm	very dark greyish brown (10YR 3/2) silt loam, moderately developed fine and medium polyhedral structure, weak soil strength, compact, friable, many fine roots
Ag	20-38 cm	pale olive (5Y 6/3) and yellowish brown (10YR 5/8) strongly mottled heavy silt loam, moderately developed fine blocky structure, slightly firm soil strength, compact, brittle failure, few small stones, few fine roots
Br	38-60 cm	grey (5Y 6/1) and reddish brown (5YR 4/4) strongly mottled clay loam, weakly developed fine and medium blocky structure, firm soil strength, compact, brittle failure, few small stones few fine roots
Cg	60-80+ cm	light brownish grey (2.5Y 6/2) stony gravel, apedal, loose many fine and medium stones

7.4. Intermediate River Terrace Soils

7.4.1. Marama Soils

Map symbols: Ma1sG, Ma0sG

Area: 360 ha: 101 auger observations plus 17 pit descriptions

Reference

Marama soils have not previously been mapped in earlier soil surveys and are identified here as the moderately deep and deep well drained soils with moderate profile development occurring on intermediate terraces of the Awatere River. The degree of soil development is distinctly greater than that found in the soils of the low terraces while having less soil development than that in the soils of the high river terraces. Marama soils were included within the Dashwood and Omaka soil map units in the 1:250,000 survey by Gibbs and Beggs (1953) and in the Dashwood and Waimakariri sets by Soil Bureau Staff (1968). Marama soils also occur in the middle Wairau Valley (Campbell, Oliver, & Rait, 2016)

Distribution, environment and soil materials

Marama soils are mapped in 22 locations including a few places together with Muritai soils. They occur on some small terrace remnant areas covering about 5 ha but they are mainly in larger areas, the greatest covering 90 ha. They are present on both sides of Awatere River but are more extensive on the north side and toward the eastern end of the valley. The family includes Marama moderately deep sandy loam (Ma1sG) and Marama deep sandy loam (>90cm Ma0sG). The terrace surfaces on which Marama soils lie are mainly flattish and even sloping. They occur between 15-20 m above river level and 10-15 m below the main valley outwash surface. They occur between 8-165 m above sea level and within a rainfall range of 650-800 mm. The soil material is Awatere River alluvium comprising mainly loamy alluvium over unconsolidated coarse gravel at an average depth of 83 cm below the surface.

Characteristics and distinguishing features

Marama soils are weakly to moderately weathered (profile form A/Bw/Bt/BC/C) with a weathering depth that extends to around 80 cm. They are well drained soils with a very dark greyish brown to brown sandy loam to silt loam A horizon with moderately developed structure, overlying sandy loam to silt loam yellowish brown weakly structured B horizons. A lower B horizon with some clay enrichment (Bt) may be present before passing into a transitional olive brown BC horizon which in turn overlies the C horizon which in most cases is stony gravel at an average depth of 84 cm.

Range of profile features, variation and distinctions

The A horizon thickness varied between 18-30 cm while a silt loam texture in the A horizon was common (45%). The B horizon thickness ranged between 24- 53 cm and textures are also varied with silt loam approximately 40% and sandy textures around 5%. The mean depth to underlying gravel for Marama moderately deep soils was 68 cm (range 52-85 cm). A few stones are sometimes present within the soil profiles and where the stone content increases and the depth to gravel decreases within the map unit, Marama soils merge into Muritai soils. There are occasional occurrences of soils with a few mottles in some lower lying areas. The underlying gravels are weakly consolidated and sometimes bouldery rather than stony. Marama soils have similar profile features to the Marathon soils which are formed on stream deposited sediments.

Analytical features (SB937 Appendix 2)

pH values in the surface horizons are moderately to slightly acid but increase to near neutral and slightly alkaline in the lower horizons. The A horizon carbon value is low but the nitrogen value is medium. Phosphorus values are very high and increase with increasing depth. Cation exchange values are medium in the upper horizons and decrease with increasing depth. The base saturation values are high and increase with depth and indicate an absence of marked leaching and the relative youthfulness of the soil. The marked textural difference between the upper and lower horizons is indicated by the abrupt changes in the sand and clay percentages.

Representative profile: Marama moderately deep sandy loam (Ma1sG)

Horizon	Depth	Description
A	0-20 cm	very dark greyish brown (10YR 3/2) fine sandy loam-silt loam, moderately developed fine and medium polyhedral structure, weak soil strength, compact, friable, many fine roots
Bw1	20-32 cm	dark yellowish brown (10YR 4/4) fine sandy loam, weakly developed fine blocky and polyhedral structure, slightly firm soil strength, compact, friable, many fine roots
Bw2	32-46 cm	light olive brown to olive brown (2.5Y 5/4-4/4) sandy loam weakly developed fine blocky structure, slightly firm soil strength, compact, friable, few fine roots
BC1	46-65 cm	light olive brown to olive brown (2.5Y 5/4-4/4) sandy loam weakly developed fine blocky structure, slightly firm soil strength, compact, friable, few fine roots
BC(t)	65-90 cm	olive brown sand, apedal, loose, few thin clay coatings on stones, abundant stones and boulders, few fine roots
C	90-120 cm	olive (5Y 4/3) stony bouldery gravel, apedal, loose, few fine roots

7.4.2. Muritai Soils

Map symbols: Mt2sG, Mt3sG

Area: 392 ha; 86 auger observations plus 8 pit descriptions

Reference

Muritai soils were not separated in earlier soil surveys and are mapped here as the stony and shallow well drained soils with moderate profile development occurring on the intermediate terrace surfaces of the Awatere River. Muritai soils were included within the Dashwood and Omaka soil map units in the1:250,000 survey by Gibbs and Beggs (1953) and in the Dashwood and Waimakariri sets by Soil Bureau Staff (1968).

Distribution, environment and soil materials

Muritai soils are mapped in 33 places in areas of between 2 and 52 ha with some of these including the deeper Marama soils. They are found mainly on the north side of the Awatere River and are more extensive towards the eastern end of the valley. The family includes Muritai shallow sandy loam (Mt2sG, 20-45 cm to gravel) and Muritai stony sandy loam (Mt3sG, surface stones). The ground surface on which Muritai soils occur is a distinctive but discontinuous terrace, 10-15 m below the upper Starborough Terrace surface and up to 10 m above the lowermost group of recent terraces. The land is comparatively even with shallow subdued ridge and swale undulations from old river flow patterns. Muritai soils occur between about 10-175 m above sea level and within a rainfall range of 650-800 mm. The soil material is Holocene (<10k) sandy gravel Awatere River alluvium derived from greywacke, Tertiary sediments and some igneous materials

Characteristics and distinguishing features

Muritai soils have weathering profile form (A/Bw/Bt/BC/C) that extends to around 70 cm (range 44-90 cm) being influenced by the degree of subsurface stoniness. The A horizons are dark brown to very dark greyish brown weakly structured sandy loam. In 20% of observations, the texture was silt loam to heavy silt loam. . The B horizon is dark yellowish brown, weakly to moderately structured and predominantly stony sandy loam (average thickness 36 cm) and passes into a stony olive brown coloured BC horizon which in turn overlies the unweathered stony gravel C horizon which has a sandy fine fraction texture. Thin clay coatings (Bt) on stones are sometimes present in the lower B and BC horizons.

Range of profile features, variation and distinctions

The A horizon thickness for Muritai soils varied between 16-26 cm (average 20 cm). Muratai soils are moderately well drained with some subsoil mottles present in a few places. In the Muritai shallow soils, surface stones were present at 30% of the observation sites and the mean depth to gravel was 27 cm. In places, the soils may be bouldery. Muritai soils resemble Marama soils, both of which occur within the same landscape unit with Muritai soils being the shallower and stony soils and Marama soils those with deeper profiles. While Muritai soils resemble Starborough soils in respect of their degree of soil development, the latter having somewhat finer subsoil textures owing to their formation from local stream depositions.

Analytical features

There are no chemical analyses for Muritai soils but their chemical properties can be expected to be very similar to those for Marama soils.

Representative profile: Muritai shallow sandy loam (Mt2sG)

Horizon	Depth	Description
A	0-22 cm	very dark greyish brown (10YR 3/2) fine sandy loam, weakly developed fine polyhedral structure, very weak soil strength, compact, friable, abundant fine roots
Bw	22-38 cm	dark yellowish brown (10YR 4/4) fine sandy loam, weakly developed fine blocky structure, weak soil strength, compact, friable, many fine roots
Bw(t)	38-65 cm	olive brown (2.5Y 4/4) sand, weakly developed fine blocky structure, compact, many fine and medium stones, few thin dark yellowish brown clay coatings, few fine roots
BC	65-82 cm	olive brown (2.5Y 4/4) sandy gravel, apedal, compact, abundant stones and boulders, many fine roots
C	82-90 cm+	olive brown (2.5Y 4/2) to yellowish brown (10YR 4/4) sandy gravel, apedal, loose

7.5. Older Stream Sediment Soils

7.5.1. Warwick Soils

Map symbols: Wa2zG, Wa2zU, Wa3zG, Wa3zU

Area: 901 ha; 522 auger observations plus 31 pit descriptions

Reference

Warwick soils have not been separated or identified in earlier soil surveys of the region and are distinguished here as the shallow and stony soils that are formed on older alluvial surfaces in the small valley systems that drain the hilly lands on the north and south side of the lower Awatere Valley. In the earlier 1:250,000 soil surveys, Warwick soils are within the Dashwood, Seddon, Sedgemere and Jordan map units of Gibbs and Beggs (1953) and within the Dashwood, Seddon, and Sedgemere map units of Soil Bureau Staff (1968).

Distribution, environment and soil materials

Warwick soils are mapped in 44 places, occasionally in complexes with Ugbrooke, Broadbridge or Wainui soils and occur in a few small areas from 1 to 2 ha as well as in larger areas up to 110 ha. They are present on the north and south sides of the Awatere Valley and are associated with the side streams and a few larger gully systems that originate from within the adjacent hill country. The family includes Warwick shallow silt loam (Wa2zG) and the less extensive Warwick stony silt loam (Wa3zG) and similar soils (Wa2zU and Wa3zU) on fan surfaces where slopes are greater (4°-7°). The soils are formed mainly on broad, flattish and even sloping surfaces that accumulated as extensive alluvial outwash that filled the valley floors and spilled out onto the Starborough 1 Terrace surface as fan deposits. They are also present in smaller areas of sloping land where fan deposits have accumulated around the mouths of gullies. The alluvial soil material for Warwick soils is distinctive in that it contains a significant proportion of subangular greywacke rock material that was eroded from exposed hillslopes towards the end of the Last Glaciation. Warwick soils are found between 60 to 220 metres above sea level and within a rainfall range of 700 to 800 mm.

Characteristics and distinguishing features

Warwick soils are moderately weathered, well drained soils with a profile form (A/Bw/Bt/BC) that extends to greater than 100 cm depth. The A horizon is very dark greyish brown silt loam texture with moderately developed structure which is essentially stone free in Warwick shallow soils but with many or abundant stones in Warwick stony silt loam. The B horizon has yellowish brown to dark yellowish brown colours with a silt loam fine fraction texture and many to abundant, small to medium subangular and rounded stones. The B horizons extend to an average depth of 65 cm and overlies light olive brown to light yellowish brown to light yellowish brown stony sandy loam.

Range of profile features, variation and distinctions

The A horizon thickness ranges between 18 and 30 cm (average 22 cm thick) while the texture ranges from sandy loam (6% of observations) to heavy silt loam to clay loam (<5%). The average depth to gravel in Warwick shallow silt loam was 28 cm. Subsoil texture was variable with 42% of observations noted as heavy silt loam or clay loam and lenses of finer stone-free sediments are sometimes present. The weathering depth to the bottom of the B horizon varied between 43 and 87 cm while unweathered C horizon was present at 18% of the profile observation sites at an average depth of 74 cm (range 61-87 cm). At several sites, the gravelly alluvium of Warwick soils was found to overlie loess materials with properties similar to those for adjacent Sedgemere soils, indicating that the period of alluvial gravel deposition took place after the main period of loess accumulation. Warwick soils resemble the Taylor gravelly silt loam soil as described by Harris and Birrell (1932) in an early survey of the soils of the Wairau Plains. They differ from the Ugbrooke well drained to moderately well drained soils in that silt and clay percentages are lower, especially in the lower horizons and mottled subsoils are rarely present.

Analytical features (SB9380 Appendix 2)

The pH values for this soil are slightly acid in the A horizon and throughout the profile. Organic C is low in the A horizon and the values decrease to very low levels with depth. Phosphorous values are high in the

upper horizons with variations in values in the lower horizons probably related to sediment layering. The values for cation exchange capacity and total bases are medium in the upper 30 cm and fall to low levels in the subsoil. Base saturation values are high throughout the soil.

Representative profile: Warwick shallow silt loam (Wa2zG)

Horizon	Depth	Description
A	0-20 cm	very dark greyish brown (10YR 3/2) silt loam, moderately developed medium and fine polyhedral structure, weak soil strength, compact, friable, few small stones, abundant fine roots
AB	20-30 cm	very dark greyish brown and yellowish brown (10YR 3/2 +10YR 4/4) silt loam, moderately developed fine and medium polyhedral structure, compact, many small stones, many fine roots
Bw(t)	30-43 cm	dark yellowish brown (10YR 4/4) silt loam, weakly to moderately developed fine polyhedral structure, compact, many thin distinct dark yellowish brown (10YR 4/4) clay coatings, very stony, many fine roots
BC1	43-64 cm	light yellowish brown (2.5Y 6/4) sandy loam to silt loam, dense, breaking to weakly developed fine polyhedral structure, few small stones, few fine roots
BC2	64-85 cm	light olive brown (2.5Y 5/4) coarse sandy gravel, weakly developed fine polyhedral structure, loose, very stony, very few thin dark yellowish brown (10YR 3/4) clay coatings, very stony, few fine roots
C	85-100 cm+	light olive brown (2.5Y 5/4) coarse sandy gravel, apedal, loose, very stony

7.5.2. Ugbrooke Soils

Map symbols: Ug1zG, Ug0zG, Ug0zU

Area: 468 ha; 213 auger observations plus 22 pit descriptions

Reference

Ugbrooke soils have not been mapped or identified in earlier surveys of the Awatere district and are separated here as the well-drained to moderately well drained loamy soils occurring on the older stream sediments and alluvial fan deposits that are associated with the tributary streams of lower Awatere Valley. In the earlier 1:250,000 soil surveys by Gibbs and Beggs (1953) and Soil Bureau Staff (1968), Ugbrooke soils are included within the Dashwood, Seddon and Sedgemere map units.

Distribution, environment and soil material

Ugbrooke soils are mapped in 30 locations in areas from 1.5 to 65 ha. They occur on both sides of the Awatere River but are more extensive on the terrace surfaces on the south side where streams such as Richmond Brook and Starborough Creek have discharged alluvium onto the Starborough 1 terrace surfaces. The family includes Ugbrooke moderately deep silt loam (Ug1zG) and Ugbrooke deep silt loam (Ug0zG) with an added separation of Ugbrooke deep silt loam undulating phase (Ug0zU) on sloping land. Ugbrooke soils are mapped mainly on flattish to gently sloping surfaces along the lower reaches of meandering stream channels that originate within hilly lands on the north and south side of Awatere Valley. They are also mapped on a few smaller areas (Ug0zU) of gently sloping land lying on the foot slopes of the valley sides. The soil material is silty to clayey alluvium, sometimes with small stones but more commonly without underlying gravels and has been derived from greywacke rocks and redeposited loess. Ugbrooke soils occur between 10-240 m above sea level and within the rainfall range of 650-800 mm per annum.

Characteristics and distinguishing features

Ugbrooke soils have a deep weathering profile (A/Bw/B(t)/B(g)/BC) that in places extends to greater than 140 cm due to the prolonged and slow build-up of alluvial materials. The A horizons are very dark greyish brown with silt loam texture. These overlie B horizons have heavy silt loam texture and yellowish brown to olive brown colours. The underlying BC horizon has similar texture and an olive brown to yellowish brown colour. Soil structure is moderately developed throughout the profile and occasional small stones are sometimes present. In the Ugbrooke moderately deep soils, gravel layers may be present (average 70 cm). In each of the Ugbrooke soil units, some mottles may be present lower in the subsoil (moderately well drained class) with these indicative of slow subsurface water penetration rather than the presence of high ground water.

Range of profile features, variation and distinctions

The A horizon thickness for Ugbrooke soils varied between 19 and 32 cm (average 23 cm) while textural variation included 13% of observations that were heavy silt loam to clay loam and 10% were for sandy loam texture. The B horizon thickness was also variable and ranged between 70 to 120 cm. For Ugbrooke moderately deep soils, the depth to gravel averaged 73 cm and for Ugbrooke deep soils, 100 cm. A few mainly small stones were recorded within the upper soil horizons in 60% of the description sites. At 55% of the observation sites, Ugbrooke soils were well drained while the remainder had subsoil mottles that classify these soils into the moderately well drained class.

Ugbrooke soils have similarities with Broadbridge soils which are formed on similar alluvial materials, but the latter have heavier textured subsoils with impeded drainage resulting in distinct mottling into the upper subsoil. Ugbrooke soils also have some similarities with Woodbourne soils which were mapped by Laffan and Vincent (1990) which are deep, well drained loamy soils occurring on the Wairau Plains near Blenheim.

Analytical features (SB9379 Appendix 2)

The pH values for Ugbrooke are moderately acid in the upper soil horizons and increase with depth to become moderately alkaline. The A horizon carbon value is low, but the C/N value is medium. The A horizon phosphorous value is very high, and values fall in the subsurface horizons with the variable figures perhaps related to sedimentary layering and recycling of the soil parent material. Cation

exchange, total bases and base saturation values are within the high to medium range throughout the soil profile and are again a reflection of the weakly leached and weakly weathered status of the soil.

Representative profile: Ugbrooke deep silt loam (Ug0zG)

Horizon	Depth	Description
A	0-17 cm	very dark greyish brown (10YR 3/2) silt loam, moderately developed medium and coarse polyhedral structure, weak soil strength, compact, friable, many fine roots
AB	17-26 cm	very dark greyish brown and dark brown (10YR 3/2+4/3) silt loam, weakly developed fine and medium polyhedral structure, weak soil strength, compact, friable, many fine roots
Bw	26-47 cm	olive brown (2.5Y 4/4) silt loam, weakly developed fine polyhedral and blocky structure, slightly firm soil strength, compact, brittle failure, few fine roots
Bw(t)	47-80 cm	olive brown (2.5Y 4/4) heavy silt loam, moderately developed medium blocky structure, slightly firm soil strength, compact, brittle failure, few strong brown (7.5YR 5/6) and olive (5Y 5/3) fine mottles, many dark brown (10YR 4/3) clay coatings, very few fine roots
B(tg)	80-107 cm	olive brown (2.5Y 4/4) silt loam, weakly developed medium blocky structure, slightly firm soil strength, compact, brittle failure, many olive (5Y 5/3) mottles, few thin dark brown (10YR 4/3) clay coatings, few small stones, very few fine roots
BC	107-145 cm	olive brown (2.5Y 4/4) heavy silt loam, moderately developed medium blocky structure, firm soil strength, compact, brittle failure, few small stones, very few fine roots

7.5.3. Broadbridge soils

Map symbols: Bb1zG, Bb0zG, Bb0zU

Area: 680 ha; 223 auger observations plus 18 pit descriptions

Reference

Broadbridge soils have not been previously mapped in the Awatere Valley and were earlier included within the Dashwood, Seddon and Sedgemere map units of the 1:250,000 soil surveys by Gibbs and Beggs (1953) and Soil Bureau Staff (1968). Broadbridge soils were earlier differentiated by Laffan and Vincent (1990) in the Taylor, Fairhall and Omaka Valleys near Blenheim as deep, imperfectly drained soils on loamy alluvium and in the Awatere Valley, they are formed on similar alluvial materials associated with tributary stream deposits.

Distribution, environment and soil material

Broadbridge soils are mapped in 28 locations in areas from 4 to 45 ha and are present on both sides of Awatere Valley on the high river terrace surface where side-stream alluvium has accumulated, as well as in stream valley bottom surfaces. They occur in irregular shaped areas on flattish to gently sloping ground, principally in lower lying places within the stream systems of the Richmond Brook, Starborough Creek and Stafford Creek areas. Included in the Broadbridge family are Broadbridge moderately deep silt loam (Bb1zG), Broadbridge silt loam (Bb0zG) and an undulating phase (Bb0zU) on some footslope land where the slope is between 4°-7°. Soil drainage is restricted, partly because the subsoil is compact and also because land slopes are dominantly gentle and with shallow stream channel entrenchment limiting effective subsurface drainage. The soil materials are predominantly Late Pleistocene to Holocene silty to clayey alluvium, sometimes with gravelly layers and derived from greywacke and loess cover beds in the adjacent hilly terrain. The soils occur between 50-250 m ASL and within a rainfall range of 700- 850 mm.

Characteristics and distinguishing features

Broadbridge soils are moderately well drained to imperfectly drained and have a deep weathering profile (A/Bw/B(g)/Bgt) that extends to greater than 1 metre and with distinctive mottle patterns in the subsoil below an average depth of 38 cm. The A horizon is predominantly dark greyish brown silt loam. The upper B horizon is light yellowish brown to yellowish brown silt loam to heavy silt loam (average thickness 20 cm). It overlies heavy silt loam to clay loam textured B horizons with coarse, low chroma mottles that are predominantly within the olive to olive grey range and high chroma mottles with mainly strong brown to brown colours. The subsoil horizons have firm to very firm consistence with medium to coarse blocky structure. Some stones within the soil profile were noted in 36% of the pit observations and were generally scattered rather than occurring in gravelly layers.

Range of profile features, variation and distinctions

The A horizon thickness range was between 17 and 27 cm (average 21 cm) and in 29% of the observations, topsoil texture was heavy silt loam or clay loam. In around 5% of the observations, stones were present in the A horizon. The intensity and extent of subsoil mottles varies greatly with the depth at which mottles appear varying from 22-47 cm. Dark brown Fe concretions are sometimes present indicative of periods of standing water in the profile and mobilisation of iron. In 35% of the soil pit observations, the subsoils had very firm to hard soil strength with development of coarse prismatic structure (Bx horizon) and associated mottling down vertical cracks. Unweathered C horizon gravelly material was observed at a depth of 90 cm on a few occasions. Broadbridge soils differ from the more poorly drained Wainui soils mapped in this survey with the latter being imperfectly to poorly drained and characterised by mottles which may extend into the A horizon.

