DERWENT REPORT

Land Capability Survey of Tasmania

R A MUSK and R C DE ROSE
Department of Primary Industries, Water and Environment
Newtown Offices
2000

with contributions from
Julie Finnigan, Salinity Officer, DPIWE Launceston

Derwent Report
and accompanying 1:100 000 scale map

DEPARTMENT *of* PRIMARY INDUSTRIES, WATER *and* ENVIRONMENT
Tasmania

Natural Heritage Trust
Helping Communities Helping Australia

Published by the Department of Primary Industries, Water and Environment, Tasmania with financial assistance from the Natural Heritage Trust

Printed in house, New Town and by the Printing Authority of Tasmania, Hobart.

ISSN 1036 5249
ISBN 0-7246-4806-2

Refer to this report as:

Musk R. and De Rose R. (2000), Land Capability Survey of Tasmania. Derwent Report. Department of Primary Industries, Water and Environment, Tasmania, Australia.

Accompanies 1:100 000 scale map, titled ‘Land Capability Survey of Tasmania. Derwent.’ by R Musk and R De Rose, Department of Primary Industries, Water and Environment, Tasmania, 2000.

Contents

ACKNOWLEDGEMENTS

Many people and organisations have combined to make the production of this report and map possible. The authors wish to thank each of them for their respective contributions.

- The farmers and land managers who allowed us access to their properties during fieldwork, and gave freely of their knowledge about crop varieties, rotations, and productivity on their properties. The authors would like to express their sincere thanks to all those individuals for their time and advice.

- The Bureau of Meteorology for providing climate data.

Department of Primary Industries, Water and Environment staff, who contributed to the production of this map and report include:

- Matthew Lawless, who assisted with all aspects of the land capability project from logistical support during field mapping to preparation of figures and digitising of the final map.

- Chris Grose for guidance during mapping, and editing and reviewing of the final report.

- The GIS team of Mark Brown, Simon Lynch and Tony Davidson, for preparation of base maps, climate modelling, and digitising and preparation of the 1:100 000 map.

- The soil survey team of Peter Zund and Paul Pohlner for soil investigations of the alluvial plains. Also, to Stacey Spanswick for her helpful insights regarding soil description and classification.

- Frank Walker, Lindsay Richley and Allan Harradine for reviewing the report prior to publication.

- The staff of Land Information Services for supplying digital topographic data.

And finally, the Natural Heritage Trust, without whose financial support the project would not have been possible.

SUMMARY

This map describes and classifies the land resources occurring on privately owned and leased Crown land within the area defined by the limits of the Derwent 1:100 000 scale topographic map (Sheet No: 8312). The survey area extends over 211321ha of land of which 37 726ha is mapped as exclusion area.

The area lies in central south eastern Tasmania and includes the city of Hobart, and the smaller centres of Kingston, New Norfolk, Bridgewater, Kempton, Campania, Richmond, Rokeby and Lauderdale. The survey area extends along the lower reaches of the Derwent Valley from Kingston to approximately six kilometres upstream from New Norfolk. It includes the major part of the Jordan and the Coal River catchments from five kilometres north of Kempton and Colebrook respectively, as well as the upper reaches of Mountain River to the south of Mt Wellington. Mt Wellington and adjacent peaks form the dominant topographic feature of the survey area.

The land is described and assigned land capability classes according to the system defined in the Tasmanian Land Capability Handbook (Noble 1992a, Grose in press). The land capability assessment categorises land units according to their ability to produce agricultural goods without impairment to their long term, sustainable, productive potential. Each land unit is assigned one of seven capability classes, from Class 1 to Class 7 with increasing degree of limitation to agricultural production and decreasing range of potential agricultural uses. Class 3 or better land represents prime agricultural land and is generally restricted to the better soil types under the more favourable site and climatic conditions. Classes 1 to 4 land is suitable for broad acre cropping. Classes 5 to 6 land are suitable for pastoral activities only, and Class 7 land is unsuitable for agricultural use.

In interpreting information contained within this report the reader needs to be aware of the following important points relevant to the land capability classifications system:

- Land capability assessment in Tasmania is based on rainfed agriculture and does **not** consider the potential for irrigated agriculture.
- Climate is an important factor in determining land capability. Thus in areas of low rainfall, the lack of precipitation may limit land capability to Class 4 although, with irrigation, the land may be used at a capability Class 3 level or higher (see comments below).
- Land capability is assessed for broad acre cropping and grazing activities. Horticultural activities, notably orcharding and viticulture are not considered in the evaluation.
- The 1:100 000 scale of survey restricts the area of contiguous land that can be reasonably mapped to about 64ha or above. Smaller areas of land are occasionally mapped where they are considered significant.
- Mapped units are not pure, and may contain up to 40% of another class, although in most cases the area of inclusions will be much smaller than this.

The land capability survey was achieved through a combination of field work, aerial photo interpretation and computer modelling. The major limitations to agriculture were

identified as poor soil properties (poor internal drainage, low fertility, dryland salinity, shallow rooting depth and stone content), water and wind erosion potential and unsuitable climate (low or high rainfall and frosts). The range of agricultural activities and their distribution across the survey area largely reflect the limitations identified.

Table 1 indicates the amount of each land capability class identified. Few areas of prime agricultural land (Class 1, 2 and 3 land) were mapped within the survey area. Small areas of Class 3 land were mapped on basalt and alluvial soils south west of Hobart where annual rainfall was considered adequate to support a range of cropping activities. Throughout much of the remainder of the survey area, low temperatures coupled with extremely low summer rainfall produce a short growing season from October to December. This severely restricts the range and types of crops that can be grown. Consequently, most of the land north and north east of Hobart, irrespective of the soil types present, is restricted to Class 4 or poorer.

The main agricultural activities within the Derwent survey area include dairying, ley farming, and irrigated or dryland broadacre cropping enterprises on the more fertile valley flats and footslopes (Class 4 and 5 land). Here, a wide range of soil types have developed in Triassic sediments, Tertiary basalt, Jurassic dolerite, and Tertiary and Quaternary alluvial deposits. There is a growing trend towards non-traditional agricultural production, such as viticulture, where suitable microclimates and soil types occur. The upper reaches of the Huon Valley to the south of Mount Wellington have generally poor soils developed in Permian sediments, but the higher rainfall here supports pome fruit enterprises and very productive pastures on Class 5 land. Grazing enterprises also dominate in the south east region where extensive Quaternary sand sheets cap older sediments (Class 5 land). The lower slopes and benches of the rises and hills provide grazing on productive native and improved pastures (Class 5 and 6 land). These areas are typically underlain by Permian and Triassic rocks which produce nutrient poor, erodible soils. Jurassic dolerite commonly occurs further upslope and, while producing more fertile soils, they are often stony and shallow. Extensive areas of hilly country support rough grazing both on cleared land and under native forest and woodland, particularly on steeper slopes (Class 6 land). Mountain lands above about 800m, together with very steep rocky slopes, and coastal swamps are unsuitable for any form of agriculture (Class 7).

Within valley systems in north and eastern parts of the survey area (eg. Coal River, Jordan Rivers, River Derwent west of New Norfolk) more fertile black to brown gradational clay rich soils have developed from underlying basalt, dolerite, or recent alluvium and these produce among the best soils for cropping in the region. The agricultural potential for these fertile areas is often limited only by low rainfall (less than 600mm per annum) and can be significantly improved through irrigation, thereby allowing a wider range of crops to be grown with higher crop yields. Much of the pea, poppy and brassica production in the survey area, for example, occurs within the South East Irrigation Scheme (SEIS).

While it is recognised that these lands have the potential for improved productivity under irrigation it is acknowledged that there are significant risks associated with intensive irrigation practices. The development of secondary salinity is of particular concern given the variable quality of stream and dam water used for irrigation. Soil salinity is potentially one of the major issues that will determine the long term viability of irrigated agriculture in Tasmania. However, there is presently insufficient information available to evaluate the long term consequences of irrigation in these environments. A review of our current state of knowledge of salinity issues, with particular reference to south eastern Tasmania, is presented in Chapter 7.

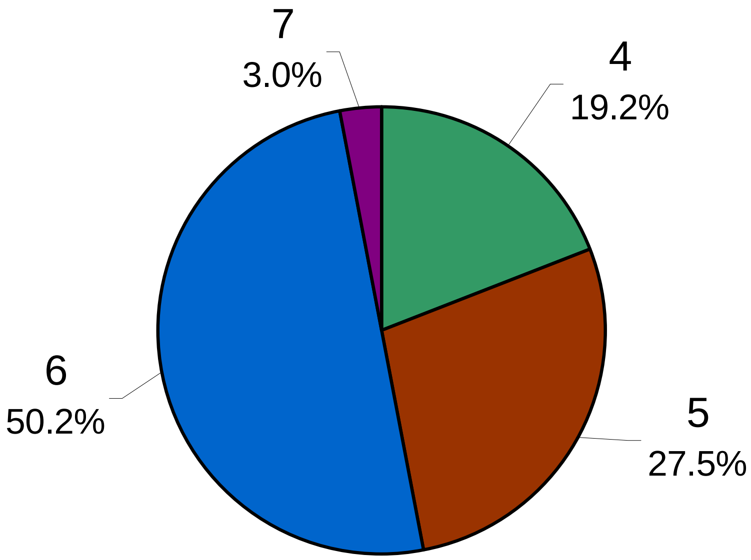


Figure 1. Relative proportion of Land Capability Classes on privately owned and leased Crown land within the Derwent map. Class 3 land makes up only 0.08% of the surveyed area and is too small to be shown on this chart relative to other classes.

Figure 1 above indicates the extent of the identified land capability classes within the survey area. These include complex units in which two land classes have been identified but cannot be usefully separated at the scale of mapping. Within each complex the first land class identified is dominant, occupying 50-60% of the unit, while the second class occupies only 40-50%. Complexes occupy only a small percentage of mapped units.

Table 1. Extent of Land Classes and Land Class Complexes on the Derwent map.

Capability Class	Area (ha)	% of Derwent map
3	45	0.02
4	32 186	15.23
4+3	249	0.12
4+5	586	0.28
5	44 481	21.05
5+4	1 569	0.74
5+6	3 178	1.50
6	85 024	40.23
6+5	879	0.42
7	4 796	2.27
7+6	602	0.29
E	37 726	17.85
TOTAL	211 321	100.00

1. INTRODUCTION

This report describes the land capability of the agricultural land within the Derwent 1:100 000 map sheet (Sheet No. 8312) The distribution of the land capability classes identified is depicted in the accompanying map.

This report continues the series published by the Department of Primary Industries, Water and Environment as part of a 1:100 000 scale land capability survey of Tasmanian agricultural land which first started in 1989. This report and map describe and depict the land capability of private freehold and leased or unallocated crown land only. Other areas are considered non-agricultural and are mapped as exclusion areas. Being one of a series, much of the framework of this report, and some chapters, have been reproduced from the earlier reports by Noble (1991, 1992b, 1993), Grose and Moreton (1996), and Moreton and Grose (1997).

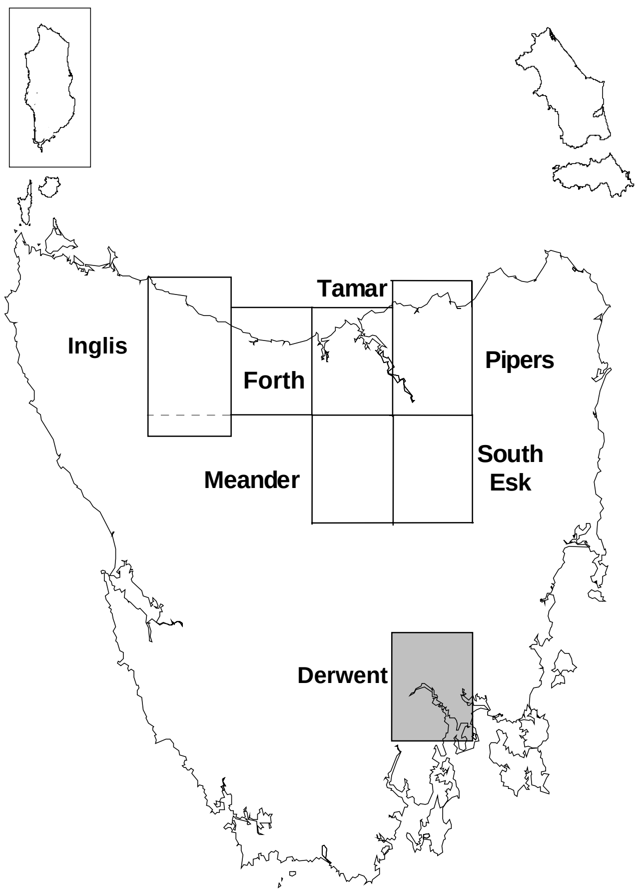


Figure 2. Derwent Survey Location and Previous Land Capability Surveys in Tasmania

The land capability survey aims to: a) identify and map the extent of different classes of agricultural land in order to provide an effective base for land use planning decisions; and b) ensure that the long term productivity of the land is maintained at a sustainable level through the promotion of compatible land uses and management practices. It undertakes to achieve these aims through a program of mapping activities and associated extension and awareness programs such as Farmwi$e and Best Farm Practice.

The land capability classification system for Tasmania comprises a seven class classification which ranks the capability of land to support a range of agricultural uses on a long term sustainable basis (Noble 1992a). The classification system ranks the capability of land to support sustained agricultural production and does not consider suitability for individual crops, silviculture, horticulture, viticulture or other non-agricultural uses. The information printed here and in the accompanying map is intended for use at a regional planning level and is inappropriate for farm scale planning. However, the system and the methodology can be applied at any level.

Chapter 3 explains land capability classification in detail and provides explicit definitions of land capability classes and subclasses. Chapter 4 of this report explains the survey method and the guidelines which were used in assessing land within the survey area. A detailed description of the survey area appears in Chapter 5. A detailed account of land capability classes occurring within the survey area is presented in Chapter 6, wherein the land capability information is arranged hierarchically, firstly by class and secondly by the geology unit on which the class occurs. Chapter 7 presents a general discussion on soil and water salinity in the Derwent survey area together with some issues and concerns relevant to the development of irrigated agricultural enterprises.

Ever increasing demands are placed on our agricultural land to produce greater yields with a corresponding greater risk of land degradation. For Tasmania to continue to support a productive agricultural industry into the future, land holders must employ appropriate soil conservation measures. Much of Tasmania's agricultural land has limitations which restrict the variety of crops that can be grown both productively and sustainably. The land capability classification system provides the framework to determine these limitations, and the classification that results from this process allows land managers to make informed decisions to ensure productive and sustainable use of the land. In other words, the use of land within its' capability.

In addition to its use as an agricultural land management tool, land capability information is required by regional planners to make informed, objective land use planning decisions. High quality agricultural land is irreplaceable and needs to be protected from loss to urban development and rural subdivision. To this end, this report and accompanying map are a valuable tool for Councils to assist with implementation of the State Policy for the Protection of Agricultural Land (1999).

2. HOW TO USE THIS MAP AND REPORT

This publication comprises a report and map. It is important that the land capability map be used in conjunction with the accompanying report.

Land capability classes are briefly defined in the map legend, and more detailed definitions may be found in Chapter 3 of this report. Further information regarding limitations for each of the land capability classes may be found in Chapter 6.

2.1 Limitations of Scale

Special attention must be paid to the limitations of the map imposed by the scale at which it was surveyed.

It is important that the map is used at the scale at which it is published (1:100 000). **The map should not be reproduced at a larger scale (eg. 1:25 000)**. The land capability boundaries found on this map are accurate only at the published scale of 1:100 000. Errors in interpretation will occur if the map is enlarged. If more detail is required, the area of interest should be remapped at a more suitable scale for the end use.

Gunn *et al* (1988) state that, at a scale of 1:100 000, the standard minimum area for a map unit which can be adequately depicted on the map is approximately 64ha. There appears to be little consistency however, as Landon (1991) suggests that a wide range of minimum areas are currently in use. For the purposes of this work, unit areas of less than 64ha have been mapped only where they are identifiable on the basis of clearly visible boundaries (usually topographic), or where they appear at the margins of the map or adjacent to exclusion zones. Impurities in map units will occur where land class changes are a result of less obvious changes in land characteristics.

In any mapping exercise there are always areas which are physically too small to delineate accurately at a given map scale. These areas are usually absorbed by surrounding units. The map units shown on this map will therefore often contain more than the one land capability class or sub-class. The map units are assigned the dominant land capability class within them, but it must be recognised that some map units may contain up to 40% of another class. In the majority of cases however, a land capability map unit is approximately 80%, and in more uniform areas, up to 90% pure.

COMPLEX map units (eg. 4+5) have been mapped in some areas where two land classes are identified that cannot be delineated separately at this scale of mapping. These complex units represent areas where each class occupies between 40% and 60% of the unit area and are shown as striped units on the map. The first digit of the map unit label and the slightly wider of the two coloured stripes represent the dominant land capability class. Further discussion of this issue and the method of labelling units is found in Chapter 3.

The accuracy of the land capability class boundaries depends on a number of factors including the complexity of the terrain, soils and geology. Class boundaries are accurately mapped where topography, or other visible features important in boundary detection, change abruptly. Alternatively, where landscape changes are gradual, such as is often the case with changes in soil depth or slope, the class boundary may be gradual and therefore less accurately mapped.

2.2 Interpretation of the Land Capability Information

The scope and range of applications of land capability information depend upon the scale of the mapping program. This map has been surveyed at a 1:100 000 scale and is targeted for use at the district or regional planning level. Therefore, best use can be made of this map and report by local government, as well as regional and State land use planning authorities.

The information at this scale is **not** suitable for use in planning at the farm level. It does however, provide a general indication of land capability which makes it a useful starting point for more detailed studies. Larger scale maps (1:5 000 or 1:10 000) are suitable for farm planning purposes. For example, they are a useful information source for planning farm layouts, and identifying appropriate soil conservation and land management practices. The methodology applies to all scales of mapping and can be utilised equally well by local landowners, and local, regional or State planning authorities. A detailed discussion of the methodology may be found in Chapter 4.

Some examples of suitable uses of land capability information at 1:100 000 scale are:

- **Identifying areas of prime agricultural land to be protected for agricultural use**
- **Enabling rational planning of urban and rural subdivisions**
- **Identifying areas for new crops, enterprises or major developments**
- **Identifying areas for expansion of particular land uses**
- **Planning of new routes for highways, railways, transmission lines, etc.**
- **Identifying areas of land degradation, flooding or areas that may require special conservation treatment**
- **Identifying areas of potential erosion hazard**
- **Resolving major land use conflicts**
- **Establishing integrated catchment management (depending on catchment size)**

Describing land capability information through this report and accompanying map is insufficient to ensure the adoption of sustainable land use practices. The move towards more sustainable practices can only occur through increased social awareness and education (a recognition that change is needed) together with the development of an appropriate implementation framework. This includes the legislative and administrative support responsible for putting land use policies into practice.

The land capability maps and reports do not purport to have legal standing as documents in their own right, nor should they attempt to stand alone in planning decisions without being supported by other relevant land resource, economic, social or conservation considerations. Indeed, the interpretation of land capability information can be greatly enhanced when viewed in concert with other resource information. The information is intended as a guide to planning development. More detailed plans, for example route alignments or farm plans, require further fieldwork at a more appropriate scale.

2.3 Copyright

The maps, reports and digital information stored on the DPIWE databases are copyright, and the data is solely owned by the Department of Primary Industries, Water and Environment, Tasmania. We offer every encouragement to individuals and organisations who wish to use the information contained in this report and accompanying map to assist in property management or regional planning activities. However, commercial organisations or individuals wishing to reproduce any of this information, by any means, for purposes other than private use, should first seek the permission of the Secretary, Department of Primary Industries, Water and Environment, Hobart.

2.4 Availability of Other Reports and Maps in this Series

Land Capability Publications (based on the TASMAP 1:100 000 Series) currently available :

Inglis Report and Accompanying Map
Forth Report and Accompanying Map
Pipers Report and Accompanying Map
Tamar Report and Accompanying Map
Meander Report and Accompanying Map
South Esk Report and Accompanying Map
Land Capability Handbook (Second Edition)
Land Capability Classification in Tasmania, Information Leaflet

Maps, reports and the handbook are available for purchase by contacting Service Tasmania or direct from:
Department of Primary Industries, Water and Environment
Resource Management and Protection Division
Land and Water Assessment Branch
GPO Box 46
KINGS MEADOWS, TAS 7249.

3. LAND CAPABILITY CLASSIFICATION

Land capability classification is an internationally recognised means of land evaluation used to determine the capability of land to support a range of land uses on a long term, sustainable basis.

For the Tasmanian classification system, only agricultural land uses are considered. These are defined as broad scale grazing and cropping uses. Land capability ratings for specific land uses are not evaluated, nor is the capability of land for silvicultural, viticultural, or horticultural use incorporated into the classification system.

Land capability may be defined as a rating of the ability of land to sustain a range of land uses without degradation of the land resource. It is an interpretive and somewhat subjective assessment based on the physical limitations and hazards of the land, potential cropping and pastoral productivity, and the versatility of the land in producing a range of agricultural goods.

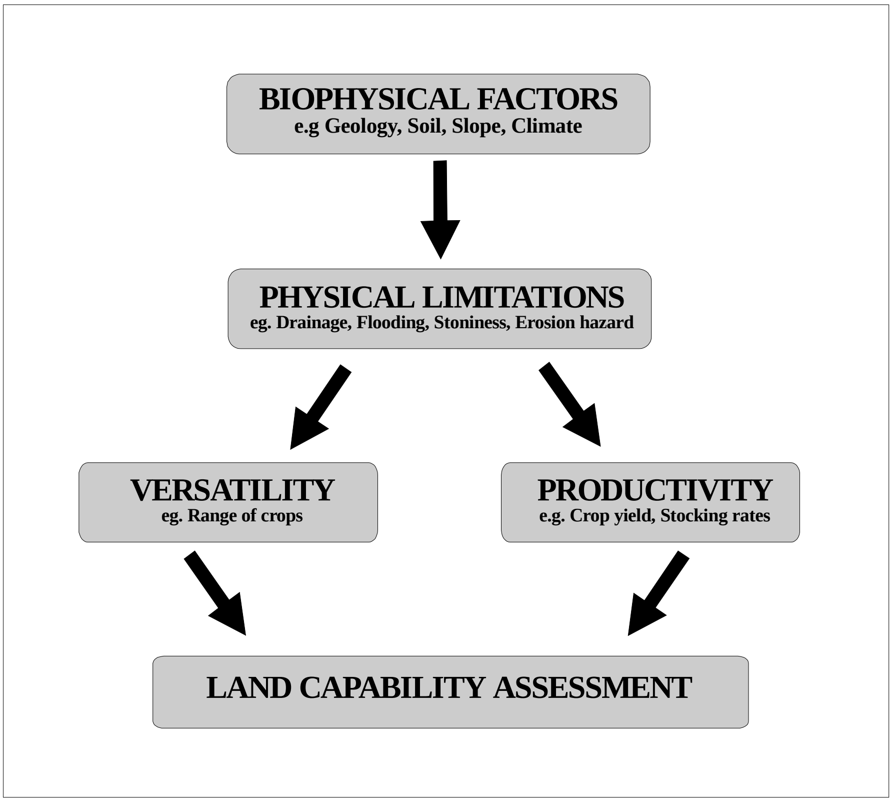


Figure 3. Factors in land capability assessment.

Land capability assessment takes into account the physical nature of the land (e.g geology, soils, slope) plus other factors (eg. climate, erosion hazard, land management practices) which determine how that land can be used without destroying its long term potential for sustainable agricultural production. It also takes into account limitations that might affect agricultural use, such as stoniness, drainage, salinity or flooding. Land capability assessment is therefore based on the permanent biophysical features of the land (including climate), and does not take into account the economics of agricultural production, distance from markets, or sociopolitical factors.

Land capability assessment should not be confused with land suitability assessment which, in addition to the biophysical features, may assess economic, social and/or political factors to determine the best use of a particular type of land. Land capability classification gives a grading of land for broad scale agricultural uses, whereas land suitability classification is applied to more specific, clearly defined land uses, such as classifying land ‘suitable’ for growing carrots. In addition, land suitability usually defines specific management systems.

3.1 Features of the Tasmanian Land Capability Classification System

The Tasmanian system of land capability classifies land into seven classes according to its’ capability to produce agricultural goods. The system is modelled on the United States Department of Agriculture approach to land capability (Klingbiel and Montgomery 1961) and is described in full by Noble (1992a) and Grose (in prep). A summary of the system is presented here to assist in the interpretation of the report and accompanying map. The classification does not attempt to portray specific land uses, nor rank the value of any particular agricultural land use above another. Neither does it attempt to give an indication of land values.

The classification relates primarily to three permanent biophysical features of the landscape - soil, slope and climate - and their interactions, such as soil erodibility, flood risk, soil moisture holding capacity, etc. These three factors have a major influence in determining the capability of the land to produce agricultural goods. Past land use history and present management practices, such as the range of crops grown and soil conservation treatment required, are used as a guide in land capability assessments.

Three levels are defined within the Tasmanian land capability classification:

- The land capability **Class** - which gives an indication of the general degree of limitation to use
- **Subclass** - which identifies the dominant kind of limitation
- and the **Unit** - which groups land with similar management and conservation requirements, potential productivity, etc.

The land capability system can be used and applied at various scales by mapping to the class, subclass and unit levels. The level at which the mapping is undertaken and presented depends on the purpose and scale of the survey. The levels of the land capability classification system are shown in Figure 4.

The classification system comprises seven classes ranked in order of increasing degree of limitation, and in decreasing order of versatility, for agricultural use. The system is hierarchical. Class 1 land can produce a wider variety of crops and pastures at higher levels of production with lower costs, or with less risk of damage to the land, than any other of the land classes. Class 2 land is more productive than Class 3, and so on.

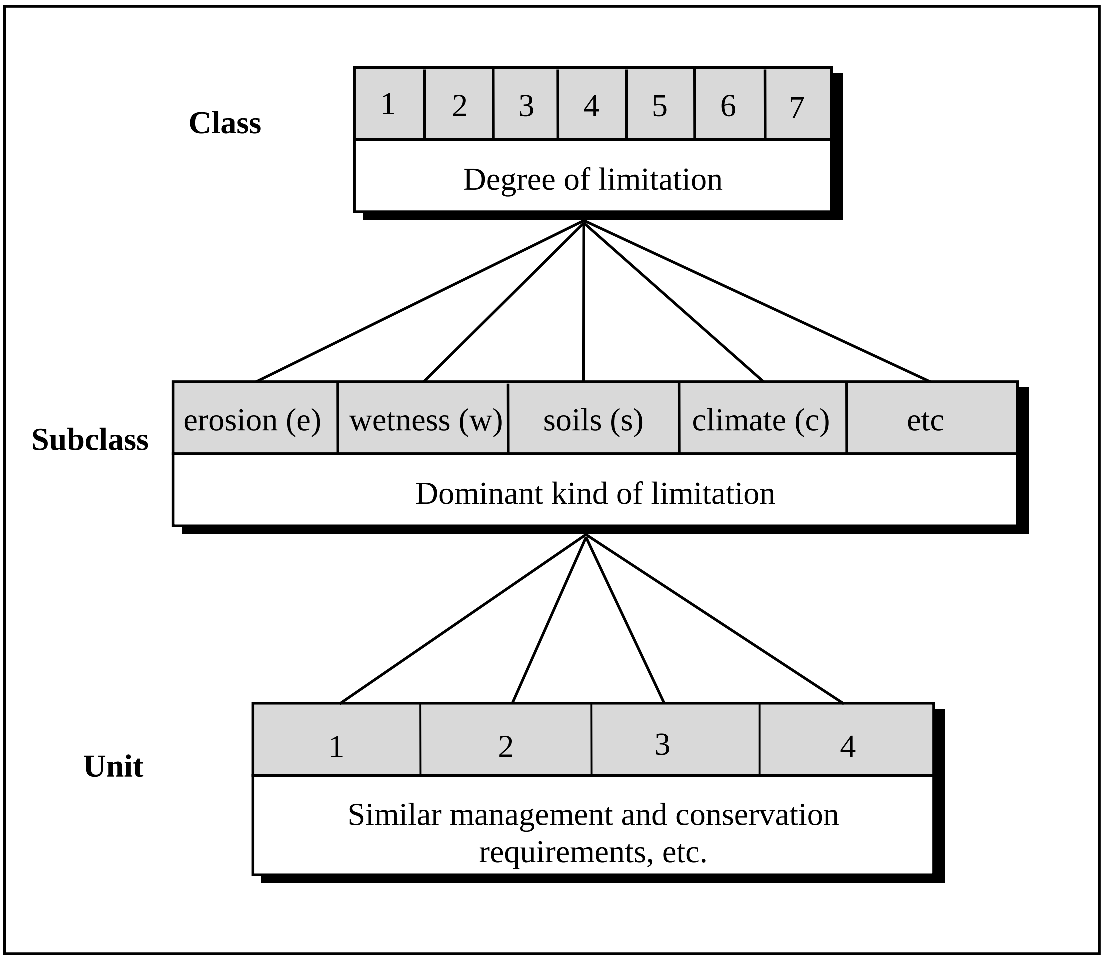


Figure 4. Levels of the land capability classification system. (Adapted from: National Water and Soil Conservation Organisation, 1979, Our Land Resources. NWASCO, Wellington, New Zealand).

