6. LAND CAPABILITY CLASSES ON THE FORTH MAP

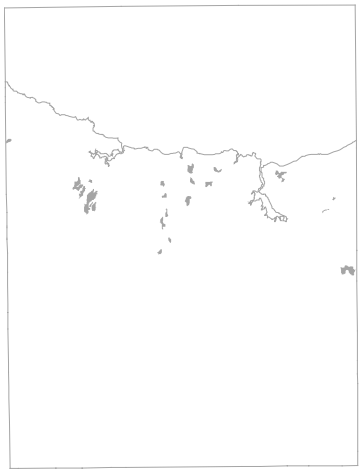
The following sections of this report describe the different classes of land that have been identified during the course of the survey. General information on the nature of the land, soil type and geology are given together with an assessment of the major limiting factor and any other information that is considered relevant.

In undertaking the field mapping considerable reliance has been placed on the available geological information and soil boundaries in the adjacent forestry areas (Hill, 1995), together with slope class maps derived from a digital elevation model using 10 m contour interval data.

Throughout the text references are made to subclass codes. While sub-classes do not appear on the map they are used in the text to give the reader further information relating to the nature of limitations in some areas. Also, for each class of land a simple diagram is presented indicating the distribution of that land class across the map together with the hectares each occupies. These figures include areas of complex map units. When determining the extent of a particular land class it should be remembered that these complexes represent a ratio of the two land classes identified in the range 60-40 to 50-50 (ie Class 4+5 represents an area of 50-60% Class 4 land plus 40-50% Class 5 land).

6.1 CLASS 1 LAND

Class 1	734 ha
Class1+2	178 ha
Class2+1	98 ha



Class 1 land on the area is found only on Tertiary basalt parent materials and only where the soils are freely draining and stone free, the land almost level and the climate suitable for a wide range of crops and with virtually a year round growing season. Despite being the best land in the State some care is still needed to prevent structural decline, erosion or other degradation.

Class 1 Land on Tertiary Basalt

Several small and scattered areas of Class 1 land on soils derived from basalt parent materials have been mapped in the Forth survey area, most of which are to be found within 20km of the coast and below 180m elevation. The main areas occur on the Tertiary lava flows in the Kindred, North Motton, Gawler and West Penguin areas while smaller areas are to be found at Forth, Sassafras, East and West Devonport.

Photo 6. Complex of Class 1+2 on very gently inclined basalt soils (GR E455500, N5429800).

Photo 7. Class 2 land on basalt is suitable for intensive agricultural production (GR E434425, N5433250).

The iron-rich red soils, known as Ferrosols (formerly krasnozems) have developed from basaltic parent materials extruded through fissures in the earths crust some 30 million years ago. The soils are typically, deep, freely draining, have a well developed structure and are stone free. Soil depths are typically greater than one metre and always more than 80cm. These soils occur on broad level to very gently sloping (<5%) ridge crests where natural erosion (as opposed to accelerated or man induced erosion) is virtually nil. The free draining nature and robust structure of the soils make them easy to cultivate at a wide range of moisture contents. Topsoil organic matter is high in these soils and levels need to be maintained to help preserve soil structure stability. Also, organic matter in the soil can help to retain essential nutrients such as calcium, potassium, nitrogen and phosphorous, many of which are supplied to the soil through expensive fertiliser applications.

Despite the high quality of the basalt soils, Class 1 land on Tertiary basalt is still subject to degradation from sheet and rill erosion and structural decline if preventative management techniques are not implemented (Chilvers 1996). The major limiting factor on these soils is the risk of erosion (e), particularly when the crop grown requires a fine seed bed, such as onions or carrots. In places where very flat land (<1%) occurs the erosion risk is greatly reduced. Other limitations include the risk of structural degradation (s) if the soils are not managed properly ensuring at least one year of pasture in ten, or equivalent green manuring, or where trafficking occurs when soils are at field capacity.

With the proximity to the coast and the lower elevations, frosts are generally confined to winter months and the risk of out of season frosts that could cause significant damage to young crops is not great. While summer rainfall is low, moisture deficits during the growing season can be overcome by using on-farm water supplies for irrigation. A full range of crops can be grown throughout the summer with brassicas planted during the autumn or early winter.

Complexes

Small areas of Class 1 land are found complexed with Class 2 land where irregular topography occurs in conjunction with more even, gently sloping land. Slopes range between 0% and 12% in a pattern which cannot be resolved at this scale of survey.

6.2 CLASS 2 LAND

Class 2	6506 ha
Class 2+1	98 ha
Class 1+2	178 ha
Class 2+3	382 ha
Class 3+2	710 ha

Like Class 1, Class 2 land only occurs on basalt parent materials. The major limitation for this land class is the increased risk of erosion (e) on slopes above 5%. Climate (c), particularly frost risk, is also considered a limitation as land elevations rise above 170 m.

Class 2 Land on Tertiary Basalt

Extensive areas of Class 2 land on basalt occur at East Devonport, Wesley Vale, Sassafrass, Barrington, Kindred, Gawler, North Motton and West Penguin. It occurs on gently sloping land or undulating hills with gradients up to 12%, or on flatter land where soils are shallower (60-80 cm), or sufficient stones or rocks are present to affect cultivation, yields or crop quality. In some areas, Class 2 land is mapped as a complex with Classes 1 or 3. This usually occurs where there is significant variation in the slope and or soil drainage pattern which cannot be separated at the scale of mapping.

The basalt soils are similar to those described for Class 1 land. However, shallower soils or slightly increased stone content will reduce yields or make cultivation or harvesting slightly more difficult. Class two land with steeper gradients will require more intensive management and care to protect the soils from erosion than for Class 1 land. Creation of a fine seed bed should not be undertaken without appropriate conservation measures as the basalt soils can be easily eroded in this state. Erosion control measures are of particular importance where long slopes greater than 50 m occur. As well, compaction by heavy machinery can lead to degraded soil structure resulting in reduced infiltration, increased runoff and erosion, and reduced yields. Generally the range of crops that can be grown on Class 2 is similar to that of Class 1 but a higher level of management is required to prevent degradation or yields may be slightly reduced. In most areas climate is suitable for several crops a year including winter brassicas. Minor climatic limitations may occur between 170-270 m.

Complexes

Class 2 land is mapped as a complex with both Classes 1 and 3. Small areas occur in association with Class 1 land where slopes range between 0% and 12% in a complex pattern. Similarly, Class 2 land occurs in association with Class 3 where gradients range between 5% and 18%.

6.3 CLASS 3 LAND

Class 3	14375 ha
Class 3+2	710 ha
Class 2+3	382 ha
Class 3+4	1205 ha
Class 4+3	2060 ha

Land classified as Class 3 occurs predominantly on Tertiary basalt parent materials but other small areas have been identified on Permian and Tertiary sediments and recent alluvium. Some Class 3 land is identified on older, Cambrian basalts. Dominant limitations for agriculture include climate, particularly increased frost risk and a shorter growing season, erosion and stoniness.

Class 3 Land on Tertiary Basalt

This land is often located further inland and at higher elevations than Class 1 and 2 land. Areas of Class 3 land on basalt are found at Weegena, Sheffield, Barrington, Sprent and Preston and Abbotsham. These areas represent rolling basalt hill country on gradients up to 18% and consequently more intensive management is required to control soil erosion. In some places the soil lies wet for long periods of time (s limitation). This may preclude the growing of certain crops, thereby reducing the versatility of the land, or increase the risk of damage to the soil during cultivation or harvest.

While the soils in these areas are still considered to be Ferrosols they are more variable than those found in areas of Classes 1 and 2. Much Class 3 land on basalt is found at the margins of larger basalt flows or on colluvial slopes of basaltic material below the main basalt ridge. In such areas the soils are often thinner and more stony than on better land classes. Stony Ferrosols in particular are more common inland than nearer the coast and the amount and size of stone can hinder cultivation or affect yields or crop quality. In some areas, the Class 3 land receives substantial run-on of water from upslope areas. This can impact significantly on the timing of cultivation and harvest activities and potentially reduce the length of growing season. Such areas can often be identified by soils which are browner or blacker in colour, reflecting poorer site drainage than where the redder soils occur.

Some class 3 land is identified above 270 m and crop versatility is considered to be significantly limited by frost risk and a shorter growing season (c limitation). These areas often coincide with more exposed situations or areas that receive cold air drainage from surrounding higher elevations. The risk of damaging out of season frosts is considerable and potential crops are limited to those with greater frost tolerance and shorter rotations. Even the practice of growing winter brassicas may be severely restricted in areas of Class 3 land.

The occurrence of frost hollows and the risk of out of season frosts is determined to some extent by topography and local microclimatic conditions most of which lie beyond the scope of this report to determine. For the purpose of this survey elevation is used as a surrogate for frost risk and a height of about 270 m is generally considered to be the cut-off between Class 2 and 3 land.

Other Class 3 Land

Included in this section are a group of soils which occur at the margins of the basalt flows, including thin layers of basalt colluvium mixed with other soil materials, creating a complex soil pattern. The soils are not true Ferrosols and cannot withstand the intensity of cropping that areas of Class 1 and 2 will support. These areas are limited by inferior soil structure, reduced soil depth or increased stone content. Also, they are not as free draining as other Ferrosols and are often browner or blacker in colour.