Analytical features

No laboratory analyses were undertaken for Broadbridge soils but their chemical and physical features can be expected to have close similarities with those for Ugbrooke soils (SB9379) and Wainui soils (SB9377)

Representative profile: Broadbridge silt loam (Bb0zG)

Horizon	Depth	Description
A	0-24 cm	very dark greyish brown (10YR 3/2) silt loam, weakly developed fine polyhedral structure, weak soil strength, compact, friable very few small stones many roots
Bw	24-42 cm	dark brown (10YR 3/3) heavy silt loam, weakly developed fine blocky and polyhedral structure, slightly firm soil strength, compact, friable, few fine roots
Bw(g)	42-60 cm	dark yellowish brown (10YR 4/4) clay loam, moderately developed medium blocky structure, firm soil strength, compact, brittle failure, few to many yellowish brown (10YR 6/8) and light brownish grey (2.5Y 6/2) medium distinct mottles, few small stones few fine roots
Bg(t)	60-84 cm	yellowish brown (10YR 5/4) clay loam, moderately to strongly developed medium blocky structure, very firm soil strength, dense, brittle failure, many brownish yellow (10YR 6/8) and light brownish grey (2.5Y 6/2) mottles few yellowish brown to olive brown (10YR 5/4-2.5y 6/4) clay coatings, few fine roots
Bg(t)	84-105 cm	yellowish brown (10YR 5/6) clay loam, moderately to strongly developed coarse blocky structure, very firm soil strength, dense, brittle failure, abundant medium distinct strong brown (7.5YR5/8) and light brownish grey (2.5Y 6/2) mottles, many distinct brown to dark brown (10YR 4/3) clay coatings, few fine roots

7.5.4. Wainui soils

Map symbols: Wn1zG, Wn0zG, Wn0zU

Area: 256 ha; 110 auger observations plus 20 pit descriptions

Reference

Wainui soils have not been previously identified and were separated in the present survey as the imperfectly to poorly drained loamy soils are formed on lower lying surfaces associated with older stream deposited sediments on the high river terrace surfaces. They were included within the Dashwood, Seddon and Sedgemere map units of the earlier 1:250,000 soil surveys by Gibbs and Beggs (1953) and Soil Bureau Staff (1968).

Distribution, environment and soil material

Wainui soils are mapped in 15 places and occur in areas ranging between 3 and 66 ha and are usually found alongside Broadbridge soils, with which they are closely associated. They are located in low lying areas principally within the stream systems of the Richmond Brook, Starborough Creek and Stafford Creeks. Surface water is sometimes present in these areas and this wet environment leads to the distinctive mottling patterns that distinguish these soils. Included in the Wainui family are Wainui moderately deep silt loam (Wn1zG), Wainui silt loam (Wn0zG) and an undulating phase (Wn0zU) on some footslope land where water seepages occur. The soil material is fine textured stream alluvium or colluvium, sometimes slightly gravelly or overlying gravels and is derived from greywacke, conglomerate or loess cover sediments eroded from within the stream catchment areas. Wainui soils occur between 50-210 m above sea level and within a mean annual rainfall range of 700-820 mm.

Characteristics and distinguishing features

Wainui soils have a moderately deep weathering profile (A/BG/CG) that is dominated by soil features indicative of severe drainage impedance. The A horizon is very dark greyish brown to black silt loam with weakly developed structure and averages 19 cm thick. The underlying BG horizons (average 36 cm thick) have mainly clay loam to clay textures, weakly to moderately developed blocky structure and are dominated by a range of greyish colours with some strong brown or reddish brown mottles. The lowermost horizons have colours ranging from light grey to greenish grey and olive grey with few strong brown or reddish brown mottles, have clay loam to clay textures, weakly developed fine blocky structure with gravel present in the moderately deep Wainui soils at an average depth of 76 cm.

Range of profile features, variation and distinctions

The A horizon thickness of Wainui soils was between 16 and 27 cm, heavy silt loam or clay loam texture was noted in 40% of the observations and some stones present in 20% of the observations. At a few sites, some reddish mottles were present in the A horizon, indicative of the watertable rising to the surface. The subsoil colour and mottle colours are quite variable owing to differences in soil drainage from place to place and blackish manganese concretions were observed at some sites.

In the lower subsoil, soil structure was absent in 30% of the profile observation sites where the C horizons were massive. The depth to gravel in the Wainui moderately deep soil averaged 72 cm and shallow soils with depth to gravel <45 cm were recorded in 10% of the observations. For the deeper Wainui soils, the average depth to gravel was 102 cm. At 15% of the pit description sites a watertable was present at an average depth of 80 cm. Within this landscape unit, Wainui soils grade into Broadbridge soils as soil drainage conditions improve. Wainui soils have somewhat similar drainage characteristics as Awadale soils but the later are formed from deposits with a volcanic material component. Wainui soils also have some affinities with Paynter soils mapped in the Fairhall and Taylor Valley areas south of Blenheim (Harris & Birrell, 1939; Laffan & Vincent, 1990).

Analytical features (SB 9377 Appendix 2)

The pH values for the Wainui soil were near neutral in the A horizons and alkaline in each of the subsoil horizons. The A horizon organic C value is medium in the uppermost horizon and is greater than those for the other Awatere soils that were sampled. This is perhaps a reflection of the wetter soil conditions which favour a slower rate of decomposition of C and build-up of organic matter. P values are high throughout the soil with an extremely high value at the 79-107 cm depth, perhaps due to some mineralogical change

within the soil material. Cation exchange and total bases and base saturation values are all high to very high and are a reflection of the wet soil conditions and the lateral movement of nutrients through the soil. The high clay content values are a reflection of the deposition of fine soil materials on the lower surfaces of alluvial fans.

Representative profile: Wainui silt loam (Wn0zG)

Horizon	Depth	Description
A	0-15 cm	black (10YR 3/1) silty clay loam, weakly developed fine blocky structure, weak soil strength, compact, friable, few fine reddish brown (5YR 4/4) mottles, many fine roots
Ag	15-23 cm	black, (10YR 2/1) and light brownish grey (2.5Y 6/2) heavy silt loam, weakly developed fine blocky and polyhedral structure, weak soil strength, compact, sticky, plastic, many distinct strong brown (7.5YR 5/8) and greenish grey (5G 5/1) mottles, few medium stones, few fine roots
BG1	23-40 cm	light brownish grey (2.5Y 6/2) clay, weakly developed medium blocky structure, slightly firm soil strength, compact, slightly sticky and plastic, few large stones, few fine roots
BG2	40-79 cm	light brownish grey (2.5Y 6/2) clay, weakly developed medium blocky structure, slightly firm soil strength, compact, slightly sticky and plastic, few greenish grey (5G 5/1) mottles, few medium stones, few fine roots
CG	79-107 cm	pale olive (5Y 6/3) clay loam, apedal, massive, few greenish grey (5G 5/1) and olive brown (2.5Y 6/3) mottles, many medium and large stones, few fine roots
CG	107-130 cm+	dark greenish grey (5BG 4/1) clay loam, apedal, slightly sticky and plastic, few medium stones

7.6. Soils of the High River Terraces

7.6.1. Dashwood Soils

Map symbols: Dw2zG, Dw3zG

Area: 1150 ha; 395 auger observations plus 18 pit descriptions

Reference

Dashwood soils were first mapped by Gibbs and Beggs (1953) in the Awatere Valley as the gravelly silt loam soils that covered most of the terrace land on the north side of the lower Awatere Valley. They were shown as covering the same area in the 1:250,000 survey of the soils of South Island (Soil Bureau Staff, 1968).

Distribution, environment and soil material

Dashwood soils are mapped in 39 places including several occurrences in combination with Stafford, Seddon and Toi soils. The family includes Dashwood shallow silt loam (Dw2zG) and Dashwood stony silt loam (Dw3zG) and they are present over much of the prominent Starborough 2 Terrace surface on the north side of the valley and in a fewer number of places on the south side. Separately mapped areas range in size from between 1 and 165 ha but many of the Dashwood shallow and Dashwood stony soil areas separated are contiguous and reflect the variable conditions at the time of deposition of the alluvium. The ground surfaces are planar and near level but with undulations, sometimes up to 1 m deep from the river flow patterns at the time of deposition. The soils are formed from Late Pleistocene stony alluvium derived from greywacke, Tertiary sediments and some volcanic materials. The upper part of the soil may however include some loess, as the sand, silt and clay percentages in the upper gravelly material closely resembles those of the Seddon and Seaview soils which are formed from loess. Dashwood soils are found between an altitude of 25-260 m above sea level and within the rainfall range of 630-850 mm per annum.

Characteristics and distinguishing features

Dashwood soils are well drained with shallow or stony surface horizons overlying stony and often bouldery gravel. They are moderately weathered soils (profile form A/B/Bt/BC/C) with the weathering depth extending to >70 cm in the gravelly subsurface. The A horizon is very dark greyish brown to dark brown silt loam, (average thickness 18 cm) with weakly developed polyhedral structure and many stones in Dashwood stony silt loam and few stones in the Dashwood shallow silt loam soils. The underlying stony B horizons have yellowish brown colours, silt loam texture and weakly developed blocky structure. These pass into an olive brown coloured very stony BC horizon (average thickness 25 cm) with coarse sandy textures and very weakly developed structure. The average depth to gravel in Dashwood shallow silt loam was 37 cm.

Range of profile features, variation and distinctions

The A horizon thickness range was between 15 and 23 cm and the somewhat shallower depths noted for the Dashwood soils maybe a result of wind erosion, as dust clouds were sometimes observed when the soils were being cultivated. The B horizon thickness varied between 29 and 64 cm.

Within each of the Dashwood map units there is much variation in the degree of stoniness with 8% of the observations recorded as very stony and 20% of the observations recording surface boulders. Soils with some mottles (moderately well drained class) and with heavy silt loam or clay loam subsoil texture (5% of the observations) were noted and these soils were found in lower lying swales on the gently undulating terrace surface. Occurring within the same landscape formation as Dashwood soils are Stafford and Toi soils. Stafford soils, formed from similar materials as Dashwood soils, have a deeper cover of loamy alluvium over gravel while Toi soils, also formed from the same alluvial materials occur in areas of impeded drainage. Dashwood soils are not recognised or mapped other than in the Awatere and Ward area but they have similarities with the Hillersden family which occurs in central Wairau Valley (Campbell et al., 2016; Harris & Birrell, 1939).

Analytical features (SB9288 Appendix 2)

The pH values for the Dashwood soil are moderately acid in the A horizon and increase with depth to near neutral to slightly alkaline. The A horizon C value is low and the N and C/N ratio values are medium. The P values are high to very high in the upper soil horizon and increase greatly in the lower less weathered gravelly horizons. The cation exchange and total bases values are medium and the base saturation values are very high.

Representative profile: Dashwood shallow silt loam (Dw2zG)

Horizon	Depth	Description
A	0-20 cm	dark brown (10YR 3/3) silt loam, weakly developed medium and fine polyhedral structure, weak soil strength, compact, friable, many fine roots
Bw	20-45 cm	yellowish brown (10YR 5/4) silt loam, moderately developed medium polyhedral structure, weak soil strength, compact, friable, many fine and medium stones, many fine roots
B(t)	45-67 cm	dark yellowish brown (10YR 4/4) sandy loam, very weakly developed fine polyhedral structure, loose abundant small to large stones, many dark yellowish brown (10YR 4/4) clay coatings on upper surfaces of stones, many fine roots
BC	67-80 cm	light olive brown (2.5Y 5/4) loamy sand, apedal, loose, abundant coarse stones, few fine roots
C	80-90+	olive brown (2.5Y 5/4) sandy gravel, apedal, loose, abundant coarse and large stones, very few fine roots

7.6.2. Stafford Soils

Map symbols: Sf1zG

Area: 195ha; 122 auger observations plus 11 pit descriptions

Reference

Stafford soils have not been mapped previously and are here separated as the soils with moderately deep profiles (loamy soils up to 90 cm deep over gravel) which have formed from Awatere River alluvium on the Starborough 2 terrace surface. In the initial survey of the soils in Awatere Valley, by Gibbs and Beggs (1953) and in the 1:250,000 survey by Soil Bureau Staff (1968), they were included within the Dashwood soil map unit in the Awatere Valley which covered most of the terrace land on the north side of the lower Awatere Valley.

Distribution, environment and soil material

Stafford soils are mapped in 15 locations in areas from 5 to 15 ha and are present together with Dashwood soils with which they are closely associated. The family includes Stafford moderately deep silt loam (Sf1zG) with no other distinctions being separated. They are found in places where deposits of loamy Awatere River alluvium exceed 45 cm on the Starborough 2 Terrace valley floor surface. The land is gently sloping with shallow ridge and swale undulations formed by river flow patterns at the time of alluvium deposition. The soil material for Stafford soils is Late Pleistocene quartzofeldspathic alluvium derived from greywacke, Tertiary sediments and some volcanic materials and they occur between 60-210 m above sea level and within the rainfall range of 700-825 mm per annum.

Characteristics and distinguishing features

Stafford soils are well drained, moderately deep soils with silt loam texture in the upper horizons and stony sandy gravel at greater depth. They are moderately weathered soils (profile form A/B/Bt/BC/C) with some weathering and oxidation extending into the subsurface gravels. The A horizon is dark greyish brown to dark brown (average thickness 21 cm) with silt loam texture and moderately developed soil structure. It overlies the yellowish brown to olive brown silt loam textured B horizon (average thickness 50 cm). This passes into a lower BC horizon that has olive brown colours, weakly developed structure and sandy texture with many stones.

Range of profile features, variation and distinctions

The A horizon thickness was between 16 and 26 cm and sandy loam texture was recorded in 26% of the observations. The upper B horizon thickness ranged between 30 and 80 cm while sandy loam textures were recorded at 30% of the observation sites and heavy silt loam texture at 9% of the sites. Soils with subsoil mottles (moderately well drained soils) were noted for 15% of the observations, these sites usually being located in the shallow swales of former river flow channels. A few stones are sometimes present within the upper horizons and the depth to underlying gravel was an average of 62 cm. As the depth to gravel diminishes and stoniness increases, Stafford soils merge with Dashwood soils. Stafford soils have similarities with moderately deep members of the Hillersden family which occurs in central parts of the Wairau Valley (Campbell et al., 2016; Harris & Birrell, 1939).

Analytical features (SB9378 Appendix 2)

The pH values increase with increasing depth from moderately acid in the surface horizon to near neutral in the lower horizons. The topsoil C value is low but the C/N ratio values are medium throughout the profile. Phosphorus values are high in the upper horizons and increase to very high in the lower stony subsoils. The cation exchange and total base values are medium in the A horizon and diminish with depth while the base saturation values are high throughout the profile and are indicative of the absence of a strong weathering or leaching regime. The sharp differences in clay and sand percentages between the upper and lower soil horizons highlights the distinction between the finer textured upper horizons and the gravelly deeper horizons.

Representative profile: Stafford moderately deep silt loam (Sf1zG)

Horizon	Depth	Description
A	0-18 cm	dark greyish brown to very dark greyish brown (10YR 4/2-3/2) silt loam, moderately developed medium and fine polyhedral structure, weak soil strength, compact, friable, abundant fine roots
AB	18-28 cm	dark greyish brown (10YR 3/2) and olive brown (2.5Y 5/4) silt loam, weakly developed medium and fine polyhedral structure, weak soil strength, compact, friable, many fine roots
Bw	28-51 cm	olive brown (2.5Y 4/4) silt loam, weakly developed fine blocky structure, slightly firm soil strength, compact, friable, few medium stones, many fine roots
Bw(t)	51-78 cm	olive brown (2.5Y 4/4) sandy gravel, weakly developed fine polyhedral structure, compact, few distinct dark brown (7.5YR 4/4) clay coatings on upper stone surfaces, abundant stones, many fine roots
BC	78-100 cm	olive brown to light olive brown (2.5Y 5/4) sandy gravel, apedal, loose, abundant stones, few fine roots
C	100-125 cm	olive (5Y 5/3) sandy gravel, many fine roots

7.6.3. Toi Soils

Map symbols: To2zG

Area: 90 ha; 31 auger observations plus 5 pit descriptions

Reference

Toi soils have not been previously identified and are mapped here as imperfectly to poorly drained shallow soils occurring on the Starborough 2 terrace surface. They occur alongside Dashwood soils with only one family member separated, Toi shallow silt loam (To2zG). In the previous soil surveys covering the Awatere Valley, (Gibbs & Beggs, 1953; Soil Bureau Staff, 1968) Toi soils are present within the Dashwood soil map units.

Distribution, environment and soil material

Toi soils are mapped in 8 locations on the north side of the Awatere River and occupy irregular shaped areas from 4 to 20 ha. They are present on the main Awatere Valley terrace in areas adjacent to the toe slopes of the alluvial fans that spill onto the terrace surface. Their imperfect to poor drainage is due to water seepages or accumulations around the lower margins of the fan surfaces where natural drainage channels are absent. The soil material is Awatere River alluvium and the land surface for Toi soils is essentially flat. They are found between 50 and 235 m above sea level and within a rainfall range of 700-850 mm per annum.

Characteristics and distinguishing features

Toi soils have a well-developed profile form (A/B(g)/Bg/BCg) with properties indicative of soil wetness during soil formation. The A horizon is very dark grey with silt loam texture, weakly to moderately developed polyhedral structure and it overlies B horizons that have predominantly greyish colours with grey and reddish-brown distinct mottle patterns, clay loam texture and blocky structure. The upper B horizons are stony or very stony with bouldery gravel encountered at an average depth of 55 cm.

Range of profile features, variation and distinctions

The A horizon thickness varies from 8 to 25 cm (average 17 cm) and sometimes has strong brown or reddish-brown mottles depending on the site wetness. Silt loam texture was noted in 55% of the observations and heavy silt loam to clay loam texture in 45% of the observations. Some stones in the A horizon were recorded in 16% of the observations and the average depth to gravel for Toi shallow silt loam was 35 cm.

The B horizons vary widely in respect of their colour patterns due to site differences in drainage characteristics with a grey colour and few mottles present in sites with poor drainage. A watertable at 50 cm was encountered in 20% of the observations. At 40% of the sites, moderately deep soils, with an average depth to gravel of 60 cm were encountered. Bluish colours are sometimes present in the gravelly subsoil where the watertable is present.

Within the Toi soil map units, Dashwood soils are present at well drained sites. Toi soils have similarities with Wainui soils, but the latter have poorer drainage and have clayey textures. Glenbrae soils have similar drainage characteristics to Toi soils but they are formed from younger stream deposits and have soil profiles that are less developed.

Analytical features

There are no analytical data for Toi soils, but their chemical properties would be expected to have similarities to those of Wainui soils.

Representative profile: Toi shallow silt loam (To2zG)

Horizon	Depth	Description
A	0-19 cm	very dark grey (10YR 3/1) silt loam, weakly developed fine to coarse polyhedral friable, many fine roots
B(g)	19-30 cm	light olive brown (2.5Y 5/4) heavy silt loam, weakly developed medium blocky structure, slightly firm soil strength, compact, friable, many distinct yellowish brown (10YR 5/8) mottles, common medium to coarse stones, many fine roots
Bg	30-50 cm	olive (5Y 5/3) stony silt loam, weakly developed medium blocky structure, compact, many distinct brownish yellow 10YR 6/6) mottles, few thin pale olive (5Y 5/3) clay coatings, abundant medium to large stones, few fine roots
BCg	50-80+ cm	olive grey (5Y 5/2) stony silty clay loam, weakly developed medium blocky structure, compact, many medium distinct brownish yellow (10YR 6/8) mottles, abundant medium to large stones, few fine roots

7.6.4. Seddon Soils

Map symbols: Sd0sG, Sd0zG

Area: 1178 ha; 255 auger observations plus 28 pit descriptions

Reference

Seddon soils were first identified by Gibbs and Beggs (1953) and were mapped as moderately deep to deep loamy soils that covered most of the high river terrace land on the south of the lower Awatere Valley. At that time, there was uncertainty about the nature of the soil material which was described then as 'loess-like sandstone'. In the General Survey of the Soils of South Island (Soil Bureau Staff, 1968) Seddon soils were likewise mapped on the high Awatere River terrace surface but covered three times the area of Seddon soils identified in the present survey.

Distribution, environment and soil material

Seddon soils are mapped in 18 locations in areas of between 5 and 470 ha and the family includes Seddon silt loam (Sd0zG) with a small area on undulating land (Sd0zU, 5 ha) and the much less extensive Seddon fine sandy loam (Sd0sG, 78 ha). Seddon soils occur extensively on the uppermost Starborough Terrace (Eden 1989) and in somewhat smaller areas on degradation terrace surfaces at slightly lower elevations. Their distribution is restricted to the southern side of the Awatere Valley terrace lands owing to the prevailing west/northwest wind flow, which picked up silty material from the bare river bed surfaces and deposited it as aeolian sediment (loess) on adjacent higher ground. Seddon sandy loam is found near the Awatere River toward the east of the valley where more turbulent air flows could transport coarser aeolian sediment. The loess material for Seddon soils is comparatively uniform down through the soil profile at any one site although the texture does vary from place to place and is commonly a little coarser nearer to the terrace edges. Its thickness also varies and may be greater than 1 m nearer the river becoming thinner further away. Seddon soils are formed within an altitude range of 15 to 240 m above sea level and 625-825 mm of rainfall.

Characteristics and distinguishing features

Seddon soils are well drained to moderately well drained, are deep to moderately deep with silt loam texture and have a well-developed profile form (A/B/B(g)/BC(x)/C). The A horizon is very dark greyish brown with weak to moderate polyhedral structure. B horizons are yellowish brown, friable to firm and polyhedral to blocky structured, passing at around 60 cm into firm to very firm silt loam with common strong brown to reddish brown mottles. Lower BC horizons are massive or have coarse structure, with sandy loam texture and overlie dark yellowish-brown stony gravel.

Range of profile features, variation and distinctions

The A horizon thickness was between 20 and 37 cm (average 25 cm) with thicker topsoils noted in areas where additions of aeolian sediment were currently occurring. In the Seddon silt loam map unit (Sd0zG), the A horizon texture was consistently silt loam with only 10% of observations recorded as sandy loam. In the Seddon fine sandy loam map unit (Sd0sG), there was greater A horizon textural variation with 40% of observations noted as silt loam.

In the Seddon silt loam map unit, the B horizon colours may be brown to dark brown, yellowish brown or olive brown with 60% of observations silt loam texture and 40% sandy loam and clay loam. In the Seddon sandy loam map unit 70% of the observations were sandy loam and 30% silt loam. The lower B horizons vary considerably in respect of the intensity of mottle patterns and the depth where they occur, with reddish to greyish and fine to coarse mottles beginning anywhere from between 50 to 80 cm depth. The deeper subsoil structure is likewise variable with 40% noted to have prismatic structure and 45% unstructured and massive (fragic (x) or hard pan). In both of the Seddon silt loam and sandy loam map units, moderately deep profiles (gravel at 85 cm) were noted in 30% of the observations while in the deep profiles, the average depth to gravel was 105 cm (range 90-145 cm for auger observations).

