SECTION 1: BACKGROUND MATERIAL

Introduction

This report provides a description of the topography, soil and land capability assessments for the proclaimed water supply catchments[1] of the "Wimmera Systems" and the "Rocklands".

The project area occupies some 5,728 km^2 of land centering on the Grampians National Park. Specifically this involves the 4,386 km^2 of the Wimmera Systems together with the 1,342 km^2 of the Rocklands water supply catchment. The study incorporates sections of the Horsham, Portland, Ballarat and Bendigo regions of the Victorian Department of Conservation, Forests and Lands. The survey was undertaken at a scale of 1:100,000 between the months of October 1984 and June 1985, its principal objective being to identify the major landforms and soil features, and to produce a broad-scale land capability rating for the catchments. These ratings allow land degradation to be minimised through improved soil conservation and land management practices. The project can be viewed as a broad scale "first approximation" inventory assessment, which will facilitate subsequent more detailed work. The study is based upon component mapping and is complementary to the "Land System" approach.

The land under study is part the Northern Slopes Appraisal Project. Land north of the Great Dividing Range and above the Riverine Plains along the Murray River, is being characterized to assist in the documentation of land degradation management guidelines. Land use in the Wimmera-Rocklands area presently includes aspects of forestry (around the Grampians and the Black Range to the west); recreation (along the Black and Pyrenees ranges, and within the Grampians National Park); cereal cropping; grazing; water supply storage, and urban development. The major land degradation problems are associated with dryland salinity, water erosion, overgrazing (particularly by sheep) and water supply catchment hazards. The problems arising are largely due to a lack of understanding or recognition of the capability of land to support certain forms of use. An improved "Data Base" of land capability information will facilitate the development and adoption of land management practices which are appropriate for the different land types encountered.

The study was initiated under the "National Soil Conservation Programme" (NSCP) and is jointly funded by the Federal Department of Primary Industry and the Land Protection Service of the Department of Conservation, Forests and Lands. The project involved a small team from the Land Capability Assessment Section (of the Land Protection Service) with assistance from other divisions within the Department.

The report is presented in three parts: general information on method, environment and the land capability assessment approach; results and interpretive maps, together with a tabulated summary of land characteristics; and appendices providing information including a glossary and land capability assessment criteria.

The maps and information presented in this report should not be extended beyond the scale at which they are presented, nor should they be regarded as providing detailed appraisal of individual sites. The reader should be aware that the information presented relies upon aerial photo interpretation and as the scale of mapping is very broad, the assessment can only be regarded as meaningful at a regional level. Detailed land capability studies require a high degree of uniformity and homogeneity of land characteristics within specific map units. Such uniformity cannot be expected at a scale of 1:100,000. The capability ratings, highlighted within this report have been directed to the most commonly occurring type of terrain and soil within each unit. It is beyond the scope of this report to fully describe and discuss each of the individual map units. Likewise the presentation of Climatic and Geological information has been kept to a minimum.

The purpose of the report is to present the major physical land characteristics in the study area which may influence land use. Information presented should therefore be seen as a guide to planning. To ensure effective implementation of the recommendations within the report, consultation with personnel specializing in soil conservation practice is desirable during the planning and implementation of development programmes.

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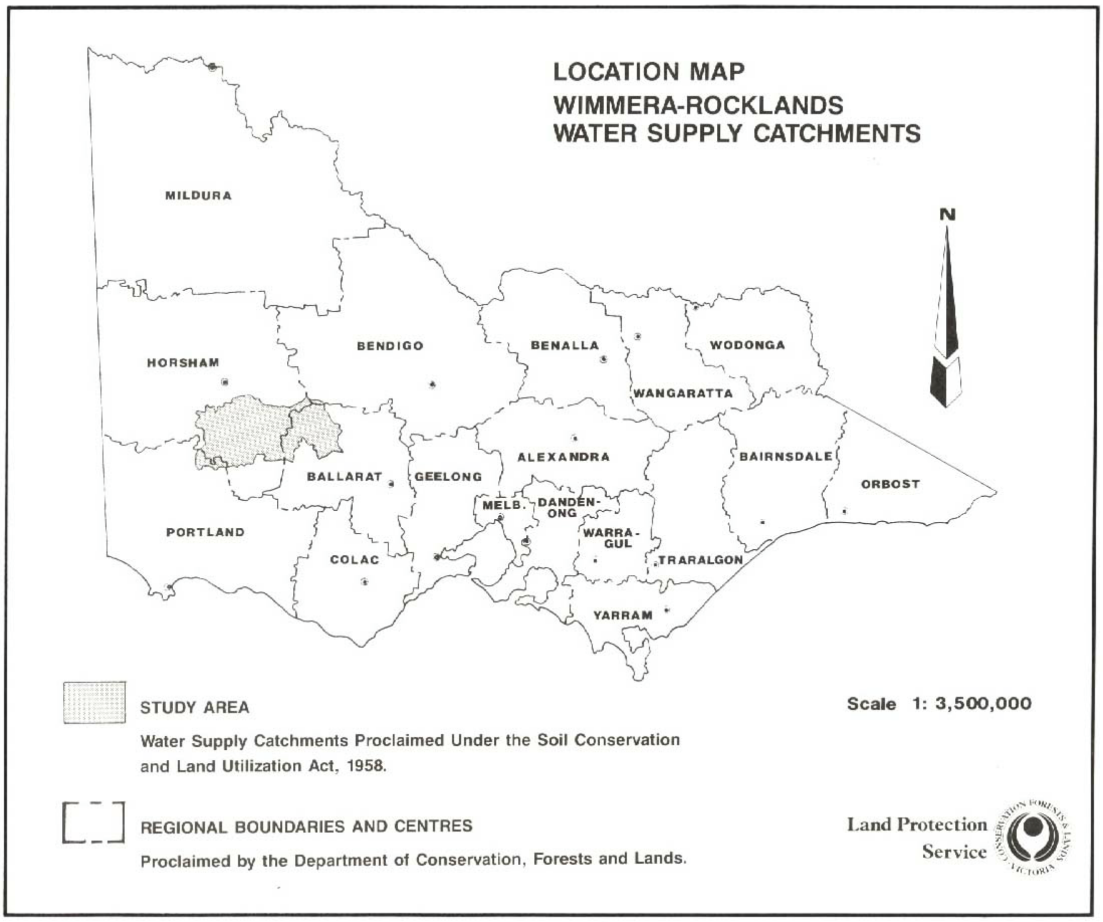
[1] Water supply catchments are proclaimed under the *Soil Conservation and Land Utilization Act (Victoria)* 1958

