SOILS OF PART OF THE PORT HILLS AND ADJACENT PLAINS, CANTERBURY, NEW ZEALAND

by

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Soil Bureau, DSIR
Havelock North

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Soil map of part of the Port Hills and adjacent plains, Canterbury, New Zealand Scale 1:31 680.  
Pocketed inside rear cover

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by

E. GRIFFITHS

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ABSTRACT

The survey area can be divided into two distinct physiographic units—the Port Hills and the adjacent plains. The soils of the hills are formed on basalt, loess, and mixtures of basalt and loess in varying proportions ranging from pure basalt to pure loess. There is a distinct climatic gradient from subhumid on the plains and lower parts of the hills, to humid on the upper parts of the hills above 275-300 m. This is reflected in the soils—the zonal soils are yellow-grey earths on the lower parts of the hills, and yellow-brown earths on the upper parts. Brown granular loams (intrazonal soils) are formed on dominantly basalt material.

On the adjacent plains the soils are recent, formed on alluvium derived from the Waimakariri River system and lacustrine sediments. The soils near Lake Ellesmere are strongly saline and those away from it are less saline.

INTRODUCTION

The area surveyed is on the eastern margin of the Canterbury Plain and on the western end of Banks Peninsula, to the south of Christchurch (figure 1).

Most of the area is in Halswell County, shown on NZMS 2, sheets S84/4 and S84/7. It covers approximately 13,100 hectares and is bounded by Lake Ellesmere in the south, Paparua County and Ellesmere County in the west, Heathcote County in the north, and the Summit Road in the east. It includes two distinct physiographic units—the south-west to western part of the Port Hills, and the adjacent plain from Taitapu to Motukarara.

The survey was made to complete soil information on a part of the Port Hills and plains which was considered a likely area for the growth of Christchurch. Basic soil information on both the hills and plains was required for planning purposes.

GEOLOGY AND GEOMORPHOLOGY

PORT HILLS

The Port Hills are the north-western to south-western sides of the erosion caldera that surrounds the volcanic crater centred on Lyttelton Harbour. Remnants of the main cone are andesitic with basalt occurring on the flanks at Halswell and Otahuna (Speight 1916). However, Liggett and Gregg (1965) suggest that the main flow types are a mixture of andesite and basalt. The volcanic material also consists of basaltic ash, tuff, agglomerate, vesicular basalt, scoriaceous basalt, and basic lava flows. In the Gubbies Pass area a series of slates and greywacke is exposed, with rhyolite forming the prominent hills on the west side of the Pass.

*1 acre = 0.4047 hectare

The hills are partly covered by a mantle of loess. The thickest deposits are found on north-facing slopes at low elevations (i.e., up to 270 m above sea level), although some deposits on rolling tops near the summit are also thick. On moderately steep, south-facing slopes at lower elevations, and on all moderately steep slopes at higher elevations, little or no loess remains. Loess deposition in Canterbury occurred mainly during the late Pleistocene and probably covered all the Port Hills. Under the periglacial conditions that would have existed in the Port Hills at that time, frost-lift and freeze-thaw would have initiated erosion of the loess almost as soon as it was deposited. Downslope movement initiated by these processes would have most effect on the shadier south-facing slopes, which would remain frozen for considerable periods during the winter. Some of the loess has
been redeposited on lower slopes. Several distinct layers of loess can be recognised, apparently deposited at different times (Raeside 1964). Not all the layers are found at any one place and the thickness of those that do appear may vary considerably.

The structural features of the erosion caldera are residual sections of the volcanic cone, bounded by steep valleys which join in their higher reaches. These valleys radiate from the cone with their streams cutting back towards the crater. They run in the direction of the dip of the lava, at right angles to the strike, and are trench-like with steep sides (Speight 1916). Distinct amphitheatres have formed at the heads of some of the larger valleys. Streams which are mainly consequent in character are now tending to cut subsequent valleys and the subsequent tributaries are diminutive intermittent torrents that carry little or no water in the summer. In the lower reaches the valleys are flat, owing to aggradation of streams unable to carry their loads.

Of the spurs separating the valleys on the south-west and west of the caldera, the northern slopes are longer and gentler than the southern. Of the few spurs running

![Locality map of survey area.](image)
north-west/south-east, both slopes tend to be short and steep. As the spurs descend from the summit, they level out at about 230 m above sea level for some distance before continuing down to the plains, and this levelling-out is accompanied by a change from a rough hilly surface, with numerous outcrops of volcanic material, to a smooth rolling surface. This change of slope may be a bench marking a former sea level (Speight op. cit.), but no evidence has been found to support this view; or the levelling-out may mark the end of a lava flow. Before reaching plains level, at or below 30 m, there is often another levelling-out (figure 2).

The Port Hills reach a maximum altitude of 573 m at Coopers Knob, with most of the summit ridge being 460 m above sea level.

ADJACENT PLAINS

Alluvium derived from the Waimakariri River system occurs on the plains, together with lacustrine deposits of the old Lake Ellesmere (which was much larger than the present lake and reached as far inland as Taitapu). Small patches of loess have been found on the plains outside the old lake margin. Remnants of an intermediate terrace of the Waimakariri fan exist to the south of Taitapu. Beach ridges associated with the littoral zone of the old Lake Ellesmere rise to a height of 4.6 m at the mouths of the valleys north of Motukarara and across the plain south of Taitapu. The plains at Motukarara are only about 2 m above sea level, and they rise to about 6 m near Taitapu.

CLIMATE

Rainfall records have been kept by the North Canterbury Catchment Board, for Hoon Hay Valley and Cashmere Valley since 1962. Eight rain gauges (figure 3) are sited in various parts of the catchment, ranging from valley floor to the summit. Although figures are available for only 6 years, the relative differences in rainfall are shown to be consistent over this period (figure 4) and give a fair indication of the shadow aspect and altitude effect on the rainfall.

Elevation in itself is not important, as shown by gauge 3 on Worsley Road, which is at 366 m yet has the lowest rainfall of all gauges other than Christchurch (gauge 9). The highest rainfalls recorded in the catchment were at gauges 2 and 4 at altitudes of 335 m and 381 m respectively. These gauges are on different topography: gauge 2 (Kennedy Bush Road) is on the crest of a rolling part of a spur, and gauge 4 is at the head of the Cashmere Valley near the Summit Road. There is no simple explanation of the differences but in general the lower slopes and valley floors receive about 760 mm of rain per annum, and the higher parts (over 300 m,) about 1020 mm. The rainfall on the plains is probably fairly well represented by that shown by the rain gauges at Lincoln and Christchurch which have an average of 633 mm and 668 mm per annum respectively. Most of the rain is directional, coming from the south-west, the stations on the south-west side receiving more rain than those on the north and north-west. Otahuna, which is in the south of the survey area, has an average of 810 mm, while Rhodes Home in the north has an average of 686 mm per annum. The south-west wind has a convectional current in which the saturated air masses deposit rain on the first high ground that they meet. Most of the rain, therefore, is released on the south-west side of the peninsula (Mr A. P. Ryan, N.Z. Meteorological Service, Ministry of Transport, pers. comm.). Unofficial records from farmers also show that the south-west side of the Port Hills has more rain than the north-west side.

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**Figure 2** Topographic section along one of the SE–NW spurs of the caldera to show relationship of soils to parent material and climate.
Figure 3  Location of rain gauge sites in Hoon Hay and Cashmere catchments. (Data supplied by North Canterbury Catchment Board.)
The climate is subhumid on the plains and lower parts of the hills, and humid on the higher parts of the hills. The relationship of soils to parent material and climate is shown in figure 2.

The soils of the subhumid climate suffer little leaching, but on soils of the humid climate of the hills, rainfall exceeds evapotranspiration sufficiently to give a surplus for leaching.

Freeze-and-thaw is still an important erosional factor at higher elevations on the south (shady) slopes of spurs, but has less effect on the soils of the north (sunny) slopes.

**VEGETATION**

According to early vegetation maps held by the Department of Lands and Survey, the vegetation of the valley floors was mostly raupo (Typha orientalis) swamp, with flax (Phormium tenax), toetoe (Cortaderia richardii), and bracken (Pteridium aquilinum var. esculentum) in the upper, narrower parts of the valleys. The Port Hills were mostly covered with tussocks, and according to Laing (1927) the Lyttelton Hills were never fully bush-clad but were always covered by tussock grassland, the chief species being hard tussock (Festuca novae-zelandiae) at lower elevations, and silver tussock (Poa laevis) with some danthonia (Notodanthonia spp.) higher up. Patches of mixed podocarp forest occurred on the summits and for some distance down the south-facing shady faces.

Today, in general, the vegetation is more related to management than to soils and climate. The valley floors and plains have been drained and cultivated, and the present vegetation consists of improved pasture, with browntop (Agrostis tenuis), cocksfoot (Dactylis glomerata) and white clover (Trifolium repens) being co-dominant pasture plants. On the hills and steep land, silver tussock and danthonia are found, with ryegrass (Lolium perenne), sweet vernal (Anthoxanthum odoratum) and/or browntop as co-dominants; cocksfoot, white...
clover, and suckling clover (*T. dubium*) are minor pasture constituents. At lower elevations, where there are mostly introduced grasses, the vegetation on loess-derived soils is dominated by ryegrass, whereas that on soils derived from volcanic material is dominated by cocksfoot.

Soil moisture (i.e., effective rainfall) has more effect on vegetation than total rainfall, and aspect, topography, elevation, soil depth and texture, which control moisture availability at a site, help determine the vegetation patterns. For instance, where there is excess soil moisture caused by topographic factors, rushes and sedges occur; native bush, if it has been protected from fire and allowed to grow, survives on the shady sides of the valleys down to 75 m; manuka, which can grow in dry sunny situations, is found on drier north-facing slopes; tussock is usually denser, with a higher proportion of bushes and shrubs, on southern than on northern slopes.

There are also large patches of scrub on the hills (figure 5), of which the main species are gorse (*Ulex europaeus*), broom (*Cytisus scoparius*), some patches of blackberry (*Rubus fruticosus agg.*), and, especially at higher elevations where rainfall is over 890 mm, bracken fern.

The vegetation of the plains is influenced by salinity, and as the salinity of the soil increases pasture plants are replaced by other plants that are able to tolerate greater concentrations of soluble salts. For example, weakly saline soil is characterised by buck's-horn plantain (*Plantago coronopus*), bachelor's button (*Cotula coronopifolia*), and creeping bent (*Agrostis stolonifera*). A moderately saline soil is characterised by salt barley grass (*Hordeum marinum*), salt grass (*Puccinellia stricta*), and selliera (*Selliera radicans*). A strongly saline soil is characterised by glasswort (*Salicornia australis*) and glaucous goosefoot (*Chenopodium ambiguum*).
SOILS

The area is included in the General Survey of the South Island, mapped at a scale of 1 inch to 4 miles (N.Z. Soil Bureau 1968b), and the field sheet from that reconnaissance survey was used in the initial appraisal of the Port Hills survey. The soil survey of Heathcote County (Fitzgerald 1966), which has a common boundary with the north boundary of the survey area, was also used to establish the soil series. The soil units are shown on the accompanying map (in pocket) and in table 1 are correlated with those defined in previous surveys.