Other Class 3 land is found on Permian and Tertiary sediments, recent alluvium and Cambrian Spilites and Keratophyres. These areas occur at Gunns Plains, North Motton, Lower Beulah, Sheffield and north of Kimberley. Class 3 land on Permian and Tertiary sediments, and on the Quaternary alluvium, generally occurs on level to very gently sloping land. Major limitations include minor drainage limitations, moderate structural stability or moderate stoniness, (all s limitations). Soils developed on Permian parent materials have typically loamy textured top soils with heavier, but well structured, subsoils. Unlike other soils on Permian rocks, these soils show little inclination to slaking or dispersion, suggesting a relatively stable soil structure.

Soils developed on Tertiary sediments and recent alluvium have a loamy to sandy loam surface structure and may become slightly heavier with depth. While the soil structure is relatively weak the coarse textures make for a freely draining soil suitable for intensive broad acre agriculture. The major limitation to agricultural production in these areas is the risk of soil erosion on even gently sloping country, and compaction from tillage implements.

The Cambrian spilites and keratophyres weather to produce soils similar to Ferrosols. However, soil structure is not as well developed and the soils are more fragile and liable to structure decline and compaction (s limitation). Nevertheless, these soils will support a variety of horticultural and broadacre crops. Cereals, potatoes, poppies and beans plus small areas of other horticultural crops are grown in rotation with pasture or a green manure crop. Intensive vegetable production is practiced in some places and evidence of soil degradation is already visible where these soils have been cultivated too often without adequate pasture phases or equivalent green manuring. The soil then either becomes powdery and prone to surface crusting and water erosion or they suffer from compaction and appear very cloddy when cultivated, often requiring extra passes with machinery to produce adequate seed bed conditions. Topsoil depths are often variable on the spillites and keratophyres, especially on hill shoulders where movement by gravity (through ploughing) and water erosion has led to the exposure of subsoils in some areas.

Photo 8. Class 3 land on well drained alluvial soils (GR E449800, N5434800).

Photo 9. Class 3+4 land on basalt colluvium and alluvial soils at Gunns Plains (Class 5 land on forested hill slopes) (GR E417500, N5428500).

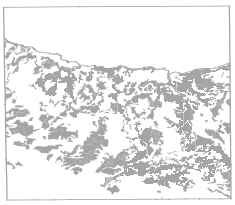
The utilisation of irrigation in some areas has led to a more intensive use of this land. With this intensification has come an increased risk and rate of degradation. Careful management is even more essential to keep these soils in the best condition. Compacted, cloddy soils are to be found in some areas of North Motton and Sheffield and especially those lower lying areas that are susceptible to wet harvests. Soil moisture monitoring is critical in the management of these soils to prevent degradation of the resource.

Complexes

Small areas of Class 3 land are complexed with Class 2 where slopes range between 5% and 18%. Larger areas are complexed with Class 4 land. Complex units of Classes 3 and 4 occur where slopes range between 12% and 32%, where Class 3 land occurs in association with areas of imperfectly drained soils or where Class 3 land occurs with areas of particularly stony soils. Complexes of Class 3 and 4 often represent areas of complex geology including basalt and Wesley Vale or Permian sediments.

6.4 CLASS 4 LAND

Class 4	40841 ha
Class 4+3	2060 ha
Class 3+4	1205 ha
Class 4+5	7149 ha
Class 5+4	1163 ha



Class 4 land is the dominant land class found in the Forth survey area. It ranges over many geological types and landforms and has a correspondingly wide range of limitations to agricultural use.

Class 4 Land on Tertiary Basalt

Areas of Class 4 land on Tertiary basalt are found throughout the survey area. They include areas of *insitu* basalt parent rocks and basalt derived soils occurring on colluvium and landslip materials. These areas are found around Kindred, Kimberley, Weegena, Penguin, Sheffield, Wilmot, Preston and Ulverstone. Class 4 land on basalt is found on undulating to rolling country with gradients up to 32%. Agricultural capability is limited by imperfect soil drainage, excessive rockiness (up to 20% stones and 30% gravel), and high erosion risk on steeper gradients (including the risk of landslip). Some areas may even have a combination of these limitations, reflecting the varied landforms that this land class occupies.

Like Ferrosols elsewhere, the soils developed in areas of Class 4 land on basalt are inherently well structured and well drained. However, many basalt soils in this land class have a significant stoniness limitation. The large number and size of rocks and stones necessitates frequent stone picking to minimise the impact upon both crops and cultivation and harvest machinery if the land is to be used for cropping enterprises. At the break in slope between ridge crests and valley sides stoniness and rock outcrop

occurrence increases. These areas are frequently unsuitable for cropping and would be classified as Class 5 or 6 land but are included with the adjacent land class as they are too small to map separately at this scale.

On slopes of 18-32% the basalt soils are at significant risk of erosion without very careful management practices and intensive on-ground works. Sustainable management of this land requires the strictest of soil conservation measures to be implemented if the land is used for occasional cropping. In some areas these steeper gradients can be prone to landslip. While many of these slips are old they could easily be reactivated by increased water infiltration as a consequence of cultivation. Areas of old landslip are clearly evident as they show an uneven, hummocky land surface. This uneven land surface is difficult to cultivate and manage and is best reserved for grazing purposes and only cropped on an occasional basis.

Other areas of Class 4 land on basalt occur inland and at elevations above 380 m, for example at Staverton, South Preston and Roland in the south of the survey area. Here it is no longer the landform and its related erosion management problems that limit the agricultural capability of the land but the local climatic conditions (c limitation). The risk of damage to crops by frost and exposure to strong winds, together with a shortened growing season resulting from cooler temperatures and/or poor aspect, is very restrictive to where and when crops can be sown, as well as the range of suitable crops.

At the margins of basalt flows Ferrosols have developed in basaltic colluvium. These soils are usually shallow and often mixed with the underlying Permian materials resulting in soils with poor structural characteristics and other severe limitations.

Finally, other Class 4 land on basalt are found in low lying areas which collect the run-off from surrounding landforms. These areas often have imperfectly drained soils characterised by a dark, more loamy topsoil and browner, mottled subsoil. On this land a major limitation is the shortened working window due to excessive soil wetness together with the mildly anaerobic conditions that can exist in the subsoil. Trafficking of the soils by cultivation and harvest machinery while they are wetter than their plastic limit leads to compaction and structure degradation. Use of these areas for more intensive cropping without appropriate remedial action can result in soil structural degradation, such as plough pans and crusting, which further decrease the land's viability.

Class 4 Land on Other Volcanics

This land is found at North Motton, Roland, Lower Barrington, to the West of Nietta, Isandula Road and Beulah and includes land on Cambrian spillites and keratophyres. It occurs on gentle to moderate slopes (0-32%) and land capability is mainly limited by the amount of surface stone and within the soil profile. As well, topsoil depth can be very variable, soil drainage may be imperfect to poor and subsoils may be compact.

Photo 10. Class 4 land on Quaternary deposits showing evidence of impeded infiltration and internal soil drainage (GR E4511000, N54212500).

Photo 11. Class 4 land on Gog Range Greywacke in middle distance and on alluvium in foreground (GR E433070, N5424830).

Stony soils usually occur higher in the landscape, close to hill crests and ridges. In such places stone content severely limits cultivation and reduces yields. Despite the stoniness, many of these areas support farm and commercial forestry plantations. On steeper gradients, between 18-32%, erosion risk becomes the main limitation to agricultural use. While the soils are similar to those developed on Tertiary basalt they are prone to structure decline if over used and can become highly erodible.

Class 4 Land on Permian Sediments

Class 4 land has been identified on a range of Permian sediments including the Mersey Coal Measures, Kelcey Tier Mudstone and the Ferntree Group which includes sandstones and siltstones. Areas of Class 4 land are found in north-east and eastern parts of the survey area around Latrobe, Spreyton and Railton. Slopes are typically moderately steep (12-32%) and landforms comprise rolling hills and valleys generally up to 300 m elevation. The major limitations to agricultural land use are drainage and erosion risk. Landslips are a common feature of the landscape, particularly at the junction with overlying basalt flows, and a large, active slip is clearly visible on Railton Road, 2km south-east of Railton.

Given the variable lithology of the sediments the soils are correspondingly complex. Hill (1995) describes several soils developed on Permian Sediments identified during surveys of State Forest reserves and similar soils have been identified during the course of this survey. Imperfect soil drainage is usually indicated where mottling occurs within 30 cm of the surface. Some soils are slightly sodic, that is exchange sites on the clay minerals contain a high proportion of sodium, and this results in soil aggregates that slake or weakly disperse when added to distilled water, indicating a susceptibility to erosion and structural decline. This characteristic is very variable and some profiles may show no signs of instability. Other limitations for land use occur where soils are duplex in nature, indicating a potential drainage limitation or, where A horizons are sandy, a high erosion risk. Other soils are excessively stony or gravelly, which can inhibit rooting depth or reduce nutrient availability while other soils are just inherently infertile, particularly if bleached A horizons are present.

The restricted permeability of most soils derived from the Permian sediments, together with their often dispersive nature severely limits the safe working window for cultivation, thereby restricting the versatility of this land for agricultural activities.