Analytical features (Site 1: SB9287 Site 2: SB8384, Site 3: SB9385 Appendix 2)

pH values for the soils at the three Seddon sample sites are broadly similar with moderately to slightly acid values in the A horizons and increasing values to moderately alkaline in the lower soil horizons. The

A horizon organic C values are low and very low in the subsoils, N values are low to medium while the C/N ratio values are medium throughout the profiles. Phosphorus values are high in the surface horizons and become less with depth except at site 1 where the values increase with depth. Cation exchange values are within the low to medium range through the soil profiles with total exchangeable bases within the medium range. The base saturation values are very high in all soil horizons. There are some indications the soil at site 1 east of Seddon is less leached than at the other two sites which were further inland. For example, traces of $CaCO_3$ are present in subsoil horizons at site 1 (also found in other soils in the driest parts of Marlborough) and higher subsoil base saturation and P values and lower P retention values are suggestive of weaker soil leaching. The annual rainfall at site 1 is probably around 100 mm less than at sites 2 and 3.

Representative profile: Seddon silt loam (Sd0zG)

Horizon	Depth	Description
A	0-21 cm	very dark greyish brown (10YR 3/2) silt loam, moderately developed fine and medium polyhedral structure, weak soil strength, compact, friable, abundant fine roots
Bw1	21-37 cm	olive brown (2.5Y 4/4) to dark yellowish brown (10YR 4/4) silt loam, weakly developed fine blocky and polyhedral structure, weak soil strength, compact, friable, many fine roots
Bw2	37-54 cm	dark yellowish brown (10YR 4/4) silt loam, weakly developed medium blocky structure, slightly firm soil strength, compact, friable, few dark yellowish brown (10YR 3/4) and olive (5Y 5/3) mottles, few fine roots
Bw(g)	54-77 cm	olive brown (2.5Y 4/4) to dark yellowish brown (10YR 4/4) silt loam, weakly developed medium blocky structure, firm soil strength, compact, brittle failure, many olive (5Y 5/3 and reddish brown (5YR 4/3) mottles, few fine roots
Bw(g)	77-110 cm	olive brown (2.5Y 4/4) fine sandy loam, weakly developed coarse prismatic structure, very firm soil strength, dense, brittle failure, many olive to pale olive (5Y 5/3-6/4) and strong brown (7.5YR 5/6) coarse mottles, very few roots

7.6.5. Seaview Soils

Map symbols: Sv0zG Sd0zU

Area: 314 ha; 76 auger observations plus 8 pit descriptions

Reference

Seaview soils were initially identified by Gibbs and Beggs (1953) in the survey of the soils of the Marlborough-Kaikoura districts and were mapped on the higher elevation rolling lands to the south of the Awatere Valley and north of Blind River. They were recognised as deeper soils with similarities to Seddon soils, likewise formed from material described as loess-like sandstone. In the General Survey of the Soils of South Island (Soil Bureau Staff, 1968) they were shown as having the same distribution as in the earlier soil survey.

Distribution, environment and soil material

Seaview soils are mapped in 6 locations in areas of between 3.5 and 160 ha. They occur only on the south side of the Awatere Valley on undulating higher terrace land east and west of Richmond Brook and are mostly a little further away from the Awatere River. The land surface on which they occur is around 15 m above that on which Seddon soils are found and is part of the older Downs Terrace (Eden 1989) of the Awatere Valley terrace system (Figure 12). Seaview silt loam (Sv0zG) is mapped on gently undulating land surfaces as well as on more strongly undulating to rolling surfaces (Sv0zU). The undulating to rolling land ground surface has a few shallow depressions (deflation hollows) and an undulation pattern with a subdued northwest-southeast alignment that is consistent with the formation of old dunes on the terrace surface. Seaview soils are formed on Late Pleistocene quartzofeldspathic loess deposits that are several metres thick and layered due to changing conditions over time. They have an appreciably lower sand content than that of Seddon soils because of the greater distance from the aeolian source. The lower layers of the loess materials are commonly sandier and are probably a result of very strong windy conditions at the time of deposition. Seaview soils occur within an elevation of 130 to 210 m above sea level and under a mean annual rainfall of around 680-800 mm.

Characteristics and distinguishing features

Seaview soils are deep, moderately well drained and moderately weathered soils (profile form A/Bw/B(g)/Bg/B(x)BC) with a silt loam to clay loam texture. The A horizon colour is dark yellowish brown with silt loam texture and moderately developed polyhedral structure. This overlies a yellowish brown to light olive brown upper B horizon with silt loam to clay loam textured and blocky/polyhedral structure. The lower heavy silt loam to clay loam B horizons have greyish and brownish mottles (commencing at 37 cm average depth) with mottles becoming more intensive with increasing depth. Below about 80 cm, the soil texture becomes sandier and at an average depth of 90 cm, the subsoil becomes massive (Bx) with prismatic structure.

Range of profile features, variation and distinctions

The A horizon thickness was between 20 and 26 cm (average 20 cm) while 75% of the observations recorded silt loam texture, 10% heavy silt loam and 15% clay loam. The B horizon textures had a similar range of variation with 76 % silt loam to heavy silt loam and 13% clay loam (average thickness 20 cm). The depth at which subsoil mottling was present was between 26 and 47 cm and is in part related to site variation with more intensive mottle patterns noted in depression areas where imperfectly drained soils may occur. A compact and massive lower subsoil with some prismatic soil structure was recorded in 75% of the observations with sandy or sandy loam texture appearing at an average depth of 105 cm. Underlying gravel was recorded in one soil profile pit at 170 cm. A few small stones were occasionally found within the soil profiles and these are most likely of a wind-blown origin. Seaview soils differ from Seddon soils in having deeper profiles, more intensive subsoil mottling and somewhat heavier textures. They differ from Sedgemere soils which have stronger mottle patterns (imperfectly drained) and heavy silt loam to silty clay textures and a well-developed subsoil hard pan (Bx or fragic horizon).

Analytical features (SB9533 Appendix 2)

The pH values for the upper horizons of the Seaview soil are moderately acid and increase downwards to moderately alkaline. The organic C values are low in the A horizon becoming very low in the horizons

below. The C/N values are low to very low in the surface horizons but increase to high between 60 and 120 cm depth. Phosphorous values are predominantly very high but the values vary at different depths within the profile. This is possibly a reflection of fluctuations in aeolian materials during deposition of the loess deposits. Cation exchange values are medium and total exchangeable bases are medium to high while base saturation values are high in the surface horizons and very high in the horizons below.

Representative profile: Seaview silt loam (Sv0zG)

Horizon	Depth	Description
A	0-23 cm	very dark greyish brown (10YR 3/2) silt loam, moderately developed fine polyhedral structure, weak soil strength, compact, friable, many fine roots
AB	23-27 cm	very dark greyish brown (10YR 3/2) and yellowish brown to light olive brown (10YR 5/4-2.5Y 5/4) silt loam, weakly developed fine polyhedral and blocky structure, weak soil strength, compact, friable, many fine roots
Bw	27-47 cm	light olive brown (2.5Y 5/4) silt loam, weakly developed fine blocky structure, few fine yellowish red (5YR 4/6) mottles, common fine roots
B(g)	47-62 cm	yellowish brown (10YR 5/6) heavy silt loam to silty clay, moderately developed coarse blocky structure, firm soil strength compact, brittle failure, abundant greyish brown (10YR 5/2) and yellowish brown (10YR 5/6) mottles, few fine roots
B(gt)	62-96 cm	yellowish brown (10YR 5/6) heavy silt loam to silty clay, moderately developed coarse blocky structure, firm to very firm, light brownish grey (2.5Y 6/2) and yellowish brown (10YR 5/4) mottles, many distinct dark brown (10YR 4/3) clay coatings, very few fine roots
Bg(t)	96-122 cm	dark yellowish brown (10YR 4/4) clay loam, weakly developed medium prismatic to blocky structure, very firm soil strength, brittle failure, many coarse olive (5Y 5/3-5/4) mottles, many thin dark brown (10YR 4/3) clay coatings, very few fine roots
B(x)	122-144 cm	dark yellowish brown (10YR 4/4) heavy silt loam, apedal, massive, very firm, very few fine roots
B(x)		

7.7. Soils of the High Dissected Terraces

The high dissected terraces encompass the oldest and highest elevation landscapes within the survey area with some of the soils showing more advanced weathering features. Also included within this topographic unit are some distinctive soils of younger age that are derived from volcanic rock materials that have been eroded from higher elevation valley side surfaces and deposited on terrace surfaces below.

7.7.1. Altimarlock Soils

Map symbols: Ak2zG, Ak2zU, Ak3zU, Ak3zR

Area: 132 ha; 69 auger observations plus 13 pit descriptions

Reference

The Altimarlock soil family has not been previously identified and is separated here as soils which are formed on colluvial materials that are derived from the erosion of volcanic rock materials and which have been deposited on old terrace surfaces. They were not recognised in the earlier surveys and are included within the Hundalee-Kekerengu map unit both by Gibbs and Beggs (1953) and in the South Island Soil Survey (Soil Bureau Staff, 1968)

Distribution, environment and soil material

Altimarlock soils are mapped in 12 places in areas ranging between 4 and 36 ha. The soil family includes Altimarlock shallow silt loam on flat to undulating and undulating land (Ak2zG, Ak2zU) and Altimarlock stony silt loam on flat to undulating and rolling land (Ak3zG, Ak3zR). Altimarlock soils are found on the north side of the Awatere River toward the western part of the survey area. They occur on higher elevation, on somewhat narrow Starborough and Downs Terrace remnant surfaces that are 50 to 75 m above river level and which lie adjacent to the steep valley side slopes of the Black Birch Range. The uneven undulating and rolling surfaces may be partly due to ground movement on the Awatere Fault which traverses the area in which Altimarlock soils occur. The soil material comprises predominantly angular stony igneous material with some greywacke gravel, derived from the erosion of volcanic rock intrusives (Challis, 1960), which are within the greywacke rocks on the Black Birch Range valley side. The sediments have been deposited on the adjacent terrace surfaces, as erosional detritus and possibly landslide debris, as suggested by bouldery material that is sometimes present. Altimarlock soils occur within the altitude range of 220 to 280 m above sea level and within a rainfall range of 800 to 850 mm per annum.

Characteristics and distinguishing features

Altimarlock soils are well drained, shallow and stony with distinctive reddish subsoil colours and have a moderately deep to deep profile weathering form (A/B/B(t)/BC). The A horizon has a dark brown colour, an average thickness of 21 cm and has well developed polyhedral structure. The B horizons extend to around 75 cm depth, have reddish brown colours, stony heavy silt loam texture, weak soil structure and pass into reddish brown weakly to moderately consolidated stony gravel. The average depth to gravel for Altimarlock shallow silt loam was 33 cm.

Range of profile features, variation and distinctions

The A horizon thickness varied between 15 and 26 cm, reddish brown colours were noted in 25% of the observations and a topsoil sandy loam texture was found at 20% of the recording sites. The B horizons have a wide colour range within the reds and browns while the textural range was between silt loam and clay loam. The degree of soil stoniness was likewise highly variable, largely due to layering within the parent material with surface boulders recorded in 30% of the observations. In the Altimarlock shallow silt loam map unit, some stones were nearly always present in the upper 45 cm and the average depth to stony gravel was 32 cm. Moderately deep soils were found at 10% of the observation sites.

Altimarlock soils have similarities with Middlehurst soils, which were mapped further inland in Awatere valley by Gibbs and Beggs (1953). The latter are reddish brown clayey soils formed from volcanic rocks and they have somewhat different physical and chemical properties. Rossmore soils, distinguished in the present survey, also have similarities with Altimarlock soils but they are formed on younger deposits of

volcanic detritus and while having similar soil colours, are less weathered with weaker soil profile development. Blairich and Awadale soils are related to Altimarlock soils, being formed on similar materials but they occur in lower lying places and are imperfectly to poorly drained.

Analytical features (SB9388 Appendix 2)

The two Altimarlock soils that were sampled have differing soil materials, with the SB9387 soil having some loess material present and which was noticeable as a distinct layer between 66 and 111 cm. The silt fraction of SB9387 is significantly greater throughout than in SB9388 which suggests that there may be some aeolian material through the entire soil. The pH values for the A horizons of both of the Altimarlock soils are strongly to moderately acid and with increasing depth the pH values increase to slightly alkaline. The organic C , total N and C/N values are similar in A horizons for both soils and are in the low to medium range, the C values being a little higher than for the other soils in the survey area. Phosphorus values in SB9378 are very high but values in SB9388 are more than twice as high. The phosphate retention values are in the medium range for SB9388 and lower in SB9387. Cation exchange capacity and total bases are in the medium range and base saturation values are medium and increase to very high in the lower soil horizons. The somewhat greater values for Ca, Mg, K and extractable Fe compared with the other soils of the survey area are a reflection of the mineralogical composition of the basic igneous rock soil materials which typically have a high ferromagnesian mineral content.

Representative profile: Altimarlock shallow silt loam (Ak2zG)

Horizon	Depth	Description
A	0-19 cm	dark brown (7.5YR 3/2) silt loam, weakly developed fine and medium polyhedral structure, weak soil strength, compact, very friable, few small stones, abundant fine roots
AB	19-27 cm	reddish brown to dark brown (5YR 4/4-7.5YR 3/2) heavy silt loam, weakly developed fine polyhedral structure, weak soil strength, compact, friable, few small stones, many fine roots
Bw1	27-40 cm	reddish brown (5YR 4/4) heavy silt loam, weakly developed fine blocky and polyhedral structure, weak soil strength, compact, friable, few to many medium stones, few fine roots
Bw2	40-56 cm	reddish brown (5YR 4/4) clay loam, weakly developed fine blocky structure, compact, friable, many small and medium stones, few fine roots
B(t)	56-90 cm	dark red (2.5YR 3/6) stony gravel, massive, breaking to weak fine blocky structure, firm, many distinct red (2.5YR 4/4) clay coatings, few fine roots
BC	90-130 cm	reddish brown (2.5YR 4/4) stony gravel, massive, firm, few fine yellowish red (5YR 4/6) mottles, few reddish brown (2.5YR 4/4) clay coatings, very few fine roots

7.7.2. Blairich Soils

Map symbols: Bl2zG, Bl2zU

Area: 22ha; 12 auger observations plus 3 pit descriptions

Reference

Blairich soils are a new soil group in this survey that separates moderately well drained to imperfectly drained soils from the well-drained Altimarlock soils formed from similar colluvial volcanic materials. Unidentified in the earlier soil surveys by Gibbs and Beggs (1953) and Soil Bureau Staff (1968) in the Lower Awatere Valley, Blairich soils are included within the area mapped as Hundalee-Kekerengu soils in those surveys.

Distribution, environment and soil material

Blairich soils occur on a higher-level terrace remnant surface on the north side of Awatere River in the vicinity of Black Birch stream. The family is mapped in 4 locations in areas of between 1 and 11 ha and includes Blairich shallow silt loam (Bl2zG) on flat to gently undulating land and Blairich shallow silt loam (Bl2zU) on undulating land. The soils are present on small fan deposits that lie on the lowermost slopes of the Black Birch Range and their impeded drainage attributes are a result of runoff water from higher ground permeating through the lower ground surfaces. As with Altimarlock soils with which they are associated, they are formed from gravelly volcanic materials that have eroded from Valley side surfaces on the Black Birch Range. The soils are moderately weathered with weathering and oxidation extending to greater than one meter (profile form (A/B/Bg/Bg(t)) and are probably of late Pleistocene age. They occur within an altitude range of 220-280 m above sea level and under a rainfall of around 825-850 mm per annum.

Characteristics and distinguishing features

The A horizon has a brown to dark brown colour (average thickness 22 cm) with silt loam texture, well developed polyhedral structure and with a few small stones present. The upper B horizons have well developed polyhedral structure a reddish-brown soil colour, silt loam texture with many stones (average depth to gravel 28 cm), an average thickness of 50 cm and few to many weak red to yellowish red mottles. The lower B horizons are massive with little structural development, texture is gravelly sandy clay with reddish brown clay coatings and the soil colour is varied with weak red, reddish brown and yellowish-brown mottle patterns.

Range of profile features, variation and distinctions

The A horizon thickness range was between 20 and 24 cm and at times had a reddish-brown colour while for 25% of the observations, the texture was heavy silt loam. The depth to gravel is variable with 15% of the observations being moderately deep soils. The subsoil mottle patterns vary from moderate to intense. Blairich soils have affinities with Altimarlock soils which are from similar materials but well drained and also with Awadale soils, which likewise have a component of volcanic materials but which have poor drainage.

Analytical features

There are no analytical data for Blairich soils but their chemical properties are likely to have similarities with Altimarlock soils and Awadale soils which are both formed in deposits originating from volcanic materials.

Representative profile: Blairich shallow silt loam (Bl2zG)

Horizon	Depth	Description
A	0-20 cm	dark brown (7.5YR 4/2) silt loam, moderately developed fine and medium polyhedral structure, weak soil strength, compact, very friable, few faint reddish brown (5YR 4/4) mottles, few fine stones, many fine roots
B(g)1	20-45 cm	weak red (10R 5/4) silt loam, moderately developed medium blocky and polyhedral structure, weak soil strength, compact, friable, few to many reddish brown 5YR 5/4) distinct mottles, many small and medium stones, many fine roots
B(g)2	45-73 cm	weak red (10R 5/4) sandy clay loam, apedal, compact breaking to single grains, few reddish brown (5YR 4/4) distinct mottles, few weak red (10R 5/3) clay coatings, many medium and small stones, many fine roots
Bgt	73-100 cm	weak red to reddish brown (2.5YR 5/2-5/4) sandy loam, apedal, massive, many weak red to reddish brown (2.5YR 5/2-5/4) and yellowish red (5YR 4/8) mottles, many weak red (10Y 5/3) clay coatings, few small stones

7.7.3. Awadale soils

Map symbol: Ad1zG

Area: 13 ha; 15 auger observations plus 2 pit descriptions

Reference

Although small in area, the Awadale soil family is separated because it distinguishes poorly drained soils formed from colluvium with volcanic materials from the moderately well to imperfectly drained (Blairich) and well drained (Altimarlock) soils within the same area, which are also formed from similar materials. In the earlier soil surveys by Gibbs and Beggs (1953) and Soil Bureau Staff (1968), Awadale soils are contained within the Hundalee-Kekerengu map unit.

Distribution, environment and soil material

Awadale soils are mapped in two locations, one small area of approximately 1 ha and the other larger area of 12 ha. The family includes Awadale moderately deep silt loam (Ad1zG) and occurs on a high terrace surface around 50 m above the Awatere River and southwest side of Black Birch stream. The land surface is flat to gently undulating and the poor soil drainage characteristics for Awadale soils may be a result of land movement on the Awatere Fault with uplift on the southern side impeding ground-water flow. The soil material is Holocene aged colluvial silty to gravelly sediment, deposited primarily as fan debris, originating from igneous and greywacke rock material on adjacent valley side surfaces. Awadale soils occur within an elevation range of 220 to 240 m above sea level and under a mean annual rainfall of around 850 mm.

Characteristics and distinguishing features

The Awadale soil family are poorly drained soils with heavy silt loam to silty clay textures, weathering differentiation extends to around 1 m depth (profile form A/Br/Bg/Bgt/BCg) and the soil depth class is moderately deep. The A horizon is black to dark reddish brown with heavy silt loam texture, has an average thickness of 20 cm and is very friable with strongly developed fine polyhedral structure. The upper B horizons have predominantly greyish soil colours with reddish or weak red coloured mottles, silty clay texture and blocky structure and an average depth to gravel of 65 cm. The lower B horizons below around 60 cm also have greyish colours but with greater concentrations of reddish mottles, gravelly clay loam texture, weakly developed soil structure and firm consistence.

Range of profile features, variation and distinctions

Although small in area, an appreciable degree of variability was observed in the Awadale family. The A horizon thickness was between 15 and 30 cm and in places where the watertable was high the surface horizon was slightly peaty (15% of the observations). Subsoil colours and mottle intensity are also highly varied depending on the degree of soil wetness with red hues ranging from pinkish grey to dark red. Surface stones were recorded in 35% of the observations, the depth to gravel was between 50 to 70 cm and occasionally greater than 1 m depth. Awadale soils are distinguished from Blairich soils in having greyer subsoil colours, indicative of poorer soil drainage. Where non-volcanic colluvial material is present, the soil profiles resemble those of Wainui soils.

Analytical features (SB9376)

The soil pH values at the Awadale soil sample site are strongly acid in the two A horizons with soil acidity becoming moderately to weakly acid with increasing soil depth. The organic C values in the A horizons are high (slightly peaty) and although the values diminish becoming low to very low with increasing depth, the subsoil C values are somewhat greater than for those found at the other sample sites. The higher soil acidity and organic C values are a reflection of the site wetness and diminished decomposition of organic matter. The N values in the A horizons are likewise high but low to very low in the subsoil horizons while the C/N ratio values are medium through the soil profile. All values for P (H_2SO_4, inorganic and total P) are very high to exceedingly high while P retention values are within the medium to high range. The cation exchange values are very high to high throughout the profile as are the total exchangeable bases and the base saturation values.

Representative profile: Awadale moderately deep clay loam

Horizon	Depth	Description
A(H)	0-8 cm	very dark grey (5YR 3/1) humic clay loam, moderately developed fine polyhedral structure, very weak soil strength, loose, very friable, abundant fine roots
A	8-15 cm	black (5YR 2.5/1) clay loam, moderately developed fine polyhedral structure, very weak soil strength, compact, friable, many fine roots
Br1	15-30 cm	light brownish grey (10YR 6/2) silt loam, moderately developed medium polyhedral and blocky structure, slightly firm soil strength, compact, friable, many grey 10YR 6/1) and few pink (5YR 7/4) fine mottles, few fine roots
Br2	30-45 cm	light grey (2.5Y 7/2) silty clay, moderately developed medium blocky structure, slightly firm soil strength, compact, brittle failure, few yellowish red (5YR 5/8) and pale brown (10YR 6/3) mottles, few fine roots
Bg	45-58 cm	light grey (2.5Y 7/2) silty clay, weakly developed fine and medium blocky structure, firm soil strength, compact, semi deformable, abundant yellowish red (5YR 4/6) mottles, few fine roots
Bg(t)	58-80 cm	reddish yellow (5YR 6/6) clay loam, strongly developed coarse blocky structure, very firm, dense, semi deformable, many yellowish red (5YR 4/8) and light grey (2.5Y 7/2) mottles, few thin dark red (10YR 3/6) clay coatings, many small stones, few fine roots
Bg		

7.7.4. Sedgemere Soils

Map symbols: Sm0zG, Sm0zU, Sm0zR.

Area: 614 ha; 115 auger observations plus 10 pit descriptions

Reference

Sedgemere soils were first identified by Gibbs and Beggs (1953) and were shown as occurring in a few places south of Blenheim and more extensively between Seddon and Ward. They were mapped on undulating to easy rolling land the soils being formed from loess materials with a characteristically slow soil drainage. In the General Survey of the Soils of South Island (Soil Bureau Staff, 1968). Sedgemere soils in the Awatere Valley are mapped to the west of Seddon as in the survey by Gibbs and Beggs (1953).