Each land class can be subdivided into subclasses depending on the nature of the dominant limitation or hazard to the use of that land. Limitations may be defined as physical factors or constraints, which affect the versatility of the land and determine its' capability for long term sustainable agricultural production. Some limitations can be removed or modified through normal management practices or other means. Where such improvements are considered feasible, both physically and economically, land may be classified higher than its' current condition may indicate. Such improvements do not include the use of irrigation water but may include drainage or stone picking.

Each subclass may be further subdivided to unit level. Land capability units are areas of land with similar management and conservation requirements, or differences in productivity, which may not be significant at higher levels within the classification system. Thus an area identified as Class 4h may be further subdivided into 4h1 (Class 4h land subject to gully erosion) and 4h2 (Class 4h land subject to sheet erosion).

The system assesses the versatility of the land to produce a range of agricultural goods that are considered typical for Tasmania, and not just those that are specific or suited to localised areas. For example, small-scale intensive activities like soft fruit orchards and floriculture are not considered when evaluating the versatility of an area. Opportunities for silviculture are another activity that the system does not consider. The main agricultural land uses that are considered when evaluating land include cereals, poppies, broadacre vegetable production, pyrethrum and essential oils, together with pastoral activities such as dairying, and beef, lamb and wool production.

The system considers degradation of the soil resource and does not take into account the possible effects of agricultural land use on landscape values or biodiversity, except where they might impact on the quality of the agricultural resource.

The classification, in particular at the unit level, takes into account the management strategies and soil conservation requirements that the land may need in order to maintain a level of production without long term degradation.

As with most land classification systems certain assumptions are necessary. These include:

a) The land capability classification is an interpretive classification based on the permanent biophysical characteristics of the land.

b) A moderately high level of management being applied to the land.

c) Appropriate soil conservation measures having been applied.

d) Where it is reasonable and feasible for an individual farmer to remove or modify physical limitations (eg. surface and sub-surface drainage, stoniness, low fertility) the land is assessed assuming the improvements have been made.

e) Land capability assessments of an area can be changed by major schemes that permanently change the nature and extent of the limitations (eg. drainage or flood control schemes).

f) The land capability classification is not a productivity rating for specific crops, although the ratio of inputs to outputs may help to determine the land capability class.

g) Land capability does not take into account economic, social or political factors. It is not influenced by such factors as location, distance from markets, land ownership, or skill of individual farmers.

h) Present and past uses of the land (or similar land elsewhere) are guides to potential, in that they can indicate the limits of the capability of the land. Present land use and vegetation cover are not always good indicators of land capability class. The system of land capability is aimed at assessing the potential sustainable productivity of land rather than current productivity.

i) Assessments are based on the capability of the land for sustained agricultural productivity, since use of the land beyond its capability can lead to land degradation and permanent damage.

j) Irrigation, or the potential access to irrigation, is not considered when evaluating land capability.

k) The system is consistent across the State.

It is important to remember that the land capability of an area can change as a result of improved farming practices, such as improvements in crop variety and technical innovations. The information in this report has a limited lifespan and care should be given to its interpretation in future years. Farming practices that today are only available for the advanced or innovative farmer may become common practice in the future.

3.2 Land Capability Class Definitions

The criteria used to define classes are based on observation and experience only, and not on experimental work. Figure 5 outlines the main features of the capability classes. Classes 1-4 only are considered capable of supporting cropping activities on a sustainable basis; Classes 5 and 6 are suitable for grazing activities only, although pasture improvement may be possible on Class 5 land (Class 6 land remaining as native pasture); Class 7 land is unsuitable for any form of sustainable agricultural activity.

Also, there is a range of land that can occur in any one capability class. Thus it is often possible, for example, to identify good and poor quality Class 4 land. While the intensity of mapping required to achieve this is not feasible when mapping land classes at 1:100 000 scale it would be possible to map such differences at the unit level.

The land capability class definitions are as follows:

CLASS 1

Land well suited to a wide range of intensive cropping and grazing activities. It occurs on flat land with deep, well drained soils, and in a climate that favours a wide variety of crops. While there are virtually no limitations to agricultural usage, reasonable management inputs need to be maintained to prevent degradation of the resource. Such inputs might include very minor soil conservation treatments, fertiliser inputs or occasional pasture phases.

Class 1 land is highly productive and capable of being cropped eight to nine years out of ten in a rotation with pasture or equivalent without risk of damage to the soil resource or loss of production, during periods of average climatic conditions.

CLASS 2

Land suitable for a wide range of intensive cropping and grazing activities. Limitations to use are slight, and management and minor conservation practices can readily overcome these. However the level of inputs is greater and the variety and/or number of crops that can be grown is marginally more restricted than for Class 1 land.

This land is highly productive but there is an increased risk of damage to the soil resource or of yield loss. The land can be cropped five to eight years out of ten in a rotation with pasture or equivalent during ‘normal’ years, if reasonable management inputs are maintained.

CLASS		LIMITATIONS	CHOICE OF CROPS	CONSERVATION PRACTICES
1	Under cultivation	very minor	any	very minor
2		slight	slightly reduced	minor
3		moderate	reduced	major
4		severe	restricted	major + careful management
5	Under pastoral use	slight to severe	grazing	
6		severe	grazing	
7		very severe to extreme	No agricultural value	

Figure 5. Features of land capability classes

CLASS 3

Land suitable for cropping and intensive grazing. Moderate levels of limitation restrict the choice of crops or reduce productivity in relation to Class 1 or Class 2 land. Soil conservation practices and sound management are needed to overcome the moderate limitations to cropping use.

Land is moderately productive, requiring a higher level of inputs than Classes 1 and 2. Limitations either restrict the range of crops that can be grown, or the risk of damage to the soil resource is such that cropping should be confined to three to five years out of ten in a rotation with pasture or equivalent during normal years.

CLASS 4

Land primarily suitable for grazing but which may be used for occasional cropping. Severe limitations restrict the length of cropping phase and/or severely restrict the range of crops that could be grown. Major conservation treatments and/or careful management is required to minimize degradation.

Cropping rotations should be restricted to one to two years out of ten in a rotation with pasture or equivalent, during 'normal' years to avoid damage to the soil resource. In some areas longer cropping phases may be possible but the versatility of the land is very limited.

CLASS 5

This land is unsuitable for cropping, although some areas on easier slopes may be cultivated for pasture establishment or renewal and occasional fodder crops may be possible. The land may have slight to moderate limitations for pastoral use. The effects of limitations on the grazing potential may be reduced by applying appropriate soil conservation measures and land management practices.

CLASS 6

Land marginally suitable for grazing because of severe limitations. This land has low productivity, high risk of erosion, low natural fertility or other limitations that severely restrict agricultural use.

CLASS 7

Land with very severe to extreme limitations which make it unsuitable for agricultural use.

E - Exclusion Areas

Land that is not private freehold or leased crown land, is not included for assessment. Other exclusions included urban centres and other obviously non-agricultural areas.

Note on Class Definitions

The length of cropping phase given for Classes 1-4 is intended as a general guide only. Some land will not support production beyond the intensity recommended due to the unacceptable risk of erosion or soil structure decline. Other areas are limited by the risk of loss occasioned by more unpredictable factors such as adverse climatic conditions or flooding. Also, the classification system takes into account the *variety* of crops that can be grown. Thus Class 4 land often incorporates areas where production may be sustainable over a longer period than one or two years out of ten but only a relatively small range of crops can be grown. Whereas in other areas, Class 4 land is such that significant periods of cultivation without a break can lead to severe structure decline, hindering germination, water infiltration, soil aeration and increasing the likelihood of erosion.

It should be noted that capability classes have not been defined on the basis of productivity although a general relationship does exist.

3.3 Land Capability Subclass Definitions

The major subclass limitations together with their respective codes are summarised below. The decision as to whether a subclass should be recorded at the unspecified level (e, w, s, c) or at a more specific level is dependent on the ease with which specific limitations can be identified. For example, the aeolian erosion limitation is recorded only if it is clear that erosion has been caused by wind. If the cause of erosion is uncertain then unspecified erosion is recorded.

- **e** (erosion). Unspecified erosion limitation.
  - **a** (aeolian). Erosion caused by the effects of wind. Usually affects sandy or poorly aggregated soils and can occur on slopes of very low gradient.
  - **h** (water). Erosion resulting from the effects of rainfall, either directly through raindrop impact or through secondary effects of overland flow and surface runoff (including stream bank erosion).
  - **m** (mass movement). Landslip, slumping, soil creep and other forms of mass movement.
- **w** (wetness). Unspecified wetness limitation.
  - **f** (flooding). Limitations created through the surface accumulation of water either from overbank flow from rivers and streams, run-on from upslope areas or because the area lies in a topographic depression.
  - **d** (drainage). Limitations resulting from the occurrence of a high groundwater table, or restricted or impeded permeability within the soil profile, leading to the development of anaerobic conditions.
- **s** (soils). Unspecified soil limitation.
  - **g** (coarse fragments). Limitations caused by excess amounts of coarse fragments (particles of rock 2 - 600mm in size), including gravel, pebbles and stones, which impact on machinery, damage crops or limit growth. Coarse fragments may occur on the soil surface or throughout the profile.
  - **r** (rockiness). Limitations caused by boulders or outcrops of bedrock material greater than 600mm in size.
  - **k** (conductivity). Land at risk from salinity (as indicated by high electrical conductivity readings of a 1:5 ratio soil:water paste).
  - **l** (limiting layer). Rooting depth or depth to some limiting layer.
- **c** (climate). Unspecified climatic limitation.
  - **p** (precipitation). Limitations resulting from insufficient, excessive or uneven distribution of rainfall.

  - **t** (temperature). Limitations caused by frost risk or by reduced length of growing season due to low temperatures.

- **x** (complex topography). Limitations caused by irregular, uneven or dissected topography which hinder vehicular access or cultivation.

Use of Information

A valid criticism of the Land Capability methodology is that it is very subjective and dependent on the interpretation of individual surveyors. For this reason, a set of guidelines is being developed (Grose *in prep*) to ensure consistency among surveyors. The guidelines are based on a quantitative assessment of a range of a land attributes critical to the evaluation of land capability. There will, however, always remain some subjectivity in the determination of cut-offs points for each land class. This is largely due to the gradational nature of boundary conditions between each class. The guidelines provide as high a level of consistency for land assessment as is possible at the time of writing of this report. Future improvements to the classification may result from increases in knowledge acquired during subsequent mapping programs.

The authors therefore 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 Senior Land Assessment Officer, Land Assessment Section, Resource Management and Conservation, DPIWE.

4. SURVEY METHOD

Field work for the Derwent Land Capability map was undertaken between July 1998 and April 1999 using information drawn from a wide variety of sources. These included existing soil descriptions held by DPIWE, the advice of farmers, land managers and agricultural advisers within DPIWE, field assessments, aerial photo interpretation and computer modelling.

Field assessments involved land capability site descriptions and reconnaissance surveying to extrapolate and map class boundaries. In all, some 310 land capability descriptions were recorded. This site information was recorded on field sheets which were then transferred to the DPIWE soils database. The field sheet records the site information required to justify the assessment, together with both the assigned land capability class and subclass. This information included site location, landform description, site aspect and slope. Soils were examined in the field where necessary. This was done using either a push-tube rig, a hand held soil auger, or by examination of existing soil exposures. The information collected included soil horizon depth, pH and EC_e levels, texture, colour, structure and drainage characteristics. An example of a completed land capability description site card appears in Appendix A. Figure 6 presents the distribution of land capability description sites and existing soil description sites across the survey area.

Land capability assessments for the most part follow guidelines outlined in the revised Land Capability Handbook for Tasmania (Grose in prep). The guidelines provide criteria for determining the major subclass limitations. These involve assessments of land capability in relation to climate (rainfall, temperature), topographic limitations (slope, wetness, uneven ground, flood risk), soil factors (depth, stoniness, rock outcrops, salinity, drainage), and erosion hazard (wind, water, mass movement). Assessments of soil erosion are based primarily on soil texture and organic matter content in the case of wind erosion, and on topographic gradient, soil texture, dispersion, and structure in the case of water erosion. In the case of tunnel and mass movement, assessments are based on erosion features evident on hillslopes.

Subclass codes appear only on digital versions of the map maintained by DPIWE. These codes are intended to provide further information for potential users as to the nature of limitations that might occur within a particular map polygon. However, as individual subclass boundaries are not identified at this scale of mapping, several subclass codes may appear within a single polygon. The dominant limitation for a polygon is always recorded. In addition, other limitations may be observed. For example, an area of land classified 5r on the basis of significant rock outcrop, may additionally contain small areas with a drainage limitation. Consequently, the land is assigned an additional drainage limitation subclass (hence 5rd), although the actual area limited by poor drainage has not been specifically identified. The first limitation recorded in the polygon is the dominant limitation.

Some departures from the guidelines were noted due to local soil and climatic conditions within the survey area, and these were as follows:

- Climate becomes limiting for Class 5 land between 500 and 650m, and for Class 6 between 650 and 800m.

- For a given slope gradient, erosion risk on dolerite landforms carrying Brown Dermosol soils is considered greater due to the combined effects of low rainfall and high stone content.

Stereo-pairs of 1:42 000 black and white aerial photographs and computer generated slope maps were used extensively to extrapolate field assessments and delineate unit boundaries. The slope maps are derived from 1:25 000 contour data with a 10m contour interval. They portray accurate slope information and spatially accurate base information not available with the air photo stereo-pairs. These two information sources were used in concert, whereby map unit boundaries were delineated on the stereo-pairs, then fine tuned according to the additional information provided on the slope map. Once defined accurately, these boundaries were transferred to 1:50 000 base maps from which they were eventually digitized.

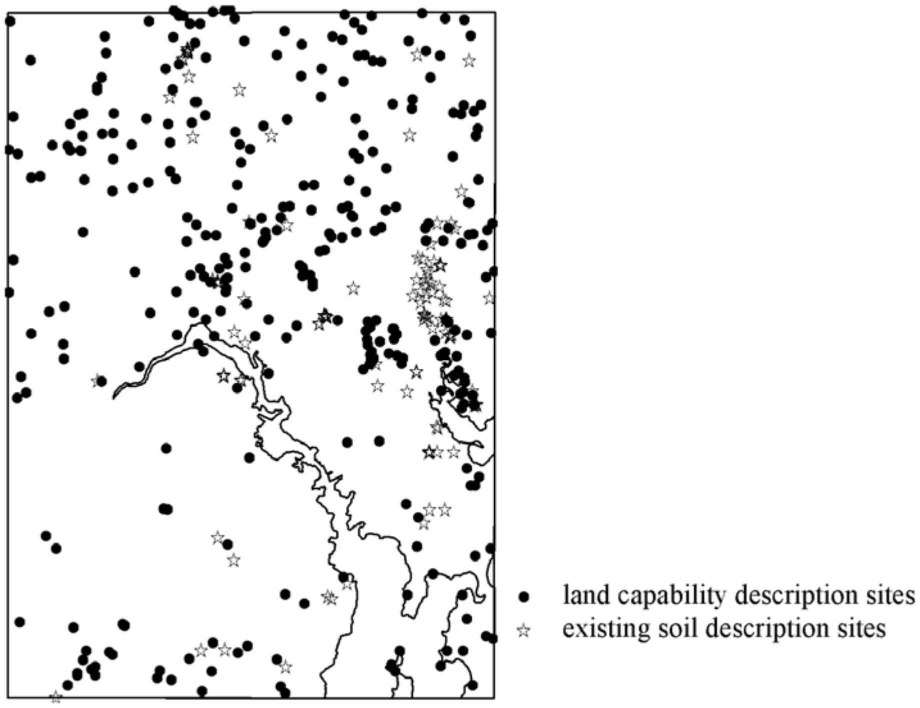


Figure 6. Distribution of land capability description sites and existing soil description sites in the Derwent survey area.

Existing maps, reports and site data were drawn upon where available. These included detailed soils information for the Coal and Huon valleys (Holz 1987; Taylor and Stephens 1935), 1:50 000 geology information (Leaman *et al.* 1972, 1975), reconnaissance scale soil information (Loveday 1955, Dimmock 1957), and 1:200 000 land systems information (Davies 1987). It was generally found that the geology maps provided a more reliable indicator of the major soil boundaries than the reconnaissance scale soil maps, particularly in the more remote and inaccessible mountainous areas. The detailed soils maps and reports provided information on soil-landscape associations which could be extrapolated to other areas.

In line with accepted land survey method, not all map units have been surveyed. Rather, informed assumptions have been made based on information extrapolated from other similar units. This method was applied only in areas where a good understanding existed of the relationships between known information, such as soil type or landform, and land capability class.

The 1:50 000 base maps, with land capability boundaries appended, were digitised and stored using ARC/INFO software. Final publication scale is at 1:100 000. Peers within the DPIWE with experience in agronomy and soil and land evaluation techniques have field checked the land capability map before publication.

Survey information from this report is currently being used to develop a computer model that will in future assist with the mapping of land capability over large areas of previously unmapped land. In this model, climate data and landform attributes such as elevation, slope, geology, soils, and a wetness index are first converted into digital (raster) format. These layers of information are then interrogated using standard spatial modelling software (in this case the Spatial Modeller within IMAGINE), to predict the dominant limitation for any given area of land. The interrogation process utilises simple conditional statements which relate the 7 classes of land to specific landform, soils or climatic attributes. The relationships used are based on field assessed criteria as outlined in the Land Capability Handbook. For example Class 7 land in the Derwent survey area occurs under the following conditions: elevation>800m, or slope >55%, or geology = dolerite scree. Similarly, Class 6 land occurs under the following conditions: 800>elevation>650m, or slope>28%, or 55%>slope>18% where geology = Permian mudstone and Triassic sandstone, or 55%>slope>12% where soils = Podosols, and so on.

A preliminary model of this type was applied to the Derwent survey area and found to produce a land capability map that was better than 70% accurate when compared to the field survey. Future improvements to the model should yield greater accuracy, although the ultimate accuracy will depend on the quality of input layers of information, particularly the spatial accuracy of soil maps.

5. THE DERWENT SURVEY AREA

5.1 Introduction

The study area lies in the south east of Tasmania and includes the city of Hobart together with local centres of Elderslie, Broadmarsh, New Norfolk, Collinsvale, Kempton, Bagdad, Brighton, Colebrook, Campania, Richmond, Cambridge, Lauderdale, Opossum Bay, Kingston, Lower Longley and Grove. It extends over an area of 2113km^2 of which 377km^2 are exclusion areas. Most of these exclusion areas comprise State and National Parks or Forest Reserves.

The area as a whole covers a diverse range of landforms, soils and climate and encompasses a broad range of land uses. In general there are very few areas of high class agricultural land, although extensive areas in valley systems in the north and west of the survey area are suited to broad scale cropping activities, particularly where irrigation water is available. In these areas the capability of the land to support sustainable agricultural development will largely depend on careful implementation and management of irrigation.

5.2 Climate

The Derwent survey area experiences a temperate maritime climate with mild summers and cool winters. This is attributed to the stabilising effect of the Southern Ocean that varies in temperature through the year by only approximately 5^{o}C. Altitude is the principal factor dictating the range of climatic conditions experienced across the survey area and larger climatic extremes occur with increasing distance from the coast and increasing elevation.

There are a number of climate recording stations throughout the survey area, although limited data is available in the northern half. Data from Bothwell and Oatlands are included to demonstrate the climatic trend in the far northern regions of the survey area. The figures presented in this section are derived from the ANUCLIM climate model. The climate data for specific stations is published by the Bureau of Meteorology.

Rainfall

Table 2 shows mean monthly rainfall, average annual rainfall, and median annual rainfall for a selection of stations. The distribution of average monthly rainfall is skewed slightly towards late winter and spring at Grove. In all other areas average monthly rainfalls are highest in late spring and early summer. A comparison of annual average rainfall with annual median rainfall demonstrates that, more often than not, the rainfall for any particular year will be slightly lower than the average annual rainfall.

Weak high pressure systems that carry warm, dry air are most common in the months of January, February and March and, correspondingly rainfall is relatively low during this period. Active low pressure cold fronts driven by westerly air streams usually bring wetter, cool conditions to the area during August, September and October. Much of the moisture released by the cold fronts as they cross the island falls as rain and snow on the windward side of the mountains to the west, and so much of the survey area lies in a rain shadow. This rain shadow is weakest to the south of Mount Wellington and rainfall in the Huon Valley and Lower Longley districts is correspondingly heavier and more frequent.

Rainfall (mm)	J	F	M	A	M	J	J	A	S	O	N	D	Annual average	Annual median
Oatlands	45	39	40	48	44	48	44	46	41	54	51	57	556	549
Bothwell	39	39	38	50	45	44	46	47	43	55	53	53	551	535
New Norfolk	40	35	39	48	45	49	48	47	49	55	47	50	550	546
Hobart	45	38	43	48	44	50	49	47	48	56	55	53	578	570
Risdon	43	45	45	52	49	52	48	51	44	60	55	56	602	586
Hobart Airport	41	36	36	47	37	29	48	49	41	49	45	59	516	484
Kingston	46	46	52	59	55	59	56	56	52	68	62	66	677	663
Grove	48	45	47	67	64	63	77	77	73	69	69	66	765	750

Table 2. Average monthly rainfall, average annual rainfall and median annual rainfall (mm) for selected stations. Figures have been rounded to the nearest mm.

Figure 7 shows the distribution of average annual rainfall across the survey area. Rainfall correlates most strongly with altitude and increases markedly in the mountains with the summit of Mount Wellington receiving over 1000mm per year. The principal agricultural districts are found in the driest parts of the survey area, with the Kempton, Teatree, Campania and Richmond districts all receiving an average rainfall of less than 550mm. The higher rainfall agricultural districts are found in the Huon Valley and at Lower Longley, away from the Mount Wellington rain shadow where average annual rainfall exceeds 700mm. The Colebrook area also receives slightly higher rainfall, experiencing an average of 550 to 650mm each year.

Snowfalls and hail storms are largely confined to upland areas and may occur at any time during the year. Snow often lies on the Mount Wellington plateau for up to several weeks during July, August and September.

Moisture Availability

The length of the growing season, as limited by moisture availability, has been estimated using the index $P/E_w^{0.75}$, where P equals average daily rainfall per month and E_w equals average daily pan evaporation per month (Prescott *et al.* 1952). Index values above 0.8 indicate the available moisture is adequate to sustain growth. In addition, periods with index values above 0.4 may be considered part of the growing season if preceded by substantial periods with values above 0.8. Figure 8 demonstrates how the index varies at different stations in the area. While rainfall is skewed to the later months of the year in most areas, higher temperatures during this time ensure that the rain is more quickly evaporated and thus index values drop rapidly in spring. Index values are greater than 0.8 at Oatlands for 5 months of the year with another 5 months above 0.4 following this time. The potential length of the growing season at Oatlands may therefore be considered to be up to 10 months in length. The Hobart airport records

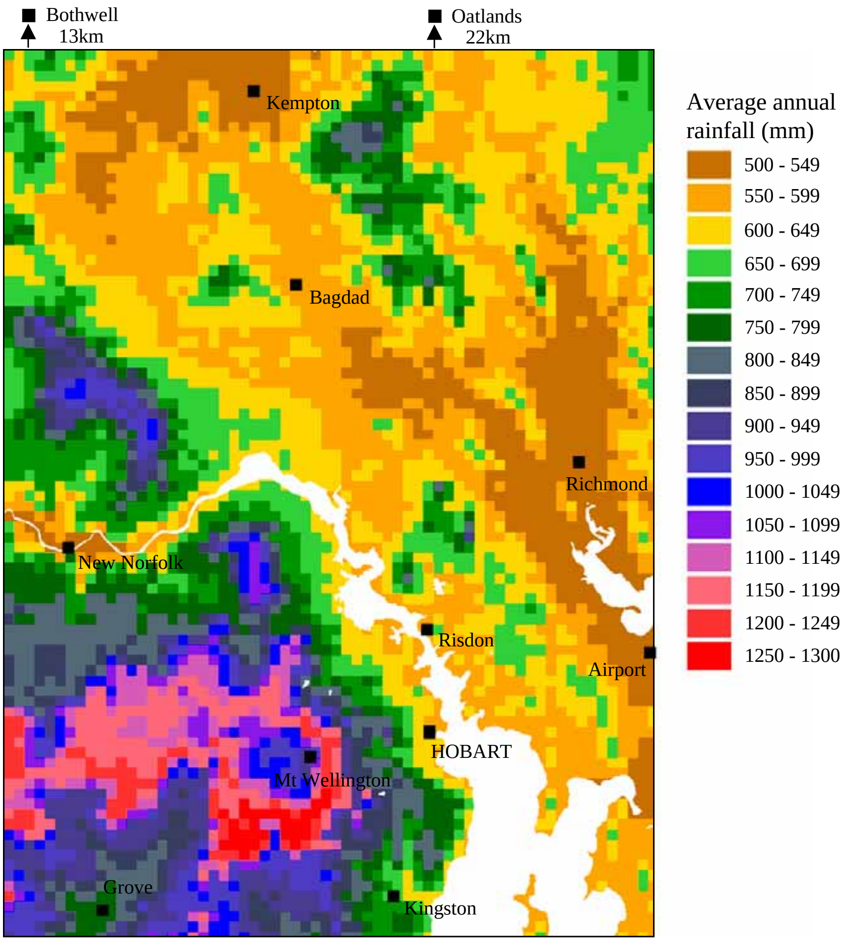


Figure 7. Average annual rainfall (mm) for the Derwent survey area (derived from ANUCLIM climate modelling). Selected climate stations recording rainfall are indicated.

