SOIL CONSERVATION SERVICE

OF

NEW SOUTH WALES

ALBURY

DISTRICT TECHNICAL MANUAL

APRIL, 1978

CONTENTS

1 INTRODUCTION

R.S.Junor

The Albury soil conservation district comprises approximately 6703 sq. kilometres. It extends from the western footslopes of the Great Dividing Range to the edge of the Western Plains and includes the main agricultural lands of the Hume Reservoir Catchment, within New South Wales.

Albury, with a population of 30,000, is the main commercial and industrial centre of the region. Smaller centres are located on the periphery and include the towns of Corowa, Walla Walla, Culcairn, Holbrook and Tumbarumba.

This district is one of six Soil Conservation districts of the Riverina administration area, centred at Wagga Wagga.

1.1 Boundaries

The southern boundary is formed by the Murray River. Part of the northern boundary between Walbundrie and Holbrook is formed by Billabong Creek. From Holbrook, the northern boundary is the catchment boundary of the Hume Reservoir. The western boundary is the Corowa –Walbundrie road, while the eastern boundary is the western boundary of Kosciusko National Park.

1.2 Local Government Administration

The Albury district is administered by Albury City Council and the Shire Councils of Hume, Corowa, Culcairn, Holbrook and Tumbarumba.

The Albury district is part of the Murray Region determined by the N.S.W. Department of Decentralisation and Development.

The Albury-Wodonga Development Corporation has been established by the Australian Government and State Governments of New South Wales and Victoria. The Corporation is responsible for the accelerated growth of the City complex and as a Statutory Authority has acquired lands for development within the Albury City boundary and adjacent Hume Shire.

1.3 Historical Development

The explorers Hamilton Hume and William Hovell first explored the district, reaching the Murray River on 16th November, 1824. Pastoralists soon followed and in 1836 the first permanent dwellings were established. A village was established around “the Crossing Place” and this became the Town of Albury in 1839.

The district became highly regarded for agricultural and pastoral production, particularly in the 1850’s when it supplied the gold settlements of Beechworth and Chiltern.

The greatest impetus to agricultural production came with the inauguration of a paddle steamer service in 1855 to transport produce from the area. By 1880, Albury was a principal wheat growing area of the State.

Extensive vineyards were also established in 1860. However, at the turn of the century the disease phyloxera appeared and threatened the industry.

Cereal farming up until the 1940's was a minimal wheat–fallow rotation where stubble was burnt. Much of the accelerated erosion of drainage lines and the general depletion of soil is attributed to these farming methods. Many district farmers refer to a major event in 1939, when 1204 mm of rain (4739 points) was received for the year, which followed two prolonged droughts. The consequent severe erosion caused many farmers to reduce cultivation areas. Also, with high values for wool in the early 1950's, much of the district became predominantly pastoral.

Rabbits first appeared in 1884 and quickly infested the area. Heavy infestations, particularly in the rocky hills caused extensive sheet erosion and stocking rates were reduced. In 1951, introduction of the virus myxamotosis controlled this pest and subsequently, poisons such as 1080 have reduced the threat these animals posed to the stability of the landscape.

Patterson's Curse (Echium plantagineum) first appeared in Australia in 1880 at "Cumberoona" and spread rapidly throughout the district. Cape weed (Aretotheca calendula) also presents a problem when it becomes dominant on hill crests and sheep camps. Both these weeds may contribute to a soil erosion problem by leaving the soil exposed in late summer.

Since World War II the widespread use of subterranean clover and rye grasses as improved pastures, the control of rabbits and annual aerial applications of superphosphate, particularly in the steeper grazing country, has significantly improved the stability of the land in this district.

Today, there is a greater diversity of production and also a marked increase in beef cattle numbers particularly since 1970.

The accelerated erosion that occurred during the first half of this century has been significantly reduced by improved land management, introduction of soil conservation methods and an awareness by the farming community of the impact of erosion on the productive capability of their land. However, a significant erosion potential continues. This was well demonstrated in the two successive wet winters of 1973 and 1974 when gully erosion increased dramatically. In addition, land management trends such as reduction of fertilizer application, changes in land use and economic conditions may create circumstances that would reverse the present stable situation. A continuing programme of soil conservation management and treatment of problem areas is required on most properties in the district.

2 GEOLOGY

R.S. Junor

2.1 Introduction

The geological history of the Albury district is a complex series of erosion and sedimentation, followed by deformation and metamorphism.

The stratigraphy is comprised of sediments and metasediments of Ordovician and Devonian age. Granitic intrusions and acid volcanics also occur. Recent deposits of Tertiary and Quaternary alluvium occur along the Billabong Creek and Murray River Systems.

2.2 Description of Geological Units

Reference is made to Figure 2.2.

2.2.1 Cainozoic

A significant area of the Albury District is covered by alluvium of Quaternary age. (Qrs). These sediments occur principally along the water–courses of the Murray River and Billabong Creek and on areas of low relief which form the boundary of the Riverina Plain, mainly west of Howlong. Similar deposits occur along the major tributaries, particularly the Tumbarumba, Bowna, Mullengandra, Mountain, Petries, Burrumbuttock and Majors Creeks. Tertiary alluvium underlies most of the broad exposures of Quaternary alluvium.

Tertiary basalt (CZb) occurs in the eastern portion of the district as the remnant caps of more extensive sheet flows.

2.2.2 Upper Devonian Sediments

The broad western slopes of the Table Top Range are composed of conglomeratic and arenaceous sediments $\left(\frac{Q}{DLS}\right)$ which dip gently west at about 10 to 15 degrees. The terrain is characterised by a cuesta with a steep escarpment on the eastern face. Small exposures of these sediments occur south of the Range and to the southeast of Culcairn.

2.2.3 Siluro–Devonian Acid Volcanics

A variety of volcanic and hypabyssal rock types $\left(\frac{Q}{S-Dv}\right)$ are located in a broad belt of land east of Albury extending from Thurgoona to Table Top and Yambla Range.

These igneous rocks range from quartz feldspar porphyry $(S-Dv)$ which outcrop on the lower slopes of Table Top range, to banded rhyolite and tuff exposed along the middle reaches of Table Top Creek, near Ten Mile Hill, Budginigi and Hurricane Hill.

The acid volcanics are characterised by a deep weathering profile and infrequent outcrop. Deep fertile red–brown, brown to yellow sandy loam soils are derived from these rocks and they are especially well–developed in the Table Top district and along the valley of the Table Top Creek.

2.2.4 Silurian Granites

Porphyritic and biotite granites and granodiorites (Sg) intrude the Ordovician gneiss and metasediments e.g. the Jindera Granite and Run Boundary Granodiorites north of Albury. The red soils occurring on the gently undulating country from Jindera to Walla Walla are underlain by the Jindera Granite. The depth of weathering is substantial and outcrop is mainly restricted to the residual hills east of Burrumbuttock, west of Gerogery, and east of Jindera. The coarse textured Jindera Granite has weathered to a coarse residium that is useful road material. However, extraction pits on these granites erode rapidly and required stabilisation.

In the uplands east of Albury between Bowna and Khancoban is a broad mountainous tract of granitic rocks (Sg), a component of the Corryong Batholith. Extensions of this rock type reach the Woomargama area to the north of the I-flame Highway. Here relief is more subdued and deep weathering increases as the alluvial plain of Billabong Creek system is approached. Deep gully erosion occurs on the weathered granites.

2.2.5 Ordovician Sediments, Metasediments and Gneiss

Three grades of metamorphism occur in the Ordovician rocks which occur in the Albury district.

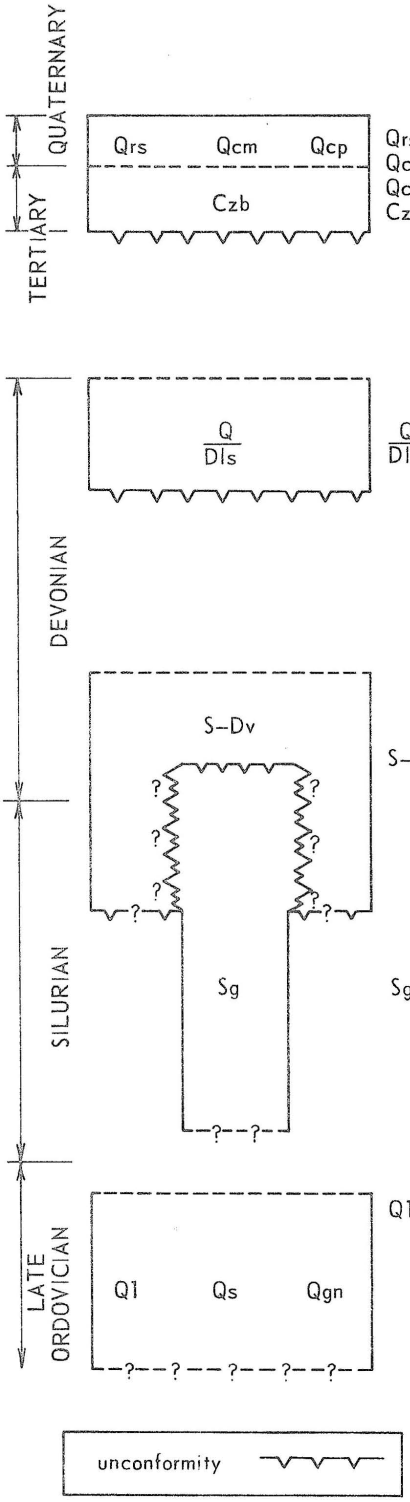
The lowest, either phyllitic slates or slate, phyllitic grade of metamorphism is represented by slate, phyllite; siltstone, sandstone and greywacks $(Q1)$ located in the Mullengandra–Woomargama area and Jingellic–Rosewood areas.

The transitional grade of metamorphism is found in the remaining slate, phyllite and schists designated in $(Q1)$.

High grade metamorphism is represented by quartz mica schist occuring in a broad zone to the west and north-west of Albury which includes the hills in the Splitters Creek, Bungowannah, Jindera and Burrumbuttock areas. Soils derived from these rocks are highly erodible and generally dispersible.

Pegmatites intrude the high grade metamorphics, and are characterised by graphic–textured orthoclase feldspar, abundant muscovite and some tourmaline. The pegmatites are usually aligned to the major lineation and are generally discontinuous and more resistant to weathering and erosion than the surrounding schists and slope facets development.

FIGURE 2.2 DIAGRAMATIC STRATIGRAPHIC TABLE FOR THE ALBURY REGION



Qrs Unconsolidated riverine deposits of clay.
Qcm Silt, sand, gravel. Includes floodplains.
Qcp Alluvial terraces, high–level terraces.
Czb Basalt

Q/Dls Conglomerate, pebbly sandstone, sandstone, minor siltstone.

S–Dv Acid volcanics and associated intrusives. Volcanics include quartz–feldspar, porphyry, rhyolite, tuff, dellenite.

Sg Biotite granite, granodiorite. Frequently with muscovite; may be porphyritic, foliated, xenolithic. Includes Jindera Granite, Hawkesview, Run Boundary Granodiorites, and portion of the Corryong Batholith.

Q1 Low–grade metasediments and sediments: slate, phyllite, greywacke, siltstone, mudstone, shale. In large part metamorphosed to high–grade quartz–mica schist and quartzofeldspathic biotite gneiss.

Extract from "The Stratigraphy of the Albury Region"
I.Willis: Geological Survey Report No. G.S. 1974/021

2.3 Relationship of Geology to Erosion

In the Albury District a distinct relationship exists between the geology and the extent and development of gully erosion.

Extensive gully erosion is located on soils derived from high grade metamorphic rocks such as the quartz-mica-schists, (Qs) biotite gneiss (Qgn) and the residual colluvial deposits derived from Ordovician sediments. The dispersible nature of the soils contributed to the development of the gully erosion.

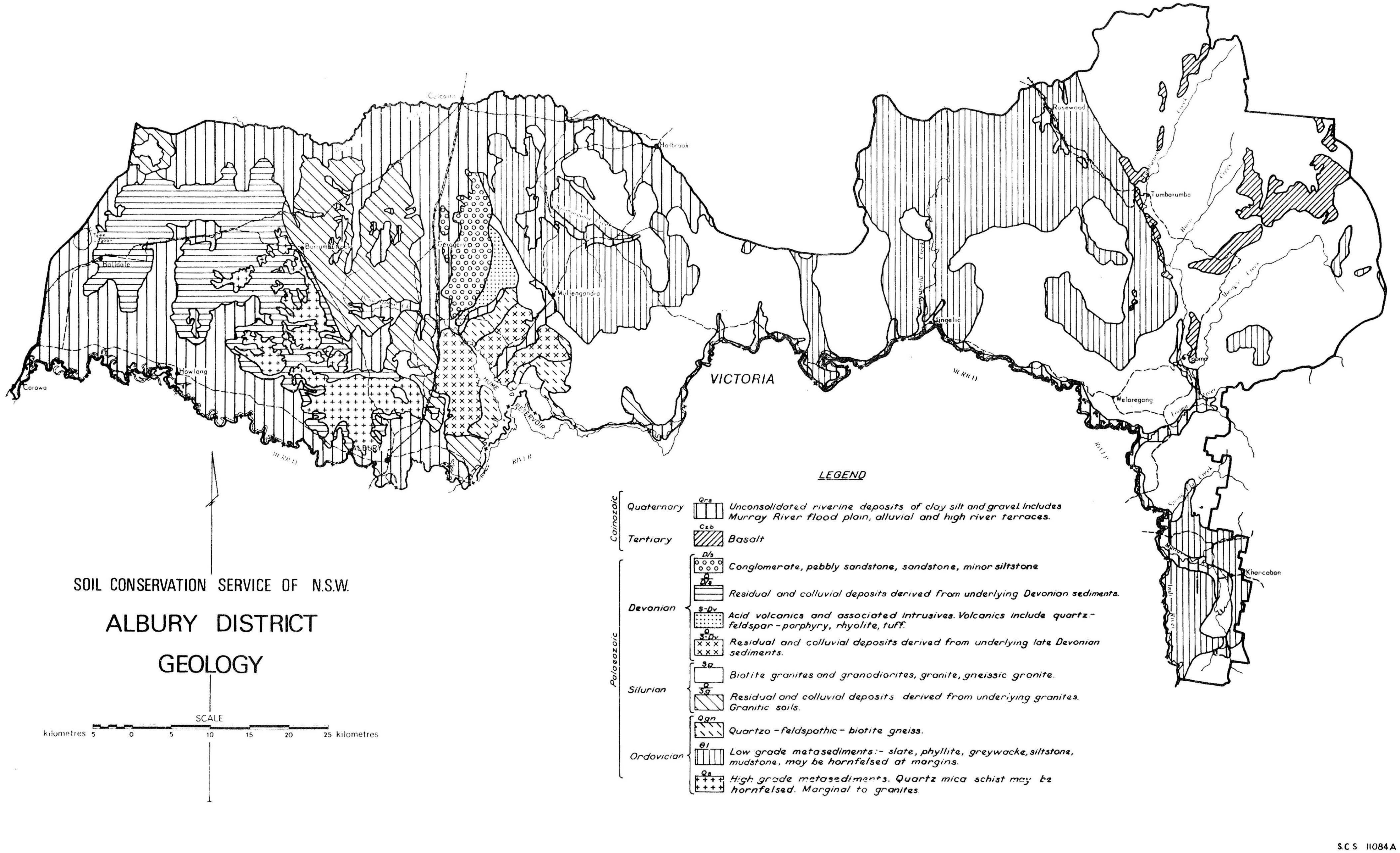
Moderate gully erosion occurs of the granite and acid volcanic rocks designated (Sg), $(S-Dv)$ and $\left(\frac{Q}{S-Dv}\right)$

Some deep gullies, 10 metres deep, have developed on deeply weathered granites in the Holbrook, Tooma and Bringenbrong areas.

Minor gully erosion occurs in watercourses draining quartzite, slates and phyllites represented as $(Q1)$ and the residual colluvial deposits of Silurian granites $\left(\frac{Q}{Sg}\right)$

Gully erosion occurs on the soils formed on Late Devonian residual and colluvial deposits $\left(\frac{Q}{D1s}\right)$ and Quaternary unconsolidated riverine deposits (Qrs). This has been partly caused by man's agricultural pursuits, particularly the diversion and containment of runoff on these 'run on' slopes, Without adequate waterways, a potential for extensive gully erosion exists in these areas, e.g. Red Creek, south of Culcairn.

Figure 2.1


SOIL CONSERVATION SERVICE OF N.S.W.
ALBURY DISTRICT
GEOLOGY
SCALE
kilometres 5 0 5 10 15 20 25 kilometres
LEGEND
Cainozoic
Quaternary
Qrs
Unconsolidated riverine deposits of clay silt and gravel. Includes Murray River flood plain, alluvial and high river terraces.
Tertiary
Czb
Basalt
Palaeozoic
Devonian
D/s
Conglomerate, pebbly sandstone, sandstone, minor siltstone
Q/D/s
Residual and colluvial deposits derived from underlying Devonian sediments.
S-Dv
Acid volcanics and associated intrusives. Volcanics include quartz-feldspar-porphyry, rhyolite, tuff.
Q/S-Dv
Residual and colluvial deposits derived from underlying late Devonian sediments.
Silurian
Sg
Biotite granites and granodiorites, granite, gneissic granite.
Q/Sg
Residual and colluvial deposits derived from underlying granites. Granitic soils.
Ordovician
Ogn
Quartzo-feldspathic-biotite gneiss.
Ol
Low grade metasediments:- slate, phyllite, greywacke, siltstone, mudstone, may be hornfelsed at margins.
Qs
High grade metasediments. Quartz mica schist may be hornfelsed. Marginal to granites.
VICTORIA
Corowa
Howlong
Culcairn
Holbrook
Tumbarumba
Rosewood
Mullengandra
Welaregang
Khancoban
S.C.S 11084.A

3 LANDFORM

C.M. Adamson

3.1 Introduction

The topography of the Albury district is complex, being dominated by the proximity of the Australian Alps. Flat areas are not extensive and the majority of the district is comprised of sloping country.

In the east, high, rugged, mountainous land predominates. There is a gradual change to lower hill country further west. The Riverina plain forms the westward extremity of the district.

Elevation varies from 125 metres at Corowa to 1450 metres at Granite Mountain.

The district is mainly drained by the Murray River and major tributary, Billabong Creek. There is a small area in the rugged north-east which drains towards the Tumut River.

3.2 Description of Landform Classes

The district has been mapped using four slope classes. These are:—

slopes	0	3%	mostly flat
slopes	3	10%	undulating
slopes	10	30%	hilly
slopes greater than		30%	rugged

Slope classes have been mapped using aerial photograph interpretation. Details from a previous survey of the Hume Catchment (Morland, 1958) have also been incorporated in the map. (Figure 3.1)

3.2.1 Slopes 0-3%

The most extensive area of flat country occurs in the western extremity of the district and is part of the Riverina plain.

Areas of poor drainage occur in association with the grey and brown clay soils and yellow solonetzic soils. Poor profile drainage restricts cropping to favourable seasons only.

3.2.2 Slopes 3-10%

This unit consists of the footslopes of hill systems that project outwards to the Riverina plain.

Land use is mainly arable. Although these slopes are relatively gentle, they are long and hence present a serious erosion hazard.

3.2.3 Slopes 10 –30%

Extensive areas of this unit occur throughout the district over a wide range of soils and environnents.

Land use is mainly grazing but cultivation of slopes below 20 percent for pasture renovation is tolerated.

There is a serious gully erosion hazard in areas that have been cleared excessively, or over grazed.