Map Units within this report are designated an alpha-numeric character. The alpha coding describes the topographic (or landform) element while the numeric code highlights soil type. The relevant key for map unit decoding is shown on the facing page to each map with the Glossary in Appendix 1, detailing relevant descriptions for topographic terms.

The topographic and soil descriptions are based on a low sampling density and generally, map unit boundaries correspond to recognised landform and soil type changes. The delineation of map units reflects a map resolution accuracy of ± 3 mm or approximately ± 300 m on the ground.



Geology

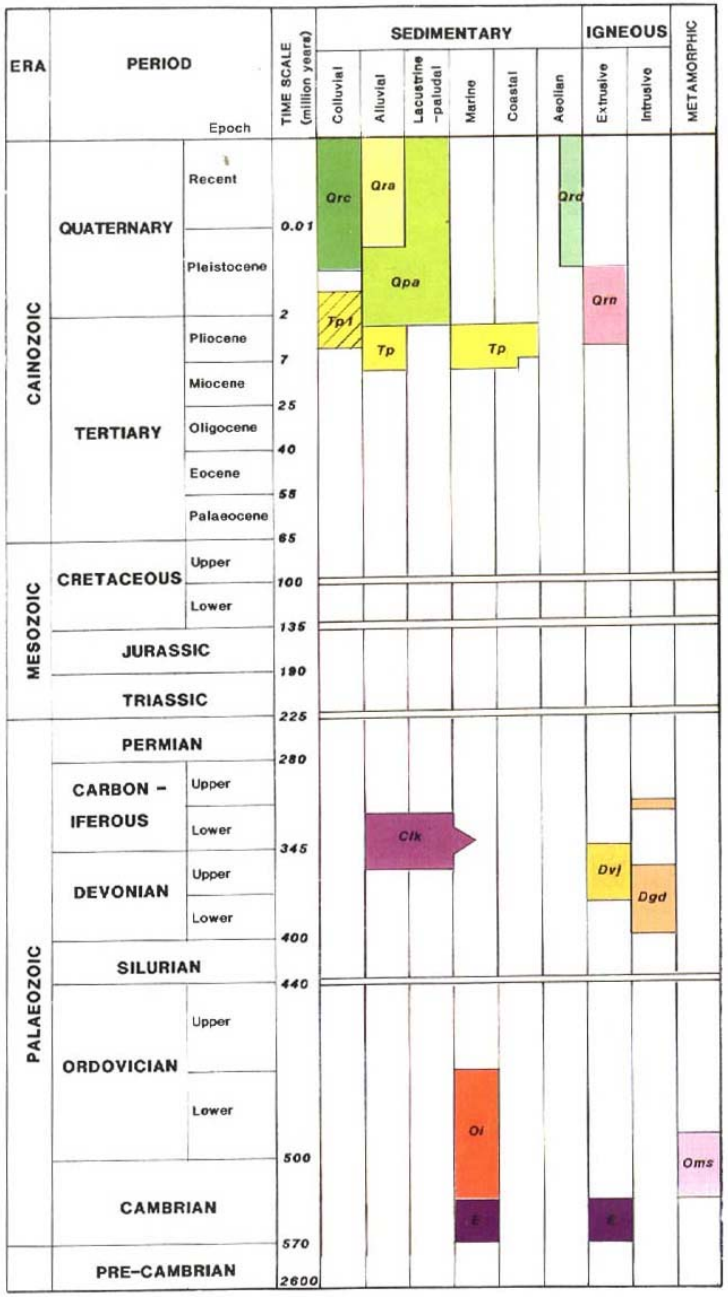
Geologically the area has a history extending into Cambrian times some 570 million years ago. At this time the Tasman Geosyncline (which extended from Queensland to Tasmania) allowed for vast sediment depositions. Sub-marine volcanic eruptions lead to large basic lava sheets on the sea bottom. These Cambrian flows now extend to two thin belts to the east and west of the Grampians. Sediments from the surrounding terrain continued to infill the Geosyncline into early Ordovician times building up thick sequences of sandstone and greywackes, interbedded with shales thousands of metres thick. There is some conjecture as to the exact age of these marine sediments with various reports placing them from Cambrian, Lower Ordovician to Carboniferous times. Nevertheless all authors indicate that these sediments were laid down over a period of approximately 50 million years, with older materials found in the northern parts of the Pyrenees. These materials were later faulted and folded extensively and raised above sea level to be subjected to erosion. A long period of breakdown followed with some intermittent volcanism in Silurian/Devonian times of extruded acidic lavas about the Rocklands Reservoir. The edge of the Tasman Geosyncline shifted eastward in Middle Ordovician times. The north-south crustal weakness remained and developed into a large trough flanked by mountains. Major sedimentation commenced, depositing more than 6 000 m of material which includes red-siltstone, sandstones, pebbles of rhyolites, Cambro-Orodvician sediments and Cambrian greenstone. This formed the Grampians group. The sediments appear to be predominantly unfossilized, suggesting they were laid down in fresh water. Some authors suggest these sediments were laid down in the Lower Carboniferous/Upper Devonian periods, however recent isotopic dating of granites (which have intruded into the Grampians complex), appears to show that the Grampians are in fact no younger than Lower Devonian. Similar granites to those which intruded into the Grampians, form the eastern “Black Range” about Stawell and Great Western and those to the south east Mt Cole, Mt Langi, Ben Nevis and Mt Direction. Metamorphosed aureoles occur in isolated areas about the sedimentary-granitic interface, particularly around Moyston.