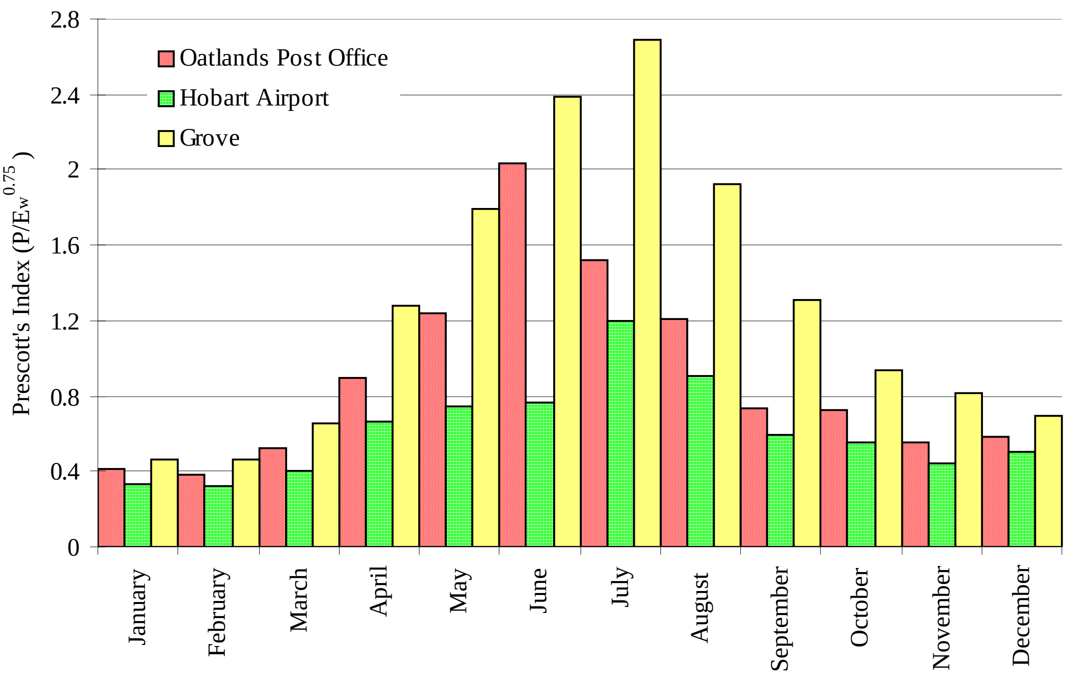


Figure 8. Prescott's index of moisture availability per month for selected stations.

index values above 0.8 for only two months of the year with another four months recording values above 0.4 after this time. The short period of time when values are above 0.8 suggests that the potential growing season may be closer to four months intotal. Records from Grove show that index values are above 0.4 all year and above 0.8 for ten months of the year so the potential growing season in this area may be considered to last all year.

Temperature

Average monthly maximum and minimum temperatures for selected stations are presented in Figure 9. There is a distinct seasonality evident, with maximum temperatures occurring during January and February and minimum temperatures occurring during July. Elevation is the most significant factor affecting temperature variation across the survey area. The proximity to the coast is a less significant factor.

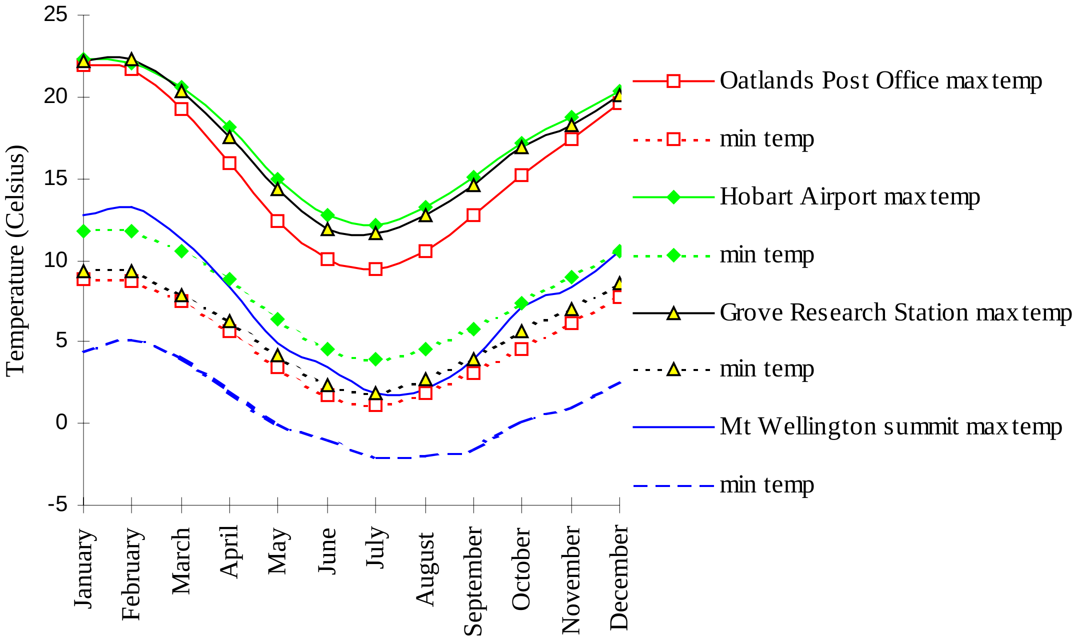


Figure 9. Average monthly minimum and maximum temperatures for selected stations (^{o}C).

The summit of Mount Wellington is situated 1271m above sea level and experiences an alpine climate with average maximum temperatures similar to the average minimum temperatures recorded at other stations. Average minimum temperatures are 0^{o}C or below for 5 months of the year.

Oatlands is situated at 400m above sea level and experiences average maximum temperatures at least one degree Celsius lower than both the Hobart airport and Grove every month from March to October. The average minimum temperatures are similar to those recorded at Grove where cold air drainage from the Mount Wellington plateau keeps night time temperatures low.

Average minimum temperatures at the Hobart airport are approximately 2^{o}C higher than at Grove and Oatlands while average maximum temperatures do not differ significantly. This is attributable to the moderating effects of the nearby ocean.

Figure 10 shows the average number of frost days per month for selected stations. This is based on the number of days per month when minimum temperatures fall to 0^{o}C or less. Frosts may occur across most of the survey area at almost anytime of year although most frosts generally occur between May and September for inland areas, and from June through to August closer to the coast. Once again, altitude is the dominant factor controlling frost incidence, with frosts occurring on the summit of Mount Wellington regularly throughout the year. Coastal areas are far less frost prone than inland areas.

The effect of altitude and distance from the coast is well demonstrated in Figure 11, which presents the average minimum temperatures across the survey area during the months of spring. For example, coastal areas such as Acton and Rokeby experience average minimum temperatures of 7 to 8^{o}C during the period from September to November, while inland areas such as Colebrook and Kempton experience average minimum temperatures of 6 to 7^{o}C during the same period. Average minimum temperatures drop dramatically with a rise in altitude, with the upper slopes of Quoin Mountain, Mount Dromedary and the Mount Wellington plateau experiencing minimum temperatures below 3^{o}C during this time.

Length of Growing Season

The length of the growing season is determined by the combined effects of rainfall, evaporation and temperature. The coastal areas experience the mildest temperatures and least number of frosts yet the low rainfall and high evaporation rates limit plant growth to those same months which experience the most frosts. Therefore, the length of the growing season is limited to a small window in spring when frosts are less common and the soil moisture store has been replenished from winter rains. Further inland with increasing elevation, the number of months when moisture is available for plant growth increases. However, the lower minimum temperatures and greater number of frosts again limit the growing season significantly. Dryland farming practices, such as grazing of perennial grasses and fallowing prior to sowing, allow the soil moisture store to be effectively utilised. Irrigation can lengthen the growing season where suitable soils are found.

5.3 Geology and Landforms

There are a wide range of rock types occurring within the Derwent survey area. These have had an important influence on the present day distribution of soils and landforms. For this reason geological information has played an important role in the land capability survey. The relationship between geology and landforms is illustrated in Figure 12 where a 1:250 000 scale geology map has been draped over a digital elevation model (DEM) of the survey area.

The principal lithologies include Permian mudstones, Triassic sandstones, Jurassic dolerite, and Tertiary basalt. Together, they comprise 91% of the land area. Dolerite landforms dominate the survey area. These form mountain peaks rising to 1271m in elevation. Much of the NW-SE trending hill country rising to 600m in elevation is comprised of dolerite rocks. Permo-Triassic rocks underlie the dolerite cap rocks and

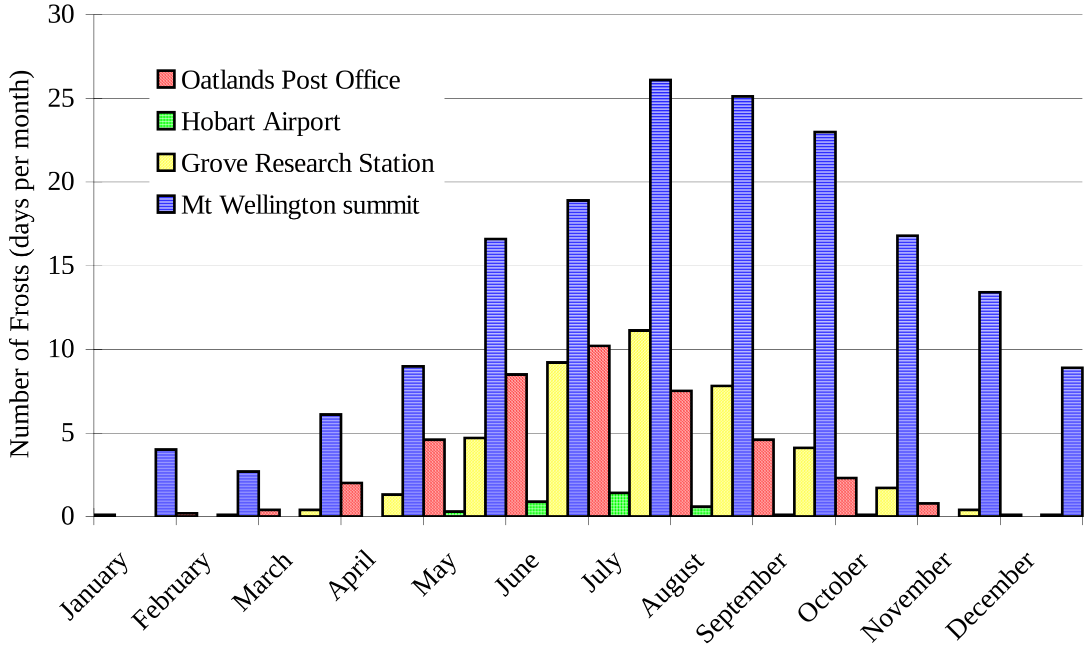


Figure 10. Average number of frost days per month for selected stations (minimum temperatures less than 0°C)

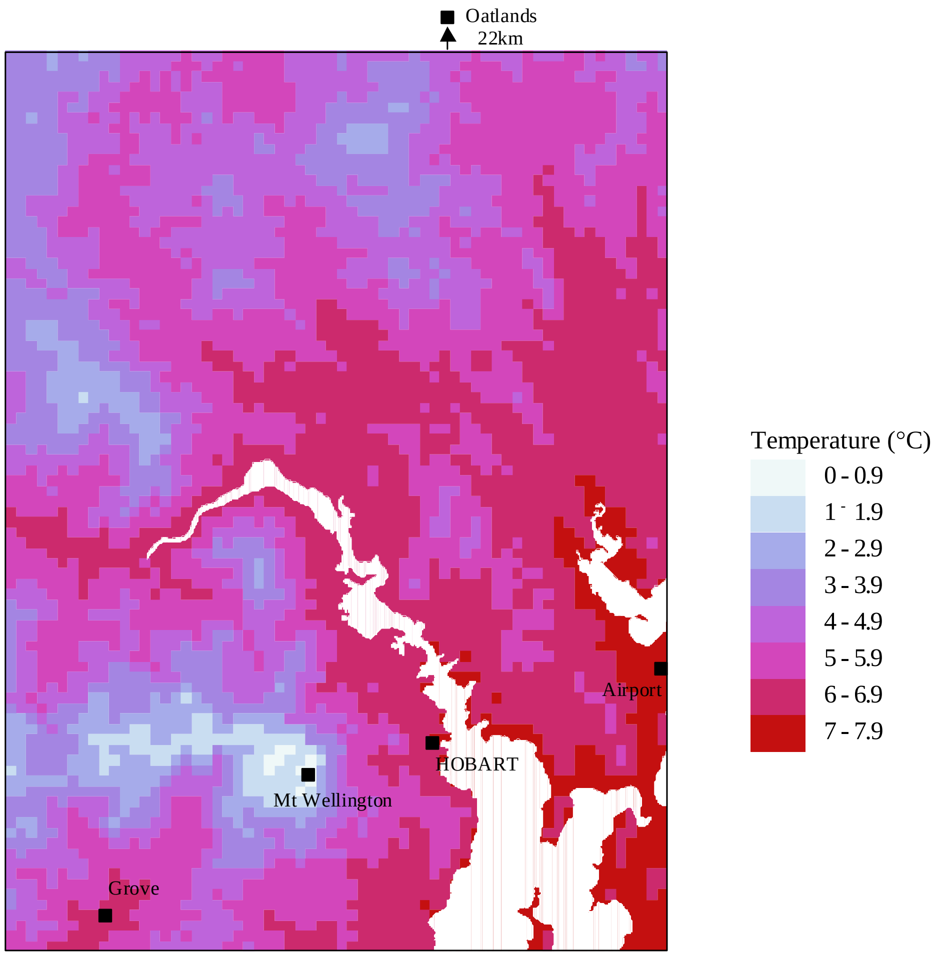


Figure 11. Average minimum temperatures for the Derwent survey area during the months of Spring from September to November (derived from ANUCLIM climate modelling). Selected climate stations recording daily minimum temperatures are indicated.

these tend to crop out on lower slopes and valley margins (Photo 1). Tertiary basalt is less extensive and confined to the larger valley systems, forming either dissected flows or, less commonly, denuded volcanic cones. Younger deposits consist of Tertiary sediments and Quaternary scree, talus, wind blown sands, alluvium and swamp deposits. The scree and talus are found blanketing upperslopes at higher elevations. The wind blown sands, alluvium and swamp deposits are generally limited in extent to valley flats and coastal plains.

Photo 1. **The typical relationship between geology and landform in the Derwent survey area. Jurassic dolerite hills cap Triassic sandstone on the lower slopes with Quaternary alluvium filling valley floors (Woodlands Creek GR E529500, N5275500).**

Geological formations have also had a strong influence on erosion history and the formation of present day drainage patterns. The more erosion resistant dolerite landforms have confined rivers to NW-SE trending graben structures. Today, three major river systems, the Derwent, Jordan and Coal Rivers, drain water to the south into tidal estuaries of the River Derwent and further east at Pitt Water. Low energy streams and smaller rivulets form dendritic drainage patterns among rolling hills, and these drain water into the larger rivers. Streams with steeper gradient and higher energy drain water from the higher dolerite massifs.

The survey area is covered by two 1:50 000 scale geology maps (Leaman 1972, 1975). The main geological formations and associated landforms are described below from oldest to youngest. Idealised cross-sections (Figures 13,14 and 15) are also presented for representative regions of the survey area, to help illustrate the associations between geology, landform, soils and land capability.

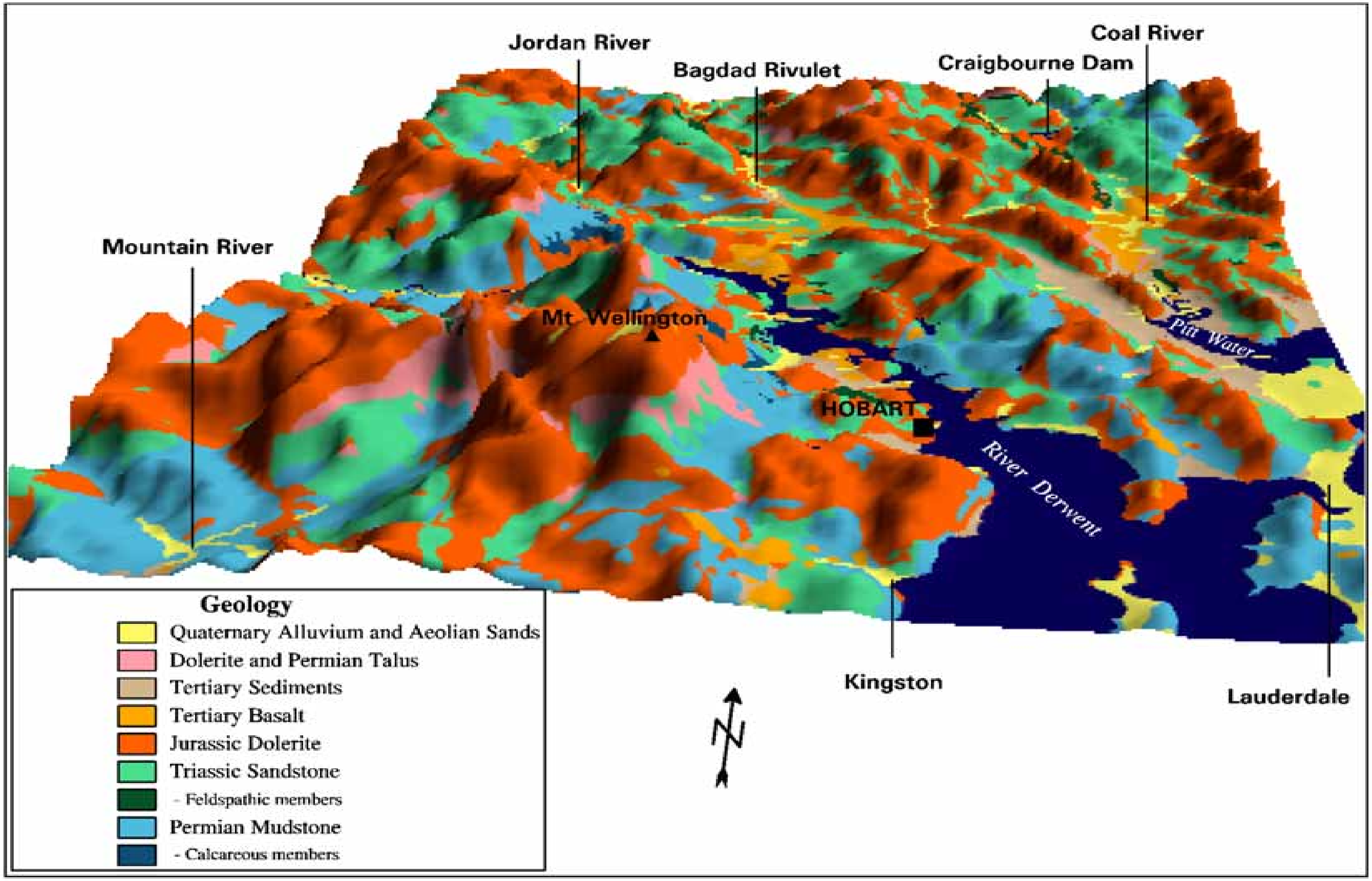
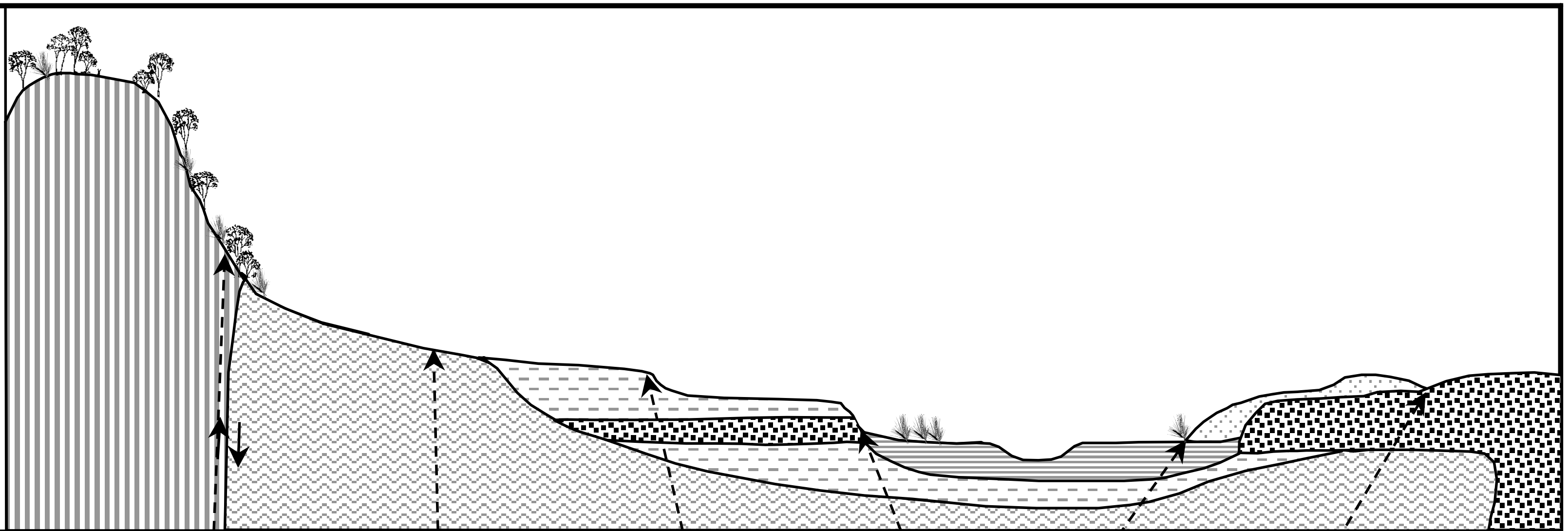


Figure 12. Simplified geology information draped over an elevation model of the Derwent survey area**.**



Typical Landform	Steep hill slopes	Moderately sloping footslopes	Gently sloping footslopes and dissected pediments	Alluvial plain	Valley floors and flood plain	Dune	Gentle rises
Geology	Jurassic Dolerite	Jurassic dolerite and Triassic sandstone	Triassic sediment, Tertiary sediment	Tertiary sediment and Quaternary alluvium	Quaternary alluvium,	Quaternary aeolian sands,	Tertiary basalt
Soil Type	Stony brown Dermosols	Dermosols, Chromosols, and Sodosols	Sodosols and Kurosols	Chromosols, and Sodosols	Vertosols and Dermosols	Tenosols and Chromosols	Vertosols and Dermosols
Slope Range	25 - > 56%	12 - 25%	5 - 18%	0 - 18%	0-5%	0-18%	0-18%
Drainage Status	Well to moderate	Well to imperfect	Imperfect	Imperfect	Moderate to imperfect	Rapid to well	Well to moderate
Permeability	Moderate	Moderate	Moderate to slow	Moderate to slow	Moderate to slow	High	Moderate to slow
Erosion Risk	Moderate to high	low to moderate	low to moderate	low to moderate	Low	High	Low
Main Limitations	Stony soils, shallow soils, mass movement and sheet erosion	Stony soils, poor soil structure and erosion	Erosion, soil drainage and poor soil structure	Erosion, soil drainage, poor topsoil structure	Soil drainage, structural decline	Erosion from wind or water	Stony soils, soil drainage and soil structure
Land Capability Classes	5,6	4,5	4	4	4	5,4	4

Figure 13. Stylised cross-section across the Lower Coal River Valley, illustrating valley floors and pediments. The order of appearance of land capability classes reflects their areal extent within each landform.

Permian sediments

Rocks of Permian age are the oldest exposed soil forming parent materials within the survey area. They are comprised of an alternating sequence of siltstones and mudstones, occasionally interspersed with limestone and sandstone units. These rocks are glacio-marine sediments which accumulated between 300 and 250 million years ago in a depression that widened and deepened towards the south east of Tasmania. Permian rocks are characteristically cream coloured and well bedded with tan staining on block faces. Landforms developed in Permian rocks are generally highly dissected, rising to 600m above sea level. These occur mainly in the west and south of the survey area and comprise 16% of the total survey area. Permian rocks are often exposed in valley systems (eg. Mountain River) on the up-thrown side of faults. They occasionally crop out as thin units capping Jurassic dolerite on elevated plateaux. The most common formations represented are fossil free quartz siltstones (eg. Ferntree Group and Malbina Formation). Small areas of limestone (Berriedale Limestone) crop out on the lower slopes of Mount Faulkner from Limekiln Point to Collinsvale.

Triassic sandstone

During the late Permian and early Triassic Periods (approximately 240 million years BP) the Tasmanian landmass rose above the sea. At this time much of Tasmania consisted of poorly vegetated flood plains. Thick sequences of predominantly medium-coarse quartz rich sandstones accumulated from sediment transported by rivers flowing towards the south east. These sediments now form the Triassic rocks that are observed today. They are more extensive than the underlying Permian rocks and crop out over 31% of the survey area. Triassic rocks are generally yellow brown to light brown, often massive, with cross-bedded sequences. The landforms developed on Triassic rocks can be found across much of the study area, with particularly large tracts of land occurring in the north west and north east. These often form steep-sided plateaux rising to 650m above sea level (eg. Pelham and Huntingdon Tier). Triassic rocks also commonly form gently sloping valley floors along many of the major river systems. Upper Triassic lithologies tend to be finer textured and richer in feldspars and micaceous minerals. These rocks are less extensive and crop out mainly on the foot slopes to the west of the Coal River, north from Campania.

Jurassic dolerite

Much tectonic activity took place during the Jurassic Period (about 200 to 160 million years BP), causing extensive block faulting in the Permo-Triassic sediments described above. The land was uplifted as large volumes of magma rose through the crust and intruded into the overlying sediments. The magma cooled to form the dark coloured dolerite rock. Cooling of the magma tended to produce columnar jointing in the dolerite, giving rise to the appearance of the Mt Wellington Organ Pipes. Subsequent erosion of the older overlying sediments has exposed large areas of dolerite rock to the extent that dolerite landforms now form most of the major mountain peaks (41% of the survey area). These include Mount Wellington, Mount Patrick, Mount Dromedary, Quoin Mountain, Gunners Quoin, and Mangalore Tier. Dolerite rocks are generally more resistant to erosion than other lithologies, and consequently, dolerite now caps many of the low lying hills and ridges which rise to between 200 and 600m above sea level over much of the survey area (Photo 1). However, deep seated failures and mountain side collapses have occurred in the past on the steeper dolerite terrain. These are often seen where steep walled scarps form a backdrop to lowerslopes of predominantly hummocky terrain (eg. western face of Gunners Quoin).

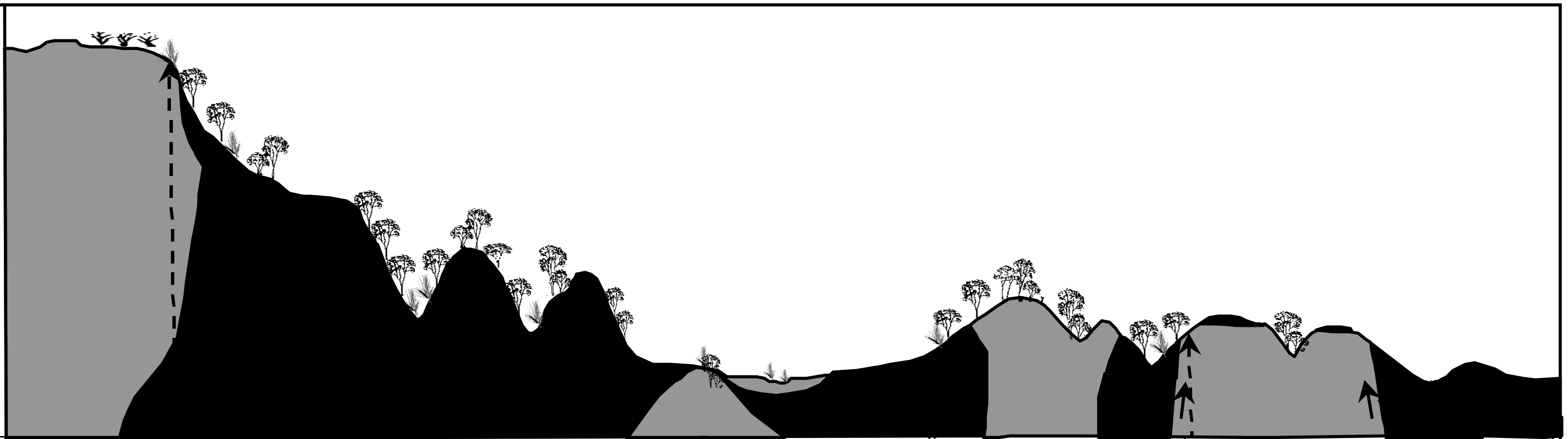
Faulting also caused large vertical offsets in the Permo-Triassic rocks. In some locations (such as north and south from Mt Wellington) Permian sediments, which now cap dolerite plateaux rising to between 300 and 400m above sea level, have been displaced several hundred metres from correlatives exposed along the nearby valley floors (Figure 14). Similarly, small pockets of Triassic sandstone can also be found in localised depressions scattered throughout the dolerite hill country.