Distribution, environment and soil material

Sedgemere soils are mapped in 15 locations in areas from between 5 to 96 ha and occur on the south side of Awatere River west of Seddon and are also mapped in one small area on the north side near Alton Downs. Mapping units that are separated include Sedgemere silt loam on flat to gently undulating surfaces (Sm0zG, 139 ha) and Sedgemere silt loam on undulating and rolling land (Sm0zU, 6 ha and Sm0zR 166 ha). The soils are formed on older dissected terraces of the Awatere Valley (Downs Terrace, Eden 1989) which is around 5 m above the Starborough 1 surface. Sedgemere soils are formed from loess deposits that are several metres thick, are finer textured than the loess material for Seddon and Seaview soils (Table 1) and which are older in the basal layers. The Sedgemere soil loess, like the other soil forming loess deposits is dominated by a quartzofeldspathic mineralogy, but the presence of muscovite throughout the profile (Appendix 3), which is largely absent in the Seddon and Seaview soils, is indicative of a somewhat different provenance likely to be inputs of Wairau Valley Loess derived from the schist geologies found to the north of the Wairau Valley.. Sedgemere soils occur between 120 to 250 m above sea level and within a rainfall range of approximately 750-800 mm per annum.

Characteristics and distinguishing features

Sedgemere soils are deep, moderately weathered and imperfectly drained soils (profile form A/B(g)/Bg/B(t)g/Bx) characterised by distinct mottle patterns below the topsoil and a very firm lower subsoil fragic (Bx) horizon or hard pan. The A horizon (average 22 cm thick) is very dark greyish brown silt loam with weakly to moderately developed fine polyhedral structure and overlies a thin (15 cm average) upper B horizon that is yellowish brown to pale brown heavy silt loam with weakly developed blocky structure. The lower B horizons between 35 cm to 75 cm have silty to clayey textures, strongly developed coarse mottle patterns dominated by both light grey to light brownish grey and, strong brown to reddish brown mottle colours. Structure is blocky to prismatic. The lowest soil horizons have a silt loam texture are mainly massive, very hard and have coarse prismatic structure forming the Bx horizon.

Combined with the slightly higher rainfall regime under which the soils are formed, the distinctive subsoil mottle pattern of the Sedgemere soil reflects poorer drainage resulting from restricted downward water movement caused by the impermeable subsoil hard pan. These soils may be saturated for a period over winter months with surface water ponding observed on some occasions.

Range of profile features, variation and distinctions

The A horizon thickness varied between 19 and 30 cm with 70% of the observations recording a silt loam texture and 30% heavy silt loam. The upper most B horizon varied in thickness between 10 and 22 cm and in 60% of the observations there were some reddish- or yellowish-brown mottles present. Silt loam texture in the B horizon was noted in 10% of the observations. The depth to the Bx horizon (hard pan) was between 60 and 80 cm. In some places, patches of gravelly or stony soils are present within the Sedgemere map units where local streams have spilt some alluvium onto the terrace surface. Sedgemere soils have similarities with Jordan soils, the later commonly overlying partly weathered gravel and often distinguished by a pale brown, weakly structured upper B horizon.

Analytical features (SB9533 Appendix 2)

The ph values for the Sedgemere soil are moderately acid in the upper horizons and increase to near neutral and moderately alkaline in the lower horizons. The A horizon C value is low with very low values in all of the horizons below. The N value is medium in the A horizon and the values are low to medium in the underlying horizons. The P value in the A horizon is very high and values decrease downwards then increase to very high in the two lowest horizons. The cation exchange values are medium to low through the soil and the total exchangeable bases medium to high while the base saturation values are high in the upper horizons and very high in the horizons below.

Representative profile: Sedgemere silt loam (Sm0zG)

Horizon	Depth	Description
A	0-21 cm	very dark greyish brown (10YR 3/2) silt loam, weakly developed fine polyhedral structure, weak soil strength, compact, friable, many fine roots
Bw(g)	21-31 cm	yellowish brown (10YR 5/4) heavy silt loam, weakly developed fine blocky and polyhedral structure, weak soil strength, compact, friable, few fine reddish brown and strong brown (5YR 3/4 & 7.5YR 5/6) mottles, weak soil strength, compact, friable, many fine roots
Bw(g)	31-47 cm	light yellowish brown to light olive brown (10YR 6/4-5/4) heavy silt loam, weakly developed medium blocky structure, weak soil strength, compact, friable, few yellowish red (5YR 5/8) mottles, few fine roots
Bwg	47-76 cm	light yellowish brown (2.5Y 6/4) heavy silt loam to silty clay, moderately developed medium blocky structure, firm soil strength, compact, brittle failure, many strong brown and yellowish red (7.5YR 5/8 & 5YR 4/6) mottles
Bgt	76-106 cm	light yellowish brown (2.5Y 6/4) heavy silt loam, moderately developed medium and coarse blocky structure, firm to very firm soil strength, compact, brittle failure, abundant strong brown, yellowish red and pale olive (7.5YR 5/6, 5YR 4/6 &5Y 6/3) coarse mottles, many distinct dark brown (5YR 4/8-2.5Y 4/2) clay coatings, very few roots
Btg	106-109 cm	dusky red (2.5Y 3/2) silt loam, massive, apedal, abundant yellowish red, strong brown and pale olive (5YR 4/8, 7.5YR 5/8 & 5Y 6/3) mottles, many dark reddish brown (5YR 3/2) clay coatings, very few roots
Bx	109-120 cm+	light olive brown to olive brown (2.5Y 5/4-4/4) silt loam, moderately developed coarse prismatic structure, massive, extremely firm

7.7.5. Jordan soils

Map symbols: Jd0zG Jd0zR

Area: 260 ha; 58 auger observations plus 6 pit descriptions

Reference

Jordan soils have been previously mapped in the Marlborough district in the soil survey by Gibbs and Beggs (1953) and were shown as occurring chiefly on rolling land surfaces in the Waihopai Valley area, in the Awatere Valley and in a number of places extending southwards to beyond Kaikoura. Elsewhere, Jordan soils have been mapped on similar old terrace surfaces in the Lower Wairau Plains survey (Omaka Valley) by Laffan and Vincent (1990) and by Campbell et al. (2016) in the Wairau Valley. In the Awatere Valley, they were identified during this survey within an area on the north side of the Awatere River in the vicinity of Taylor Pass Road. They are also shown as occurring within the present survey area in the General Survey of the Soils of South Island (Soil Bureau Staff, 1968). They were earlier recognised as slow draining and heavy textured soils, formed on undulating to rolling land and from greywacke alluvium.

Distribution, environment and soil material

Jordan soils are mapped in 12 locations and in areas ranging between 3.5 and 63 ha. They are found on the north side of the Awatere River within the vicinity of the Taylor Pass Road and are mapped in one small area on a higher terrace remnant near Upton Downs. Jordan soils occur on undulating to rolling land on the Downs Terrace (Eden, 1989) and while they cover a significant area within the Awatere district, they are of limited extent within the present survey area. The map units separated are Jordan silt loam (Jd0zG) on gently undulating land and Jordan silt loam (Jd0zR) on rolling land. Jordan soils are formed from loess, up to around 1 m thick which overlies old partly weathered gravels. The loess material has a finer texture than the other loessial soils (Table 1) and may have been accumulating since Late Otarian time (circa <28,000 yrs) as indicated by the volcanic ash deposits that are seen elsewhere (Eden, 1989). Jordan soils occur within an altitude range of 100 to 280 m above sea level and within a rainfall range of 750-825 mm per annum.

Characteristics and distinguishing features

Jordan soils are imperfectly drained soils and are moderately to strongly weathered (profile form A/Bw/Btg/Bt/Bx). The A horizon averages 21 cm thick, is a very dark greyish brown colour, with silt loam texture and weakly developed polyhedral structure. The underlying upper B horizon (average thickness 19 cm) has a somewhat pale light yellowish brown colour, a silt loam to heavy silt loam texture and weakly developed blocky structure. The deeper B horizons are characterised by clayey texture, blocky and prismatic structures, very firm consistence, intensive mottle patterns and a thin greyish brown or pinkish-grey gleyed horizon that rests on a very hard massive or prismatic structured, fragic hard pan horizon. The imperfect soil drainage results from the underlying hard pan which restricts downward water movement and causes distinctive gleyic features in a thin layer at its surface.

Range of profile features, variation and distinctions

The A horizon thickness was between 17 and 23 cm. The upper B horizon thickness was between 11 and 20 cm and a few dark brown concretions and some fine brown mottles were sometimes present. The B horizon texture variation was recorded as 36% of observations were clay loam, with 40% heavy silt loam to clay loam and 24% silt loam. The depth to the Bx horizon varied between 72 and 92 cm. In some places, weathered gravel is present at depths of around 1 metre. In terms of soil horizon formation, Jordan soils can be regarded as deep soils with weathering features extending to greater than one metre depth, however in an agronomic sense, they may be considered as moderately deep soils, because the very hard subsurface horizon is very restrictive for moisture and root penetration.

Analytical features (SB9386 Appendix 2)

The pH value in the A horizon at the Jordan sample site was strongly acid but the values increased to moderately to slightly acid in the underlying horizons, while the organic C value for the A horizon was low to medium with very low values in the other horizons. The A horizon N and C/N values are medium with the N values in the lower horizons very low and the C/N values medium. The A horizon P values are high

to medium in the lower horizons while the P retention values are somewhat elevated when compared with the P retention values for the other soils that were sampled. The cation exchange values are medium through the soil profile while the total bases are low to medium. The base saturation values are medium in the upper horizons and are low in the deeper soil horizons.

The analytical data for this soil profile suggest a somewhat greater degree of soil weathering than is evident in the other soils that were analysed. The higher fine clay values are an indication of more advanced weathering, with the higher value (32%) in the 110-112 cm horizon a result of clay movement down through the soil profile and accumulation in this layer. These features are all indicative of older soils that have been exposed to weathering for a longer period.

Representative profile: Jordan silt loam (Jd0zG)

Horizon	Depth	Description
A	0-15 cm	very dark greyish brown (10YR 3/2) silt loam weakly developed fine polyhedral and blocky structure, weak soil strength, compact, friable, many fine roots
Bw	15-33 cm	light yellowish brown (2.5Y 6/6) silt loam, weakly developed fine blocky and polyhedral structure, very weak soil strength, compact, friable, few fine roots
B(g)t	33-47 cm	light olive brown (2.5Y 5/4) heavy silt loam, moderately developed medium blocky structure, firm soil strength, compact, brittle failure, few yellowish brown and light grey (10YR 5/6 & 2.5Y 7/2) mottles, few to many dark brown (10YR 4/3) clay coatings, few fine roots
Bgt1	47-68 cm	yellowish brown (10YR 5/4) clay loam, moderately developed coarse blocky structure, firm soil strength, compact, brittle failure, many yellowish red and pale olive (5YR 4/6 & 5Y 6/3) mottles, many dark brown (10YR 6/3) clay coatings, few fine roots
Bgt2	68-92 cm	yellowish brown (10YR 5/6) clay loam, weakly developed prismatic and moderately developed blocky structure, very firm soil strength, compact, brittle failure, abundant light olive brown, yellowish red and pale olive (2.5Y 5/4, 5YR 4/6 & 5Y 6/3) mottles, many dark brown clay coatings, few fine roots
Bgt3	92-110 cm	light yellowish brown (2.5Y 6/4) clay loam, moderately developed medium prismatic structure, very firm soil strength, dense, brittle failure, many strong brown, and red (7.5YR 5/8 & 2.5YR 5/6) mottles, many brown (10YR 5/3) clay coatings, few fine roots
Bg	110-112 cm	brown to yellowish brown (10YR 5/5) clay loam, apedal, sticky, many pale olive (5Y 6/3) mottles, very few roots
Bx		

8. Appendix 1 – Awatere Valley Extended Legend

Summary of soil distribution, environmental and physical properties for soils mapped in Lower Awatere Valley.

Soil name	Soil family [1]	Soil classification [2]	Occurrence & soil area	Soil family member	Soil map symbol	Distribution and topography [3]	Rainfall range (mm)	Altitude range (m)	Soil parent material	Soil drainage class [4]	Main physical features [5]	Horizon & thickness		Brief representative soil description	Avg depth to gravel 6	PRD [7]	Estimated PAW 8
Awatere	Awatere	Fluvial Recent/ Raw soil	38 locations 2-21 ha total 201 ha	Awatere complex	Aw1bG	Small floodplain patches alongside river; undulating river-channelled ground, often bouldery	630-850	5-210	Recent river alluvium, mainly from greywacke	Well drained	Stony, shallow, moderately deep or deep, loamy sand or silt loam over gravel, weathering depth (U)	A C C	8 cm 44 cm on	dark greyish brown (2.5Y 4/4) loamy sand, olive to olive grey (2.5Y 4/3-4/2) sand, olive grey stony sand	42 cm	70 cm+	80 mm
Galtymore	Galtymore	Fluvial Recent soil	21 locations 1-21 ha total 120 ha	Galtymore moderately deep sandy loam	Gm1sG	Low river terraces of Awatere River; flat to gently undulating surfaces	630-825	7-175	Recent river alluvium, mainly from greywacke	Well drained	Moderately deep sandy loam, weathering depth (S)	A (B) C	22 cm 25 cm 23 cm	brown to dark brown (10YR 4/3) sandy loam, dark brown ((10YR 3/3) sandy loam, dark brown and dark greyish brown (10YR 3/3+2.5Y 4/2), stony sand, on gravel	55 cm	90 cm+	70 mm
				Galtymore deep sandy loam	Gm0sG	Low river terraces of Awatere River;weathering depth (S)	630-825	30-190	Recent river alluvium, mainly from greywacke	Well drained	Deep sandy loam from greywacke weathering depth (S)	A (B) C	20 cm 18cm 62 cm	brown to dark brown (10YR 4/3) sandy loam, olive brown (2.5Y 4/4) sandy loam, olive 5Y 4/3) sandy loam, on gravel	91 cm	100 cm+	130 mm
Wairau	Condersbend	Fluvial Recent soils	50 locations 1-55 ha total 355	Wairau bouldery sandy loam	Wr4sG^B	Low river terraces of Awatere River; uneven river channelled surfaces	650-850	7-200	Recent bouldery river alluvium, mainly from greywacke	Well drained	Bouldery soils, weathering depth (S)	A (B) C	29 cm 21 cm 54 cm	very dark greyish brown (10YR 3/2) stony sandy loam, many coarse stones and boulders olive brown (2.5Y 4/4) stony loamy sand, abundant coarse stones and boulders greyish brown (2.5Y 4/2) stony gravel	<10 cm	80 cm+	55 mm
				Wairau stony sandy loam	Wr3sG	Low river terraces of Awatere River; uneven river channelled surfaces	650-850	7-200	Recent bouldery river alluvium, mainly from greywacke	Well drained	Stony soils, weathering depth (S)	A BC	23 cm 23 cm	dark brown (10YR 4/3) stony sandy loam olive grey (5Y 4/2) sandy loam, on bouldery gravel	<10 cm	80 cm+	55 mm
				Wairau shallow sandy loam	Wr2sG	Low river terraces of Awatere River; uneven river channelled surfaces	650-850	7-200	Recent river alluvium, mainly from greywacke	Well drained	Shallow (20-45 cm) sandy loam, soils, weathering depth (S)	A (B) C	31 cm 26 cm 23 cm+	greyish brown to very dark greyish brown (10YR 4/2-3/2) sandy loam brown to dark brown (10YR 4/3) sand, abundant stones and boulders olive (5Y 4/3) bouldery gravel	24 cm	80 cm+	65 mm
Rossmore	Rossmore	Orthic Melanic soil	3 locations 1-4.5 ha total 8.5 ha	Rossmore stony sandy loam	Rm3sG	Small fan areas; gently sloping undulating surface (U)	800-820	180-200	Recent fan colluvium from reworked volcanic material	Well drained	Stony gravel; reddish soil colours; reddish colours, weathering depth (S)	A (B) C bB	24 cm 22 cm 21 cm 33 cm	dark reddish brown (5YR 3/2) stony fine sandy loam, dark reddish brown (5YR 3/4) stony sandy loam dark reddish brown to dark brown (5YR 3/3-7.5YR 3/2) sandy gravel reddish brown stony sandy loam	<10 cm	100 cm +	60 mm
Dumgree	Dumgree	Orthic Recent soil	17 locations 1-26 ha total 195 ha	Dumgree moderately deep sandy loam	Dg1sG	Small areas on lower intermediate terraces, flat to gently undulating with river channelled surfaces	625-825	10-210	River alluvium mainly from greywacke	Well drained	Moderately deep sandy loam over gravel, weathering depth (M)	A (B) BC C	18 cm 12 cm 55 cm 25 cm+	very dark greyish brown (10YR 3/2) sandy loam very dark greyish brown to dark grey (10YR 3/2-3/1) sandy loam olive brown (2.5Y 4/4) fine sandy loam olive (5Y 4/3) bouldery sandy gravel	63 cm	100 cm+	130 mm
				Dumgree sandy loam	Dg0sG	Small areas on lower intermediate terraces, flat to gently undulating with river channelled surfaces	630-800	50-200	River alluvium mainly from greywacke	Well drained	Deep sandy loam over gravel, weathering depth (M)	A (B) BC C	24 cm 15 cm 20 cm 25 cm	very dark greyish brown (10YR 3/2) fine sandy loam, brown to dark brown (10YR 4/3) silt loam, olive brown (2.5Y 4/4) silt loam light olive brown (2.5Y 4/4) fine sandy loam, firm	98 cm	100 cm+	125 mm
Omaka	Tata	Orthic Recent soil	35 locations 1.5-50 ha total 395 ha	Omaka bouldery sandy loam	Om4sG^B	Small areas on older Recent river terraces, flat to gently undulating with river channelled surfaces	675-850	20-215	Bouldery river alluvium, mainly from greywacke	Well drained	Sandy loam/sand textures with boulders, weathering depth (M)	A (B) BC C	22 cm 13 cm 21cm 17 cm	dark brown bouldery sandy loam yellowish brown (10YR 5/4) very stony sand olive brown (2.5Y 4/4) stony coarse sand dark greyish brown (2.5Y 4/4) bouldery coarse sand	<10 cm	100 cm+	45 mm
	Omaka			Omaka stony sandy loam	Om3sG	Small areas on older Recent river terraces, flat to gently undulating with flood channelled surfaces	675-850	20-215	Stony river alluvium, mainly from greywacke	Well drained	Stony sandy loam, weathering depth (M)	A (B) BC C	24 cm 13 cm 23 cm 20cm+	dark greyish brown (10YR 3/2) stony fine sandy loam light olive brown (2.5Y 4/4) stony silt loam olive brown (2.5Y 4/4) sand dark greyish brown (2.5Y 4/2) stony gravel	<20 cm	100 cm+	70 mm
	Omaka			Omaka shallow sandy loam	Om2sG	Small areas on older Recent river terraces, flat to gently undulating with river channelled surfaces	675-850	20-215	Sandy river alluvium over gravel, mainly greywacke	Well drained	Shallow sandy loam, weathering depth (M)	A (B) BC C	20cm 15 cm 20cm 25 cm+	very dark greyish brown (10YR 3/2) sandy loam dark yellowish brown (10YR 4/4) coarse sandy loam dark yellowish brown (10YR 4/4) loamy sand, abundant coarse stones olive brown (2.5Y 4/4) very stony sandy gravel	24 cm	100 cm+	70 mm