Glaciation followed to the Permian times with the proceeding ice retreats causing extensive erosion. Permian geologies are restricted to areas far to the west of the study area.

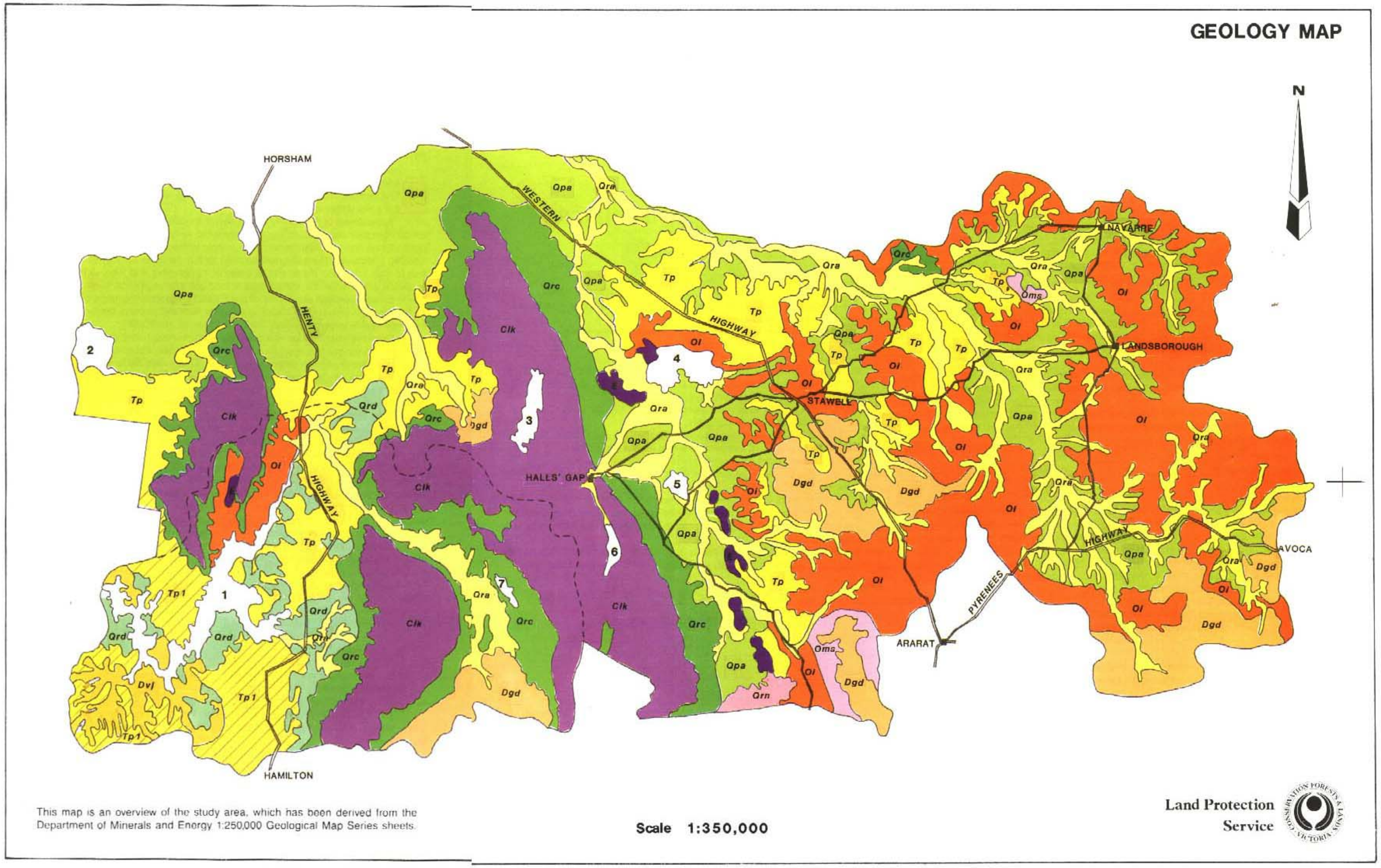
From Upper Cretaceous periods at least four to five cycles of oceanic advance and retreat occurred with each marine transgression again causing extensive erosion. Each inflow was directed by crustal warping. By the end of the Miocene epoch the sea had reached its maximum occupation of the Murray Basin extending ad far north as Glenorchy. The Avoca and Wimmera Rivers were estuarine. In late Tertiary (Pliocene)/early Quaternary (Pleistocene) times some Basaltic flows occurred to the south-east of the Grampians Range.