Tertiary sediments and volcanic rocks

Many of the landforms observed today throughout Tasmania, began to take form during the Cretaceous Period when crustal fracturing caused subsidence and the formation of north west trending horst and graben structures. Erosion of highland areas supplied sediment to the gradually evolving valley systems. At the beginning of the Tertiary period (55 million years BP), volcanoes began to erupt along fault lines at the edge of the graben structures. Subsequent erosion has reduced these cones to very low elevations above the surrounding landscape. Examples include Howards Hill and Wingys Sugar Loaf, north west and west of Richmond respectively, and several small hills either side of the Tasman Highway near Cambridge.

Volcanic activity appears to have reached a peak by the Mid-Tertiary (22 million years BP) when basalt lava flowed down many pre-existing river courses in the region (Leaman 1977). The two most extensive flows occurred in what is now the Coal River valley north from Richmond, and the Jordan River valley and Bagdad Rivulet north from Bridgewater (Brighton basalt). The Brighton basalt is considered relatively young and may be of late Tertiary age (Leaman 1976).

These flows have been subsequently dissected by fluvial erosion processes. Basalt flows, together with denuded basalt cones and talus, are mapped over 2% of the survey area. During the Tertiary Period, erosion from surrounding landforms supplied sediment to aggrading river valleys and lakes at a time when sea levels were higher than the present day. These sediments continued to accumulate and infill valleys until a cooling of the climate about 3 million years ago brought about a fall in sea level. Streams began to erode into the Late Tertiary valley floor, remnants of which now occur as elevated pediments about 40m above present day flood plains. Tertiary sediments, which are mapped over 3% of the survey area, are comprised predominantly of unconsolidated clays which contain beds of fine sand and occasional gravels. The beds are characterised by relatively large limonite (ferricrete) nodules, and are mainly sub-basalt, implying deposition prior to extensive volcanism. The largest areas of Tertiary sediments occur primarily along the lower Coal and Jordan valleys, along Pages Creek, and either side of Pitt Water Estuary.



Landform	High rolling plateaux	Escarpments & steep slopes	Steep, highly dissected hills	Valley floors	Steep dissected hills	Dissected plateaux	Rises and low hills
Geology	Jurassic Dolerite	Jurassic dolerite and dolerite talus	Triassic sediments and Permian sediments	Quaternary alluvium, Permian sediments, Triassic sediments and Jurassic dolerite	Jurassic dolerite and Triassic sediments	Permian sediments and Jurassic dolerite	Tertiary basalt
Soil Type	Boulder fields, Organosols and Ferrosols	Rock, boulder fields and Ferrosols	Kurosols and Podosols	Dermosols, Rudosols, Sodosols, Chromosols and Podosols	Chromosols, Kurosols, Dermosols and Ferrosols	Chromosols and Kurosols	Dermosols and Ferrosols
Slope	0-25%	25->56%	18-56%	0-12%	12-45%	0-12%	0-18%
Drainage Status	Well to very poor	Rapidly to well	Well to imperfect	Well to very poor	Well to imperfect	Poor to very poor	Well to imperfect
Permeability	Moderate to slow	High to moderate	High to moderate	Moderate to slow	Moderate to slow	Moderate to slow	Moderate to slow
Erosion Risk	Moderate to high	High to extreme	High to extreme	Low to moderate	Moderate to extreme	Low to moderate	Low
Limitations	Cold climate, stony soils, shallow soils and wetness	Cold climate, stony soils, shallow soils, irregular topography and erosion	Erosion, shallow soils, stony soils and low fertility	Stony soils, shallow soils, low fertility, short working window and wetness	Stony and shallow soils, erosion and irregular topography	Stony soils, shallow soils and wetness	Stony soils and wetness
Land Capability Classes	7,E	7,6,E	6	5,4,6,3	6,5	5,6	4,5,3

Figure 14. Stylised cross-section across the region from the Mount Wellington plateau to Grove, illustrating mountains and hills. The order of appearance of classes reflects areal extent within each

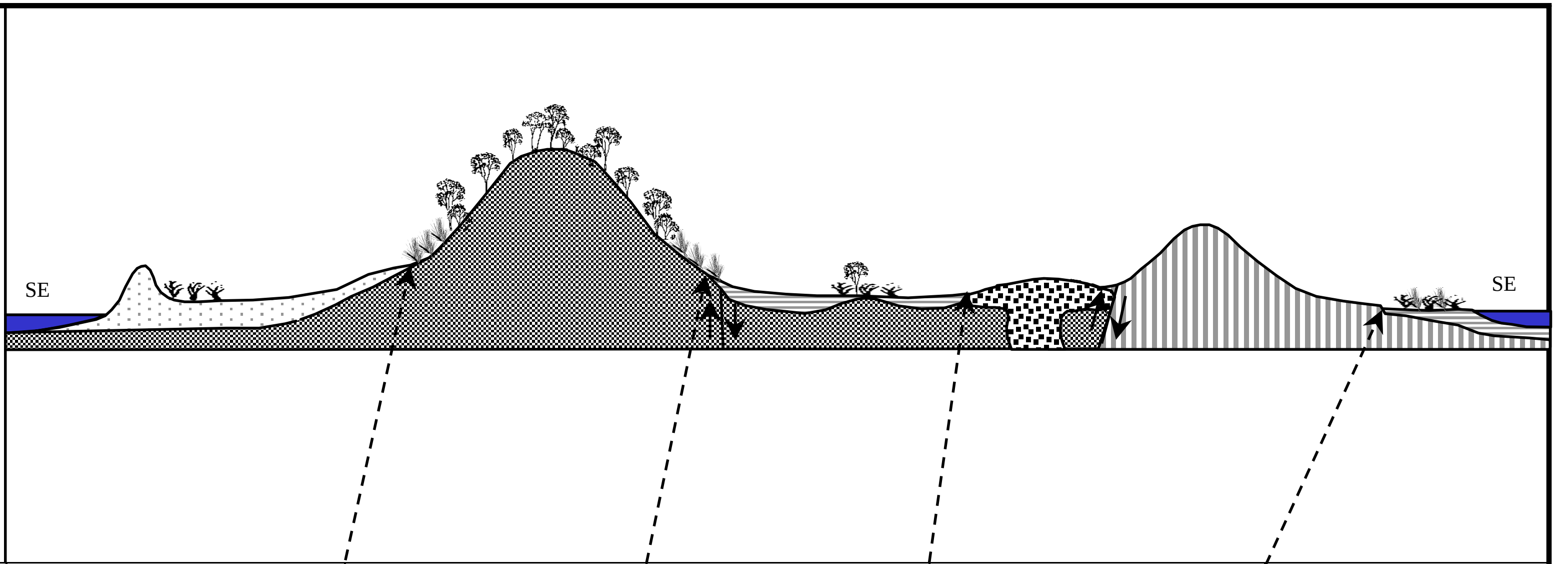
Quaternary sediments

Over the past 3 million years erosion processes and geomorphic activity, coupled to cyclical changes in vegetation and climate, have played an important role in the development of soils and landforms. The southern region has undoubtedly fluctuated between a warm temperate climate, much like the present day, and very cold, peri-glacial conditions which persisted during the Ice Ages. While several Ice Ages have been recognised in Tasmania, the Last Glaciation (approximately 18,000 to 20,000 years BP) was very severe and erosion processes at this time had an important influence in shaping present day landforms, and had a direct impact on soil development. Pollen evidence suggests that a sparsely forested grassland occurred over much of Eastern Tasmania at this time (Macphail 1979). Mean annual temperatures may have been 6.5°C lower and the climate was probably drier with a marked decrease in precipitation from west to east. Geomorphic features which point to the effect of the colder climate on landscape processes include debris fields of scree and talus, alluvial fan deposits, river terraces and associated gravels, loess deposits, and aeolian cover sands and dunes.

Extensive scree fields, composed primarily of dolerite boulders, surround many of the major mountain peaks in the region. Fine grained talus and solifluction deposits often underlie these boulder fields and occur adjacent to many of the higher dolerite capped hills such as Mount Dromedary and Quoin Mountain. Both scree and talus are indicative of a time when freeze-thaw processes were active in transporting soils materials at higher elevations. Similarly, alluvial fans and associated deposits can be found along many of the small streams and rivulets draining mountain slopes. These often overlie Triassic rocks or Tertiary sediments. The fans are typically composed of Jurassic dolerite or Permian clastic sediments. Wasson (1977a,b) investigated fan deposits of Late Glacial age in the lower Derwent River and attributed these to debris-flows from catchments which were peri-glacial at high altitudes. Gravelly fan deposits can also be seen along road cuttings through Permian hill country (eg. Tasman Highway dissecting the Meehan Range).

Some fans occur at very low elevations such as those along the Lower Derwent (Siglio 1979) and some observed about Mount Mather (140m above sea level), suggesting that active erosion extended to very low altitudes during the Last Glacial or earlier glacial periods. In most valley systems, a veneer of Quaternary alluvium and aeolian deposits overlie basement geology. These have been mapped together as ‘soils from alluvial deposits’ in the reconnaissance soil surveys. Only recent flood plain (Holocene) alluvium is shown on 1:50 000 geological maps. Present day valley forms often show a sequence of at least 2 to 3 terrace heights below Tertiary aged pediments (Figure 13). These are interpreted to represent different base levels and periods in the downcutting and infilling by streams.

The dissected remnants of old gravelly terrace alluvium occur up to 30m above the present river level on both sides of the Derwent valley and margins of Pitt Water. These are probably pre-Last Interglacial and formed at times of much higher stream discharge. Alluvial deposits up to 5m thick resting on a gravel base are found along the axes of most of the larger rivers and streams (Photo 6). Carbon dating (Goede 1973), supports a mid-Holocene or younger (<6,200 years before present) age for much of the alluvial fill.



Typical Landform	Foredunes and backplain	Low hills	Valley bottom	Low hills	Tidal marsh
Geology	Quaternary sands and alluvial deposits	Permian	Quaternary sands and Alluvial deposits over Permian sediments	Jurassic dolerite and Tertiary Basalt flows	Quaternary silts
Soil Type	Rudosols and Podosols	Kandosols and Kurosols	Sodosols and Podosols	Dermosols, Vertosols, and Anthroposols	Organosols
Slope Range	0-12%	5-45%	0-12%	5-24%	0-3%
Drainage Status	Very well to poor	Imperfect	Poor to imperfect	Moderate to imperfect	Very poor
Permeability	Rapid	Moderate	High to Moderate	Moderate to slow	Moderate
Erosion Risk	Low to high	Moderate to high	Low to moderate	Low to moderate	Low
Main Limitations	Wind erosion, drainage, salinity	Erosion, shallow soils, stony soils	Drainage, salinity, wind erosion	Drainage, erosion, soil depth	Drainage, salinity
Land Capability Classes	7,6,5	6,5	5	4,5	7,6

Figure 15. Stylised cross-section across South Arm, illustrating coastal dunes, aeolian sands and low hills. The order of appearance of land capability classes reflects their areal extent within each landform.

Aeolian deposits of predominantly fine quartz sand are found pocketed throughout the survey area. These are indicative of previous periods of active dune building. Sand sheets tend to be located on the eastern and south eastern side of river courses indicating that sand was transported in prevailing westerly and north westerly winds (Figure 13). Deep sand deposits occur on the footslopes and alluvial terraces along many of the river systems, especially in regions dominated by Triassic sandstone sediments in the northern part of the survey area. This association implies that sand was derived in the past from the deflation of surrounding hills. Extensive sand deposits also occur near to, and east of Hobart Airport, and from Lauderdale to South Arm and around to Opossum Bay. Here sand sheets extend up valley bottoms onto the footslopes of Permian hills. Recent foredunes occur along most beach frontages on South Arm (Figure 15).

At least two major periods of aeolian activity have been recognised in the survey area (Siglio 1979) with the latest thought to be of late Last Glacial age. Carbon dates (Siglio 1979, Siglio and Colhoun 1982) also indicate that aeolian instability and reworking of underlying sand sheets continued at times during the mid to late Holocene, possibly related to human impacts on the environment. Anecdotal evidence from landholders suggests localised erosion and movement of sand sheets earlier this century due to agricultural practices and particularly dry seasons.

Estuarine sediments occur near to sea level along the Lower Derwent valley between New Norfolk and Bridgewater, along the lower Coal valley and around Pitt Water, and in semi-circular embayments around South Arm, south of Lauderdale (Figure 15, Photo 15). These sediments can be up to 25 to 29m thick and have accumulated since the post-Last Glacial rise in sea level.

5.4 Soils

This chapter describes the principal soils found in the Derwent survey area. Soils information pertaining to soil performance and limitations to land use are described in the relevant land capability sections. Available soils information for the Derwent survey area ranges from broad scale reconnaissance surveys to detailed surveys of alluvial flats and individual farms (Appendix B). The Australian Soil Classification (Isbell 1996) has been used when classifying soils and the appropriate terminology appears at the end of each relevant sentence. Other descriptive nomenclature follows the suggested standards which appear in the Australian Soil and Land Survey Field Handbook (McDonald *et al* 1990).

Background

Two 1:63 000 reconnaissance scale soil maps (Loveday 1955, Dimmock 1957) give complete coverage of the survey area. In these, 14 principal great soil groups were identified and mapped primarily on the basis of basement geology.

A subsequent 1:25 000 scale soil survey of the Lower Coal River valley (Holz 1987) sought to differentiate the previously mapped alluvial soils in the valleys (‘soils of alluvial deposits’, Loveday 1955, Dimmock 1957). A total of 32, sometimes closely associated, soils were mapped across a range of lithologies. Nineteen of these soils were mapped on Tertiary and Quaternary sediments and were grouped in accordance with valley terrace morphology (Figure 13). This, together with a much earlier survey of part of the Huonville District (Taylor and Stephens 1935), in which 8 soil types were mapped over a comparatively small area, illustrate the highly variable nature of soils throughout much of the region. This has been further highlighted by a number of unpublished 1:5 000 scale farm surveys (Doyle pers comm).

All previous surveys point to a clear association between soils and underlying geology. Soil parent materials have, for the most part, been derived from weathering of underlying geological formations, although slope processes have clearly caused localised redistribution of soil materials. In places, coverbed sequences overlie basement geology, and soils are formed in colluvial slope deposits or alluvium along river channels.

The key features of soils occurring within the survey area are described in more detail below. They are arranged by soil parent material and reflect decreasing importance for agricultural use.

Soils derived from Tertiary Basalt

Basalt soils within the survey area can encompass a significant range in profile variability, particularly with respect to soil texture, soil depth, stone content, and drainage condition.

On gently sloping sites, moderately well to imperfectly drained, alkaline black cracking clay soils are generally found overlying weathered basalt or basalt colluvium (Endocalcareous Epipedal to Self Mulching Black Vertosols). These soils typically have a black, light clay surface horizon, which overlies a black or very dark grey upper, and greyish or olive brown lower, medium to heavy clay subsoil horizon. In places (eg. west of Brighton, east of Campania, south of Gagebrook), basalt soils have lighter textured, sandy clay loam to fine sandy loam surface horizons, which can be up to 30cm in depth (Vertic to Melanic Eutrophic Black Dermosols). Very occasionally, a bleached subsurface A2 horizon may be present. Wetter soils often occur near drainage lines. These soils generally have both higher pH and salinity levels in the upper horizons, and sodic subsoil horizons (Epipedal Aquic Vertosols).

Stony clay soils are often found overlying weathered basalt at shallow depths of 40 to 60cm on sloping sites and along hill crests. These soils have firm, black to dark reddish brown, strongly structured, light clay or clay loam surface horizons, overlying dusky red to brown, moderately structured, medium to heavy clay, subsoil horizons. Particularly stony and shallow profiles can be found on basalt to the north west of Bridgewater. In these soils, black, stony topsoils grade to black or brown blocky structured, heavy clay, transitional horizons which contain abundant subangular basalt stones. All of the above soils have been previously mapped as ‘black soils on basalt’ (Loveday 1955, Dimmock 1957).

Red-brown soils mapped near Kingston (Dimmock 1957) represent an association between neutral, well drained, uniformly textured loam soils on ridge crests and steeper slopes, and acid, mottled clay soils on the lower slopes, flats and drainage lines (Brown Ferrosols and Black Dermosols).

Soils derived from Jurassic dolerite

Black soils on dolerite (Loveday 1955, Dimmock 1957) are uniformly textured, moderately to strongly structured, alkaline, black, cracking clay soils (Epipedal to Self Mulching Black Vertosols). The soils are very similar in appearance to black soils on basalt, except that they overlie decomposing dolerite, or dolerite colluvium. As with the black soils on basalt, black soils on dolerite can encompass significant variability with respect to soil texture, drainage condition, stone content and soil depth. Many soils have clay loam surface textures and those on sloping terrain tend to have better topographic drainage. Other soils contain abundant lime in the lower horizons (Vertic Eutrophic to Hypocalcic Black Dermosols). Colluvial soils (Photo 2) extend onto terraces and are generally imperfectly drained, more alkaline, with moderately saline and sodic subsoil horizons (Endocalcareous Epipedal Black Vertosols).

In contrast, brown soils on dolerite (Loveday 1955, Dimmock 1957) are neutral, moderately to strongly structured, gradational soils. The typical profile has a brown to dark brown, loam or clay loam surface horizon, overlying a brown or reddish brown, medium to heavy clay subsoil. This in turn rests on weathered rock or regolith at about 45cm depth (Eutrophic Brown or Red Dermosols). Dolerite fragments usually occur throughout the soil profile in varying amounts, while transitional horizons that contain abundant rounded (exfoliating) stones, may be present to depths of about 70cm. Deeper profiles can also occur on colluvial footslopes and gently sloping fans. Here, black clay loam topsoils overlie greyish-brown subsoils, which pass to gravelly slope deposits at depth. Lime is occasionally present in the decomposing bedrock. Small extents of gradational to texture contrast loam over clay textured brown soils have developed on dolerite deposits along some river flats (eg. Woodbridge loam and sandy loam near Grove, Taylor and Stephens 1935).

Small areas of uniform, coarse sandy loam textured soils occur at some locations (eg. Ridgeway) in dolerite hill country (Red and Brown Ferrosols). These soils are well drained with dark reddish brown horizons. Stone content is highly variable across these areas, but cobble and stone sized dolerite rock fragments commonly occur evenly distributed throughout the stonier profiles.

Podzolic[1] soils on dolerite (Loveday 1955 and Dimmock 1957) cover extensive areas throughout the Derwent region generally where annual rainfall exceeds about 640mm. These are texture contrast soils with grey-brown loam or sandy loam surface, and massive light grey, fine sandy loam or loamy sand subsurface A2 horizons (Eutrophic Grey Chromosols). Surface horizons overlie a light yellow-grey and yellow-brown, medium to heavy clay subsoil, which gradually passes to decomposing dolerite at depths as little as 30cm. The surface horizons are generally apedal or weakly structured, while subsoil horizons have weakly to moderately developed prismatic or subangular blocky structures. Soil materials are generally dispersive and these soils may be prone to surface erosion where vegetation disturbance occurs. The subsurface A2 horizons are often weakly mottled, indicating impeded profile drainage. In low lying areas, and on very broad gently sloping crests, the soils become poorly drained, and consequently, more intensely mottled. Some soils have strongly acid profile trends (Bleached

[1] The term podzolic is loosely used to describe texture contrast soils with an A2 horizon

Eutrophic Grey Kurosols), while others in lower slope positions, may be sodic (Mottled-subnatric Grey Sodosols). These 'podzolic' soils are often shallow and stony throughout and, for the most part, retain their natural native forest cover.

Extensive areas of yellow-brown soils developed in solifluction deposits (Loveday 1955, Dimmock 1957) also occur within the survey area, but these are generally confined to moderate to steep hillslopes at elevations above 600m around the main dolerite massifs of Mount Wellington and Mount Dromedary (Acidic Dystrophic Red Ferrosols). The soils are mostly bright yellow-brown, gravelly clay loams or clays throughout, with most horizon differentiation relating to rock stratification. They are invariably stony, particularly in surface horizons. Close to the mountain peaks, the soils may be capped by a layer of dolerite boulder scree. At high elevations, under wetter and colder conditions where little topographic drainage occurs, yellow-brown soils merge with moorland peat soils (Loveday 1955, Dimmock 1957). Here, a peaty surface horizon overlies a gleyed, sandy loam or clay loam subsoil, that often contains a thin convoluted iron pan. This pan tends to perch water and help create the very wet soil conditions.

Soils derived from Tertiary sediments and Quaternary alluvial sediments.

The majority of valley systems contain Quaternary alluvial coverbeds on which a broad range of soils types have developed. Small areas of soils developed from Tertiary clay sediments occur on dissected terraces where coverbeds have been removed through erosion.

Relatively small extents of moderately to strongly structured brown soils occur adjacent to rivers and streams (eg. Roslyn soil, Holz 1987). These soils are typically uniformly textured throughout, black to very dark brown, light clay or fine sandy clay loams, averaging 60cm in depth. The surface horizons are firm to hardsetting and may be up to 40cm in depth (Melanic Eutrophic Black Dermosols). They are usually moderately well drained with some mottling in lower B horizons, indicating periodic saturation at depth. Close to rivers where infrequent flooding can occur, soils become lighter textured, grading to fine sandy clay loams. Profiles are generally shallower and horizons may contain sand or gravel layers (eg. Stockdale soil, Holz 1987). In areas where flooding is more frequent, the soils are well drained, dark brown, loose, sandy loam to loamy sands. However, these soils are often shallow (30cm) and contain many stones and boulders (Fluvic Clastic Rudosols).

Black and grey cracking clay soils have formed on gently sloping sites, in low lying areas, in depressions between dissected terraces; and within the modern floodplain of rivers (eg. Churchill and Cranston soil, Holz 1987). These soils are classed as Endohypersodic Epipedal to Self-mulching Black Vertosols. They are imperfectly to poorly drained soils which have uniform, light to medium or heavy clay profiles, with black or very dark grey surface horizons and upper subsoil horizons. Subsoil horizons become dark grey, brown or yellowish brown with depth, and are characterised by lenticular structures and prominent slickensides. These are variably saline soils with vegetation associations characterised by salt tolerant species (see Section 7, Photo 16).

Photo 2. **Black Vertosols developed in colluvial dolerite are common on footslope positions. These make reasonable cropping soils where topographic drainage is good (Pitt Water, GR E534400 N5261300).**

Extensive areas of texture contrast to gradational soils occur on pediment surfaces and higher terraces within most valley systems (Photo 3). These soils usually have alkaline, sodic, weakly structured, clay subsoils with impeded profile drainage characteristics (Eutrophic Subnatric Brown or Black Sodosols). Soil materials are often dispersive and may be subject to rill erosion in cultivated areas where surface runoff occurs (see Section 6.3, Photo 8). The surface horizons (A1) are generally weakly structured, hardsetting, dark greyish brown, sandy clay loam to sandy loams, which are between 10 and 20cm in depth (eg. Carrington, Nugent and Coal soils, Holz 1987). In places, the surface horizons have loose, loamy sand textures (eg. Strelley soil, Holz 1987). A thin, sporadically bleached subsurface A2 horizon is commonly present, which abruptly overlies weak to moderate blocky or prismatic, brown or yellowish brown, fine sandy light to medium clay subsoil horizons. These generally become less well structured and paler with increasing depth. Soft manganiferous segregations and occasionally calcareous nodules may be present in lower horizons, while rounded ferruginous gravels may be common in upper horizons. Most soils contain very few stones, although some profiles can have very stony subsoil horizons where Quaternary gravel deposits occur at shallow depths (eg. along the Derwent River).

Photo 3. **Sodosols are common in many lower landscape positions. This Sodosol has a loamy sand surface horizon which overlies an intermittent, bleached subsurface horizon and a strongly mottled, slowly permeable, clay subsoil horizon. (Pitt Water, GR E534800 N5260500).**

Texture contrast soils with similar profile characteristics have developed on Tertiary clay sediments. These are generally differentiated by the presence of medium gravelly, subangular ferricrete nodules in upper soil horizons (Mesotrophic Mottled-Subnatric Brown Sodosols).

Acid-sodic soils (‘Soloths’), at a more advanced stage of development, have formed in alluvium on some pediment surfaces (Mottled-Sodic Magnesic Brown Kurosols). These occur along the periphery of many valley systems in the area (eg. Lower Coal River, Pitt Water). They are strongly texture contrast soils with well developed, relatively compact and impermeable, columnar or prismatic structured subsoils (Section 7, Photo 18). They differ from other alluvial soils in having strongly acid pH trends, extremely low exchangeable calcium and Ca/Mg ratios (<0.1), and absence of carbonate segregations in the subsoil. These soils are also characterised by kaolinitic clays, a zone of ferruginous gravels in upper soil horizons, and haematitic mottling patterns at depth. These are features that are generally indicative of laterization.

Tertiary sediments support small areas of cracking clay soils which show some variation in colour, texture, drainage and chemical properties. The common soil consists of a very dark brown to very dark grey, sandy light to medium clay A horizon, which overlies dark brown to brown or olive-brown, light-medium or medium-heavy clay B horizons (Endocalcareous Self-Mulching Black or Grey Vertosols). Heavier textured Grey Vertosols are formed in Tertiary exposures on the sideslopes of stream incisions along Pitt Water. Brown Vertosols have formed on sites where significant amounts of colluvial dolerite material is present in upper soil horizons.

Sandy, texture contrast soils, with comparatively little profile differentiation in upper soil horizons have developed in coastal areas and on terraces adjacent to the modern flood plains of the rivers and streams (Sodic Eutrophic Brown Chromosols). These soils are characterised by deep (50-80cm), dark grey brown to brown surface and light yellow brown subsurface A2 horizons. These horizons are normally loose, single grained and coarse textured, ranging from sandy loams to loamy sands. The subsoils are generally mottled and either, single grain, yellowish brown, sandy loams, or weakly to moderately structured, brown, sandy clay or sandy clay loams. These soils may overlie either Tertiary sediments, Quaternary gravelly alluvium, older weathered aeolian deposits, or Tertiary basalt.

In places (eg. Woodlands Creek near Campania), acid-sodic soils have a thin (4cm) brown Bh horizon, present immediately below the bleached subsurface A2 horizon (Humic Semi-Aquic Podosols). These are very unusual soils, and while limited in extent, they indicate that podzolising processes (translocation of organic matter and perhaps aluminium) are active within some of the more acid alluvial soils.

In higher rainfall areas (eg. Grove district), alluvial soils become more podzolised in character with the development of strong acid pH trends, pronounced bleached A2 horizons, and heavily mottled clay subsoils. The common soil type is represented by the Huon sand (Taylor and Stephens 1935), a Dystrophic Grey Kurosol. This soil consists of a dark grey, loamy sand topsoil, which overlies a bleached light grey eluvial subsurface A2 horizon, that in turn overlies a profusely mottled, yellow and grey, medium to heavy clay subsoil. The surface and subsurface A2 horizons are single grain, or weakly structured, and average 45cm in depth. These soils are mostly poorly drained, owing to both the low topographic position in which they are found, and the weak structure and slowly permeable nature of subsoils. In low lying areas and depressions an indurated gravelly hardpan occurs in the subsurface A2 horizons, and these soils are very poorly drained (Kurosolic Redoxic Hydrosols).

The Huon series (Taylor and Stephens 1935) also consists of a range of soil types with increasingly finer textures (sandy clay, loams, and silty loams) in surface and near surface horizons, primarily due to inputs of silt and clay from the surrounding Permian lithologies. Despite this textural variation, all these soils have profusely mottled clay, or occasionally clay loam subsoils, and are poorly drained. Hardpan phases are common in most of these soils. Little analytical data is available, but these soils appear to have variously neutral or acidic profile trends, and sodic or less commonly, non-sodic upper B horizons (Magnesic-Natric Grey Kurosols or Mesotrophic Yellow Chromosols). Not all soils show a strong texture contrast, as is the case with the Huon silty loam, which commonly forms a Grey Kandosol.