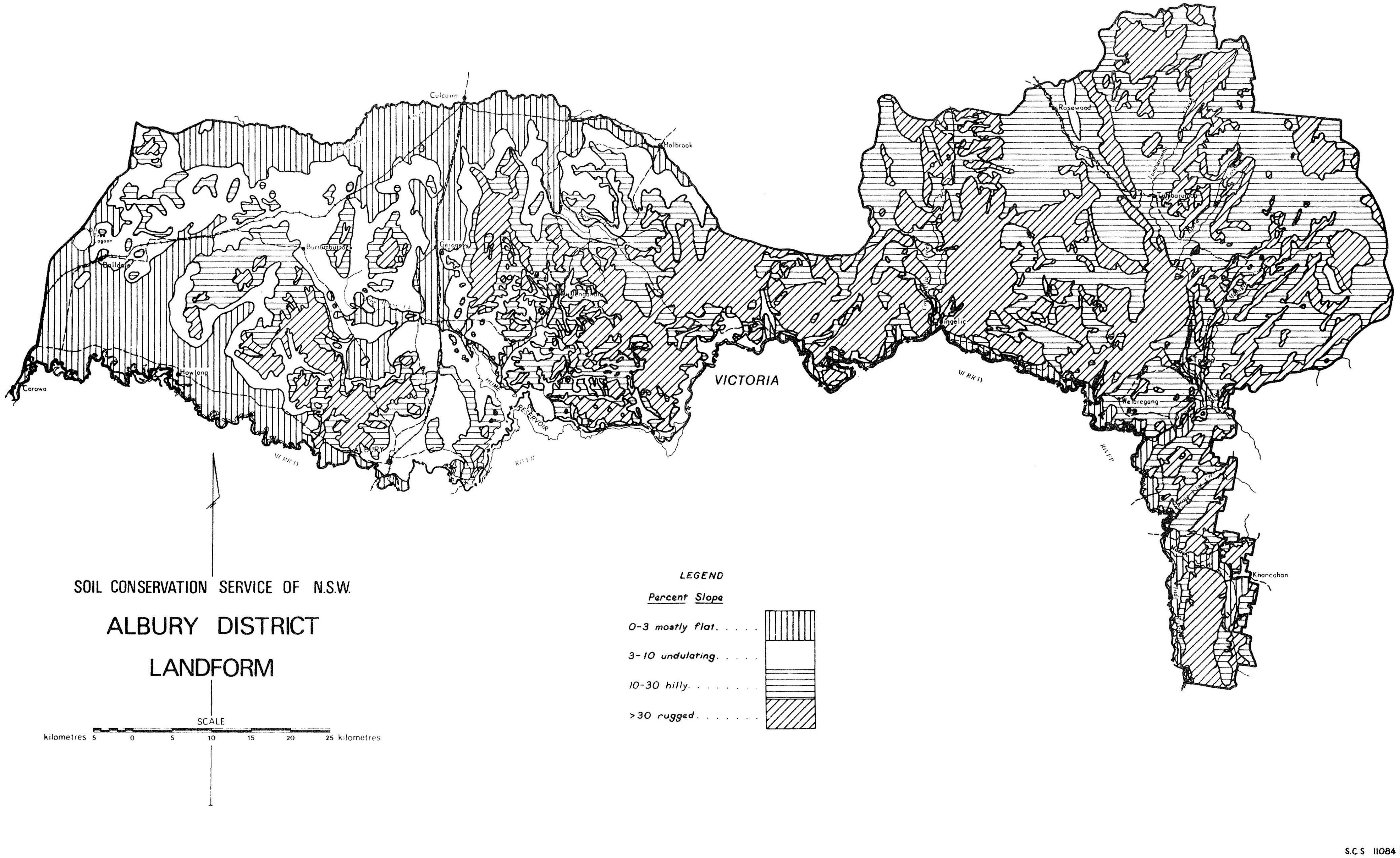
3.2.4 Slopes greater than 30%

This is the most extensive slope class within the district and is characteristic of both hill and mountain systems.

These areas have no agricultura1 potential due to steepness and lack of soil depth and are mainly used for forestry, recreation, or managed for catchment protection.

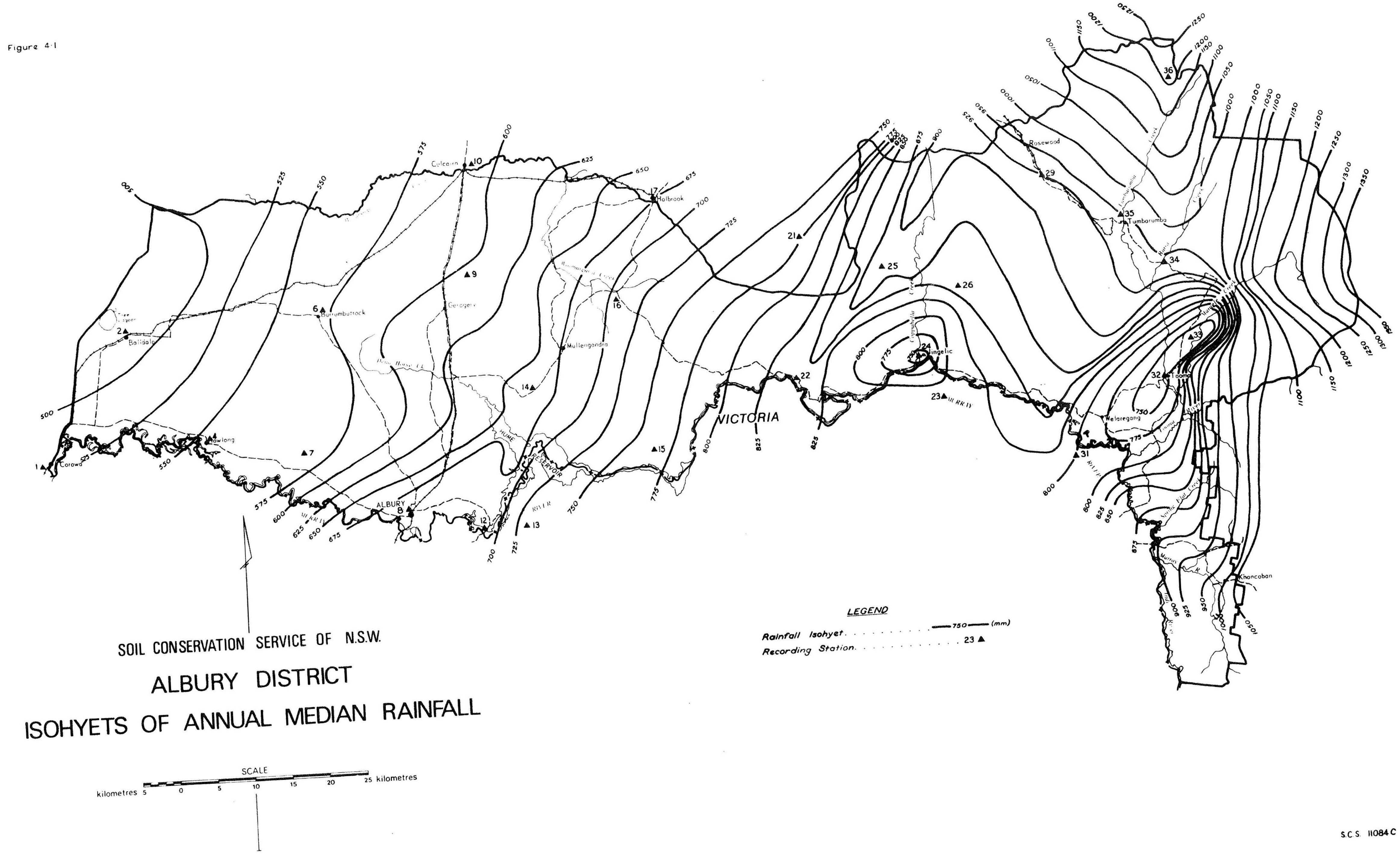
Large areas with slopes greater than 180 occur within this unit.

Figure 3·1



map

Figure 4·1


SOIL CONSERVATION SERVICE OF N.S.W.
ALBURY DISTRICT
ISOHYETS OF ANNUAL MEDIAN RAINFALL
LEGEND
Rainfall Isohyet .... 750 (mm)
Recording Station 23
SCALE
kilometres 5 0 5 10 15 20 25 kilometres
VICTORIA
Corowa
Balldale
Howlong
Burrumbuttock
Culcairn
Gerogery
Holbrook
Mullengandra
ALBURY
Rosewood
Tumbarumba
Jingellic
Khancoban
S.C.S. 11084C

4 CLIMATE

W.H.Johnston

4.1 Introduction

The climate of the Albury district is mainly controlled by eastward moving low pressure cells and associated frontal systems along the southern margins of the continent. An annual cycle of latitudinal shift gives rise to seasonal change. The systems move south during summer and their influence on southern New South Wales decreases.

In the Albury area there are two principal causes of rainfall. During winter the frontal process mentioned above gives rise to widespread protracted rainfall. This rain is due to the lifting of a relatively warmer air mass with the passage of a cold front. It is usually associated with the formation of stratus or layer cloud.

During the summer, convectional lifting of moist air, during the hottest part of the day, results in the formation of cumulus or cumulo-nimbus clouds, which produce showers and thunderstorms. These storms usually occur towards the evening. They are of short duration and high intensity and occur over small areas.

The summers may be described as warm to hot and winters cool to cold. Temperature decreases with altitude and frost occurrence increases.

This section provides basic climatic data, an interpretation of this data and its application to soil conservation practice. Relationships between climate, particularly rainfall and plant growth, are examined in depth.

4.2 Rainfall

Rainfall records have been obtained from landholders and the Bureau of Meteorology.

Details of stations for which rainfall records were obtained are listed in Table 4.2.1.

4.2.1 Analysis of Data

Monthly rainfall data for selected stations from Table 4.2.1 were analysed to determine the upper and lower quartiles, the median and the deviations from the median on a monthly, quarterly and annual basis.

Rainfall equal to or greater than the median can be expected in 50% of years. Falls exceeding the value of the upper quartile or less than the value of the lower quartile can be expected in 25% of years. The interquartile range represents 50% of the rainfall totals.

Table 4.2.1
Rainfall Stations in the Albury District

Station Name	CBM No.	Period of Record	Type of Data	Location No *
Corowa Bowling Club	074034	1890-1972	Monthly/yr	1
Balldale	074004	1909-1972	Monthly/yr	2
Rand (Claverton)		1931-1971	Monthly/yr	3
Howlong PO	074054	1885-1972	Monthly/yr	4
Henty (Munyabla Pk.)		1920-1971	Daily/yr	5
Burrumbuttock	074025	1899-1972	Monthly/yr	6
Bungowannah	074023	1893-1972	Annual median **	7
Albury	072001	1893-1969	Monthly/yr	8
Gerogery East Past. Co.		1898-1971	Daily/yr	9
Culcairn Bowling Club	074188	1912-1972	Daily/yr	10
Henty P.O.	074053	1907-1972	Monthly/yr	11
Hume Reservoir	072023	1922-1975	Monthly/yr	12
Bethanga	082005	1908-1970	Monthly/yr	13
Bowna (Toonalook)		1927-1972	Daily/yr	14
Wymah	072050	1902-1972	Monthly/yr	15
Woomargama	072049	1881-1972	Monthly/yr	16
Holbrook P.O.	072022	1885-1972	Monthly/yr	17
Holbrook “Kinross”		1905-1971	Daily/yr	18
Holbrook “Stonehaven’		1938-1971	Daily/yr	19
Glenfallock	072019	1909-1972	Monthly/yr	20
Fordell	072076	1931-1972	Annual median **	21
Talmalmo	072096	1887-1917	Annual median **	22
Walwa	082052	1884-1973	Monthly/yr	23
Jingellic	072065	1886-1939	Monthly/yr	24
Lankeys Creek	072030	1898-1968	Monthly/yr	25
Tumbarumba “Rippling Waters”			Daily/yr	26
Carabost S.F.	072013	1938-1972	Annual median **	27
Carabost	072012	1886-1950	Annual median **	28
Wolseley Park	072053	1937-1972	Annual median **	29
Ournie	072030	1951-1972	Daily/yr	30

Table 4.2.1 (Cont'd)

Station Name	CBM No.	Period of Record	Type of Data	Location No *
Tintaldra	082062	1953-1972	Annual median **	31
Tooma			Annual median **	32
Maragle	072033	1885-1963	Monthly/yr	33
Burra Creek	072010	1900-1960	Daily/yr	34
Tumbarumba P.O.	072043	1885-1972	Monthly/yr	35
Laurel Hill	072031	1887-1967	Monthly/yr	36
Green Hills SF	072020	1924-1972	Monthly/yr	37
Batlow	072004	1886-1972	Monthly/yr	38
Yellowin	072051	1885-1967	Monthly/yr	39
Humula	072024	1896-1972	Monthly/yr	40
Murraguldrie SF	072035	1938-1972	Annual median **	41

* Location as per isohyet map, (fig. 4.1)

** Long term annual median rainfall only

As a measure of variability, the percentage median deviations from the median have been calculated. For Albury, the March median is 38 mm and the percentage deviation from this is 66 percent. That is, in half of the years the departure from the median is 66 percent of the median or less.

Rainfall data was analysed over all available years, regardless of the particular period. Years of record for all stations are also shown in Table 4.2.1.

Table 4.2.2 lists annual rainfall means, medians, quartiles and percentage deviations from the median for all stations analysed.

4.2.2 Annual Median Rainfall

Isohyets of annual median rainfall for the Albury district are shown on the accompanying map. Rainfall decreases from total falls in excess of 1200 mm in the east and north—east to less than 500 mm in the west.

The large change in annual median rainfall is mainly due to topography and altitude and in particular the proximity of the Great Dividing Range. Rainfall generally increases towards the east, with the exception of two small rain shadow areas near Jingellic and Tooma, which are relatively sheltered from the south.

A range of hills between Howlong and Albury appears to induce a higher rainfall and there is a. corresponding decrease in rainfall east of Albury.

Table 4.2.2
Annual Rainfall Statistics – Albury District (mm)

Station	Location No.	Annual mean Rainfall	Annual Median Rainfall	Lower quartile	Upper Quartile	Percentage deviation from the median
Corowa	1	532	518	430	623	18
Balldale	2	496	483	393	565	29
Rand (Claverton)	3	524	520	419	617	26
Howlong P.O	4	581	553	472	664	15
Henty (Munyabla Pk.)	5	535	525	450	619	26
Burrumbuttock	6	595	574	492	698	27
Bungowannah	7	-	551	-	-	
Albury	8	694	695	574	769	23
Gerogery East Past. Co	9	597	603	505	677	26
Culcairn Bowling Club	10	585	594	482	666	25
Henty	11	588	580	487	664	25
Hume Reservoir	12	700	678	583	803	29
Bethanga	13	756	740	645	866	24
Bowna "Toonalook"	14	662	664	562	796	29
Wymah	15	744	761	616	874	25
Woomargama	16	722	708	615	831	24
Holbrook P.O.	17	693	675	594	796	23

Table 4.2.2 (Cont'd)

Station	Location No.	Annual mean Rainfall	Annual Median Rainfall	Lower quartile	Upper Quartile	Percentage deviation from the median
Holbrook "Kinross"	18	630	630	544	722	23
Holbrook "Stonehaven"	19	588	599	485	706	28
Glenfallock	20	675	673	565	763	24
Fordell	21	-	776	-	-	-
Talmalmo	22	-	844	-	-	-
Walwa	23	802	806	663	964	22
Jingellic	24	735	742	615	900	29
Lankeys Creek	25	948	895	795	1114	25
Tumbarumba "Rippling Water"	26	911	853	737	1067	29
Carabost S.F.	27	-	918	-	-	-
Carabost	28	-	745	-	-	-
Wolseley Park	29	-	912	-	-	-
Ournie	30	766	739	640	878	28
Tintaldra	31	-	799	-	-	-
Tooma	32	-	737	-	-	-
Maragle	33	765	733	640	885	22
Burra Creek	34	945	949	808	1100	24

Table 4.2.2 (Cont'd)

Station	Location No.	Annual mean Rainfall	Annual Median Rainfall	Lower quartile	Upper Quartile	Percentage deviation from the median
Tumbarumba P.O.	35	972	937	825	1110	24
Laurel Hill	36	1323	1219	1071	1580	27
Green Hills S.F.	37	1275	1300	1030	1475	24
Batlow	38	1310	1260	1078	1528	24
Yellowin	39	1020	989	818	1169	23
Humula	40	703	686	563	851	27
Murraguldri S.F.	41	-	879	-	-	-

4.2.3 Monthly Rainfall Distribution

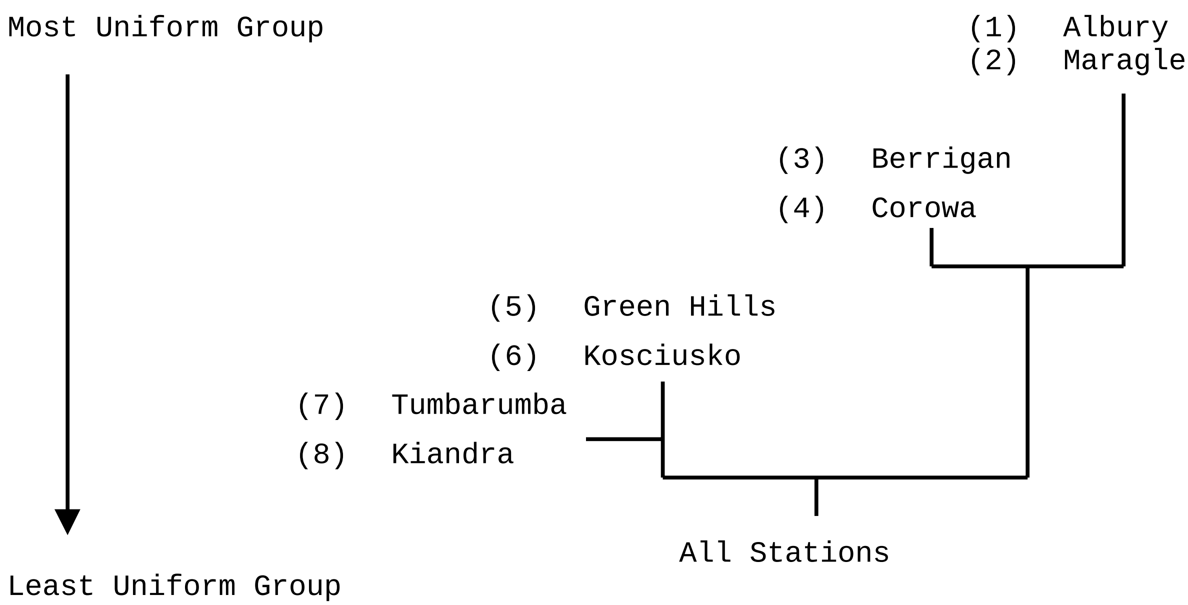
Table 4.2.3 lists monthly quartiles and median rainfalls for thirteen selected stations in the Albury district.

To help interpretation, an analysis of monthly median rainfalls of selected stations from Table 4.2.1 was undertaken to determine their similarity. The stations were then grouped into eight zones and the mean and standard deviations of the medians for stations in each zone calculated. These are given in Table 4.2.4 and diagramatically in Figure 4.2.2.

This technique of grouping stations is similar to that used by Edwards and Johnston (1975) for the Upper Murrumbidgee Valley.

Generally June and October are the months of highest rainfall expedtancy with February having the lowest.

Grouping sequence is as follows:—



4.2.4 Seasonal Rainfall Distribution

Seasonal distribution of rainfall, showing upper and lower quartiles, median and percentage deviation from the median is given for selected stations in Table 4.2.5.

Throughout the district, rainfall expectancy is highest during winter and spring and lowest during summer.

4.3 Temperature

4.3.1 Monthly Averages

Table 4.3.1 details the mean monthly maximum, minimum and mean temperatures for recording stations in and adjacent to the Albury district (Bur. Met. 1969). Relative humidity data is shown where available.

A regression analysis was undertaken of mean monthly temperatures and altitude using data from twenty stations in and adjacent to the district.