Class 4 Land on Alluvium

The majority of this land class occurs along major river valleys, estuaries and lowlands throughout the survey area. The main areas occur on the western bank of the Mersey River near Spreyton, parts of the foreshore flats along the northern coastline from Northdown Beach in the east to Ulverstone in the west, Gunns Plains, Merseylea, Railton and areas adjacent to the Dasher River in the south. Scattered small areas are also found in most minor stream valleys.

While the alluvium is often quite fertile in nature, a number of other factors limit the versatility of this land for agricultural production. Many soils in these areas are fine

textured and have limited permeability resulting in profiles which are typically poorly to imperfectly drained. This factor is compounded by the relatively low positions in the landscape (receiving run-on from upslope areas), minimal surface gradients providing limited surface drainage, and significant flood risk throughout the year. The resulting imperfect soil drainage and prolonged periods of surface wetness severely limit the potential growing season and the variety of crops that can be grown. Some of soil profiles were identified as having dispersive or saline subsoil. If cultivation should bring this material to the surface soil crusting could occur. Soil crusting can reduce water infiltration and increase surface run-off and the risk off erosion, as well as reduce seedling emergence. Deep cultivation of soils with known sodic or saline subsoil is strongly discouraged.

In some areas, intensive management practices have enabled higher than normal productivity from otherwise Class 4 land. These practices include a system of permanent beds (mounding seed beds prior to the onset of winter so as to provide a deeper, better drained bed for early planting in spring), and deep drains with pumping required to remove water to a higher outfall. These techniques effectively increase the capability of the land but the management levels are beyond the resources of most farmers and thus the classification of these areas remains at Class 4.

Areas of Recent Alluvium and Marsh Deposits often have soil profiles with deep 'A' horizons but the proximity to shallow groundwaters limits rooting depth and restricts agricultural versatility. In some areas extensive gravel beds occur within the alluvium. These gravel beds can comprise relatively small gravel to stones or rocks above 15 cm in size. Class 4 land is recognised where the coarse fragment content of the soil profile exceeds 20% (or 30% for finer gravel).

Other Class 4 Land

Other Class 4 land includes that occurring on Jurassic Dolerite, Wesley Vale and Tertiary Sediments, Cambrian and Ordovician sediments, and small areas of limestone and granodiorite.

South of Weegena, at Bonney's Tier, north east of Beulah, around South and East Devonport Class 4 land on Jurassic Dolerite is identified where soils are moderately stony or shallow. Topography is typically gently undulating to moderately steep hills up to 18% slopes. Many areas retain a natural vegetation cover suitable for stock grazing and protection through the winter. In areas where soil depth and stone content allow, such as Dooleys Hill and Stagg Hill to the east of Devonport occasional cropping can be sustained but elsewhere the land is mainly used for grazing purposes.

At Leith, Don Heads and south of Penguin Class 4 land is often characterised by sandy soils formed from sub-basaltic quartzite and sandstone These soils are highly erodible and prone to severe water erosion and areas where slopes are below 5% have been classified Class 4e. Occasional cropping utilising direct drilling, stubble retention and strict water management practices have seen moderate returns for some land managers. Most land managers recognise the risks of cultivating this land and predominantly utilise it for grazing and only occasional cropping.

Around Wesley Vale and Moriarty deep sandy soils with bleached A2 horizons are intermixed with the Ferrosols of Class 3 quality and above. These Wesley Vale soils are highly erodible by wind and water, and are very low in nutrients. Land with these soils is classified as Class 4 only where the topography does not exceed 5% slope. Even at such low gradients these soils remain susceptible to erosion if left bare. The intermixing with the Ferrosols creates a very complex pattern of soils and deposition of windblown sediments in areas of basalt soils can effectively lead to degradation of the better land. Like the soils at Leith and Don Heads, the Wesley Vale soils require very careful management to minimise erosion, but their proximity and intermixing with the better Ferrosols rarely allows this to occur. As a result, degradation of good red soils and the Wesley Vales alike continues to occur.

On Cambrian greywackes and mudstones Class 4 land is identified at Beulah, Rowland and around Lower Wilmot. The main limitations are the shallow soil depth and imperfect subsurface drainage of many of the soils. Some of the less sloping land has been cultivated for vegetable production but compaction, mixing and cloddiness were observed in areas where this had occurred. Timely tillage at 'correct' workable moisture levels and reducing the depth of cultivation to avoid mixing topsoil and subsoil will help to minimise degradation of these areas.

Small areas of Class 4 land on Ordovician limestone, Devonian granites and sediments of various ages have been mapped in the Gunns Plains, Beulah, Latrobe and Claude Road localities, on gentle slopes where the degree of rock outcrop and the amount of stone within the soil profile makes occasional cropping a viable option.

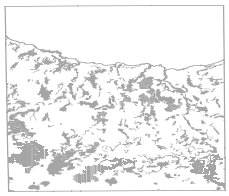
Complexes

Like other classes of land described previously, complexes of Class 4 with either Class 3 or 5 may occur where the complexity of the unit is too great to separate at this scale of mapping.

Complexes of Class 4 and 3 occur where slopes range between 12% and 32% or where Class 4 land occurs in association with better soils (ie moderately well drained, less stony). Such areas include units where basalt soil are found in association with soils developed on Wesley Vale sediments. Significant areas complexed with Class 5 occur where soils are poorer (ie poorly drained, very stony) or where gradients range between 18% and 56%. These areas often occur on Permian sediments or where Permian sediments are associated with Ordovician or Cambrian rocks.

6.5 CLASS 5 LAND

Class 5	29033 ha
Class 4+5	7149 ha
Class 5+4	1163 ha
Class 5+6	2157 ha
Class 6+5	440 ha



Class 5 land in the Forth survey are is represented by areas of stony land, steep dissected gullies, creek lines, active landslips, poorly drained soils and steeper gradients or areas with highly erodible soils. It also includes those areas at elevations above 500 m in the south west that are restricted by climatic conditions. Complexes of this land class have been identified with Classes 4 and 6.

Class 5 Land on Tertiary Basalt and Derived Material

The largest expanses of this land class are found in the Forth River valley east of Braddons Lookout, the basalt scarps along the north coast stretching from Northdown Beach in the east to Sulphur Creek in the west, and further inland at South Nietta, Staverton, Erriba and Weegena.

The major limiting factor in these areas are the steep slopes which create a high erosion risk. In some areas numerous minor landslips have created a highly variable microrelief which makes any sort of cultivation practically impossible. Consequently most agricultural activity is limited to grazing and some farm forestry. Erosion risk, in the form of mass movement, is very high as is the risk of erosion by concentrated surface run-off.

Inland and at altitudes above 500 m, Class 5 land on basalt occurs where climatic conditions (c limitation) are unsuitable for any form of cropping activity with the exception of occasional fodder crops. Such areas are identified at Smiths Plains and Jean Brook near Leven Canyon, Erriba and the Moina area. Here climatic conditions (mainly temperatures) impinge greatly upon agricultural activity reducing the length of the growing season and resulting in the predominance of grazing and plantation forestry enterprises. Growth rates of pasture and maintaining stock condition over winter are the main concerns for farming in these areas.

Other Class 5 land on basalt occurs where surface stone (including sporadic outcrops) or stone content within the soil profile (r limitation) makes regular cultivation impractical. Pasture renewal becomes very challenging in these instances and cultivation of the soil can severely damage farm implements. Surface stone picking has taken place in a number of areas in an attempt to maximise pasture productivity but he value of such activities, with respect to any increased productivity, is questionable. These areas are also utilised for farm forestry which can better tolerate high levels of stoniness.

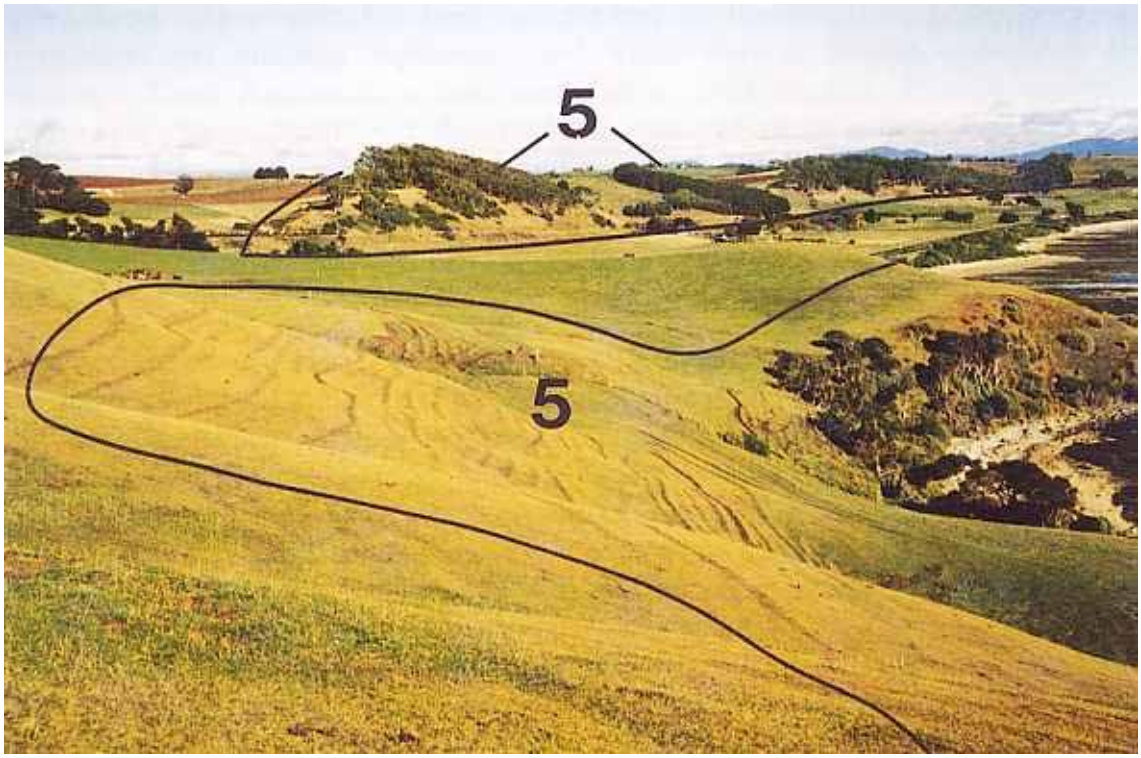


Photo 12. Class 5 land on basalt occurs along the coastal escarpment and is subject to mass movement (GR E442500, N5443200).