The soils have been described and grouped according to the New Zealand genetic soil classification (N.Z. Soil Bureau 1968a), see table 2.

A physiographical arrangement of the soils is given in table 3.

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| Table 1 Correlation with other soil surveys |

YELLOW-GREY EARTHS

(pallic soils)

These are zonal soils developed under a subhumid climate where the mean annual rainfall ranges from 630 to 890 mm, and soil moisture is in the subhygrous class (N.Z. Soil Bureau 1968a).

Takahe Series

These soils were formed under tussock grassland from loess overlying basalt or from colluvium derived from the loess. The colluvium has accumulated on the lower
Table 2  Soils arranged pedologically

**YELLOW-GREY EARTHS (pallic soils)**

*from loess*
- with subhumid climate
  - Takahe silt loam (1)
  - Takahe fine sandy loam (1a)
  - Takahe hill soils (1H)

**UPLAND YELLOW-BROWN EARTHS (elfulvic soils)**

*from loess*
- with humid climate
  - Summit silt loam (2)
  - Summit hill soils (2H)*

**BROWN GRANULAR LOAMS (prospadic and elprospadic soils)**

*from basalt*
- with subhumid climate
  - Cashmere silt loam (3)
  - Cashmere hill soils (3H)
- with humid climate
  - Rapaki clay loam (4)
  - Rapaki hill soils (4H)*

**STEEPLAND SOILS RELATED TO BROWN GRANULAR LOAMS (clini-prospadic and clini-elprospadic soils, etc.)**

*from basalt*
- with subhumid climate
  - Evans steepland soils (5)
- with humid climate
  - Stewart steepland soils (6)

**COMPLEXES OF YELLOW-GREY EARTHS, BROWN GRANULAR LOAMS, AND INTERGRADES (pallic, prospadic, prospado-pallic, and palli-prospadic soils, etc.)**

*from loess with some basalt*
- with subhumid climate
  - Takahe–Cashmere complex (1–3)
  - Takahe–Cashmere hill soils complex (1H–3H)

*from basalt with some loess*
- with subhumid climate
  - Cashmere–Takahe complex (3–1)
  - Cashmere–Takahe hill soils complex (3H–1H)

**COMPLEXES OF UPLAND YELLOW-BROWN EARTHS, BROWN GRANULAR LOAMS, AND INTERGRADES (elfulvic, elprospadic, elfulvi-prospadic, and prospado-elfulvic soils, etc.)**

*from loess with some basalt*
- with humid climate
  - Summit–Rapaki complex (2–4)
  - Summit–Rapaki hill soils complex (2H–4H)

*Areas too small to be mapped separately.

*from basalt with some loess*
- with humic climate
  - Rapaki–Summit complex (4–2)
  - Rapaki–Summit hill soils complex (4H–2H)

**GLEY SOILS (madentic soils)**

- Temuka silt loam (7)

**SALINE GLEY RECENT SOILS (soloni-madenti-luvic and soloni-luvi-madentic soils)**

- Motukarara silt loam, strongly saline phase (8)
- Motukarara silt loam, moderately saline phase (8a)
- Motukarara silt loam, weakly saline phase (8b)
- Motukarara silt loam, imperfectly drained and strongly saline phase (8c)
- Motukarara silt loam, imperfectly drained and moderately saline phase (8d)
- Motukarara silt loam, imperfectly drained and weakly saline phase (8e)
- Motukarara silt loam, moderately well drained and weakly saline phase (8f)
- Motukarara sandy loam, moderately saline phase (8g)
- Motukarara sandy loam, imperfectly drained and moderately saline phase (8h)
- Motukarara sandy loam, imperfectly drained and weakly saline phase (8i)
- Motukarara sandy loam, moderately well drained and moderately saline phase (8j)
- Motukarara sandy loam, moderately well drained and weakly saline phase (8k)
- Motukarara sand, moderately saline phase (8l)

**GLEY RECENT SOILS (luvi-madentic and madenti-luvic soils)**

- Horotane silt loam (9)
- Horotane silt loam, imperfectly drained phase (9a)
- Horotane silt loam, moderately well drained phase (9b)
- Horotane sandy loam (9c)
- Horotane sandy loam, imperfectly drained phase (9d)
- Taitapu silt loam (10)
- Kaiapoi silt loam (11)
- Kaiapoi sandy loam (11a)
- Kaiapoi sand (11b)

**YELLOW-BROWN SANDS (voli-subfulvic soils)**

- Waikuku sand (12)

**ORGANIC SOILS (platic soils)**

- Waimairi peaty loam (13)
Table 3 Soils arranged physiographically

Soils of the Hills
of the rolling land
- Takahe silt loam (1)
- Takahe fine sandy loam (1a)
- Summit silt loam (2)
- Cashmere silt loam (3)
- Rapaki clay loam (4)

of the hilly land
- Takahe hill soils (1H)
- Summit hill soils (2H)*
- Cashmere hill soils (3H)
- Rapaki hill soils (4H)*

of the steep land
- Evans steepland soils (5)
- Stewart steepland soils (6)

Soils of the Plains
of the valley floors
- Horotane silt loam (9, 9a, 9b)
- Horotane sandy loam (9c, 9d)

of the intermediate terrace
- Temuka silt loam (7)

of the low terrace and flood plain
- Taitapu silt loam (10)
- Motukarara silt loam (8 to 8f)
- Motukarara sandy loam (8g to 8k)
- Motukarara sand (8l)
- Kaipoi silt loam (11)
- Kaipoi sandy loam (11a)
- Kaipoi sand (11b)
- Waimairi peaty loam (13)

of the sand dunes
- Waikuku sand (12)

*Areas too small to be mapped separately.

parts of slopes, and has originated from loess eroded from the tops of narrow ridges and the upper parts of slopes. This colluvium overlies loess; it has been thoroughly mixed by the activities of soil animals, and the boundary between loess and colluvium is diffuse.

Soil moisture is above field capacity during July, August, and September, below wilting point during January, February, and March, and between field capacity and wilting point for the remainder of the year. Generally the soils† consist of friable, dark greyish brown sandy loam or silt loam topsoil, with weakly to moderately developed nut structure, overlying firm, light olive brown silt loam with weakly developed nut or massive structure and strong brown mottling or iron-manganese concretions, which rests on a very firm or compact, massive silt loam. When dry, this last horizon is very hard and brittle, appearing to be strongly cemented; it is called a fragipan because the cementation disappears when moistened (Taylor and Pohlen 1962). The upper part of the fragipan has faint gammate features – faint grey veins which run horizontally through the top and penetrate vertically into the joints. With a greater amount of leaching, gammate increases in both its frequency and intensity, and this is seen on the Port Hills. As rainfall increases with elevation, more gammate occurs on the higher parts of the Hills, accompanying a gradual change to yellow-brown earths at c. 270–300 m.

Takahe silt loam (1):

covers 770 hectares as a pure unit, and is also mapped in complexes (1–3, 3–1) with Cashmere silt loam (3). It occurs on the rolling tops of spurs and has developed on primary loess and loess colluvium. On the crests of ridges some of the loess has been eroded, and there is only a shallow topsoil (15–30 cm) overlying the fragipan (figure 6), but on the sides of the ridges, where colluvial material has accumulated, the depth varies from 30 to 46 cm, and at the toe of a long slope it may be as deep as 60 cm.

A representative profile consists of 23 cm of friable dark greyish brown silt loam with a weakly developed nut structure, on 23 cm of yellowish brown firm silt loam, which has many fine strong brown mottles, on 30 cm of light olive brown very hard massive silt loam, heavier than that above, with many prominent strong brown mottles. This is the fragipan, the upper part of which has some mottling and gammate: a few horizontal, sandy, grey veins with reddish brown margins run across the upper part, and continue for a short distance into the top of the vertical-joint system. The vertical joints are 3–5 cm wide at the top, tapering to mere slits at the bottom of the silt loam layer. At about 76 cm there is a gradual change to a massive fine sandy loam layer, probably the unweathered loess parent material. This becomes sandier with depth, until at about 1.5–2 m the texture is sandy loam to sand. At about the same depth, soft filamentous lime deposits appear, increasing in number and intensity with depth. Hard lime concretions also appear in the lower parts of this layer.

The topsoil is thinner on the upper convex part of the slopes where it has been eroded and more run-off occurs. On the gentler slopes approaching easy rolling (5°) grade, mottling is more frequent and intense, especially below outcrops of basalt.

Takahe fine sandy loam (1a):

covers 150 hectares and is found on the broad, easy rolling tops of spurs and on the knobs at the end of spurs. It is the least disturbed soil of the Takahe series, being formed from primary loess with no colluvium, although some stripping of the surface layer has occurred. It is similar to Takahe silt loam on rolling land, but is distinguished from it by fine sandy loam texture in the topsoil and, often, in its subsoil, shallower depth to the fragipan (38 cm), thinner fragipan (23 cm), more intense mottling,
the presence of iron–manganese concretions, and less intense gammatation.

At lower elevations along the tops of ridges nearest the plain, the textures are sandier, with pockets of sand, and the depth to the fragipan is only 30–38 cm, but higher up the ridges the textures become finer and the depth to the fragipan increases. In the flat areas towards the centres of the ridges more concretions are found, and more gleying occurs above the fragipan.

**Takahe hill soils (1H):**

occur on moderately steep land and cover 1780 hectares as a pure unit, and are also mapped in complexes (1H–3H, 3H–1H) with Cashmere hill soils (3H). They are found on the north-facing valley sides and on the moderately steep to steep tops of some ridges (figure 7).

The hill soils are similar to those Takahe soils on rolling land, but their range of variation is much wider. Textures vary from silt loam to loamy sand in the topsoil and upper subsoil, and where the fragipan has been stripped sandy textures may also be found in the subsoil; again, soils on valley sides nearest the plains have sandier textures and are the thickest over the fragipan and basalt rock. The depth to the fragipan is about 15 cm on the upper part of the slope, increasing to 60 cm at the foot of the slope. The fragipan is missing at the top of the slope and gradually increases in thickness down the slope from 15–46 cm. Gammation is most intense in the soils on moderately steep slopes, increasing in intensity from the plains to the upper parts of the Hills. From the middle of the slope downwards, the horizon above the fragipan is often bleached, with many reddish brown mottles and iron-manganese concretions.

A profile from a long slope facing north shows 15 cm of friable dark greyish brown sandy loam with weakly developed nut structure, on 15 cm of firm pale yellow silt loam with moderately developed blocky structure, on 38 cm of very hard light olive brown massive silt loam with many strong brown mottles, weakly net-gammate with many vertical joints, on firm light olive brown massive fine sandy loam. The loess is usually thin over
underlying basalt rock on the tops of ridges and on the shoulders of hills, but thickens downslope where colluvial material usually covers the eroded loess surface. Erosion is much more severe on these slopes, the top layer of loess having been stripped in almost all cases, and the fragipan also having been stripped on steeper slopes and near the shoulders that mark the transition between rolling and hilly land.

On short, moderately steep valley sides facing north, 15–46 cm of colluvial material overlies loess, which lies on rock at about 1 m. Remnant patches of deep primary loess are found only on the flatter portions.