Soil name	Soil family [1]	Soil classification [2]	Occurrence & soil area	Soil family member	Soil map symbol	Distribution and topography [3]	Rainfall range (mm)	Altitude range (m)	Soil parent material	Soil drainage class [4]	Main physical features [5]	Horizon & thickness		Brief representative soil description	Avg depth to gravel 6	PRD [7]	Estimated PAW 8
Castlebrae	Dome	Typic Fluvial Recent soil	22 locations 1-50 ha total 580 ha	Castlebrae stony sandy loam	Cb3sG Cb3sU	Small areas on recent fan and stream surfaces; gently undulating (G) to undulating (U); even, hummocky or channelled surfaces	700-800	60-220	Recent fan alluvium/colluvium mainly from reworked greywacke sediments	Well drained	Stony sandy loam or sand soil material, weathering depth (S)	A BC C	28 cm 30 cm 32 cm+	dark greyish brown (10YR 3/2) stony sandy loam light olive brown (2.5Y 5/4) stony sand light olive brown (2.5Y 4/4) stony sand	<20 cm	90 cm+	50 mm
	Castlebrae			Castlebrae shallow sandy loam	Cb2sG Cb2sU	Small areas on recent fan and stream surfaces; gently undulating (G) to undulating (U); even, hummocky or channelled surfaces	700-800	60-220	Recent fan alluvium/colluvium mainly from reworked greywacke sediments	Well drained	Shallow (20-45 cm) sandy loam over gravel, weathering depth (S)	A AB B C	11 cm 19 cm 13 cm on	dark brown (10YR 3/3) fine sandy loam, few stones very dark grey (10YR 3/1) silt loam, few stones yellowish brown (10YR 5/4) sandy loam, many stones very dark greyish brown (2.5Y 5/2) sandy gravel	34 cm	90 cm+	80 mm
Pinedale	Taitapu	Mottled Orthic Recent soil	10 locations 2-11 ha total 73 ha	Pinedale silt loam	Pd0zG	Small irregular areas at the toe of fans channels; flat surfaces	650-825	10-180	Recent fan alluvium/colluvium greywacke sediments	Moderately well drained	Deep silt loam over gravel; structure, weathering depth (M)	A AB(g) BCg Cg	24 cm 16 cm 35 cm 20 cm	very dark grey (10YR 3/1) silt loam very dark grey and light yellowish brown (10YR 3/1+2.5Y 6/4) heavy silt loam light yellowish brown to light olive brown (2.5Y 6/4-5/4) silty clay loam, many olive grey and olive brown (5Y 5/2+2.5Y 5/6) mottles pale olive to olive (5Y 6/3-5/3) silty clay loam	95 cm	95 cm+	150 mm
Marathon	Galtymore	Fluvial Recent soil	10 locations 2-23 ha total 68 ha	Marathon moderately deep silt loam	Mn1zG Mn1zU	Small areas on older Recent fan or terrace surfaces of side streams, flat to gently undulating surfaces	630-780	40-200	Fan/stream colluvium or alluvium from greywacke and loess	Well drained to moderately well drained	Moderately deep silt loam over gravel, weathering depth (M)	A Bw BC	24 cm 43 cm 27 cm	dark greyish brown (10YR 3/2) silt loam, few stones yellowish brown (10YR 5/4) silt loam, few stones light olive brown (2.5Y 5/4) fine sandy loam, many	54 cm	94 cm+	135 mm
				Marathon silt loam	Mn0zU	Small areas on older Recent fan or terrace surfaces of side streams, undulating surfaces	630-780	40-200	Fan/stream colluvium or alluvium from greywacke and loess	Well drained	Deep silt loam over sandy loam, weathering depth (M)	A Bw C	26 cm 44 cm 20 cm	dark greyish brown (10YR 3/2) silt loam brown to dark brown and olive brown (10YR 4/3+2.5Y 4/4) silt loam and fine sandy loam light olive brown sandy loam	104 cm	100 cm+	130 mm
Starborough	Starborough	Typic Fluvial Recent soil	29 locations 3.5-27 ha total 267 ha	Starborough stony sandy loam	Sb3sG Sb3sU	Small areas on older Recent fan surfaces from valley side gullies, flat to undulating surfaces to undulating surfaces	700-825	60-250	Fan sediments, mainly greywacke stony colluvium	Well drained	Stony sandy loam over gravel, weathering depth (S)	A Bw C	18 cm 57 cm on	very dark greyish brown (10YR 3/2) stony sandy loam yellowish brown and light olive brown (10YR 4/4+2.5Y 5/4) stony sandy loam dark yellowish brown and olive 10YR 4/4+5Y 4/3) very stony sandy loam	<25 cm	120 cm+	90 mm
				Starborough stony silt loam	Sb3zG Sb3zU	Small areas on older Recent fan surfaces from valley side gullies, flat to undulating surfaces undulating surfaces	700-825	60-250	Fan sediments, mainly greywacke stony colluvium	Well drained	Stony silt loam over gravel, weathering depth (S)	A Bw BC C	24 cm 20cm 16 cm on	black (10YR 2/1) stony silt loam dark yellowish brown (10YR 4/3) stony silt loam dark brown (10YR 4/3) stony gravel dark greyish brown (2.5Y 4/2) stony gravel	<25 cm	120 cm+	60 mm
				Starborough shallow fine sandy loam	Sb2sG	Small areas on older Recent fan surfaces from valley side gullies, flat to undulating surfaces	700-825	60-250	Fan sediments, mainly greywacke stony colluvium	Well drained	Shallow fine sandy loam over gravel, weathering depth (S)	A AB Bw C	23 cm 7 cm 32 cm 58 cm	dark yellowish brown (10YR 4/4) fine sandy loam very dark brown (10YR 2/2) and light olive brown (2.5Y 5/4) fine sandy loam olive brown (2.5Y 4/4) sandy loam, very stony light yellowish brown (2.5Y 6/4) coarse sand, abundant stones	40 cm	120 cm+	110 mm
				Starborough shallow silt loam	Sb2zG Sb2zU	Small areas on older Recent fan surfaces from valley side gullies, flat to undulating surfaces to undulating surfaces	700-825	60-250	Fan sediments, mainly greywacke stony colluvium	Well drained	Shallow (20-45 cm) silt loam over gravel, weathering depth (S)	A Bw1 Bw2 BC	25 cm 15 cm 25 cm 25 cm	dark grey (10YR 4/1) silt loam, few stones brown (10YR 4/3) silt loam, few stones light olive brown (2.5Y 6/4) sandy gravel dark yellowish brown stony heavy silt loam	29 cm	120 cm+	80 mm
Glenbrae	Flaxton	Typic Fluvial Gley soil	16 locations 1-14 ha total 102 ha	Glenbrae moderately deep silt loam	Gb1zG	Small areas on older Recent fan or terrace surfaces of side streams, flat to gently undulating surfaces	650-750	60-260	Fan/stream colluvium or alluvium from greywacke and loess	Imperfectly drained	Moderately deep silt loam over clay loam, grey mottled subsoil, weathering depth (M)	A Bg Br Cg	20 cm 18 cm 22 cm 20cm	very dark greyish brown (10YR 3/2) silt loam pale olive (5Y 6/3) and yellowish brown (10YR 5/8) strongly mottled silt loam grey (5Y 6/1) and reddish brown (5YR 4/4) strongly mottled clay loam light brownish grey (2.5Y 6/2) stony gravel	64 cm	60 cm+	110 mm
				Glenbrae silt loam	Gb0zG	Small areas on older Recent fan or terrace surfaces of side streams, flat to gently undulating surfaces	650-750	60-260	Fan/stream colluvium or alluvium from greywacke and loess	Imperfectly drained	Deep silt loam/clay loam	A Bg Cr	18 cm 52 cm 30 cm	very dark grey (10YR 3/1) silt loam grey (5Y6/1) heavy silt loam to clay loam, abundant yellowish red (5YR 5/8) mottles light brownish grey and yellowish red (2.5Y 6/2 +5YR 4/6) mottled heavy silt loam to clay loam	>100 cm	60 cm+	150 mm

Soils of the Lower Awatere Valley

Soil name	Soil family [1]	Soil classification [2]	Occurrence & soil area	Soil family member	Soil map symbol	Distribution and topography [3]	Rainfall range (mm)	Altitude range (m)	Soil parent material	Soil drainage class [4]	Main physical features [5]	Horizon & thickness		Brief representative soil description	Avg depth to gravel 6	PRD [7]	Estimated PAW 8
Marama	Marama	Typic Immature Pallic soil	22 locations 5-90 ha total 360 ha	Marama moderately deep sandy loam	Ma1sG	Small areas on upper intermediate terraces, flat to gently undulating with river channelled surfaces	650-800	8-165	River alluvium mainly from greywacke	Well drained	Moderately deep sandy loam over gravel, weathering depth (M)	A	20 cm	very dark greyish brown (10YR 3/2) fine sandy loam	68cm	120 cm+	105 mm
												Bw1	12 cm	dark yellowish brown (10YR 4/4) fine sandy loam			
												Bw2	14 cm	light olive brown to olive brown (2.5Y 5/4-4/4) sandy loam			
												BC	44 cm	olive brown (2.5Y 6/4) sand, few stones			
												C	30 cm	olive (5Y 4/3) stony bouldery gravel			
				Marama sandy loam	Ma0sG	Small areas on upper intermediate terraces, flat to gently undulating with river channelled surfaces	650-800	8-165	River alluvium mainly from greywacke	Well drained	Deep sandy loam over gravel, weathering depth (M)	A	25 cm	very dark greyish brown (10YR 3/2) fine sandy loam	>100 cm	120 cm+	130 mm
												Bw1	18 cm	dark brown (10YR4/3) fine sandy loam			
												Bw2	25 cm	olive brown (2.5Y 4/4) sandy loam			
												BC	22 cm	dark greyish brown (2.5Y 4/2) sand			
												C	20 cm	very dark greyish brown (2.5Y 3/2) sand			
Muritai	Dashwood	Typic Immature Pallic soil	33 locations 2-52 ha total 392 ha	Muritai stony sandy loam	Mt3sG	Small areas on upper intermediate terraces, flat to gently undulating with river channelled surfaces	650-800	10-175	River alluvium mainly from greywacke	Well drained	Stony sandy loam over gravel, weathering depth (M)	A	18 cm	very dark greyish brown (10YR 3/2) stony sandy loam	<25 cm	82cm+	75 mm
												Bw1	27 cm	dark brown (10YR 3/3) stony sandy loam			
												Bw2	33 cm	dark greyish brown (2.5Y 4/4) stony sand			
												BC	12 cm	brown to dark brown (10YR 4/3) stony sand			
				Muritai shallow sandy loam	Mt2sG	Small areas on upper intermediate terraces, flat to gently undulating with river channelled surfaces	650-800	10-175	River alluvium mainly from greywacke	Well drained	Shallow sandy loam over gravel, weathering depth (M)	A	22 cm	very dark greyish brown (10YR 3/2) fine sandy loam	27 cm	80 cm+	100 mm
												Bw1	26 cm	dark yellowish brown (10YR 4/4) fine sandy loam			
												Bw2	27 cm	olive brown (2.5Y 4/4) sand, many stones			
												BC	17 cm	olive brown (2.5Y 4/4) stony gravel			
												C	8 cm+	olive brown to yellowish brown (2.5Y 4/2-10YR 4/4) stony gravel			
Warwick	Glenrock	Typic Immature Pallic soil	44 locations 1-110 ha total 901 ha	Warwick stony silt loam	Wa3zG	On old fan deposits on higher terrace surfaces, flat to gently undulating	700-800	60-220	Stream alluvium/colluvium with subangular gravel, mainly from greywacke with some igneous	Well drained	Stony silt loam, over stony gravel, brown subsoil colours, weathering depth (M)	A	30cm	very dark grey (10YR 3/1) stony silt loam	15 cm	85 cm+	100 mm
												Bw	18 cm	yellowish brown (10YR 5/4) stony silt loam			
												Bw2	37 cm	light yellowish brown (2.5Y 6/4) stony heavy silt loam			
												C	15 cm+	dark greyish brown stony gravel			
				Warwick shallow silt loam	Wa2zG	On old fan deposits on higher terrace surfaces, flat to gently undulating to	700-800	60-220	Stream alluvium/colluvium with subangular gravel, mainly from greywacke with some igneous	Well drained	Shallow silt loam, over stony gravel, brown subsoil colours, weathering depth (M)	A	20 cm	very dark greyish brown (10YR 3/2) silt loam, few stones	28 cm	85 cm+	70 mm
												AB	10 cm	very dark greyish brown and dark yellowish brown (10YR 3/2+10YR 4/4) silt loam, many small stones			
												Bw	13 cm	dark yellowish brown (10YR 4/4) silt loam, many stones			
					Wa2zU	undulating surfaces						BC	42 cm	light yellowish brown and light olive brown (2.5Y 6/4+5/4) sandy gravel			
												C	15 cm+	light olive brown (2.5Y 6/4) sandy gravel			
Ugbrooke	Friston	Typic Argillic Pallic soil	30 locations 1.5-65 ha total 468 ha	Ugbrooke moderately deep silt loam	Ug1zG	On tributary stream and fan surfaces on high terraces; flat to gently undulating, lower lying ground	650-800	10-240	Fine textured stream alluvium/colluvium, mainly from greywacke and loess	Moderately well drained to well drained	Moderately deep silt loam, some mottles at depth, scattered stones, weathering depth (M/D)	A	21 cm	very dark greyish brown (10YR 3/2) silt loam	63 cm	110 cm+	115 mm
												Bw	23 cm	yellowish brown (10YR 5/4) silt loam			
												B(g)	25 cm	yellowish brown (10YR 5/4) silt loam, light brownish grey and yellowish red (2.5Y 6/2+5YR 3/8) distinct mottles			
												BC	14 cm	light olive brown (2.5Y 5/4) stony loamy sand			
												C	17 cm	olive (5Y 4/4) stony sand			
				Ugbrooke silt loam	Ug0zG	On tributary stream and fan surfaces on high terraces; flat to gently undulating, lower lying ground	650-800	10-240	Fine textured stream alluvium/colluvium, mainly from greywacke and loess	Moderately well drained to well drained	Deep silt loam, some mottles at depth, weathering depth (D)	A	17 cm	very dark greyish brown (10YR 3/2) silt loam	102 cm	110 cm+	150 mm
												AB	14 cm	very dark greyish brown and dark brown (10YR 3/2+4/3) silt loam			
												Bw	54 cm	olive brown (2.5Y 4/4) silt loam to heavy silt loam			
					Ug0zU	On tributary stream and fan surfaces on high terraces; undulating surfaces						B(t)g	27 cm	olive brown (2.5Y 4/4) silt loam,many olive (5Y 5/3) mottles, few stones			
												BC	38 cm	silt loam, many olive (5Y 5/3) mottles, few small stones			

Soil name	Soil family [1]	Soil classification [2]	Occurrence & soil area	Soil family member	Soil map symbol	Distribution and topography [3]	Rainfall range (mm)	Altitude range (m)	Soil parent material	Soil drainage class [4]	Main physical features [5]	Horizon & thickness		Brief representative soil description	Avg depth to gravel 6	PRD [7]	Estimated PAW 8
Broadbridge	Waipara	Mottled Argillic Fragic Pallic soil	28 locations 4-45 ha total 680 ha	Broadbridge moderately deep silt loam	Bb1zG	On tributary stream and fan surfaces on high terraces; gently undulating lower lying ground	700-850	50-250	Fine textured stream alluvium/colluvium, mainly from greywacke and loess	Moderately well to imperfectly drained	Moderately deep (45-90 cm) silt loam distinct subsoil mottles, occasional stones	A	20 cm	very dark greyish brown (10YR 3/2) silt loam	73 cm	105 cm+	120 mm
												Bw	20 cm	light olive brown (2.5Y 5/4) silt loam			
					Bb1zU	On tributary stream and fan surfaces on high terraces; undulating lower lying ground						B(g)	25 cm	light olive brown (2.5Y 5/4) silt loam, many light brownish grey and reddish yellow (2.5Y 6/2+5YR 5/8) mottles, few medium stones			
												Bg	10 cm	pale olive (5Y 6/3) stony heavy silt loam, few reddish yellow (5YR 4/6) mottles			
												C	15 cm+	dark olive brown (2.5Y 4/4) stony gravel			
				Broadbridge silt loam	Bb0zU	On tributary stream and fan surfaces on high terraces; undulating lower lying ground	700-850	50-250	Fine textured stream alluvium/colluvium, mainly from greywacke and loess	Moderately well to imperfectly drained	Deep (>90 cm) silt loam; distinct subsoil mottles; occasional stones; weathering depth (D)	A	24 cm	very dark greyish brown (10YR 3/2) silt loam	100 cm	105 cm+	145 mm
												Bw	18 cm	dark brown (10YR 3/3) heavy silt loam			
												Bwg	18 cm	dark yellowish brown (10YR 4/4) clay loam, many yellowish brown and light grey (10YR 6/8+2.5Y 6/2) mottles, few small stones			
												Bg(t)	45 cm	yellowish brown (10YR 5/4) clay loam, many yellowish brown and light grey mottles, very firm			
Wainui	Wainui	Typic Orthic Gley soil	15 locations 3-66 ha total 256 ha	Wainui moderately deep silt loam	Wn1zG	Small areas on old tributary stream terraces and fans on the high terrace surfaces, flat to gently undulating	700-820	50-210	Fine textured alluvium/colluvium from greywacke and reworked cover materials	Poorly to imperfectly drained	Moderately deep silt loam, mottled grey subsoil with clayey texture, some stones, on gravel, weathering depth (D)	Ag	23 cm	dark brown (7.5YR 4/2) heavy silt loam, many reddish brown (5YR 4/4) mottles	72 cm	110 cm+	150 mm
												BG	16 cm	greyish brown to light brownish grey (2.5Y 5/2-6/2) clay loam, many yellowish brown (10YR 5/8) mottles			
												BG	23 cm	light brownish grey (2.5Y 6/2) clay loam, many greenish grey and yellowish brown (5BG 6/1+10YR 5/8) mottles			
												Bg	24 cm	red and greenish grey (2.5YR 5/8+5G 6/1) stony clay loam, many yellowish brown (10YR 5/8) mottles			
				Wainui silt loam	Wn0zG	Small areas on old tributary stream terraces and fans on the high terrace surfaces, flat to gently undulating to	700-820	50-210	Fine textured alluvium/colluvium from greywacke and reworked cover materials	Poorly to imperfectly drained	Deep silt loam, mottled grey subsoil with clayey texture, some stones, on gravel, weathering depth (D)	A	15 cm	black (10YR 3/) silty clay loam	102 cm	85 cm+	130 mm
												Ag	8 cm	black, (10YR 2/1) and light brownish grey (2.5Y 6/2) heavy silt loam, many distinct strong brown and greenish grey (7.5YR 5/5+5G5/1) mottles			
					Wn0zU	undulating surfaces						BG	56 cm	light brownish grey (2.5Y 6/2) clay, few greenish grey (5G 5/1) mottles, few medium stones			
												CG	55 cm+	pale olive (5Y 6/3) and dark greenish grey (5BG 4/1) clay few to many stones			
Dashwood	Shaldash	Typic Argillic Pallic soil	39 locations 1-165 ha total 1150 ha	Dashwood stony silt loam	Dw3zG	On high river terrace, north & south side of Awatere River, flat to gently undulating	630-850	25-260	Stony river alluvium, greywacke gravel with igneous and some sedimentary rock	Well drained	Stony silt loam, brown subsoil, weathering depth (D)	A	22 cm	very dark greyish brown (10YR 4/2) stony silt loam	<25 cm	90 cm+	90 mm
												Bw	33 cm	dark yellowish brown and dark brown (10YR 3/3+3/6) stony silt loam			
												BC	35 cm	olive brown (2.5Y 4/4) stony coarse sand			
												C	10 cm+	very dark greyish brown (2.5Y 3/2) stony gravel			
				Dashwood shallow silt loam	Dw2zG	On high river terrace, north & south side of Awatere River, flat to gently undulating	630-850	25-260	Stony river alluvium, greywacke gravel with igneous and some sedimentary rock	Well drained	Shallow silt loam over brownish stony gravel, weathering depth (D)	A	20 cm	dark brown (10YR 3/3) silt loam	27 cm	90 cm+	85 mm
												Bw	25 cm	yellowish brown (10YR 5/4) silt loam, many stones			
												Bw	22 cm	dark yellowish brown (10YR 4/4) sandy loam, abundant small to large stones			
												BC	23 cm	light olive brown (2.5Y 5/4) loamy sand, abundant stones			
												C	10 cm	olive brown (2.5Y 5/4) sandy gravel			
Stafford	Marama	Typic Immature Pallic soil	15 locations 5-15 ha total 195 ha	Stafford moderately deep silt loam	Sf1zG	On high river terrace, north & South side of Awatere River, flat to gently undulating	700-825	60-210	Fine textured river alluvium over stony greywacke gravel	Well drained	Moderately deep silt loam over gravel at around 60 cm, weathering depth (D)	A	18 cm	dark greyish brown to very dark greyish brown (10YR 4/2-3/2) silt loam	62 cm	125 cm+	100 mm
												AB	10 cm	dark greyish brown (10YR 3/2) and olive brown (2.5Y 5/4) silt loam			
												Bw	23 cm	olive brown (2.5Y 4/4) silt loam, few stones			
												Bw	27 cm	olive brown (2.5Y 4/4) sandy gravel			
												BC	25 cm+	olive (5Y 5/3) sandy gravel			
Toi	Willowby	Typic Orthic Gley soil	8 locations 4-20 ha total 90 ha	Toi shallow silt loam	To2zG	On high river terrace, north side of Awatere River, lower lying areas, flat to gently undulating	700-850	50-235	Fine textured alluvium over old river terrace gravels	Imperfectly to poorly drained	Shallow mottled silt loam over mottled stony clay loam, weathering depth (D)	A	19 cm	very dark grey (10YR 3/1) silt loam	35 cm	80 cm +	130 mm
												B(g)	11 cm	light olive brown (2.5Y 5/4) heavy silt loam, many yellowish brown (10YR 5/8) mottles, few stones			
												Bg	20 cm	olive (5Y 5/3) stony silt loam many brownish yellow (10YR 6/6) mottles, abundant stones			
												BCg	30 cm	olive grey (5Y 5/2) stony silty clay loam			

Soils of the Lower Awatere Valley

Soil name	Soil family [1]	Soil classification [2]	Occurrence & soil area	Soil family member	Soil map symbol	Distribution and topography [3]	Rainfall range (mm)	Altitude range (m)	Soil parent material	Soil drainage class [4]	Main physical features [5]	Horizon & thickness		Brief representative soil description	Avg depth to gravel 6	PRD [7]	Estimated PAW 8
Seddon	Pukeuri	Mottled Fragic Pallic soil	18 locations 5-470 ha total 1178 ha	Seddon silt loam	Sd0zG	On high terrace, south side of Awatere River, flat to gently undulating to	625-825	15-240	Silty/loamy Late Pleistocene to Holocene quartzofeldspathic loess, over gravel	Moderately well drained	Deep silt loam/sandy loam, few subsoil mottles, coarse subsoil structure, weakly fragic, gravel underlying, weathering depth (D)	A	21 cm	very dark greyish brown (10YR 3/2) silt	not present	110 cm	150 mm
					Sd0zU	undulating						Bw1	17 cm	olive brown to dark yellowish brown (2.5Y 4/4-10YR 5/4) silt loam			
												Bw2	17 cm	dark yellowish brown (10YR 4/4) silt loam, few dark yellowish brown and olive (10YR 3/3+5Y 5/3) mottles			
												Bw(g)	23 cm	olive brown to dark yellowish brown (2.5Y 4/4-10YR 4/4) silt loam, many olive (5Y 5/3 and reddish brown (5YR 4/3) mottles			
												Bwg	33 cm	olive brown (2.5Y 4/4) fine sandy loam, many olive (5Y 5/3) and strong brown(7.5YR 5/6) mottles, very firm			
												BCx	25 cm	dark yellowish brown (10YR 4/4) fine sandy loam, very firm, massive			
	Barrhill			Seddon sandy loam	Sd0sG	On high terrace, south side of Awatere River, flat to gently undulating	625-825	15-240	Loamy Late Pleistocene to Holocene quartzofeldspathic loess,	Moderately well drained	Deep sandy loam, few subsoil mottles coarse subsoil structure, weakly fragic, weathering depth (D)	A	37 cm	very dark greyish brown (10YR 3/2) sandy loam	not present	110 cm	150 mm
												Bw	44 cm	brown to dark brown and yellowish brown (10YR 4/3+10YR 5/4) silt loam,			
												B(g)	28 cm	very pale brown (10YR 7/4) silt loam, few reddish brown and light brownish grey (5YR 4/4+2.5Y 6/2) mottles, firm			
												BCx	14 cm+	light olive brown (2.5Y 5/4) silt loam, many yellowish red and light yellowish brown (5YR 4/6+2.5Y 6/4) mottles, very firm, massive			
Seaview	Seaview	Mottled Fragic Pallic soil	6 locations 3.5-160 ha total 314 ha	Seaview silt loam	Sv0zG	On high terrace, south side of Awatere River, flat to gently undulating to	650-800	130-210	Silty/loamy Late Pleistocene to Holocene quartzofeldspathic loess over older loess	Moderately well drained	Deep silt loam, subsoil mottles at depth,coarse to very coarse subsoil structure, moderately fragic weathering depth (D)	A	27 cm	very dark greyish brown (10YR 3/2) silt loam	not present	140 cm	150 mm
					Sv0zU	undulating						Bw	20 cm	light olive brown (2.5Y 5/4) silt loam, few yellowish red (5YR 4/6) mottles			
												B(g)	49 cm	yellowish brown (10YR 5/6) heavy silt loam, abundant greyish brown and yellowish brown (10YR 5/2 +10YR 5/6) mottles			
												B(gt)	26 cm	dark yellowish brown (10YR 4/4) clay loam, many olive (5Y 5/3-5/4) mottles, very firm			
												Bx	48 cm	dark yellowish brown (10YR 4/4) heavy silt loam, massive			
Altimarloch	Altimarloch	Typic Mafic Melanic soil	12 locations 4-36 ha total 132 ha	Altimarloch stony silt loam	Ak3zG	Small areas below hill slopes, on fans formed on high terraces, flat to gently undulating	800-850	165-340	Gravelly colluvium derived from erosion of nearby volcanic rock outcrops	Well drained	Stony silt loam with surface stones or boulders, stony subsoil and red soil colours, weathering depth (D)	A	24 cm	dark brown (7.5YR 3/2) stony heavy silt loam	20 cm	130 cm	75 mm
												Bw1	19 cm	reddish brown (5YR 4/3) stony gravel			
												Bw2	35 cm	reddish brown (5YR 4/4) stony gravel			
												Bc	54 cm	reddish brown to dark brown (5YR 4/4-7.5YR 4/4) gravel			
	Highcliff			Altimarloch shallow silt loam	Ak2zG	Small areas below hill slopes, on fans formed on high terraces, flat to gently undulating to	800-850	165-340	Gravelly colluvium derived from erosion of nearby volcanic rock outcrops	Well drained	Shallow silt loam with surface stones or boulders, stony subsoil and red soil colours, weathering depth (D)	A	19 cm	dark brown (7.5YR 3/2) silt loam, few stones	32 cm	130 cm	85 mm
					Ak2zU	undulating						AB	8 cm	reddish brown to dark brown (5YR 4/4-7.5YR 3/2) heavy silt loam			
												Bw	29 cm	reddish brown (5YR 4/4) heavy silt loam, many stones			
												B(t)	34 cm	dark red (2.5YR 3/6) stony gravel			
												BC	40 cm	reddish brown (2.5YR 4/4) stony gravel, firm, massive			
Blairich	Blairich	Mottled Mafic Melanic soil	4 locations 1-11 ha total 22 ha	Blairich shallow silt loam	Bl2zG	Small areas below hill slopes, on fans formed on high terraces, flat to gently undulating, lower lying ground	800-850	220-280	Gravelly colluvium derived from erosion of nearby volcanic rock outcrops	Imperfectly drained	Shallow silt loam over stony silt loam/clay loam with reddish subsoil mottles, weathering depth (D)	A	20 cm	dark brown (7.5YR 4/2) silt loam, few faint reddish brown (5YR 4/4) mottles	28 cm	75 cm	130 mm
												Bg	53 cm	weak red (10R 5/4) silt loam and sandy clay loam, many reddish brown (5YR 5/4) mottles, many stones			
												Bg(t)	27 cm	weak red to reddish brown (2.5YR 5/2-5/4) sandy loam, many weak red to reddish brown and yellowish red (2.5YR 5/2-5/4+5YR 4/8) mottles, few stones			
Awadale	Shaftsbury	Melanic Orthic Gley soil	2 locations 1-12 ha total 13 ha	Awadale moderately deep silt loam	Aw1zG	Small areas on the toe slopes of poorly drained fans, flat to gently undulating	800-850	220-280	Fine textured basaltic and greywacke colluvium	Poorly drained	Moderately deep silt loam/clay loam, grey and red mottles, firm subsoil, weathering depth (D)	A(H)	15 cm	very dark grey and black (5YR 3/1+5YR 2.5/1) clay loam	70 cm	100 cm	130 mm
												Br	30 cm	light brownish grey and light grey (10YR 6/2+2.5Y 7/2) silt loam and clay loam, many grey to yellowish red (10YR 6/1-5YR 4/6) mottles			
												Bg	35 cm	light grey and reddish yellow (2.5Y 7/2+5YR 6/6) clay loam, many yellowish red and light grey (5YR 6/6+2.5Y 7/2) mottles, many stones			
												Bg	20 cm	reddish brown (5YR 5/3) clay loam, yellowish red and grey (5YR 5/8+5Y 67/1) mottles, many stones			