Photo 13. Poor soil conditions lead to Class 5 land on some Permian sediments (GR E454425, N5435125).

Where poorly drained soils occur a wetness limitation (w) is identified. These areas often occur where water has been concentrated by the surrounding landforms, eg springlines and drainage depressions, and where there is limited opportunity for drainage. These features have been identified at West Kentish, Paradise and near Barrington. Some draining of this land has occurred in an effort to prevent soil compaction by stock and improve pasture growth. Land managers generally have avoided utilising these areas other than during the drier months of the year.

Class 5 Land on Permian Sediments

The occurrence of Class 5 land on Permian sediments has been identified west of Sassafrass, south of Latrobe and Spreyton, and in the vicinity of Railton and Kimberley. Soil types are similar to those described within Class 4 land but hills and valley sides are steeper, ranging between 18% and 32%, and the risk of erosion on soil types prone to dispersion is significantly greater. Areas of current or recently active landslip are included within this land class as are areas of irregular topography which make cultivation difficult. These areas have typically been classified 5(e) and 5(t).

Elsewhere, Class 5 land has been identified where poorly drained soils have developed in low lying depressions. These soils are usually mottled to, or near to, the soil surface and may remain wet for substantial periods of time.

Class 5 Land on Quartzites and Schists

The soils that have formed from these parent materials are very erodible and relatively infertile soils. Where found on the lower hillslopes and flatter hill tops south-east of Forth township and east of Abbotsham, north of Spalford and north-west of Railton on slopes ranging between 5% and 32% the land has been classified as Class 5. Most of this land is limited by high erosion risk of shallow sandy to sandy loam topsoils. Much of this land remains under native vegetation and is planted for forestry or used for grazing. Care is needed when developing this land to minimise the risk of erosion caused by run-on of surface water from upslope and to protect bare ground from wind erosion. Best management practices keep the length of time these areas are left bare to a minimum. Small areas of rock outcrop, normally classified as Class 6 land, are included in some map units as they are too small to map as separate units.

Class 5 Land on Alluvium

These areas are characteristically limited by long periods of seasonal inundation (w) and/or poor soil drainage, high water tables and large amounts of stone in the soil profile (s). They are usually found adjacent to, or complexed with, areas of Class 4 land on alluvium which have imperfectly drained soils.

Class 5 land is identified in areas where regular inundation can occur at any time of year. These areas include alluvial flats adjacent to the Leven River at Gunns Plains, at Paradise adjacent to the Dasher River and at Merseylea on the flood plains of the River Mersey. While flooding mainly occurs during the winter period severely restricting

activities at this time of the year, summer flooding can also take place and the risk of significant crop loss is considered too great to classify this land as Class 4.

At Spreyton and along some of the foreshore areas of the north coast, Class 5 land on alluvium occurs in small pockets often characterised by poorly drained soils with high saline water tables. These areas often lie within close proximity to major river mouths and the groundwater tables may be subject to tidal influence.

Class 5 Land on Acid Volcanics

Class 5 land on the Cambrian volcanics occurs at scattered locations throughout the southern part of the survey area including Weegena, Beulah, Lower Wilmot, Leven and east of Central Castra. Some of the soils are similar to those developed from Tertiary basalt but are typically more stony, shallower or less robust. Much of this land occurs on steep slopes in excess of 32% or on rocky or stony land where cultivation is difficult. Some areas are heavily dissected by valleys, rivers and streams to such a degree that the landscape is very broken and cultivation would be impractical. This land is extremely difficult to manage and in recent times has often been left under native vegetation. Most of the cleared land was developed by pioneering timber harvesters and graziers and converted to pasture many years ago. Where less steep or less stony ground occurs above 500 m, land use is limited by climate due to low temperatures, slow growth rates and high frost risk.

Class 5 Land on Greywackes, Mudstones and Conglomerates

Class 5 land on conglomerate rock types typically has loose sandy soils overlying very stony subsoils. The soils are highly erodible even on slopes below 18% and together with the high stone content are limited Class 5 land. Other areas of Class 5 are confined to poorly drained hollows and depressions. This land class has been identified east of Lower Barrington and at Sullocks Hill south of Penguin.

Class 5 land on greywackes and mudstones occur on gentle slopes and have deeper soils but are prone to compaction and structural decline after cultivation. The sheet and gully erosion risk on these areas is also high and is clearly apparent in a number of areas that have been cleared of their natural vegetation. Prevention of topsoil loss is extremely important on this land as, once lost, it becomes very difficult to re-establish vegetation on these sites.

Small areas of Class 5(c) land occur at elevations above 500 m near Cethana and at Smiths Plain south-west of Leven Canyon. Here low temperatures and high frost risk restrict agricultural enterprises to grazing and farm forestry.

Other Class 5 Land

Class 5(e) land has been identified on slopes greater than 5%, where deep sandy soils, often with only thin A horizons, occur. These areas include the light textured sands at Wesley Vale and Moriarty and other light textured soils at Penguin, Leith and south west of Turners beach along Stubbs Road. All these locations represent areas with a high risk of soil erosion by wind and/or water due to the loose, sandy nature of the soil.

Other Class 5 land has been identified on Ordovician limestone, Devonian granite, Jurassic dolerite, and land with talus materials relating to these geological units. Most of these areas are limited by the extent of stones within the soil profile, steep slopes and the instability of the landscape. All this land occurs on moderate to very steep slopes up to 56%. Some areas have been complexed with Class 4 and sometimes with Class 6 depending upon the degree of broken terrain and the distribution of outcrop and stone.

The limestone areas can be found at Gunns Plains and take the form of steep dissected hillsides with occasional sinkholes and cave systems. Outcrops of limestone are visible in some locations, particularly at Windus Road, and combined with the instability and broken terrain of this area limit this land to Class 5.

The granite country south of Beulah occurs as steep rounded hills with small amounts of outcrop. Here the gradients are such (>32%) that machinery cannot safely operate to cultivate this ground. Erosion risk is extremely high with soil creep and sheet erosion evident in many places.

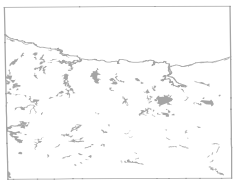
Class 5 land on dolerite, conglomerate and associated talus occurs on prominent ridges, hills and colluvial fans. It is very stony country, commonly with sporadic outcrop and surface boulders characterising these land units. This land can be found at Claude Road at the base of Mt. Roland, Staggs Hill and Kelcey Tier near Latrobe and Mount Riana to the west. Where the degree of outcrop and stoniness is reduced but a gradient of 32% or more exists, erosion risk and the physical inability to work the land using conventional machinery become the most limiting factors, and land use is consequently limited to grazing activities.

Complexes

Significant areas complexed with Class 5 occur where soils are poorer (ie poorly drained, very stony) or where gradients range between 18% and 56%. These areas often occur on Permian sediments or where Permian sediments are associated with Ordovician or Cambrian rocks. Other complexes are with Class 6 land where Class 5 occurs in association with very rocky or stony land, seasonal swamps or areas where erosion risk is significantly increased due to steeper slopes or more erodible soil conditions.

6.6 CLASS 6 LAND

Class 6	4894 ha
Class 5+6	2157 ha
Class 6+5	441 ha
Class 6+7	367 ha



Class 6 land in the Forth survey area identifies all land considered marginal for sustainable agricultural production. These areas are severely limited for agricultural use by a range of physical limitations including erosion risk, rock outcrop, stoniness, slope steepness, climate and poor soil drainage. Complexes are identified with Classes 5 and 7.

Class 6 Land on Quartzites and Schists

Precambrian quartzites and schists have been exposed in the Forth River valley by the down cutting of the river through the overlying younger sediments to form steep (32%-56%) valley sides. These steep slopes and the erodible nature of the topsoil on this land combine to produce an extremely high risk of erosion, particularly if vegetation is removed or the ground disturbed. Some areas, such as Sayers Hill adjacent to the Forth River, have been extensively quarried for construction materials.

Class 6 Land on Conglomerates and Associated Materials

These areas are often characterised by long linear ridge formations and include the colluvial fans at the base of these ridges. They are found at Claude Road, east of Nook near Sheffield, Bott Gorge, Leven Canyon and the lower slopes of the Dial Range.