As the seas continued to retreat wash from the Ordovician terrain was laid down under coastal and marine conditions. Extensive deposits of coastal (Parilla) sand were laid down to the end of the Tertiary period. Pliocene deposits undertaking varying degrees of laterization with particular deposits occurring in the south-west portion of the study area (about the Rocklands Reservoir). These laterites have developed in humid climates where marked seasonal changes in water-tables took place. Northwards towards Horsham these sands from NNW/SSE linear ridges which are considered to be of chenier origin. Large areas have been masked by later Quaternary deposits with only ridge tops obvious.

With the onset of Quaternary times the seas retreated still further with leaching and weathering taking place and the loose siliceous materials being redistributed by the wind to form simple sandsheets and low terrestrial dunes. Below the Grampians scarps and along its “internal valleys” extensive sometimes long scree, sand colluvium and fan deposits developed. To the north, drainage systems were more pronounced with the clay and silt alluvium developing vast heavy clay swampy plains. Throughout the Pleistocene and early Recent epochs alluvial deposits of gravels, sand and clays were laid down in what are the present major drainage courses. With the final uplifting and recession of the sea numerous salty lakes and swamps were left in the north west Wimmera Plains with minor swamp depressions on the eastern side of the Grampians where Lakes Lonsdale and Fyans occur. Vast areas both east and west of the Grampians suffer from salt seepage.



Quaternary complex	Qra	Stream alluvium, flood plain and low level terrace deposits, clay, sand and sandy clay, often grey, slight soil development; also deposits of playas – often grey clay, in paces buried beneath a thin layer of sand. (incl. Qc).
Quaternary complex	Qc	Colluvium, fan deposits, fault aprons, hillwash, scree, gravel, clay and sand
Quaternary complex	Qrd	Aeolian, siliceous sand sheets and dunes.
Quaternary complex	Qpa	High level river terraces, older alluvium and colluvium, flood plain deposits, abandoned swamps, ridges, lagoonal and lacustrine deposits of the red gum plains, heaths and marshes. Clay, silt, sand, gravel, clay of fluviatile and lacustrine origin, extensive plains traversed by leveed stream traces. Minor lunette deposits and dune networks. (incl. Qs-Qrs-Qu-Q1).
New Volcanics	Qrn	Basalt, flows of olivine and iddingsite basalt, limburgite, scoria, minor tuff, frequently vesicular.
Tertiary Sands Complex	Tp	Sand, sandstone and silt, white to yellow, cross bedding, lateritic weathering; often with thin covering of dark grey clay; Ferruginous sandstone, calcareous, locally altered t quartzite gravel, generally lacking a well developed lateritic profile. Includes deep lead material. (incl. Tpp-Tpb-Tbd).
Tertiary Lateritic Group	Tp1	Laterite on rocks of various age. (undifferentiated).
Grampians Group	Clk	Quartzose sandstone, red sandstone, siltstone, minor mudstone.
Rocklands Rhyolites	Dvj	Rhyolite, rhyodacite, pyroclastics.
Granites, Granodiorites	Dgd	Granodiorite, adamelite, associated porphyrite, aplite, monchiquite, lamprophyre, dolerite.
		Granite, biotite granite, pegmatite, soda granite, granophyre. (incl. Dgr-Cgv-Cgm).
Metamorphic group	Oms	Schist, gneiss, amphibolite, schistose hornfels, quartzite, phyllite, associated with granite intrusions as metamorphic aureoles. (incl. ms).
Ordovician Group	Oi	Sandstone, subgreywacke, mudstone, dolomitic shale. Sediments similar to Ordovician, but includes green shales, interbedded with graded turbidite units. Age is uncertain because of lack of fossils, but may extend into Upper Cambrian. (inc. Eo).
Cambrian Group	E	Greenstone-albitised basic lavas, chert and shale.



