Soil Survey of Part of the Wither Hills - Redwood Hills Area, Marlborough

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MARLBOROUGH DISTRICT COUNCIL

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Executive Summary

A soil survey of approximately 1600 ha of land in the Wither Hills-Redwood Pass area has shown that the tunnel gully erodable Wither and Vernon soils from loessial material cover about 45% of the area, somewhat less than is shown on previously published soil maps. Waihopai soils from Marlborough Conglomerate, which are subject to slip erosion on steep slopes occupy approximately 52% and are more extensive than previously shown, while Sedgemere soils from loess on undulating old terrace land cover approximately 3%. A small area of Tahunanui soils from windblown sand is also present. Approximately 50% of the area has steepland soils (slopes 26º-35º) and 47% hill soils (16º-25º).

The soils are extremely variable with Wither and Vernon soils from loess and Waihopai soils from conglomerate often merging to each other over very short distances. The loessial soils more commonly occur on easier slopes that are sheltered from westerly winds. Soliflucted clasts in the loess, vesicular structure in the fragic horizon and ventiformed clasts on ridges indicate that at the time of loess deposition, the climate was probably very cold, arid and very windy. The depositional sequence for the materials that lie above the Marlborough Conglomerate is correlated with changing conditions from the time of the Last Glacial Stage onset.

In the 1970's extensive remedial gully infilling of severely eroded areas was carried out, but tunnel gully and sheet erosion in these areas are continuing as well as in the unmodified previously eroded areas. There is little sign of soil instability on flat to gently undulating loess-covered land but with increasing slope, soil dispersion and shallow gulling was observed on slopes greater than 12º. Deep gully erosion is continuing on the steep upper slopes of some catchments. Initiation of the tunnel gully erosion in the Wither Hills-Redwood pass area may have been triggered in part by ground fracturing in the 1848 Awatere Valley and 1855 Wairarapa earthquakes when widespread land-slides in the area were reported.

Some sediments originating from the past widespread erosion have accumulated on gully floors but vast amounts have probably been lost as suspended sediment and transported into waterways on the plains. Climate change is likely to result in more extreme weather conditions with an increased risk of sediment loss and debris flows in some gullies, but improved sediment retention structures could minimise the off-site risks.

Soils from Marlborough Conglomerate on easy sloping land show little sign of instability and are suited for building sites. Easy sloping land with Vernon or Wither soils may also be suitable, provided the dispersible soil materials are removed and the building platform is on underlying gravels, however, detailed soil/geotechnical inspections and adequate provision for runoff waters should be required for all sites.

Contents

1. Introduction

The Wither Hills on the south side of the Wairau Plain, along with land of similar physical characteristics further to the east in vicinity of Redwood Pass Road, forms part of a block of terrain with a strongly dissected landscape. To the west, the hills have a more or less radial ridge pattern centred on Mt Vernon in the Wither Hills and a linear ridge system further east in the Redwood Pass area (Fig. 1).

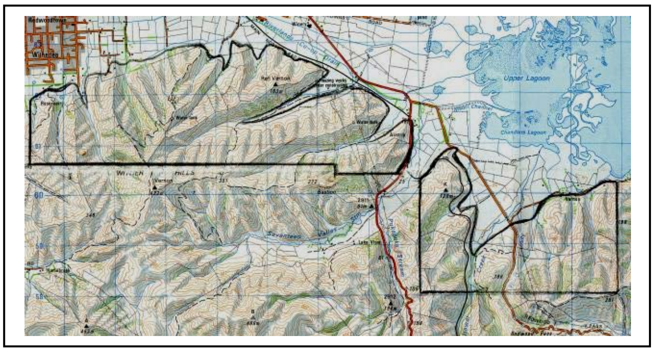

Figure 1. Location of the soil survey area, outlined in black.

Like much of New Zealand, Blenheim's urban growth has largely been at the cost of ongoing loss of productive land. Urbanisation of land immediately adjacent to the Wither and Redwood Hills has occurred slowly due to issues around land instability, associated with the extensive tunnel gully erosion that commenced in adjacent hills in the late 1800's. Increasingly however, elevated building sites with views are becoming sought after largely for aesthetic reasons. Extending urban growth onto the foot slopes and hills, while helping to satisfy the desire for elevated building sites would, more importantly, help conserve land of higher productive value.