These areas are severely limited for agriculture by having shallow soils and much rock outcrop. Some areas also occur on very steep terrain where the risk of erosion becomes the most limiting factor. The soils formed on these materials are often coarse textured and have a thin organic-rich A horizon. If disturbed these soils are likely to be susceptible to massive erosion. Rough grazing of native grasses is possible in these areas but stocking rates need to be monitored carefully to avoid excessive degradation of the vegetative cover and the soil cover itself, from hoof impact.

Class 6 land on Cambrian materials and Permian sediments

Most of the Class 6 land on these rock types occurs on steep slopes and has shallow erodible topsoil or is susceptible to landslide. Land on Cambrian material is found adjacent to the Dial Range, Mt. Roland, Lobster Creek and The Three Brothers east of Leven Canyon. These areas are particularly stony or are limited by rock outcrop.

Class 6 land on mudstone and greywackes tends to be limited by steep slopes with occasional rock outcrop. While having a similar appearance to the Cambrian landforms, the Permian landscape is more unstable in terms of landslip and the subsoils tend to be

Photo 14. Class 6 is often very steep or, as in this instance, where it occurs on very rocky ground (GR E451900, N5436700).

Photo 15. Class 7 land, such as these coastal dune systems, is unsuitable for agriculture (GR E454625, N5443075)

dispersive and subject to erosion by surface water run-off.. Landslips are particularly evident at Ellice Hill and south of Railton road.

This land, with its steep valley sides, rockiness, irregular landscape and instability has very severe limitations for agricultural use. Erosion risk on the steeper country and the physical barrier to cultivation attributable to both slope and rockiness limits this land to grazing of native pasture only.

Class 6 Land on Alluvium

Small areas of land mapped as Class 6 on Quaternary sediments occur along the north east coastline on the wet coastal plains and tea tree swamp areas south of Northdown Beach and Moorland Beach. The land is wet for much of the year and some areas have soils that contain many large rocks and stones at, or near the surface. The heavy clay nature of the subsoil and the lack of slope prevents this land from being drained satisfactorily and limits the use of this land to rough grazing during the drier period of the year only.

Other Class 6 Land

Class 6 land on Jurassic dolerite contains areas of rocky knolls and land with considerable boulders and rock outcrop and which have only limited grazing potential. Areas of Class 6 on dolerite occur at Kelcey Tier, Bonneys Tier, Stagg Hill and Dooleys Hill.

Some areas of Class 6 land on basalt are found at Don Heads, Devonport, west of Penguin at West Ridge Road and on the steep landslip and slump complexes west of Isandula Road near Gawler and north-west of Warringa.

Complexes

Class 6 occurs mainly as a complex with Class 5 where the land is less steep, less liable, less stony or rocky or better drained. Only small units of Class 6 and 7 are identified, usually where the land is excessively stony or steep or erosion risk is very high, such as along some of the coastal dune areas.

6.7 CLASS 7 LAND

Class 7	520 ha
Class 6+7	367 ha

Class 7 land has been mapped at the coastal margins where cliffs and sand dunes occur, in areas which are subject to tidal inundation, and inland areas with very steep gradients. These locations represent the areas in which the physical nature of the topography or quality of the soils so severely affect land use that agriculture is not a realistically feasible option.

Class 7 Land on Quaternary Dune Material

This land is very fragile and susceptible to degradation by wind erosion if disturbed or loss of vegetation occurs. Small areas have been mapped along the coast at Lillico and Northdown. Numerous other small areas occur throughout the survey area but some are of insufficient size to map at this scale and have been absorbed into adjacent land classes.

Soils are very fragile with only thin “A” horizons. The dunes are partially stabilised by marram grass but are still prone to erosion and movement. If disturbance of these areas occurs the sand particles can be carried for large distances by the prevailing NW winds and migration of the dunes onto agricultural and urban areas could occur. As well, the soils are inherently low in fertility and their excessively freely draining nature results in very low moisture retention.

Other Class 7 Land

Other areas of Class 7 land occur along the coastline and take the form of cliffs, scarps and shore platforms on Precambrian conglomerates, Cambrian megabreccias and sandstones, and Tertiary basalts, and have minimal soil depth (in places none). Again small areas of a size too small to map at 1:100 000 scale occur along the coastline west of Ulverstone and are absorbed into surrounding units.

Areas of tidal marshland are identified as Class 7(ws) at Spreyton on the Mersey River estuary and a smaller unit south of Leith on the western bank of the Forth River. These areas comprise estuarine silt traps, mudflats and swamps which are characterised by various species of rushes and occasional stands of remnant tea tree. They are almost all permanently wet with water tables at or near the surface for much of the year. As a result conditions within the potential root zone are anaerobic and saline. Inundation by king tides is not uncommon. These features make these areas unsuitable for agricultural use.

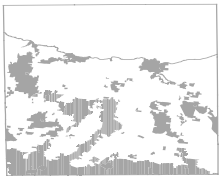
Areas of very steep ground and cliffs at Mt Roland, Blackberry Hill, Bott Gorge and Leven Canyon are mapped as Class 7 due to their precipitous nature, degree of rock outcrop and erosion hazard.

Photo 16. Exclusion areas such as this limestone quarry and the forested ridge in the background, do not form part of the survey (GR E450400, N5424400).

Photo 17. Land capability information is a valuable tool to evaluate for route alignments and determine priority areas for urban subdivision (Penguin by-pass, GR E421400, N5447200).

6.8 EXCLUSION AREAS

Exclusion areas 50623 ha



The Forth survey area contains extensive areas of State Forest and other reserves which are not included in the land capability classification survey. Many of these areas represent high land or rugged hills and include Bonney's Tier, Badger Range, Mount Roland Range, Leven Canyon, Dial Range and hills adjacent to Lake Barrington. These areas, together with major urban areas, Conservation Areas, State Recreation and Protected Areas, Hydro Electric Commission areas and Commonwealth Administered areas are collectively termed Exclusion areas and do not form part of the area surveyed. These areas appear on the map as white areas identified with the letter E.

The boundaries for these areas have been supplied in digital format by Forestry Tasmania and some discrepancies have been identified in comparison to the published 1:100 000 scale Land Tenure maps. In addition, some boundaries around urban centres, and the mine site at Railton, have been defined by the survey team and represent areas excluded from agricultural activity on the basis of current land use. Such boundaries are not intended to represent the boundaries of individual land titles. Therefore, the published exclusion boundaries in this report and accompanying map should be used with caution and do not purport to identify the exact cadastral location of said boundaries.

A summary of the major land capability map units and their characteristics is presented in Table 4 below. The Table is not intended as an exhaustive list of all the combinations of the various land characteristics used to define land capability but simply as a guide to the nature of map units identified within the survey area.

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology Type	Slope	Topography and Elevation (metres)	Erosion Type and Severity (under cultivation)	Climatic Limitation	Soil Qualities	Main Limitation to Agricultural Use	Land Management Requirements (under cultivation)	Cropping Versatility
1	Tertiary basalt.	0-5%	Flat and very gently sloping land. <200m	Nil - very minor sheet and rill erosion risk.	Very minor frost risk.	Well drained. Stone free.	Erosion.	Minimal. Very minor conservation practices for some crops.	All annual crops.
2	Tertiary basalt.	0-5%	Flat and very gently sloping land. 200-270m	Nil - very minor sheet and rill erosion risk.	Minor frost risk.	Well drained. Stone free.	Climate.	Minimal. Very minor conservation practices for some crops.	Not frost sensitive crops.
2	Tertiary basalt.	5-12%	Gently inclined undulating rises. <200m	Minor sheet and rill erosion risk.	Very minor frost risk.	Well drained. Stone free.	Erosion.	Minor soil conservation practices.	All annual crops.
3	Tertiary basalt.	0-12%	Gently inclined undulating rises and low hills. 250-380m	Minor sheet and rill erosion risk.	Moderate frost risk.	Well drained.	Climate.	Minimal. Very minor conservation practices for some crops.	Not frost sensitive crops.
3	Tertiary or Cambrian basalt.	12-18%	Moderately steep rolling hills and rises. <380m	Moderate sheet and rill erosion, slight gully erosion risk.	Variable frost risk.	Well to moderately well drained. Up to 20% stones or rocks	Erosion.	Moderate soil conservation practices.	Slightly restricted range.
3	Tertiary or Cambrian basalt.	<12%	Gently inclined undulating rises and low hills. <380m	Minor sheet and rill erosion risk.	Variable frost risk.	Moderate soil drainage. 10-20% stones or rocks.	Soil drainage. Rockiness.	Soil drainage. Stone picking. Minor soil conservation practices.	Restricted range.
3	Tertiary or Cambrian basalt.	12-18%	Moderately steep rolling hills and rises. <380m	Moderate sheet and rill erosion. Minor mass movement.	Very minor frost risk.	10-20% rocks.	Undulating, broken terrain. Rockiness.	Moderate soil conservation practices.	Slightly restricted range.
3	Alluvial and Permian sediments.	0-5%	Flat and very gently sloping land. <270m	Minor wind (on sandy soils) and slight rill and sheet erosion risk.	Minor frost risk.	Up to 20% stones and rocks. Moderately well drained.	Occasional winter flooding. Soil drainage. Erosion. Low structural stability.	Soil drainage and flood protection.	Restricted range.
4	Tertiary or Cambrian basalt.	0-18%	Very gentle to moderately steep undulating to rolling rises and low hills. 380-500m	Moderate sheet, rill and gully erosion risk.	Severe frost risk and shortened growing season.	Up to 30% stones and rocks.	Climate.	Minor soil conservation practices.	Severely restricted range of crops.