MAJOR WATER CATCHMENTS:

1 Rocklands Res
2 Toolondo Res
3 Wartook Res
4 Lake Lonsdale
5 Lake Fyans
6 Lake Bellfild
7 Moora Moora Res

Highways
Main connecting roads
Boundary between Wimmera-Rocklands Water Supply catchments

Climate

Due to its extent and the range of topographical features contained within the Wimmera-Rocklands area, there is considerable variation in climate.

In the north around Horsham and to the north-west it tends to be mild. Temperatures are relatively uniform with a tendency for slightly warmer summer conditions as one moves north[2]. The winter months, during which most rain falls, tend to be mild with few frosts.

In the south of the survey area around the Grampians, annual rainfall is considerably higher due to the surrounding mountain ranges. Summer and winter temperatures tend to be slightly lower than those experienced further north. These conditions extend to the east around the Pyrenees Ranges.

The climatic information presented here has been drawn from the Land Conservation Council of Victoria reports on the Wimmera, Ballarat and South-West Districts, and from the Bureau of Meteorology.

Rainfall

The average annual rainfall increases southward through the survey area, from about 550 mm in the north and north east to 900 mm in the higher areas of the Grampians. The Pyrenees Ranges experience a slightly lower annual rainfall than the Grampians. Most of the year's rainfall occurs between late April and October.

Although sporadic, summer rainfall tends to be in the range of 20-38 mm per month with the larger falls occurring in February and March. High summer rainfall occurs in the Grampians and to the east around Ararat and Eversley. Rainfall with the highest erosivity occurs predominantly during the months of December to April. Generally, the lowest annual rainfall occurs in the east of the survey area around Navarre and Landsborough.

Temperature

Mean daily temperature is a vital factor in plant growth and it is also an important determinant of evaporation rate. It is calculated by averaging the daily maximum and minimum temperatures[3].

Throughout the survey area figures indicate that January and February are the hottest months of the year with the mean daily maximum temperature ranging from 28.5^{O}C in the south to 30.8^{o}C in the north. In the coolest months – June and July – the temperature gradient between the north and the south is much less, with the daily maximum temperature in the south being 12.4^{o}C – only one degree lower than in areas in the north around Horsham. Generally, the average minimum temperatures through the year remain fairly constant showing little variation between recording stations.

All stations, on occasion, have experienced very hot days with temperatures exceeding 42^{o}C. From November to late March temperatures above 38^{o}C are common and such conditions usually coincide with dry and turbulent northerly and north westerly winds.

The average daily temperature range increases as one moves north. These areas often show the maximum temperature extremes.

Evaporation

Although evaporation data is very scarce, it is likely that the annual rate of evaporation exceeds the annual rainfall on all the open sites of the survey area, excepting perhaps the areas of higher rainfall in the Grampians. This assumption is based on data collected by the Bureau of Meteorology which indicates that the greatest calculated daily evaporation occurs in January. Values are 4.0 mm/day in the southern portion of the survey area and 6.5 mm/day in the north. The yearly average evaporation rate measured near Horsham was recorded at 4.15 mm/day (between 1965-1979). This equals 1 500 mm/year in comparison to an annual rainfall in the same area of only 500 mm/year.

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[2] Victoria. Land Conservation Council. "Wimmera Area". (Government Printer: Melbourne 1985).
[3] Victoria. Land Conservation Council. "South-Western Area, District 2:. (Government Printer: Melbourne 1978).

Frost and Snow

Light ground frosts can occur when the air temperature falls below 2.2^{o}C whilst heavy frosts are likely when the air temperature falls to 0^{o}C. Although variable from year to year, light frosts have been recorded within the survey area as early as March, whilst conditions for severe frosts usually prevail between June and late August. In the south of the survey area damaging frosts have been recorded as late as early December.

Although snow falls are recorded on the more elevated parts of the Grampians in most years, it seldom lasts very long.

Drought

In the northern and north western parts of the survey area surface water resources are often limited and these areas tend to be prone to summer drought. Although less common in the south, dry conditions can prevail and severe summer droughts are not unlikely. Generally vegetation in these southern areas recovers quickly once sufficient rain has fallen. Winter droughts are much less common.

Wind damage and substantial wind erosion is likely during times of drought and the associated depletion of vegetation. Severe wind erosion occurs in the northwest of the survey area although such events do not appear to occur as frequently as in the past.