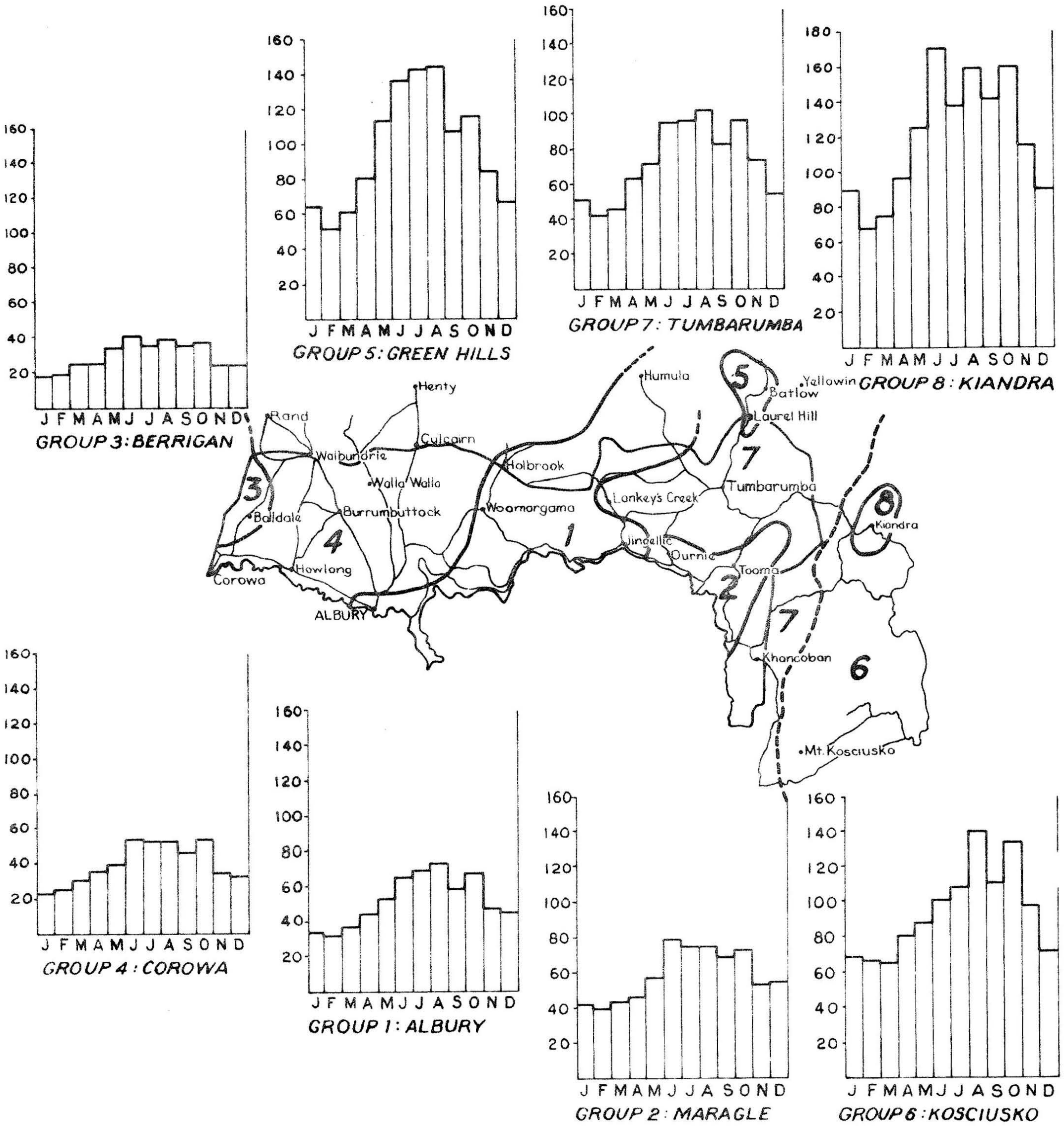


Figure 4.2.2. MEDIAN RAINFALL ZONES – ALBURY DISTRICT

S.C.S. 12432/12

Table 4.2.3

Monthly Rainfall Statistics for Selected Stations in the Albury District

		Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1)	Corowa Bowling Club - 1890-1972												
	1st Quartile	7	8	9	11	21	34	30	35	27	28	13	14
	Median	25	22	31	33	37	59	48	52	44	47	29	27
	3rd Quartile	42	52	58	61	66	77	69	70	60	72	54	53
	Percentage Deviation	72	82	74	70	51	37	42	33	36	43	69	67
	% Chance of Zero Rain	12	9	5	4	2	0	0	0	0	1	2	2
2)	Balldale - 1909-1972												
	1st Quartile	6	6	10	11	17	26	25	27	23	25	9	10
	Median	21	24	26	31	34	44	41	45	42	40	26	27
	3rd Quartile	54	59	50	49	60	71	64	63	56	67	49	53
	Percentage Deviation	76	79	81	61	59	48	49	40	43	45	81	70
	% Chance of Zero Rain	8	113	10	5	3	0	0	0	2	2	8	8
3	Rand (Claverton) - 1931-1971												
	1st Quartile	6	10	10	15	14	26	29	32	24	28	19	15
	Median	17	23	30	34	31	43	51	45	36	53	36	32
	3rd Quartile	56	51	62	58	66	67	66	68	63	69	54	53
	Percentage Deviation	88	65	73	59	61	49	35	44	58	40	47	53
	% Chance of Zero Rain	7	10	10	0	2	0	0	0	0	2	2	5
6	Burrumbuttock - 1889-1972												
	1st Quartile	9	6	10	18	22	43	35	38	28	33	15	12
	Median	25	24	30	36	43	64	56	57	48	52	34	31
	3rd Quartile	61	49	63	64	67	100	86	80	63	77	63	56
	Percentage Deviation	84	83	77	64	49	42	45	39	40	42	59	71
	% Chance of Zero Rain	10	11	6	3	3	0	0	0	1	1	3	4

Table 4.2.3 (Cont'd)

		Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
8	Albury - 1862-1969												
	1st Quartile	10	6	12	21	32	47	42	50	37	36	19	17
	Median	28	29	38	42	58	75	69	70	60	66	40	43
	3rd Quartile	61	63	62	71	85	102	98	96	85	100	68	59
	Percentage Deviation	75	86	66	57	45	36	39	31	38	45	60	58
	% Chance of Zero Rain	2	5	3	3	2	0	0	0	0	0	3	1
10	Culcairn Bowling Club - 1912-1972												
	1st Quartile	9	6	9	19	20	31	34	42	24	31	14	19
	Median	20	29	28	38	41	52	52	58	50	55	35	39
	3rd Quartile	55	57	68	51	67	87	76	78	70	89	66	67
	Percentage Deviation	80	86	75	42	56	48	44	33	46	47	69	56
	% Chance of Zero Rain	8	12	5	0	2	0	0	0	0	2	2	3
16	Woomargama - 1881-1972												
	1st Quartile	11	9	11	21	31	47	49	50	35	39	22	12
	Median	36	32	31	49	52	75	75	76	57	69	49	35
	3rd Quartile	58	57	64	80	94	115	91	96	83	104	84	66
	Percentage Deviation	67	75	77	61	56	40	33	29	42	46	59	71
	% Chance of Zero Rain	8	10	4	8	3	0	0	0	0	3	5	7
17	Holbrook PO - 1885-1972												
	1st Quartile	15	11	12	25	24	44	43	41	37	31	21	20
	Median	32	31	39	43	46	70	62	66	56	63	50	51
	3rd Quartile	61	69	72	77	87	116	87	93	72	90	76	81
	Percentage Deviation	66	77	72	56	54	41	35	39	32	46	54	59
	% Chance of Zero Rain	2	5	6	1	1	0	0	0	0	1	4	2

Table 4.2.3 (Cont'd)

		Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
20	Glenfalloch - 1909-1972												
	1st Quartile	11	15	17	23	28	42	40	45	38	35	27	23
	Median	33	32	39	39	53	57	67	67	58	57	50	46
	3rd Quartile	55	58	73	65	74	88	92	91	81	87	79	69
	Percentage Deviation	67	63	62	51	40	37	39	34	34	42	48	50
	% Chance of Zero Rain	5	8	7	0	2	0	0	0	0	0	3	0
24	Jingellic - 1886-1936												
	1st Quartile	14	13	12	24	19	39	44	53	38	47	32	17
	Median	33	30	38	47	52	62	70	69	56	76	57	54
	3rd Quartile	69	70	75	72	77	101	99	96	85	111	82	88
	Percentage Deviation	85	80	74	51	62	42	39	26	38	39	42	65
	% Chance of Zero Rain	5	3	8	3	3	0	0	0	0	0	0	0
25	Lankeys Creek - 1898-1968												
	1st Quartile	13	15	18	29	42	72	69	70	53	50	28	24
	Median	40	39	43	63	75	112	104	98	76	88	61	44
	3rd Quartile	67	64	83	84	109	158	154	137	106	125	99	86
	Percentage Deviation	68	62	60	44	45	38	35	33	32	43	57	66
	% Chance of Zero Rain	6	9	6	2	3	0	0	0	0	3	5	5
33	Maragle 1885 –1963												
	1st Quartile	17	14	19	23	33	46	42	49	41	41	27	20
	Median	45	43	43	46	52	72	73	70	68	77	52	50
	3rd Quartile	67	69	84	69	74	109	103	96	93	103	86	85
	Percentage Deviation	60	63	65	50	40	38	41	33	37	44	58	64
	% Chance of Zero Rain	6	6	4	3	3	0	1	1	0	1	0	4

Table 4.2.3 (Cont'd)

	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Tumbarumba P.O. - 1885-1972												
1st Quartile	33	16	26	29	48	68	58	74	54	62	31	28
Median	57	44	49	56	72	92	89	99	82	94	66	62
3rd Quartile	81	79	86	88	108	140	136	135	116	129	101	99
Percentage Deviation	42	70	63	49	42	41	40	30	37	35	53	56
% Chance of Zero Rain	2	4	2	1	0	0	0	0	0	0	2	1

Table 4.2.4

Means of Medians and Standard Deviations of selected Rainfall Stations within Defined Median Rainfall Zones

Zone and Number of Stations **			Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Albury	Mean	33	32	37	45	53	66	69	73	58	67	47	45
	(9)*	SD	5	2	3	4	5	6	5	6	4	6	5	6
2.	Maragle	Mean	42	39	43	47	57	79	75	75	69	73	53	54
	(4)	SD	3	4	1	1	4	8	2	7	4	3	3	6
3.	Berrigan	Mean	13	19	25	25	34	41	35	39	35	37	24	24
	(6)	SD	3	4	5	4	3	4	4	6	4	2	2	2
4.	Corowa	Mean	23	25	31	36	40	54	53	53	46	53	35	33
	(7)	SD	4	4	3	3	6	8	4	6	5	4	5	4
5.	Green Hills SF	Mean	64	51	61	81	114	137	144	145	108	117	85	67
	(3)	SD	6	4	6	6	6	17	8	4	7	9	2	4
6.	Kosciusko	Mean	69	67	66	81	88	102	109	142	112	136	99	73
		SD	4	9	5	7	9	4	21	9	3	1	9	4
7.	Tumbarumba	Mean	52	42	46	63	72	96	97	103	83	97	67	55
	(4)	SD	9	5	3	3	7	20	9	4	5	11	11	9
8.	Kiandra	Mean	90	68	75	97	126	172	139	160	143	161	116	91
	(1)	SD	Only one member											

* Number of stations in zone

** Zone number indicates order of grouping or similarity between groups

Table 4.2.5

Seasonal Rainfall Statistics —

Selected Stations, Albury District

		Sum	Aut	Win	Spr
(1)	Corowa Bowling Club - 1890-1972				
	1st Quartile	42	73	128	88
	Median	62	118	164	128
	3rd Quartile	109	163	198	173
	Percentage Deviation	42	38	21	31
(2)	Balldale - 1909-1972				
	1st Quartile	46	72	86	77
	Median	65	99	142	123
	3rd Quartile	116	154	183	168
	Percentage Deviation	49	31	30	37
(3)	Rand (Claverton) - 1931-1971				
	1st Quartile	42	71	118	97
	Median	66	112	152	146
	3rd Quartile	110	153	176	178
	Percentage Deviation	47	37	20	30
(6)	Burrumbuttock - 1889 1972				
	1st Quartile	43	87	113	105
	Median	74	124	188	155
	3rd Quartile	117	168	235	195
	Percentage Deviation	47	31	26	30
(8)	Albury - 1862-1969				
	1st Quartile	49	99	160	126
	Median	80	145	223	174
	3rd Quartile	127	203	274	223
	Percentage Deviation	43	37	25	28
(10)	Culcairn Bowling Club - 1912-1972				
	1st Quartile	43	76	133	107
	Median	72	129	180	160
	3rd Quartile	117	170	212	196
	Percentage Deviation	42	40	21	28
(16)	Woomargama - 1881-1972				
	1st Quartile	46	97	181	130
	Median	83	160	244	187
	3rd Quartile	134	215	291	243
	Percentage Deviation	51	38	23	30

	Sum	Aut	Win	Spr
(17) Holbrook P.O - 1885-1972				
1st Quartile	53	92	161	119
Median	89	153	219	176
3rd Quartile	142	193	272	223
Percentage Deviation	46	39	25	27
(20) Glenfallock - 1909-1972				
1st Quartile	50	93	158	128
Median	87	144	202	170
3rd Quartile	133	190	254	238
Percentage Deviation	46	35	23	31
(24) Jingellic - 1886-1939				
1st Quartile	73	90	155	138
Median	94	151	229	217
3rd Quartile	130	213	286	261
Percentage Deviation	23	40	27	26
(25) Lankey’s Creek - 1898-1968				
1st Quartile	61	123	251	171
Median	96	189	324	223
3rd Quartile	154	270	430	300
Percentage Deviation	40	35	27	28
(33) Maragle - 1885-1963				
1st Quartile	93	107	180	143
Median	150	169	225	206
3rd Quartile	213	208	298	259
Percentage Deviation	41	31	24	29
(35) Tumbarumba P. O.- 1885-1972				
1st Quartile	79	135	233	170
Median	115	199	310	260
3rd Quartile	176	271	389	314
Percentage Deviation	41	33	25	29

The relationships between altitude and temperature for December and June respectively are given by :-

$$Y = 22.9 - 0.008X \quad (r^2 = 0.953)$$

$$Y = 9.6 - 0.006X \quad (r^2 = 0.927)$$

where Y is the temperature in ^{o}C and X is the altitude in metres.

It is noteworthy that the lapse rate of $8C^{O}$ per 100 metres change in altitude determined for December differs from that of 6 C^{O} which is the generally accepted figure and corresponds to that found for June.

Table 4.3.1

Temperature Statistics — Mean monthly Maxima and Minima and Means — Albury District (Bur. Met. 1969)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Albury													
Max.	32.2	32.4	29.1	23.1	18.3	14.1	13.6	15.8	19.6	23.2	27.4	30.8	23.3
Min.	15.4	15.7	12.9	8.8	5.7	4.1	3.4	4.4	6.2	8.7	11.6	14.2	9.3
Mean	23.8	24.1	21.0	15.9	12.0	9.1	8.5	10.1	12.9	16.0	19.5	22.5	16.3
Index R.H.	47.0	48.0	54.0	61.0	68.0	74.0	74.0	71.0	67.0	61.0	53.0	48.0	58.0
Brookfield (Tumbarumba)													
Max.	28.8	27.6	24.3	18.8	14.5	10.6	9.8	11.9	15.4	18.4	22.1	26.2	19.1
Mm.	10.4	9.8	7.0	3.6	1.2	0.2	-0.6	-0.2	1.3	3.1	6.2	7.9	4.2
Mean	19.6	18.7	15.7	11.2	7.8	5.4	4.6	5.8	8.4	10.7	14.2	17.1	11.6

Table 4.3.1 (Cont’d)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Corowa													
Max.	31.4	31.3	28.3	22.6	17.9	13.7	13.1	15.5	19.1	22.9	27.4	30.5	22.8
Min	15.2	15.1	12.7	8.3	5.2	3.2	2.8	3.7	5.5	8.3	11.4	13.9	8.8
Mean	23.3	23.2	20.5	15.5	11.6	8.4	7.9	9.6	12.3	15.6	19.4	22.2	15.8
Green Hills (State Forest)													
Max.	26.4	25.2	22.3	16.9	12.9	9.2	8.2	9.7	13.3	16.3	19.7	24.3	17.1
Mm.	11.9	11.8	9.6	5.6	3.1	1.1	0.1	0.4	2.1	4.6	7.9	11.2	5.8
Mean	19.2	18.5	15.9	11.2	8.0	5.2	4.1	5.1	7.7	10.4	13.8	17.7	11.4

4.3.2 Diurnal Temperature Range

Daily temperature data is not available. However, Table 4.3.1 shows that the range decreases over the winter months.

Extreme temperatures for several stations are given in Table 4.3.2 (Bur. Met. 1969).

Table 4.3.2
Extreme Temperatures Recorded at Selected Stations within and around the Albury district (^{o}C) – (Bur.Met. 1969).

Station	No. Years of Record	Max.	Min.
Albury	30.0	46.0	-6.6
Brookfield (Tumbarumba)	11.0	43.8	-7.7
Corowa	26.0	47.5	-6.1
Green Hills S.F.	12.0	40.5	-6.6

4.3.3 Frost Incidence

Table 4.3.3 summarises the frost data for the area as given by Foley (1945). A frost was assumed to have occurred when screen trmperature fell below 2.2^{o}C. No distinction is made between heavy and light frosts.

Table 4.3.3
Frost Incidence in the Albury Area
(Foley, 1945)

Screen Temperatures: First 2.2^{o}C			Last 2.2^{o}C%		Average Frost Free Period (Days)
Station	Mean date of occurrence	SD	Mean date of occurrence	SD	
Albury	May 17th	11	Sept 9th	14	249
Berrigan	May 8th	7	Oct 5th	8	214
Corowa	May 9th	6	Sept 23rd	10	227
Hume Reservoir	May 13th	15	Sept 13th	12	241
Pilot Hill (Laurel Hill)	Feb 12th	23	Dec 15th	12	58
Walwa	March 31st	12	Nov 9th	15	141

The average frost free period is 214 days. However, local topographic effects which produce cold air drainage will exert a major influence on frost incidence at specific localities. Over most of the district, frosts may be expected from April until October. Heavy frosts are likely to occur from late May until early September.

4.4 Evaporation

Estimates of mean monthly evaporation from an Australian Standard tank are shown in Table 4.4.1. The estimates are based on radiation, air temperature and relative humidity data (Anon, 1975).

Table 4.4.1
Evaporation Statistics (estimated)
Albury district (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Headwaters*												
147	97	97	86	61	23	23	36	43	71	97	122	903
Holbrook												
201	147	125	76	51	28	25	38	56	97	127	190	1161
Albury												
253	210	179	105	51	31	31	51	74	140	179	253	1557

* headwaters of the Murray River

Evaporation is least during winter and greatest in summer

4.5 Climate and Plant Growth

4.5.1 Introduction

The need to classify climatic regimes has long been recognised by agriculturalists and geographers throughout the world. Most classification systems have been based on a moisture index or indices of humidity and aridity.

Several problems result from the classification of climate using indices or factors. To appreciate the full meaning of a particular system, it is necessary to study the basic concepts of the system and understand the meaning of the various symbols and terms. Also, most systems are too insensitive for use over small areas.

Slatyer (1958) attempted to overcome the difficulties of climate assessment by applying a simple water balance model based on time intervals of seven days. This was later modified to monthly intervals by Fleck, (1971) The assumption is made that actual evapo-transpiration (ET) is related to evaporation (E) from a standard Australian sunken tank evaporimeter by the relationships: -

(i) ET = 0.8 E for months with residual soil moisture storage plus rainfall equal to or exceeding 50 mm.

(ii) ET = 0.4 E for months with residual soil moisture less than 50 mm.

Soil moisture storage capacity is assumed to be 100 mm. Runoff is assumed to have occurred when rainfall in excess of this capacity is received.

Three classes of soil moisture availability are defined. (Fleck, loc. cit.):-

Class 1 Total storage at the beginning of any month is greater than 50 mm and the residual storage carry–over, after allowing for evaporation losses, is available at the commencement of the subsequent month.

Soil moisture is considered adequate for plant growth .

Class 2 Total storage greater than 50 mm with no residual carry–over storage occurring, or total storage less than 50 mm with a residual carry–over storage available. Moisture conditions are considered to be sub-optimal for plant growth.

Class 3 Total storage less than 50 mm and no residual storage accrues.

Moisture conditions are considered inadequate for plant growth.

It must be stressed that the model is a very general one. Differences in moisture regimes due to factors such as topography, soil type and water table influences have not been considered.

In applying the moisture balance models to the Albury district, the evaporation values from Table 4.4.1 were used together with monthly rainfalls from Table 4.2.3.

Evaporation values for the headwaters of the Murray River were applied to stations with altitudes ranging from 500 to in excess of 1000 metres. The data for Holbrook was used for stations in the range 300 to 500 metres and the data for Albury for stations with altitudes less than 300 metres.

The percentage frequency of class 1, 2 and 3 months for selected stations in the Albury district is shown in Table 4.5.1.

Spatial comparison of the data in Table 4.5.1 was improved by grouping stations with similar probability of class 3 or drought months. The zones so determined are shown in Figure 4.3.1 and the means and standard deviations for each zone are shown in Table 4.5.2. The percentage probability of months in which plant growth occurs is given by (100-D) where D is the percentage probability of a class 3 month.

4.5.2 Drought

The probability of an up to six months duration drought is shown in Table 4.5.3 for selected stations. These probabilities are based on the occurrence of class three months.

For Albury the probability that January will be a drought month is 0.95 or 95 percent.

Table 4.5.1

Frequency of Class 1, 2 and 3 Moisture Classes
(%) selected Stations, Albury district

		J	F	M	A	M	J	J	A	S	O	N	D
(1)Corowa													
Class	1	0	2	5	11	41	74	93	95	90	51	7	0
Class	2	6	9	13	29	40	26	7	5	10	38	26	9
Class	3	94	89	82	60	18	0	0	0	0	11	67	91
(2)Balldale													
Class	1	1	0	3	13	38	60	85	88	83	30	7	0
Class	2	7	15	10	25	40	40	15	12	13	47	25	7
Class	3	92	85	87	62	22	0	0	0	3	23	68	93
(3)Rand													
Class	1	0	0	2	20	37	61	88	90	90	49	2	0
Class	2	7	10	10	22	39	37	12	10	5	32	41	0
Class	3	93	90	88	59	24	2	0	0	5	20	56	100
(6) Burrumbuttock													
Class	1	0	1	3	15	48	77	92	95	96	63	10	0
Class	2	5	10	20	27	33	23	8	5	3	25	38	13
Class	3	95	89	77	58	19	0	0	0	1	11	52	87
(8) Albury													
Class	1	0	2	5	22	64	91	99	99	98	78	21	2
Class	2	5	10	14	30	25	9	1	1	0	19	42	12
Class	3	95	88	80	48	11	0	0	0	2	3	37	86
(10) Culcairn													
Class	1	0	0	7	17	43	63	85	88	75	47	5	0
Class	2	2	13	21	20	30	37	15	10	20	35	35	12
Class	3	98	87	72	63	27	0	0	2	5	18	60	88

Table 4.5.1

(16) Woomargama													
Class	1	0	0	7	23	59	89	99	99	96	79	25	1
Class	2	13	16	15	31	27	11	1	1	3	19	36	17
Class	3	87	84	97	47	15	0	0	0	1	3	39	81
(17) Holbrook													
Class	1	1	5	18	34	60	92	99	98	99	95	72	11
Class	2	19	25	22	35	32	8	1	2	1	2	16	44
Class	3	80	71	60	31	8	0	0	0	0	2	12	46
(20) Glenfalloch													
Class	1	2	5	16	31	69	90	100	98	97	97	67	13
Class	2	11	18	21	34	25	10	0	2	3	2	23	34
Class	3	87	77	62	34	7	0	0	0	0	2	10	52
(24) Jingellic													
Class	1	3	3	18	39	68	87	100	97	97	97	76	16
Class	2	24	29	21	26	21	13	0	3	3	8	13	45
Class	3	74	68	61	34	11	0	0	0	0	0	11	39
(25) Lankeys Creek													
Class	1	27	29	35	53	77	100	100	100	100	100	97	68
Class	2	29	30	27	27	15	0	0	0	0	0	2	26
Class	3	44	41	38	20	8	0	0	0	0	0	2	6
(33) Maragle													
Class	1	1	1	4	20	37	66	96	99	99	99	79	19
Class	2	26	30	24	30	27	4	1	1	1	1	14	41
Class	3	73	66	56	33	7	0	0	0	0	0	7	40
(35) Tumbarumba													
Class	1	41	40	44	60	84	98	100	100	100	100	100	79
Class	2	27	30	27	21	13	2	0	0	0	0	0	17
Class	3	33	30	29	19	3	0	0	0	0	0	0	3

There is an 82 percent chance that both January and February will be drought months and a 70 percent chance that a three-month drought, starting in January, will occur.