On long, moderately steep valley sides facing north, the loess is usually deeper, with a slightly browner layer of colluvial material, about 30–46 cm thick, overlying it. On the upper and steeper part of the valley sides the colluvial material, usually silt loam in texture, overlies sandy loess (see profile in appendix); on the lower, gentler parts of the valley sides it overlies the fragipan. These soils are usually badly eroded, with tunnel gullies running the whole length of the slope in many valleys.

On the northern flanks of the hills and at the mouths of the valley the long, moderately steep slopes have about 90 cm of colluvial material overlying the loess or basalt rock. These slopes have obviously been subjected to much erosion, and the only common characteristic is the deep colluvium on top, which gives a characteristic surface dimpled by series of terracettes. This colluvium sometimes overlies the fragipan and sometimes a sandy, lime-rich loess. The colluvium is usually medium sandy loam in texture, friable and porous, and does not resemble other loess. It is possible that this material is not colluvium but a more recent, coarse loess which has blown on to the flanks of the hills, burying the earlier fine loess (Mr C. G. Vucetich, pers. comm.). However, the obvious signs of movement on the slope, and the relationship of the deeper soils to the topography, suggest that it is, in fact, colluvial material.

Shallow soils over basalt occur on moderately steep to steep slopes on north-facing valley sides with short steep slopes, and on the lower convex parts of long slopes. Many outcrops of unweathered basalt occur, and the soil is formed on 15–46 cm of colluvium derived from reworked loess, lying on thin primary loess which lies on unweathered basalt rock. A few small pieces of basalt rock are found in the reworked loess, but they are unweathered and do not seem to have influenced the soil greatly.

**UPLAND YELLOW-BROWN EARTHS**

(elfulvic soils)

These are zonal soils developed under a humid climate, where the rainfall is higher than 890 mm per annum, and the soil moisture is in the hygrous class (N.Z. Soil Bureau 1968a).

**Summit Series**

Soils of this series have developed from loess parent material overlying basalt at an elevation above 270–300 m, where the mean annual rainfall ranges from
890 to 1140 mm. The soil moisture is at or above field capacity for 7 months (March–September) and below field capacity for 5 months (October–February) but seldom drops to wilting point. The climate here is at the lower end of the humid class, and aspect has a marked effect on soil moisture, so that the soils on the north-facing slopes are drier than those facing south and approach the intergrades between yellow-grey earths and yellow-brown earths. The soils were probably formed under podocarp forest which was later destroyed by fire and replaced by silver tussock.

Generally, these soils consist of very dark greyish brown friable nut-structured silt loam, on yellowish brown friable nut-structured silt loam or heavy silt loam, on light olive brown firm massive light silt loam or sandy loam (loess parent material).

The field test for allophane (Fieldes and Perrott 1966) shows a moderate reaction for allophane in the topsoil and a strong reaction in the subsoil loess parent material.

**Summit silt loam** (2) (*figure 8*):

covers 6 hectares as a pure unit, and is also mapped in complexes (2–4, 4–2) with Rapaki clay loam (4). It is found on the rolling tops of ridges and the summit of the caldera wall. Although it is formed mainly on loess, some soils are formed from loess with an overlying thin layer of colluvium (15–30 cm thick and derived from a mixture of loess and basalt). A representative profile similar to *figure 8* has 15 cm of friable very dark greyish brown silt loam, with moderately developed nut structure, on 10 cm of friable yellowish brown silt loam with a moderately developed nut structure, on 15 cm of friable yellowish brown heavy silt loam with very weakly developed nut structure, on 8 cm of firm light olive brown massive light silt loam, on firm light olive brown massive sandy loam (loess parent material).

These soils occupy small areas on “island” remnants of loess which have been left relatively undisturbed along the summit of the Port Hills. Even on these sites occasional basaltic stones are found in the loess but they have had little or no influence on the soil. Aspect differences are very important; on north-facing slopes the soils are drier and the subsoils have cracks which are connected to bleached joints in the loess parent material, whereas on the south-facing slopes there is little or no jointing and the soils remain moist all year.

Some of the parent material loess contains thin horizontal bands of small (<2 mm) fragments of scoria, tuff and basalt, probably washed into the loess from higher slopes during pauses in the loess deposition. Even on the higher parts of the Port Hills, therefore, the loess may be contaminated by colluvium.

**Summit hill soils** (2H):

occur on moderately steep to steep land but individual areas are too small to be shown separately so they are mapped as complexes (2H–4H, 4H–2H) with Rapaki hill soils (4H). They are found on the moderately steep slopes of the upper valley sides below the Summit silt loam, and are similar to these soils on the rolling land but are shallower, consisting of 38–50 cm of soil on the loess parent material.

**BROWN GRANULAR LOAMS**

(prosapid and elprosapid soils)

These are intrazonal soils with strongly developed structure, formed on basalts, basaltic tuffs, and basaltic ash. They have been divided into soils under a subhumid climate (Cashmere soils) and those under a humid climate (Rapaki soils).

**Cashmere Series**

These are formed mainly on basaltic tuff, ash, and some basalt but also contain some loess, with the deeper soils on the tuff and ash and shallow soils on the basalt. They are found on the rolling and easy rolling tops of ridges and on moderately steep to steep slopes where the loess has been stripped, exposing the underlying rock to weathering. Some of the original loess may still be mixed with the volcanic material and thus may influence the topsoils, but the characteristics of the subsoils are mainly those acquired from the basic rocks.

Although the climate is subhumid and similar to that prevailing over Takahe soils, the soil moisture characteristics of Cashmere soils are different from those of Takahe soils because of their higher field capacity and higher available moisture; these soils therefore tend to remain moist for longer and below wilting point for less time than Takahe soils.

**Cashmere silt loam** (3):

occurs on rolling and easy rolling land, covers 110 hectares as a pure unit, and is also mapped as complexes (3–1, 1–3) with Takahe silt loam (1). It is found on the crests of spurs and ridges which have rock outcrops over 5–10% of the area. A representative profile in a soil derived from tuff shows 15 cm of friable dark reddish brown silt loam with strongly developed crumb structure, overlying 30 cm of friable reddish brown clay loam with moderately developed crumb structure, on 40 cm of friable dark reddish brown clay loam with moderately developed nut structure and a few basalt stones, on basalt.

The soils near the crests and on easy rolling slopes are shallower. A typical profile (similar to *figure 9*) consists of 23 cm of friable dark brown silt loam with strongly developed crumb structure, on 23 cm of friable dark reddish brown clay loam with moderately developed crumb structure and many basalt stones, lying on basalt. The soils are deeper (*figure 9*) away from the crests except on shoulders of hills where rocks are often exposed, and an escarpment has formed.
Figure 8  Profile of Summit silt loam showing friable, nut-structured A horizon over a weakly developed, nut-structured B horizon on a firm, massive C horizon.

Cashmere hill soils (3H): occur on moderately steep land, cover 45 hectares as a pure unit and are also mapped as complexes (3H-1H, 1H-3H) with Takahe hill soils (1H). They occur on upper valley sides. The soil is 46-76 cm deep where formed on tuff but shallow on basalt, and is similar to the Cashmere silt loam except for the presence of a few angular fragments of basalt in the upper subsoil, and many such fragments in the lower subsoil.

Shallow soils are found on moderately steep to steep land, at the top of short steep slopes under escarpments, or on the convex lower parts of long slopes where they drop to stream level. They are generally shallow and stony; a representative profile consists of 15 cm of friable dark brown silt loam with moderately developed crumb structure, on 25 cm of friable dark reddish brown clay loam with crumb structure, on 20 cm dark reddish brown clay loam with moderately developed nut structure with fragments of basalt, on basalt rock. Many rock outcrops occur, covering 5-10% of the surface.

Most of the soils are formed on slightly weathered basalt with little tuff or ash on these slopes. However,
remnants of deeper material are found on terracettes. These hill soils merge with Evans steepland soils which occur above them on escarpments.

**Rapaki Series**

Rapaki soils are found on the Hills above 270–300 m, although their position varies on each ridge; they occur on the rolling tops of ridges, and on the moderately steep and moderately steep to steep slopes where the loess has been stripped off to expose the underlying rock to weathering. They are formed mainly on basaltic tuff and ash, and some are on scoriaceous basalt but also contain some loess; those on the tuff and ash are the deeper soils.

**Rapaki clay loam (4):**

covers 60 hectares as a pure unit and is also mapped as complexes (4-2, 2-4) with Summit silt loam (2). It is found on the rolling tops of spurs where there are many rock outcrops, and is usually shallow. A soil derived from tuff on a rolling crest near the Summit Road is about 76 cm deep. It consists of 23 cm of friable very dusky red clay loam with strongly developed crumb structure on 25 cm of friable dusky red clay loam with moderately developed crumb structure, on 30 cm of
Figure 10 Profile of Rapaki clay loam showing strongly developed nut structure in the A and B horizons, stones and gravel-sized fragments of basalt are scattered throughout the profile.

Friable dark reddish brown clay loam with moderately developed nut structure, on basaltic tuff.

Profiles near outcrops of scoriaceous basalt are shallower and stonier, and texture may be silt loam (figure 10). On pure basaltic tuff with little basalt rock a red loam is formed which consists of dark reddish brown clay loam overlying red clay loam or silt clay loam.

Rapaki hill soils (4H):

occur in areas too small to be shown separately, so are mapped as complexes (4H-2H, 2H-4H) with Summit hill soils (2H) on moderately steep land. They are found on the crests of ridges which drop down from the summit, and on valley sides where many outcrops of basalt occur. The soils are similar to Rapaki clay loam except for the presence of angular basalt fragments in the profile. A representative profile on a valley side has 8 cm of friable very dusky red clay loam with strongly developed crumb structure and many basalt fragments, on 18 cm of friable dusky red clay loam with strongly developed nut structure and many angular basalt fragments, on 50 cm of friable dark reddish brown clay loam, on scoriaceous basalt. The upper 25 cm of material
appears to be colluvium derived from basalt and tuff, overlying the soil derived from scoriaceous basalt.

On moderately steep to steep land on upper valley sides the soil is very shallow. A representative profile shows 15 cm of very dark reddish brown friable clay loam with strongly developed crumb structure, on 15 cm of friable dark reddish brown stony clay loam, on basalt. This soil is somewhat similar to the Stewart steepleand soil on steep land.

**STEEPLAND SOILS RELATED TO BROWN GRANULAR LOAMS**

(clini-prospadic and clini-elprospadic soils, etc.)

These are intrazonal soils with strongly developed structures formed mainly on basalts, basaltic tuffs and ash, but also containing some loess. They are shallower and stonier than related Cashmere and Rapaki soils. They have been divided into soils with a subhumid climate (Evans steepleand soils) and those with a humid climate (Stewart steepleand soils).

**Evans steepleand soils (5):**
cover 160 hectares, are shallow and stony and are derived mainly from basalt but also contain some loess, with abundant rock outcrops (20–30% of the surface area). The soil consists of 13 cm of friable very dark grey stony silt loam with strongly developed nut structure, on 13 cm of friable dark brown silt loam with moderately developed nut structure, on 13 cm of friable dark reddish brown gravelly clay loam with moderate nut structure, on basaltic agglomerate.

The soils may be deeper where terracettes have formed but some consist of only 15 cm of black topsoil on rock.