Surface Water Resources

The northern parts of the study area are poorly served by river systems. The major water-courses include:

i. The Mackenzie River – This drains the north western slopes of the Grampians and the Wimmera plains in the north west of the survey area. The only water storage reservoir on this river is Lake Wartook.

ii. Mt William Creek – This drains the eastern slopes of the Grampians and the plains to the east of the Grampians. Lake Lonsdale is the major water storage reservoir on this waterway.

iii. Fyans Creek – This aids water storage of Lake Bellfield in the Grampians and then flows into Lake Lonsdale.

These river systems all originate in the Grampians and subsequently drain into the Wimmera River near Horsham. Besides draining the eastern and northern Grampians, the Wimmera River also drains a significant area in the east of the survey area. This includes the Pyrenees Ranges and the northern slopes of the midlands.

Southern parts of the survey area drain into two major rivers.[4]

i. The Glenelg River – This drains the western slopes of the Grampians and areas west of the Black Range. The major water storage reservoir in this area is the Rocklands Reservoir.

ii. The Wannon River – This drains the wooded southern slopes of the Grampians, and ultimately join the Glenelg River near Casterton.

[4] Victoria, Land Central Planning Authority. "Glenelg Region – Resources Survey" (Government Printer: Melbourne 1960).

Water Quality

Salinity is the most important factor affecting the suitability of water for domestic and stock consumption in the survey area. Generally, the quality of the headwaters of most streams in the area is suitable for domestic water supply, containing less than 1000 mg/l TDS.[5] Most sheep and cattle will tolerate up to 12,000 mg/l TDS.[6] All the major reservoirs in the study area have a calculated maximum salt content below 600 mg/l TDS, ensuring their suitability for domestic consumption. Salinity levels in the major rivers of the study area, the Wimmera, Glenelg and Wannon, are variable, but maximum salt contents of greater than 2000 mg/l have been recorded. These high salt levels are generally restricted to areas downstream from the survey area.

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[5] Total Dissolved Solids (TDS).
[6] Victoria, Central Planning Authority. "Wimmera Region". (Government Printer: Melbourne 1961).

Soil Survey Method

The survey was carried out in three separate stages:

i. A brief reconnoitre of the study area to gain some preliminary knowledge of the terrain and accessibility.
ii. An assessment of the region by initially using aerial photographic interpretation, together with soil and map unit data collected in the field; and finally
iii. The compilation of map unit descriptions and land capability ratings for the units within the region.

Assessment of the survey area entailed dividing the landscape into units, which were delineated according to topographic variations and the principle soil profile forms. Steroscopic aerial photographic interpretation of black and white, 1:85,000 photos, was the basic method used for the identification of units. Delineation of map units was made on the basis of topographic and tonal differences in photos, often caused by differences in land use and vegetation cover. In addition to photos, use was also made of the 1:100,000 topographic maps produced by the Division of National Mapping together with the relevant Department of Minerals and Energy geological maps and reports (1:250,000).

Once the interpretation was complete and preliminary map units were identified, field investigation began. Due to the large number of map units, representative units were chosen for detail description. These were the largest map units within the randomly selected areas of the survey region. Units with suitable catenas were chosen where possible. This method was employed to reduce heterogeneity of soil types between large and small map units in a specified area. Where road cuttings, gullies, or other soil exposures were not available to be used for the soil descriptions, soil samples were taken to a depth of 150 cm, (where possible), with a 10 cm diameter soil auger. Soils were classified according to The Factual Key for the Recognition of Australian Soils (Northcote, 1979).[7] The physical description of sites included aspects of landform type, slope and profile characteristics including colour, texture, structure, fabric, mottling, consistence and inclusions. Other aspects of the surrounding terrain were also described including soil and site drainage, depth to watertable, hard rock, soil permeability and erosion. No chemical or physical analyses were undertaken, however rudimentary dispersion and slaking tests were undertaken whilst in the field.

After compilation of the soil and map unit data in the field, interpretations of land capability assessment, were made. Land was assessed for erosion risks associated with cropping and grazing, rural subdivision and urban development. Within rural and urban development are a number of activities considered essential for each of the two land uses to satisfactorily carried out. They were for Rural Subdivision:

- Secondary Roads
- Septic Tank Absorption Field
- Building Foundations.

And for Urban Development:

- Building Foundations
- Secondary Roads
- Shallow Excavations.

The land capability rating systems utilised in this report, identify the kind and degree of limitation that may be created by key land characteristics with regard to the sustainability of specific land uses or activities.

The ratings for either rural or urban development are dependent on the land capability of the major limiting activity. For example, if soil drainage is unsatisfactory for the building of secondary roads then rural and urban development would show poor capability, due to the poor soil conditions available for road construction. (Land capability rating tables appear in Appendix 2).