4.5.3 Length of the Growing Season

The length of the growing season, either from the onset of opening rain or from sowing, can be calculated using the data in Table 4.5.1.

For example; for Albury, the chance of receiving adequate rain in any month is given by:—

$$\frac{\text{(probability of class three month)}}{100}$$

The chance of receiving adequate rain in consecutive months is the product of the separate probabilities.

e.g. for each month at Albury, the chance of receiving adequate rain in a month is

J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**0**	**N**	**D**
0.05	0.22	0.20	0.52	0.89	1.00	1.00	1.00	0.98	0.97	0.63	0.14

and the chance of receiving adequate rain for five consecutive months commencing in any month is:

J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**0**	**N**	**D**
0.050	0.011	0.002	0.001	0.001							
	0.200	0.044	0.023	0.020	0.020						
		0.200	0.104	0.093	0.093	0.093					
			0.520	0.463	0.463	0.463	0.463				
				0.890	0.890	0.890	0.890	0.872			
					1.000	1.000	1.000	0.980	0.950		
						1.000	1.000	0.980	0.951	0.599	
							1.000	0.980	0.951	0.599	0.084
0.004								0.980	0.951	0.599	0.084
0.004	0.000								0.970	0.611	0.086
0.004	0.000	0.000								0.630	0.098

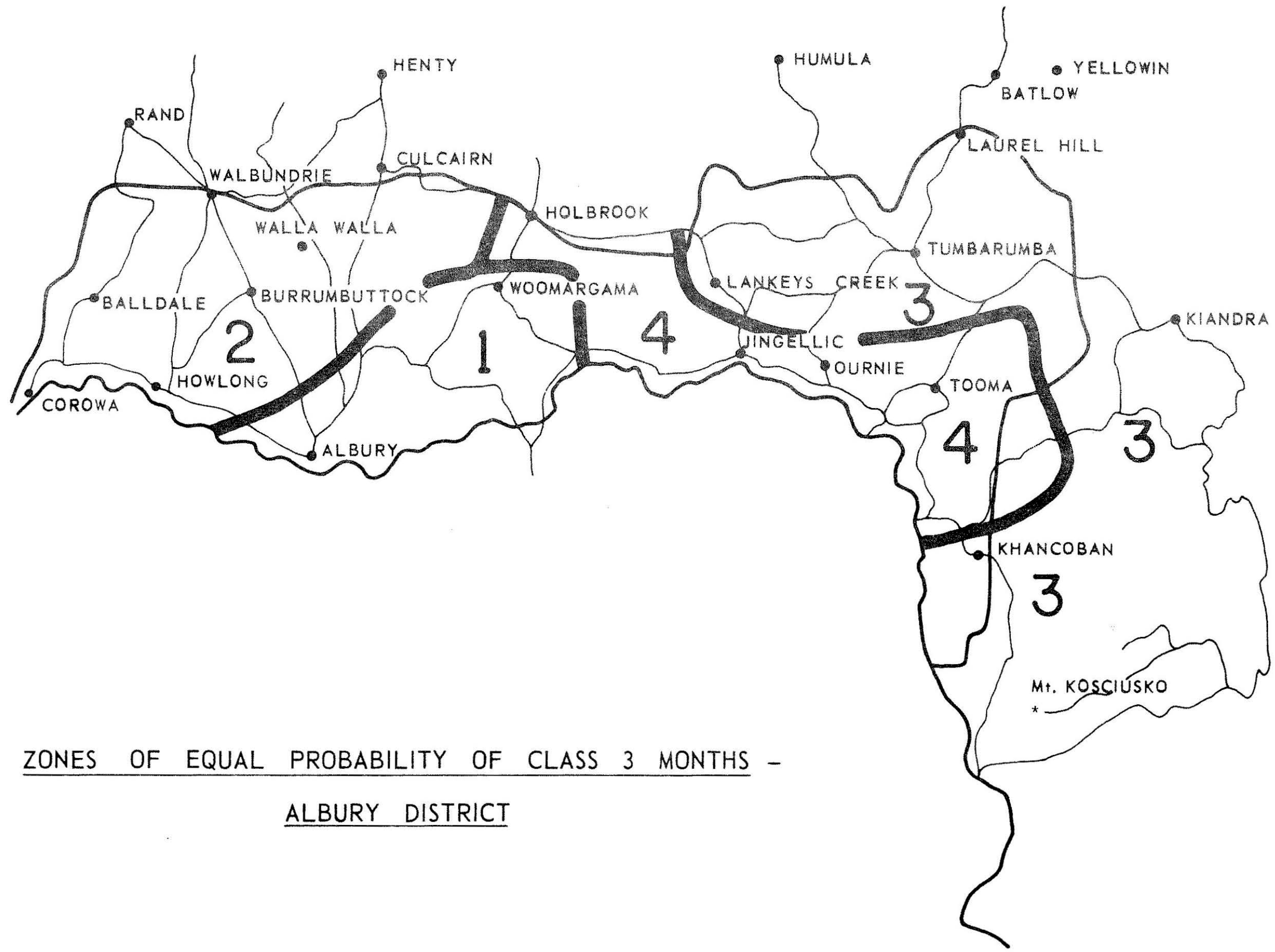


Figure 4.3.1 ZONES OF EQUAL PROBABILITY OF CLASS 3 MONTHS – ALBURY DISTRICT

S.C.S. 12432/10

Table 4.5.2

Means and Standard Deviations _Probability of class 3 months

Defined zones - Albury district

Zone and No.of Stations**		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
l.Albury	Mean	89	86	75	44	13	0	0	0	1	4	33	78
	Std.Dev	3	2	5	3	5	0	0	0	1	3	6	6
2.Corowa	Mean	94	88	92	60	21	0	0	0	3	16	60	91
	Std.Dev	3	2	6	2	4	1	0	1	2	5	6	5
3.Green Hills	Mean	33	31	26	14	3	0	0	0	0	0	0	4
S.F.	Std.Dev	13	11	9	7	3	0	0	0	0	0	1	2
4.Maragle	Mean	78	69	58	32	7	0	0	0	0	1	9	41
	Std.Dev	7	6	5	5	3	0	0	0	0	1	5	10

* Number of stations in zone

** Zone number indicates order of grouping or similarity between zones

Table 4.5.3

Drought Statistics, Selected Stations – Albury District

COROWA Location 1						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.94	0.89	0.82	0.60	0.18	0.00	0.00	0.00	0.00	0.11	0.67	0.91
2	0.84	0.74	0.49	0.12	0.00	0.00	0.00	0.00	0.00	0.09	0.62	0.86
3	0.70	0.45	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.62	0.79
4	0.43	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.56	0.65
5	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.48	0.41
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.31	0.09
BALLDALE Location 2						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.92	0.85	0.87	0.62	0.22	0.00	0.00	0.00	0.03	0.23	0.68	0.93
2	0.80	0.78	0.55	0.15	0.00	0.00	0.00	0.00	0.03	0.20	0.62	0.84
3	0.73	0.50	0.15	0.00	0.00	0.00	0.00	0.00	0.03	0.18	0.59	0.72
4	0.45	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.17	0.48	0.67
5	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.14	0.47	0.41
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.14	0.31	0.10

Table 4.5.3 (Cont'd)

RAND Location 3						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.93	0.90	0.88	0.59	0.24	0.02	0.00	0.00	0.05	0.20	0.56	1.00
2	0.85	0.83	0.54	0.15	0.00	0.00	0.00	0.00	0.05	0.12	0.56	0.90
3	0.8	0.54	0.15	0	0.00	0.00	0.00	0.00	0.05	0.12	0.57	0.82
4	0.54	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.13	0.55	0.80
5	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.13	0.52	0.55
6	0	0	0	0	0	0	0	0	0.05	0.13	0.38	0.15

BURRUMBUTTOCK Location 6						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.95	0.89	0.77	0.58	0.19	0.00	0.00	0.00	0.01	0.11	0.52	0.87
2	0.84	0.71	0.48	0.13	0.00	0.00	0.00	0.00	0.00	0.09	0.46	0.83
3	0.66	0.44	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.45	0.73
4	0.42	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.40	0.61
5	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.35	0.39
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.28	0.08

Table 4.5.3 (Cont'd)

ALBURY Location 8					STARTING IN							
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.95	0.88	0.80	0.48	0.11	0.00	0.00	0.00	0.02	0.03	0.37	0.86
2	0.82	0.75	0.43	0.05	0.00	0.00	0.00	0.00	0.01	0.03	0.33	0.81
3	0.70	0.40	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.31	0.72
4	0.37	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.25	0.60
5	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.23	0.34
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.14	0.05

CULCAIRN Location 10					STARTING IN							
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.98	0.87	0.72	0.63	0.27	0.00	0.00	0.02	0.05	0.18	0.60	0.89
2	0.85	0.68	0.48	0.17	0.00	0.00	0.00	0.02	0.03	0.15	0.53	0.85
3	0.67	0.47	0.13	0.00	0.00	0.00	0.00	0.00	0.03	0.13	0.53	0.73
4	0.45	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.44	0.58
5	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.39	0.37
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.27	0.08

Table 4.5.3 (Cont'd)

WOOMARGAMA Location 16.						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.87	0.84	0.79	0.47	0.15	0.00	0.00	0.00	0.01	0.03	0.39	0.81
2	0.73	0.69	0.37	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.36	0.71
3	0.60	0.31	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.33	0.61
4	0.25	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.28	0.49
5	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	0.21
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.11	0.04

HOLBROOK Location 17						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.80	0.71	0.60	0.31	0.08	0.00	0.00	0.00	0.00	0.02	0.12	0.46
2	0.56	0.45	0.21	0.07	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.40
3	0.38	0.18	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.31
4	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.20
5	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01

Table 4.5.3 (Cont'd)

GLENFALLOCK Location 20						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.87	0.77	0.62	0.34	0.07	0.00	0.00	0.00	0.00	0.02	0.10	0.52
2	0.67	0.49	0.30	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.49
3	0.44	0.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.39
4	0.23	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.05	0.27
5	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02

JINGELLIC Location 24						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.74	0.68	0.61	0.34	0.11	0.00	0.00	0.00	0.00	0.00	0.11	0.39
2	0.53	0.47	0.24	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.34
3	0.37	0.21	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.17
4	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.14
5	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00

Table 4.5.3 (Cont'd)

LANKEYS CREEK Location 25						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.44	0.41	0.38	0.20	0.08	0.00	0.00	0.00	0.00	0.00	0.02	0.06
2	0.23	0.21	0.11	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
3	0.11	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
4	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MARAGLE location 33						STARTING IN						
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.73	0.66	0.56	0.33	0.07	0.00	0.00	0.00	0.00	0.00	0.07	0.40
2	0.49	0.39	0.27	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.38
3	0.24	0.20	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.27
4	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.13
5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

Table 4.5.3 (Cont'd)

TUMBARUMBA Location 35	STARTING IN											
No. of Consecutive Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.33	0.30	0.29	0.19	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03
2	0.16	0.15	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
3	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.5.4

Moisture and Plant Growth Statistics, Selected Stations - Albury District

COROWA Location 1	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	0.00	1.70	0.00	17.10	34.10	35.40	18.30	2.40	0.00	0.00	50.00
First Quartile	0.00	0.00	0.00	0.00	0.00	6.00	13.00	10.00	16.00	10.00	0.00	0.00	18.00
Median	0.00	0.00	0.00	0.00	0.00	18.00	23.00	18.00	19.00	30.00	0.00	0.00	45.00
Third Quartile	0.00	0.00	0.00	0.00	0.00	55.00	39.00	34.00	38.00	49.00	0.00	0.00	80.00
SMI+ First Quartile	0.00	0.00	0.00	0.00	0.20	0.50	0.70	1.00	1.00	0.60	0.00	0.00	0.40
Median	0.00	0.00	0.10	0.10	0.40	0.70	1.00	1.00	1.00	1.00	0.10	0.00	0.50
Third Quartile	0.10	0.20	0.20	0.50	0.70	1.00	1.00	1.00	1.00	1.00	0.60	0.20	0.60
Temp. Index+ Cool	0.76	0.77	0.95	0.85	0.43	0.09	0.05	0.22	0.51	0.86	0.89	0.88	0.61
Warm	0.49	0.49	0.39	0.20	0.06	0.00	0.00	0.00	0.09	0.21	0.35	0.45	0.23
GI* Cool													
First Quartile	0.00	0.00	0.00	0.00	0.20	0.10	0.00	0.20	0.50	0.60	0.00	0.00	0.20
Median	0.00	0.00	0.10	0.10	0.40	0.10	0.00	0.20	0.50	0.90	0.20	0.00	0.20
Third Quartile	0.10	0.20	0.20	0.50	0.40	0.10	0.00	0.20	0.50	0.90	0.60	0.20	0.30
GI* Warm													
First Quartile	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.10	0.20	0.00	0.00	0.10
Median	0.00	0.00	0.10	0.10	0.10	0.00	0.00	0.00	2.00	0.20	0.20	0.00	0.10
Third Quartile	0.10	0.20	0.20	0.20	0.10	0.00	0.00	0.00	0.10	0.20	0.30	0.20	0.10

Table 4.5.4 (Cont'd)

BALLDALE Location 2	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	0.00	1.70	0.00	11.70	28.30	26.70	13.30	3.30	0.00	0.00	38.30
First Quartile	0.00	0.00	0.00	4.00	0.00	19.00	12.00	7.00	5.00	1.00	0.00	0.00	23.00
Median	0.00	0.00	0.00	4.00	0.00	30.00	21.00	14.00	23.00	4.00	0.00	0.00	51.00
Third Quartile	0.00	0.00	0.00	4.00	0.00	53.00	34.00	28.00	46.00	7.00	0.00	0.00	77.00
SMI First Quartile	0.00	0.00	0.00	0.00	0.20	0.40	0.60	0.70	0.60	0.30	0.00	0.00	0.30
Median	0.00	0.00	0.00	0.10	0.30	0.60	0.90	1.00	1.00	0.70	0.10	0.00	0.40
Third Quartile	0.10	0.20	0.20	0.50	0.70	0.90	1.00	1.30	1.00	1.00	0.60	0.20	0.50
Temp. Index Cool	0.76	0.77	0.95	0.86	0.46	0.12	0.05	0.22	0.50	0.81	0.99	0.91	0.62
Warm	0.49	0.49	0.39	0.21	0.07	0.00	0.00	0.00	0.08	0.19	0.32	0.43	0.22
GI Cool													
First Quartile	0.00	0.00	0.00	0.00	0.20	0.10	0.10	0.20	0.50	0.30	0.00	0.00	0.20
Median	0.00	0.00	0.00	0.10	0.30	0.10	0.10	0.20	0.50	0.70	0.10	0.00	0.20
Third Quartile	0.10	0.20	0.20	0.50	0.50	0.10	0.10	0.20	0.50	0.80	0.60	0.20	0.30
GI Warm													
First Quartile	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.10	0.20	0.00	0.00	0.10
Median	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.10	0.20	0.00	0.00	0.10
Third Quartile	0.10	0.20	0.20	0.20	0.10	0.00	0.00	0.00	0.10	0.20	0.30	0.20	0.10

Table 4.5.4 (Cont'd)

RAND Location 3	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	0.00	0.00	2.40	14.60	31.70	26.80	14.60	7.30	0.00	0.00	43.90
First Quartile	0.00	0.00	0.00	0.00	59.00	15.00	6.00	4.00	5.00	9.00	0.00	0.00	30.00
Median	0.00	0.00	0.00	0.00	59.00	38.00	21.00	17.00	17.00	14.00	0.00	0.00	56.00
Third Quartile	0.00	0.00	0.00	0.00	59.00	70.00	41.00	46.00	43.00	39.00	0.00	0.00	95.00
SMI First Quartile	0.00	0.00	0.00	0.00	0.10	0.40	0.60	0.90	0.90	0.40	0.10	0.00	0.40
Median	0.00	0.00	0.10	0.10	0.40	0.60	0.90	1.00	1.00	0.90	0.20	0.10	0.50
Third Quartile	0.20	0.20	0.30	0.50	0.80	0.90	1.00	1.00	1.00	1.00	0.50	0.10	0.50
Temp. Index Cool	0.76	0.77	0.95	0.86	0.46	0.12	0.05	0.22	0.50	0.81	0.99	0.91	0.62
Warm	0.49	0.49	0.39	0.21	0.07	0.00	0.00	0.00	0.08	0.19	0.33	0.43	0.22
GI Cool													
First Quartile	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.20	0.50	0.40	0.10	0.00	0.20
Median	0.00	0.00	0.10	0.10	0.40	0.10	0.10	0.20	0.50	0.80	0.20	0.10	0.20
Third Quartile	0.20	0.20	0.30	0.50	0.50	0.10	0.10	0.20	0.50	0.80	0.50	0.10	0.30
GI Warm													
First Quartile	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.20	0.10	0.00	0.10
Median	0.00	0.00	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.20	0.20	0.10	0.10
Third Quartile	0.20	0.20	0.30	0.20	0.10	0.00	0.00	0.00	0.00	0.20	0.30	0.10	0.10

Table 4.5.4 (Cont'd)

BURRUMBUTTOCK Location 6	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	1.30	0.00	0.00	6.30	27.80	44.30	51.90	25.30	6.30	0.00	0.00	68.40
First Quartile	0.00	5.00	0.00	0.00	10.00	8.00	20.00	14.00	10.00	5.00	0.00	0.00	24.00
Median	0.00	5.00	0.00	0.00	34.00	36.00	34.00	25.00	21.00	25.00	0.00	0.00	73.00
Third Quartile	0.00	5.00	0.00	0.00	75.00	71.00	61.00	46.00	33.00	116.00	0.00	0.00	135.00
SMI First Quartile	0.00	0.00	0.00	0.10	0.30	0.50	0.90	1.00	1.00	0.70	0.10	0.00	0.40
Median	0.00	0.00	0.10	0.20	0.50	0.80	1.00	1.00	1.00	1.00	0.30	0.00	0.50
Third Quartile	0.20	0.10	0.30	0.50	0.80	1.00	1.00	1.00	1.00	1.00	0.70	0.20	0.60
Temp. Index Cool	0.82	0.82	0.96	0.81	0.43	0.09	0.04	0.18	0.45	0.77	0.98	0.93	0.61
Warm	0.47	0.47	0.37	0.19	0.06	0.00	0.00	0.00	0.07	0.18	0.13	0.41	0.21
GI Cool													
First Quartile	0.00	0.00	0.00	0.10	0.30	0.10	0.00	0.20	0.50	0.70	0.10	0.00	0.20
Median	0.00	0.00	0.10	0.20	0.40	0.10	0.00	0.20	0.50	0.80	0.30	0.00	0.20
Third Quartile	0.20	0.10	0.30	0.50	0.40	0.10	0.00	0.20	0.50	0.80	0.70	0.20	0.30
GI Warm													
First Quartile	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.10	0.20	0.10	0.00	0.10
Median	0.00	0.00	0.10	0.20	0.10	0.00	0.00	0.00	0.10	0.20	0.30	0.00	0.10
Third Quartile	0.20	0.10	0.30	0.20	0.10	0.00	0.00	0.00	0.10	0.20	0.30	0.20	0.10

Table 4.5.4 (Cont'd)