The proximity of an area of land with known erosion potential immediately adjacent to significant urban development raises the question as to the degree of hazard presented in the event of extreme weather events that might result from climate change or from severe tectonic events. At the request of the Marlborough District Council, a survey of the soils of the Wither Hills-Redwood Pass area was undertaken between June and September 2010. The purpose was to provide a more detailed assessment of the soils and their distribution than was available from previously published work, to review the potential for erosion and the risks for urban expansion in these and adjacent areas and to consider what action might be required in the event of any increased urban development.

2. Topography

The area examined in the survey covers approximately 1600 ha of hilly and steep land south of Blenheim extending from Mt Vernon eastward to near Vernon Station (Fig. 1). Valley floors and flat lands (undifferentiated soils) on the plains bordering the hills were not investigated.

The overall landscape pattern resembles that commonly described as fine-textured dissection (Fig. 2) with the principal valleys having a closely spaced system of sub-parallel, regularly spaced minor gullies and spurs that extend from the valley bottoms to the nearby ridge tops. This valley and gully system is in most places asymmetric with one side of the valley or gully commonly being more steeply sloping than the other (Fig. 3). In some valleys, the fine-textured dissection pattern is best developed on the south or east facing slopes with the north or west facing slopes having a somewhat broader dissection pattern. This suggests that there may be a long-term climatic influence on the development of the topography. Many of the valleys and gullies are straight-sided and merge upslope to rounded ridges, but lower slopes are sometimes over steepened and appear to mark a more recent phase of down-cutting.

In several places adjacent to the Wairau Plain, the slopes are steep and rise abruptly, probably due to trimming by marine erosion during the Holocene period when the sea extended into the Wairau Valley. While overall, the topography and dissection pattern is far from uniform, in many places slopes generally increase in steepness with distance up the valleys but become less steep in the heads of the valleys. The ridges at first rise abruptly from the Wairau Plain but then continue as long, narrow, gently sloping rounded surfaces (Fig. 2). Valleys are predominantly V shaped in their upper reaches and are un-terraced with narrow bottoms but flare to about 0.5 km wide towards the valley entrances with fan shaped configurations. The lower slopes of spurs separating the gullies in the main valleys commonly have steep slopes with faceted surfaces (Fig. 4) that may have formed in response to later valley downcutting. In the Redwood Pass area, lower elevation undulating land is part of an earlier (Pleistocene) terrace system.

Figure 2. **Typical fine-textured dissection pattern of regularly spaced ridges and gullies. The southeast facing side is commonly more steeply sloping than the northeast facing side. The ridges and spurs are easy to moderately sloping but increase in steepness near the valley floor.**

Figure 3. A common pattern of asymmetric gullies with eroded Wither and Vernon soils on one side and Waihopai soils on the other side and on the ridges.

Figure 4. Fine-textured dissection with the ends of the spurs between the gullies over-steepened, either by valley downcutting or possibly by faulting.

3. Geology

The Wither Hills and Redwood Hills are formed from Late Tertiary gravels referred to as Great Marlborough Conglomerate (Thomson 1913, Lensen 1962, Suggate *et al*. 1978) or Wairau Conglomerate by Branch and Dagger (1934). These deposits comprise well-rounded gravels, locally with large subangular blocks, interbedded with sandstone and siltstone beds. The basal beds are considered to be marine Tertiary and grade upwards in the survey area into non-marine poorly to well sorted (predominantly greywacke) gravel with clasts ranging upwards to >60 cm. Lithologically, the gravels are moderately consolidated but lack the extensive alteration and clay cementing typical of the old Moutere Gravel Formation found in the Nelson region. However, in exposed sections, coarser clasts are commonly fractured, sometimes with oxide coatings, while some clay infilling between clasts is at times present suggesting that there may have been some prior and deeper weathering.

In a few places, the conglomerate is cemented and was found on ridges as hard outcrops. In a number of places towards the heads of the valleys there is deep downcutting in comparatively weakly consolidated gravels and slip erosion is extensive. Occasionally, evidence of significant erosion and re-deposition of gravel within the valley systems was noted (Fig 5).

Throughout the survey area, the imprint on the landforms of Quaternary climate cycles related to past glacial periods is somewhat meagre. Although traces of previous gully filling deposits from earlier erosional episodes remain in some gullies (Fig. 6), the absence of older landscape related depositional sequences suggest that downcutting and landscape rejuvenation have been active through the Quaternary and Late Quaternary times up until the loessial materials were deposited.

Figure 5. Valley head downcutting in older redeposited gravel materials. The layer of coarse gravels are an indication of earlier active erosion and local scree type aggradation. Waihopai soils are on the steep slopes.