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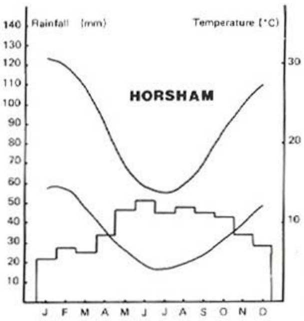
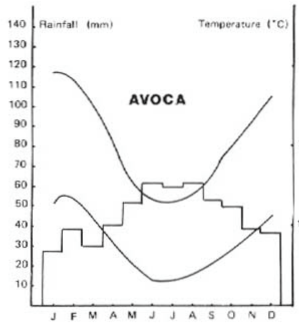
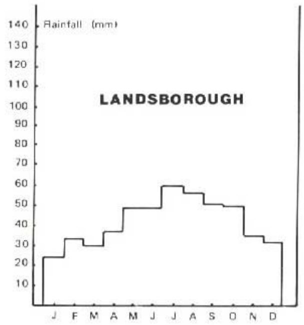
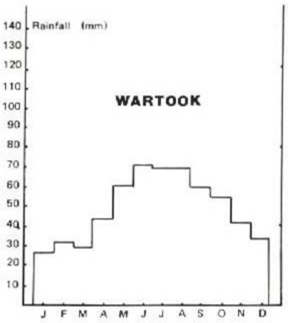
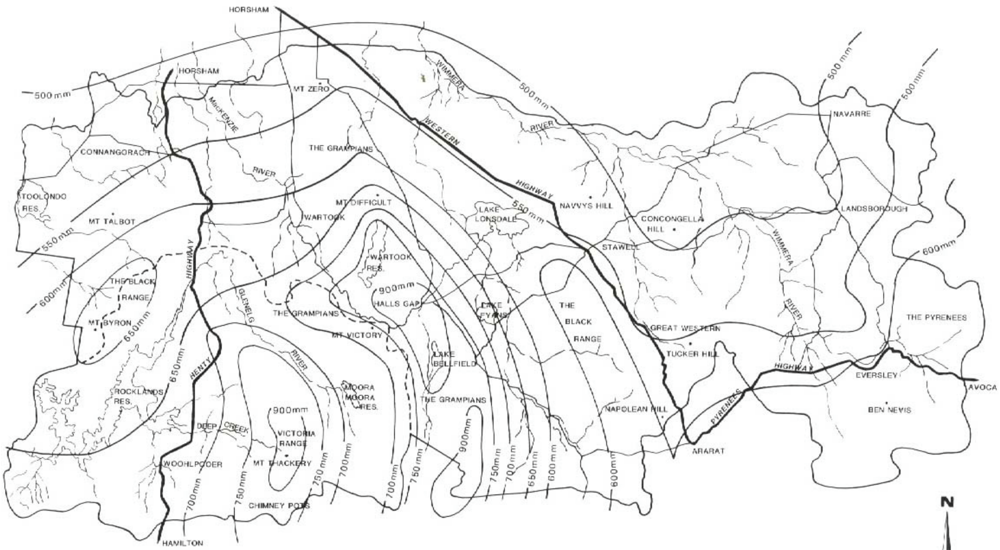
[7] Northcote, K.H. (1979). "A Factual Key for the Recognition of Australian Soils". 4th Edn. Rellim. Tech. Publ. Glenside. S.A.











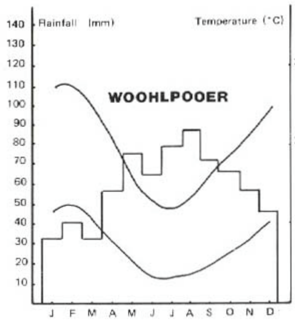
CLIMATE MAP

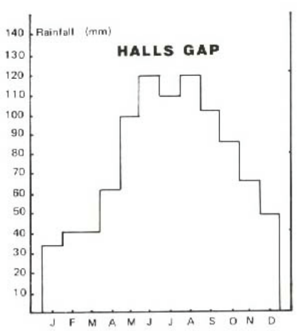
WIMMERA- ROCKLANDS WATER SUPPLY CATCHMENTS

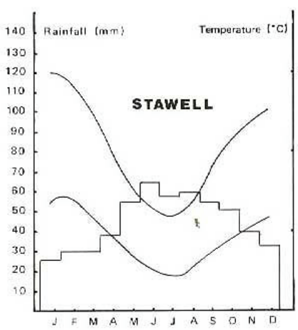
- 500 mm - AVERAGE ANNUAL RAINFALL ISOHYETS (mm)

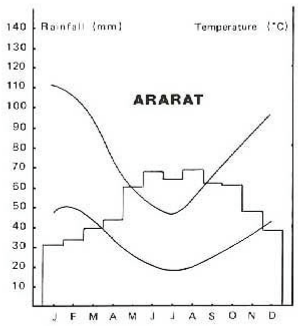
Scale 1:410,000

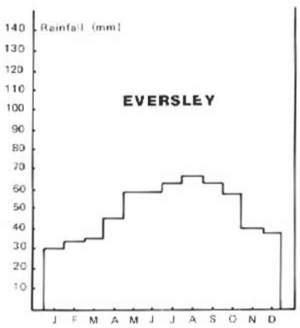
Land Protection Service











Land Evaluation and Supply Interpretation

A report that solely summarises soil types and landform categories is of limited use to land planners or developers unless they are quite familiar with the procedural and technical aspects of the map unit descriptions involved.