ALBURY Location 8	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	0.00	3.30	5.50	34.10	62.60	70.30	44.00	15.40	0.00	0.00	80.20
First Quartile	0.00	0.00	0.00	1.00	7.00	20.00	20.00	21.00	11.00	5.00	0.00	0.00	61.00
Median	0.00	0.00	0.00	35.00	20.00	48.00	45.00	41.00	26.00	20.00	0.00	0.00	98.00
Third Quartile	0.00	0.00	0.00	51.00	39.00	72.00	74.00	58.00	51.00	43.00	0.00	0.00	194.00
SMI First Quartile	0.00	0.00	0.00	0.10	0.40	0.70	1.00	1.00	1.00	1.00	0.10	0.00	0.50
Median	0.00	0.10	0.10	0.30	0.60	1.00	1.00	1.00	1.00	1.00	0.50	0.10	0.60
Third Quartile	0.20	0.20	0.30	0.70	1.00	1.00	1.00	1.00	1.00	1.00	0.70	0.30	0.60
Temp. Index Cool	0.71	0.68	0.89	0.89	0.48	0.17	0.10	0.27	0.37	0.90	0.98	0.85	0.62
Warm	0.51	0.52	0.45	0.22	0.07	0.00	0.00	0.00	0.11	0.22	0.35	0.46	0.24
GI Cool													
First Quartile	0.00	0.00	0.00	0.10	0.40	0.20	0.10	0.30	0.60	0.90	0.10	0.00	0.30
Median	0.00	0.10	0.10	0.30	0.50	0.20	0.10	0.30	0.60	0.90	0.50	0.10	0.30
Third Quartile	0.20	0.20	0.30	0.70	0.50	0.20	0.10	0.30	0.60	0.90	0.70	0.30	0.40
GI Warm													
First Quartile	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.10	0.20	0.10	0.00	0.10
Median	0.00	0.10	0.10	0.20	0.10	0.00	0.00	0.00	0.10	0.20	0.40	0.10	0.10
Third Quartile	0.20	0.20	0.30	0.20	0.10	0.00	0.00	0.00	0.10	0.20	0.40	0.30	0.10

Table 4.5.4 (Cont'd)

CULCAIRN Location 10	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	0.00	0.00	5.00	16.70	26.70	30.00	11.70	6.70	0.00	0.00	41.70
First Quartile	0.00	0.00	0.00	0.00	7.00	14.00	9.00	12.00	4.00	8.00	0.00	0.00	17.00
Median	0.00	0.00	0.00	0.00	16.00	41.00	38.00	19.00	7.00	18.00	0.00	0.00	64.00
Third Quartile	0.00	0.00	0.00	0.00	19.00	69.00	46.00	31.00	41.00	26.00	0.00	0.00	103.00
SMI First Quartile	0.00	0.00	0.00	0.00	0.10	0.40	0.70	0.90	0.80	0.30	0.00	0.00	0.40
Median	0.00	0.00	0.10	0.20	0.40	0.90	0.90	1.00	1.00	0.90	0.30	0.10	0.50
Third Quartile	0.10	0.20	0.40	0.50	0.70	1.00	1.00	1.90	1.00	1.00	0.60	0.30	0.60
Temp. Index Cool	0.67	0.68	0.93	0.91	0.49	0.19	0.09	0.25	0.54	0.88	0.98	0.82	0.62
Warm	0.53	0.52	0.41	0.23	0.08	0.00	0.00	0.00	0.10	0.21	0.36	0.47	0.24
GI Cool													
First Quartile	0.00	0.00	0.00	0.00	0.10	0.90	0.10	0.30	0.50	0.30	0.00	0.00	0.20
Median	0.00	0.00	0.10	0.20	0.40	0.20	0.10	0.30	0.50	0.90	0.30	0.10	0.30
Third Quartile	0.10	0.20	0.40	0.50	0.50	0.20	0.10	0.30	0.50	0.90	0.60	0.30	0.30
GI Warm													
First Quartile	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.10	0.20	0.00	0.00	0.10
Median	0.00	0.00	0.10	0.20	0.10	0.00	0.00	0.00	0.10	0.20	0.30	0.10	0.10
Third Quartile	0.10	0.20	0.40	0.20	0.10	0.20	0.00	0.00	0.10	0.20	0.40	0.30	0.10

Table 4.5.4 (Cont'd)

WOOMARGAMA Location 16	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	0.00	0.00	10.70	40.00	62.70	72.00	40.00	14.70	0.00	0.00	82.70
First Quartile	0.00	0.00	0.00	0.00	34.00	28.00	20.00	24.00	17.00	14.00	0.00	0.00	64.00
Median	0.00	0.00	0.00	0.00	45.00	52.00	51.00	42.00	30.00	27.00	0.00	0.00	121.00
Third Quartile	0.00	0.00	0.00	0.00	82.00	98.00	85.00	58.00	58.00	53.00	0.00	0.00	208.00
SMI First Quartile	0.00	0.00	0.00	0.10	0.30	0.70	1.00	1.00	1.00	1.00	0.20	0.00	0.50
Median	0.10	0.10	0.10	0.30	0.60	1.00	1.00	1.00	1.00	1.00	0.70	0.10	0.60
Third Quartile	0.20	0.20	0.30	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.30	0.60
Temp. Index Cool	0.92	0.92	0.99	0.68	0.28	0.04	0.03	0.05	0.32	0.63	0.93	0.98	0.56
Warm	0.42	0.42	0.32	0.14	0.01	0.00	0.00	0.00	0.02	0.13	0.25	0.36	0.17
GI Cool													
First Quartile	0.00	0.00	0.00	0.10	0.30	0.00	0.00	0.00	0.30	0.60	0.20	0.00	0.20
Median	0.10	0.10	0.10	0.30	0.30	0.00	0.00	0.00	0.30	0.60	0.70	0.10	0.20
Third Quartile	0.20	0.20	0.30	0.70	0.30	0.00	0.00	0.00	0.30	0.60	0.90	0.30	0.30
GI Warm													
First Quartile	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.00	0.10
Median	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.10	0.10
Third Quartile	0.20	0.20	0.30	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.30	0.10

Table 4.5.4 (Cont'd)

HOLBROOK Location 17	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	1.20	3.50	11.80	41.20	64.70	75.30	56.50	29.40	3.50	0.00	87.10
First Quartile	0.00	0.00	15.00	19.00	34.00	15.00	23.00	22.00	12.00	12.00	2.00	0.00	59.00
Median	0.00	0.00	15.00	33.00	54.00	45.00	46.00	41.00	25.00	22.00	14.00	0.00	131.00
Third Quartile	0.00	0.00	15.00	49.00	76.00	81.00	67.00	63.00	44.00	48.00	123.00	0.00	206.00
SMI First Quartile	0.00	0.00	0.00	0.10	0.40	0.70	1.00	1.00	1.00	1.00	0.70	0.10	0.60
Median	0.10	0.10	0.20	0.40	0.60	1.00	1.00	1.00	1.00	1.00	1.00	0.40	0.70
Third Quartile	0.30	0.40	0.50	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.70	0.70
Temp. Index Cool	0.92	0.92	0.99	0.68	0.28	0.04	0.03	0.05	0.32	0.63	0.93	0.98	0.56
Warm	0.42	0.42	0.32	0.14	0.01	0.00	0.00	0.00	0.02	0.13	0.25	0.36	0.17
GI Cool													
First Quartile	0.00	0.00	0.00	0.10	0.30	0.00	0.00	0.00	0.30	0.60	0.70	0.10	0.30
Median	0.10	0.10	0.20	0.40	0.30	0.00	0.00	0.00	0.30	0.60	0.90	0.40	0.30
Third Quartile	0.30	0.40	0.50	0.70	0.30	0.00	0.00	0.00	0.30	0.60	0.90	0.70	0.40
GI Warm													
First Quartile	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.10	0.10
Median	0.10	0.10	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.40	0.10
Third Quartile	0.30	0.40	0.30	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.40	0.10

Table 4.5.4 (Cont'd)

GLENFALLOCK Location 20	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	0.00	4.90	9.80	31.10	63.90	70.50	60.70	9.83	3.30	1.60	88.50
First Quartile	0.00	0.00	0.00	6.00	45.00	16.00	15.00	30.00	13.00	14.00	12.00	23.00	54.00
Median	0.00	0.00	0.00	25.00	65.00	45.00	36.00	44.00	25.00	3.00	16.00	23.00	98.00
Third Quartile	0.00	0.00	0.00	34.00	83.00	75.00	62.00	65.00	42.00	57.00	19.00	23.00	221.00
SMI First Quartile	0.00	0.00	0.00	0.10	0.40	0.70	1.00	1.00	1.00	1.00	0.80	0.10	0.60
Median	0.10	0.10	0.20	0.40	0.70	0.90	1.00	1.00	1.00	1.00	1.00	0.30	0.60
Third Quartile	0.20	0.30	0.50	0.70	0.90	1.00	1.00	1.00	1.00	1.00	1.00	0.70	0.70
Temp. Index Cool	0.91	0.92	0.99	0.70	0.30	0.04	0.03	0.60	0.34	0.66	0.94	0.97	0.57
Warm	0.43	0.43	0.33	0.15	0.01	0.00	0.00	0.00	0.03	0.14	0.26	0.37	0.18
GI Cool													
First Quartile	0.00	0.00	0.00	0.10	0.30	0.00	0.00	0.10	0.30	0.70	0.80	0.10	0.30
Median	0.10	0.10	0.20	0.40	0.30	0.00	0.00	0.10	0.30	0.70	0.90	0.30	0.30
Third Quartile	0.20	0.30	0.50	0.70	0.30	0.00	0.00	0.10	0.30	0.70	0.90	0.70	0.40
GI Warm													
First Quartile	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.10	0.10
Median	0.10	0.10	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.10	0.10
Third Quartile	0.20	0.30	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.40	0.10

Table 4.5.4 (Cont'd)

JINGELLIC Location 24	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	2.60	2.60	10.50	28.90	63.20	76.30	60.50	44.70	10.50	0.00	86.80
First Quartile	0.00	0.00	4.00	68.00	53.00	30.00	30.00	25.00	13.00	16.00	12.00	0.00	54.00
Median	0.00	0.00	4.00	68.00	73.00	44.00	52.00	41.00	29.00	21.00	24.00	0.00	152.00
Third Quartile	0.00	0.00	4.00	68.00	100.00	114.00	76.00	68.00	55.00	52.00	61.00	0.00	277.00
SMI First Quartile	0.00	0.00	0.00	0.10	0.30	0.60	0.90	1.00	1.00	1.00	1.00	0.00	0.60
Median	0.10	0.10	0.10	0.50	0.60	0.90	1.00	1.00	1.00	1.00	1.00	0.60	0.70
Third Quartile	0.40	0.40	0.60	0.80	0.90	1.00	1.00	1.00	1.00	1.00	1.00	0.70	0.70
Temp. Index Cool	0.94	0.94	0.97	0.62	0.24	0.05	0.02	0.04	0.27	0.59	0.91	0.99	0.55
Warm	40.00	0.40	0.30	0.13	0.00	0.00	0.00	0.00	0.00	0.11	0.23	0.34	0.16
GI Cool													
First Quartile	0.00	0.00	0.00	0.10	0.20	0.00	0.00	0.00	0.30	0.60	0.90	0.30	0.30
Median	0.10	0.10	0.10	0.50	0.20	0.00	0.00	0.00	0.30	0.60	0.90	0.60	0.30
Third Quartile	0.40	0.40	0.60	0.60	0.20	0.00	0.00	0.00	0.30	0.60	0.90	0.70	0.30
GI Warm													
First Quartile	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10
Median	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10
Third Quartile	0.40	0.40	0.30	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10

Table 4.5.4 (Cont'd)

LANKEYS CREEK Location 25	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	3.00	0.00	12.10	13.60	18.20	72.70	97.00	92.40	84.80	68.20	34.80	12.10	100.00
First Quartile	1.00	0.00	16.00	7.00	41.00	35.00	52.00	46.00	30.00	24.00	15.00	6.00	210.00
Median	4.00	0.00	22.00	50.00	90.00	62.00	81.00	72.00	50.00	48.00	23.00	17.00	308.00
Third Quartile	7.00	0.00	57.00	70.00	146.0	112.0	131.0	109.0	83.00	87.00	51.00	64.00	516.00
SMI First Quartile	0.10	0.00	0.00	0.40	0.50	1.00	1.00	1.00	1.00	1.00	1.00	0.80	0.70
Median	0.50	0.40	0.40	0.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80
Third Quartile	1.00	0.80	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90
Temp. Index Cool	0.94	0.94	0.73	0.28	0.30	0.00	0.00	0.00	0.03	0.55	0.55	86.00	0.38
Warm	0.27	0.26	0.16	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.10	21.00	0.08
GI Cool													
First Quartile	0.10	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.80	0.20
Median	0.50	0.40	0.40	0.30	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.90	0.20
Third Quartile	0.90	0.80	0.70	0.30	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.90	0.30
GI Warm													
First Quartile	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.20	0.10
Median	0.30	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.20	0.10
Third Quartile	0.30	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.20	0.10

Table 4.5.4 (Cont'd)

MARAGLE Location 33	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	0.00	0.00	1.40	4.30	10.00	37.10	72.90	85.70	72.90	40.00	10.00	2.90	94.30
First Quartile	0.00	0.00	9.00	13.00	21.00	21.00	21.00	24.00	20.00	12.00	11.00	11.00	83.00
Median	0.00	0.00	9.00	33.00	26.00	52.00	47.00	42.00	34.00	29.00	18.00	16.00	146.00
Third Quartile	0.00	0.00	9.00	36.00	40.00	97.00	77.00	78.00	53.00	62.00	74.00	21.00	249.00
SMI First Quartile	0.00	0.00	0.00	0.10	0.40	0.80	1.00	1.00	1.00	1.00	1.00	0.30	0.60
Median	0.10	0.20	0.20	0.50	0.70	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.70
Third Quartile	0.50	0.40	0.70	0.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.70	0.80
Temp. Index Cool	0.94	0.94	0.97	0.62	0.24	0.03	0.02	0.04	0.27	0.59	0.91	0.99	0.55
Warm	0.40	0.40	0.30	0.13	0.00	0.00	0.00	0.00	0.00	0.11	0.23	0.34	0.16
GI Cool													
First Quartile	0.00	0.00	0.00	0.10	0.20	0.00	0.00	0.00	0.30	0.60	0.90	0.30	0.30
Median	0.10	0.20	0.20	0.50	0.20	0.00	0.00	0.00	0.30	0.60	0.90	0.50	0.30
Third Quartile	0.50	0.40	0.70	0.60	0.20	0.00	0.00	0.00	0.30	0.60	0.90	0.70	0.40
GI Warm													
First Quartile	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10
Median	0.10	0.20	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10
Third Quartile	0.40	0.40	0.30	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10

Table 4.5.4 (Cont'd)

TUMBARUMBA Location 35	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Surplus PC Occurrence	4.70	3.50	14.00	12.80	29.10	68.60	90.70	93.00	91.90	75.60	36.00	19.80	100.00
First Quartile	16.00	12.00	21.00	8.00	16.00	31.00	40.00	46.00	25.00	30.00	15.00	20.00	204.00
Median	20.00	14.00	49.00	34.00	33.00	58.00	66.00	72.00	56.00	55.00	30.00	43.00	310.00
Third Quartile	46.00	64.00	72.00	71.00	98.00	117.0	113.0	106.0	88.00	79.00	55.00	72.00	493.00
SMI First Quartile	0.20	0.10	0.20	0.40	0.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80
Median	0.70	0.60	0.50	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80
Third Quartile	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90
Temp. Index Cool	0.96	0.97	0.92	0.52	0.06	0.01	0.00	0.02	0.14	0.50	0.71	0.85	0.48
Warm	0.37	0.36	0.25	0.09	0.00	0.00	0.00	0.00	0.00	0.08	0.16	0.27	0.13
GI Cool													
First Quartile	0.20	0.10	0.20	0.40	0.10	0.00	0.00	0.00	0.10	0.50	0.70	0.90	0.30
Median	0.70	0.60	0.50	0.50	0.10	0.00	0.00	0.00	0.30	0.50	0.70	0.90	0.40
Third Quartile	1.00	1.00	0.90	0.50	0.10	0.00	0.00	0.00	0.10	0.50	0.70	0.90	0.40
GI Warm													
First Quartile	0.20	0.10	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10
Median	0.40	0.40	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10
Third Quartile	0.40	0.40	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.10

At Albury, there is a 50 percent chance of a five month growing season occurring between May and July. August sowings have a 59.9 percent chance of adequate moisture for four months but only an 8.4 percent chance of a five months *growing* season.

Sowings made later than August are unlikely to be successful, although there is a better than 80 percent chance that sufficient moisture will be available for germination and growth until October.

There is a less than ten percent chance of a sowing before April being successful, even though there is a better than 20 percent chance that germination would occur in February and March. The best time to sow, in terms of seasonal moisture availability is during May.

The moisture balance also shows that for only one year in five will fallowing result in nett gain in soil moisture during February or March.

Computations for additional, selected, stations indicating the chance of receiving adequate moisture for a growing season of five months or less are given in the Appendix.

4.5.4 Soil Moisture and Erosion Control

Using the moisture balance model outline in section 4.5.2, an indication of when long duration or trickle flows can be expected is possible.

In addition, because runoff occurs when the soil moisture profile is fully saturated, the likelihood of interference to earthwork construction can also be evaluated.

Table 4.5.4 lists the percentage occurrence, on a monthly basis, of moisture surpluses, together with the 1st quartile, median and 3rd quartile values for selected stations.

It must be remembered that the values given in Table 4.5.4 are only comparative because they are the difference between estimated evaporation and rainfall when the soil is assumed to be at field capacity. Differences between calculated and actual values can be considerable, as actual runoff will be influenced by local factors such as soil type, soil depth, slope, vegetation cover and rainfall intensity.

For Albury, the month with the highest incidence of calculated moisture surpluses is August (70.3%)

Despite this, runoff can be expected to be higher during June and July. The more reliable rainfalls during August are responsible for a greater incidence of moisture surpluses. Higher but less reliable rain during June and July produces greater but less frequent surpluses. (See Table 4.2.3)

4.6 Interrelationships of Factors

Soil moisture is one of a number of factors which may limit revegetation and plant growth. Apart from soil fertility, other factors are temperature, frost occurrence and growing season of specific plant species. Plant growth, both with respect to soil fertility and environmental influences is subject to the law of limiting factors. This law states that the effect of a factor is least when another factor limits growth and greatest when all other factors are in optimal supply. It is thus possible to evaluate the overall effect of more than one limiting factor on plant growth, provided that relationships between growth and each factor when maintained at a sub–optimal level can be determined.

Apart from the occurrence of frost which is directly related in effect to the tolerance of particular species, the three primary factors relating to growth are:–

- seasonality
- soil moisture availability
- temperature

Plants may be classified depending on whether they grow predominantly during the cooler or warmer part of the year. Cool season perennial species are generally dormant over the summer whilst warm season species are usually dormant over winter. Dormancy is directly related to temperature or moisture availability.

The effect of temperature on plant growth has been widely documented. Fitzpatrick and Nix (1970) have developed a thermal index based on the relationship between fractional dry matter production and daily mean temperature for three broad groups of pasture species. The fractional dry matter production was defined as the dry matter production at a given factor level relative to production at optimal or non–limiting levels of that factor, which in this case was temperature.

The relationships are shown in Figure 4.6.1.

The concept of fractional dry matter production can be extended to include the effect of moisture stress on plant growth. It is possible to equate both temperature and moisture as limiting factors and derive a combined growth index.

The data for selected stations in Table 4.5.4 shows the effect of moisture and temperature separately, then considers which of these factors are limiting for each month, following calculation of a Growth Index (G.I.)

At Albury the April median soil moisture index (S.M.I.) is 0.3. That is, in half the years, growth may occur at a rate of 0.3 or 30 percent of the optimum, or better. In one quarter of the years, growth may exceed 70 percent of the optimum.

The temperature index for cool season species is 0.89 and for warm season species 0.22. That is, given ample water, plant growth will occur at a rate of 89 percent of the optimum for cool season species and 22 percent for warm season species.

The cool season species temperature index is greater than the median and quartile soil moisture indices, therefore the median and quartile growth indices (0.1.) correspond with these values. In other words, the temperature index value of 0.89 sets the limit to plant growth under optimum moisture conditions.

For warm season species in April, the temperature index value of 0.22 or twenty two percent again sets the growth limit irrespective of soil moisture conditions.

To demonstrate the effect of both soil moisture and temperature on plant growth throughout the district, stations have been grouped according to their similarity in median monthly cool season growth indices. The zones are shown in Figure 4.6.1 and the growth index means and standard deviations in Table 4.6.2.

4.7 Climate and Soil Conservation

Effective soil erosion control requires an awareness of climate, its variability, extreme events, its effect on plant growth, farm management and its influence on the implementation of erosion control measures. The most important extreme events of climate relate to daily rainfalls and the possibility of storms of high intensity and short duration.

Table 4.7.1 lists the frequency of occurrence of daily rainfalls exceeding specified values for selected stations in the district. Although as stated in section 4.2.3, monthly rainfalls are usually lower during the warmer months, Table 4.5.6 indicates that higher daily totals occur during this period. Reduced plant growth, together with higher daily rainfalls means that erosion risk will be higher during summer, particularly under unrestricted heavy grazing.

Factors affecting plant growth are relevant to revegetation and vegetative cover maintenance. The growth index analysis suggests that vegetative cover will be a limiting factor to erosion control during the warmer part of the year and that growth rates may be reduced over the winter by low temperatures.

Erosion control based on farm management must consider:

- the increased erosion risk in summer.
- the desirability and likely benefits of summer fallow.
- the reduced rate of plant growth in mid—summer and winter.
- the need to sow pastures and undertake revegetation programmes with sufficient length of season remaining for sown annual species to set seed.

The most effective erosion control is possible when all conditions and factors are favourable. However, knowledge of the variations and probabilities will enable erosion control to be effectively planned on a year round basis.