Table 4. Characteristics of the main land capability classes identified in the Forth survey area.

(NB. Not all map units are described. Some generalising of unit descriptions has been undertaken to avoid excessive repetition of data)

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology Type	Slope	Topography and Elevation (metres)	Erosion Type and Severity (under cultivation)	Climatic Limitation	Soil Qualities	Main Limitation to Agricultural Use	Land Management Requirements (under cultivation)	Cropping Versatility
4	Tertiary or Cambrian basalt.	0-18%	Very gentle to moderately steep undulating to rolling rises and low hills. <500m	Moderate sheet, rill and gully erosion risk.	Low to moderate frost risk.	Imperfect soil drainage or 30-40% stones and rocks.	Soil drainage. Stoniness.	Soil drainage. Stone picking. Minor soil conservation practices.	Severely restricted range.
4	Tertiary or Cambrian basalt.	18-32%	Moderately steep rolling rises and low hills. <500m	Moderate sheet, rill and gully erosion risk. Severe mass movement.	Low to moderate frost risk.	Variable soil drainage. Variable stoniness.	Broken terrain. Erosion.	Major soil conservation practices.	Severely restricted range.
4	Permian and other Alluvial Sediments.	5-18%	Gentle to moderately steep undulating and rolling rises and low hills. <500m	Moderate sheet, rill and gully erosion risk.	Low to moderate frost risk.	Imperfect soil drainage. Up to 30% stones and rocks.	Soil drainage. Low structural stability.	Soil drainage. Soil structure maintenance.	Severely restricted range.
4	Jurassic Dolerite.	5-18%	Gentle to moderately steep undulating and rolling rises and low hills. <500m	Minor sheet, rill and gully erosion risk.	Low to moderate frost risk.	Up to 40% stones. Up to 35% rock outcrop.	Rock outcrop and stony soils.	Stone picking. Soil structure maintenance.	Severely restricted range.
4	Jurassic Dolerite.	18-32%	Moderately steep rolling rises and low hills. <500m	Severe sheet, rill and gully erosion risk.	Low to moderate frost risk.	Up to 20% stones.	Erosion risk.	Major soil conservation practices.	Severely restricted range.
4	Tertiary or Cambrian Sediments.	0-18%	Very gentle to moderately steep undulating rises. <380m	Minor wind erosion on sandy soils. Moderate sheet, rill, and gully erosion risk.	Low to moderate.	Imperfect soil drainage. Up to 40% gravel and stones in topsoil.	Soil drainage. Gravel.	Soil drainage. Minor soil conservation practices. Stone picking.	Severely restricted range.
5	Tertiary basalt, Conglomerates, mudstones and Acid volcanics.	0-32%	Very gentle to moderately steep undulating and rolling rises and low hills. Above 500m	Moderate to severe sheet, rill and gully erosion risk. Severe mass movement	Very severe frost risk or generally low temperatures.	Variable soil drainage and stone content.	Climate. Growing season.	Managing stocking rates.	Pasture activities and occasional fodder crops.
5	Tertiary basalt and Acid volcanics.	32-56%	Steep rolling hills. <700m	High rill and gully erosion risk or severe mass movement.	Very low to severe frost risk.	>40% stones and rock outcrop.	Steep slopes. Broken terrain. Erosion risk.	Managing stocking rates. Stone picking.	Pasture activities and occasional fodder crops.

Table 4 (continued).

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology Type	Slope	Topography and Elevation (metres)	Erosion Type and Severity (under cultivation)	Climatic Limitation	Soil Qualities	Main Limitation to Agricultural Use	Land Management Requirements (under cultivation)	Cropping Versatility
5	Tertiary basalt.	0-32%	Very gentle to moderately steep undulating and rolling rises and low hills. <700m	Moderate to high sheet, rill and gully erosion risk. Severe mass movement.	Very low to severe frost risk.	Greater than 40% stones, rocks and rock outcrop.	Stoniness and rock outcrop.	Stone picking. Managing stocking rates.	Pasture activities.
5	Permian and alluvial sediments.	18-32%	Moderately steep rolling rises and low hills. <700m	Moderate to high sheet, rill and gully erosion risk. Severe mass movement.	Very low to severe frost risk.	Imperfect soil drainage. Dispersive soils.	Erosion risk. Soil structure decline.	Erosion control. Managing stocking rates.	Pasture activities and occasional fodder crops.
5	Permian and alluvial sediments.	0-32%	Valley flats to moderately steep rises and low hills. <700m	Low to moderate erosion risk.	Very low to severe frost risk.	Poorly drained soils and moderately high groundwater tables.	Soil drainage. Flood risk.	Soil drainage. Managing stocking rates.	Pasture activities.
5	Quartzite, Schists and Tertiary sediments.	5-32%	Gentle to moderately steep valley sides and ridge crests. <700m	Very high rill and gully erosion risk.	Low to severe frost risk.	Shallow soils. Low nutrient levels.	Erosion. Soil depth.	Managing stocking rates.	Pasture activities.
6	Quartzite and Schists.	32-56%	Steep rolling hills. <700m	Very high rill and gully erosion risk.	Low to severe frost risk.	Low nutrient levels.	Erosion. Soil depth. Stoniness.	Managing stocking rates.	Limited pasture potential.
6	Cambrian and Permian sediments.	32-56%	Steep rolling hills. <700m	Very high rill and gully erosion risk. Very severe mass movement.	Low to severe frost risk.	Poor soil structure stability.	Erosion. Dispersive soils.	Managing stocking rates.	Limited pasture potential.
6	Alluvium.	Level	Seasonal swamps and marshes. <700m	Low sheet erosion risk.	Low to high frost risk.	Saturated soils.	Soil drainage. High groundwater tables.	Land drainage.	Limited pasture potential.
6	Jurassic Dolerite.	0-56%	Level to steep rolling hills. <700m	Low to moderate sheet erosion risk.	Low to high frost risk.	>60% rock outcrop and boulders.	Rock outcrop.	Stone clearance.	Limited pasture potential.
7	Quaternary sand dunes.	Variable	Coastal sand dunes. <30m	Very severe wind erosion risk.	Very low frost risk.	Very low fertility.	Wind erosion. Soil nutrients.	Unsuitable for agriculture.	Nil.
7	Recent sediments.	Level	Recent tidal flats.	Very low erosion risk.	Very low frost risk.	Saturated soils. High salt levels.	Soil drainage. Salinity. High groundwater tables.	Unsuitable for agriculture.	Nil.
7	Any.	Any	Rocky foreshores and very steep cliffs at any altitudes.	Moderate rock fall risk in cliff areas.	Low to very severe frost risk at higher elevations.	Predominantly rock outcrop.	Rock outcrop.	Unsuitable for agriculture.	Nil.

Table 4 (continued)

7 DISCUSSION

7.1 Complex Units

A glance at the land capability map will show a significant proportion of complex units indicated by a series of diagonal stripes. These units represent areas of land where two land classes are identified, with proportions ranging between 40%-60%, but where the pattern is too complex to map individual classes at 1:100 000 scale. For example Class 2+3 land indicates a complex unit containing 50%-60% Class 2 land and 40%-50% Class 3 land. Considerable effort is made to map areas of a single land class but the nature of the country, and the scale of mapping dictate that some complex units are unavoidable. It is likely that more detailed investigations, at a more appropriate scale, could resolve many of the complex areas into units of a single land class.

7.2 The land Capability System

During the course of the field work attempts have been made to try to improve the land capability classification system. For field purposes the number of limiting factors has been increased beyond the original four (e, s, w and c) outlined by Noble 1992. This was done through the addition of a stoniness limitation (r), topographic limitation (t) and a flooding limitation (f). Although the published maps do not define individual map units to subclass level, each site observation recorded describes the land class and subclass at that point as well as additional soil and topographical information. This information is retained on a database for reference purposes and for quality control. The potential exists for the addition of other limiting factors or the further subdivision of existing limitations (eg erosion into wind erosion and water erosion). While the concept of identifying limitations to agricultural land use is very useful, the practice has significantly increased the amount of time spent on field work and led to considerable useful discussion of how to identify different limitations (eg wetness versus flooding; wetness as a soil limitation). When recording site information during the survey a subclass code has also been identified for each observation point. While this code may not be applicable to an entire map unit potential users of this map and report should be aware that additional information relating to subclasses information for individual observation sites is available from Land and Water Assessment Branch at DPIF's Prospect Office.

A valid criticism of the Land Capability methodology is that it is very subjective and dependent on the interpretation of individual surveyors. To overcome this problem a set of guidelines is being developed which, it is hoped, will make classifications between surveyors more consistent. The guidelines are based on a quantitative assessment of a range of land attributes critical to the evaluation of land capability. A certain amount of subjectivity remains in the determination of cut-offs for each land class but the guidelines at least provide for a consistent approach to land evaluation between surveyors.