In other places, coarse textured soils (eg. Grove and Lucaston sand, Taylor and Stephens 1935) occur with coarse sandy organic surface and bleached subsurface A2 horizons that overlie a reasonably thick, black or dark brown, organic hardpan (Bh horizon). As with the Huon sand, a hardpan, consisting predominantly of quartz gravel, may also be present within the A2 horizon (Humic Aquic Podosols). These soils occur on slight rises along valley flats, and although they have highly permeable surface horizons, they are generally poorly to very poorly drained and are subject to frequent saturation, due to the combination of low landscape position and soil hardpans.

Soils derived from Quaternary aeolian sand deposits

Small areas of deep sandy soils with minimal profile development (eg. Penrise soil, Holz 1987) occur both along most rivers systems adjacent to the modern floodplain, and on coastal spits in the southern part of the survey area (eg. west of Brighton, Shark Point, and South Arm). These soils consist of uniformly textured, deep, single grain, loose, fine to coarse loamy sands with a 20cm deep, black or dark brown surface horizon. The subsoils are typically strong brown to light yellow brown in colour and may contain a darker coloured tenic B horizon (Arenic Rudosols, Arenic Orthic Tenosols).

Reddish brown soils (eg. Inverquharity, Holz 1987) have developed in older sand deposits, and these are characterised by subplastic, sandy clay loam or sandy loam subsoils, which have a weakly developed large columnar, breaking to subangular blocky, structure. These soils may also contain clay bands and calcium segregations (lime). The surface horizons can show considerable variation. In the Coal River valley the soils are uniform to texture contrast, with a single grain or weakly structured, loose, dark brown surface horizon, overlying a paler coloured A2 horizon which may be bleached (Argic Orthic Tenosols, Eutrophic Red Chromosols). In coastal areas, the soils lack the A2 horizon, and can have black, loam or sandy loam, surface horizons containing abundant shell fragments resulting from pre-historic human activity (Cumulic Anthroposols).

Deep Podzols have also formed in coastal aeolian sand deposits (South Arm and south of Kingston) that have accumulated in valleys and on the footslopes of surrounding hills. These soils are characterised by thick, loose, single grain, light grey to white, coarse sandy subsurface A2 horizons, which overlie irregular reddish black and yellow sandy subsoil (Bh, Bhs) horizons (Pipey Aeric Podosols).

Soils derived from Triassic sediments

Limited areas of brown soils on Triassic sandstone have been identified mainly in the northern part of the survey area and these show considerable variation in texture depending on slope position and the underlying lithology. Most soil horizons, however, are weakly structured and have peds with low cohesive strength. On upper slope positions the soils are typically well drained, with uniformly textured sandy loam to sandy clay loam horizons. A deep (20-40cm) very dark brown surface horizon usually overlies a weak to massively structured, brown to strong brown subsoil horizon (Eutrophic Brown Kandosols). On lower slope positions the soils tend to be heavier textured. Typically, a sandy clay loam surface horizons overlies a sandy light to medium clay, moderately structured, subsoil horizon (Brown Dermosols). The surface horizons may be hardsetting, with a thin (5-10cm) subsurface A2 horizon. Lower subsoil horizons are often a paler olive-brown or yellow brown colour and are mottled to varying degrees depending upon permeability in the subsoil and landscape position.

Podzolic soils (Loveday 1955, Dimmock 1957) are the most common soil identified on Triassic sandstone. Upper soil horizons consist of a very dark greyish brown, 8-15cm deep A1 horizon, over a conspicuously bleached, grey subsurface A2 horizon. The subsoil is invariably a mottled, grey to yellow brown, sandy clay horizon which has a weak to moderately developed subangular blocky structure (Bleached-Mottled

Dystrophic Brown Kurosols). This in turn overlies massive bedrock at depths between 60 and 100cm. These soils are generally imperfectly drained due to the weak grade of structure and heavy texture of the subsoil horizons. Profiles show considerable variation in surface texture and degree of profile development. They range from loose, single grain sands with a pronounced bleached subsurface A2 horizon, to weakly structured sandy loams or sandy clay loams, often without the bleached A2 horizon. On lower slope positions and colluvial footslopes, they commonly have neutral pH trends, are sodic in the subsoil, and have moderate but variable salinity levels throughout the profile (Magnesic Mottled-Subnatric Brown or Yellow Sodosols). Subsoil horizons are generally dispersive and these soils are prone to tunnel and gully erosion in sites of flow accumulation. In general, soils become shallower and stonier along ridge lines and with increasing slope gradient. On upper slope positions, the soils tend to be strongly acid, non-sodic, with slight salinity and low cation exchange capacity.

Podzols on Triassic sandstone (Loveday 1955, Dimmock 1957) are rapidly drained soils transitional to the yellow brown podzolic soils. The upper profile typically consists of a 15-25cm very dark grey loose fabric sand, over a loose grey sand, which may extend to 50cm depth (Humosesquic Aeric Podosol). This in turn overlies a thin, black, sandy Bhs horizon, and massive strong brown sandy loam, or sandy clay loam, upper Bs horizon. The subsoil is generally a massive, dark yellowish brown sandy clay loam, which passes to decomposing sandstone at depths exceeding one metre. Podzols developed in deeper coarse siliceous sand deposits are characterised by thick loose grey and white sands which irregularly overlie (tongued boundary) black organic enriched sand (Pipey Aeric Podosol).

Soils derived from Permian Sediments

Grey brown podzolic soils occur in areas where rainfall is less than about 700mm yr^{-1}. The typical profile is texture contrast, and consists of a shallow (8-10cm), very dark grey or brown, fine sandy loam, surface horizon, overlying a grey, fine sandy loam subsurface A2 horizon. This in turn overlies a dark greyish brown or brown, light to medium clay subsoil that passes to consolidated Permian mudstone at 40 to 60cm depth (Dystrophic Grey or Brown Kurosol). In places, a Bh horizon may underlie a relatively thick A2 (Humic Semiaquic Podosol). Angular coarse fragments ranging in size from gravels to stones are common throughout the soil and often litter the ground surface. The subsoil horizons are massive, or weakly to moderately structured, and have low cohesive strength, easily breaking to a fine powder when the soil is in a dry state. Surface horizons are characteristically hardsetting and in places form a barrier to root development.

On steeper slopes, the soils are usually shallow and commonly more gradational with silty loam to clay loam or light clay profiles (Dystrophic Grey or Brown Kandosols). On benches and lower slopes, the soils tend to be deeper, with strongly mottled sodic subsoils (Natric Brown Kurosols). The soils show more neutral pH trends and stronger structure where associated with more calcium rich sediments. More strongly structured soils with alkaline pH trends are also found in some isolated coastal locations (eg. South Arm). Shell fragments often occur scattered throughout upper horizons.

Permian soils with texture contrast profiles and grey to yellow brown or yellow, strongly mottled subsoil horizons are common in the higher rainfall areas (>700mm yr^{-1}), predominantly to the south and north-west of Hobart (Yellow or Grey

Kurosols). Most soils overlie decomposing Permian rock between 50 and 80cm depth. In low lying areas, soils have developed in fine textured colluvium and are characterised by moderately structured, silty loam or silty clay loam surface and subsurface A2 horizons, overlying strongly mottled, light to medium clay subsoils (eg. Huon silty loam, Taylor and Stephens 1935). Some soils may show little textural contrast (Grey Kandosols). The surface horizons may be deeper (13-25cm) than Permian soils in drier areas and on steeper slopes. They are also moderately well structured and may have root mottling extending to the soil surface in low lying areas, indicating very wet soil conditions.

A brown soil on limestone (Loveday 1955, Dimmock 1957) has developed on the small extents of Berriedale formation (Leaman 1972) west of Granton. This soil is a Terra Rossa and consists of a dark grey brown, loam surface horizon, overlying a red brown, clay loam to clay subsoil, which gradually merges with decomposing limestone. The soil is generally moderately well structured, and well drained, owing to good topographic drainage. Cobbles and stones are common throughout the profile.

5.5 Vegetation

Vegetation was not studied in any detail during the survey and the following discussion provides only a broad overview of the diversity of vegetation types and their more common soil or landscape associations.

The distribution of native vegetation types is broadly correlated with geology, altitude and climate. Fire and grazing history have also played an important role in the development of the native vegetation types we see today. The areas with soil and/or climatic conditions that severely limit agriculture most often retain sclerophyll forests and woodlands (Duncan and Brown, 1985), while the valleys and low lands have been extensively cleared for agricultural uses. While some cleared areas are cropped, the remainder retain native pastures or higher yielding introduced grasses and clovers. The pastured areas contain a variety of grasses and clovers, together with many volunteer weed species.

There are two main types of improved pasture which have been identified within the survey area (Friend *et al.* 1985). Perennial ryegrass (*Lolium perenne*)/Subterranean clover (*Trifolium subterraneum*) pastures occur in areas with light textured topsoils and relatively low rainfall. Perennial ryegrass (*L. perenne*)/White clover (*T. repens*) pastures are more common on heavier textured soils where rainfall is relatively higher. Both pasture types are dominated by annual clovers. Other grass species may be common in improved pastures such as Phalaris (*Phalaris* spp.) and Cocksfoot (*Dactylis glomerata*).

Native pastures containing Wallaby grass (*Danthonia* spp.), Weeping grass (*Ehrharta stipoides*) and Tussock grass (*Poa labillardierei,* and *P. rodwayii*), are common in areas where no pasture improvement has occurred. These pastures usually have a large number of volunteer weed species. Aerially seeded and fertilised native pastures typically contain Wallaby grass (*Danthonia* spp.) and Subterranean clover (*T. subterraneum*). These are most commonly found on Jurassic dolerite hillslopes.

Pastures which are dominated by Buck's Horn plantain (*Plantago coronopus)* are often found on saline sites. Other indicator species include Sea Barley grass (*Hordeum marinum*) and Water Buttons (*Cotula coronopifolia*).

Coastal dune systems typically support a Coastal wattle (*Acacia sophorae*) and Marram grass (*Ammophila arenaria*) association. Casuarina dry sclerophyll forests, dominated by Drooping sheoak (*Casuarina stricta*), are most common on coastal margins in the absence of dune sands and on very steep, stony Jurassic dolerite hillslopes.

The remaining dry sclerophyll forests contain a wide range of species which are best categorised by floristic structure.

Grassy dry sclerophyll forests, with a dense grass cover and sparse shrub cover, are common on the lowland plains and hills, particularly on Jurassic dolerite and Permian mudstone lithologies. They usually occupy sites that are well drained and stony. The Meehan range is a prime example, where Silver peppermint (*E. tenuiramis*) and Risdon's white gum (*E. risdonii*) form open stands. Blue gum (*E. globulus)* is also often found here, as well as in other associations.

Heathy dry sclerophyll forests, with a dense, low, shrub layer, are most often found on infertile or quartzose soils on the lowland plains and undulating Triassic sandstone country. The Black peppermint forests (*E. amygdalina*) of Huntingdon Tier are a suitable example.

Sedgey dry sclerophyll forests are a common feature in poorly drained hollows and flats. They are characterised by a sparse tree cover and dense ground layers of sedges and cords. Extensive areas are found on the poorly drained Permian benches to the south of Lower Longley while isolated pockets are common at higher altitudes in much of the dolerite hill country across the survey area.

Shrubby dry sclerophyll forests have a characteristic multi-layered shrubby understorey and occur on sites which are well drained and fertile. These forests often intergrade with wet sclerophyll forests, occupying the more exposed areas. Much of the higher country around Butlers Hill and Lagoon Tier contains this forest type.

Wet sclerophyll forests in the survey area are restricted to areas with higher moisture availability and more favourable soil conditions. The soils are usually fertile and well drained. The dominant species are Stringybark (*E. obliqua*) and White topped Stringybark (*E. delegatensis*). Examples may be found on the upper slopes of Mount Wellington, Mount Dromedary and Quoin Mountain.

5.6 Land Use

The diversity of landforms, climate and soils throughout the Derwent area support an equally diverse range of land uses. Native pastures remain in the hills and in areas of shallow and stony soils. These areas support grazing, principally for fine wool production. Many areas retain native forest and are used for rough grazing and wood production. The dry sclerophyll forests supply both the local firewood market and woodchips for export. Small areas of Ash dominated forests on Mt. Dromedary supply sawlog to mills in the region and export woodchips. Radiata pine is grown at Pelham Tier.

The valley flats, rises and footslopes throughout the survey area are used extensively for agriculture. The greatest area is given over to grazing or grazing and cropping enterprises that produce fine wool, beef cattle, and fat lambs. In the drier areas, the pastures are grazed in rotation with dryland crops of barley, oats, triticale, wheat, and poppies. Grazing areas that are unsuited to commercial crops are often rotated with fodder crops, such as turnips and oats, during pasture renewal. Several small alternate grazing enterprises produce deer, ostrich and emu products.

Various irrigated agricultural enterprises occur within the survey area, particularly within the South East Irrigation Scheme (SEIS). Irrigation allows a wider range of crops to be grown with less risk than is otherwise possible under dryland conditions. Irrigation is available from a number of sources. Many landholders with river frontage draw water under license for this purpose. The main sources include the Derwent, Jordan, and Coal Rivers, together with a number of smaller rivulets and creeks. On-farm dam storage is becoming more common in many areas, collecting irrigation water from rivers or surface runoff.

The Craigbourne Dam in the Coal River Valley supplies irrigation water to properties within the bounds of the SEIS. The dam was constructed in 1986 and supplies up to 3500 megalitres of water each year to irrigators within the Scheme. This was first fully utilised in the 1995 irrigation season. Stage one of the SEIS currently delivers water from the Coal River to users with frontage to the Craigbourne dam and those users downstream in the Coal River valley as far south as Richmond. Stage two of the SEIS delivers piped water from the Coal River at Richmond weir to the Pages Creek and Duckhole Rivulet catchments.

Photo 4. **Irrigated Brassica production on Class 4p land below Coal River Sugarloaf (SEIS, Campania GR E535200 N5279200).**

Irrigated cropping options include canning peas, brassicas, poppies, fodder crops and turf. Some small areas of land are used intensively for market gardening, principally on alluvial sites at Bagdad and Richmond. Dairying on irrigated pastures is common along the Jordan valley. Viticultural enterprises are found on a wide range of sites north of

Hobart, including several irrigated vineyards within the SEIS. Horticultural enterprises are also common. Pome fruit production is centred in the Grove area. Some stone fruits are also grown here, and to the north east within the SEIS. Cane fruits have been an important industry in the past in some areas.

In some areas the use of low quality irrigation water and poor management, combined with natural soil salinity levels, have resulted in soil degradation and elevated salinity levels sufficient to cause productivity declines in salt sensitive crops. At least one landholder has reported extracting water under licence from the main Hobart supply in order to ensure good irrigation water quality and the sustainability of his cropping enterprise.

Large areas of Mount Wellington and the Meehan Range are gazetted for recreation and conservation. Domestic water production is also an important land use in the Mount Wellington area.

Roading materials are mined from Jurassic dolerite massifs in many areas. Materials that are well suited for surfacing sealed roads are mined from Tertiary basalt at Bridgewater. Mortar sand is mined from aeolian deposits, both those bordering the river terraces and from deeper deposits found on South Arm.

Large areas of land within the survey area have been subdivided for rural residential developments. These include the developments at Acton, Sandford, Lower Longley, Brighton, and Old Beach.

6. LAND CAPABILITY CLASSES ON THE DERWENT MAP

This chapter describes 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 indication of the major limiting factors to agricultural production. Throughout the text references are made to subclass codes and these are shown in parenthesis. A figure is presented for each class indicating its' distribution across the map. The area of each mapped class is also shown in hectares.

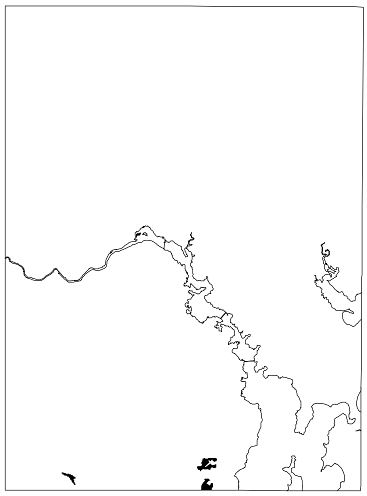
Land capability assessments reported here do not consider potential for irrigation, even where irrigated agriculture may currently exist. The authors do however recognise that there is potential for increased land capability rating in some areas where good quality irrigation water is available. This is relevant only to areas of land that have been assigned a precipitation limitation (p) at the subclass level. The classification remains unchanged where other limitations also occur. Land suitability assessments for irrigation require an assessment of several soil characteristics including the potential for sodification and salinisation under irrigated agriculture. It lies outside the scope of this report to determine these soil characteristics.

6.1 CLASS 1 AND 2 LAND

No Class 1 or 2 land is found in the survey area. Low rainfall (p) and unsuitable soil conditions (s) limit land capability to Class 3 and above.

6.2 CLASS 3 LAND

Class 3	45ha
Class 4+3	249ha



Small areas of Class 3 land occur on Quaternary alluvium and Tertiary basalt where average annual rainfall exceeds 700mm. The dominant limitations include climate, stoniness and soil depth.

Class 3 Land on Tertiary Basalt

Small areas of Class 3 land occur where Red Ferrosols have developed on the sloping ridge crests of basalt flows near Kingston. These are well drained and fertile loam textured soils in which the main limitations are stoniness (g) and soil depth (l). These soils tend to occur in association with imperfectly drained heavier textured Black Dermosols that are situated on flats or occur along drainage depressions and have occasionally led to the identification of a complex of Class 4+3.

Areas identified as Class 3 on basalt are of limited extent, and consequently have not been used for cropping despite their high capability. Some areas have already been subdivided for residential development.

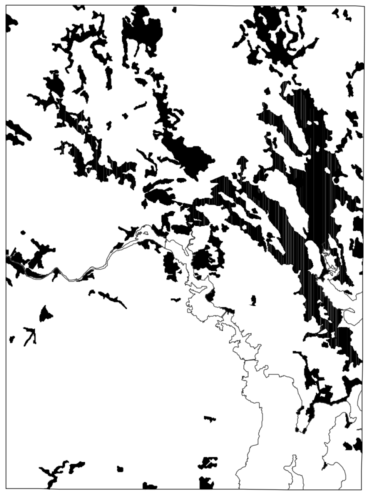
Class 3 land on Quaternary and Tertiary Alluvium

One small area of Class 3 land on Quaternary and Tertiary Alluvium is located just south of Grove. This area contains a well structured Brown Dermosol which is ideally suited to careful soil tillage and cropping (s). Here, the average annual rainfall is 765mm and this should permit a broader range of crops to be grown than elsewhere in the Derwent region. However, this area is not utilised at Class 3 level owing to its very limited occurrence and small extent. Areas too small to be mapped separately may occur pocketed through Class 4 and Class 5 land adjacent to streams and rivers.

Photo 5. Small extents of Class 3s land occur alongside streams and rivers in higher rainfall regions to the south of the survey area. Here, Brown Dermosols which are less prone to soil compaction, make for easy soil tillage (Grove, GR. E507500 N5240750)

6.3 CLASS 4 LAND

Class 4	32 186ha
Class 4+3	249ha
Class 4+5	586ha
Class 5+4	1569ha



Class 4 land is the second most common capability class identified in the survey area. It occupies extensive areas along most valley flats together with the footslopes and lowerslopes of most major landforms. It ranges across most geological types and has a correspondingly wide range of limitations to agricultural use. Approximately 10% of the area mapped as Class 4 had low rainfall as the sole limitation. A further 25% of Class 4 land contained areas where the dominant limitation was rainfall in association with other limitations. Dominant limitations include erosion, drainage, soil depth, stone content, frost risk, salinity and poor soil structure.

Class 4 Land on Tertiary Basalt

The majority of this land may be found on broad plains and rises in the lower reaches of the Jordan Valley around Mangalore, Brighton, and Bridgewater. Significant areas also occur on basalt flows in the Coal River valley, to the east and south of Campania. Smaller areas occur on the gentle footslopes of denuded volcanic cones and flows near Cambridge, Kingston and west of the Coal River. Other pockets occur at Rokeby, South Arm, near Old Beach, and New Norfolk.

Class 4 land on Tertiary basalt is characterised by Black Vertosols and Black Dermosols. These soils have heavy textured clay subsoil horizons, and show characteristic surface cracking in dry summer months. The surface textures are variable, and range from fine sandy loams to light clays. These soils are reasonably fertile, well structured and capable of high crop yields. However, the potential range and yield of crops is severely restricted by low average annual rainfall (p). The low rainfall limitation is exacerbated by the high clay content of the soils, which retains soil moisture at a tension beyond that available to plants, and hence further restricts plant available moisture (eg. high permanent wilting points). Dryland cropping activities can be limited in years with below average rainfall. Many of these areas have the potential for improved capability under irrigation where good quality water is available.

The physical properties of these soils mean that careful management may be required for cropping. Where clay textures extend to the surface, blocky soil structures may make the establishment of seed beds difficult and significant fallow periods may be required to exploit the self-mulching property of some soils (Black Vertosols) and produce a more friable seed bed. In wetter sites, a narrow window of opportunity may exist for cultivation and machinery operations, and these need to be carefully timed in order to avoid subsoil compaction (d). Wetter sites occur in depressions or in areas of higher rainfall such as are found on several basalt rises to the west of Kingston.

Some areas of Class 4 land on basalt are currently supporting irrigated agriculture. However, not only is there concern about the quality of irrigation water used, but many of these soils contain significant salt stores at depth, which could be mobilised up through the soil profile under irrigation. This is especially the case for areas of gentle or flat land where a high water table could bring salts into the root zone causing on-site salinity problems (k). While some areas may be suitable for irrigated agriculture, high quality water (EC<700µs cm^{-1}) and good irrigation management are essential to achieve sustainable land use. Continued irrigation from one season to the next is not recommended as this will lead to a deterioration in soil drainage through a lack of drying and subsequent soil shrinkage. Soil shrinkage during summer months is an important process in these soils, helping to maintain good soil structure and porosity, particularly at depth.

Areas containing Black Dermosols in sites of good topographic drainage (gradients of 5-12%) provide the best sites for irrigated agriculture. The loam textured surface horizons provide for easier cultivation and crop establishment, and have higher plant available water storage than the heavier clay soils. However, erosion may result under more intensive cropping on steeper slopes (gradients of 12 to 18%) and erosion control techniques such as the use of cut-off drains, or contour ploughing or mounding, should be employed in these situations (e).

Along ridge crests, Class 4 land on basalt is limited to shallow root crops and only occasional tillage due to shallow (l) and stony soils (g). In places, stones and larger boulders may provide an inconvenience to cropping, although it is generally feasible to remove these by hand picking.

Mapped units are relatively pure and do not contain significant areas of other classes of land, except for Class 5 land where slopes locally exceed 18% and surface soil horizons are lighter textured, or where areas become excessively stony (stone abundance 35-50% or higher). These areas are most commonly found where streams and rivers dissect the basalt rises.

Class 4 Land on Jurassic Dolerite

Class 4 land has been identified on Jurassic dolerite throughout the survey area, excepting the Kingston and Lower Longley areas to the south of Mount Wellington. Within this Class, areas of Jurassic dolerite typically form rises, low hills and rounded hills rising to 500m above sea level. It also includes some localised areas within slump complexes situated at the base of larger hills, such as that found at the base of Gunnings Sugarloaf.

Class 4 land is generally associated with footslopes and lower slopes along valley margins, but may also extend onto terraces and flats where colluvial dolerite occurs, such as is found at Pitt Water and in the lower Coal River Valley. As with basalt, dolerite may produce Black Vertosol and Dermosol soils and these tend to occur within a 30km radius of Hobart, where average annual rainfall is below 640mm. These soils are reasonably fertile and well structured, with a self mulching surface. The high clay content in these soils restricts water availability in summer months thereby limiting dryland cropping activities in some years. The range of crops is always restricted by low rainfall (p) and irrigation allows for a wider range of crops to be grown with less risk of crop failure. Some small areas of land are limited by wetness where significant run on occurs from upslope (w). These are principally found in drainage depressions. When wet these areas drain very slowly and this tends to restrict the working window for cropping activities. Ploughpans may develop if cultivated when wet, restricting soil aeration and root penetration. In colluvial soils, moderate subsoil salinity indicates a potential salinity hazard under irrigation (k). The small areas where Black Vertosols are found on slopes between 18 and 28% are limited by erosion potential (h). The most extensive areas occur on the footslopes of dolerite hills north from Hobart City along the Derwent, along Middle and Back Tea Tree roads and in the lower Coal River valley.

Brown or Red Dermosols, or Red Ferrosols are found on footslopes and lowerslopes and on mid to upper slopes and ridge crests across the survey area. These soils are reasonably fertile, moderately to well structured, and well drained. The areas in which they are found are usually limited by soil depth and stone content (l and/or g). Low rainfall is the dominant limitation in the few areas where soils are sufficiently deep and stone free to facilitate cropping (p). As with the Vertosols described above, such areas mostly occur on colluvial footslopes, and gently sloping fans of dolerite hills. Erosion is the dominant limitation on slopes from 12 to 18% in the case of sandy clay loam surface textures, or from 18 to 28% in the case of light clay surface textures. However, in most cases, both soil depth and stone content become the main limitations on steeper slopes. As with the Vertosols, the Dermosols and Red Ferrosols also occur where average annual rainfall totals are less than about 640mm. However, they are more extensive in area, occurring on gently to steeply sloping low hills to elevations of 300m, along most valley systems to the north and east of Hobart. Small areas containing these soils extend to elevations of approximately 500m where cropping may also be limited by frost risk (t).

Inclusions of small areas of Class 5 land on Jurassic dolerite are common due to the limitations of mapping at this scale. They are usually found along ridge crests and on convex slopes and contain shallow and stony soils (l and g). Localised areas containing soils with lighter soil textures and slope gradients over 18% are unsuitable for cropping due to erosion risk (h).

Class 4 Land on Quaternary and Tertiary Alluvium

Class 4 land on Quaternary and Tertiary alluvium includes most areas on the modern day flood plains of the rivers, streams and tributaries of the survey area, together with higher terraces and dissected pediments of up to about 40m in elevation above the present stream levels. The major areas of Class 4 land include most of the Coal and Jordan River valleys, Bagdad and Strathallan Rivulet valleys, either side of Pitt Water, and many smaller valley systems such as Pages Creek, Duckhole Rivulet, Woodlands Creek, and White Kangaroo Rivulet.

Class 4 land on Quaternary and Tertiary alluvium encompasses a wide range of soil types. These are predominantly Sodosols and Vertosols, but less commonly, Kurosols and Dermosols. The principal limitations relate to soils and climate. Major soil limitations (s) relate to poor soil structure and internal drainage characteristics. Low annual rainfall (p) is the main limitation for cropping where no other major soil limitations occur. This is due to the fact that most valley systems fall within the rain shadow of NW/SE trending mountain ranges.

Photo 6. Class 4p land is often associated with well to moderately drained, fertile Dermosols formed on Quaternary alluvial deposits. These areas are limited in extent, but common alongside streams and rivulets in the northern half of the survey area (Strathallan Rivulet, GR E527000 N5276500)

Land where the range and productivity of crops grown is limited by low rainfall (p) is limited in extent, but common along the floodplains of most of the major rivers and smaller rivulets and streams, predominantly within the northern part of the survey area. These areas contain Black and Brown Dermosols which drain freely, are well aerated and friable. They are well suited to intensive grazing and regular broadacre cropping. However, care should be taken to avoid structural decline and subsoil compaction through excess tillage. Many of these areas have the potential for improved capability under irrigation if high quality water is available. Salinity levels measured in topsoils at some localities ($EC_e \approx 1\text{-}2 ds\ m^{-1}$) are sufficient that use of poor quality irrigation water ($700 < EC_w < 2000\ \mu S\ cm^{-1}$) is likely to cause productivity declines in salt sensitive crops.