From Fitzpatrick and Nix (1970) SCS 10007

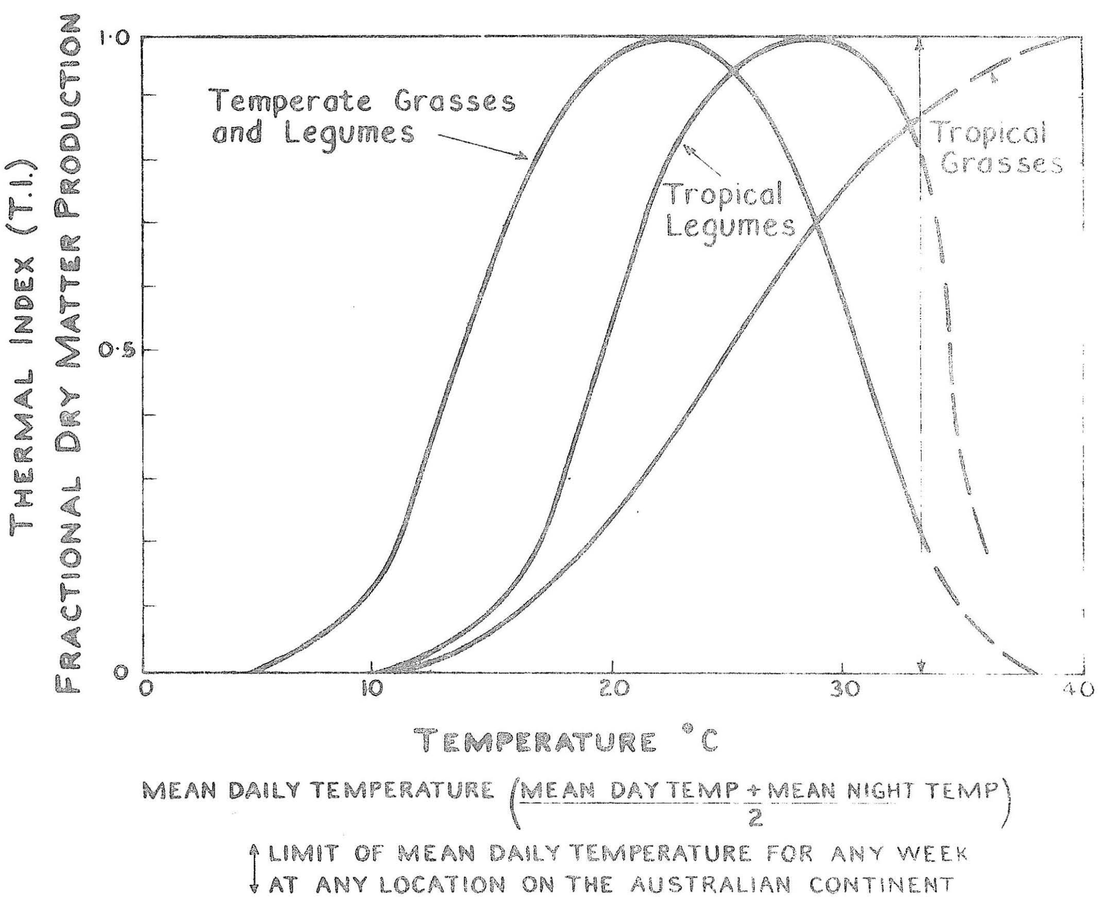


Figure 4.6.1.

Table 4.6.2

Means and standard deviation - Growth index zones, Albury district

Zone and No. of stations**		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Albury	**mean**	0.0	0.1	0.1	0.3	0.4	0.1	0.0	0.2	0.5	0.8	0.5	0.1
(12)	**SD**	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
2. Berrigan	**mean**	0.0	0.0	0.0	0.1	0.3	0.2	0.1	0.2	0.5	0.5	0.1	0.0
(17)	**SD**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3. Green Hills S.F.	**mean**	0.8	0.8	0.9	0.4	0.1	0	0	0	0	0.3	0.7	1
(1)	**SD**			Only	one	station	in	zone					
4. Tumbarumba	**mean**	0.6	0.5	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.9
(6)	**SD**	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
5. Maragle	**mean**	0.1	0.1	0.2	0.4	0.3	0.0	0.0	0.0	0.3	0.5	0.9	0.4
(8)	**SD**	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2
6. Kosciusko	**mean**	0.6	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4
(2)	**SD**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* Number of stations in zone.

** Zone number indicates order of grouping or similarity between zones.

Table 4.7.1
Percentage of monthly rainfall within specified daily rainfall classes for selected stations in the Albury district

Station and location No.	Class mm/day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(5) Munyabla Pk.	0 to 9	31.4	28.2	26.9	37.0	45.6	49.0	52.7	53.2	37.3	34.6	38.7	26.9
Henty	10 to 19	26.6	23.7	27.6	21.1	24.7	14.6	32.8	27.5	27.2	30.2	32.4	40.4
	20 to 29	16.3	15.4	20.2	17.9	18.5	14.3	7.5	9.3	29.1	22.6	22.0	14.1
	30 to 39	11.6	20.7	7.1	15.4	8.0	8.4	7.0	6.1	2.7	9.9	6.9	9.4
	40 to 49	14.1	5.7	8.1	3.8	3.2	3.7	0	3.9	3.7	2.7	0	9.2
	50 to 59	0	6.3	10.1	4.8	0	0	0	0	0	0	0	0
	> 60	0	0	0	0	0	0	0	0	0	0	0	0
(10) Culcairn Bowling	0 to 9	24	24.2	20.7	39.0	40.4	44.9	47.8	49.4	41.7	34.3	35.3	26.9
club	10 to 19	19.8	27.3	33.4	30.1	34.5	30.3	28.3	31.7	39.7	22.6	28.0	23.9
	20 to 29	17.1	25.6	19.2	9.7	15.1	18.5	16.6	10.2	10.9	22.9	15.0	17.4
	30 to 39	2.8	6.8	7.7	5.0	7.5	6.3	7.3	2.0	4.8	8.9	11.5	13.9
	40 to 49	6.5	3.8	9.9	7.1	2.5	0	0	6.7	2.9	0	6.0	5.7
	50 to 59	13.2	0	9.1	4.2	0	0	0	0	0	8.1	4.1	4.0
	> 60	6.6	12.3	0	4.9	0	0	0	0	0	3.2	0	8.2

Table 4.7.1 (Cont'd)

Station and location No.	Class mm/day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(18) Holbrook "Kinross"	0 to 9	26.7	11.5	24.6	30.5	40.7	47.8	53.7	54.6	39	32.9	31.6	26.9
	10 to 19	39.0	25.8	30.5	29.8	30.0	36.0	28.8	33.1	33.4	29.7	28.8	22.6
	20 to 29	14.5	27.9	17.1	10.1	15.5	11.9	10.6	12.3	15.2	17.0	17.5	23.1
	30 to 39	6.4	15.8	10.9	11.4	8.7	4.3	6.9	0	10.0	5.0	5.8	12.4
	40 to 49	0	0	7.7	5.8	0	0	0	0	2.4	9.1	8.3	2.9
	50 to 59	0	7.4	4.3	3.9	5.1	0	0	0	0	3.1	3.2	7.6
	> 60	13.4	11.6	4.9	8.5	0	0	0	0	0	3.2	4.8	4.5
(34) Burra Creek	0 to 9	23.3	22.3	24.8	27	33.2	28.6	30.5	38.9	33.3	31.7	28.8	28
	10 to 19	28.1	28.0	23.6	31.2	28.1	34.5	32.4	33.0	32.0	25.4	32.3	35.8
	20 to 29	19.8	33.7	13.7	11.5	20.8	11.6	24.9	18.0	17.7	17.2	17.7	14.1
	30 to 39	11.7	10.3	7.4	20.2	10.5	10.9	7.9	7.4	8.1	11.0	16.0	14.7
	40 to 49	7.7	5.7	8.9	6.7	7.4	4.4	4.3	2.7	1.6	8.0	2.0	4.4
	50 to 59	9.4	0	5.8	0	0	0	0	0	2.0	1.7	0	3.0
	> 60	0	0	15.8	4.3	0	0	0	0	5.3	5.0	3.2	0

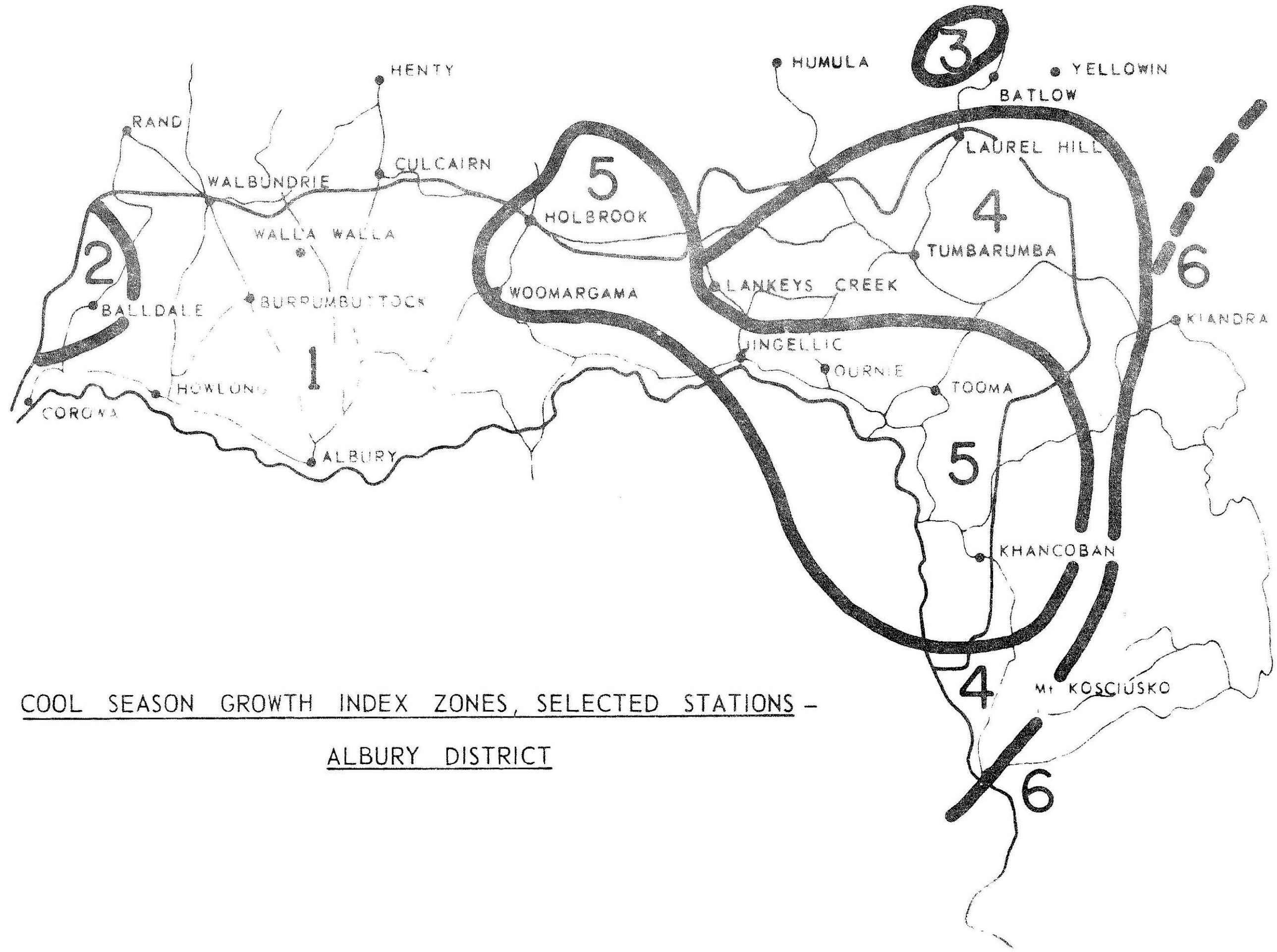


Figure 4.6.2 COOL SEASON GROWTH INDEX ZONES, SELECTED STATIONS – ALBURY DISTRICT

S.C.S. 12432/9

APPENDIX - CLIMATE SELECTION

Chance of receiving adequate moisture for a growing season of five months or less, commencing on the month indicated

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Corowa	0.060	0.110	0.180	0.400	0.810	1.000	1.000	1.000	1.000	0.890	0.330	0.090
	0.060	0.007	0.001	0.000	0.000							
		0.110	0.020	0.008	0.006	0.006						
			0.180	0.072	0.058	0.058	0.058					
				0.400	0.324	0.324	0.324	0.324				
					0.810	0.810	0.810	0.810	0.810			
						1.000	1.000	1.000	1.000	1.000		
							1.000	1.000	1.000	0.890	0.294	
								1.000	1.000	0.890	0.294	0.026
	0.002								1.000	0.890	0.294	0.026
	0.002	0.000								0.890	0.294	0.026
	0.002	0.000	0.000								0.330	0.030
	0.005	0.000	0.000	0.000								0.090

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Balldale	0.080	0.150	0.130	0.380	0.780	1.000	1.000	1.000	0.960	0.770	0.320	0.070
	0.080	0.012	0.002	0.000	0.000							
		0.150	0.020	0.007	0.006	0.006						
			0.130	0.049	0.039	0.039	0.039					
				0.380	0.296	0.296	0.296	0.296				
					0.780	0.780	0.780	0.780	0.749			
						1.000	1.000	1.000	0.960	0.739		
							1.000	1.000	0.960	0.739	0.237	
								1.000	0.960	0.739	0.237	0.017
	0.001								0.960	0.739	0.237	0.017
	0.001	0.000								0.770	0.246	0.017
	0.002	0.000	0.000								0.320	0.022
	0.006	0.000	0.000	0.000								0.070

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Burrumbuttock	0.050	0.110	0.230	0.420	0.810	1.000	1.000	1.000	0.990	0.880	0.480	0.130
	0.050	0.006	0.001	0.000	0.000							
		0.110	0.025	0.011	0.009	0.009						
			0.230	0.097	0.078	0.078	0.078					
				0.410	0.340	0.340	0.340	0.340				
					0.810	0.810	0.810	0.810	0.802			
						1.000	1.000	1.000	0.990	0.871		
							1.000	1.000	0.990	0.871	0.418	
								1.000	0.990	0.871	0.418	0.054
	0.003								0.990	0.871	0.418	0.054
	0.003	0.000								0.880	0.422	0.055
	0.003	0.000	0.000								0.480	0.062
	0.007	0.000	0.000	0.000								0.130

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Culcairn	0.020	0.130	0.280	0.370	0.073	1.000	1.000	0.980	0.950	0.820	0.400	0.120
	0.020	0.003	0.000	0.000	0.000							
		0.130	0.036	0.014	0.010	0.010						
			0.280	0.104	0.076	0.076	0.076					
				0.370	0.270	0.270	0.270	0.265				
					0.730	0.730	0.730	0.715	0.679			
						1.000	1.000	0.980	0.931	0.763		
							1.000	0.980	0.931	0.763	0.305	
								1.000	0.931	0.763	0.305	0.037
	0.001								0.950	0.779	0.312	0.037
	0.000	0.000								0.820	0.328	0.039
	0.000	0.000	0.000								0.400	0.048
	0.002	0.000	0.000	0.000								0.120

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Woomargama	0.130	0.160	0.220	0.540	0.860	1.000	1.000	1.000	0.990	0.980	0.061	0.180
	0.130	0.021	0.005	0.003	0.002							
		0.160	0.035	0.019	0.016	0.016						
			0.220	0.119	0.102	0.102	0.102					
				0.540	0.464	0.464	0.464	0.464				
					0.860	0.860	0.860	0.860	0.852			
						1.000	1.000	1.000	0.990	0.970		
							1.000	1.000	0.990	0.970	0.592	
								1.000	0.990	0.970	0.592	0.107
	0.014								0.990	0.970	0.592	0.107
	0.014	0.002								0.980	0.598	0.108
	0.014	0.002	0.000								0.610	0.110
	0.023	0.004	0.000	0.000								0.180

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Holbrook	0.200	0.300	0.400	0.690	0.920	1.000	1.000	1.000	1.000	0.970	0.880	0.550
	0.200	0.060	0.024	0.017	0.015							
		0.300	0.120	0.083	0.076	0.076						
			0.400	0.276	0.254	0.254	0.254					
				0.690	0.635	0.635	0.635	0.635				
					0.920	0.920	0.920	0.920	0.920			
						1.000	1.000	1.000	1.000	0.970		
							1.000	1.000	1.000	0.970	0.854	
								1.000	1.000	0.970	0.854	0.469
	0.094								1.000	0.970	0.854	0.469
	0.094	0.028								0.970	0.854	0.469
	0.097	0.029	0.012								0.880	0.484
	0.110	0.032	0.013	0.009								0.550

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jingellic	0.270	0.320	0.390	0.650	0.890	1.000	1.000	1.000	1.000	1.000	0.890	0.610
	0.270	0.086	0.034	0.022	0.019							
		0.320	0.125	0.081	0.072	0.072						
			0.390	0.254	0.226	0.226	0.226					
				0.650	0.579	0.579	0.579	0.579				
					0.890	0.890	0.890	0.890	0.890			
						1.000	1.000	1.000	1.000	1.000		
							1.000	1.000	1.000	1.000	0.890	
								1.000	1.000	1.000	0.890	0.543
	0.147								1.000	1.000	0.890	0.543
	0.147	0.047								1.000	0.890	0.543
	0.147	0.047	0.018								0.890	0.543
	0.165	0.053	0.021	0.013								0.610

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lankeys Ck	0.560	0.590	0.620	0.800	0.920	1.000	1.000	1.000	1.000	1.000	0.990	0.940
	0.560	0.330	0.205	0.164	0.151							
		0.560	0.366	0.293	0.269	0.269						
			0.620	0.496	0.456	0.456	0.456					
				0.800	0.736	0.736	0.736	0.736				
					0.920	0.920	0.920	0.920	0.920			
						1.000	1.000	1.000	1.000	1.000		
							1.000	1.000	1.000	1.000	0.990	
								1.000	1.000	1.000	0.990	0.930
	0.521								1.000	1.000	0.990	0.930
	0.521	0.307								1.000	0.990	0.930
	0.521	0.307	0.191								0.990	0.930
	0.526	0.311	0.193	0.154								0.940

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maragle	0.270	0.340	0.440	0.670	0.930	1.000	1.000	1.000	1.000	1.000	0.930	0.600
	0.270	0.092	0.040	0.027	0.025							
		0.340	0.150	0.100	0.093	0.093						
			0.440	0.295	0.274	0.274	0.274					
				0.760	0.623	0.623	0.623	0.623				
					0.930	0.930	0.930	0.930	0.930			
						1.000	1.000	1.000	1.000	1.000		
							1.000	1.000	1.000	1.000	0.930	
								1.000	1.000	1.000	0.930	0.558
	0.151								1.000	1.000	0.930	0.558
	0.151	0.151								1.000	0.930	0.558
	0.151	0.151	0.023								0.930	0.558
	0.162	0.055	0.024	0.016								0.600

APPENDIX (Cont'd)

Station	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tumbarumba	0.680	0.700	0.710	0.810	0.970	1.000	1.000	1.000	1.000	1.000	1.000	0.960
	0.680	0.476	0.338	0.274	0.266							
		0.700	0.497	0.403	0.390	0.390						
			0.710	0.575	0.558	0.558	0.558					
				0.810	0.786	0.786	0.786	0.786				
					0.970	0.970	0.970	0.970	0.970			
						1.000	1.000	1.000	1.000	1.000		
							1.000	1.000	1.000	1.000	1.000	
								1.000	1.000	1.000	1.000	0.960
	0.650								1.000	1.000	1.000	0.960
	0.650	0.457								1.000	1.000	0.960
	0.650	0.457	0.324								1.000	0.960
	0.650	0.457	0.324	0.263								0.960

5 SOILS

R.J. Crouch

5.1 The Soils Map

Soils in the Albury district reflect a large variation in climate, parent material and relief from the mountain ranges around Khancoban to the plains north of Corowa. As elevation drops and climate changes from alpine to semi—arid, soils change from sandy yellow earths (Gn 1.22) and shallow chocolate soils (Gn 4.12) to solodised red—brown earths (Dr 2.43) and grey clay soils (tig 5.25).

The distribution of major soil types in the Albury district is shown on the soils map as associations of great soil groups (figure 5).

Soils were identified using. the "Factual Key for the Recognition of Australian Sails" (Northcote, 1971) Great soil groups were determined from Appendix I – "Soil Identification" in Charman (1975) and checked against profiles in Stace et al. (1968)

Soil types and map unit boundaries were determined by examination of soils along major and minor access routes.

In the west of the district, the points so determined were extrapolated by aerial photograph interpretation and 1:50,000 photomosaics. In the rugged eastern half, soils are closely related to three parent materials, namely:

- Granite, which has produced sandy soils and the red and yellow podzolic soils.
- Metamorphic rocks, which have produced the yellow earths.
- Basalt, which has produced the chocolate soils.

Therefore the map unit boundaries were made to correspond with the geologic boundaries of the 1:250,000 geologic map series prepared by the N.S.W. Department of Mines.

More detailed soil maps have been prepared for the Albury Growth Centre. They are available from Wagga Research Centre or the Albury district office.