7.3 Use of Information

Land capability information remains a valuable interpretative tool for long term regional and State planning and the system can be applied relatively easily at a more detailed level for local and farm planning. There continues to be a demand for this type of information from local government, landcare and catchment management groups and the system is being applied at farm level through Whole Farm Planning. Should the current draft State Policy on the Protection of Agricultural Land (DPIF 1997) be implemented, the demand for this information by local councils is likely to significantly increase. In an attempt to pre-empt this demand, the DPIF has substantially increased the resources it is putting into this work and, with additional funding through the Natural Heritage Trust, it is hoped that capability mapping of a significant part of the States agricultural areas will be completed during the next two or three years.

Potential users of the information should be aware of the problems of trying to use the information at a scale larger than the published one. Land capability information has been collected at an intensity appropriate to the scale of the final map (1:100 000). The level of impurity of each map unit and the accuracy of boundaries are therefore acceptable at this level of mapping but would be inappropriate for use at a more detailed scale.

The authors welcome constructive comment and criticism of the report and accompanying map and, in the unlikely event that significant errors in classification are identified at a scale appropriate to the level of mapping, they should be reported to the field officers concerned.

For any information regarding land capability maps and the land capability system contact should first be made with staff at your local DPIF office or with staff of the Land and Water Resource Assessment Branch at the Department's Prospect Office.

8. SOIL MANAGEMENT FOR SUSTAINABLE AGRICULTURE

Bill Cotching, Regional Land Management Officer, DPIF

This section looks specifically at some management issues relating to the use of a variety of cropping land in the Forth survey area. Soils found in this survey area include some of the most intensively used in Tasmania. This 'intensive use' includes cropping a range of vegetables (potatoes, onions, peas, beans, brassicas), cereals (oats, barley, wheat), poppies and pyrethrum, and growing pasture for dairying. Cropping regimes and rotations often include more than one crop a year with significant areas cultivated in most years. The intensive cultivation required for this type of agriculture has the potential to result in significant soil degradation through the impact of heavy machinery destroying soil structure, and through erosion by exposing bare soil surfaces to the effects of raindrop impact and surface water run off. High stocking rates associated with dairying also have the potential to adversely impact on soil structure condition.

The most intensively used soils in the area are the red Ferrosols (locally known as krasnozems). These soils have developed from basaltic parent material and are clearly identifiable by their strong red colour. These soils represent all of the Class 1 and 2 land identified and most of the Class 3 land. Ferrosols are also found on land classified up to Class 6. The major challenges for long term management of Ferrosols are the prevention of:

- soil loss by accelerated (man induced) erosion,
- structural deterioration, and
- declining organic matter levels.

Soil erosion

Accelerated soil erosion, or the erosion resulting directly from the impact of man, on sloping cultivated paddocks continues to occur at rates which threaten the sustainability of land use. Erosion rates on Ferrosols have been measured at up to 140 t/ha/yr (or 14 mm soil loss per year across the paddock) on some paddocks. In comparison, natural rates of soil formation are estimated at 0.2 t/ha/yr (equivalent to 1 mm in 50 years). These rates of soil loss are clearly unsustainable and a number of strategies to reduce the risk and severity of soil erosion have been developed over recent years, and shown to be successful by local farmers.

Firstly, an integrated approach to soil erosion control needs to be adopted by farmers, starting with the development of a property management plan. A farm plan, or appropriately annotated aerial photograph, allows for integration of soil erosion control measures into a farming system which act across paddock boundaries.

The key element in preventing soil erosion is the minimisation and control of surface water. Strategies recommended to address these elements on red Ferrosols include:

- Prevention of run on of surface water from upslope paddocks, roads and tracks onto cultivated ground by using diversion (cut-off) drains. This applies to all cultivated land, even Class 1 land. Class 1 land is susceptible to erosion where a

fine seed bed has been created, for onions for example, as any movement of water across this can rapidly lead to sheet and rill erosion - even on slopes as low as 3 or 4%.

- Protection and stabilisation of natural drainage lines as grassed waterways or vegetated stream lines.
- Control of surface water on the paddock by shortening the length of slope with contour banks, grassed buffers or temporary contour drains. For class two land with a gradient of 6-12%, contour drains or banks every 25 to 60 m are recommended, depending on the crop grown. Similarly, Class 4 land, with steeper slopes of 18-32%, requires breaks every 10-30 m.
- Disposal of water into vegetated natural watercourses, grassed waterways or grassed irrigator runs. This is particularly important for Classes 2, 3 and 4 where erosion (due to increased slope gradients) is the major limiting factor and where cut off drains redirect surface run-off. Vegetated waterways are far more stable and consequently less erosion prone than bare ground.
- Vegetating areas at high risk when using irrigation equipment (i.e. grassed irrigator runs).
- Establishment of grassed buffer strips between cropped areas and waterways or dams.

Surface water movement can also be reduced by increasing the infiltration of water into, and permeability through, the soil.

Such management practices might include:

- cultivation across the slope prior to sowing, cross slope furrows thereby helping to retain some water,
- retention of crop residues after harvest,
- growing cover crops during crop establishment to protect bare ground against rainfall impact and to decrease run off,
- sow a green manure immediately after harvest. Short rotation ryegrass is the best soil rejuvenator,
- following harvest, cultivation across the slope by deep ripping or shallow cultivation as appropriate to increase surface roughness, thereby increasing surface retention of water and reducing over land flow velocities,
- growing green manure crops as ground cover or "biological insurance” between production crops. Long fallows are not good for maintaining soil structure and fertility.

All the above practices are considered good management practices and should be applied to all land in classes 1 to 4.

Photo 18. Severe rill and gully erosion can occur if land is not managed within its capability.

Photo 19. A very high level of management, such as a system of raised beds, can allow land use above the identified land capability class. Both inputs and risks are greater, however.

Soil structure

One of the features of the red Ferrosols is that they inherently have better physical attributes than other soils, e.g. infiltration rates are an order of magnitude greater than on soils formed from sedimentary or metamorphic rocks and soil structure is significantly more stable than many other soil types. Even following years of poor husbandry resulting in significant soil structural decline, degraded Ferrosols can still have better attributes than other non-degraded soils. This can be a problem when trying to convince farmers of red Ferrosol soils of the importance of maintaining good soil structure. Despite their apparent robustness many of the Ferrosols are now in a degraded condition following years of intensive agricultural production. It is essential that farmers become more aware of the importance of maintaining soils in good condition.

The most significant aspect involved in soil structure degradation on red Ferrosols appears to be soil compaction by cultivation and harvest machinery. While some compaction can inevitably result from intensive use of the land it can also occur where inappropriate land management practices are applied. Preventing degradation is far better and, in the long term, cheaper, than trying to revitalise it. Techniques for preventing soil compaction include:

- avoid cultivating and harvesting in the wet,
- Minimise impact of stock on soil by store feeding through winter,
- underwork rather than overwork your soil,
- combine operations in a single pass,
- restrict traffic to designated tracks.

Farmers have to be convinced to adopt management practices which not only minimise deterioration in soil structural attributes but also improve the condition of these attributes. Recommended practices on all land capability classes to enhance soil structure of red Ferrosols include:

- growing green manure crops -"biological ripping"- such as annual ryegrass, oats, lupins, or ryecorn,
- deep ripping of compacted soils and plough pans when soils are slightly moist to increase aeration and drainage,
- incorporating a pasture phase in any crop rotation. Pasture grasses have vigorous fine root systems which bind soil particles into aggregates and create new drainage paths. A longer pasture phase gives greater benefits than a quick green manure crop as the pasture roots will have many seasonal growth cycles allowing for more aggregate binding and greater soil organic matter contributions.
- retaining crop residues and incorporating them rather than harvesting or burning off.

The history of operations on areas of a paddock will often identify localised soil structure problems. These may have been caused by inappropriate harvesting, trafficking or irrigation operations. Remedial action, such as deep ripping, may need to be undertaken only on badly affected areas such as headlands, tracks and gateways, rather than the whole paddock.

Organic matter

The maintenance of organic matter levels is critical in the long term management of red Ferrosols because of its contribution to the cation exchange capacity (the ability of the soil to retain nutrients), as well as to aggregate stability. Decreases in organic matter associated with management changes jeopardise future crop yields by reducing the soil's cation exchange capacity, and store of nutrients including exchangeable cations (Mg, K, Ca) and total nitrogen. Processes associated with intensive cropping which result in loss of organic matter, such as erosion and oxidation through excessive cultivation, must be managed to minimise these adverse effects. Appropriate soil conservation strategies should be adopted to minimise erosion, the minimum amount of tillage should be undertaken, harvest residues should be retained and green manure crops grown using techniques similar to those for the maintenance of good soil structure described above. These measures apply to all land capability classes. Chilvers (1996) provides figures which should act as a guide as to the desirable organic matter levels for a range of Tasmania’s cropping soils.

Sandy soils

A range of soil types exist in the Wesley Vale/Moriarty district which occur in association with the Ferrosols. Many of these soils are very sandy and easily eroded by surface water or wind erosion. Many of these soils fall into land Classes 4 or 5 but, because of the complex association with Ferrosols, are often cropped intensively resulting in significant erosion and loss of organic rich topsoil. Maintenance of a good ground cover for as long as practicable is critical to prevent erosion and to keep the soil on the paddock. Minimum tillage techniques, such as direct drilling, should be adopted. Powered implements are inappropriate on these sandy soils as they increase the loss of organic matter and leave the soil in a more erodible condition by breaking up the already fragile soil structure. Installation of contour drains on Class 4 land with sandy soils, where gradients are less than 5%, should be a prerequisite for any cropping activity. Drain spacing should not exceed 30 m.