Stone content (g) is often the main limitation in areas where recent soils (Clastic Rudosols) have developed in flood plain alluvium. This alluvium is deposited by high energy streams draining the higher mountains such as Mount Wellington (eg. Mountain River). These valley flats are also prone to flooding with a major flood expected about 1 year in 20 (Huon River Flood Plain Report 1991). This is not considered to pose a significant risk to cropping at the Class 4 level. Climate, however, does pose a significant problem with cold air drainage, late frosts, and strong winds making crop establishment difficult (t). Shelter belts of *Poplar* species have historically been planted perpendicular to the stream course in some valleys to help protect crops and orchards.

Photo 7. Class 4d land. Waterlogging on this slow draining Black Vertosol hinders plant growth and limits trafficability (Campania, GR E536000, N5279500).

Floodplains and drainage depressions elsewhere often develop Vertosols with black to grey, light to medium clay textures throughout. These soils can be distinguished by characteristic large cracks which appear during dry summer months. Drainage is rapid upon first wetting. However, as they absorb water, they swell and the cracks close. Subsequently, they can remain wet for long periods of time. Under these circumstances tillage can be difficult and lead to smearing of the topsoil and compaction of the subsoil (d). Many of these Vertosols are highly saline, generally at a depth corresponding to the depth of the winter water table. This is typically found at 70 to 100cm below the surface, but can be found nearer the surface in some areas. Under these circumstances, root growth and plant vigour are significantly reduced in most crops and the dominant limitation is salinity (k).

Class 4 land is also associated with Black Vertosols developed in Tertiary clay sediments. These occur on older surfaces elevated above the present floodplain. The most extensive area occurs between Duckhole Rivulet and Malcolms Creek, south west of Richmond. Similar Vertosols developed in Tertiary clays also occur on the side of incisions and colluvial footslopes adjacent to dolerite landforms. These soils have better drainage and lower salinity readings than the Black Vertosols in lower lying areas and drainage depressions. Consequently, these areas are better suited to irrigation as the main limitation is generally the lack of rainfall (p). However, as with other Black Vertosols (eg. those developed on dolerite and basalt) careful management is needed for cropping due to the physical limitations of the soil. Excessive irrigation and the use of poor quality water should be avoided.

Photo 8. Class 4d land. Imperfectly drained soils require careful management under irrigation. Rill erosion and waterlogging occur where irrigation scheduling is inappropriate or when storm rains occur (albeit infrequently) (SEIS Stage 2, GR E533800 N5265700).

Class 4 land is common in most valley systems on alluvial coverbeds on the higher terraces and dissected pediments. Brown Sodosols are the most common soil found. Large areas are located between Mangalore and Bagdad, in the lower reaches of the Coal Valley, at Rokeby, and bordering the shores of Pitt Water. The land is predominantly flat to gently rolling with slopes to 12%. The main limitations here relate to the physical and chemical characteristics of the soil. Sodosols generally have weakly structured, light textured topsoils, overlying sodic, relatively impermeable, strongly alkaline clay subsoils (s). The weakly structured topsoils are prone to rapid structural decline under cultivation. This can leave the soils prone to sheet and rill erosion (h), particularly on sloping sites where surface horizons are dispersive. Soil structural decline can also leave these areas at risk to wind erosion (a), particularly where the topsoils have low clay contents. Most Sodosols are also imperfectly drained due to the dispersive nature of the clay subsoil (d). This usually limits trafficability and can impede root development where topsoils are shallow. Many of these soils also have hardsetting surface horizons which can further restrict root development. Some poorer areas contain Sodosols with an acid trend and associated fertility problems.

Irrigation should only be considered on Sodosols if extremely careful management practices are put in place. The risks of waterlogging, and sheet and rill erosion are increased in these areas due to the slow rates of water movement in the subsoils. Most soils have low to moderate salinity levels, however the poor drainage character of the subsoils means that these areas will be particularly prone to salinisation if anything other than high quality water is used. Flushing of salts is generally required through artificial drainage and this may be difficult to achieve given the dispersive nature of the sodic clay subsoils. Application of gypsum is generally required to help stabilise these clays and maintain porosity. However, even with irrigation and appropriate drainage, the physical limitations inherent within these soils do not allow an increase in the land capability classification of this land.

Inclusions of Class 5 land within Class 4 land occur on the sides of incisions where slopes locally exceed 12% and Sodosols are the main soil type. They also occur on steep terrace escarpments, along drainage lines where poorly drained and saline Vertosols are the main soil type, on raised pediments where Kurosols occur with sand or loamy sand textured surface horizons and columnar structured subsoils, on outcrops of shallow and stony Tertiary Basalt or Jurassic Dolerite, and finally, on aeolian sandsheets.

Class 4 Land on Aeolian Sands

Some small areas of Aeolian sand deposits are found in the survey area which are suited to intensive grazing and occasional cropping. These areas are of limited extent, and are found proximate to rivers in the northern half of the survey area, pocketed along coastal areas about Pitt Water and South Arm. The landform is typically a gently sloping bench (gradient <12%) which may exhibit some slight dune development. The largest areas are located between Bridgewater and Boyer on both sides of the Derwent River. The soils along the rivers are typically Orthic Tenosols or Red Chromosols with topsoil textures which are heavier than clayey sands. They are relatively fertile soils with good drainage characteristics, however they are at risk of wind erosion due to the combination of their light textured and weakly structured topsoils and their inherently windy landscape position (a). In coastal areas the soils are typically Cumulic Anthroposols with loam or sandy loam surface horizons containing abundant shell fragments from ancient aboriginal middens. They too are limited by wind erosion risk (a).

Class 4 Land on Triassic Sediments

Class 4 land has been identified on Triassic sediments across the survey area, predominantly limited to the valley footslopes, pediments, rises and low hills. Examples of extensive areas of Class 4 land on Triassic sediments are at Kempton, Acton, Colebrook and south of Broadmarsh. The Triassic sediments are predominantly composed of quartzose sandstone but also contain varying proportions of shale and mudstone, giving rise to a range of soil types. The dominant limitations are soil drainage and erosion, with some small areas limited by low rainfall.

Class 4 land limited by low rainfall (p) tends to occur predominantly in regions adjacent to dolerite capped hills where average rainfall totals less than 700mm each year, the altitude is less than 380m above sea level, and topographic gradients are less than 12%. The largest areas are found below Gunnings Sugarloaf, north of Campania, and immediately to the east of Richmond, although small units are common across the survey area. The landform is typically that of a fan or sheet deposit, with long, broad, uniform to concave slopes. The typical soils are Brown Dermosols with moderate structure throughout. They are moderately fertile and have neutral pH trends. The even, slight slope of the typical landform affords these areas good topographic drainage. However, these areas have subsoils which drain slowly, therefore machinery operations need careful timing to avoid compaction of wet subsoils. These areas are generally suitable for irrigation where good quality water is available.

Class 4 land on Triassic sediments most commonly contains texture contrast soils and these may extend from the hillslopes onto the valley flats. The soils are typically Brown or Yellow Sodosols. They commonly have neutral pH trends, are sodic in the B horizons, have moderate but variable salinity throughout, and very low fertility. Those areas with particularly light textured topsoils are vulnerable to erosion from wind and water (e). Most areas have topsoils which are poorly to moderately structured, making them susceptible to structural decline when over-cultivated. This also leaves them prone to erosion, to the extent that many parts of the survey area with a long cropping history, contain soils with reduced topsoil depths. The texture contrast nature of the Triassic soils, combined with the sodic subsoils limits soil drainage (d) and root development and, in some cases, exacerbates the water erosion potential (h). Many areas contain soils with infertile, bleached subsurface horizons directly below the topsoil. All tillage operations should avoid disturbance of these bleached horizons and indeed the B horizons. Mixing will reduce soil fertility, damage topsoil structure and lead to hardsetting.

On some upper slope sites, well drained, uniformly textured Brown Kandosols provide potentially better soils for cropping. However, they are of limited extent and found principally on steeper country and are therefore erosion prone (e). The soils are generally weakly structured with low cohesive strength throughout and are therefore prone to structural decline under cultivation (s).

Class 4 Land on Permian Sediments

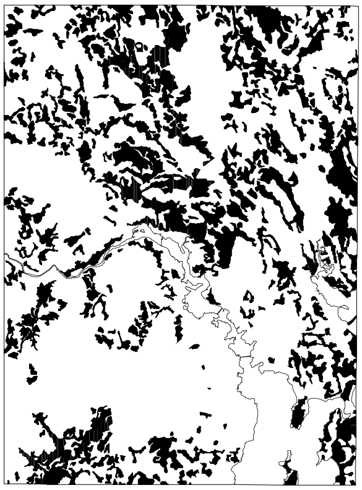
Class 4 land on Permian sediments is generally restricted to small areas of gentle lowerslope and valley floor sites of up to 12% gradient in areas of lower average annual rainfall (<650mm yr^{-1}). These are found to the east and southeast of Hobart. The soils are commonly Natric Brown Kurosols or Brown Sodosols. They are generally nutrient poor, often strongly acid, and require substantial improvement to make commercial cropping viable. Use of these areas is normally restricted by imperfect subsoil drainage (d) and hard setting character of surface horizons (s). On many colluvial footslope sites the soils are very gravelly and have hardsetting topsoils. This provides a shallow effective rooting depth and poor establishment conditions for plants (g and s). The relatively light textures (silty or fine sandy loams or clay loams), weak structure and poor cohesive strength of the topsoils when disturbed, makes these areas prone to wind and sheet erosion, particularly on exposed or steeper sites (e). The shallow topsoils are easily lost under repeated cultivation.

Class 4 land also occurs in one small area of Permian limestone near Granton where land is generally stony and occurs on steeper slopes (e + g). This has proved ideal for viticulture, given the north easterly aspect of the site. Some of the soil limitations associated with Permian soils are alleviated in sites where colluvial additions from dolerite occur. Dryland cropping activities are undertaken on a limited basis in these localities.

Areas of Class 4 land on Permian sediments generally do not contain inclusions due to the small aerial extent of individual polygons.

6.4 CLASS 5 LAND

Class 5	44 481ha
Class 5+4	1 569ha
Class 5+6	3 178ha
Class 6+5	879ha



Class 5 land is generally found where stoniness, slope steepness, soil erodibility or shallow soils preclude cultivation, except for pasture improvement. It often occurs at the break in slope between Class 4 land on valley bottoms and steeper Class 6 land. Class 5 land also includes areas restricted by cold temperatures at elevations above 500m, together with areas restricted by major soil limitations at lower elevations.

Class 5 Land on Tertiary Basalt

Large areas of Class 5 land on basalt are found between Bridgewater, Brighton and Pontville. These areas have very shallow (l) and stony (g) soils unsuitable for cropping. They are invariably too stony at depth to warrant picking for land improvement. These areas are commonly located on broad ridge crests and convex slopes, but also include the steep river banks along the Jordan River. The soils are characteristic Black and Brown Dermosols.

Very small pockets of Class 5 land are associated with extinct volcanic cones distributed across the survey area. These areas generally form small hills with gradients between 18 and 45%. They contain very stony soils unsuitable for cultivation other than for pasture improvement (g). Steeper slopes may be subject to soil creep (m) and downslope movement of topsoil if overgrazed.

Inclusions of Class 4 land occur off the crest of hills, particularly on concave slopes where the soils may deepen a little. Inclusions of Class 6 land occur alongside stream incisions where slopes become very steep with large areas of exposed rock.

Class 5 Land on Jurassic Dolerite

Class 5 land on Jurassic dolerite may be found to altitudes of 600m above sea level. Some small areas above 500m sea level are limited by low temperatures and a resultant short growing season.

Extensive areas of this land are found throughout the survey area. Most of these areas contain Brown or Red Dermosols, or Red Ferrosols that are moderately fertile. However, high stone contents make these areas unsuitable for regular cultivation (g). In addition, many of these areas contain shallow soils which do not hold enough moisture to allow commercial crop growth (l). They are commonly found on the mid to upper convex slopes and crests of the hills and rises. The slopes are usually moderate to steep, up to 28%, yet there are some areas where stoniness and shallow soil depth limit production on very gentle slopes. Examples of this may be seen at White Banks west of Kempton and on the lower slopes of Lodge Hill at Brighton.

Photo 9. Class 5e + 4e land. Class 5e land on Jurassic dolerite occurs where slopes range from 18 to 28%. Class 4p land occurs along valley flats in the foreground (Coal River near Nairns Sugarloaf, GR E534900 N5280700).

Areas of limited extent, principally in the hills in regions where average yearly rainfall exceeds 640mm, contain Grey Chromosols with coarsely textured topsoils and poorly structured subsoils. These areas are typically stony (g) and have a high erosion risk on slopes between 12 and 18% (e). Wetness (w) and poor internal drainage (d) are often additional limitations in low lying areas, and on very broad gently sloping crests.

Small inclusions of Class 4 land and Class 6 land are common within this class. The Class 4 land is typically found on concave slopes and colluvial deposits while the Class 6 land is more common along ridge crests and slopes over 28%. Variations in topographic gradient, stone content and soil depth are the principal limitations dictating the amount and type of inclusion within this class. In many areas Class 5 land on Jurassic dolerite forms a narrow band less than 300m wide between the Class 4 valley floors and footslopes, and the steep stony Class 6 hillslopes. These areas have generally been merged with the adjacent Class 4 land at the 1:100 000 scale of mapping.

Class 5 Land on Quaternary and Tertiary Alluvium

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

Saline areas are found in regions of lower rainfall (<700mm yr^{-1}), particularly in coastal localities on sites with restricted topographic drainage, such as near Hobart airport and the valley floors behind the foredunes on South Arm. Here, poorly drained Vertosols and Dermosols are saline (EC_e>8ds m^{-1}) in the top 70cm of the soil and this restricts growth in many pasture species and precludes cropping (k).

Extensive areas of Class 5 on alluvium occur south of Mt Wellington along Mountain River and its tributary rivulets and creeks. Here, a combination of higher rainfall, low topographic gradient, and hard-pans within the soils lead to poor drainage and frequent soil saturation. Most of the soils are either Aquic Podosols, Yellow Chromosols or Yellow Kurosols. The former soils commonly contain organic hardpans and gravel layers near the soil surface, while the Yellow Chromosols and Yellow Kurosols occur in drainage depressions and have thixotropic surface and subsurface horizons. Surface flooding commonly occurs during winter months, severely restricting agricultural activities at this time of the year. Furthermore, summer flooding can also take place and the risk of significant crop loss is considered too great to classify this land as Class 4. The thixotropic character of these soils also makes cultivation difficult, except during the drier summer months. However, dry periods normally occur too late in the season for commercial cropping. The soils are also commonly strongly acid and have low natural fertility. They respond well to fertilisers and produce some of the better grazing land within the survey area.

Inclusions of Class 4 land occur where small areas of alluvial soils have formed in the dolerite basement rocks exposed along terraces near Grove. Small inclusions of Class 6 land occur either on very steep terrace escarpments, or where very shallow and stony soils derived from Permian rocks are exposed on rises.

Class 5 Land on Aeolian Sands

Several large areas of wind blown sand are suitable only for grazing due to poor soil condition (s) and erosion risk (e). The area on the south bank of the Jordan River to the west of Brighton, that north of Kempton, and the extensive sandsheets at Sandford are the largest examples of this class. The soils are typically Arenic Rudosols or Orthic Tenosols. The topsoils are loose and generally structureless. In combination with very low organic matter levels and low clay content, this makes these soils particularly prone to wind erosion. They are also inherently infertile and have low moisture holding capacities (s). As a result, the risk of crop failure and subsequent wind erosion on unprotected bare soil is very high (a). They require careful grazing management to ensure adequate vegetation cover at all times.

Aeric Podosols have formed in many of the coastal sand deposits. Much like the Rudosols and Tenosols found in other aeolian sand deposits, the areas containing these soils are unsuitable for any cropping due to poor soil conditions (s) and the risk of wind erosion on unprotected soil (a). Class 5 land in these situations is restricted to slopes less than 12%.

Class 5 Land on Triassic Sediments

Class 5 land occurs on Triassic sediments where either soil properties (s) or potential for soil erosion (e) form the major limitations to cropping. Class 5 land is limited to slopes between 12 and 18% where the soils are finer textured Brown Sodosols or Kurosols. The potential for water, tunnel and gully erosion is a major limitation in these areas.

Class 5 land on Triassic sediments also occurs in places where topsoils are coarse textured and unsuitable for cropping. These areas of Class 5 land are generally found on the upper slopes of the low hills and rises. The typical soil is a Dystrophic Brown Kurosol. These soils contain very low amounts of clay and organic matter in the A horizons. This results in very weakly structured or loose topsoils that are highly erodible by water (h) and wind (a). Slopes up to 18% have been identified in this class. In higher parts of the landscape these soils have a strong acid trend, are very infertile (s) and often are shallow (l) and stony (g). These features become the dominant limitations where slopes are less than 12%. Extensive areas are located along the footslopes of the hills north of Elderslie.

Class 5 land is also associated with areas of coarser grained sandstones which often develop Aeric Podosols. Major limitations are soil related (s). The soils have an acid trend, very low natural fertility and sand or loamy sand textured A horizons. They have very low moisture holding capacities and may contain impermeable iron rich pans. These features drastically limit potential productivity and make them highly susceptible to wind (a) and water (h) erosion when cultivated. Some limited areas are suitable for pasture improvement where slopes are less than 12%. These are usually in landscape positions where run on provides an additional moisture source, but increased erosion risk. These areas are common on the benches and along drainage lines in the Tiers and hills of the north west of the survey area. The dominant limitation is erosion risk (e), although some areas also contain large amounts of stone (g) and rock outcrop (r).

Class 5 Land on Permian Sediments

Class 5 land on Permian sediments ranges from valley floors through to moderately sloping low hills and gently sloping benches at elevations of around 650m. Principal areas occur in and around valley systems near Grove and along Mountain River, near Lachlan, and on elevated plateaux near Collinsvale and west from Kingston. Other areas include lowerslopes along Back River, hillslopes to the west and southwest of Mangalore and in the northern section of the Jordan River, and moderate slopes and valley floors along Clarence Plains Rivulet and near Sandford.

Class 5 land has similar, but often shallower and stonier, soils compared to Class 4 land on Permian sediments. Angular stone sized rock fragments are a common surface feature of hillslopes. Soils are also highly erodible in most places and subject to tunnel erosion in sites of flow accumulation. Consequently erosion (e) is the dominant limitation on terrain with slopes ranging from 12 to 18%. In addition to tunnel erosion, sheetwash is likely where soil remains exposed for any length of time. Stone content (g) and soil depth (l) are the main limitations along ridge crests. Cultivation in these areas is either difficult to achieve or too risky due to the high erosion potential.

Deeper soils are occasionally present on steeper slopes, particularly those developed in calcareous lithologies. These areas are moderately erodible (e) and can provide good grazing on steeper slopes to about 28%. In places, stone content can be high (g).

Photo 10. Class 5sw on Permian sediments, illustrating wet soil conditions resulting from poor topographic drainage and slowly permeable clay subsoils (Leslie Vale, GR. E517700 N5243500).

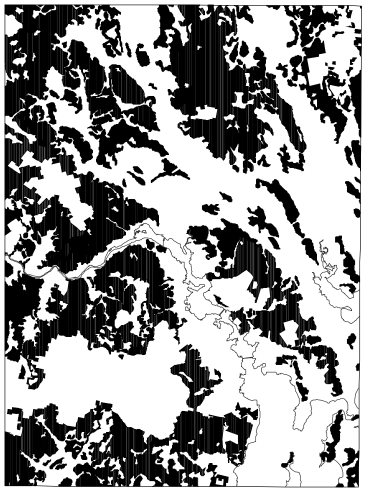
On gentler slopes (<12%), the dominant limitations are soil related ranging from very shallow (l), stony (g) and infertile soils through to poorly drained soils in depressions (w). In lower landscape positions, these soils are often poorly to very poorly drained and contain thixotropic subsoil horizons which flow when wet and set hard when dry, drastically impeding tillage operations and limiting root development (s). They also exhibit weak structure throughout, are very pale in colour, infertile and are unproductive without intensive management inputs. For example, extensive apple orchards have traditionally been planted on these soil types in the Grove area, because despite low natural fertility, these soils generally respond well to fertiliser additions and liming to alleviate the strong acidity. In wetter areas, they provide very productive pastures, although they may be subject to severe pugging during wet winter months.

Plateaux underlain by Permian sediments also have poor topographic drainage and soils that remain wet for considerable periods (w). These soils are also unusually shallow (l), making soil tillage impractical. At higher elevations of around 500 to 650m, frost risk and wind exposure, particularly near Mt Wellington, limit pasture growth and make cropping impractical (t). Soils at these sites are also often very stony (g).

Class 5 land may contain small inclusions of Class 4 land where drainage restrictions are alleviated by increased runoff. These occur on rises within areas of predominantly gently sloping terrain.

6.5 CLASS 6 LAND

Class 6	85 024ha
Class 5+6	3 178ha
Class 6+5	879ha
Class 7+6	602ha



Class 6 land is the most extensive capability class occurring within the Derwent survey area and is most commonly found on steeply sloping terrain comprised of dolerite, or Triassic and Permian rocks. It identifies all land considered marginal for sustainable agricultural production. Agricultural activities are severely restricted by a range of limitations including climate, soil drainage, shallow soil depth, excessive stoniness, rock outcrops, topographic gradient and very high erosion risk.

Class 6 Land on Jurassic Dolerite

Extensive areas of Class 6 land on Jurassic dolerite are distributed across the survey area and predominate in areas where topographic gradients exceed 28% and/or elevation is over 600m above sea level. In addition, many of the higher ridge crests and upper slopes below 600m within the Dolerite hills also fall within this class due primarily to stoniness (g), shallow soil depths (l) and severe erosion risks.

At lower elevations, this land commonly contains Brown or Red Dermosols, or Red Ferrosols and is found on steep hills, together with the ridges, crests and steeper slopes of low hills. This land is only marginally suitable for grazing activities due to the shallow (l) and stony (g) nature of soils. Pasture improvement is limited to aerial seeding and/or fertilising. Rock outcrop is the dominant limitation on a limited number of ridge crests. Erosion risk becomes the dominant limitation on gradients over 28%, partly due to the high stone content, low rainfall and the lighter textured nature of topsoils in many areas. Poor pasture cover during late summer can leave steeper slopes prone to erosion. Many areas are still under the natural forest and most which have been cleared are actively eroding. This erosion is most evident on the many north facing dolerite slopes in the region which remain free of vegetation cover for much of the year. The high insolation levels combined with the low moisture holding capacities of the shallow stony soils conspire to drastically limit pasture growth. Once bare, the soils are prone to wind and sheet erosion (a and h). Rill and gully erosion are common also, particularly on the longer slopes (h). Prime examples can be seen on the north facing slopes of Jews Hill to the east of Brighton and Johnsons Hill to the west of Kempton.

Steep slopes with deeper soils are usually found facing south and often the soils grade through to Grey Kurosols and Grey Chromosols. These sites are not subject to the same erosion risks since the pastures perform better due to the deeper soils and lower insolation levels. These areas are however, prone to mass movement (m), such as is occurring on the south facing slope of Coal River Sugarloaf.

Photo 11. Class 6eg land. Many steep, north facing Jurassic dolerite hillslopes do not maintain adequate pasture cover and are subject to wind, sheet, rill and gully erosion (The Tang, GR E512500 N5292500).

Class 6 land with Grey Kurosols and Grey Chromosols also become more common at higher elevations and in higher rainfall areas. Here, the topsoils are often sandy loams and the subsoils poorly structured, with a concomitant higher erosion risk, such that slopes over 18% fall into this class (e). The soils in these areas are also generally shallow and stony (l and g), and for the most part retain their native vegetation cover.

Small areas of Class 5 land on Jurassic dolerite are the most common inclusions and these are found mostly where Class 6 land bounds Class 4 land. Some areas of Class 5 land are also found to elevations of 600m above sea level or on slopes above 28% where the soils are deeper, less stony or heavier textured. This represents the highest occurrence of Class 5 land on dolerite, rather than where Class 5 land is limited by climate. These soils are generally Brown or Red Dermosols, or Red Ferrosols and the limitations, again, are usually erosion risk, stoniness or shallow soil depths (e, l, or g). Small areas of Class 7 land on Jurassic dolerite are found as inclusions in this class, principally on areas of cliffs and bluffs, but also on small boulder fields at higher altitudes.

Class 6 land on Quaternary and Tertiary Alluvium

Small areas of land mapped as Class 6 on Quaternary and Tertiary Alluvium occur along the river systems which drain from Mt Wellington. The land is wet for much of the year and some areas have soils that contain many large rocks and stones (g) at, or near to the surface. The heavy clay nature of the subsoils, combined with low topographic gradients, prevent this land from being drained satisfactorily (d). This limits its use to rough grazing during drier periods of the year only.

An area of Class 6 land on a drained coastal lagoon is located near Hobart airport. It has poor vegetative cover except for salt tolerant species. Pasture productivity is severely reduced due to high salinity levels ($EC_e > 16 ds\,m^{-1}$) which is the dominant capability limitation (k).

Class 6 Land on Aeolian sands

Class 6 land on aeolian sands occupies small areas where sand has been deflated from coastal sites or from river beds and blown onto the footslopes of surrounding hills. While most of the areas comprise Class 5 land, some small areas have been identified as Class 6 land where the topographic gradients exceed 12%. These areas are highly susceptible to wind (a) and water erosion (h). Sand blowouts caused by overgrazing and stock ‘bathing’ are a common feature in these areas. Significant areas are found on South Arm and at Kingston. Small areas are found along the Jordan River.

Class 6 land on Triassic sediments

Class 6 land on Triassic sandstone covers extensive areas of moderate to steep sloping hills rising to 600m in elevation, principally in the north west and north east of the survey area.

Most of this land contains Aeric Podosols, or Brown Kurosols. These soils are characterised by coarse textured, structureless surface horizons which are highly erodible. Where Podosols are found, the slopes are typically over 12% and erosion risk is the dominant limitation (e). The Brown Kurosols are slightly less erodible and areas where slope gradients exceed 18% should be left under perennial vegetation (e).

These areas are inherently unproductive and are very difficult to manage without damage. Most areas remain under native forest and are only grazed lightly. Rock and boulder outcrops are common features (g and r). Huntingdon Tier, Pelham Tier and Heathy Hills are prime examples of this land class.

Class 6 Land on Permian Sediments

Class 6 land is the most extensive class mapped on Permian sediments. This land covers large areas of steeper terrain in the southern part of the survey area. It includes dissected hills to 700m in elevation occurring below, and to the east of the major mountain peaks of Mounts Dromedary, Wellington, and Faulkner. It also includes steeply sloping terrain in other localities, such as, either side of the Derwent River near New Norfolk, east of Mt Misery and Mt Ruddy in the south west corner, large areas of the Meehan Range east of Hobart between Cambridge and Risdon Vale, and an area from Dawsons Hill to Snows Hill in the north east corner. Low hills rising to 200m from Howrah to South Arm, including Mt Mather and Augustus, are also predominantly Class 6 land.

Class 6 land occurs mainly on the steeper slopes and hill crests where soils are too shallow (l), stony (g), and infertile (s) to allow tillage or productive grazing. The soils are commonly Dystrophic Grey Kandosols or Brown Kurosols and these tend to show limited profile differentiation with the exception of hardsetting topsoils and weakly structured subsoils, which directly overlie bedrock to depths as little as 25cm. The topsoils are normally shallow and show little accumulation of organic matter. Stones

Photo 12. Class 6a land. Aeolian deposits of structureless, nutrient poor sand are very difficult to manage. Pasture establishment and maintenance are problematic and these areas are often subject to wind erosion (Blackbrush GR E515100 N5276025).