5.2 Major Soil Associations

5.2.1 Siliceous Sands (Uc 2.21)

Siliceous sands have formed both in situ and on colluvial material on the granitic hills and ranges throughout the Albury district. They occur extensively east of the Hume Highway through to Tumbarumba and Khancoban and on isolated outcrops near Gerogery and Walbundrie.

Usually they are deep, slightly acid soils of a uniform clayey sand texture throughout. The softer minerals in the granite have weathered to clay, leaving the coarser sand size grains.

The extent of other granite derived soils within this unit is limited. Red and yellow podzolic soils (Dr. 2.21, Dy 3.41) and deep colluvial sands (Ucl.22) occur in more open areas. The red podzolic soils occur on more stable, gentle slopes and the yellow podzolic soils in the drainage lines.

In areas of extensive, relatively flat land, the sands have been cleared and are used for sheep and cattle grazing on improved pasture (e.g. around Basin Creek)

Morphology

The siliceous sands are uniform sand textured soils although they have clearly differentiated horizons with a marked colour difference between the A_2 and B horizons.

A typical profile consists of:

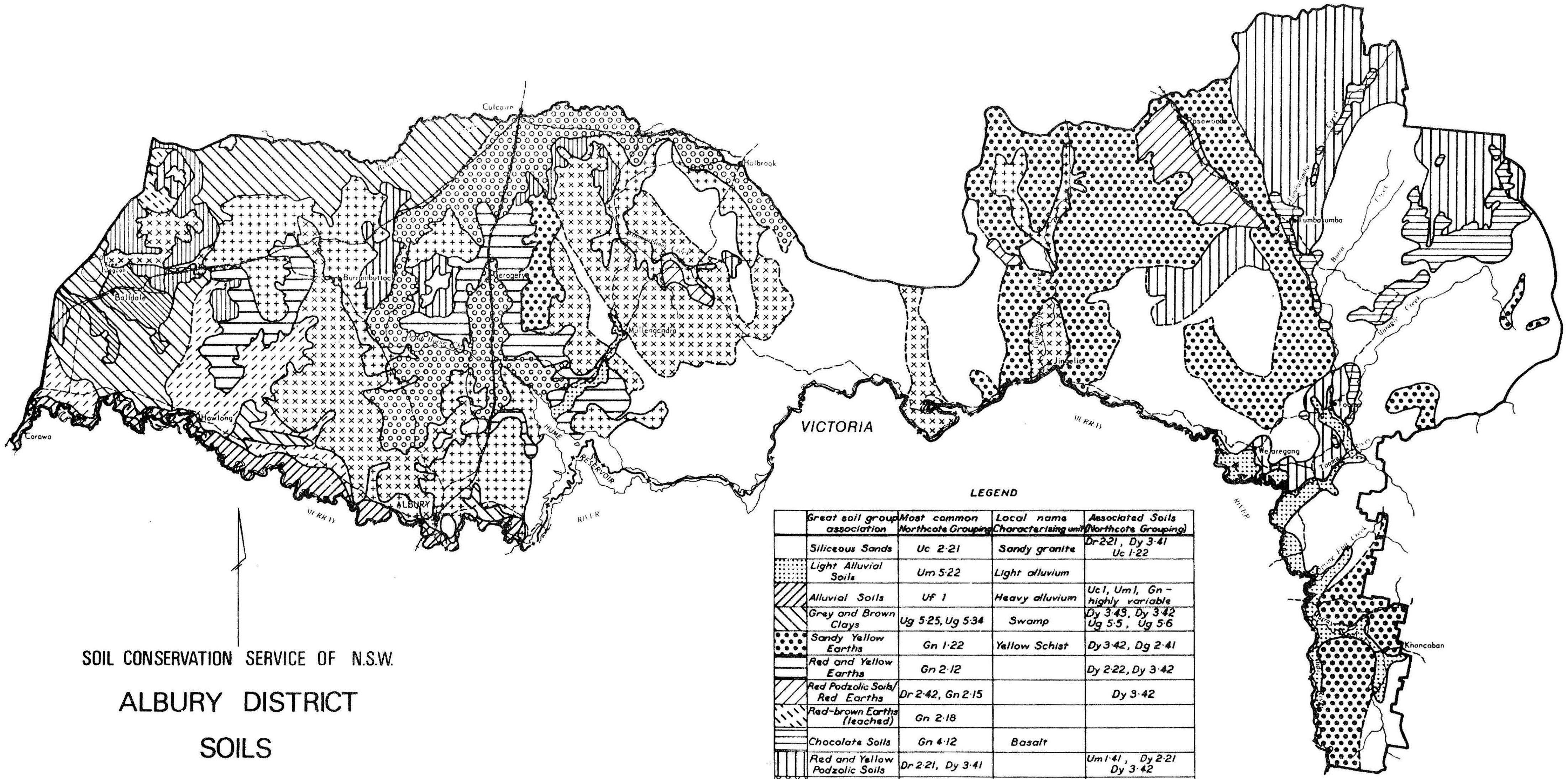
Horizon	Depth (cm)	Morphology
A_1	5 – 10	Brown to greyish brown (10YR 4/2moist), sandy loam, Slight crumb structure, moderately coherent pH 6.5. Gradual to:
A_2	20 – 40	Bleached (10YR 5/2 moist, 10YR 7/2 dry) loamy sand. Apedal When moist this horizon disperses. pH 5 to 7. Abrupt to:
B_1	80 +	Usually mottled with a mixture of grey (1.5YR 6/1 moist) pinkish white (7.5YR 8/2 moist) mottles. Clayey sand with coarse blocky to columnar structure (peds 30 to 45 cm diameter). Horizon depth is very variable. It may overlie a more clayey horizon or a sandy C horizon of weathered granite.

Identification

The main features of this soil used in identification by the Factual Key are:

1. Sandy texture throughout.
2. Bleached A_2 horizon.
3. Absence of a hard pan.

Figure 5·1



SOIL CONSERVATION SERVICE OF N.S.W.

ALBURY DISTRICT SOILS

SCALE

kilometres 5 0 5 10 15 20 25 kilometres

LEGEND

Great soil group association	Most common Northcote Grouping	Local name Characterising unit	Associated Soils (Northcote Grouping)
Siliceous Sands	Uc 2·21	Sandy granite	Dr 2·21, Dy 3·41 Uc 1·22
Light Alluvial Soils	Um 5·22	Light alluvium	
Alluvial Soils	Uf 1	Heavy alluvium	Uc 1, Um 1, Gn - highly variable
Grey and Brown Clays	Ug 5·25, Ug 5·34	Swamp	Dy 3·43, Dy 3·42 Ug 5·5, Ug 5·6
Sandy Yellow Earths	Gn 1·22	Yellow Schist	Dy 3·42, Dg 2·41
Red and Yellow Earths	Gn 2·12		Dy 2·22, Dy 3·42
Red Podzolic Soils/ Red Earths	Dr 2·42, Gn 2·15		Dy 3·42
Red-brown Earths (leached)	Gn 2·18		
Chocolate Soils	Gn 4·12	Basalt	
Red and Yellow Podzolic Soils	Dr 2·21, Dy 3·41		Um 1·41, Dy 2·21 Dy 3·42
Red Podzolic Soils	Dr 2·32		
Solodized Red-brown Earths	Dr 2·43	Hard red	
Red-brown Earths	Dr 4·33	Soft red	
Yellow Solodic Soils	Dy 2·42, Dy 2·32		Dy 3·42
Hardsetting, Yellow Solonetzic Soils	Dy 3·42		Ug 5·25, Ug 5·34
Yellow Solonetzic Soils	Dy 5·43		

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Chemical and Physical Status

Soils in this unit, with the exception of patches of deep red podzolic soil, are of low fertility both physically and chemically.

They are usually highly dispersible and when wet, (during the winter) they are in a semi-liquid state. When dry (during the summer) they set very hard. Numerous deep gullies occur wherever water flow is concentrated, for example, beside roads, in cultivated land and along fences.

They are best left under natural timber. Where soil conservation works are required, banks should be constructed with low grades. Gully control structure sites should be examined individually for depth of soil and presence of sand deposits. “Good clay” can often be found on the shoulders of depressions. (Figure 5.1)

5.2.2 Light Alluvial Soils (Um 5.22)

Light alluvial soils are found on the alluvial flats along the Murray and its tributaries above the Flume Reservoir. Many of these areas are too small to map.

They have formed on recent alluvium and hence are extremely variable.

Most of the soils are layered; the depth and texture of each layer depending on the length and velocity of flow at the time of deposition. Soils may consist of layers of clays, silts, sands and gravels of variable depth and sequence.

The unit is situated alongside streams. The micro topography is variable indicating periodic inundation by high velocity flows. Some swampy areas are also within this mapping unit.

Morphology

The extreme variability makes a typical morphological description impossible. The soils are readily recognised by the layering and lack of profile development.

Chemical and Physical Status

Very fertile patches alternate with areas consisting entirely of stones and gravel.

Since this map unit is located on relatively flat land banks would not normally be constructed.

Gully control structure sites must be investigated for sand and gravel deposits.

5.2.3 Heavy Alluvial Soils (Ufl)

Alluvial grey clay soils occupy the floodplain of the Murray River below the Hume weir. The floodplain is characterised by low relief and billabongs and swamps associated with river meanders.

Soils are primarily dark grey clays with low erodibilities and moderate shrink swell potentials. They are associated with other alluvially derived soils and patches of sand and gravel. Some low ridges of wind blown sand are also present towards the edge of the unit, often continuing into neighbouring associations.

Morphology

The alluvial grey clay soils are uniformly textured soils that crack on drying. They have a silty clay A horizon rich in organic matter which grades into a typical stratified alluvial deposit which may be silt, sand or gravel.

A typical profile consists of:

Horizon	Depth (cm)	Morphology
A_1	15	Dark brown (7.5YR 3/2 moist), silty clay with medium crumb structure. Rich in organic matter. pH 6. Gradual to:
B_1	20	Dark brown (7.5YR 3/3 moist, 7.SYR 4/4 dry), silty clay medium blocky. Hard consistency. pH 6. Gradual to:
B_2	120	Dark brown (7.5YR 4/4 moist), silty clay, medium blocky. pH 6. Gradual to:
	180 +	Dark yellowish brown (10YR 4/4 moist) sandy clay loam with slight structure and soft consistency. pH 7.5.

These soils are highly variable and, there are no particular identifying features.

Chemical and Physical Status

Soils of the floodplain are relatively fertile being inundated reqularly with silt. The higher less swampy areas have been sown with subterranean clover or lucerne and are used for grazing.

The soils are heavy textured, with the exception of sand deposits, and are correspondingly impermeable.

Owing to their topographic location, they are not important in terms of construction of soil conservation works.

5.2.4 Grey and brown clays (Ug 5.25)

Grey and brown clay soils occur in swampy areas in the western half of the district. They are found extensively along the western half of Billabong Creek and north of the Corowa – Howlong road.

Although the macro-relief is essentially flat, numerous small hummocks and depressions known as gilgais occur.

During wet seasons the area is generally under water. Soil colour reflects the extent of waterlogging. The grey clay in the centre of the depression is usually under water, the brown clay on the edge is intermittently under water, and the associated yellow solonetzic soil on the higher areas is less frequently inundated.

The drainage of this area is mostly self contained. Owing to the impervious nature of the clay, water loss is primarily by evaporation.

Morphology

The grey and brown clays can be recognised by the uniformly clay profile. The silty clay A horizon contrasts with the loam and sandy loam A horizons of soils in other associations. The gradual transition to a medium or heavy clay B horizon identifies these soils as uniform clays.

A typical profile consists of:

Brown Clay (Ug 5.34)

Horizon	Depth (cm)	Morphology
A_1	0 – 15	Pale brown (10YR 6/3 moist), silty clay, moderate crumb to slightly platy structure. High organic content. pH 6. Gradual to:
B	15 - 150 +	Light yellowish brown (2.5 Y 6/4 moist) medium to heavy clay, strongly structured subangular units 10 to 15 cm in diameter, calcium carbonate earth is present at 120 cm developing into nodules in lower layers. pH 8.5.

Grey clay (Ug 5.25)

Horizon	Depth (cm)	Morphology
A_1	0-25	Dark grey (10YR 4/1 moist), silty clay. Moderate crumb structure, high organic matter content. pH 5.5. Gradual to:
B_1	25-80	Dark grey (5YR 4/1 moist) medium clay, strongly structured into subangular units 10 to 15 cm in diameter. pH 6. Gradual to:—
B_2	150	Light olive brown (2.5Y 5/4) medium clay, strongly structured into aggregates about 20 cm diameter. Calcium carbonate earth present. pH 8.5

Identification

The main features used to identify these soils by the Factual Key are:—

1. Uniform clay texture throughout.
2. Seasonal cracking.
3. High level of pedality to the surface.
4. Grey or brown B horizon.
5. Unweathered country rock not encountered

Chemical and Physical Status

The grey and brown clays are relatively fertile, but crop production is restricted by regular inundation.

They consist of a strongly structured plastic clay with high volume expansion, but since soil conservation works are infrequently built the volume expansion is of little practical significance.

5.2.5 Sandy Yellow Earths (Gnl.22)

Sandy yellow earths predominate on schists in the east of the district and in the Table Top Range area. They are young soils with little profile development. Their high inherent erodibilities probably accounts for this lack of profile development. In many cases they are only weathered yellow shists with the planes and crystals of the original rock fabric still evident.

Lithosols or partly weathered schists cap the hills and grade into the sandy yellow earths which dominate the association sideslopes. Despite the sharp incision of the stream& some colluvial material has accumulated on the lower slopes. On this, yellow solonetzic soils (Dy 3.42) and gleyed podzolic soils (Dg 2.41) have developed. (See figure 5.2)

Morphology

The yellow earths consist of a sandy loam A horizon darkened by organic matter overlying a yellow sandy clay B horizon that grades into yellow schists. They are slightly acid throughout.

A typical profile consists of:—

Horizon	Depth (cm)	Morphology
A_1	15	Dark grey brown (2.5Y 4/2 moist). Sandy loam, slight platy structure. pH 5. Gradual or diffuse to:
B	100	100 Brownish yellow (10YR 6/6 moist). Sandy clay earthy fabric. Contains schist fragments increasing in size with depth. pH 6. Grading into weathered rock.

Identification

The main features of this soil used in identification by the Factual Key are:

1. Gradational texture change.
2. Earthy fabric.
3. Yellow B horizon.
4. Acid soil reaction trend.

Chemical and Physical Status

The sandy yellow earths are poor soils both physically and chemically. Crops and pastures should respond to most fertilizers particularly those with a high phosphorus content. Owing to this low fertility and steep topography, most land in this unit has not been cleared.

They have poor structure and are moderately dispersible resulting in a high runoff yield and erosion hazard in undulating areas; bank and gully control structure construction may be necessary. The upstream gully control structure batters must be covered and banks built on a low grade to prevent channel erosion.

5.2.6 Red and Yellow Earths (Gn 2.12)

This association occurs on the strongly weathered granitic ridges north of Albury around Table Top, Bowna and Gerogery and west of Burrumbuttock.

It is associated with upper slopes and crests of wide low ridges with yellow solonetzic soils dominating the lower ridges. Some ridges were too small to map individually and were included in neighbouring units.

Soils in the association include:—

- red earths (Gn 2.12) (Dominant)
- a duplex form of the red earth that approaches a red podzolic
- a similar yellow earth and yellow podzolic lower down the slope

- a yellow solonetzic (Dy 3.42) in the drainage lines and seepage areas.

The relationship between these soils is shown in Figure 5.3.

Where they are exposed (e.g. in road cuttings) this unit can be readily recognised by the bright colours of the B horizon and lack of A_2 horizon development. Elsewhere a red tinge in the colourof the A horizon indicates that these soils may be present.

Morphology

These soils are borderline between duplex and gradational. The A horizon varies in texture from a loam to clay loam while the B horizon, varies horn a light to medium clay.

The boundary between the A and B horizons is usually gradual in colour but diffuse in texture.

Typical profiles consist of:

Red Earth/Red Podzolic

Horizon	Depth (cm)	Morphology
A_1	20	Reddish brown (SYR 4/3 moist, 5YR 5/6 dry), loam fine sandy, platy or fine crumb, strongly structured. Usually a high organic matter content and numerous roots. pH 6. Gradual or diffuse to:—
B_1	50	Yellow red (5YR 5/6 moist, 5YR dry), light medium clay with an earthy fabric and fine structure. Friable. pH 6.5. Diffuse to:—
B_2	75	Yellow red (SYR 4/6 moist 5YR6/6 dry) with some yellow mottles. Medium clay earthy fabric. pH 6.5. Diffuse to:
B_3	120	Strong brown (7.5YR 5/6 moist7.5YR 7/6 dry), medium clay, medium blocky structure with smooth faces. pH 6.5. Diffuse to :
	170	Brownish yellow (10YR 6/6 moist, 10YR 5/6 dry), medium clay medium blocky structure, some buckshot to 1 cm diameter. pH 6.5.

The B_3 horizon may continue to a greater depth or in other situations any of the B horizons may grade into weathered granite. These soils become shallower near hill crests.

Yellow Earth/Yellow Podzolic

Horizon	Depth (cm)	Morphology
A_1	15	Dark brown (7.5YR 4/4 moist, 7.5YR 5/6 dry). Loam textured. Friable. Numerous roots. pH 6. Gradual to:—
B_1	90	Strong brown (7.5YR 5/6 moist and dry). Light clay medium fine subangular blocky structure pH 6. Gradual to:—
B_2	120	Dark yellowish brown (10YR 4/8 moist) with 40 percent yellowish brown (10YR 5/4 moist). Light medium clay, fine subangular blocky. Some ferro—manganiferous nodules. pH 6. Gradual to:
B_3	180+	Olive (SY 4/4 moist) medium clay with strong blocky structure. Mica crystals dominate fabric.

Identification

The main features of these soils used in identification by the Factual Key are:—

1. Texture difference and the nature of the boundary between the A and B_1 horizons.
2. Lack of A_2 horizon development.
3. Colour of the B_1horizon.

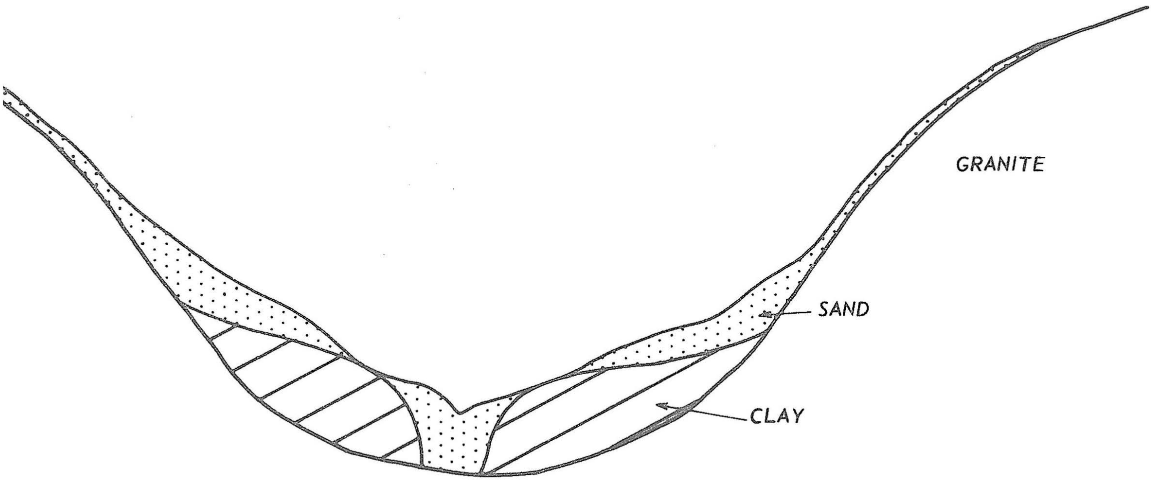

Figure 5.1 A typical section across a drainage line in the Siliceous Sand association.

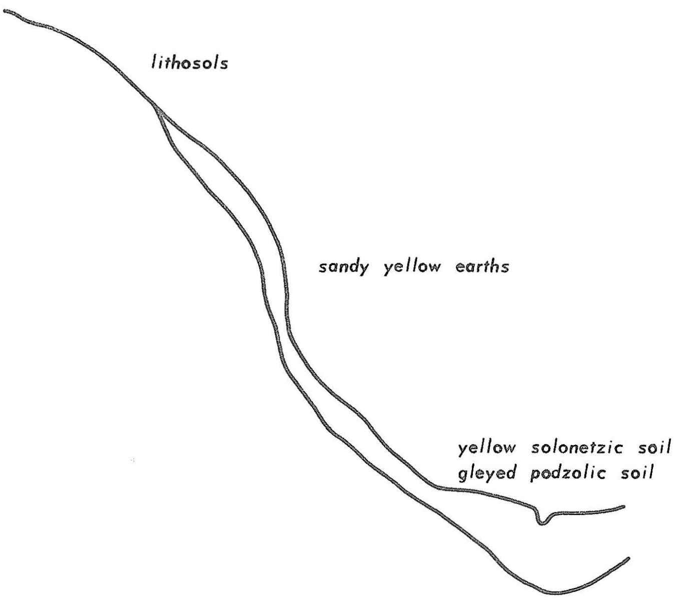

Figure 5.2 A typical section in the Sandy Yellow Earth association.