**Stewart steepleand soils (6):**
cover 150 hectares, are shallow and stony with abundant rock outcrops, and occur on scarps and steep valley sides. A representative profile consists of 15 cm of friable dark reddish brown heavy silt loam, on 15 cm of friable dark reddish brown clay loam with strongly developed crumb and nut structure and a few angular basalt fragments, on 8 cm of friable reddish brown clay loam with moderately developed nut structure and many angular pieces of basalt, on basalt.

**SOIL COMPLEXES**

On sloping land the loess has been stripped in varying amounts, partly or completely exposing the basalt. On such slopes, colluvial mixtures of loess and basalt are formed which comprise the parent materials of most of the soils on the Port Hills. A complete range of soils occurs, therefore, from those derived from loess only to those derived from basalt only, with intergrades between them formed from mixed colluvium. Where such soils are intimately mixed in the landscape they cannot be mapped as homogenous soil units (the soil type), and have therefore been mapped as soil complexes which include not only the soil types named but also their intergrades. For example, where there is more basalt than loess in the colluvium the complexes have been mapped as Cashmere–Takahe or Rapaki–Summit complexes, and where loess predominates, as Takahe–Cashmere or Summit–Rapaki complexes. Because of the widespread distribution of the complexes and the differences between them in land use, each complex has been described separately in the following section. The soil types that occur within the complexes have been described separately under the appropriate series; the representative soil profile described for each complex in the *Extended Legend* refers to an intergrade and is only one of a range occurring within that mapping unit, but is fairly representative.

**Complexes of Yellow-grey Earths, Brown Granular Loams, and Intergrades**

(pallic, prospadic, prospado-pallic, and palli-prospadic soils, etc.)

These soils are formed under a subhumid climate. Where the dominant parent material is loess or colluvium derived mainly from loess, with a fragipan underlying it, the soils are mapped as Takahe–Cashmere complexes (1–3, 1H–3H). Where the dominant parent material is basalt or colluvium derived mainly from basalt, and the fragipan is absent, they are mapped as Cashmere–Takahe complexes (3–1, 3H–1H).

**Takahe–Cashmere complex (1–3):**
cover 30 hectares on the rolling tops of ridges where there are many rock outcrops; it usually consists of separate units of Takahe soil (about 75%) and numerous patches of Cashmere soil surrounding the outcrops. Not much mixing has occurred between the parent materials.

**Takahe–Cashmere hill soils complex (1H–3H):**
cover 575 hectares on moderately steep land below a few outcrops on the lower valley sides, generally those facing north. The soils are formed from loess, basalt, and colluvium of loess and basaltic tuff or ash, overlying loess. Fifty percent of the soils consist of intergrades between Takahe and Cashmere soils, 25% of Takahe hill soils, and 25% Cashmere hill soils. A representative profile of an intergrade soil has 25 cm of friable very dark brown silt loam with moderately developed nut structure, on 25 cm of friable yellowish brown silt loam with moderately developed nut structure, on 30 cm of very hard light olive brown silt loam with strong brown mottles and massive structure, on firm light olive brown sandy loam with a few vertical joints showing clay skins on their faces.
There is a gradation from Takahe hill soils, which have about 15 cm of colluvium, to the intergrades of the Takahe–Cashmere hill soils complex, where 30–46 cm of colluvium derived from loess and basalt overlies loess. It can be distinguished from the Takahe soil by the browner colours and the strongly developed structure.

Cashmere–Takahe complex (3–1):
covers 225 hectares on the rolling tops of ridges, and the soils are formed from basalt, loess, and colluvial material derived from basaltic tuff and loess, overlying basalt or sometimes loess. About 25% of the area is covered by intergrades between the two soil types, with about 50% of Cashmere silt loam and 25% of Takahe silt loam. A representative profile of an intergrade soil consists of 23 cm of friable very dark greyish brown silt loam with moderately developed nut structure, over 46 cm of friable brown clay loam with weakly developed nut structure, on 23 cm of friable brown sandy loam with weakly developed nut structure and a few basalt fragments, on basalt. Shallow profiles on rock are common, and many outcrops occur.

Cashmere–Takahe hill soils complex (3H–1H):
occurs on moderately steep land and covers 1300 hectares, generally on south-facing slopes and on the upper valley sides facing north (figure 3). The soils are formed from basalt, loess, and colluvium from loess and basalt, which overlies basalt or sometimes loess. About 25% of the area is covered by Cashmere silt loam, about 25% by Takahe silt loam, and 50% by intergrade soils between these two. A representative profile of an intergrade soil consists of 25 cm of friable very dark greyish brown silt loam with strongly developed fine nut structure, on 20 cm of friable dark brown silt loam with moderately developed nut structure and a few basalt stones, on 15 cm of friable dark yellowish brown gravelly silt loam with weakly developed nut structure, overlying basalt.

The intergrade soils often have angular fragments of basalt up to the surface and the texture may be heavy silt loam in the upper subsoil. The profiles which overlie basalt rock are usually stonier and shallower than those overlying loess.

Summit–Rapaki complex (2H–4H):
covers 40 hectares on the rolling tops of ridges above 270–300 m. The soils are formed from loess, basalt, and colluvium from loess and basalt which overlies loess or sometimes basalt. The unit has 50% Summit silt loam, 25% Rapaki clay loam, and 25% intergrades between these two. A representative profile of an intergrade soil has 15 cm of friable dark greyish brown silt loam with strongly developed nut structure, on 23 cm of friable yellowish brown silt loam with moderately developed nut structure, on 23 cm of friable firm yellowish brown silt loam with massive structure and a diffuse boundary, on firm light olive brown massive sandy loam with a few vertical cracks. A similar intergrade soil is shown in figure 11.

The intergrade soils are distinguished from Summit silt loam (figure 8) by the sandier texture in their topsoils, the presence of coarse sand in their silt loam subsoils, and the strongly developed structure in the topsoil. Soils show a gradual change of parent material from colluvium to pure loess.

Rapaki–Summit complex (4–2):
covers 140 hectares on the rolling tops of ridges. The soils are formed on basalt, loess, and colluvium from basalt and loess, overlying basalt or sometimes loess. The unit has 50% Rapaki clay loam, 25% Summit silt loam, and 25% intergrades between the two soil types. A representative profile of an intergrade soil has 23 cm of friable very dark greyish brown silt loam with strongly developed nut structure, on 23 cm of friable brown silt loam with moderately developed nut structure and a few angular fragments of basalt, on 30 cm of friable brown silt loam with weakly developed nut structure and a few basalt stones, on basalt.

These soils are shallow and stony near outcrops but away from them, where the soils contain a higher proportion of loess, they are deep.
Profile of an intergrade soil of the Summit-Rapaki complex showing colluvium with moderately developed nut structure in the A and B horizons overlying massive loess (cf. figure 8).

Figure 11

Rapaki–Summit hill soils complex (4H–2H):

covers 955 hectares on the upper parts of moderately steep valley sides (figure 5) below Summit soils. The soils are formed from basalt, loess, and colluvium from basalt and loess, overlying basalt or sometimes loess. The unit is made up of 25% Rapaki hill soils, 25% Summit hill soils, and 50% intergrades between these. A representative profile of an intergrade soil shows 23 cm of friable very dark greyish brown silt loam with strongly developed nut structure and many basalt stones, on 23 cm of friable brown clay loam with strongly developed nut structure and a few basalt stones, on 30 cm of friable brown clay loam with moderately developed nut structure, on basalt. A similar intergrade soil is shown in figure 12. Where the basalt and loess colluvium overlies loess there is a sharp boundary between the colluvium and the loess (figure 13), which appears to have a shaved surface. The contact zone is often mottled or has grey veins running across the upper part of the loess. The higher the content of basalt, the more pronounced is the mottling and veining.
Figure 12  Profile of an intergrade soil of the Rapaki-Summit complex, showing the stony and gravelly, moderately structured A and B horizons from colluvium, overlying basalt.

GLEY SOILS
(madentic soils)

These occur at the toes of the outwash fans and on low-lying parts of an intermediate terrace and old flood plain of the Waimakariri system. They are poorly drained, with high ground water in winter.

TEMUKA SERIES

Temuka silt loam (7):

covers 75 hectares on an old flood plain of the Waimakariri system as a remnant ridge of the intermediate terrace which has escaped erosion and covering by younger sediments. The soil is formed from alluvium derived from reworked loess which, at the sides of the terrace, is covered by the younger sediments. A representative profile consists of 23 cm of friable very dark greyish brown silt loam with strong brown root stains and moderately to strongly developed nut structure, on
Figure 13  Profile of an intergrade soil of the Rapaki-Summit complex, overlying loess, showing the moderately developed nut structure in the A and B horizons from colluvium and the sharp boundary to the loess.

23 cm of firm grey silt loam with many strong brown mottles and weakly developed nut structure, on 38 cm of very firm massive grey heavy silt loam with many strong brown mottles, on 23 cm of friable massive greyish brown fine sandy loam, on grey fine sand which is gleyed and has abundant brown mottles.

SALINE GLEY RECENT SOILS
(soloni-madenti-luvic and soloni-luvi-madentic soils)

These soils are similar to gley recent soils but contain soluble salts in their profiles.

MOTUKARARA SERIES

Motukarara soils are formed from greywacke alluvium derived from the Waimakariri and Halswell rivers, overlying lacustrine sediments.

The soils have been closely affected by the history of Lake Ellesmere and its sediments. This somewhat saline lake is separated from the sea only by a narrow spit which is about 4.5 m above sea level. Before 1868 the lake level would reach the top of the spit every 2 or 3 years, when the Maoris would let the lake out to the sea at the lowest point of the spit. The boundaries of this pre-1868 high lake level are clearly represented by a littoral
sand dune system, delineated by soils of the Waikuku series, which is found at the mouths of the valleys and crossing the plain south of Taitapu. Since 1868, after the European settlers arrived, the lake has been opened to the sea every year or even two or three times a year, whenever the level of the water reaches 1 m above mean sea level. The area has thus been successfully drained every year except during the disastrous floods of 1895 when the opening could not be made and seven tides swept over the embankment. This brought the lake level to 3 m above mean sea level. Before this flood, according to the older farmers in the district, the area to the north of the lake had been relatively salt-free and was used for fattening sheep. The flood waters would have been very saline, and today, except where the Halswell River has flooded its banks and leached out the salts, most of the land covered by the 1895 flood has some degree of salinity. The salinity is generally low near Taitapu, gradually increasing further south, but around Taitapu itself there are hollows with heavier soils in which much salt has accumulated because of the slow internal soil drainage.

As the ground water in the survey area is an extension of the lake, it is strongly saline near the lake and less so away from it. The salinity of the soils is directly related to that of the ground water. Although many of the soils have sandy subsoils, and internal drainage is rapid so that these soils are easily drained, little leaching occurs under the present subhumid climate and the salts have remained in the soil, despite the fact that deep drains have been dug in the area. Even in winter, when extra moisture is available, little or no leaching occurs because the ground water is high. Some land has been successfully leached during summers by the use of fresh water from the Halswell River or from boreholes. However, the deep drains dug in the area also lower the ground water so far in summer that the capillary fringe drops below the root zone and the soils become very droughty, requiring irrigation.