Photo 13. Class 6e land on Triassic sediments is found on slopes with gradients over 18%. Here, poor pasture cover is exacerbating the erosion problem. Class 4p land is found on the alluvial flat in the foreground (Brandy Bottom, GR E 532700 N5293500)

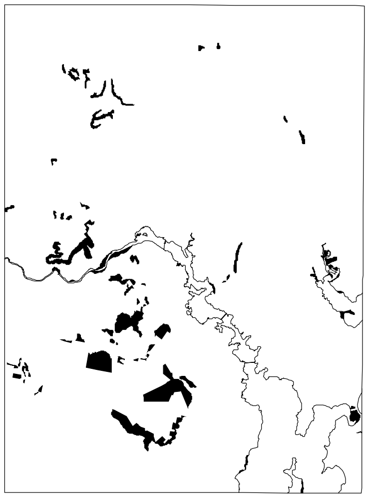
and quartz pebbles are common features of surface layers. These areas are highly erodible (e) and prone to surface wash processes if cleared, and should remain under perennial vegetation cover wherever possible. Inappropriate clearance has resulted in some dramatic cases of soil erosion as can be seen by now barren ridge crests on the eastern side of Grasstree Hill Road towards Richmond. Forest clearance has, in effect, converted this area to Class 7.

Permian soils developed in the more calcareous lithologies are generally more productive, especially in areas where average annual rainfall exceeds 700mm. In these areas, Class 6 land is restricted to gradients over 28%. Mass movement (m) in the form of shallow soil slips is often a feature of steeper slopes cleared of forest vegetation.

Class 6 land commonly contains areas of Class 5 land which are too small to be mapped separately. These areas tend to occur at higher elevations, either along broad ridge crests, or on gently sloping benches. Soils are generally deeper and often comparatively stone free. Most areas support rough grazing. Class 7 inclusions also occur where topographic gradients exceed 55%, or become excessively stony (surface stones > 90%).

6.6 CLASS 7 LAND

Class 7	4796ha
Class 7+6	602ha



Class 7 land represents areas unable to support agricultural activities on a sustainable basis. These are usually either very steep areas comprised of large areas of bare rock and shallow soils, or areas capped by boulder scree. Most Class 7 land occurs at elevations above 800m and is restricted by cold temperatures and strong winds. Most areas border exclusion zones.

Class 7 Land on Jurassic dolerite

Class 7 land on dolerite is limited to areas where rock and boulder scree cover the ground surface (g). These areas are typically found on the mountain plateaux or below cliffs on the upper slopes. Most areas lie over 800m above sea level. The largest areas identified were found on the upper slopes of Mount Wellington and surrounding peaks, the upper slopes of Mount Dromedary, and the peak of Quoin Mountain and Mount Faulkner. An extensive area of Class 7 land was identified where boulder scree extends to the valley floor in the region of Big Rocky (Photo 14), north west of Collinsvale.

Small areas of Class 6 land on Jurassic dolerite are found as inclusions in this class.

Photo 14. Class 7g land. Extensive boulder scree precludes agricultural use (Big Rocky, GR E514500 N5258900).

Class 7 land on Quaternary and Tertiary Alluvium

Class 7 land on Quaternary and Tertiary Alluvium has been identified on tidal marshlands downstream from Boyer in the Derwent River estuary and on the shores of Pitt Water to the south of Richmond (Photo 15). These areas comprise estuarine silt traps, mudflats and swamps which are characterised by 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 (w). As a result, conditions within the potential root zone are anaerobic and saline (s). Inundation by king tides is not uncommon. These features make these areas unsuitable for agricultural use.

Class 7 Land on Aeolian sands

Coastal dune systems are very fragile and susceptible to degradation by wind erosion (a) if disturbed or loss of vegetation occurs. Small areas have been mapped along the coast on South Arm at Opossum Bay, and south of Lauderdale. The soils are inherently low in fertility and are very well drained. This results in very low soil moisture retention. They are predominantly stabilised by perennial vegetation, but are still prone to erosion and movement where disturbance has occurred.

Class 7 Land on Triassic sediments

Small areas of Class 7 land are found on the steep slopes of Huntingdon Tier and Harry Walker Tier in the north east. These areas are characterised by very steep slopes over 55% and abundant rock outcrops which form cliffs and bluffs. The soils are typically shallow and coarse textured and therefore these areas have a high erosion potential. This land cannot be grazed without severe erosion and difficult access precludes agricultural use. Some areas, too small to map at the 1:100 000 scale, are found in areas associated with Class 6 land. In places, such as on slopes west of Magra, Class 7 has been complexed with Class 6 land to form Class 6+7 land capability map units.

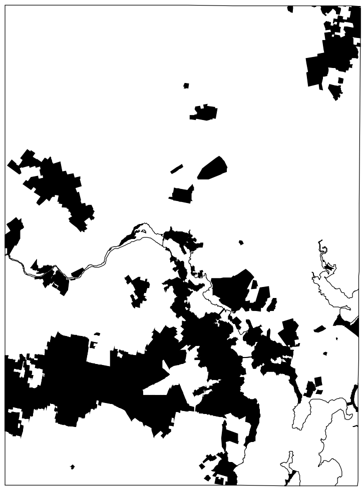
Class 7 Land on Permian sediments

Several small areas of Class 7 land have been mapped where topographic gradients exceed 55% to the north of Mt Faulkner. These sites are generally too steep to support soil and are largely composed of bare rock (r).

Photo 15. Class 7wk land is common in some coastal locations (Lauderdale, GR E539900 N5246850).

6.7 EXCLUSION AREAS

Exclusion areas 37 726ha



The Derwent survey area contains 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 the Mount Wellington plateau, the upper slopes of Mount Dromedary and Quoin Mountain, and parts of the Meehan Range. 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 as white with the letter E on the Derwent Land Capability map.

The boundaries for these areas have been supplied by Forestry Tasmania and some discrepancies have been identified in comparison to the published 1:100 000 scale Land Tenure maps. In addition, arbitrary boundaries have been defined by the survey team and represent areas excluded from agricultural activity on the basis of current land use (usually urban). These boundaries are not intended to represent the boundaries of individual land titles or local council planning schemes and do not purport to identify exact cadastral locations.

6.8 SUMMARY TABLES

Table 3 summarises the major land capability map units and their characteristics. It does not represent an exhaustive list of all possible units, but instead identifies the most common groupings present within each Land Capability Class. The table attempts to draw upon links between land capability, landforms and geology identified during mapping, and is therefore useful as a guide to the nature of map units identified within the survey area. It also provides an indication of agricultural versatility for each unit in relation to broad-acre cropping and stock grazing. A general indication is given of the main land management practices required to sustain this versatility.

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology	**Slope**	**Topography and elevation**	**Erosion type and severity**	**Climatic limitation**	**Soil qualities**	**Main limitations to agricultural use**	**Main land management requirements (under cultivation)**	**Agricultural versatility**
3	Tertiary basalt	0-12%	crests of low hills <160m	minor sheet and rill	low rainfall	well drained, some stones, moderate depth	rockiness (g), soil depth (l), low rainfall (p)	stone picking, moderate soil conservation	restricted range of crops, very good grazing
3	Quaternary alluvium	0-5%	alluvial plains <160m	very minor sheet	low rainfall	well drained, few stones, well structured	low rainfall (p)	minor soil conservation	restricted range of crops, very good grazing
4	Recent alluvium	0-5%	narrow flood plains <200m	very minor sheet and rill	low rainfall, minor flood risk	variable depth, some stones, weak structure	low rainfall (p), stoniness (g), soil structure (s)	moderate soil conservation	severely restricted range of crops, good grazing
4	Quaternary alluvium	0-5%	alluvial plains <200m	very minor sheet and rill	low rainfall	good fertility, well structured, moderate drainage	low rainfall (p)	minor soil conservation	severely restricted range of crops, good grazing
4	Tertiary basalt	0-12%	riser crests and upper slopes <160m	minor sheet and rill	low rainfall	well structured, minor salinity, moderate drainage	low rainfall (p)	minor soil conservation	severely restricted range of crops, good grazing
4	Tertiary basalt	12-28%	riser slopes <160m	moderate sheet and rill	low rainfall	heavy textures, well structured, moderate drainage	stoniness (g), erosion (e), soil depth (l)	erosion control, moderate soil conservation, stone picking	severely restricted range of crops, good grazing
4	Tertiary basalt	0-12%	lower slopes and footslopes of risers <200m	minor sheet and rill	low rainfall	imperfect soil drainage, heavy textures	low rainfall (p), stoniness (g), soil drainage (d)	soil drainage, minor soil conservation, stone picking	severely restricted range of crops, good grazing
4	Jurassic dolerite	0-12%	gentle slopes and colluvial footslopes <300m	minor sheet and rill	low rainfall	heavy textures, minor salinity, moderate drainage	low rainfall (p), stoniness (g)	stone picking, minor soil conservation	severely restricted range of crops, good grazing
4	Jurassic dolerite	12-18%	lower slopes and fans <500m	moderate sheet and rill	minor frost risk, low rainfall	moderate drainage, some stones, well structured	erosion (e), stoniness (g), shallow depth (l)	stone picking, erosion control, moderate soil conservation	severely restricted range of crops, good grazing
4	Tertiary sediments and alluvium	0-12%	high terraces and dissected pediments <40m	moderate sheet, rill and gully	low rainfall	imperfect drainage, dispersive, minor salinity	soil permeability (d), salinity (k), erosion (e)	erosion control, major soil conservation	severely restricted range of crops, good grazing
4	Triassic sandstone (feldspathic)	0-12%	colluvial footslopes <380m	minor sheet and rill	low rainfall	moderate drainage, moderate structure	low rainfall (p)	moderate soil conservation	severely restricted range of crops, good grazing
4	Triassic sandstone	0-12%	gentle slopes and colluvial footslopes <300m	moderate sheet, rill and gully	low rainfall	dispersive, imperfect drainage, minor salinity	erosion (e), salinity (k), soil permeability(d)	erosion control, major soil conservation	severely restricted range of crops, good grazing

Table 3: Characteristics of the main land capability classes identified in the Derwent survey area.

	Land Characteristics						Land Management Issues		
Land Capability Class	**Geology**	**Slope**	**Topography and elevation**	**Erosion type and severity**	**Climatic limitation**	**Soil qualities**	**Main limitations to agricultural use**	**Main land management requirements (under cultivation)**	**Agricultural versatility**
4	Triassic sandstone	0-12%	gentle slopes and colluvial footslopes <300m	moderate sheet, rill and gully	low rainfall	dispersive, imperfect drainage, minor salinity	erosion (e), salinity (k), soil permeability(d)	erosion control, major soil conservation	severely restricted range of crops, good grazing
4	Quaternary aeolian sands	0-12%	gently rolling lands proximate to rivers and coasts, <200m	moderate wind	low rainfall	coarse texture, weak structure, well drained	wind erosion (a), low rainfall (p) soil structure (s)	erosion control, major soil conservation	severely restricted range of crops, good grazing
4	Permian mudstone	0-12%	gentle footslopes and fans <300m	moderate sheet and major tunnel	minor frost risk, low rainfall	high gravel content, weak structure, dispersive	stoniness (g), erosion risk (e), soil fertility (s)	erosion control, major soil conservation	severely restricted range of crops, good grazing
5	Tertiary basalt	18-45%	moderately steep risers <200m	minor sheet and rill	low rainfall	common stones	stoniness (g)	stone picking	grazing, fodder crops
5	Jurassic dolerite	18-28%	moderately steep rolling hills <400m	minor sheet and rill	minor frost risk, low rainfall	common stones, shallow depth	stoniness (g) soil depth (l), erosion (e)	stone picking, erosion control	grazing, fodder crops
5	Jurassic dolerite	12-18%	moderately steep rolling hills <600m	moderate to major sheet and tunnel	minor to moderate frost risk, low rainfall	common stones, shallow depth, dispersive soil	stoniness (g), erosion (e)	erosion control, stone picking,	grazing, pasture improvement
5	Quaternary alluvium	0-5%	terrace flats and gentle risers <200m	minor wind	low rainfall	coarse textured surface, poor drainage, low fertility	soil drainage (w), soil fertility(s)	soil drainage, moderate soil conservation	grazing, pasture improvement
5	Quaternary alluvium	0-3%	low lying areas and depressions <200m	very minor sheet	low rainfall	heavy texture, poor drainage, salinity	salinity (k), site drainage (w)	salt tolerant pasture species, surface drains	grazing, pasture improvement
5	Tertiary sediments and alluvium	12-18%	incisions in valley floors <40m	very major sheet and rill	low rainfall	dispersive, weak structure	erosion (e), soil structure (s)	erosion control, major soil conservation	grazing, pasture improvement, fodder crops
5	Tertiary sediments and alluvium	0-12%	dissected pediments <40m	moderate wind, major sheet and rill	low rainfall	loose structure, coarse texture, poor drainage	erosion (e), soil permeability (d)	erosion control, major soil conservation	grazing, pasture improvement, fodder crops
5	Triassic sandstone	12-18%	moderately steep hillslopes <600m	major sheet and tunnel	minor frost risk, low rainfall	coarse texture, weak structure, low fertility	erosion (e), soil fertility (s)	erosion control, major soil conservation	grazing, pasture improvement
5	Triassic sandstone	0-12%	ridge tops and footslopes <650m	moderate wind and tunnel	minor to major frost risk, low rainfall	loose structure, coarse texture, low fertility	erosion (e), soil fertility (s), temperature (t)	erosion control, major soil conservation	grazing, pasture improvement, fodder crops
5	Permian mudstone	0-5%	gentle footslopes and raised plateau <650m	minor tunnel and gully	moderate to major frost risk	poor drainage, low fertility, weak structure	site drainage (w), soil limitations (s) temperature (t)	drainage, stone picking, major soil conservation	grazing, pasture improvement, horticulture

Table 3 (continued).

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology	Slope	Topography and elevation	Erosion type and severity	Climatic limitation	Soil qualities	Main limitations to agricultural use	Main land management requirements (under cultivation)	Agricultural versatility
5	Permian mudstone (limestone)	12-18% 12-28%	moderately steep hills, elevated benches, <500m	major sheet, tunnel, and gully	moderate frost risk	dispersive soil, low fertility, stony	erosion (e, m), shallow depth (l), soil fertility (s)	erosion control, major soil conservation	grazing, pasture improvement, fodder crops
5	Quaternary aoelian sand	0-12%	sand sheets near to rivers or coastline <160m	major wind	low rainfall	low fertility, coarse texture, loose structure	wind erosion (a)	erosion control, major soil conservation	grazing, pasture improvement, fodder crops
6	Jurassic dolerite	>28%	moderate to steep rolling hills. <400m	moderate creep and soil slip	moderate frost risk, low rainfall	shallow depth, common stones	stoniness (g), rock outcrops (r)	no cultivation	limited grazing, silviculture
6	Jurassic dolerite	>18%	moderate to steep rolling hills. <800m	major sheet, rill and gully	moderate to major frost risk	dispersive soil, shallow, stony	erosion (e), stoniness (g), rock outcrops (r), temperature (t)	no cultivation	limited grazing, silviculture
6	Quaternary alluvium	Level	depressions on coastal flats. <30m	very minor sheet	none	very poor drainage, high salinity	salinity (k), soil drainage (w)	no cultivation	limited grazing,
6	Quaternary alluvium	0-3%	narrow river flats <200m	very minor sheet	moderate frost risk	stony, coarse texture, poor structure	stoniness (g) flood risk (f)	no cultivation	limited grazing, silviculture
6	Triassic sandstone (Podosols)	>18% (>12%)	steep hillslopes and elevated plateau <800m	very major sheet and rill, (major wind)	minor to major frost risk	loose, coarse texture, low fertility, stony, shallow depth.	erosion (e), soil fertility(s), stoniness (g), temperature (t)	no cultivation	limited grazing, silviculture
6	Permian mudstone, (limestone)	>18% (>28%)	steep hillslopes and ridge crests <700m	very major sheet and rill, moderate soil slip	minor to major frost risk	shallow depth, low fertility, week soil structure, stony	erosion (e), soil fertility(s), stoniness (g)	no cultivation	limited grazing, silviculture
6	Quaternary aeolian sand	>6%	footslopes and rounded dunes. <100m	moderate wind	wind	low fertility, loose structure, coarse texture	wind erosion (a), soil fertility(s)	no cultivation	limited grazing, silviculture
7	Recent sand dunes	Variable	coastal dunes <20m	major wind	wind	low fertility, loose structure , very coarse texture	wind erosion (a), soil fertility (s)	protection	unsuitable for agriculture
7	Recent sediments	Level	tidal flats <1m	very minor sheet	none	waterlogged, very high salinity	high water table (w), salinity (k)	protection	unsuitable for agriculture
7	Jurassic dolerite	0-56%	mountain tops and slopes. >800 m	minor rock fall on slopes	severe frost, strong winds	abundant boulders, poor drainage	temperature (t), boulder fields (g)	protection	unsuitable for agriculture
7	Any	>56%	very steep slopes and cliffs	moderate rock fall	severe frost at high elevations	very shallow depth, mostly rock outcrop	rock outcrop (r)	protection	unsuitable for agriculture

Table 3 (continued).

7. SOIL AND WATER SALINITY

Julie Finnigan, Salinity Officer. DPIWE

Introduction

This section reviews issues surrounding soil salinity in the Derwent survey area, with particular reference to the South East Irrigation Scheme (SEIS).

Soil salinity is a serious form of land degradation affecting millions of hectares of agricultural land Australia wide. In 1995 it was estimated that 20 000ha across Tasmania were affected by salinity (Finnigan 1995, Grice 1995, Working Party on Dryland Salting in Tasmania 1982). More recent field assessment and mapping work suggest the area affected may be as large as 40 000ha.

Salts are a natural component of many soils and have accumulated over a great period of time. They are sourced mainly through deposition from rainfall (Walker 1995), but also result from deposition by wind, and the physical and chemical weathering of rocks and sediments. The salts most commonly found affecting soils in Tasmania are sodium chloride (common table salt), magnesium chloride and calcium chloride (Hoare pers comm).

While the occurrence of salt affected land in Tasmania is not as widespread as in many mainland states it is of significant concern to some farmers including those in parts of the Derwent survey area. Most valley systems within the lower rainfall areas of the Derwent survey area contain semi-confined saline aquifers. Furthermore, soils with impeded profile drainage and those in low lying areas often have low to moderate subsoil salinity levels. Saline seeps can be found alongside channels such as areas along Pitt Water, the banks of Duck Hole Rivulet, and small streams draining into the Coal and Jordan Rivers. Water in these rivers and streams, on average, is moderately saline.

Areas directly affected by salinity are often too small to be mapped at a 1:100 000 scale. The assessment of salinity and its impact on land capability as discussed in earlier sections of this report is limited to the impact salinity has on the ability of the land to support rainfed agricultural enterprises (irrigation not being considered under the present system of land capability evaluation). However, it is recognised that irrigated farming systems are a feature of parts of the Derwent map sheet and that increases in soil salinity in irrigated areas may ultimately have an effect on crop yields and the range of crops grown. Consequently it would seem appropriate to provide some discussion on the issues relating to salinity and irrigated agriculture.

Within this report the unit of measurement of salinity is dS m^{-1}. A summary of the tolerance of various crops and livestock to salinity is presented in Table 4.

Background

Prior to European settlement, the occurrence and concentration of salt in the soil was most likely at a point of equilibrium, with little change in salt levels through time. Some areas were naturally saline, experiencing dryland salinity. Since European settlement, widespread clearing of native vegetation and the introduction of agricultural practices has created major changes to the natural water balance which are expressed principally in rising groundwater levels. Increased translocation of salts has also resulted from increased seepage leading to higher levels of salt in discharge waters. As groundwater rises, it can mobilise and carry the soluble salts present deeper in the soil upward toward the surface. Once groundwater reaches a critical depth of approximately 3m (depending on soil types), capillary rise and evaporation leads to the concentration of salts at the soil surface. This concentration of salts affects the growth and productivity of plants due to decreased osmotic potential in the soil which reduces water uptake and causes leaf necrosis. This can lead to serious forms of land degradation through plant dieback and increased dispersion of clays. This type of salinity, which has occurred as a result of land use change post-European settlement, is termed secondary salinity, or man-induced salinity. Much of the dryland salinity we see in Tasmania is secondary, or man induced.

The dramatic changes in land use which led to the development of secondary salinity in Tasmania are still occurring today. While much of Tasmania's agricultural lands have long since been cleared of their original forest cover, conversion to irrigated agricultural systems is a relatively new and rapid change in land use. The threat of exacerbating secondary salinisation under irrigated agriculture is very real. This is of particular relevance to the SEIS where use of irrigation has become more widespread since development of the scheme in 1986.

Photo 16. Class 5k and 6k land. Salinity can severely limit pasture productivity and is a common problem in low lying areas, particularly along stream courses and close to the coast. Much of this land is dominated by salt resistant pasture species (Acton GR E539400 N5256400).

Soil and Water Salinity within the South East Irrigation Scheme

The Coal River Valley has a long history of agricultural activity, with small scale irrigation occurring well before the SEIS was opened in 1986. From this time onwards, the provision of a more reliable source of water allowed agricultural productivity in the valley to increase and diversify. With the opening of the SEIS, the Coal River Valley has again seen major changes in land use, with intensive vegetable cropping, viticulture and horticulture becoming more widespread. Irrigation within the Coal River Valley is influencing the processes of soil and water salinisation leading to increased soil salinity in some situations.

The occurrence of soil salinity within the Coal River Valley has been known for some time. It was first detailed in a survey of 2695ha of the alluvial soils in the lower Coal River Valley (Holz 1987). In his report, Holz clearly outlined the presence of low soil salinity levels in all surface soils, high subsoil salinity levels in approximately 26% of the area surveyed, and moderate subsoil salinity levels in a further 24%. Soils with high salinity levels were found to occur high in the landscape, highlighting the possible threat of salt redistribution under irrigated agriculture.

Subsequent detailed soil salinity assessment work in the SEIS began in 1992, wherein the extent and severity of soil salinity was assessed using a number of techniques, ultimately providing some understanding of surface soil salinity and apparent soil salinity storage to depths of approximately 6m within the soil profile (Finnigan 1995). A total of 1641.5 hectares of land within Stages 1 and 2 of the SEIS were identified as saline, equating to 13.7% of the total scheme area. It is important to note that the total area of saline land identified was most likely underestimated due to limitations of the initial air photo interpretation technique in identifying potential saline land.

The areas of salt affected soils in Stage 1 of the SEIS were typically small in size and mainly restricted to drainage lines and lower to mid slope areas. Most of the alluvial soils along the current flood plains exhibit minimal surface salting and storage, which is possibly due to the flushing effect of the river, or that salt has not accumulated due to good soil drainage. Incidences of high and severe salting in Stage 1 are few and quite small in area in comparison to Stage 2, where approximately 60% of all salt affected soils were found. Low to moderate salinity levels include two thirds of the saline soils within Stage 2. Severe salting was found along the upper reaches of Pitt Water, the banks of Duck Hole Rivulet, and the mid and lower slope areas along Pages Creek.

Since 1995 there have been several small scale projects conducted by Mineral Resources Tasmania and the University of Tasmania, which have attempted to identify the true source of salts within the SEIS. These projects are still in their infancy at the time of writing, but should provide natural resource managers with a far greater understanding of the nature and processes of salinisation within the SEIS. Naturally saline drainage water seeps from the foot hills of the tiers bounding the valley, and this strongly suggests that large salt storages are contained within them. However, at present the real origin of these salts is still questionable, and the processes responsible for mobilising the salts through to the lower slopes is also unknown.

It is noteworthy that in many soils on hilly terrain, salinity commonly increases with decreasing depth in profiles, and EC_e in surface horizons can be up to 2dS m^{-1}. This implies that rainfall maybe an important source for salts. Although these salinity levels are relatively low compared with salt stores in low lying areas, cumulatively there maybe a considerable salt store present within the surface horizon of soils in total catchment areas. This is readily available to groundwater recharge in low lying terrain by lateral subsurface flow through the more permeable coarser textured upper soil horizons.

Photo 17. Kurosols like this, together with Sodosols, have a high potential for salt accumulation due to the very low permeability and poor drainage of subsoil horizons (Pitt Water, GR E535800 N5262400).

On lowerslopes and valley bottoms many soils have moderate subsoil salinity, particularly those occurring in lower rainfall areas. Typical salinity levels (based on soil conductivity) for Sodosols for example, increase from an EC_e of between 0.5 and 2dS m^{-1} in surface horizons, to between 3 and 6dS m^{-1} in lower subsoil horizons. Soils in drainage depressions and sites of flow accumulation (Aquic Vertosols) have higher salinity levels, with EC_e levels ranging from 2 to 4dS m^{-1} in surface horizons, to between 5 and 20dS m^{-1} in subsoil horizons. These soils are also invariably sodic due to continued saturation by sodium ions present in groundwater. Land carrying soils with salinity levels of 2 to 8dS m^{-1} in the top 50cm of profiles was considered to pose a significant risk for irrigated agriculture. In contrast, Dermosols on alluvial plains or sloping terrain with low salinity levels in the subsoil can be managed at a higher capability class under irrigation with less risk of salinisation.

The presence of naturally saline soils within the valley, coupled with the potential for secondary salinity, impose very real limitations to the agricultural capability of the SEIS. However, other additional factors, such as irrigation practices, use of low quality water, presence of very shallow, semi-confined highly saline aquifers, are clearly adding to the problem.

Crop	Soil Salinity EC_e (dS m^{-1})	
	Threshold	25% Yield loss
Lettuce	1.3	3.2
Potatoes	1.7	3.8
Broccoli	2.8	5.5
Perennial Pasture (Rye Grass)	5.6	8.9
Wheat	6.0	9.5
Beef Cattle (limit in drinking water to maintain stock condition)	8.0	-

Table 4. Threshold values for soil salinity for a variety of land uses
(NB Desirable limit in water for human consumption is 0.83dS m^{-1} and water tastes salty at 1.7dS m^{-1})

Irrigation and Salinity

The application of irrigation water to agricultural soils has the potential to significantly increase productivity of an area, as long as careful irrigation practices are applied. If irrigation scheduling is ignored, or appropriate drainage is not installed, the application of irrigation water can cause waterlogging, soil structural damage and ultimately result in reduced crop yields. Within the SEIS and many other agricultural areas of Tasmania, salt levels in irrigation water impose additional complicating factors to the ability of land managers to apply irrigation water without causing secondary salinity.

Throughout the survey area there is evidence to indicate that many on-farm dams used for storing irrigation water are saline. Craigbourne Dam, which supplies irrigation water for the SEIS, also contains water of questionable water quality, although salinity levels vary significantly over time, particularly in response to rainfall events. During winter months when there is typically a greater occurrence of rainfall events, the salinity levels of water bodies are usually at their lowest. The salinity levels of these water bodies increase during summer months when rainfall events are less frequent. This increase is caused by high evaporation rates which concentrate salt levels in the water. This inherent variability of water quality restricts the ability of land holders to irrigate without causing soil salinisation and resultant soil damage and crop losses.

On-farm water storages within the SEIS have been tested *adhoc* over the last 7 years, with recorded salinity levels ranging anywhere between 0.2dS m^{-1} and 13dS m^{-1}. One particular dam is known to vary by 12.5dS m^{-1} between high and low rainfall periods. The water quality of Craigbourne Dam typically varies between 0.3dS m^{-1} and 0.5dS m^{-1}. The salinity level of the irrigation water released into the Coal River increases as it passes through Stage 1 and into Stage 2. Depending on the time of the year, the salinity level of this water may increase up to 1.4dS m^{-1}. This is partly due to runoff from saline drainage lines and flushing of salts from soils by irrigation water.

The effect of saline irrigation water on crop persistence and vigour depends on the ability of crop types to tolerate saline water (McMahon and Bell, 1992). Although some crops are quite tolerant of saline water, the majority are not. In order to avoid significant reductions in yield, crop types should be chosen carefully with respect to the quality of the irrigation water used.

The potential to accumulate salts in the soil profile is the other very important consequence of irrigating with saline water. For example if an irrigator used water with a conductivity level of 1dS m^{-1}, they would be applying 600kg of salt to the soil with every ML applied to each hectare. Therefore if 4 ML of water was applied throughout a season and salinity levels were fairly consistent at 1dS m^{-1}, almost 2.5 tonnes of salt would be applied over each hectare of irrigated agricultural land. This type of land use cannot be sustained over the long term without appropriate drainage or flushing to remove the accumulated salts. It is unlikely that added salt will be flushed out by the relatively low annual rainfall of most areas where irrigation is used.