Soil name	Soil family [1]	Soil classification [2]	Occurrence & soil area	Soil family member	Soil map symbol	Distribution and topography [3]	Rainfall range (mm)	Altitude range (m)	Soil parent material	Soil drainage class [4]	Main physical features [5]	Horizon & thickness		Brief representative soil description	Avg depth to gravel 6	PRD [7]	Estimated PAW 8
Sedgemere	Sedgemere	Perch Gley Fragic Pallic soil	15 locations 5-96 ha total 614 ha	Sedgemere silt loam	Sm0zG Sm0zU Sm0zR	On high terrace remnants, southside of Awatere River, flat to gently undulating to undulating surfaces to dissected rolling surfaces	750-800	120-250	Late Pleistocene quartzofeldspathic loess	Imperfectly to moderately well drained	Silt loam over silt loam/clay loam, mottled subsoil with coarse structure, firm fragic horizon	A B(g) Bg Bgt Bx	21 cm 27 cm 29 cm 30 cm 11 cm+	very dark greyish brown (10YR 3/2) silt loam light yellowish brown to light olive brown (10YR 6/4-5/4) heavy silt loam, few reddish brown and strong brown (5YR 3/4+7.5YR 5/6) mottles light yellowish brown (2.5Y 6/4) heavy silt loam ,many strong brown and yellowish red (7.5YR 5/8+5YR 4/6) mottles light yellowish brown (2.5Y 6/4) heavy silt loam, abundant strong brown, yellowish red and pale olive (7.5YR 5/6, 5YR 4/6+5Y 6/3) mottles, very firm light olive brown to olive brown (2.5Y 5/4) silt loam, massive	not present	110 cm	150 mm
Jordan	Jordan	Perch Gley Fragic Pallic soil	12 locations 3.5-63 ha total 260 ha	Jordan silt loam	Jd0zG Jd0zR	On higher remnant surfaces, north and south side of Awatere River, flat to gently undulating to dissected rolling surfaces	750-825	100-280	Late Pleistocene quartzofeldspathic loess	Imperfectly drained	Silt loam over clay loam, strong mottle patterns and coarse subsoil structure, very firm fragic horizon	A B B(gt) Bgt Bgt Bx	15 cm 18 cm 15 cm 45 cm 18 cm 18 cm+	very dark greyish brown (10YR 3/2) silt loam light yellowish brown (2.5Y 6/6) silt loam light olive brown (2.5Y 5/4) heavy silt loam, few yellowish brown and light grey (10YR 5/6+2.5Y 7/2) mottles yellowish brown (10YR 5/4) clay loam, many yellowish red and pale olive (5YR 4/6 +2.5Y 7/2) mottles light yellowish brown (2.5Y 6/4) clay loam, many strong brown, and red (7.5YR 5/8+2.5YR 5/6) mottles, very firm yellowish brown (10YR 5/6) heavy silt loam, massive	98 cm	110 cm	150 mm

Notes:

1. The soil family name is the name given in the S Map. An additional family name implies a correlation with that family which occurs at some other location or region
2. For a detailed outline of the soil classifications, refer to *New Zealand Soil Classification* as outlined by Hewitt (1998).
3. Land slope classes are as follows: 0-3° flat to gently undulating, 4-7° undulating, 8-15° rolling.
4. Soil drainage classes are assessed on the basis of the proportions, intensity and depth of soil mottles with greyish or ocherous colours. Refer to Soil Description Handbook (Milne et al. 1995) for details.
5. The weathering depth is the depth to which soil oxidation and alteration of mineral material has taken place in well drained soils and is an indicator of soil age. The classes used here are U (unweathered), S (shallow), M (moderate) and D (deep).
6. The average depth to gravel is derived from observations from auger borings and pit descriptions and generally represents the change from fine fraction dominant to coarse fraction dominant.
7. The potential rooting depths (PRD) are based on observations of root depths in the recorded soil profiles or the presence of horizons that may obstruct downward penetration by roots. Root penetration may be much greater, depending on attributes of particular plant species.
8. The plant available water (PAW) is based on 100 cm soil depth assessments and have been determined using values given for Water Retention Properties for Agricultural Soils by the American Society of Civil Engineers. The figures are based on the representative soil profile and will vary across each soil family dependant on variations in soil texture and stoniness.

A spreadsheet version of this extended legend is available on request from the Land Resources Scientist, Marlborough District Council.

8.1. Appendix 1.1- Interpreting soil symbols

Depth
0 >90cm deep
1 45-90cm moderately deep
2 20-45cm shallow
3 10-20cm stony
4 <10cm very stony
y/o loamy silt on peat

Texture
a sand
b loamy sand
b/a loamy sand on sand
b/z loamy sand on silt loam
c clay loam
c/d clay loam on silty clay
d silty clay
d/a silty clay on sand
d/b silty clay on loamy sand
d/c silty clay on clay loam
d/s silty clay on sandy loam
d/z silty clay on silt loam
e clay
f fine sandy loam
f/a fine sandy loam on sand
f/c fine sandy loam on clay loam
f/p fine sandy loam on peaty loam
f/s fine sandy loam on sandy loam
f/z fine sandy loam on silt loam
o peat
o/b peat over loamy sand
o/d peat over silty clay
o/f peat over fine sandy loam
o/p peat over peat loam
p peaty loam
p/c peaty loam over clay loam
p/d peaty loam silty clay
p/s peaty loam over sandy loam
p/z peaty loam over silt loam
q loamy peat
q/z peaty loam over silt loam
r/a slight peaty clay loam on sand
r/b slight peaty clay loam on loamy sand
r/z slight peaty clay loam on silt loam
s sandy loam
s/a sandy loam on sand
s/c sandy loam on clay loam
s/z sandy loam on silt loam
y loamy silt
y/a loamy silt on sand
y/b loamy silt on loamy sand
y/d loamy silt on silty clay
z silt loam
z/a silt loam on sand
z/b silt loam on loamy sand
z/c silt loam on clay loam
z/d silt loam on silty clay
z/e silt loam on clay
z/f silt loam on fine sandy loam
z/o silt loam on peat
z/p silt loam on peaty loam
z/s silt loam on sandy loam
z/y silt loam on loamy silt

Slope
G 0-3° gently undulating
H 16-25° hilly
R 8-15° rolling
S >25° steep
U 4-7° undulating

Phase (not always present)
B bouldery phase
BM bouldery, mottled phase
C complex
D disturbed variant
E eroded variant
G strongly gleyed variant
J argillic variant
JM argillic mottled variant
M mottled phase
MX mottled, weakly saline phase
MXX mottled, moderately saline phase
P peaty phase
T thickened topsoil variant
U undifferentiated
W raw variant
X weakly saline phase
Y moderately saline phase
Z strongly saline phase

Example: Ug1zG
Series Ug = Ugbrooke
Depth 1 = moderately deep
Texture z = silt loam
Slope G = gently undulating
Phase (not used)
Ug1zG = Ugbrooke moderately deep silt loam, gently undulating.

9. Appendix 2: Results of chemical and physical analyses for selected soils

Notes: The methods used for the chemical analyses of these soils are those described by Blakemore et al. (1981)
The ratings for the chemical properties (very high to very low) given in the soil report are after Metson (1956).

A spreadsheet version of the chemical and physical results is available on request from the Land Resources Scientist, Marlborough District Council

SOIL FAMILY: Awatere

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9373A	(A)	0-8	5.80	5.2	1.3	0.12	11	12	60	61	13	74	3		4	1.012	7.8	0.03	7.1	91	5.1	1.36	0.53	0.11	50	0.58	0.06	0.14	0.04	0.007	1
B	C_1	0-25	6.10	5.2	0.6	0.07	9		63	66	8	74	4		<1	1.011	7.1	0.01	6.6	93	5.3	1.00	0.18	0.15			0.06	0.14	0.04	0.008	1
C	C_2	35-45	7.0	6.0	0.2	0.02	10		69	72	4	76	2		<1	1.008	5.1	0.00	5.3	(100)	4.0	1.08	0.12	0.13	53	0.55	0.05	0.11	0.04	0.005	0
D	C_3	55-65	7.3	6.5	0.4	0.03	13		74	76	7	83	3		76	1.009	5.8	0.02	65.8	(100)	5.5	1.03	0.09	0.14			0.04	0.09	0.03	0.004	0

Physical data			Particle size Fine earth fraction							
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002
SB9373A	(A)	0-8	47	39	14	28	10	57	19	14
B	C_1	0-25	50	48	2	34	15	56	27	2
C	C_2	35-45	88	9	3	73	73	57	5	3
D	C_3	55-65	87	8	5	84	84	31	4	5

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	96	95	86	56	32	13
	22	24	21	3	2	1

SOIL FAMILY: Wairau

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9372A	A	0-15	5.8	5.2	1.9	0.18	11	6	50	50	22	72	7			1.014	9.5	0.03	8.2	86	6.1	1.70	0.31	0.12	45	0.54	0.08	0.22	0.05	0.009	2
B	A	15-30	6.5	5.5	1.4	0.13	11		48	48	25	73	8		7	1.014	9.7	0.02	8.9	92	6.7	1.91	0.13	0.20			0.11	0.26	0.05	0.010	1
C	B	30-50	6.8	5.8	0.9	0.09	10		56	57	22	79	10		69	1.013	8.4	0.01	7.9	94	5.9	1.66	0.16	0.19	50	0.52	0.11	0.22	0.04	0.006	0.1
D	C	70-85	7.0	6.0	0.3	0.02	15		88	89	8	97	4		79	1.008	4.4	0.00	4.6	(100)	3.3	0.97	0.14	0.14			0.04	0.09	0.02	0.006	0

Physical data			Particle size Fine earth fraction (mm %)							
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002
SB9372A	A	0-15	51	44	5	16	3	74	18	5
B	A	15-30	52	39	9	24	9	64	18	9
C	B	30-50	66	28	6	48	30	50	14	6
D	C	70-85	90	8	2	81	66	29	3	2

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
19	93	91	85	50	25	8
44	31	28	22	11	6	2
20	21	13	7	3	1	0

SOIL FAMILY: Dumgree

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9374A	A	0-15	6.6	5.0	2.4	0.22	11	16	49	50	37	87	10			1.019	12.8	0.04	11.0	86	7.9	2.44	0.46	0.56	41	0.56	0.12	0.31	0.05	0.013	3
B	Bw	20-30	6.7	5.5	1.0	0.10	10		52	52	26	78	10			1.016	10.6	0.02	10.0	94	7.1	2.53	0.17	0.22			0.12	0.26	0.02	0.010	1
C	BC	35-50	7.0	5.9	0.4	0.04	10		61	62	14	76	7			1.014	9.2	0.03	9.1	99	6.2	2.58	0.11	0.21	53	0.49	0.10	0.25	0.05	0.008	0
D	C1	55-80	7.2	6.1	0.3	0.03	10		73	76	11	87	8		62	1.013	8.5	0.02	8.6	(100)	5.8	2053	0.11	0.19			0.07	0.19	0.03	0.006	0.2
E	C2	85-108	7.3	6.2	0.2	0.01	20		86	87	5	92	5		77	1.010	6.3	0.00	6.3	100	4.4	1.59	0.10	0.19			0.06	0.19	0.04	0.009	0

Physical data			Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9374A	A	0-15	34	42	24	14	3	52	21	24	12	0.50
B	Bw	20-30	33	45	22	15	3	51	24	22	11	0.50
C	BC	35-50	34	49	17	12	2	57	24	17	5	0.29
D	C1	55-80	47	35	18	32	10	50	22	18	3	0.17
E	C2	85-108	81	12	7	77	57	29	7	7	2	0.29

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
35	38	38	34	21	15	7
45	23	19	10	5	3	2

SOIL FAMILY: Castlebrae

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9381A	A	0-11	5.2	4.7	2.7	0.23	12		35	36	35	71	10		<1	1.019	13.9	0.00	11.1	80	8.1	2.43	0.47	0.08	24	0.07	0.09	0.34	0.04	0.21	6
B	b A	11-30	6.1	5.2	1.5	0.12	13		32	32	29	61	11		<1	1.018	13.2	0.00	11	88	8.4	2.72	0.35	0.09	26	0.68	0.08	0.36	0.04	0.21	4
C	C1	30-43	6.6	5.5	0.4	0.03	13		37	39	10	49	5		20	1.011	7.6	0.00	7.3	96	5.1	1.87	0.22	0.10	25	0.62	0.04	0.18	0.03	0.01	0.1
D	C2	43-75	6.8	5.7	0.2	0.02	10		41	45	6	51	5		69	1.011	7.1	0.00	6.8	96	4.7	1.80	0.18	0.08			0.04	0.17	0.03	0.009	1

Physical data		Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9381A	A	0-11	31	41	28	22	12	32	28	28	14	0.50
B	b A	11-30	26	46	28	17	10	31	31	28	15	0.54
C	C1	30-43	83	9	8	78	65	21	6	8	2	0.25
D	C2	43-75	90	5	5	89	83	9	3	5	1	0.20

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	80	60	28	14	11	6
36	31	16	5	3	2	2

Fabric-related analyses																	
Lab. No.	Soil Horizon	Sample depth	Water content	Bulk Density	Total Porosity	Large Pores		Water content % at tensions (bar)					Field cap.	15 bar (PWP)	Available Water	15 bar water %	
		cm	(%)	mg/m^3	%	%		0.05	0.1	0.2	0.4	1.0	%v/v	%v/v	%v/v	Field	Air dry
PA263	0-11	1-8	16.4	1027	50.8	14.3		28.7	26.6	24.8	22.8	20.9	31.5	12.6	18.9	9.9	8.8
264	11-30	11-23	17.8	1.45	45.2	12.9		22.6	21.3	20.1	18.5	17.0	28.8	13.7	15.1	9.4	8.2
265	30-43	31-41	10.7	1.51	43.7	23.2		13.6	11.9		9.4	8.3	17.0	6.6	10.4	4.4	4

SOIL FAMILY: Starborough

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9382A	A	0-23	5.6	5.1	3.6	0.30	12	10	73	75	61	136	10		25	1.02	16.9	0.00	14.5	86	10.7	1.62	2.08	0.09	22	0.74	0.16	0.31	0.02	0.049	13
B	AB	23-30	5.7	4.8	1.6	0.14	11		57	59	47	106	14		44	1.016	11.0	0.05	7.5	68	5.4	0.97	1.06	0.08			0.16	0.27	0.02	0.040	6
C	Bw2	30-62	6.1	4.9	0.5	0.05	10		40	43	22	65	8		26	1.011	7.1	0.06	5.4	76	3.8	0.88	0.66	0.09	23	0.61	0.10	0.18	0.01	0.016	4
D	BC	62-120	6.6	5.4	0.2	0.02	10		30	33	9	42	5		32	1.011	6.4	0.00	6.1	95	4.4	1.20	0.35	0.11			0.05	0.16	0.01	0.008	5

Physical data		Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9382A	A	0-23	41	34	25	34	27	24	24	25	11	0.44
B	AB	23-30	44	33	23	39	35	20	22	23	10	0.43
C	Bw	30-62	54	30	16	46	40	25	19	16	6	0.38
D	BC	62-120	64	25	11	57	47	26	16	11	3	0.27

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
15	75	63	55	45	37	19
16	56	42	36	32	25	13
	74	53	44	36	26	12
	68	46	36	25	18	7

SOIL FAMILY: Marama

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9375A	A	0-15	5.8	5.0	2.5	0.21	12	14	49	49	47	96	13			1.019	13.0	0.04	9.8	75	6.9	2.16	0.57	0.18	34	0.58	0.14	0.34	0.03	0.026	1
B	Bw1	20-30	605	5.2	1.1	0.11	10		58	59	34	93	14			1.014	10.6	0.05	8.0	75	5.6	1.89	0.35	0.17			0.15	0.33	0.02	0.021	0.03
C	Bw2	35-45	607	5.4	0.6	0.06	10		61	62	24	86	8			1.012	9.3	0.05	7.7	83	5.3	1.83	0.26	0.27	45	0.53	0.13	0.29	0.03	0.015	0.03
D	BC1	50-60	609	5.6	0.3	0.03	10		75	77	12	89	9		1	1.010	7.5	0.04	6.6	88	4.8	1.49	0.17	0.16			0.08	0.20	0.04	0.005	0
E	BC2	70-90	7.1	5.8	0.3	0.03	10		91	93	12	105	6		81	1.012	8.0	0.03	6.8	85	5.1	1.32	0.18	0.19			0.09	0.29	0.04	0.010	0.1
F	C	90-120	7.3	5.9	0.2	0.02	10		97	98	12	110	5		79	1.011	8.0	0.03	7.7	96	5.8	1.47		0.22			0.07	0.32	0.04	0.013	0

Physical data		Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9375A	A	0-15	33	42	25	17	4	48	23	25	12	0.48
B	Bw1	20-30	37	39	24	24	9	44	23	24	11	0.46
C	Bw2	35-45	48	30	22	37	18	41	19	22	9	0.41
D	BC1	50-60	69	20	11	62	33	43	13	11	4	0.36
E	BC2	70-90	80	12	8	75	61	24	7	8	3	0.38
F	C	90-120	85	6	9	82	71	17	3	9	1	0.11

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	99	96	66	32	24	11
30	19	15	8	4	3	2
45	21	14	6	3	3	2

SOIL FAMILY: Warwick

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9380A	A	0-20	6.1	5.5	2.7	0.24	11		38	44	54	98	8		9	1.020	14.2	0.52	11.6	82	8.7	1.49	1.24	0.20	22	0.63	0.17	0.30	0.00	0.042	34
B	AB	20-30	5.9	5.1	1.5	0.13	12		27	33	45	78	18		40	1.017	11.0	0.00	8.2	75	6.6	1.02	0.45	0.14			0.20	0.29	0.00	0.037	5
C	Bw1	30-43	6.3	5.2	0.8	0.07	11		30	34	32	66	18		51	1.015	8.7	0.04	6.3	72	4.8	1.01	0.39	0.14	26	0.51	0.17	0.25	0.00	0.021	3
D	Bw2	43-64	6.4	5.3	0.4	0.03	13		11	14	18	32	10		7	1.011	6.8	0.10	5.0	74	3.4	1.29	0.16	0.18			0.10	0.16	0.00	0.007	2
E	BC	64-85	6.5	5.2	0.3	0.02	15		39	33	11	44	9		78	1.014	8.8	0.21	7.2	82	5.1	1.76	0.14	0.18			0.08	0.16	0.00	0.005	2
F	C	85-100	6.3	5.1	0.2	0.01	20		46	49	9	58	8		70	1.013	8.8	0.27	7.3	83	5.6	1.36	0.15	0.17			0.06	0.14	0.00	0.005	2

Physical data			Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9380A	A	0-20	30	43	27	20	14	31	28	27	11	0.41
B	AB	20-30	30	44	26	22	16	29	29	26	13	0.50
C	Bw1	30-43	41	37	22	33	28	25	25	22	8	0.36
D	Bw2	43-64	40	43	17	29	20	36	27	17	3	0.18
E	BC	64-85	68	21	11	62	53	24	12	11	3	0.27
F	C	85-100	87	7	6	85	81	8	5	6	1	0.17

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	91	84	78	67	50	25
17	60	54	50	44	33	16
16	49	39	35	30	23	11
12	93	84	74	59	41	16
35	22	15	10	7	5	2
25	30	12	6	4	3	2