Salinity has been measured by the electrical conductivity of the soil solution, and estimated by using plant indicators (Taylor and Pohlen 1962). It has been described as weak, moderate, or strong, and the soil types and phases have been grouped according to their salinities.

The areas of the different salinity phases of Motukarara soils are as follows:

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<th>Type of Salinity Phase</th>
<th>Area (ha)</th>
<th>Percentage</th>
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<tr>
<td>Moderately saline phase</td>
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</tbody>
</table>

**Motukarara silt loam, strongly saline phase (8):** covers 730 hectares. It is found in depressions and hollows, is poorly drained and strongly gleyed, and has a layer of fine alluvium overlying coarse alluvium. The thickness of the fine alluvium varies, being about 76 cm near Taitapu and thinning to 15 cm near Lake Ellesmere. A representative profile shows 23 cm of black friable silt loam with strongly developed crumb and nut structure and many reddish brown root stains, on 15 cm of friable massive greyish brown sandy loam, on 30 cm of friable single-grained grey medium sand, on 30 cm of firm massive grey silt loam, on very friable grey fine sand (lacustrine). In very strongly saline patches a variation occurs in the topsoil where it is dark brown and fibrous, and of a loose and fluffy structure. In old channels the silt loam can be 76 cm deep, but textures are very variable and change rapidly in a lateral direction.

**Motukarara silt loam, moderately saline phase (8a):** covers 165 hectares and is found in depressions of the flood plain of the Halswell River. It is similar to the previous soil except that it is less saline.

**Motukarara silt loam, weakly saline phase (8b):** covers 60 hectares on the flood plain of the Halswell River where leaching of salts has occurred so that the salinity is reduced. Apart from this the soil is similar to the strongly saline phase.

**Motukarara silt loam, imperfectly drained and strongly saline phase (8c):** covers 140 hectares on the flood plain of the Halswell River. A representative profile shows 23 cm of friable dark grey silt loam with strong brown root stains and strongly developed crumb and nut structure, on 15 cm of friable olive grey medium sand, on 15 cm of firm massive olive silt loam, overlying very friable light grey fine sand (lacustrine). There are many bare patches where the topsoil is fluffy and salt appears on the surface.

**Motukarara silt loam, imperfectly drained and moderately saline phase (8d):** covers 40 hectares and is similar to the previous soil except for its decreased salinity.

**Motukarara silt loam, imperfectly drained and weakly saline phase (8e):** covers 620 hectares on the flood plain alongside the Halswell River where leaching has occurred. The soil is similar to the strongly saline phase except that it is less saline.

**Motukarara silt loam, moderately well drained and weakly saline phase (8f):** covers 425 hectares on a levee of the Halswell River. A representative profile shows 23 cm of friable dark greyish brown light silt loam with nut structure, on 15 cm of friable greyish brown medium sand, on very friable light grey fine sand.

**Motukarara sandy loam, moderately saline phase (8g):** covers 115 hectares at the southern end of the survey area and is formed where thin alluvial sediments overlie lacustrine sands. It is poorly drained and strongly gleyed, being found in depressions. A representative profile has 23 cm of friable black sandy loam with reddish brown root stains and weakly developed nut structure, on 15 cm of olive grey medium sand, on 15 cm of grey silt loam with few strong brown mottles, on light grey...
fine sand. The ground water is usually at 30–46 cm from the surface during the winter.

Motukarara sandy loam, imperfectly drained and moderately saline phase (8h):
covers 65 hectares and is found at the edge of the flood plain. A representative profile shows 23 cm of friable dark grey sandy loam with strong brown root stains and nut structure, on 15 cm of very friable greyish brown loam (medium sand), on light grey fine sand.

Motukarara sandy loam, imperfectly drained and weakly saline phase (8i):
covers 890 hectares and is found on a slightly higher part of the flood plain. It is similar to the previous soil except for its lower salinity.

Motukarara sandy loam, moderately well drained and moderately saline phase (8j):
covers 250 hectares and is found on a levee of the Halswell River. A representative profile shows 23 cm of friable dark greyish brown medium sandy loam on 23 cm of friable olive medium sandy loam, on light grey fine sand. The surface is very undulating with numerous channels and levees.

Motukarara sandy loam, moderately well drained and weakly saline phase (8k):
covers 20 hectares and is found at the edge of the flood plain on the side of Gebbies Valley. The soil is similar to the previous soil except that it is less saline.

Motukarara sand, moderately saline phase (8l):
covers 540 hectares and is found on a broad ridge which runs parallel to the lake edge. It is imperfectly drained and moderately gleyed. A representative profile shows 23 cm of friable very dark greyish brown fine sand with weakly developed nut structure, overlying light grey fine sand.

GLEY RECENT SOILS
(luvi-madentic and madenti-luvic soils)

Gley recent soils occur on or adjacent to flood plains where sediments have accumulated in recent times. They are poorly to moderately well drained, with high ground water in winter.

Horotane Series

These soils are found on flat and undulating valley floors and are formed on alluvium containing a high proportion of reworked loess with some basalt which has been eroded off the hills. They are mostly poorly or imperfectly drained, and are associated with peaty Waimairi series which are found in the depressions.

Horotane silt loam (9):
covers 120 hectares, is formed on alluvium derived from reworked loess and is poorly drained. A representative profile shows 23 cm of friable dark greyish brown silt loam with strong brown root stains and moderately developed nut structure, on 15 cm of firm grey silt loam with abundant strong brown mottles and moderately developed blocky structure, on 50 cm of massive very firm olive heavy silt loam with many strong brown mottles and strong gleying, on friable grey fine sand.

This soil is difficult to drain because it has high ground water for most of the winter and perched ground water even in summer. Moreover, the subsoil is impermeable, internal drainage is very slow and natural drainage is poor.

Horotane silt loam, imperfectly drained phase (9a):
covers 195 hectares and is similar to the poorly drained Horotane silt loam, but the ground water is slightly lower and there is a greater fluctuation of water during the winter. There are abundant iron-manganese concretions in the upper subsoil, and gleying in the lower subsoil at about 46–60 cm is only moderate.

Horotane silt loam, moderately well drained phase (9b):
covers 100 hectares, occurring in short valleys where there is a sufficient fall for surface water to drain away quickly (figure 7), or on levees alongside the streams. The ground water is lower than in the imperfectly drained phase, the subsoil being weakly gleyed at a depth of 60–76 cm.

Horotane sandy loam (9c):
covers 60 hectares in depressions at the heads of valleys where a layer of recent colluvium (sandy loam) from loess and basalt overlies a silt loam layer. Overall drainage is poor. A representative profile consists of 23 cm of friable very dark grey sandy loam with reddish brown root stains and moderately developed nut structure, on 15 cm of friable olive grey sandy loam with abundant strong brown and reddish brown mottles and weakly developed nut structure, on 38 cm of massive firm olive light silt loam with few strong brown mottles and strong gleying, on friable grey sandy loam.

The light silt loam subsoil is more permeable than the heavy silt loam subsoil of Horotane silt loam and, although the natural drainage is poor, the internal soil drainage is medium, so that these soils drain more easily.

Horotane sandy loam, imperfectly drained phase (9d):
covers 220 hectares and is very similar to the poorly drained sandy loam, except that the ground water is lower, and there is moderate gleying in the lower subsoil at 46–60 cm. The silt loam layer in the lower subsoil is usually about 23–30 cm thick but in some places there is a fine sandy loam layer.
Taitapu Series

Taitapu silt loam (10):
covers 460 hectares and is formed from greywacke allu-
vium derived from the Waimakariri River. It occurs in
low-lying sites which have high ground water along the
foot of the hills and parallel to the Halswell River. A
representative profile has 23 cm of friable dark grey silt
loam with moderately developed nut structure and many
strong brown root stains, on 30 cm of very firm light grey
massive silt loam, massive and with many strong brown
mottles, on 15 cm of firm grey medium sandy loam, on
very friable grey medium sand.

Kaiapoi Series

Kaiapoi soils are found on levees and ridges running
parallel to the Halswell River and other streams on the
flats. The ground water is at 46–60 cm in the winter and
the soils are imperfectly drained and moderately gleyed in
the subsoil.

Kaiapoi silt loam (11):
covers 295 hectares on the relatively low levees to the
south of Halswell. A representative profile shows 23 cm
of friable dark greyish brown silt loam with moderately
developed nut structure, on 23 cm of firm greyish brown
massive fine sandy loam with many strong brown
mottles, on 30 cm of very friable grey medium sand, on
loose grey fine sand.

Kaiapoi sandy loam (11a):
covers 80 hectares on levees beside the stream in Lans-
downe Valley. It is similar to Kaiapoi silt loam except
that its topsoil texture is sandy loam.

Kaiapoi sand (11b):
covers 25 hectares on high levees of the Halswell River
south of Taitapu, and consists of fine sand topsoil and
medium and coarse sand subsoil.

YELLOW-BROWN SANDS
(voli-subfulvic soils)

These soils are formed on small strips of sand dunes in
the littoral zone of Lake Ellesmere.

Waikuku Series

Waikuku sand (12):
covers 445 hectares and is found on fixed sand dunes
formed in the littoral zone on the edge of Lake Elles-
mere. These mark the extent of the lake at different
periods in its history. The outermost line of dunes occurs
at about 5 m above mean sea level, the next line at 2 m,
and the third line, parallel to the present lake edge, also
at about 2 m. The dunes are low, most of them having
been levelled by floods and erosion, so that only minor
ridges are left (figure 7), and the dunes by the present
lake edge are almost completely covered by alluvium.
The outermost dunes on the 5 m ridge overlie peat,
indicating that the lake was probably of greater extent
than this. Older sand dune systems related to this older
lake level have, in the survey area, been flattened and
covered by recent sediments from the Waimakariri
system.

The soils have accumulated some organic matter, and
a representative profile shows 15 cm of friable brown
fine sand, on 30 cm of loose grey fine sand with some
iron staining, on loose grey fine sand.

ORGANIC SOILS
(platic soils)

These soils are formed on decomposed or partly de-
composed plant residues which occur in low-lying areas
where the ground water is high and there is little or no
deposition of alluvium.

Waimairi Series

Waimairi peaty loam (13):
covers 270 hectares and is found in depressions at the
foot of the hills, between the sand dunes, and alongside
the Halswell River. The textures vary from peat to peaty
loam, depending on the content of mineral matter. The
depth of peat overlying the mineral soil also varies from
30 cm to 1.5 m. A profile with some mineral matter in the
topsoil shows 30 cm of non-sticky black peaty loam, on
50 cm of very dark greyish brown peat, on firm massive
grey silt loam.

Drains have been dug through most of the peaty areas
which are slowly drying up, but those areas associated
with springs from the hills are still very wet.
EROSION

On north-facing moderately steep slopes below 270 m it is the fragipan overlying sandy loess that contributes most to the development of the characteristic tunnel-gully erosion of the loess (Gibbs 1945). The north-west wind is probably also an important factor, drying out the soils on the northern faces so that the joint systems in the fragipan open up, leaving wide gaps for water to move down during rain. The water, once it is underneath the impermeable fragipan, forms a channel in the easily-erodable sandy loess layer below, leaving a cap of the finer loess; eventually the finer loess of the fragipan is undermined and collapses, forming a gully. It has been observed that after rain the gullies have water flowing in them, while a few metres away on the crest of a side ridge between gullies, the moisture has penetrated only a few centimetres. Where water moves laterally over the moistened fragipan, on moderately steep slopes, much rill erosion occurs.