Figure 6. Waihopai hill and steepland soils in a valley head with patches of Vernon soils on the upper eroding slopes. The lower slopes with slip and gully erosion are Waihopai steepland soils on reworked gravels.

4. Vegetation and Climate

There is little reliable information about the original vegetation cover of the Wither Hills/Redwood Hills area but it is believed to have been coastal hardwood forest prior to Polynesian settlement

(Holloway 1959). The forest was thought to have been destroyed well before European settlement and was probably replaced with tussock grassland on drier slopes and scrub on shaded faces. An early map of the Wairau district showed the Wither Hills as "high grassy range' and a photograph taken in 1850 showed a complete cover of dominantly tussock grassland. The present vegetation is dominated by grasses, weeds and mosses with scrub (broom, manuka etc) common on shaded faces and patches of Pinus radiata that have been planted for erosion control.

The main climatic characteristic of the area is its dryness, with frequent summer droughts accentuated by dry north-westerly winds. The climate is continental in character with warm dry summers and cool winters. Rainfall, measured from the Wither Hills Meteorological Station (1949-1980) is around 660mm a year (NZ Met Service Publication 1983) similar to that at Cape Campbell (640mm 1873-1980). Although severe rainfalls between 1949 and 1980 were relatively rare (Pascoe 1983), the maximum two-day rainfall recorded at Wither Hills was 121mm with an excess of 100mm over two days being recorded in several months. At Cape Campbell, the maximum two day rainfall recorded was 244mm, with three months of the year having maximum rainfalls of greater than 200mm over two days and ten months of the year in which rainfalls greater than 100mm over two days have been recorded (NZ Met Service 1980). The average daily maximum temperature recorded for Wither Hills was 18.2°C and the average daily minimum temperature was 7.5°C.

5. Previous Soil Investigations

Gibbs and Beggs (1953) first mapped soils in this district at a scale of 1:250,000 of what was then Awatere, Kaikoura and part Marlborough Counties. In the Wither Hills-Redwood Pass area, this survey differentiated Wither silt loam rolling, Wither silt loam hill soils, Wither shallow silt loam hill soils, Sedgemere silt loam on undulating easy rolling lower lying land and Waihopai stony sandy loam on the steeply sloping hills of the conglomerate.

A study of erosion on about 1450 ha of the Wither Hills, where the soil type was said to be dominantly Wither silt loam, was undertaken by Gibbs (1945) who concluded that 21% of the area studied was moderately eroded, 42% was severely eroded and 37% was extremely eroded. Gibbs noted that in the worst area, gullies were less than 5 m apart with 55 channels over a 400 m distance.

The 1:250 000 soil map of the South Island (Soil Bureau Staff 1968) separated only Wither hill soils, Waihopai steepland soils and a small area of Sedgemere soils with little difference in the distribution of the soils from that shown by Gibbs and Beggs (1953). A more recent investigation with a brief examination of the soils on a small area of hilly foothill land east of Taylor Pass Road and immediately south of Blenheim and was carried out by Vincent (1992). This report identified Wither hill soils and Vernon hill soils (Laffan 1973) as the main soils of the area. It separated several landscape units including hillsides, foot slopes and toe slopes as well as valley floor, alluvial fan and alluvial terraces on the lower lying land.

The most comprehensive soil investigation within the area was undertaken by Laffan (1973) and Laffan & Cutler (1977a, 1977b). This involved a detailed study of a small catchment (82 ha) situated southeast of Wither Road, to the south of Blenheim. Three soils were identified in this study; Wither series on thick loess and loess colluvium and Waihopai series on greywacke conglomerate with discontinuous thin loess. The third series, Vernon soils, encompassed the soils on colluvium consisting of a mixture of loess and conglomerate and is probably the equivalent of Wither shallow silt loam hill soils separated by Gibbs and Beggs (1953). Within the Wither and Vernon soil materials, various layers were identified by Laffan as ground surfaces (K1 to K7) representing separate periods of soil formation and erosion and deposition. The lower layers were thought to belong to the Waimean glacial period (second last major glacial period dating prior to 120K yrs) and possibly the even older Waimaungan Glacial period (>240K yrs), while the upper soil layers were considered to date from the Early Holocene (<12,000 yrs).

Tunnel gully erosion was identified by as being most severe on Wither soils and on some slopes with Vernon soils but varied according to slope position and aspect (Laffan 1973). Slight to moderate slip erosion was found in upper and steep backslopes in Waihopai soils and deep gully erosion along major drainage channels. In comparing 1947 and 1969 aerial photographs of the Wither Hills, there was no appreciable increase in the extent of erosion although active downcutting was still occurring and extensive sedimentation in debris traps was taking place.