Poorly drained soils

Poorly drained and black cracking clay soils are used for crop production but only summer crops are grown or crops tolerant of wetter soil conditions, such as apples. Many of these soils fall into land classes 4 or 5.

Good soil management on these soils begins with good drainage. Adequate surface drains (open ditches) are a priority, with the provision of appropriate outfalls being critical to success. Drain spacings are dependent on topographic situation and local soil conditions. Permanent bedding systems have been adopted on a farm at Forth to better manage low lying wet soils. All traffic is permanently restricted to the wheelings between beds which confines compaction to uncropped tramlines whilst the raised beds provide a better drained, more easily worked seed bed and crop growing medium.

Duplex soils

Many duplex soils also fall into land classes 4 or 5. Duplex soils are those soils with a distinct change in texture between the topsoil and subsoil, eg. sandy loam over a clay loam. Within the survey area these soils are rarely used for annual cropping but more often for grazing and pip fruit production. Keys to better soil management on duplex soils include:

- promotion of surface drainage,
- avoidance of compaction and pugging by stock,
- top working of soils with tines or discs when cultivating rather than conventional ploughs, and
- avoidance of mixing topsoil with subsoil by deep ripping or deep ploughing.

Additional information on soil management is contained in 'Managing Tasmania's Cropping Soils' (Chilvers, 1996) or "Keeping your Soil on your Farm" (Kindred Landcare Group, 1994) available from your local DPIF office.

GLOSSARY

Alluvial deposits: Material transported by rivers and deposited on alluvial plains.

CEC (Cation exchange capacity): The total amount of exchangeable cations that a soil can absorb being made up of calcium, magnesium, potassium, sodium, aluminium and hydrogen. CEC affects soil properties and behaviour, stability of structure, the availability of some nutrients for plant growth and soil pH.

Clay: Soil particles <0.002 mm.

Coarse fragments: Particles >2 mm, but not segregations of pedogenic origin (formed in soil profile).

Colluvial deposits: Weathered material transported by gravity.

Complex: The term complex is used to refer to a map unit where two land classes are identified but cannot be separated at the scale of mapping. In a complex unit the proportion of the two land classes is at least 60-40.

Conglomerate: A group of sedimentary rocks with particles greater than 2 mm which are rounded and subrounded and cemented together by a finer matrix.

Degradation: This is the deterioration of a resource through inappropriate or uncontrolled management or use.

Dispersive Soils: Refers to those soils which contain a high proportion of sodium on the exchange sites of the clay minerals. The high sodium content causes soil aggregates to break down as they absorb water. Dispersive soils are inherently unstable and easily eroded.

Dolerite: A medium grained, basic igneous rock that has crystallised near the surface of the earths crust.

Drainage: How water drains from the soil profile. Rapid drainage will cause water to move past the root zone in a short period limiting water uptake by the plant, while slow drainage will cause the soil profile to become saturated with water. A saturated profile will exclude most of the oxygen from the soil which leads to root cell death and greatly reduced uptake of moisture by the plant. Drainage depends on landscape position (which controls external drainage eg. run-off and run-on), permeability of soil (texture, structure and distribution of pore spaces) and impediments in the profile to water movement such as hardpan and rock.

Duplex Soils: These soils contain a strong texture contrast between the A and B horizons. Strong texture contrast is defined according to the *Australian Soil Classification* (Isbell, 1996).

Ferrosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996)as having a free iron content in the B2 horizon greater than 5%.

Ferruginous gravel: Gravel which is dominantly composed of iron-rich materials; also known as ironstone or laterite gravel.

Field Capacity: The amount of water held in the soil after the excess has drained away after saturation.

Fine sand: Particles from 0.06 to 0.1 mm, just visible with the naked eye and which feel similar to coarse flour or table salt.

Horizons: Layers within a soil profile which have morphological properties different from those above and below (Northcote 1979).

Land Capability: The ability of the land to support a range of practices or uses (in this report, agricultural uses) without degradation. The classification considers only the physical attributes of the land.

Land Suitability: Identifies the suitability of an area for a defined land use. Land suitability usually considers the economic and cultural suitability of a land use in addition to the land requirements. A comparison of land suitability evaluations for a range of different uses can identify the most suitable use for a particular area.

Limitation: Refers to the physical factors or constraints which affect the versatility of the land and determine it's capability for long term agricultural development.

Moisture availability: This is a measure or rating of the amount of moisture held in the soil which is available to the plant. It is defined as the difference between the field capacity of the soil and the wilting point. Field capacity occurs when the soil's large pores (>30 microns) have drained but when all the small pores and capillary channels are still filled with water. Wilting point is when the soil is dry to the point where the plants can extract no more water. Soil texture has the greatest effect on availability of water to the plant.

Nutrient availability: The ability of a soil to retain and supply nutrients for plant growth. Depends on the content and type of clay, organic matter content and pH.

pH: Soil pH is a measure of the acidity or alkalinity. A pH of 7 denotes a neutral soil with a log scale of increasing alkalinity of pH 7 to 14, and a log scale of increasing acidity of pH 7 to 1.

Podosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as being soils that have B horizons dominated by the accumulation of compounds of organic matter and aluminium, with or without iron.

Quartzite: Thermally or regional metamorphosed rocks of sedimentary origin rich in silica. The original grains recrystallise to form an interlocked mosaic texture with little or no trace of cementation.

Slake: The partial breakdown of soil aggregates in water due to the swelling of clay and expulsion of air from pore spaces.

Sodicity: This is a measure of the sodium attached to clay particles in a soil. A soil is considered sodic when the sodium concentration reaches a level that begins to affect soil structure. (usually above 6% Exchangeable Sodium).

Subsoil compaction: Potential for development of traffic compaction pan below the surface, usually 10 to 30 cm deep. Pans restrict root growth into the subsoil. Pan development can occur in most. Yield response can be obtained on some soils by deep ripping to break the traffic pan.

Soil structure decline: The degradation of the soil structure. Soil aggregates may be destroyed by excessive cultivation/harvesting or trampling by stock, leaving a compacted, massive or cloddy soil. Soils are particularly susceptible when wet.

Sustainable: The concept of sustainability in the agricultural context has given rise to considerable discussion. Very simply, *sustainable* land use implies a land use which can be continued in the long term without damage to the environment or the natural resource. It is generally agreed that agricultural inevitably results in some damage but for land use to be considered sustainable the damage has to be kept to an acceptable minimum and allow the continued long term use of that land.

Talus: Accumulation of rocks and boulders at the foot of a cliff or steep slope (also referred to as scree).

Water erosion hazard: The potential for sheet, rill or gully erosion to occur on a land surface. The land surface is most prone to erosion when cultivated and/or when little or no vegetative cover is present. Land management to suit site conditions can minimise the severity, and often prevent most occurrences of water erosion. Erosion hazard depends on soil erodibility, amount of ground cover, slope gradient, rainfall (intensity and amount), and the amount of run-on received.

Wind erosion hazard: The potential for a land surface to erode by the action of wind. Appropriate land management and ground cover will protect the soil surface. It depends on soil erodibility (especially particle size and soil structure), exposure to the wind and amount of ground cover. Loose, structureless soils are most at risk from wind erosion hazard.

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APPENDICES

APPENDIX AExample of a Completed Land Capability Site Card

APPENDIX A. Example of Completed Land Capability Site Cards

Site	Map Name	Project	Date	Describer
LC 229	LATROBE	FORTH	4-2-97	GROC.

Grid Ref: E. 454 525 N. 5437 500

Slope: 9% Rainfall: 860 Elev: 90

Drain: WELL Geol (map): TW (field): TW Aspect: 340

Soil Type: SAND PPF: Isbell:

Horizon	A1	B1	B2			
Horizon Depth (cm)	0-20	20-30	30-50			
Horizon Colour	7.5YR3/4	5YR 4/6	5YR 4/6			
Mottle abundance						
Mottle type						
Mottle %						
Structure grade	VERY WEAK					
Structure size (mm)						
Structure shape						
Texture	LOAMY SAND	CLAYEY SAND	CLAYEY SAND.			
Coarse frags<60mm	5%		15%			
Coarse frags>60mm	5%		10%			

Topography: LOWER HILLSLOPE Flooding: NIL

Veg Type: Rooting depth: 30 cm.

Land Capability: 4e Photo y/n: N Samples y/n: N

1 e- erosion
2 w- wetness
3 s- soil
4 c- climate
5 f- flooding
6 r- rockiness
7 t- topographic
E o- other.....

Location Note:
250m S.E. OF JUNCTION FRANKFORD / WESLEY VALE ROADS

Erosion type:
WIND AND WATER

Current Land Use:
PASTURE

General Note:
PRONE TO WIND AND WATER EROSION
DRIES OUT IN SUMMER, WET IN WINTER
IMPENETRABLE BELOW 50cm - BASALT GRAVELS AND HORIZON V. COMPACT.

Shaded areas indicate those fields which must be completed