Local farmers blame the severity of the erosion on rabbits, which reached a density of 37 to the hectare in some valleys. Now that most of the rabbits have been destroyed the erosion scars are healing over and most of the gullies are covered with grass (figure 7). A comparison of aerial photographs taken in 1941 with more recent photographs shows an improvement in the situation.

The next commonest type of erosion is terracette creep, apparently caused by soil creep and the treading of animals. The terracettes are step-like ledges, sloping gently outward and running across the slope (figure 7). They are found on deep sediments on moderately steep slopes and are characteristic of the soils which do not have a fragipan, such as Cashmere soils on basaltic colluvium at lower elevations, and Rapaki soils at higher elevations. The gentler the slope, the wider the step. Once stabilised, these terracettes act as a protection against further erosion, as they distribute downward movement of water and soil.

Careful pasture management in maintaining a continuous sward is essential for protection against erosion on the Port Hills.

LAND USE

The survey area is adjacent to Christchurch City, and extensions of the city into the surrounding area are iminent.

The Town and Country Planning Act (1953.3(1)) was set up so that development of a region might proceed "by means of the classification of the lands . . . for the purpose for which they are best suited by nature or for which they can best be adapted. . .". Land should therefore be classified to show areas of relative importance for different uses, but in terms of the Town and Country Planning Regulations (1960. Regulation 16(2)) "all land of high actual or potential value for production of food [is] to be included in a rural zone". Land can be productive in other ways than agricultural, but those products should be obtained from land which is not of high value for food production. To meet the requirements of the Town and Country Planning Act stated above, the soils of the survey area have been classified to show the soils that are of high actual or potential value for food production, and the remainder have been classified on their suitability for urban uses.

The important soil criteria for food production are the permanent physical characteristics of the soil which cannot be changed. These include effective rooting depth, internal soil drainage and permeability of the subsoil, and soil texture; slope is also considered a permanent physical characteristic though this can be changed by terracing. Factors such as overall drainage, salinity, and droughtiness can be changed and do not influence the potential of the land for food production.

The important criteria for urban uses are slope and the stability of the underlying material in relation to soil moisture changes (Richards 1968). For the foundations of structures such as factories and highways, the volume changes and critical strength or resistance to deformation are most important, i.e., the consolidation or settlement under load. For housing the most important are the heave and settlement due to changes in soil moisture brought about by the ejection of the building (Richards op. cit.). The engineering performance of foundations for structures can be determined by separating areas of significantly different soil types and subsurface moisture conditions (Richards op. cit.). For example, the Takahe soils have impermeable pans in the subsoil which hold up water, and because of this they are not suitable for septic tanks.

The soils of the plains and valley floors are, in general, of high value for food production and at present are used for dairying, horticulture, and general cropping. The only exception in this area is Waikuku sand on the sand dunes, which is of low value for food production.

The soils of the rolling land and hills are of low value for food production and are classified according to their suitability for urban uses; the rolling and some of the hilly land is suitable for houses and small commercial buildings; the steep land and that hilly land which is susceptible to erosion are of very restricted suitability, or are unsuitable, for urban uses. Because of their steepness and erosion potential these soils should be set aside as recreation and soil and water conservation areas for the use of the people of Christchurch.
CLASSIFICATION OF SOILS FOR LAND USE

A Soils of high actual or potential value for food production

SOILS OF THE FLAT TO EASY ROLLING LAND, WITH SLIGHT OR NEG- LIGIBLE LIMITATIONS:
- Cashmere silt loam
- Cashmere-Takahe complex
- Summitch-Rapaki complex
- Rapaki-Summit complex
- Temuka silt loam
- Motukarara silt loam, strongly saline phase
- Motukarara silt loam, moderately saline phase
- Motukarara silt loam, weakly saline phase
- Motukarara silt loam, imperfectly drained and strongly saline phase
- Motukarara silt loam, imperfectly drained and moderately saline phase
- Motukarara silt loam, moderately well drained and weakly saline phase
- Motukarara sandy loam, moderately saline phase
- Motukarara sandy loam, imperfectly drained and moderately saline phase
- Motukarara sandy loam, imperfectly drained and weakly saline phase
- Motukarara sandy loam, moderately well drained and moderately saline phase
- Motukarara sandy loam, moderately well drained and weakly saline phase
- Motukarara sand, moderately saline phase
- Horotane silt loam
- Horotane silt loam, imperfectly drained phase
- Horotane silt loam, moderately well drained phase
- Horotane sandy loam
- Horotane sandy loam, imperfectly drained phase
- Taitapu silt loam
- Kaiapoi silt loam
- Kaiapoi sandy loam
- Kaiapoi sand
- Waimairi peaty loam

SOILS OF THE ROLLING AND HILLY LAND, WITH SLIGHT LIMITATIONS:
- Cashmere hill soils
- Cashmere-Takahe hill soils complex
- Summitch-Rapaki hill soils complex

B Soils of low value for food production, suitable for urban uses

SOILS OF THE FLAT TO EASY ROLLING LAND, WITH MODERATE LIMITATIONS (e.g., subsoil pans, rock outcrops):
- Takahe fine sandy loam
- Waikuku sand

C Soils of low value for food production and of restricted suitability for urban uses (suitable for houses and small commercial buildings)

SOILS OF THE ROLLING AND HILLY LAND:
- Takahe silt loam
- Summit silt loam
- Summit hill soils
- Rapaki clay loam
- Rapaki hill soils
- Takahe-Cashmere complex
- Takahe-Cashmere hill soils complex
- Rapaki-Summit hill soils complex

D Soils of low value for food production and of very restricted suitability for urban uses

SOILS WITH UNSTABLE UNDERLYING STRATA (TUNNEL GULLIES):
- Takahe hill soils

SOILS OF THE STEEP LAND:
- Evans steepland soils
- Stewart steepland soils

ACKNOWLEDGMENTS

The author wishes to thank Mr J. D. Raeside for discussions on field work and for constructive criticism of the manuscript, and Mr W. F. Rennie for producing the photographs, maps, and diagrams.

REFERENCES


### APPENDIX: Soil Profile Descriptions

The soil descriptions in the text, and in the Extended Legend to the map, are representative of the mapping units, whereas the following soil descriptions are records of profiles at specific sites. Specific profiles seldom coincide in all details with the representative profiles.

#### Takahē silt loam

<table>
<thead>
<tr>
<th>Location</th>
<th>Off Kennedy Bush Road, NZMS2 S84/4 969475</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>On rolling top of middle spur</td>
</tr>
<tr>
<td>Slope; aspect; altitude</td>
<td>5°; S; 198 m</td>
</tr>
<tr>
<td>Parent material</td>
<td>Loess from greywacke</td>
</tr>
<tr>
<td>Rainfall</td>
<td>635–760 mm</td>
</tr>
<tr>
<td>Drainage</td>
<td>Overall – imperfect</td>
</tr>
<tr>
<td>Present vegetation</td>
<td>Ryegrass, white and suckling clover</td>
</tr>
<tr>
<td>Native vegetation</td>
<td>Hard tussock</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
<th>Present vegetation</th>
<th>Native vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁</td>
<td>0–23</td>
<td>dark greyish brown (10YR 3/1) light silt loam; friable; weak fine nut structure; many faecal pellets in pore spaces,</td>
<td>Hard tussock</td>
</tr>
<tr>
<td>B₁</td>
<td>23–46</td>
<td>yellowish brown (10YR 5/4) silt loam; firm; massive; many fine distinct strong brown (7.5YR 5/6) mottles; many worm channels filled with faecal pellets; sharp boundary,</td>
<td></td>
</tr>
<tr>
<td>B₂</td>
<td>46–76</td>
<td>light olive brown (2.5Y 5/4) silt loam, heavier than above; very firm; massive; few vertical cracks; many fine prominent strong brown (7.5YR 5/6) mottles; diffuse boundary,</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>76–86</td>
<td>light olive brown (2.5Y 5/4) sandy loam; friable; massive; few vertical veins,</td>
<td></td>
</tr>
<tr>
<td>uB₁</td>
<td>86–117</td>
<td>light olive brown (2.5Y 5/4) loamy sand; very friable; massive; veins getting wider with depth,</td>
<td></td>
</tr>
<tr>
<td>uB₂</td>
<td>117+</td>
<td>olive brown (2.5Y 4/4) sandy loam to sand; firm; massive</td>
<td></td>
</tr>
</tbody>
</table>

**Classification**

- **Common name:** southern yellow-grey earth
- **Technical name:** weakly en-leached weakly gummate pallic soil

#### Takahē fine sandy loam

<table>
<thead>
<tr>
<th>Location</th>
<th>On crest of first rise in paddock on Kennedy Bush Road, 37 m S of track, NZMS2 S84/4 901475</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>Easy rolling top of lower spur</td>
</tr>
<tr>
<td>Slope; aspect; altitude</td>
<td>5°; S; 61 m</td>
</tr>
<tr>
<td>Parent material</td>
<td>Loess from greywacke</td>
</tr>
<tr>
<td>Rainfall</td>
<td>635–760 mm</td>
</tr>
<tr>
<td>Drainage</td>
<td>Overall – imperfect</td>
</tr>
<tr>
<td>Present vegetation</td>
<td>Pasture (ryegrass, white clover)</td>
</tr>
<tr>
<td>Native vegetation</td>
<td>Hard tussock</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
<th>Present vegetation</th>
<th>Native vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₂</td>
<td>0–8</td>
<td>very dark grey (10YR 3/1) fine sandy loam;</td>
<td></td>
</tr>
<tr>
<td>A₂₁</td>
<td>8–18</td>
<td>soft; weak fine nut structure around roots;</td>
<td></td>
</tr>
<tr>
<td>A₂₂</td>
<td>18–33</td>
<td>very dark greyish brown (10YR 3/2) fine</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>sandy loam; soft; roots common,</td>
<td></td>
</tr>
<tr>
<td>B₁</td>
<td>33–40</td>
<td>dark greyish brown (10YR 4/2) light silt loam;</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>slightly hard; massive; numerous small faecal</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>pellets and worm casts, yellowish brown (10YR 5/4) in colour; few roots,</td>
<td></td>
</tr>
<tr>
<td>B₂</td>
<td>40–64</td>
<td>yellowish brown (10YR 5/4) silt loam; hard;</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>massive; abundant fine distinct strong brown</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>(7.5YR 5/6) mottles; many pores and worm</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>channels filled with faecal pellets,</td>
<td></td>
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<tr>
<td> </td>
<td> </td>
<td>light olive brown (2.5Y 5/4) silt loam; very</td>
<td></td>
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<tr>
<td> </td>
<td> </td>
<td>hard; few narrow vertical cracks but massive</td>
<td></td>
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<tr>
<td> </td>
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<td>as a whole; breaks up into weak medium nuts;</td>
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</tr>
<tr>
<td> </td>
<td> </td>
<td>abundant fine distinct strong brown (7.5YR</td>
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<tr>
<td> </td>
<td> </td>
<td>5/6) mottles and few iron concretions; slight</td>
<td></td>
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<tr>
<td> </td>
<td> </td>
<td>gleying; thin clay skins, and organic matter</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>staining on faces and some ped; and lining</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>worm channels; few worm channels; few roots,</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>light olive brown (2.5Y 5/4) fine sandy loam;</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>firm to very firm (slightly moist); massive;</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>few fine distinct strong brown (7.5YR 5/6)</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>mottles; indistinct boundary,</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>light olive brown (2.5Y 5/4) fine sandy loam;</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>friable; massive; few blotchy coarse faint</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>strong brown (7.5YR 5/6) mottles,</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>light olive brown (2.5Y 5/4) fine loamy sand;</td>
<td></td>
</tr>
<tr>
<td> </td>
<td> </td>
<td>very friable.</td>
<td></td>
</tr>
</tbody>
</table>

**Classification**

- **Common name:** southern yellow-grey earth
- **Technical name:** weakly en-leached weakly gummate pallic soil

#### Notes

This site is representative of soils of the easy rolling tops of the lower spurs where there is a variable depth of colluvial material overlying the pan. Auger holes around the site give a depth of 20 cm to the pan on the crest, and lower down the slope 46 cm to the pan. This profile is average with 33 cm of material overlying the pan. The profile described in the Extended Legend is representative of the upper parts of the ridges.