6. Survey Methods and Observations

The soils in the Wither Hills-Redwood Pass area were investigated over a four-month period between June and September 2010. Examinations were made along transects that were aligned along the sides of the valleys, typically commencing at a lower elevation near the valley mouth and rising in elevation to reach the valley heads and ridge tops. Some shorter direct up-slope transects were also made between the valley bottom and the ridge above. Soil examinations were made from the numerous sections and exposures formed as a consequence of the erosion and also through auger observations. In addition, exposures in some existing tracks were used to provide information on the continuing spatial variability of the soils.

More than 470 observations (1:3.4 ha) were recorded and these included; identification of the soil series, the observation location, altitude, slope angle and aspect; the landform type (i.e. footslope, lower, mid, upper, crest, spur); the slope length; the nature of the soil materials; extent of site erosion; type of site erosion and depth of gully. Observations that were made along transects were typically at a site that was representative of a landform unit or near where the land surface changed. The primary aim of the soil examinations was to identify the soil series encountered, which are well known from previous work, hence the soil data recorded generally only included brief description of the horizon sequences, soil colours, textures, mottles and stone presence. In addition to the recorded observations, about 1600 photographs of the soils in sections, the auger borings and various landscapes were made for later reference.

In the field, the observation sites were plotted on 1:5,000 landsat photo field sheets and the soil boundaries sketched in and finalised later after subsequent examination of the photographic images. It is customary in soil mapping to distinguish where possible the soils occupying differing land-slope classes, since increased slope is usually accompanied by increased erosion risk and difficulty of land management. Soils on land with slopes between 16°-20° are designated downlands strongly rolling hill country, those on slopes from 21°-25° are separated as moderately steep hill country and those on slopes of 26° and greater are separated as steep hill country (Lynn *et al*. 2009). The hill and steepland soil separations shown on the accompanying map, are based on the slope measurements made at the observation sites together with visual slope assessment of the surrounding terrain. In many instances, it was found that the slope measurements were close to the 25°-26° hill/steepland boundary hence the hill and steepland soil separations shown on the map are estimates only.

7. Survey Results

7.1. Soils Present and Distribution Pattern

The soils that were identified and their distribution within the survey area are shown on the accompanying map (Appendix A). The predominant soils are Waihopai soils (850 ha), Vernon soils (482 ha) and Wither soils (224 ha) on the hilly and steep terrain with Sedgemere soils (42 ha) on lower elevation dissected Pleistocene terrace land and a small area of Tahunanui soils (4 ha) on recent sand dunes at the border of the Wairau Plain and the Wither Hills.

The distribution pattern is similar to that of Laffan (1973) who, within the 82 ha catchment that he studied, found that Waihopai soils occupied approximately 40% of the area, Vernon soils approximately 25% of the area and Wither soils approximately 35%. These figures are based on including the first named soil in a compound map unit with the area of that class.

As indicated by the soil map, the soil pattern and distribution of the main soil types is much more complicated than was shown by the earlier more general surveys and more closely resembles the pattern shown by Laffan (1973). There is a high degree of soil variability within the landscape with the three main soil types grading into each other, often over just a few metres as the land surface changes. As will be discussed later, it is likely that the general soil pattern is strongly influenced by the processes involved in loess deposition and the conditions that prevailed during those times.

7.2. Waihopai Soils

Waihopai soils are formed from the gravelly conglomerate materials and occur on many of the lower elevation hilly and steep northerly facing slopes adjacent to the Wairau Plain, where there may have been minimal loess deposition owing to exposure from strong winds. They are also extensive on higher elevation more southerly and easterly surfaces and ridges where there was probably little or no loess deposited. They cover approximately 52% of the area mapped. In places where the fine-textured landscape dissection is more pronounced, Waihopai soils typically occur on one side of a gully with Wither soils and/or Vernon soils on the other side (Fig 3). Many of these gullies have a southerly aspect with predominantly steep slopes, often with scrubland vegetation. The spurs and ridgetops that separate the valleys and gullies are generally narrow and easy to moderately sloping (Waihopai/Waihopai hill soils) with rounded surfaces.