To provide a simple user-orientated land use map, the Land Protection Service (LPS) has developed guidelines for land capability assessment which are based upon interpretive systems used by the FAO[8] and the USDA[9] Soil Conservation Service.

The land capability assessment is designed to provide basic information to land users on the land's potential. The LPS uses this approach to specifically assist land users with alternative management practices so as to limit land degradation and to develop land management plans in proclaimed water supply catchments.

The approach considers whether the land's natural characteristics will be adversely affected and whether the proposed land use, will alter the environment beyond "acceptable limits", from a soil conservation viewpoint. These acceptable limits vary due to social and economical considerations.

Land capability assessment primarily relies on the interpretation of landscape and soil characteristics based upon guidelines proposed by Rowe et al (1981).[10] Assessment considers land features which are not expected to change over the foreseeable future but which, with appropriate management can be integrated with the ever changing economic and social considerations. Map units are subsequently classed depending on what land use is envisaged.

The land capability class indicates the degree of limitation which is associated with a particular use together with the level of management needed to contain any subsequent land degradation.

The Land Protection Service has found it useful to employ a five class rating system in which class one denotes the most capable map unit based on the lowest level of physical limitation. It must be stressed that no rating class stipulates that a particular activity can or cannot be undertaken. The system indicates the degree of land degradation risk together with suggested levels of management that would be required to satisfactorily pursue the proposed land use.

With time, management procedures may be evolved or found which will overcome problems more economically with respect to time, money and environmental considerations. When such a development takes place the specific land capability table would be altered to meet the new standards.

This report is restricted to land capability rating systems concerned with:

1. Erosion risk associated with cropping
2. Erosion risk associated with grazing
3. Secondary roads
4. On site effluent septic tank absorption fields
5. Building foundations
6. Earthen farm dams
7. Shallow excavations
8. Urban development (subdivision of 2 ha)
9. Rural development (subdivision of 10 ha)

Ratings for erosion risk associated with cropping and grazing are provided as first approximation only and are presented as a guide to enable broad-scale themes to emerge. Site specific ratings may depart from the broad-scale interpretations, however the relative presented in this report are considered to be a reasonable indication.

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[8] Food and Agriculture Organization of the United Nations (FAQ).
[9] United States Department of Agriculture (USDA).
[10] Rowe, R.K., Howe, D.F. and Alley, N.F. (1981). Guidelines for Land Capability Assessment in Victoria. Soil Conservation Authority Melbourne.

Further development and refining of the assessment criteria will be needed to improve the precision of the ratings.

The basic tables and criteria upon which the ratings are classified are presented in Appendix 2.

The knowledge of land capability assessment theory and its application is dynamic and evolving as the understanding of the soil/land use/management interactions improve. As such the results presented here must be used only as a guide and not definitive statements of fact.

Land Capability Classes – Generalised Definitions

Land Capability Class	Capability	Degree of Limitation	General Description	Levels of Special Management Needed to: (a) attain acceptable levels of production or satisfaction from the use; (b) contain adverse effects to the land and water to acceptable levels
1	Very Good	None to very slight	Areas within a high capability for the proposed activity or use. The limitations of long term instability, engineering difficulties or erosion hazard do not occur or they are very slight. Standard designs and installation techniques, normal site preparation and/or management should be satisfactory to minimise the impact on the environment.	(a) and (b) No special technology or management needed.
2	Good	Slight	Areas capable of the proposed activity or use. Slight limitations are present in the form of engineering difficulties and/or erosion hazard. Careful planning and/or the use of standard specifications for site preparations, construction and follow-up management should minimise developmental impact on the land.	(a) No special technology needed, and/or (b) The risk of adverse effects to land and water is low. Limited, simple conservation measures are required. Careful management is needed for both (a) and (b).
3	Fair	Moderate	Areas with fair capability for the proposed activity or use. Moderate engineering and/or high erosion hazard exist during construction. Specialized designs and techniques are required to minimise development impact on the environment.	(a) Special technology is needed, and/or (b) A moderate risk of adverse effects to land and water is always present. Special conservation measures are required. Careful management is essential for both (a) and (b).
4	Poor	High	Areas with poor capability for the proposed activity or use. There are considerable engineering difficulties during development and/or management are necessary to minimise the impact on the environment.	(a) Highly specialized technology is required, and/or (b) A high risk of adverse effect to land and water is always present. Extensive conservation measures are required. Skilled management is essential for both (a) and (b).
5	Very Poor	Severe	Areas with poor capability for the proposed activity or use. Limitations, either long term instability hazards, erosion or engineering difficulties cannot be easily overcome with current technology. Severe deterioration of the environment will probably occur if the activity or use is attempted in these areas.	The high levels of technology and management needed, are unlikely to be achieved or sustained. Severe risk of adverse effects to land and/or water is always present.