#### Takahē hill soil

<table>
<thead>
<tr>
<th>Location</th>
<th>On side of first ridge on Kennedy Bush Road, NZMS2 S84/4 958-478</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>Moderately steep</td>
</tr>
<tr>
<td>Slope; aspect; altitude</td>
<td>19°; N; 60 m</td>
</tr>
<tr>
<td>Parent material</td>
<td>Loess colluvium on greywacke loess</td>
</tr>
</tbody>
</table>

---

*See Explanatory Notes 1–4 on Extended Legend.*
Rainfall

Drainage

Present vegetation

Native vegetation

Horizon Depth cm

A 0-15 dark greyish brown (10YR 4/2) sandy loam; friable; weakly developed fine nut structure; many faecal pellets, B 15-30 pale yellow (5Y 7/4) silt loam; firm; moderately developed blocky structure; few fine

rainfall

silt loam; very firm; massive or coarse columnar; many vertical joints; many medium distinct strong brown mottles; weakly net gammate,

slope

classification

Bx 30-68 light olive brown (2.5Y 5/4) silt loam; very hard; massive or coarse columnar; many vertical joints; many medium distinct strong brown mottles; weakly net gammate,

cx 68+ light olive brown (2.5Y 5/4) fine sandy loam; firm; massive (parent material loess).

classification

Notes

Common name: southern yellow-grey earth

Technical name: weakly to moderately enleached weakly gammate pallic soil

Cashmere silt loam

Location

On Summit Road 9 m upslope from road; 366 m N of Anderson's track, NZMS2 S84/4 946468

Topography

On rolling top of summit 183 m down from crest on convex hilly slope

Slope: aspect: altitude

12º; W; 503 m

Parent material

Mainly loess from greywacke but some basaltic material

Rainfall

1 020 mm

Drainage

Overall – well drained

Internal – medium

Horizon Depth cm

A 0-15 dark reddish brown (5YR 3/2) silt loam; friable; moderate fine nut structure; many

worn casts; many stones and gravel-sized pieces of basaltic material,

B 15-46 reddish brown (5YR 4/3) clay loam; friable; moderate fine nut structure; few worm casts; few pieces of basaltic material,

B 2 46-86 dark reddish brown (2.5Y 3/4) clay loam; friable; weak fine nut structure; few stones of basaltic material;

C 86+ basalt,

classification

Common name: southern brown granular loam

Technical name: weakly enleached prospadic soil

Notes

Common name: upland southern yellow-brown earth

Technical name: moderately to strongly enleached eluvic soil

Field test for allophane shows a medium reaction in the A horizon and a marked reaction in the other horizons. This site was chosen as likely to have the least influence by volcanic material but even in this one there are stones in the profile. The colour of the soil and its structure suggest that the soil is derived mostly from loess. Outcrops of tuff on the crest and a few stones and boulders on the surface.

Notes

Common name: southern brown granular loam

Technical name: weakly enleached prospadic soil

Cashmere silt loam

Reference symbol 3

Location

805 m S on the old Taitapu Road from junction with Provincial Highway 75, 18 m up drive, NZMS2 S84/4 946468

Topography

Rolling top of ridge

Slope: aspect: altitude

8º; N; 30 m

Parent material

Basaltic tuff on basalt

Rainfall

635–890 mm

Drainage

Overall – moderately well drained

Internal – medium

Horizon Depth cm

A 0-15 dark reddish brown (5YR 3/2) silt loam; friable; moderate fine nut structure; many

worn casts; many stones and gravel-sized pieces of basaltic material,

B 1 15-46 reddish brown (5YR 4/3) clay loam; friable; moderate fine nut structure; few worm casts; few pieces of basaltic material,

B 2 46-86 dark reddish brown (2.5Y 3/4) clay loam; friable; weak fine nut structure; few stones of basaltic material;

C 86+ basalt,

classification

Common name: southern brown granular loam

Technical name: weakly enleached prospadic soil

Notes

Common name: upland southern yellow-brown earth

Technical name: moderately to strongly enleached eluvic soil

Field test for allophane shows a medium reaction in the A horizon and a marked reaction in the other horizons. This site was chosen as likely to have the least influence by volcanic material but even in this one there are stones in the profile. The colour of the soil and its structure suggest that the soil is derived mostly from loess. Outcrops of tuff on the crest and a few stones and boulders on the surface.

Notes

Common name: southern brown granular loam

Technical name: weakly enleached prospadic soil

Cashmere silt loam

Reference symbol 3

Location

805 m S on the old Taitapu Road from junction with Provincial Highway 75, 18 m up drive, NZMS2 S84/4 946468

Topography

Rolling top of ridge

Slope: aspect: altitude

8º; N; 30 m

Parent material

Basaltic tuff on basalt

Rainfall

635–890 mm

Drainage

Overall – moderately well drained

Internal – medium

Horizon Depth cm

A 0-15 dark reddish brown (5YR 3/2) silt loam; friable; moderate fine nut structure; many

worn casts; many stones and gravel-sized pieces of basaltic material,

B 1 15-46 reddish brown (5YR 4/3) clay loam; friable; moderate fine nut structure; few worm casts; few pieces of basaltic material,

B 2 46-86 dark reddish brown (2.5Y 3/4) clay loam; friable; weak fine nut structure; few stones of basaltic material;

C 86+ basalt,

classification

Common name: southern brown granular loam

Technical name: weakly enleached prospadic soil

Notes

Common name: upland southern yellow-brown earth

Technical name: moderately to strongly enleached eluvic soil

Field test for allophane shows a medium reaction in the A horizon and a marked reaction in the other horizons. This site was chosen as likely to have the least influence by volcanic material but even in this one there are stones in the profile. The colour of the soil and its structure suggest that the soil is derived mostly from loess. Outcrops of tuff on the crest and a few stones and boulders on the surface.
**Evans steepland soil**

**Location**
On valley side above Otahuna, NZMS2 S84/4 982413

**Topography**
Steep slope

**Slope; aspect; altitude**
28°; S; 244 m

**Parent material**
Basaltic agglomerate

**Rainfall**
Overall -- excessive

**Drainage**
Internal -- medium

**Present vegetation**
Silver tussock, cocksfoot, clovers, and browntop

**Native vegetation**
Silver tussock

**Parent material**
Colluvium from basalt and basaltic tuff

**Drainage**
Overall -- excessive

**Horizon Depth cm**
A1 0-8
B1 8-25
B2 25-76
C 76+

**Classification**
Common name: southern brown granular loam
Technical name: moderately to strongly enleached elprospadic soil

**Stewart steepland soil**

**Location**
On upper valley side, 100 m down from Summit Road, NZMS2 S84/4 987417

**Topography**
Steep slope

**Slope; aspect; altitude**
28°; S; 380 m

**Parent material**
Colluvium from basalt and basaltic tuff

**Drainage**
Overall -- excessive

**Horizon Depth cm**
A1 0-13
B1 13-25
B2 25-38
C 38+

**Classification**
Common name: steepland soil

**Cashmere-Takahe complex: intergrade soil**

**Location**
Near airfield above Otahuna, NZMS2 S84/7 965390.

**Topography**
Rolling top of ridge

**Slope; aspect; altitude**
8°; SE; 270 m

**Parent material**
Colluvium from basalt and loess

**Rainfall**
Overall -- well drained

**Drainage**
Internal -- medium

**Present vegetation**
Ryegrass–white clover pasture

**Native vegetation**
Hard and silver tussock

**Classification**
Common name: intergrade between brown granular loams and yellow-grey earths

**Horizon Depth cm**
A1 0-23
B1 23-69
B2 69-92
C(D) 92+

**Classification**
Common name: intergrade between brown granular loams and yellow-grey earths

**Horizon Depth cm**
A 0-15
B1 15-30
B2 30-38

**Classification**
Common name: steepland soil related to southern brown granular loams

**Classification**
Technical name: moderately to strongly enleached elprospadic soil

**Horizon Depth cm**
A 0-15
B1 15-30
B2 30-38

**Classification**
Common name: steepland soil

**Classification**
Technical name: moderately to strongly enleached elprospadic soil
### Cashmere-Takahe hill soils complex: intergrade soil

**Location**
On side of ridge, Anderson’s farm, NZMS2 S84/4 972418

**Topography**
Moderately steep slope

**Slope; aspect; altitude**
14°; S; 213 m

**Parent material**
Colluvium of basalt and loess

**Rainfall**
Overall – well drained

**Drainage**
Internal – medium

**Present vegetation**
Silver tussock and pasture species

**Native vegetation**
Hard and silver tussock

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth cm</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_1</td>
<td>0-25</td>
<td>very dark greyish brown (10YR 3/2) silt loam; friable; moderate fine nut structure; few worm casts, dark basalt (10YR 3/3) silt loam; friable; moderate fine nut structure; few worm casts,</td>
</tr>
<tr>
<td>B_1</td>
<td>25-46</td>
<td>dark yellowish brown (10YR 4/4) gravelly silt loam; friable; weak fine nut structure; many stones of basaltic material,</td>
</tr>
<tr>
<td>B_2</td>
<td>46-60</td>
<td>dark yellowish brown (10YR 4/4) gravelly silt loam; friable; weak fine nut structure; many stones of basaltic material,</td>
</tr>
<tr>
<td>C</td>
<td>60-</td>
<td>Common name: intergrade between brown granular loams and yellow-grey earths Technical name: moderately enleached palli-prosodic soil</td>
</tr>
</tbody>
</table>