SOIL FAMILY: Ugbrooke

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9388A	A	0-17	5.3	4.7	3.3	0.28	12	7	60	66	58	124	29			1.024	16.0		12.0	75	8.4	2.42	1.02	0.11	27	0.64	0.16	0.43	0.05	0.038	4
B	AB	17-26	5.7	4.8	1.9	0.18	11		48	54	51	105	28			1.021	13.3		9.0	68	6.2	2.02	0.62	0.11			0.15	0.41	0.00	0.037	4
C	Bw1	26-47	6.2	5.1	0.8	0.10	8		36	38	38	76	28			1.019	11.4		9.8	86	7.1	2.06	0.44	0.15	28	0.62	0.13	0.39	0.00	0.031	5
D	Bw2	47-80	7.1	5.7	0.3	0.05	6		34	40	14	54	26			1.021	12.0		11.8	98	8.7	2.57	0.24	0.29			0.07	0.36	0.00	0.019	8
E	Bw(g)	80-107	7.4	6.0	0.2	0.03	7		38	41	11	52	27		2	1.019	10.5		11.0	(100)	8.0	2.50	0.20	0.27			0.06	0.37	0.00	0.016	2
F	BC	107-145	7.6	6.2	0.2	0.04	5		40	42	17	59	27		<1	1.018	10.4		11.2	(100)	7.7	2.91	0.22	0.35			0.07	0.41	0.01	0.023	3

Physical data			Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9388A	A	0-17	9	61	30	3	1	25	44	30	14	0.47
B	AB	17-26	8	59	33	3	1	22	44	33	20	0.61
C	Bw1	26-47	7	59	34	2	1	28	37	34	20	0.59
D	Bw2	47-80	17	47	36	7	3	31	30	36	21	0.58
E	Bw(g)	80-107	31	41	28	19	7	41	24	28	15	0.54
F	BC	107-145	24	44	32	12	2	38	28	32	17	0.53

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	98	97	91	72	51	27

Fabric-related analyses																		
Lab. No.	Soil Horizon	Sample depth	Water content	Bulk Density	Total Porosity	Large Pores		Water content % at tensions (bar)					Field cap.	15 bar (PWP)	Available Water	15 bar water %	
		cm	(%)	mg/m^3	%	%		0.05	0.1	0.2	0.4	1.0	%v/v	%v/v	%v/v	Field moist	Air dry
PA266	0-17	1-15	18.9	1.33	47.7	7.9		30.4	29.1	26.8		24.7	35.2	15.2	20.0	11.5	9.9
PA267	17-26	17-24	20.0	1.49	42.7	6.2		24.6	23.6	21.3		19.2	31.7	16.5	15.2	11.1	9.3
PA268	26-47	27-38	17.5	1.60	39.4	6.9		20.3	19.6	17.0		16.2	28.5	17.5	11.0	10.9	8.8
PA269	47-80	48-65	14.2	1.80	32.3	4.2		15.7	15.3	14.2		13.0	25.5	19.6	5.9	10.9	8.7
PA270	80-107	83-98	15.2	1.81	31.6	2.1		16.3	15.9	15.4	14.2	13.5	28.0	16.7	11.3	9.2	7.6

SOIL FAMILY: Wainui

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9377A	A	0-15	6.7	5.7	4.8	0.18	27	2	38	48	58	106	33		10	1.034	24.4		22.4	92	13.2	7.7	0.65	0.90	8.5	0.42	0.10	0.87	0.00	0.052	12
B	Ag	15-23	7.3	6.5	1.4	0.13	11		68	85	234	108	29		33	1.037	22.7		23.2	(100)	12.5	9.1	0.34	1.22			0.10	1.08	0.05	0.52	5
C	Bg1	23-40	8.6	7.5	0.5	0.07	7		42	53	13	66	30	<0.1	13	1.041	25.1		30.7	(100)*	15.3	13.4	0.31	1.70	7	0.37	0.11	0.56	0.02	0.14	2
D	Bg2	40-79	8.8	7.6	0.2	0.03	7		21	30	4	34	28	0.2		1.043	29.4		33.2	(100)*	19.8	11.5	0.26	1.59	7		0.08	0.11	0.03	0.10	1
E	Bg3	79-107	8.4	7.1	0.1	0.02	5		150	164	4	168	27	<0.1	18	1.034	25.1		29.0	(100)*	19.0	8.9	0.30	0.81			0.04	0.34	0.06	0.14	0
F	BCr	107-130	8.5	7.5	0.1	0.02	5		70	70	2	72	38	0.2	6	1.023	13.6		15.7	(100)*	10.4	4.5	0.29	0.49			0.09	0.40		0.073	2

* Free lime

Physical data		Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9377A	A	0-15	15	35	50	6	3	24	23	50	42	0.84
B	Ag	15-23	16	41	43	7	4	27	27	43	33	0.77
C	Bg1	23-40	9	29	62	4	2	16	16	62	51	0.44
D	Bg2	40-79	9	33	58	4	2	16	16	58	49	0.82
E	Bg3	79-107	24	35	41	16	10	24	24	41	22	0.84
F	BCr	107-130	22	45	33	10	6	32	32	33	19	0.56

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	90	89	87	78	66	45
30	67	66	64	58	46	29
	87	86	85	80	71	54
30	82	79	74	64	54	34
	94	93	88	76	58	31

SOIL FAMILY: Dashwood

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9288A	A	0-18	6.2	5.4	3.3	0.28	12	5	46	52	52	104	18		1		16.2		12.9	80	7.2	4.00	1.21	0.45	28	0.62	0.19	0.35	0.01	0.043	13
B	Bw1	18-36	6.2	5.1	1.7	0.16	11	2	24	29	51	80	24		4		11.1		7.9	71	3.5	2.87	1.01-4	0.49	29	0.61	0.20	0.31	0.00	0.038	11
C	Bw2	36-58	6.4	4.9	1.2	0.11	11	2	25	29	38	67	22		66		9.7		6.9	71	3.2	1.92	0.96	0.78	31		0.18	0.29	0.00	0.025	7
D	Bw3	58-82	7.1	5.4	0.4	0.04	10	4	88	91	16	107	21		75		8.7		6.7	77	3.7	1.32	0.45	1.21	29		0.11	0.23	0.00	0.029	5
E	BC	82-100	6.9	5.5	0.6	0.05	12	4	92	95	27	122	30		89		13.4		10.4	78	6.6	1.85	0.33	1.66	30		0.19	0.67	0.00	0.022	24

Fabric-related analyses, undisturbed cores															
Lab. No. [1]	Soil Horizon	Sample Depth	Water content	Density Wet	Density Dry	Total porosity	Macro porosity	Air capacity	Water (%v/v) drained/suction range (cm H2O)				Field cap.	Wilting pt	Available wat.
		cm	%	g/cc	g/cc	%	%	%	50-100	100-200	200-400	400-1000	%v/v	%v/v	%v/v
PA17	A	1-8	12.7	1.06	0.95	63.6	33.1	39.8	3.8	2.9	1.0	4.4	23.9	10.1	13.8
PA18	Bw1	19-26	9.8	1.34	1.22	53.7	23.9	29.4	2.2	3.4	2.2	3.3	24.4	10.9	13.6

Disturbed soil			Particle size whole soil Max. size (mm %)						
Lab. No.	Soil Horizon	Sample Depth							
		cm	(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
SB9288A	A	0-18	3.0	99	97	94	81	48	23
B	Bw1	18-36	5.0	98	94	90	77	52	24
C	Bw2	36-58	70.0	44	41	39	33	21	11

SOIL FAMILY: Stafford

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9378A	A	0-18	5.6	5.1	2.9	0.23	13	3	40	38	58	96	29			1.023	14.6	0.00	11.0	75	9.0	1.61	0.22	0.15	34	0.47	0.24	0.49	0.01	0.035	3
B	AB	18-28	6.0	5.2	1.5	0.12	13		33	36	45	81	30			1.019	11.5	0.00	7.7	67	5.9	1.47	0.12	0.22			0.21	0.34	0.02	0.025	3
C	Bw1	28-51	6.4	5.1	0.5	0.05	10		38	46	19	65	29		5	1.015	9.6	0.23	7.0	73	5.0	1.69	0.10	0.17	42	0.40	0.13	0.29	0.00	0.011	2
D	Bw2	51-78	6.3	4.9	0.4	0.03	13		94	101	11	112	28		59	1.016	9.7	0.47	6.4	66	4.6	1.59	0.07	0.14			0.13	0.30	0.00	0.007	2
E	BC1	78-100	6.5	4.8	0.3	0.03	10		96	107	7	114	28		49	1.016	9.6	0.35	6.6	72	5.0	1.66	0.07	0.18			0.11	0.31	0.02	0.008	1
F	BC2	100-125	6.6	5.1	0.3	0.02	15		107	116	11	127	28		68	1.014	8.7	0.22	6.5	75	4.7	1.56	0.06	0.08			0.10	0.32	0.00	0.001	1

Physical data		Particle size Fine earth fraction									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9378A	A	0-18	26	41	33	17	7	31	29	33	14	0.42
B	AB	18-28	27	41	32	18	8	33	27	32	12	0.38
C	Bw1	28-51	38	38	24	26	12	38	26	24	8	0.33
D	Bw2	51-78	75	14	11	71	57	23	9	11	4	0.36
E	BC1	78-100	84	7	9	82	75	11	5	9	3	0.33
F	BC2	100-125	90	4	6	89	83	8	3	6	3	0.50

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
17	95	92	84	62	48	23
22	41	29	18	11	81	5
24	51	26	13	9	7	5
17	32	16	5	4	3	2

15 bar water %	
Field moist	Air dry
11.8	10.4
10.1	8.7
7.9	6.6

SOIL FAMILY: Stafford (cont)

Fabric-related analyses															
Lab. No.	Soil Horizon	Sample depth	Water content	Bulk Density	Total Porosity	Large Pores		Water content % at tensions (bar)					Field cap.	15 bar (PWP)	Available Water
		cm	(%)	mg/m³	%	%		0.05	0.1	0.2	0.4	1.0	%v/v	%v/v	%v/v
PA271	0-18	1-10	19.7	1.32	48.7	8.0		31.0	29.1	27.3	25.3	23.8	35.9	15.6	20.3
PA272	18-28	19-26	15.6	1.55	41.6	6.2		22.9	21.5	20.1	18.1	17.2	31.0	15.7	15.3
PA273	28-51	28-39	14.5	1.66	38.1	7.4		18.6	17.4	16.3	14.3	13.5	27.0	13.7	13.3

SOIL FAMILY: Seddon

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9287A	A	0-20	6.1	5.4	2.5	0.23	11	5	40	43	49	92	7				12.9		10.6	82	7.9	1.62	0.91	0.19	31	0.63	0.18	0.41	0.02	0.030	8
B	Bw1	20-36	6.6	5.7	0.6	0.07	9	7	33	37	24	61	18				9.0		7.7	86	5.4	1.86	0.21	0.18	33	0.52	0.12	0.35	0.02	0.016	0
C	Bw2	36-50	7.6	6.4	0.7	0.04	10	9	39	42	13	55	15	<.1			8.6		9.1	(100)	5.9	2.81	0.12	0.26	34		0.09	0.37	0.02	0.012	0
D	B(g)1	50-60	7.6	6.6	0.2	0.03	7	11	48	53	5	58	14	<.1			9.1		10.7	(100)	6.6	3.7	0.10	0.30	37		0.08	0.40	0.05	0.011	0
E	B(g)2	60-76	7.7	6.7	0.2	0.02	10	13	52	56	5	61	13	<.1			9.1		11.9	(100)	7.1	4.3	0.09	0.36	40		0.08	0.32	0.04	0.007	0
F	BC1	76-90	7.8	6.7	0.2	0.02	10	13	66	67	6	73	12	<.1			8.7		11.3	(100)	6.3	4.5	0.08	0.40	45		0.06	0.28	0.05	0.007	0
G	BC2	90-110	7.8	8.4	0.3	0.02	15	12	93	98	5	103	18	<.1	80		10.4		11.9	(100)	5.3	5.7	0.10	0.76	50		0.08	0.50	0.06	0.021	0
H	C	110-140	7.6	6.2	0.3	0.02	15	12	106	107	10	117	17	<.1	88		10.5		11.4	(100)	4.2	6.1	0.09	1.05	53		0.09	0.50	0.03	0.020	0

Physical data			Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9287A	A	0-20	18	62	20		50		30	20	11.6	0.49
B	Bw1	20-36	19	63	18		52		30	18	9.3	0.08
C	Bw2	36-50	22	61	17		56		27	17	8.2	0.48
D	B(g)1	50-60	30	53	17		63		20	17	8.1	0.51
E	B(g)2	60-76	39	47	14		66		20	14	6.2	0.45
F	BC1	76-90	53	37	10		77		13	10	4.5	0.43
G	BC2	90-110	69	20	11		82		7	11	3.1	0.52
H	C	110-140	64	28	8		80		12	8	3.5	0.71

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
0.6			99	82	50	20
1.0		99	98	81	48	18
1.0		99	98	78	44	17
1.0		99	97	70	37	17
1.0		99	95	61	34	14
0.6		100	89	47	23	10
80.0	45	36	27	14	8	5
100.0	25	20	16	9	5	2

Fabric-related analyses, undisturbed cores															
Lab. No.	Soil Horizon	Sample Depth	Water content	Density Wet	Density Dry	Total porosity	Macro porosity	Air capacity	Water (%v/v) drained/suction range (cm H2O)				Field cap.	Wilting pt	Available water
		cm	%	g/cc	g/cc	%	%	%	50-100	100-200	200-400	400-1000	%v/v	%v/v	%v/v
PA 11 A,B	A	4-11	15.0	1.47	1.28	51.1	18.8	22.3	1.6	2.0	1.6	3.4	28.8	12.6	16.3
	Bw1	21-28	9.7	1.65	1.50	43.6	15.5	19.5	1.5	2.5	3.8	4.6	24.1	13.6	10.6
	Bw2	37-44	8.0	1.74	1.61	39.7	9.0	15.1	3.2	2.8	3.1	4.2	24.6	12.7	11.9
	B(g)1	51-58	8.2	1.73	1.60	40.7	11.0	16.5	3.1	2.6	2.9	3.7	24.1	12.7	11.5
	B(g)2	61-68	6.7	1.65	1.55	43.0	15.6	20.6	3.1	2.1	0.9	3.0	22.3	10.2	12.1
	BC1	77-84	6.1	1.63	1.53	43.8	17.0	24.9	4.5	3.5	2.4	3.5	18.9	8.3	10.6

SOIL FAMILY: Seddon

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9287A	A	0-21	5.8	5.3	3.0	0.25	12		58	57	66	123	18			1.024	16.6	0.00	14.6	88	11.3	2.38	0.68	0.20	33	0.61	0.23	0.65	0.04	0.049	5
B	Bw1	21-37	6.3	5.4	1.5	0.14	11		42	43	57	100	22			1.022	13.3	0.00	11.4	86	8.4	2.52	0.21	0.22			0.23	0.61	0.03	0.048	4
C	Bw2	37-54	7.0	5.8	0.5	0.16	8		30	33	30	63	19			1.019	10.6	0.02	9.9	93	7.2	2.34	0.12	0.22	33	0.52	0.17	0.57	0.03	0.033	4
D	B(g)1	54-77	7.6	6.1	0.3	0.03	10		22	23	14	37	14			1.016	10.4	0.05	10.9	(100)	8.0	2.56	0.11	0.56			0.12	0.49	0.05	0.017	2
F	Bx	110-135	8.0	6.6	0.1	0.01	10		32	35	7	42	7			1.023	14.0	18.2	18.2	(100)	10.0	7.5	0.14				0.19	0.19	0.05	0.005	1

Physical data			Particle size Fine earth fraction									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9287A	A	0-21	20	53	27	3	1	45	27	27	11	0.41
B	Bw1	21-37	19	54	27	4	1	49	23	27	12	0.44
C	Bw2	37-54	17	55	28	4	1	41	30	28	13	0.46
D	B(g)1	54-77	16	56	28	3	1	40	31	28	11	0.39
F	Bx	110-135	24	50	26	7	2	46	26	26	12	0.49

Fabric-related analyses																	
Lab. No. [1]	Soil Horizon	Sample depth	Water content	Bulk Density	Total Porosity	Large Pores		Water content % at tensions (bar)					Field cap.	15 bar (PWP)	Available Water	15 bar water %	
		cm	(%)	mg/m³	%	%		0.05	0.1	0.2	0.4	1.0	%v/v	%v/v	%v/v	Field moist	Air dry
PA244	0-21	1-10	23.7	1.32	49.0	6.9		32.2	31.1	29.7	28.1	26.1	38.8	15.5	23.1	11.9	10.3
245	21-37	22-23	20.4	1.43	46.4	12.2		24.1	22.9	21.7	19.7	18.0	30.96	15.1	15.8	10.6	9.0
246	37-54	38-51	18.7	1.62	39.5	7.4		19.9	19.1	15.1	16.2	14.2	29.3	15.4	13.9	9.5	7.9
247	54-77	55-66	18.1	1.70	36.3	4.5		18.7	18.2	17.4	15.4	13.7	29.6	15.0	14.6	8.8	7.2
248	77-110	78-91	17.6	1.72	35.8	4.9		18.0	17.4	16.7	14.6	12.9	28.7	16.5	12.2		
249	110-130	110-130	9.7	1.75												9.6	7.7

SOIL FAMILY: Seddon

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9385A	A	0-25	5.6	5.1	2.0	0.17	12	13	62	62	28	90	14		1	1.018	14.0	0.00	11.5	82	8.6	2.27	0.56	0.07	43	0.71	0.11	0.32	0.03	0.013	7
B	A	25-37	6.3	5.3	1.6	0.12	13		61	61	36	97	16		2	1.019	13.6	0.00	11.5	85	8.8	2.21	0.29	0.15			0.14	0.35	0.03	0.018	5
C	AB	37-48	6.5	5.4	1.4	0.12	12		62	63	38	101	19			1.019	13.8	0.00	11.2	81	8.7	2.06	0.20	0.23			0.09	0.43	0.03	0.028	7
D	Bw1	48-71	6.8	5.8	0.9	0.08	11		44	45	35	80	19			1.016	11.5	0.00	10.0	87	7.7	1.89	0.14	0.25	37	0.51	0.17	0.42	0.02	0.025	6
E	Bw2	71-92	7.4	6.2	0.5	0.04	13		35	37	19	56	15			1.015	10.9	0.00	10.5	96	7.8	2.27	0.12	0.33			0.12	0.46	0.03	0.013	7
F	B(x)	92-120	7.7	6.5	0.3	0.03	10		46	49	9	58	16			1.019	13.5	0.00	15.5	(100)	10.3	4.6	0.14	0.45			0.12	0.54	0.07	0.009	9
G	BC	120-134	7.7	6.4	0.3	0.03	10		42	44	8	52	14			101.2	14.0	0.00	16.7	(100)	10.0	6.1	0.16	0.47			0.10	0.44	0.08	0.006	5

Physical data			Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9385A	A	0-25	26	48	26	13	9	28	27	26	10	0.38
B	A	25-37	25	45	30	14	10	31	29	30	14	0.47
C	AB	37-48	25	46	29	9	4	39	28	29	14	0.48
D	Bw1	48-71	23	50	27	4	1	44	28	27	12	0.44
E	Bw2	71-92	20	54	26	4	1	43	30	26	9	0.35
F	B(x)	92-120	24	49	27	6	1	42	30	27	12	0.44
G	BC	120-134	22	53	25	6	1	40	34	25	11	0.44

15 bar water %	
Field moist	Air dry
9.3	8.2
9.5	8.4
9.5	8.4
8.5	7.1
8.4	7.0
9.7	8.2

Fabric-related analyses															
Lab. No. [1]	Soil Horizon	Sample depth	Water content	Bulk Density	Total Porosity	Large Pores		Water content % at tensions (bar)					Field cap.	15 bar (PWP)	Available Water
		cm	(%)	mg/m^3	%	%		0.05	0.1	0.2	0.4	1.0	%v/v	%v/v	%v/v
PA 239	22-25	6-25	21.0	1.42	45.9	9.1				22.6	21.0	19.6	31.5	13.3	18.2
PA240	38-45	38-45	18.1	1.50	43.5	11.0				19.0	17.8	16.5	28.5	14.3	14.2
PA241	50-61	50-61	18.9	1.53	43.2	10.0				19.0	17.9	16.2	28.9	14.5	14.4
PA242	73-81	73-81	16.5	1.70	37.3	7.3				16.1	15.1	14.3	27.2	14.4	12.8
PA234	94-103	94-103	12.4	1.62	40.4	10.5				16.4	15.4	14.0	26.5	13.6	12.9

SOIL FAMILY: Seaview

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9533A	A	0-23	4.8	5.5	8.6	2.7	0.23	12	4	63	63	57	120	26			1.020	15.1	0.14	9.7	64	7.6	1.67	0.27	0.12	17.6	0.21	0.62	0.03	0.038	10
B	AB	23-27	4.8	5.7	8.7	1.2	0.13	9		56	55	56	111	23			1.018	12.3	0.42	7.6	62	5.8	1.60	0.10	0.12	14.3	0.19	0.63	0.00	0.050	16
C	Bw	27-47	5.4	6.5	8.6	0.6	0.05	12		49	48	26	74	20		1	1.016	10.5	0.12	8.9	85	6.1	2.51	1.10	0.23	8.1	0.14	0.58	0.02	0.026	13
D	Bg1	47-62	6.3	7.7	8.8	0.3	0.04	8		31	33	9	42	22			1.020	1306	1.14	15.4	(100)	9.2	.4	0.12	0.67	7.4	0.12	0.64	0.07	0.013	3
E	Bg2	62-96	6.9	8.4	8.7	0.2	0.01	20		24	25	3	28	15			1.023	15.0	0.23	17.9	(100)	10.0	7.1	0.10	0.72	6.1	0.10	0.43	0.06	0.006	1
F	Bg3	96-122	7.2	8.7	8.5	0.2	0.01	20		36	36	4	40	11			1.022	15.6	0.05	20.1	(100)	9.3	8.0	0.09	2.67	6.1	0.08	0.29	0.06	0.009	2
G	Bx1	122-144	7.3	8.7	8.4	0.1	0.01	10		43	43	6	49	9			1.021	14.0	0.07	18.7	(100)	7.8	7.8	0.08	2.97	5.1	0.06	0.23	0.02	0.012	2
H	Bx2	144-165	7.2	8.6	8.4.	0.1	0.01	10		48	51	2	53	9			1.017	11.6	0.09	14.5	(100)	6.0	6.2	0.09	2.20	4.3	0.06	0.21	0.05	0.013	1
I	BC	175-190	7.0	8.4	8.3	0.1	0.01	10		53	54	3	57	7		<1	1.012	8.4	0.02	10.2	(100)	4.4	4.3	0.07	1.49	3.5	0.05	0.16	0.05	0.012	0.5