Waihopai soils (Figs 7-15) are shallow, the average depth of fine material over gravel being 10cm while surface boulders are common, on both steep slopes and ridgetops. However, in 35% of the recorded observations, the depth to stony gravel was deeper with a silt loam topsoil and subsoil overlying gravel at between 25 to 70cm. These silt loam textured moderately deep soils are probably formed on a thin cover of loess overlying the gravel. In places, undisturbed substrate gravels lie close to the surface, while elsewhere there is a deeper weathering zone before the soils pass into the *in situ* conglomerate. In both cases however, some soil weathering extends into the conglomerate.

On some lower slopes, concentrations of runoff waters gives rise to soils with grey subsoil colours and reducing conditions, at times with a weak iron pan that forms a shear plane, along which shallow slipping may occur.

In exposed sections, clasts may have a thin iron oxide coating while some fractured greywacke clasts have iron oxide coatings along the fracture faces. These weathering features are probably in part relict and may relate to earlier weathering conditions.

7.3. Erosion and Instability in Waihopai Soils

Overall, the landscapes on which Waihopai soils occur are relatively stable having evolved through ongoing cycles of erosion throughout the Quaternary period. However, the absence of deep weathering and altered or weathered clasts or ghosts (completely disaggregated clasts within the soil) suggests that the land surfaces are relatively young, probably undergoing rejuvenation during cold climate cycles.

Slip erosion is the most common form of instability in Waihopai soils occurring on almost any part of the slope (Figs. 16 & 17), apart that is from the easy sloping rounded ridges and spurs, but most commonly on the steep lower slopes. The slips are initiated at times of heavy rainfall when the saturated soil slides on a bedding plane formed by the underlying consolidated conglomerate. Finer beds within the conglomerate that restrict the downward flow of water also facilitate the process of slip erosion. Where a thin loess cover is present on steeper slopes, shallow gullying may occur. Sheet erosion may also occur especially on steep dry sunny faces (Fig. 19). Previous earthquake activity may also have triggered slip erosion resulting in many of the slip scars that are present.

There is little evidence of mass instability such as deep-seated slumping or large-scale debris flows, although one area was noted where some mass movement might possibly have occurred (Fig. 18). In a few places, layers of coarse gravel are present in valley head slope deposits suggesting that in earlier Quaternary time, extensive removal and gravel re-deposition may have taken place (Figs 5 & 6). Deep gully erosion (Figs 20 & 21), however, is not uncommon and occurs mostly on steeply sloping land in the upper reaches of the valleys and tributary gullies. The gullying may be facilitated by the presence of less coherent rock units within the conglomerate, but appears also in part to take place in reworked gravels that have been re-deposited in the valley heads.

Figure 7. Waihopai hill soil with a brown to dark brown A horizon over yellowish brown B horizon, passing into a BC horizon of brownish yellow *in situ* consolidated gravel.

Figure 8. Waihopai hill soil with a thin (25 cm) loess cover and a yellowish brown B Horizon passing into olive brown *in situ* gravel at 100 cm.

Figure 9. Shallow Waihopai soil on a ridge with *in situ* gravel <25 cm from the surface. Clasts have surface oxide staining with a clayey matrix from earlier weathering.

Figure 10. Clasts in the conglomerate are frequently fractured through *in situ* weathering processes.

Figure 11. Waihopai steepland soil formed from consolidated and partly cemented conglomerate.

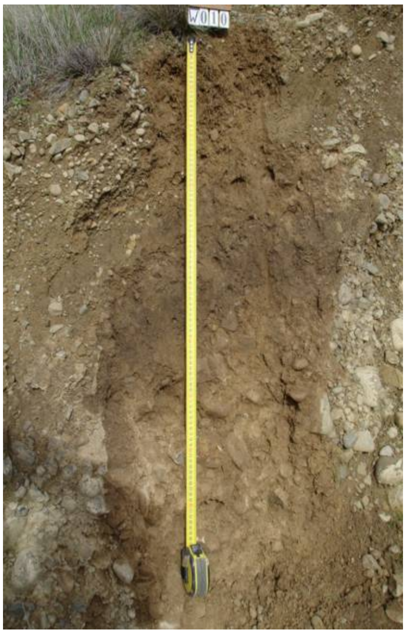

Figure 12. Waihopai steepland soil formed from re-worked material in weakly consolidated gravel. A paleosol with a distinct buried A horizon is present below 30 cm.

Figure 13. Waihopai hill soil on a lower slope from mixed reworked materials.

Figure 14. Waihopai hill soil on a lower slope with subsoil grey colours indicating drainage impedance. Reworked material lies over *in situ* firm saturated gravel on which a slip has occurred.