### Summit-Rapaki hill soils complex: intergrade soil

**Location**
On Summit Road, NZMS2 S84/4 992418

**Topography**
Moderately steep slope

**Slope; aspect; altitude**
14°; W; 490 m

**Parent material**
Colluvium of loess and a low but significant content of basaltic material

**Rainfall**
Overall – well drained

**Drainage**
Internal – rapid

**Present vegetation**
Silver tussock, bracken

**Native vegetation**
Silver tussock

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth cm</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_11</td>
<td>0-8</td>
<td>very dark greyish brown (10YR 3/2) silt loam; friable; moderate fine nut structure; abundant worm casts,</td>
</tr>
<tr>
<td>A_12</td>
<td>8-23</td>
<td>dark greyish brown (10YR 4/2) silt loam; friable; moderate fine nut structure; abundant very dark greyish brown (10YR 3/2) worm casts,</td>
</tr>
<tr>
<td>B_1</td>
<td>23-46</td>
<td>yellowish brown (10YR 5/6) silt loam; friable; weak fine nut structure; many very dark greyish brown (10YR 3/2) worm casts,</td>
</tr>
<tr>
<td>B_2</td>
<td>46-50</td>
<td>horizontal grey veins with strong brown (7.5YR 5/6) edges; few small pieces of basalt, fine loam; firm; fine loam;</td>
</tr>
<tr>
<td>C(Dr)</td>
<td>50-127+</td>
<td>Common name: intergrade between upland yellow-brown earths and brown granular loams Technical name: moderately enleached prosodic-ello-humic soil</td>
</tr>
</tbody>
</table>

### Rapaki–Summit hill soils complex: intergrade soil

**Location**
On Summit Road, NZMS2 S84/4 991428

**Topography**
Moderately steep slope

**Slope; aspect; altitude**
15°; S (shady); 460 m

**Parent material**
Colluvium of basalt and loess overlying loess

**Rainfall**
Overall – well drained

**Drainage**
Internal – rapid

**Present vegetation**
Silver tussock and pasture species (cocksfoot, ryegrass, clovers)

**Native vegetation**
Dicotylous–podocarp forest
**Motukarara silt loam, strongly saline phase**

Reference symbol 8

**Location**
800 m along Jarris Road from Ridge Road, 200 m N in paddock, NZMS2 S84/7 927329

**Topography**
Flat (in depression)

**Slope; aspect; altitude** —; —; 2 m

**Parent material**
Alluvium and lacustrine deposits from greywacke

**Rainfall**
635 mm

**Drainage**
Overall – poor

**Present vegetation**
Salt marsh vegetation: glasswort, glaucous goosefoot, salt grass, selliera

**Horon Depth cm**

<table>
<thead>
<tr>
<th>Horizon Depth</th>
<th>cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁</td>
<td>0-23</td>
</tr>
</tbody>
</table>

**Temuka silt loam**

Reference symbol 7

**Location**
400 m E of farm on Taitapu Back Road
400 m S of junction with Ward Road, NZMS2 S84/7 913392

**Topography**
Undulating, a slight ridge on flood plain, remnant of intermediate terrace of the Waimakariri River system

**Slope; aspect; altitude** —; —; 5.5 m

**Parent material**
Alluvium from reworked loess

**Rainfall**
635 mm

**Drainage**
Overall – poor

**Present vegetation**
Pasture species (ryegrass, timothy, browntop)

**Native vegetation**
Raupo swamp

**Horizon Depth cm**

<table>
<thead>
<tr>
<th>Horizon Depth</th>
<th>cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁</td>
<td>0-23</td>
</tr>
</tbody>
</table>

**Classification**

Common name: intergrade between brown granular loams and upland yellow-brown earths

Technical name: moderately to strongly enleached eluvial-prosodic soil

**Notes**

**Horotane silt loam**

Reference symbol 9

**Location**
Gebbies Valley 800 m N of Withelli Road and 400 m E of Gebbies Pass Road, NZMS2 S84/7 975340

**Topography**
In depression on valley floor

**Slope; aspect; altitude** 1°; —; 5 m

**Parent material**
Alluvium from reworked loess, basalt, and some greywacke

**Rainfall**
635–760 mm

**Drainage**
Overall – poor

**Present vegetation**
Pasture species (ryegrass, white clover)

**Native vegetation**
Raupo swamp

**Horizon Depth cm**

<table>
<thead>
<tr>
<th>Horizon Depth</th>
<th>cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁</td>
<td>0-23</td>
</tr>
</tbody>
</table>

**Classification**

Common name: grey soil

Technical name: hydrous weakly enleached madentine soil

All boundaries are diffuse.
BG 38-88 olive (5Y 5/3) heavy silt loam; very firm; massive; many strong brown (5YR 5/6) mottles; sharp boundary, grey (5Y 5/1) fine sand; single grained; friable.

**Classification**

Common name: gley recent soil
Technical name: hydrous very weakly enleached luvi-madenti-licic soil

### Taitapu silt loam

**Location**

600 m N of junction of Old Taitapu Road and Rhodes Road, NZMS2 S84/7 937417

**Topography**

Flat to gently undulating flood plain

**Slope; aspect; altitude** —; —; 7 m

**Parent material**

Alluvium from greywacke

**Rainfall**

635 mm

**Drainage**

Overall - poor

**Present vegetation**

Pasture (ryegrass, white clover)

Horizon Depth cm

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0-23</td>
</tr>
<tr>
<td>BG</td>
<td>23-53</td>
</tr>
<tr>
<td>C</td>
<td>53-68</td>
</tr>
<tr>
<td>D</td>
<td>68+</td>
</tr>
</tbody>
</table>

**Classification**

Common name: gley recent soil
Technical name: hydrous very weakly enleached luvi-madenti-licic soil

### Kaiapoi silt loam

**Location**

N of Taitapu on Old Taitapu Road 600 m S of Rhodes Road, NZMS2 S84/4 932408

**Topography**

Undulating

**Slope; aspect; altitude** —; —; 7 m

**Parent material**

Alluvium from greywacke

**Rainfall**

635 mm

**Drainage**

Overall - imperfect

**Present vegetation**

Pasture (ryegrass, white clover)

Horizon Depth cm

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0-23</td>
</tr>
<tr>
<td>B</td>
<td>23-46</td>
</tr>
<tr>
<td>BG</td>
<td>46-76</td>
</tr>
<tr>
<td>C</td>
<td>76+</td>
</tr>
</tbody>
</table>

**Classification**

Common name: gley recent soil
Technical name: hydrous very weakly enleached luvi-madenti-licic soil

### Waikuku sand

**Location**

600 m NW along Taitapu Back Road, 200 m north in middle of paddock, NZMS2 S84/7 922383

**Topography**

Undulating sand dune in littoral zone of Lake Ellesmere

**Slope; aspect; altitude** —; —; 6 m

**Parent material**

Aeolian sand

**Rainfall**

635 mm

**Drainage**

Overall - excessive

**Present vegetation**

Pasture species (browntop, timothy)

**Native vegetation**

Karamu, sand convolvulus

Horizon Depth cm

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0-15</td>
</tr>
<tr>
<td>B</td>
<td>15-46</td>
</tr>
<tr>
<td>C</td>
<td>46+</td>
</tr>
</tbody>
</table>

**Classification**

Common name: yellow-brown sand
Technical name: moderately to strongly enleached voli-subfulvic soil

### Waimairi peaty loam

**Location**

800 m E along Rhodes Road from junction with Old Taitapu Road, 9 m N of road, NZMS2 S84/4 944412

**Topography**

Depression

**Slope; aspect; altitude** —; —; 7 m

**Parent material**

Peat and alluvium

**Rainfall**

635 mm

**Drainage**

Overall - very poor

**Present vegetation**

Rushes and sedges

**Native vegetation**

Raupo, flax, toetoe

Horizon Depth cm

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0-30</td>
</tr>
<tr>
<td>A2</td>
<td>30-80</td>
</tr>
<tr>
<td>D</td>
<td>80+</td>
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</tbody>
</table>

**Classification**

Common name: organic soil
Technical name: hydrous moderately enleached luvi-platic soil
<table>
<thead>
<tr>
<th>reference symbol</th>
<th>soil name</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3H</td>
<td>Cashmere hill soils</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Cashmere series</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>Cashmere silt loam</td>
<td>16</td>
</tr>
<tr>
<td>3-1</td>
<td>Cashmere-Takahe complex</td>
<td>21</td>
</tr>
<tr>
<td>3H–1H</td>
<td>Cashmere-Takahe hill soils complex</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>Evans steepland soils</td>
<td>20</td>
</tr>
<tr>
<td>9c</td>
<td>Horotane sandy loam</td>
<td>26</td>
</tr>
<tr>
<td>9d</td>
<td>Horotane sandy loam, imperfectly drained phase</td>
<td>26</td>
</tr>
<tr>
<td>9h</td>
<td>Horotane silt loam, moderately well drained phase</td>
<td>26</td>
</tr>
<tr>
<td>11b</td>
<td>Kaiapoi sand</td>
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</tr>
<tr>
<td>11a</td>
<td>Kaiapoi sandy loam</td>
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<td>11</td>
<td>Kaiapoi silt loam</td>
<td>27</td>
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<td>81</td>
<td>Motukarara sand, moderately saline phase</td>
<td>26</td>
</tr>
<tr>
<td>8h</td>
<td>Motukarara sandy loam, imperfectly drained and moderately saline phase</td>
<td>26</td>
</tr>
<tr>
<td>8i</td>
<td>Motukarara sandy loam, imperfectly drained and weakly saline phase</td>
<td>26</td>
</tr>
<tr>
<td>8g</td>
<td>Motukarara sandy loam, moderately saline phase</td>
<td>25</td>
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<tr>
<td>8j</td>
<td>Motukarara sandy loam, moderately well drained and moderately saline phase</td>
<td>26</td>
</tr>
<tr>
<td>8k</td>
<td>Motukarara sandy loam, moderately well drained and weakly saline phase</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Motukarara series</td>
<td>24</td>
</tr>
<tr>
<td>8d</td>
<td>Motukarara silt loam, imperfectly drained and moderately saline phase</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Motukarara silt loam, imperfectly drained and strongly saline phase</td>
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<tr>
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<td>Motukarara silt loam, moderately saline phase</td>
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<td>Motukarara silt loam, moderately well drained and weakly saline phase</td>
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<tr>
<td></td>
<td>Motukarara silt loam, strongly saline phase</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Motukarara silt loam, weakly saline phase</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Rapaki clay loam</td>
<td>18</td>
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<tr>
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<td>Rapaki hill soils</td>
<td>19</td>
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<td>Rapaki series</td>
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<tr>
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<td>Rapaki–Summit complex</td>
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<td>Rapaki–Summit hill soils complex</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Stewart steepland soils</td>
<td>20</td>
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<tr>
<td></td>
<td>Summit hill soils</td>
<td>16</td>
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<tr>
<td></td>
<td>Summit–Rapaki complex</td>
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<td></td>
<td>Summit–Rapaki hill soils complex</td>
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<td>Summit silt loam</td>
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<td>Taitapu series</td>
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<td>Takahe–Cashmere complex</td>
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<tr>
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<td></td>
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SOILS INDEX

A. R. SHEARER, GOVERNMENT PRINTER, WELLINGTON, NEW ZEALAND—1974
Extended legend of soil map of part of the Port Hills and adjacent plains, Canterbury, New Zealand

Summary of soil and some agricultural properties of soil mapping units

To accompany

GRIFFITHS, I. 1990: Soil map of part of the Port Hills and adjacent plains, Canterbury, New Zealand. 1:25 000. (I.L. Ltd) Rakaia Sep 19..
Extended legend, Port Hills (continued)

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Sheet 2 of 4

Boots Hill

Rapaki, 1:50

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