Physical data			Particle size Fine earth fraction									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9533A	A	0-23	15	56	29	3	1	42	28	29	12	0.41
B	AB	23-27	13	57	30	3	2	40	28	30	15	0.50
C	Bw	27-47	16	56	28	4	3	39	30	28	13	0.46
D	Bg1	47-62	11	54	35	3	1	35	28	35	20	0.57
E	Bg2	62-96	10	53	37	1	0	42	28	37	22	0.59
F	Bg3	96-122	10	57	33	1	0	46	25	33	18	0.55
G	Bx1	122-144	14	58	28	4	1	46	25	28	12	0.43
H	Bx2	144-165	24	54	22	5	1	54	23	22	11	0.50
I	BC	175-190	48	40	12	14	3	70	15	12	7	0.58

15 bar water %	
Field moist	Air dry
11.2	10.1
10.	9.0
9.7	8.4
12.6	11.0
12.1	10.6
10.9	9.8
10.6	8.7
9.1	7.5
6.3	5.2

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	99	98	96	87	57	28

SOIL FAMILY: Altimarloch

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9387A	A	0-22	5.3	4.8	3.4	0.27	13	3	50	52	80	163	27		<1	1.026	18.8	0.00	12.6	67	9.0	1.99	1.54	0.04	32	0.58	0.28	0.55	0.03	0.081	6
B	Bw1	22-44	6.4	5.4	1.2	0.10	12		30	33	46	79	26		6	1.022	14.5	0.00	11.4	79	8.9	1.84	0.58	0.04	37	0.51	0.22	0.52	0.03	0.055	4
C	Bw2	46-66	7.2	5.8	0.4	0.04	10		42	51	22	73	27		4	1.032	18.6	0.00	20.1	(100)	16.4	3.3	0.17	0.30			0.15	0.67	0.06	0.030	1
D	Bw3	66-111	7.5	6.1	0.3	0.03	10		23	27	14	41	21			1.032	17.6	0.00	20.2	(100)	16.2	3.6	0.16	0.26			0.10	0.38	0.06	0.012	1
E	BC	111-134	7.5	6.2	0.3	0.02	15		97	98	16	114	18		74	1.028	15.6	0.00	19.4	(100)	15.0	4.0	0.20	0.20			0.09	0.37	0.05	0.036	1

Physical data		Sample depth	Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon		Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9387A	A	0-22	18	46	36	6	3	31	30	36		
B	Bw1	22-44	13	49	30	8	4	26	32	38		
C	Bw2	46-66	12	45	43	5	2	23	32	43		
D	Bw3	66-111	22	43	35	11	5	32	28	35		
E	BC	111-134	74	14	12	67	59	20	9	12		

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	94	92	90	84	66	36
	96	95	94	87	72	41
40	26	16	11	7	5	3

SOIL FAMILY: Altimarloch

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9388A	A	0-19	5.1	4.5	4.3	0.35	12	6	121	117	106	223	33		11	1.03	23.5	0.14	12.7	54	9.2	1.91	1.52	0.03	44	0.50	0.34	0.68	0.01	0.060	10
B	AB	19-27	5.6	4.6	1.8	0.13	14		116	119	73	192	38		9	1.025	18.4	1.03	8.0	44	5.9	1.20	0.79	0.06			0.39	0.77	0.03	0.060	9
C	Bw1	27-40	5.8	4.8	1.2	0.09	13		109	112	67	179	37		8	1.023	17.1	0.83	7.5	44	5.8	1.29	0.38	0.06	52	0.44	0.34	0.67	0.02	051	10
D	Bw2	40-56	6.2	5.0	0.6	0.05	12		98	109	35	144	30		24	1.026	19.1	0.71	12.4	65	9.9	2.19	0.14	0.16			0.24	0.63	0.03	0.022	6
E	Bw3	56-90	6.9	5.7	0.3	0.03	10		212	222	30	252	30		44	1.041	24.4	0.31	32.2	(100)	24.7	7.1	0.09	0.26			0.41	0.67	0.06	0.034	3
F	BC	90-130	7.1	5.9	0.2	0.02	10		206	217	22	239	29		30	1.043	24.2	0.12	33.1	(100)	24.5	8.2	0.11	0.25			0.14	0.76	0.08	0.10	2

Physical data		Sample depth	Particle size Fine earth fraction									
Lab. No.	Soil Horizon		Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9388A	A	0-19	25	41	34	17	13	25	28	34		
B	AB	19-27	25	39	36	18	13	25	26	36		
C	Bw1	27-40	25	39	36	18	13	24	27	36		
D	Bw2	40-56	35	39	26	24	18	29	27	26		
E	Bw3	56-90	49	25	26	42	34	23	17	26		
F	BC	90-130	40	32	28	33	28	22	22	28		

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	89	82	77	69	55	30
	91	85	79	70	56	33
	62	86	80	71	58	33
18	76	67	62	51	40	20
21	56	44	37	30	21	15
	70	56	50	44	35	20

SOIL FAMILY: Awadale

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9376A	A1	0-8	4.8	4.5	16	1.22	13	5	95	95	145	240	59			1.077	55.2		46.4	84	40	5.6	0.49	0.25	36	0.35	0.33	1.50	0.03	0.060	24
B	A2	8-15	4.8	4.4	+	1.03	13		72	83	122	205	69			1.073	54.8		36.1	66	32	3.6	0.28	0.20			0.42	1.30	0.03	0.043	24
C	Ahg	15-30	5.3	4.5	4.3	0.33	13		42	60	56	116	37			1.037	27.2		18.9	69	16.2	2.23	0.22	0.24	10	0.36	0.23	0.54	0.00	0.019	12
D	Bg1	30-45	5.6	4.6	2.0	0.15	13		65	71	39	110	32			1.027	17.5		12.6	72	10.5	1.72	0.19	0.23			0.16	0.52	0.00	0.013	9
E	Bg2	45-58	5.9	4.4	0.5	0.04	13		204	221	24	245	40			1.026	15.6		9.7	62	7.9	1.46	0.12	0.18			0.12	1.34	0.04	0.018	7
F	Bg3	58-80	5.8	4.6	0.4	0.03	13		275	295	22	317	42		14	1.033	21.3		16.8	79	13.5	2.76	0.16	0.34			0.13	1.88	0.03	0.028	9
G	Bcg	80-100	6.5	5.3	0.5	0.02	25		258	276	21	297	33		17	1.035	22.7		23.4	(100)	17.6	5.3	0.20	0.29			0.11	0.88	0.04	0.018	6

Physical data		Sample depth	Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon		Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9376A	A1	0-8	3	36	61	1	0	14	25	61		
B	A2	8-15	3	44	53	1	0	15	32	53		
C	Ahg	15-30	10	50	40	3	1	25	34	40		
D	Bg1	30-45	12	55	33	4	2	27	38	33		
E	Bg2	45-58	13	49	38	4	2	26	34	38		
F	Bg3	58-80	34	39	27	25	21	25	27	27		
G	Bcg	80-100	38	35	27	30	22	28	23	27		

Particle size whole soil Max. size (mm %)						
(mm)	<2	<0.6	<0.2	<0.06	<0.02	<0.002
	86	75	68	59	46	23
	83	75	65	53	42	22

SOIL FAMILY: Sedgemere

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaCO_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9383A	A	0-21	5.3	4.8	2.7	0.23	12	3	52	51	64	115	24			1.023	15.8	0.09	10.5	66	8.0	1.87	0.32	0.27	25	0.49	0.23	0.65	0.01	0.066	21
B	Bw1	21-31	5.7	4.8	1.1	0.11	10		38	40	43	83	23			1.018	11.5	0.29	7.6	66	5.0	2.06	0.12	0.28		0.46	0.19	0.64	0.01	0.036	21
C	Bw2	31-47	6.8	5.5	0.4	0.05	8		38	42	19	61	20			1.019	11.6	0.06	10.5	91	5.7	4.0	0.13	0.65	27		0.14	0.61	0.03	0.019	14
D	Bw(g)1	47-76	7.7	6.2	0.2	0.03	7		28	31	10	41	16			1.024	15.3	0.02	17.0	(100)	7.7	7.0	0.15	2.15			0.01	0.44	0.05	0.008	11
E	B(wg)2	76-106	7.1	5.8	0.2	0.02	10		21	25	6	31	11			1.029	17.4	0.01	19.0	(100)	7.5	7.7	0.18	3.60			0.07	0.23	0.05	0.001	17
F	Bwg	106-109	6.5	5.1	0.3	0.03	10		8	12	8	20	6			1.021	14.1	0.16	14.0	99	5.3	6.1	0.18	2.45			0.06	0.13	0.04	0.000	12
G	Bfe	109-110	6.5	5.1	0.6	0.03	20		65	70	7	77	30			1.026	14.3	0.19	13.3	93	5.3	5.1	0.11	2.74			0.06	1.00	0.07	0.005	12
H	Bx	110-120	6.7	5.4	0.2	0.01	20		45	47	7	54	6			1.018	11.0	0.16	13.3	(100)	5.2	5.0	0.11	2.95			0.05	0.23	0.03	0.007	8

Physical data			Particle size Fine earth fraction (mm %)									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9383A	A	0-21	13	57	30	4	2	34	34	30	14	0.47
B	Bw1	21-31	14	57	29	4	2	38	31	29	13	0.45
C	Bw2	31-47	13	54	33	4	2	35	30	33	17	0.52
D	Bw(g)1	47-76	11	51	38	2	1	32	29	38	23	0.61
E	B(wg)2	76-106	10	53	37	2	0	36	27	37	21	0.57
F	Bwg	106-109	16	53	31	2	0	45	24	31	19	0.61
G	Bfe	109-110	23	55	22	4	1	49	28	22	7	0.32
H	Bx	110-120	27	55	18	3	0	58	24	18	4	.22

15 bar water %	
Field moist	Air dry
11.9	9.6
10.5	8.1
12.0	9.3
13.8	11.4
13.5	11.4
9.3	7.1

Fabric-related analyses																
Lab. No. [1]	Soil Horizon	Sample depth	Water content	Bulk Density	Total Porosity	Large Pores		Water content % at tensions (bar)					Field cap.	15 bar (PWP)	Available Water
		cm	(%)	mg/m^3	%	%		0.05	0.1	0.2	0.4	1.0	%v/v	%v/v	%v/v
PA250	0-21	0-21	28.4	1.4	45.4	6.1		28.0	26.9	25.9	24.5	22.9	36.4	16.8	19.6
PA251	21-31	21-31	22.1	1.48	43.8	7.4		24.7	23.7	22.6	19.9	17.6	33.4	15.5	17.9
PA252	31-47	31-47	17.6	1.69	37.2	5.1		19.1	18.4	1707	16.5	15.4	29.8	20.3	9.5
PA253	47-76	47-76	16.9	1.78	33.7	1.7		18.0	7.7	17.3	16.6	15.8	30.8	24.3	6.2
PA254	76-106	76-106	18.4	1.70	36.9	1.7		20.6	20.2	19.5	18.5	17.6	33.0	22.9	10.1
PA255	106-120	106-109	6.3	1.74											

SOIL FAMILY: Jordan

Soil Chemistry Data		Sample depth	pH	pH	C	N	C/N Ratio	P (mg%)					P Retn	$CaC0_3$	Stones (>2mm)	Moisture Factor	CEC	Exch Al	Σ bases	Cation Exchange Capacity (me%)					Reserve Mg & K		Tamms Extract %				S Adsbd.
Lab. No.	Soil Horizon	cm	H_2O	$CaCl_2$	%	%		Truog	0.5M H_2SO_4	inorg.	Organ.	Total	%	%	%		meq/100g	meq/100g		% BS	Ca	Mg	K	Na	Mg_r (me%)	K_c (me%)	Al %	Fe %	Si %	Mn %	(p.p.m.)
SB9386A	A	0-15	4.9	4.4	3.5	0.27	13	2	25	26	56	82	22			1.023	17.0	0.23	9.1	54	6.5	1.46	0.96	0.06	12	0.40	0.19	0.38	0.01	0.048	11
B	Bw1	15-33	5.6	4.7	1.0	0.09	11		10	12	30	42	20			1.017	10.6	0.67	6.0	57	4.2	1.37	0.30	0.13	14	0.32	0.14	0.30	0.01	0.021	9
C	Bw(g)1	33-47	6.0	4.5	0.4	0.04	10		9	13	11	24	29			1.027	17.0	3.19	10.3	61	5.6	4.20	0.15	0.32			0.15	0.36	0.03	0.004	9
D	B(wg)2	47-68	6.0	4.2	0.4	0.04	10		13	16	10	26	38			1.031	19.7	6.34	9.1	46	4.4	4.00	0.14	0.60			0.16	0.40	0.03	0.001	5
E	Bw(g)3	68-92	5.9	4.0	0.4	0.04	10		16	20	10	30	37			1.030	18.7	7.48	7.0	37	2.9	3.20	0.12	0.78			0.15	0.44	0.03	0.003	6
F	Bwg1	92-110	5.8	3.9	0.3	0.03	10		14	17	10	27	35			1.029	17.9	7.83	6.1	34	2.4	2.82	0.11	0.75			0.14	0.39	0.04	0.004	5
G	Bwg2	110-112	5.7	3.8	0.4	0.04	10		11	15	10	25	38			1.033	20.9	8.76	6.9	33	2.4	3.40	0.14	0.92			0.14	0.27	0.03	0.001	7
H	Bx	112-130	5.7	3.8	0.3	0.02	15		12	16	7	23	26			1.023	14.1	6.02	5.0	36	1.7	2.54	0.08	0.71			0.11	0.30	0.03	0.008	5

Physical data			Particle size Fine earth fraction									
Lab. No.	Soil Horizon	Sample depth	Sand	Silt	Clay	Sand	Int. c.sd.	Int.f sd.	Int silt	Clay	Fine clay	Fine/ total clay
		cm	2-0.05	0.05-0.002	<0.002	2-0.1	2-0.2	0.2-0.02	0.02-0.002	<0.002	<0.0002	
SB9386A	A	0-15	10	62	28	4	3	30	39	28	14	0.50
B	Bw1	15-33	10	63	27	4	2	33	38	27	10	0.37
C	Bw(g)1	33-47	6	54	40	2	1	22	37	40	23	0.58
D	B(wg)2	47-68	6	48	46	2	1	20	33	46	29	0.63
E	Bw(g)3	68-92	7	49	44	3	2	22	32	44	27	0.61
F	Bwg1	92-110	7	51	42	3	1	22	35	42	24	0.57
G	Bwg2	110-112	11	42	47	4	2	22	29	47	32	0.68
H	Bx	112-130	19	46	35	8	4	29	32	35	18	0.51

15 bar water %	
Field moist	Air dry
11.2	10.3
9.3	7.9
14.3	12.4
16.7	14.3
16.4	14.5
15.8	14.1
13.8	12.1

Fabric-related analyses, undisturbed cores															
Lab. No. [1]	Soil Horizon	Sample depth	Water Content	Bulk Density	Total porosity	Macro porosity	Water content (%) at tensions (bar)						Field Capacit	15 Bar water	Available water
		cm	%	g/cc	%	%	0.025	0.05	0.1	0.2	0.4	1.0		% v/v)	
PA256	0-15	0-15	27.1	1.16	52.4	7.6		39.4	36.6	34.0	31.1	28.7	38.7	13.0	25.7
PA257	15-33	15-33	19.3	1.49	43.6	9.9		22.7	21.6	20.4	18.8	17.3	30.4	13.9	16.5
PA258	33-47	33-47	18.6	1.66	370	3.4		29.3	19.9	19.3	18.6	17.4	32.0	23.7	8.3
PA259	47-68	47-68	18.2	1.66	36.7	3.6		19.9	19.6	19.1	18.5	17.6	31.6	27.8	3.8
PA260	68-92	68-92	20.3	1.62	38.4	2.9		22.0	21.6	21.1	20.6	19.8	34.2	26.6	7.6
PA261	92-110	92-110	21.8	1.56	10.2	2.9		23.9	23.5	23.0	22.3	21.4	35.9	24.7	11.2
PA262	112-130	112-130	7.8	1.78											

10. Appendix 3: Mineralogy of the sand fractions for a range of Awatere Valley soils.

Key			
A	>50%	c	5-10%
a	30-50%	S	1-5%
C	10-30%	tr	Trace

Soil Name **Wainui**

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyanite	Garnet	Zeolite	Gibbsite	Anastase
SB9377A	a	R			R	tr	tr			tr	tr	tr		tr		tr		c	tr		S			S		tr		C												tr	tr		tr			
9377B	a	R	tr		R	tr	tr				tr	tr						C	tr		R			R		tr		S									tr			tr	tr		tr			
9377C	a	tr	tr		R	tr	tr				tr	tr		tr				C	tr		tr					tr		C									tr			tr	tr		tr			
9377D	a	tr	tr		R	tr				tr	tr	tr		tr				c	tr		tr			tr				C												tr			tr			
9377E	a	R	tr		R					tr	tr	tr						c	tr		tr				Tr			c									tr			tr			tr			

Soil Name **Dashwood**

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyanite	Garnet	Zeolite	Gibbsite	Anastase
SB9288A	a	C					tr					tr		C				c		R		C	R	c		tr										tr				tr	tr					tr
9288B																																															
9288C	a	C				tr				tr	tr	R		c				S		R		C	R			tr										tr				R	tr		tr			
9288D																																				tr											
9288E	c	tr									tr	tr		c								a																				tr	tr			

Soil Name Seddon

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyaanite	Garnet	Zeolite	Gibbsite	Anastase
SB9287A	a	C	tr	c	tr		tr		tr	C	R	R		c				c			R	c	R	tr		tr										tr				R					
9287B																																														
9287C	a	C		c			tr		tr	R	tr	R		c				c			S	a	R			tr															tr					
9287D																																														
9287E	a	c		c	S					C	tr	tr		C				R			c	C	S			tr											tr				tr					
9287F	C	C		c	R		tr					tr		C				R			tr	a	R			tr					tr														
9287G	C	C		C						C	tr	tr		C				R			R	C	R			R										tr				tr					
9287H	C		tr	c						tr	tr	tr						R			tr	A																		tr					

Soil Name Seddon

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyaanite	Garnet	Zeolite	Gibbsite	Anastase
SB9385A	a	c	tr		R		tr	tr	tr	tr	tr	tr	tr	c	tr			R					S	tr		tr		C				tr							tr				tr		
9385B	a	c			R		tr		tr	tr	tr	tr	tr	c				tr					S					C				tr							tr				tr		
9385E	a	c			tr				tr	tr	tr	tr		c				tr					S			tr		C																	
9385F	a	c			tr			tr			tr	tr	tr	c				tr					S			tr		C															tr			
9385G	a	c									tr	tr	tr	c				tr					S					C											tr				tr		

Soil Name **Seddon**

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyaanite	Garnet	Zeolite	Gibbsite	Anastase
SB9384A	A	c	tr		R	tr				tr	tr	tr	tr	R	tr			S	tr				c	tr		tr		c												tr	tr		tr			
9384C	A	c			R		tr			tr	tr	tr		R				c	R				c					c					tr							tr			tr			
9384D	A	c			tr	tr				tr	tr	tr	tr	R				c	R				c					c												tr						
9287E	a	S			tr					tr	tr	tr		S				S					S			tr		C												tr						

Soil Name **Sedgemere**

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyaanite	Garnet	Zeolite	Gibbsite	Anastase
SB9383A	A	C			R		tr	tr			tr	tr	tr	S				c					S					S												tr			tr			
9383C	A	C	tr		R			tr			tr	tr		R				c					S					S												tr						
9383D	A	C	tr		R			tr			tr		tr	R				c					S					R												tr						
9383E	A	C			R	tr		tr	tr		tr		tr	tr				c					S					c												tr						
9383F	A	C			R	tr		tr			tr	tr	tr					c					S					c												tr			tr			
9383G	a	C			R			tr			tr	tr		tr				c					S					C												tr			tr			
9383H	a	c			tr			tr				tr		tr				c					S					C															tr			

Soil Name **Jordan**

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyaanite	Garnet	Zeolite	Gibbsite	Anastase
SB9386A	A	c	tr		S		R	tr		tr	tr	tr						c	tr				S	R					S									tr			tr				
9386B	a	C	tr		S		R	tr		R	tr	tr		tr				c	tr				S	tr					S				tr		tr					tr	tr	tr	tr			
9386C	a	C	tr		S		R	tr		tr								c					S	tr					S									tr			tr						
9386D	a	C			S				tr	tr	tr							c	tr				S						S												tr	tr		tr			
9386E	a	C	tr		S			tr	tr	tr	tr	tr						c	tr				S						S												tr	tr					
9386F	a	C	tr		R				tr	tr								c	tr				S						c						tr						tr	tr		tr			
9386G	a	C	tr		R					tr	tr	tr						S					S						c												tr	tr		tr			
9386H	A	C	R		S			tr		R								S	tr				S																		R	tr		tr			

Soil Name **Altimarlock**

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyaanite	Garnet	Zeolite	Gibbsite	Anastase
SB9387A	a	S	tr		R	tr	tr	tr		S	tr	tr		tr		tr		C	R		R		S	R				c											tr	tr		tr	tr	tr	
9387B	a	S	tr		R	tr	tr	tr		S	tr	tr		tr		tr		C	R		R		C	tr		tr		c										tr		tr	tr		tr			
9387C	a	S	tr		R	tr	tr	R		S	tr	tr		tr				C	R				R			tr		C											tr	tr					
9387D	a	R	tr		tr	tr	R	R		R	tr	tr		R				S					R					C											tr	tr		tr			
9387F	c	tr			tr					R	tr			S				R	tr							tr		a											tr						

Soil Name **Altimarlock**

Lab.No.	Quartz	Orthoclase	Microcline	Albite	Oligoclase	Andesine	Glass	Muscovite	Biotite	Chlorite	Hornblende A	Hornblende B	Tremolite	Augite	Pigeonite	Hypersthene	Serpentine	Epidote	Zoisite	Sericitic Ag.	Sassurite	Quartz Ag.	Chert	Plant Opal	Aragonite	Apatite	Cristobalite	Aggregates	Chloritic Ag.	Chloritoiid	Olivine	Topaz	Spicule	Carbonate	Rutile	Magnetite	Tremolite	Titanite	Andalusite	Zircon	Tourmaline	Kyaanite	Garnet	Zeolite	Gibbsite	Anastase
SB9388A	A	S	tr		R		tr	tr	tr	R	tr	tr		R				C	tr				S	tr				c								tr				tr	tr					
9387B	A	S	tr	tr	R		tr	tr	tr	c	tr	tr		r				C	tr				S	tr		tr		c		S						tr				tr	tr		tr			
9388C	A	c			R	tr		tr		c	tr	tr		R				C					S	tr				c		S	tr			tr		tr				tr			tr			
9388D	a	c	tr		S	tr	tr	R	tr	c	tr	tr		tr				c	tr				R	tr		tr		c		S		tr				tr				tr	tr		tr		tr	
9388E	c	R	tr		tr	tr		tr									C	S					tr	tr		tr		a		R		tr				tr		tr							tr	
9388F	c	tr		tr				tr				tr		tr			C	S	tr							tr		tr		tr						tr				tr					R	

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