Shallow Groundwater Conditions and Salinity

Throughout the SEIS shallow groundwater conditions are dominated by semi confined, saline aquifers. The quality of these groundwaters is typically very poor, with conductivity levels ranging between 3.5 and 16dS m^{-1}. At these levels the water could not be used for irrigation without severe detrimental consequences. Consumption of this water by certain stock would also require special care and monitoring to avoid declines in stock health and growth. Groundwater levels are generally well within 3m of the ground surface and therefore surface salinity may develop as a consequence of capillary rise and evaporation. Collectively, these characteristics impose limitations on the ability of the soils overlying these groundwaters to sustain repeated cropping rotations in the long term. Although the rate of salinisation via these processes is very much dependent on soil type, continued cropping is most likely to facilitate secondary salinisation. This is due to increased accession of rainwater, resulting in rising groundwater levels and increased rates of evaporation leading to increased salt levels in the upper soil horizons.

Irrigation has the potential to cause rises in groundwater levels through the accession of excess waters. This is particularly true where drainage is inadequate. Where shallow saline groundwaters rise into the root zone, waterlogging decreases the availability of oxygen and nutrients to plants, thereby reducing their health and vigour. In addition, waterlogging under saline conditions effectively triples the rate of sodium uptake by most plants as waterlogged conditions inhibit the ability of the plants to screen out salts at the root surface (Barrett-Lennard & Malcolm 1995).

Shallow saline groundwater conditions are therefore an important factor imposing potentially severe limitations to the long term sustainable use of many areas in the SEIS. Although no groundwater data exists for other regions within the survey area, many of the major agricultural areas, such as the Jordan Valley, are similar in landform and geology, and experience a similar climate. Therefore, it is reasonable to assume that groundwater conditions may be similar, and caution should be exercised, particularly where irrigation waters are applied.

Salinity Management

Australian research into salinity first began in the 1950's, and has since covered all areas of assessment and management at both local and national scales (Okerby 1995). As a result of this work, management practices in some mainland areas have now enabled the productive use of once unproductive saline land.

There are many techniques and management practices that can be applied to help control and improve salt affected soils and water. Firstly, discharge areas displaying the symptoms of high salt levels should be fenced off from all stock, or at least stocked at much lighter rates. This helps to minimise the impact of stress on any existing plant cover and reduces soil compaction, improving the successful establishment and growth of plants. Remnant vegetation stands should be maintained, and where possible, deep rooted trees and shrubs should be planted in strategic mid and upper slope areas. Trees ultimately help to reduce groundwater recharge by intercepting and utilising rainfall before it can access groundwater. Sowing deep rooted perennial pastures and higher water using winter crops in mid and upper slope positions also helps to utilise rainfall and decrease accessions to groundwater.

Recommended perennial pastures include Cocksfoot (*Dactylus glomerata*), Phalaris (*Phalaris aquatica*), and Lucerne (*Medicago sativa*). Oats, Barley and Tama Rye Grass are recommended high water using winter crops. Salt tolerant grasses and clovers can also be planted in highly saline discharge areas. Tall Wheat Grass (*Agropyron elongatum*) and Puccinellia (*Puccinellia ciliata*) are suited to areas of high to severe salinity, while Tall Fescue (*Festuca arundinacea*) and Strawberry Clover (*Trifolium fragiferum*) are examples well suited to areas of moderate salinity.

Poorly drained soils are less productive and the accumulation of salts in the soil surface compounds this problem. The installation of appropriate drainage is essential in order to divert or remove excess water and salt from waterlogged sites. However, the dispersive nature of sodic soils makes this difficult to achieve in most situations. Gypsum applications can reduce dispersion and improve permeability and therefore drainage.

Extended fallow periods should also be avoided where possible as groundwater accession is increased and higher levels of evaporation occur with a lack of vegetative ground cover. This evaporation results in increased levels of salinity in the upper soil profile.

Accurate irrigation scheduling is essential for the successful management of salinity, combined with local knowledge of groundwater conditions. Sprinkler irrigation is far less wasteful of water than flood irrigation, and in appropriate conditions drip irrigation will also use less water. Soils which drain poorly need to be rested without irrigation for several seasons to flush excess salts. Under careful management, irrigation can be beneficial in flushing salts away from the upper soil horizons. However extreme care must be taken to monitor soil moisture levels to avoid creating waterlogged conditions and rises in groundwater levels.

Although these management options have been trialed and proven beneficial in various states on the Australian mainland, few management trials have been applied in Tasmania to date. Various pasture and tree trials have been established over the last few years in salt affected areas of the state and so far these have been quite successful. However continued monitoring is most essential in order to determine the true costs and benefits of these trials over the long term.

GLOSSARY

Aggradation: The sequential accumulation of sediment in fluvial environments.

Alluvial deposits: Sediment transported by rivers and deposited on flood plains.

Anthroposols: Soils resulting from human activities.

Basalt: Rock rich in base cations formed from the cooling and solidification of volcanic lava.

Calcarosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) which has no strong texture contrast, and is at least calcareous throughout the B horizons.

CEC (Cation exchange capacity): A measure of the capacity of a soil to absorb and release exchangeable cations. It is equal to the sum of calcium, magnesium, potassium, sodium, aluminium and hydrogen cations present in the soil. CEC affects soil properties and behaviour including soil structural stability, the availability of some nutrients for plant growth (fertility), and soil pH.

Clay: Soil particles of diameter less than 0.002mm.

Coarse fragments: Particles of diameter greater than 2mm which have not formed in soil profile.

Colluvial deposits: Weathered rocks and soil transported and redeposited by gravity.

Complex: 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 between 50/50 and 60/40.

Correlative: Rocks of similar age and morphology.

Chromosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having strong texture contrast, is not sodic in the upper B horizon and a pH in the upper B horizon greater than or equal to 5.5.

Degradation: Deterioration of a resource through inappropriate or uncontrolled management or use.

Dermosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having structured B horizons and no strong texture contrast.

Dispersive Soils: Soils composed of aggregates which break down to primary particles as they absorb water. Dispersive soils are inherently unstable and easily eroded. In most cases, dispersive soils are sodic.

Dolerite: A medium grained, basic rock formed from the cooling and crystallisation of magma near the surface of the earth's crust.

Drainage: A description of local soil wetness conditions as defined in the *Australian Soil and Land Survey Field Handbook* (McDonald, *et al*. 1998). Drainage is controlled by landscape position, soil permeability, and the extent of impediments to water movement within the soil profile.

EC_e : Electrical conductivity of the saturation extract of soil. This is usually derived by multiplying the 1:5 soil:water mixture electrical conductivity by a constant that is a function of soil texture.

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

Ferruginous gravel: Gravel which is composed dominantly of iron-rich materials; also known as ironstone or laterite gravel. It often forms within the soil profile.

Field Capacity: The amount of water held in a well drained soil two days after saturation.

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

Glacio-marine: Refers to sediments that accumulated in marine environments offshore from glaciated land masses.

Graben: Down faulted area of land generally forming a valley.

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

Horst: Elevated areas of land between grabens.

Hydrosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) other than Organosols, Podosols and Vertosols which is saturated for at least 2 to 3 months in most years.

Kandosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having no strong texture contrast and a weakly structured B horizon which is not calcareous.

Kurosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) other than Hydrosols, as having strong texture contrast and a pH in the upper B horizon less than 5.5.

Land Capability: The potential of the land to support a range of practices or uses without degradation. In this report only agricultural uses are considered. Land Capability considers only the physical attributes of the land.

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

Limitation: The physical factors or constraints which affect the versatility of uses of a land unit. Dominant limitations determine land capability for long term agricultural use.

Moisture availability: A measure of the amount of moisture held in the soil which is available for plant uptake. It is defined as the difference between the field capacity and the wilting point of the soil.

Nutrient availability: The ability of a soil to retain and supply nutrients for plant growth. It is principally governed by the CEC, the organic matter content and the pH of the soil.

Offset: The vertical displacement of rock strata along fault lines.

Organosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having profiles dominated by organic materials which are not inundated by tides.

Permeability: A description of the potential of a soil to transport water internally as defined in the *Australian Soil and Land Survey Field Handbook* (McDonald, *et al*. 1998).

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

Profile: A vertical cross section of a soil extending from the surface down to the lower limit of soil development.

Quartzite: Thermally or regionally 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.

Rudosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having negligible pedological development.

Saline water: Where the electrical conductivity test indicates the presence of salts. In fresh water the following categories are used to indicate relative water quality:

Low:	0 - 280μs cm^{-1}
Moderate:	280 - 800μs cm^{-1}
High:	800 - 2300μs cm^{-1}
Very high:	>2300μs cm^{-1}

Saline soil: Where the electrical conductivity of the saturation extract (EC_e) of soil material indicates the presence of salts. The following approximate categories were used to indicate relative salinity levels in this report:

Low:	<2ds m^{-1}
Moderate:	2 - 8ds m^{-1}
High:	>8 ds m^{-1}

Scree: Accumulation of rocks and boulders at the foot of a cliff or steep slope, often with little vegetative cover.

Slaking soils: Soils composed of aggregates which partially break down in water due to the swelling of the clay fraction and expulsion of air from pore spaces. In many cases, slaking soils are sodic.

Sedimentary rock: Rock formed from particles which have been transported, deposited and fused through cementing and/or compaction.

Sodic soils. Soils with a proportion of the cation exchange capacity occupied by sodium ions of greater than 6%. With respect to land use, a soil is considered sodic when the sodium concentration reaches a level that affects soil structure (See *Slaking soils* and *Dispersive soils*).

Soil pH: A measure of the acidity or alkalinity in a soil. 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.

Soil structure decline: The degradation of 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 to structural decline when wet.

Sodosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having strong texture contrast, a sodic upper B horizon and a pH in the upper B horizon greater than or equal to 5.5.

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

Sustainable agriculture: The use of farming practices and systems which maintain or enhance: economic viability of agricultural production; the natural resource base; and other ecosystems which are influenced by agricultural activities. There are five principles of sustainable agriculture.

1. Farm productivity is sustained or enhanced over the long term.

2. Adverse impacts on the natural resource base of agriculture and associated ecosystems are ameliorated, minimised or avoided.

3. Residues resulting from the use of chemicals in agriculture are minimised.

4. The net social benefit derived from agriculture is maximised.

5. Farm systems are sufficiently flexible to manage risks associated with the vagaries of climate and markets.

Talus: Accumulation of clastic sediments at the foot of a cliff or steep slope.

Tenosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having only weak pedological development.

Texture contrast soils: Soils in which the boundary between two horizons (usually the A and B horizons) is smaller than 50mm (clear, abrupt or sharp), **and**
the clay content in the upper horizon is less than 20% and the clay content in the lower horizon double that of the upper horizon (In this case the clay content must be greater than 20% in the upper B horizon), **or**
the clay content in the lower horizon is 20% higher than the upper horizon where the upper horizon is between 20 and 35% clay.

Thixotropic: Tendency of soil material to liquefy under vibration and at low moisture contents.

Vertosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having shrink swell properties with strong cracking when dry, slickensides and/or lenticular structure, and a clay field texture of more than 35% throughout.

Water erosion hazard: The potential for sheet, rill, tunnel or gully erosion to occur on a land surface. The land surface is most prone to water 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. The degree of hazard depends on soil erodibility, amount of ground cover, slope gradient and length, and rainfall (intensity and amount).

Wilting point: The amount of soil moisture below which plants can extract no more water.

Wind erosion hazard: The potential for a land surface to erode by the action of wind. The land surface is most prone to wind erosion when cultivated and/or when little or no vegetative cover is present. Appropriate land management including maintaining good ground cover will protect the soil surface from wind erosion. The degree of hazard depends on soil erodibility (especially particle size and soil structure), amount of ground cover, the timing and degree of exposure to the wind and wind speed. Loose, structureless soils are most at risk.

REFERENCES

Australian Bureau of Meteorology. 1980, Climatic Survey, Tasmania. Region 3 Northern. Australian Government Publishing Service, Canberra.

Australian Bureau of Meteorology. April 1988, Climatic Averages Australia. Australian Government Publishing Service, Canberra.

Australian Bureau of Meteorology. March 1993, Climate of Tasmania. Victoria Printing, Canberra.

Australian Bureau of Meteorology. 1999, (Unpublished data collated via personal correspondence), Average Monthly Rainfall, Monthly Temperature, Monthly Maximum and Minimum Temperature and Average Evaporation, for selected stations.

Barrett-Lennard, E. G. and Malcolm, C. V. 1995, Saltland Pastures in Australia - A practical guide. Department of Agriculture, Western Australia

Hutchinson, M. F. Houlder, D. Nix, H. A. and McMahon, J. P. 1998, ANUCLIM Version 1.8. Centre for Resource and Environmental Studies, ANU, Canberra.

Coal River Catchment Committee. 1997, Coal River Catchment Natural Resource Assessment.

Chilvers, W. 1996, Managing Tasmania's Cropping Soils. A practical guide for farmers. DPIF, Tasmania.

Davies, J. B. 1987, Land Systems of Tasmania, Region 6 South, East and Midlands - A Resource Classification Survey. Department of Agriculture, Hobart, Tasmania.

Dimmock, G. M. 1957, Reconnaissance Soil Map of Tasmania: Brighton. C.S.I.R.O. Divisional Report 2/57.

Draft Policy on the Protection of Agricultural Land. 1999, DPIF and DELM, Tasmania.

Duncan, F. and Brown, M. J. 1985, Dry Sclerophyll Vegetation in Tasmania - Extent and Conservation Status of the Communities. Wildlife Division Technical Report 85/1, National Parks and Wildlife Service Tasmania.

Finnigan, J. 1995, Salinity Assessment in Tasmanian Irrigation Schemes and Regional Areas. DPIWE Internal Report, 43pp.

Forestry Tasmania. 1996, Land Tenure of Tasmania. Digital Coverage.

Friend, D. A. Thompson, R. P. and Ball, P. D. 1997, The Pastures of the Midlands and Derwent Valley Tasmania - Relationships to Environment and Management Factors. Final Report: Project DAT 44, International Wool Secretariat.

Geode, A. 1973, Flood plain stratigraphy of the Tea Tree Rivulet. *Aust. Geogr. Stud.* 11: 28-39.

Grice, M. S. 1995, Assessment of soil and land degradation on Private Freehold Land in Tasmania. DPIF, Tasmania.

Grose, C. J. (in prep), Land Capability Handbook. Guidelines for the Classification of Agricultural Land in Tasmania. Second Edition, DPIWE, Tasmania, Australia.

Grose, C. J. and Moreton, R. M. 1996, Land Capability Classification of Tasmania. South Esk Report. Department of Primary Industry and Fisheries, Tasmania.

Grose, C. J, Doyle, R. and Farquhar, D. 1999, Tasmanian Vineyard Soils. DPIWE, Internal Report:14pp.

Gunn, R. H, Beattie J. A, Reid, R. E and van de Graaff, R. H. M. 1988, Australian Soil and Land Survey Handbook - Guidelines for Conducting Surveys. Inkata Press, Australia.

Holz, G. K. 1987, Soils of part of the Lower Coal River Valley, Tasmania. Department of Agriculture, Tasmania.

Holz, G. K. 1993, Principles of soil occurrence in the Lower Coal River Valley, South-East Tasmania. Unpublished PhD Thesis, University of Tasmania. 295pp.

Huon River Flood Plain Study Stage 2 Report. 1991, Department of Primary Industry Fisheries and Energy, Water Resources Division, Gutteridge Haskins & Davey, Launceston: 33pp.

Hydro Electric Commission Tasmania. 1986, Average Annual Rainfall Tasmania, Isohyet Map, Scale 1:500 000. Systems Development Section.

Isbell, R.F. 1996, The Australian Soil Classification. CSIRO Publishing.

Klingbiel, A. A. and Montgomery, P. H. 1961, Land Capability Classification. Agricultural Handbook No. 210, USDA Soil Con. Serv.

Landon, J. R. (ed.) 1991, Booker Tropical Soil Manual. Longman Scientific and Technical.

Langford, J. 1965, Atlas of Tasmania, Weather and Climate. Lands and Surveys Department, Hobart, Tasmania.

Leaman, D. E. 1972, Geological atlas 1:50 000 series. Sheet 82 (8312S) Hobart. Department of Mines, Hobart.

Leaman, D. E. 1976, Sheet 82 (8312S) Hobart Explanatory Report.

Leaman, D. E. 1975, Geological atlas 1:50 000 series. Sheet 75 (8312N) Brighton. Department of Mines, Hobart.

Leaman, D. E. 1977, Sheet 75 (8312N) Brighton Explanatory Report.

Loveday, J. 1955, Reconnaissance Soil Map of Tasmania: Hobart. C.S.I.R.O. Divisional Report 13/55.

Macphail, M. K. 1979, Vegetation and climates in southern Tasmania since the Last Glaciation. *Quaternary Research,* 11:306-341.

McMahon, S. and Bell, I. 1992, SALTPAK, an information package released through a joint NSCP/DPIF project: Salinity Assessment in Tasmanian Irrigation Schemes and Regional Areas, DPIF, Tasmania.

Moore, G. 1998, Soil Salinity, In: *Soil Guide. A Handbook for Understanding and Managing Agricultural Soils*, (Ed: Moore, G.) Agriculture Western Australia Bulletin No. 4343: 146 - 158.

Noble, K. E. 1991, Land Capability Survey of Tasmania, Pipers Report. Department of Primary Industries, Water and Environment and Fisheries, Tasmania.

Noble, K. E. 1992a, Land Capability Survey of Tasmania, Land Capability Handbook. Department of Primary Industry and Fisheries, Tasmania.

Noble, K. E. 1992b, Land Capability Survey of Tasmania, Tamar Report. Department of Primary Industry and Fisheries, Tasmania.

Noble, K. E. 1993, Land Capability Survey of Tasmania, Meander Report. Department of Primary Industries, Water and Environment and Fisheries, Tasmania.

Okerby, J. 1995, Regional Salinity Management. *Australian Commodity 2 (2),* ABARE, New South Wales.

Prescott, J. A. Collins, J. A. and Shirpurkar, G. R. 1952, The comparative climatology of Australia and Argentina. *Geog. Rev.* 42: 118-33.

Prescott, J. A. & Thomas, J. A. 1949, The Length of Growing Season in Australia as determined by the effectiveness of the Rainfall. *Proc. Royal Society of South Australia. Branch Vol.l 1948-49.*

Report of the Standing Committee of Agriculture Working Group on Sustainable Agriculture, 1991, pp4-5. SCA Technical Report Series No. 36 Tasmania.

Scholz, G. and Moore, G. 1998, Soil Alkalinity and Soil Sodicity, In: *Soil Guide. A Handbook for Understanding and Managing Agricultural Soils*, (Ed: Moore, G.) Agriculture Western Australia Bulletin No. 4343: 141 - 145.

Sigleo, W. R. 1978, A study of Late Quaternary Environment and man from four sites in Southern Tasmania. Unpublished PhD Thesis, University of Tasmania.297pp.

Sigleo, W. R. and Colhoun, G. A. 1982, Terrestrial dunes, man and the late Quaternary environment in Southern Tasmania. *Palaeogeography, Palaeoclimatology, Palaeoenvironment,* 39: 87-121.

Stace, H. C. T et al. 1968, A Handbook of Australian Soils. Rellim, Glenside, SA.

Taylor, B. A. and Stephens, C. G. 1935, The Apple-Growing Soils of Tasmania. Commonwealth of Australia, Council for Scientific and Industrial Research, Bulletin No. 92: 55pp.

Walker, M. 1995, Causes, effects, remedies and measurement of land and river salinity in Tasmania. Report 95/6, Co-operative Research Centre for Catchment Hydrology.

Wasson, R. J. 1977a, Catchment processes and the evolution of alluvial fans in the Lower Derwent Valley, Tasmania. *Z. Geomorph. NF*, 21(2): 147-168.

Wasson, R. J. 1977b, Last-Glacial alluvial fan sedimentation in the Lower Derwent Valley, Tasmania. *Sedimentology*, 24: 781-799.

Working Party on Dryland Salting in Tasmania. 1982,Salinity of non-irrigated land in Tasmania, Soil Conservation Authority of Victoria for Standing Committee on Soil Conservation.

APPENDICES

APPENDIX A. Example of a completed Land Capability Description

LAND CAPABILITY DESCRIPTION CARD

Project code	Site No.	Map Name	Sheet No.	Easting	Northing	Describer	Date
LCDERW	269	NEW NORFOLK	5026	516050	5267750	MUSR	01-04-1999

Rainfall	TS	TP	SP	Permiability	Drainage	Elevation	Australian Soil Class	LCC	Geology	Geology map
	O	E	NO	1 2 3 (4)	1 2 3 4 (5)	010	4ANHRYYYY	4a	Qrg	75

Element slope class(p.12)		
LE	Level	(<1%)
VG	Very Gentle	(1-3%)
(GE)	Gentle	(3-10%)
MO	Moderate	(10-32%)
ST	Steep	(32-56%)
VS	Very steep	(56-100%)
PR	Precipitous	(100-300%)
CL	Cliffed	(>300%)

Element Morphological Type	
C	Crest
H	Hillock
R	Ridge
S	Simple slope
U	Upper slope
M	Mid slope
(L)	Lower slope
F	Flat
V	Open depression
D	Closed depression

Mode of Geomorphic activity	
ER	Eroded
EA	Eroded or aggraded
(AG)	Aggraded

Element Type	
BKP	Backplain
BAR	Bar
BRI	Beach ridge
(BEN)	Bench
BOU	Blow-out
DDE	Drainage depression
DUN	Dune
EST	Estuary
FAN	Fan
FOO	Footslope
FOR	Foredune
GUL	Gully
HCR	Hillcrest
HSL	Hillslope
LAG	Lagoon
LDS	Landslide
LEV	Levee
LUN	Lunette
MOU	Mound
PLA	Plain
SCA	Scarp
STC	Stream channel
SWP	Swamp
TEP	Terrace plain
TEF	Terrace flat
TDF	Tidal flat
VLF	Valley flat
	Or code (page 24)

Pattern Type	
ALF	Alluvial fan
ALP	Alluvial plain
BEA	Beach ridge plain
COL	Covered plain
DEL	Delta
DUN	Dunefield
FLO	Flood plain
HIL	Hills
LAC	Lacustrine plain
LOW	Low hills
MEA	Meander plain
PNP	Peneplain
PLT	Plateau
(PLA)	Plain
SAN	Sand Plain
TEL	Terraced land
	Or code (page 48)

4	Slope angle (eg 10%)
350	Aspect (eg 010)

Surface Condition When Dry	
G	Cracking
M	Self-mulching
(L)	Loose
S	Soft
F	Firm
H	Hard setting
C	surface crust
X	Surface flake

Degree Of Erosion		
X	X	Not apparent
0	0	None
1	1	Minor
(2)	2	Moderate
3	3	Severe
4	4	Very severe

State of Erosion		
A	A	Active
S	S	Stabilized
(P)	P	Partly stabilized

Type of Erosion		
(W)	W	Wind
S	S	Sheet
R	R	Rill
G	G	Gully
C	C	Scald
T	T	Tunnel
B	B	Streambank
V	V	Wave
M	M	Mass movement

Inundation Frequency (p. 96)	
(0)	No Inundation
1	< once per 100 years
2	Once in 50-100 years
3	Once in 10-50 years
4	Once in 1-10 years
5	> once per year

Duration of Inundation	
1	< 1 day
2	1-20 days
3	20-120 days
4	>120 days

Coarse Fragments		
Abundance of Coarse Frag.		
0	None	0%
(1)	Very few	(<2%)
2	Few	(2-10%)
3	Common	(10-20%)
4	Many	(20-50%)
5	Abundant	(50-90%)
6	Very abundant	(>90%)

Size of Coarse Fragments		
1	Fine gravel	(2-6mm)
(2)	Med. gravel	(6-20mm)
3	Cos. gravel	(20-60mm)
4	Cobbles	(60-200mm)
5	Stoned	(200-600mm)
6	Boulders	(600mm-2m)
7	Large boulders	(>2m)

Rock Outcrops		
(0)	No rock outcrop	
1	V slightly rocky	(<2%)
2	Slightly rockey	(2-10%)
3	Rocky	(10-20%)
4	V rockey	(20-50%)
5	Rockland	(>50%)
	Lithology code (p 160)	

Notes

Substrate:

Profile: WINDBLOWN SAND OVERLYING RIVER GRAVELS

Location:

General:

		Moist colour			Primary mottles			Field Texture		Primary structure			Plus/Parting to 2ND stru			Coarse fragments		Field tests	
Horizon	Lower depth	Hue	V	C	Abundance	Size	Contrast	Qualifier	Code	Grade	Size	Type	Grade	Size	Type	Abundance	Size	pH	EC
Ap	12	10YR	2	2	(0) 1 2 3 4	1 2 3 4			LS	V G (W) M S	1 2 (3) 4 5 6 7	PL PR CO AB (SB) PO LE GR CA				1	2	6.5	0
2A1	26	10 YR	2	1	(0) 1 2 3 4	1 2 3 4			CS	V G (W) M S	1 2 (3) 4 5 6 7	PL PR CO AB (SB) PO LE GR CA				2	2	8.4	0
2B21	38	7.5 YR	3	4	(0) 1 2 3 4	1 2 3 4			CS	V G W (M) S	1 2 3 4 5 (6) 7	PL PR (CO) AB SB PO LE GR CA				0	0	8.6	0
2B22	120	10 YR	3	6	(0) 1 2 3 4	1 2 3 4			CS	V G W (M) S	1 2 3 4 5 (6) 7	PL PR (CO) AB SB PO LE GR CA				0	0	8.9	0
2B23K	132	10 YR	5	6	(0) 1 2 3 4	1 2 3 4			SL	(V) G W M S	1 2 3 4 5 6 7	PL PR CO AB SB PO LE GR CA				0	0	9.5	0.1
D	165+	10YR	5	2	(0) 1 2 3 4	1 2 3 4		—	SCL	(V) G W M S	1 2 3 4 5 6 7	PL PR CO AB SB PO LE GR CA				5	2	9.6	0

APPENDIX B. Previous soil survey information in the survey area.

Soil Survey and descriptions	Survey date	Authors	Scale	Area (ha)	Number of mapped units	Soil analysis
Huonville	1935	Taylor JK & Stephens CG	1:16000	4550 acres (part of)	7	Particle size, pH, loss on ignition.
Hobart	1955	Loveday J	1:63360	100000	14	Particle size, pH, EC_s*, cations, N, P, K C, CEC, ESP**
Brighton	1957	Dimmock GM	1:63360	115000	12	Particle size, pH, EC_s, cations, N, P, K, C, CEC, ESP
Department Agriculture	1973-1974	Kershaw R	soil descriptions	-	-	pH, EC_s
Coal River	1987	Holtz GK	1:25000	2695	32	Particle size, pH, EC_s, NaCl, cations, P, K, S, C, CEC, ESP,
University farm	1993	Holtz GK	1:25000	342 (part of)	16	12 profiles; Particle size, pH, EC_s, NaCl, cations, P, K, S, C, CEC, ESP, clay mineralogy
Glenfield and Boral Estates	1995	Doyle R & student reports	1:5000	125	28	Particle size, pH, EC_s, cations, C, porosity, aggregate stability, moisture retention, K(sat), bulk and particle density
University farm	1996	Doyle R & student reports	1:5000	342	19	Profile descriptions, pH EC_s
Houston farm	1998	Doyle R & student reports	1:5000	80	14	Profile descriptions, pH, EC_s
Selected viticulture	1999	Grose C, Doyle R & Farquhar D	soil descriptions	-	-	Particle size, pH, EC_s, Cl, cations, P, K, S, C, porosity, trace elements

*electrical conductivity of 1:5 soil:water mixture
**exchangeable sodium percentage