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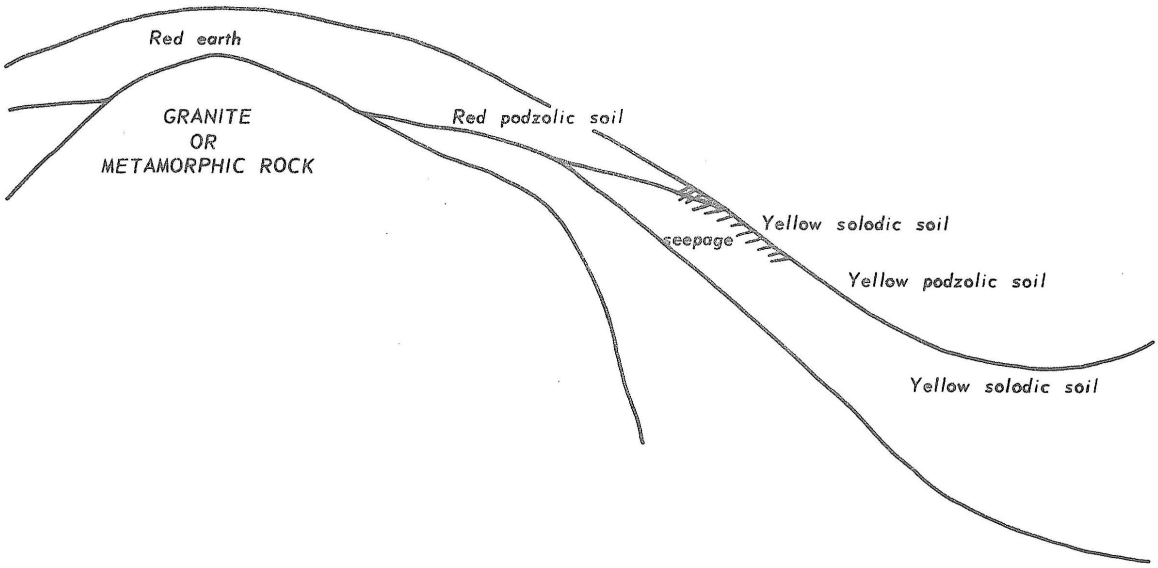

Figure 5.3 A typical section in the Red and Yellow Earth association.

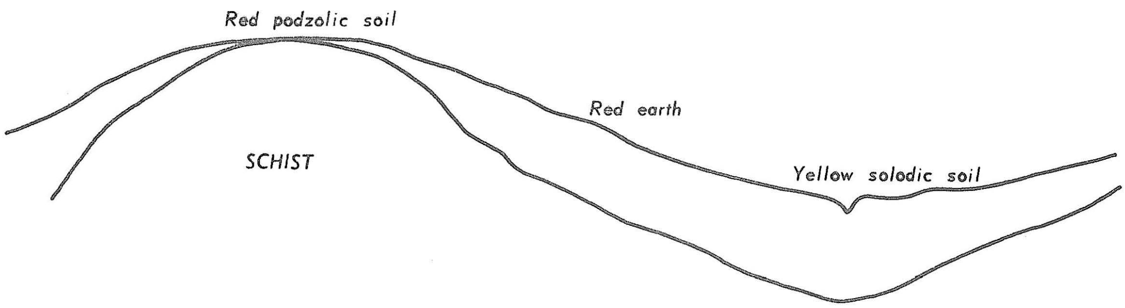

Figure 5.4 A typical section in the Red Podzolic soil – Red Earth association.

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Physical and Chemical Properties

The red and yellow earths are relatively fertile soils. However, owing to their topographic location, only limited cropping is carried out.

The structural nature of the soil promotes re– vegetation of banks and roadside batters and gives the soil a low erodibility rating. However, the B_2 horizon is highly pervious and when incorporated into gully control structures causes leaking in the top metre of the structure. This can be remedied by the application of S.T.P.P. or other dispersive agents. Wagga Research Centre should be contacted for further details.

5.2.7 Red Podzolic Soil - Red Earth (Dr2.42 Gn2.15)

This association formed on schist parent material includes the better agricultural soils of the district.

The terrain is undulating with deep red soils on the mid slopes, shallow red soils on crests and yellow or gleyed duplex soils in the drainage lines (see Figure 5.4)

The depth of the red soil in the unit is extremely variable and ranges from 30 cm to over 4 metres.

Morphology

The unit is characterised by a red duplex soil with varying degrees of bleach in the A2 horizon. Its most notable feature is a deep red friable B horizon.

A typical profile consists of:–

Horizon	Depth (cm)	Morphology
A_1	10	Dark yellow red (5YR 3/6 moist), loam with moderate structure. Friable and not hard setting. pH 6. Sharp to:–
A_2	15	Yellow-red (5YR 4/8 moist, 5YR5/8 dry), silty clay, apedal and hard when dry. pH 6.5.
B	200	Dark red (2.5 YR 3/6 moist) light clay. Friable earthy fabric with some schist fragments. pH 6.5.

Identification

Features used in the identification of this soil by the Factual Key include:

1. Texture contrast between the A_2 and B horizon.
2. Colour of the B horizon.
3. Presence of an A_2 horizon.
4. Neutral soil reaction trend.

Chemical and Physical Status

Soils in this unit are of moderate fertility and have generally had liberal superphosphate applications to increase their productivity.

They are friable to depth and therefore have high infiltration rates. Gully control structures built on these soils may leak. This can be remedied by puddling the soil with stock or adding a dispersing agent. Further details of the latter can be obtained from Wagga Research Centre.

5.2.8 Red-Brown Earths (leached) (Gn2.l8)

This map unit is limited to one small area on the western edge of the granite outcrop near Goobargarna West, in the north–western corner of the district. Soil type does not vary within this unit and is readily recognised by its red colour and narrow bleached A_2 horizon.

The unit occurs on the long midslope between the grey and brown clays of the flat swampy plains and sandy residual granitic soils (see Figure 5.5).

The A_1 and A_2 horizons are dispersible, while the strongly structured B horizon is more resistant to dispersion processes. This predisposes small gully (less than 50 cm deep) development and scalding when the surface soil is eroded.

Morphology

The leached red–brown earth consists of a reddish A_1 horizon over a bleached dispersible A_2 which in turn lies abruptly on a massive earthy red B horizion.

A typical profile consists of:

Horizon	Depth (cm)	Morphology
A_1	25	Dark reddish-brown (2.5YR 3/4 moist), loam, apedal, some organic matter, mainly fibrous roots. pH 6.5. Gradual to:
A_2	30	Weak red (10R 5/3 moist, 2.5YR7/4 dry), silty clay, apedal dispersible. pH 6.5. Abrupt to:-
B	150	Red (2.5YR 4/8 moist), medium clay, massive earthy structure. pH 7 increasing to 8.5 with carbonate present at the base.

Identification

Features used in the identification of this soil by the Factual Key include:—

1. Duplex texture profile.
2. Red B horizon.
3. Bleached A_2 horizon.
4. Alkaline reaction trend.

Physical and Chemical Properties

The leached red—brown earth is a moderately fertile soil but it will respond to additional phosphorus.

There is a sharp contrast between the A and B horizons. The A horizon is brittle, hard and poorly structured while the B horizon is more friable and earthy. This predisposes the soil to sheet erosion and the development of small gullies. However, this erosion can be easily controlled by banks and contour cultivation.

5.2.9 Chocolate Soil (Gn4.12)

Chocolate soils have formed in situ on basaltic parent material in the east of the district around Tumbarumba, Tooma and Batlow. Within this area many of the hills have shallow basaltic caps which have weathered to form chocolate and euchrozem soils of varying depths.

The soil has derived many properties from its volcanic parent material. It is fine grained, very little, if any sand is present and it is highly fertile. Where accessibility permits, these soils are used for apple and pear orchards.

The soil is recognised by its generally dark appearance, moderate to slight profile development and presence of numerous basaltic floaters.

This map unit occupies a small area of the district but due to its high fertility, it is significant agriculturally. The basalt caps overlie deeply incised granite so the edges of the caps are steep. These steep areas have been cleared creating a high erosion hazard, despite the low inherent erodibility of the soil. Banks and gully control structures are generally necessary.

Basaltic soil characteristically has a high volume expansion so that dessication cracking predisposes failure of both banks and dams. This can be overcome to some extent by increasing the thickness of the structure walls.

Morphology

This soil has a friable gradational profile with a silty A horizon grading into clay B horizons at 15 to 30 cm. It has a slightly acid reaction trend and contains floaters throughout.

A typical profile consists of:—

Horizon	Depth (cm)	Morphology
A_1	25	Dark reddish brown (5YR 3/3 moist, 5YR 3/4 dry), silty loam with strong crumb structure, friable. pH 5. Diffuse to:—
B_1	50	Dark reddish brown (SYR 3/4 moist, SYR 3/6 dry) clay loam, strong subangular blocky structure. Some small floaters. pH 6. Diffuse to:—
B_2	120	Reddish brown (5YR 4/4 moist, 5Yr 4/6 dry), clay loam, strong subangular blocky structure, large floaters greater than 30 cm diameter. pH 6.

Identification

The main profile features used in identification of this soil by the Factual Key are:

1. Gradational texture change between the A and B horizons.
2. Rough ped fabric.
3. Dark red coloured B horizon.
4. Neutral soil reaction trend.

Physical and Chemical Properties

The chocolate soils are the most fertile in the Albury district. However, their occurrence is limited and they are usually found associated with steep topography.

The most accessible part have been cleared and are either used for orchards or intensively grazed. This has resulted in gully erosion in a soil of low inherent erodibility. Because the soil is fertile and friable, reclamation should be rapid.

A major problem is the soils high shrink-swell potential. This can result in failure of barks and gully control structures due to quick rewetting of dessication cracks that form within the structure during dry spells.

5.2.10 Red and Yellow Podzolic Soils (Dr2.21 Dy3.41)

This association occurs on undulating country of granitic parent material. It occurs widely on the plateau around Tumbarumba, while limited areas are found on the mid slope to high land where granite outcrops throughout the remainder of the district.

This association consists of lithosols (Uml.41) on the ridge crests, with yellow solonetzic soils (Dy3.42) in the drainage lines and red and yellow podzolic soils on the slopes (see Figure 5.6).

Soil type boundaries are not clearly defined and transitional types occur between the dominant soil types.

Typical profile consist of:—

Red Podzolic Dr 2.21

Horizon	Depth (cm)	Morphology
A_1	15	Yellowish brown (10YR 5/4 moist, 10YR 6/3 dry), sandy clay loam. Weak crumb structure, some quartz gravel. pH 5.5. Gradual to :-
A_2	25	Reddish yellow (7.5YR 7/6 moist, 10YR 7/4 dry), sandy loam, slight crumb structure, numerous quartz gravel. pH 5.5. Sharp to:
B_1	60	Yellow red (5YR 4/6 moist, 5YR5/8 dry), sandy clay, strong angular blocky structure, quartz gravel. pH 5.5. Diffuse to:—
B_2	200+	Strong brown (7.5YR 5/8 moist, 10YR 6/8 dry), sandy clay, strong angular blocky structure quartz gravel. pH 6.

Yellow Podzolic Dy3.41

Horizon	Depth (cm)	Morphology
A_1	20	Yellowish brown (lOYR 5/4 moist, lOYR 7/2 dry), sandy clay loam, apedal. Quartz gravel. pH 6. Gradual to:-
A_2	35	Very pale brown (10YR 7/4 moist, 10YR 8/2 dry), clayey sand. Apedal, quartz gravel. pH 5.5. Abrupt to:-
B	150+	Yellowish brown (10YR 5/6 moist, 10YR 7/8 dry), sandy clay, strong blocky to columnar structures, quartz gravel. pH 5.

Identification

Main features used in the identification of this soil by the Factual Key are:-

1. Duplex primary profile form.
2. Colour of B horizon.
3. Degree of A_2 horizon development.
4. Acid soil reaction trend.

Physical and Chemical Properties

The red and yellow podzolic soils range in fertility from low to moderate. The most fertile members of the association are the deep red podzolics south of Tumbarumba, while the least fertile are the sandy lithosols.

The soils are moderately erodible and often require banks and gully control structures. These are usually successful although banks may tunnel if built over seepage patches. Sandy dispersible areas in drainage lines may result in gully control structure failure.

5.2.11 Red Podzolic Soils (Dr2.32)

This map unit consists of red podzolic soils and lithosols on the ridges, grading into highly erodible yellow solodic soils on the lower slopes and drainage lines. Occurrence is confined to the metamorphic rocks about Woomargama and Mullengandra and the hill areas west of Albury, Jindera and Burrumbuttock. The terrain is too steep for cropping, but most of the land in the association has been cleared and is used for grazing.

Many drainage lines are gullied and areas of tunnelling soil occur. Hence, investigation of sites for soil conservation works is necessary.

Morphology

The major soil of the association is a red podzolic (Dr2.32). It is a red duplex soil with an A horizon that may be bleached. A typical profile consists of:

Horizon	Depth (cm)	Morphology
A_1	15	Dark brown (7.5Yr 4/4 moist, 7.5YR 6/6 dry), loam. Friable with hard setting surface. pH 5.5. Sharp to:-
A_2	20	Red (2.5YR 5/6 moist, 2.5YR 7/2 dry), clay loam with slight structure. Dispersible in some situations and sets hard when dry. pH 6. Abrupt to:—
B	130	Red (2.5YR 4/6 moist, 2.5YR 5/8 dry), medium clay, strong sub angular blocky structure Contains weathered schist in creasing with depth. pH 6.

Identification

Main features used for identification by the Factual Key are:—

1. Duplex texture profile.

2. Red whole coloured B horizon.
3. Presence of an A_2 horizon.
4. Neutral reaction trend.

Chemical and Physical Properties

This soil has a low inherent fertility and responds well to superphosphate.

It has poor physical properties and is usually highly erodible. Much of the land in the unit is too steep for banks and the best method of soil conservation is to establish a permanent improved pasture. The best method for the initial planting of the pasture is to use a chisel seeder on the contour.

5.2.12 Solodised Red-brown Earths (Dr2.43)

These deep, red soils have formed on Quaternary deposits and are used extensively for mixed cropping in a wheat/pasture rotation. Further west, similar soils are used extensively for flood irrigation.

This association is located on the shelf—like area between the hills and the low swampy areas of grey and brown clay soils. To the south, between Howlong and Corowa the solodised red—brown earths form a high terrace of the Murray River, backed by grey clay soils (see Figure 5.7). In this situation, they have occasionally been covered with deep sand drifts.

Morphology

Soils in this unit are predominantly red throughout with a bleached A_2 horizon. They have a hard setting surface and set hard throughout when dry.

A typical profile consists of:—

Horizon	Depth (cm)	Morphology
A_1	10	Dark reddish brown (SYR 3/3 moist), loam, with platy structure. pH 5.5. Sharp to:-
A_2	15	Reddish brown (2.5YR 4/4 moist, 2.5YR 7/4 dry) clay loam with slight structure. Very hard consistency. pH 6. Abrupt to:-
B_1	70	Dusky red (10R 3/4 moist), medium clay with strong crumb structure. This layer was moist in most horizons examined. pH 6. Gradual to:-
B_2	100	Yellow red (5YR 3/6 moist), medium clay with strong blocky structure. pH increasing to 7.
B_3	150	Yellow red (5YR 4/8 moist), medium clay with strong blocky structure, some carbonate earth at the base. pH 8.5.

Identification

Main features used in classifying this soil by the

Factual Key are:—

1. Duplex texture profile.
2. Red B horizon.
3. Bleached A_2 horizon.
4. Alkaline soil reaction trend.

Chemical and Physical Status

These soils are of moderate fertility after application of phosphorus and nitrogen. The main limiting factor to production is insufficient moisture.

This unit occupies flat areas away from hills and therefore water erosion is evident.

5.2.13 Red Brown Earths (Dr 4.33)

The red brown earths, as mapped, are the lighter textured red soils of the district. They have formed on gently undulating country adjacent to both shale and granite. They are differentiated from the solodised red—brown earths by a soft light textured surface soil and less development of an A_2 horizon.

Morphology

This soil can be described as a red—brown earth which is predominantly red with a soft surface, slight or no A_2 horizon development and an alkaline soil reaction trend.

A typical profile consists of:—

Horizon	Depth (cm)	Morphology
A_1	20	Dark reddish brown (SYR 3/4 moist), clay loam with medium blocky to crumb structure, friable. Numerous fibrous roots. pH 6. Gradual to:—
B_1	40	Dark reddish brown (SYR 3/4 moist, SYR 4/8 dry), light medium clay with moderate crumb structure. pH 7. Sharp to:—
B_2	60	Yellow red (SYR 3/6 moist) with some red mottles. Medium clay with moderate crumb structure. pH 7. Gradual to:—
B_3	150	Yellow—red (SYR 4/8 moist), medium clay, moderate crumb structure pH 8. Increasing to 8.5 at base with carbonate earth.

Identification

Features used to identify this soil by the Factual Key are:—

1. Duplex or gradational texture profile.
2. Red B horizon.
3. Not hard setting.
4. Alkaline soil reaction trend.

Chemical and Physical Properties

This soil is moderately fertile and is suitable for cereal crops and improved pasture. Superphosphate has proved beneficial in most cases.

The soil has a low erodibility since the friable surface soil promotes infiltration and reduces initial runoff.- This soil type is usually suitable as a construction material for soil conservation works.

5.2.14 Yellow Solodic Soils (Dy2.42 Dy2.32)

This soil has formed on terraces, the wider creek valleys and in deep colluvial sediments north of Albury. It is closely related to the yellow solonetzic soils Dy3.42 but has developed under drier conditions. The terrain is more undulating and there are none of the swampy depressions associated with the latter soils.

Morphology

This is a duplex soil with a bleached A horizon. It differs from other similar soils by having a Leached A_2 horizon and a whole coloured B horizon.

A typical profile consists of:—

Horizon	Depth (cm)	Morphology
A_1	20	Brown (7.5YR 5/4 moist), loam, fine sandy, with slight structure. This is a moderately friable horizon with a hard setting surface 1 to 2 cm thick. pH 6. Gradual to:-
A_2	45	Brownish yellow (10YR 6/8 moist, 10YR 7/4 dry), sandy”’loam. Structureless and dispersible. Sets hard when dry. pH 6.5. Abrupt to:—
B_1	120	Light olive brown (2.5Y 5/4 moist), light medium clay. Moderate blocky structure may be dispersible. pH 6. Gradual to:—
B_2	180	Olive brown (2.5Y 4/4 moist) medium clay. Coarse blocky structure. pH 7.5.

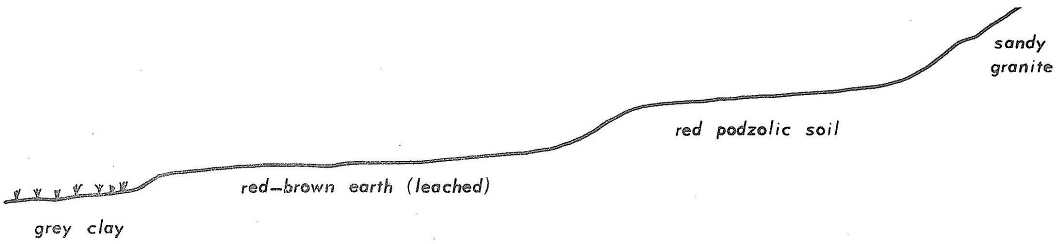


Figure 5.5 A typical section in the Red – brown Earth, (leached) association.

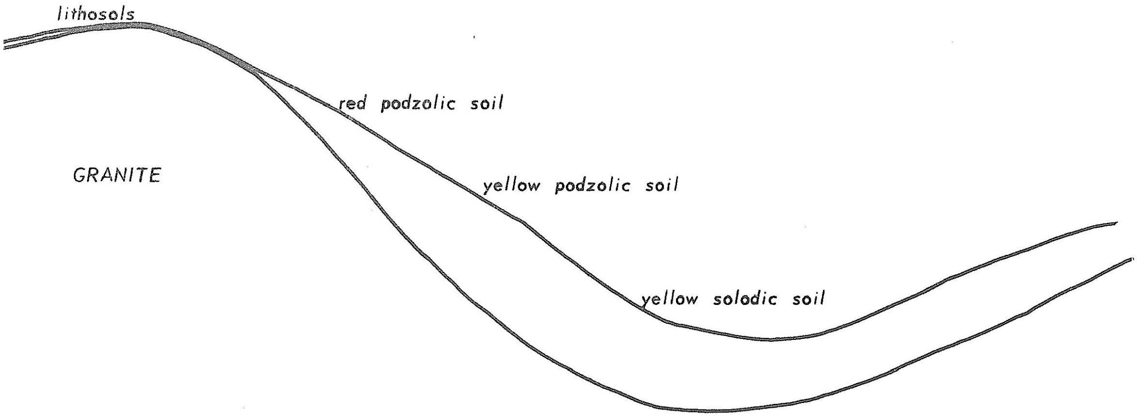


Figure 5.6 A typical section in the Red and Yellow Podzolic Soils association.

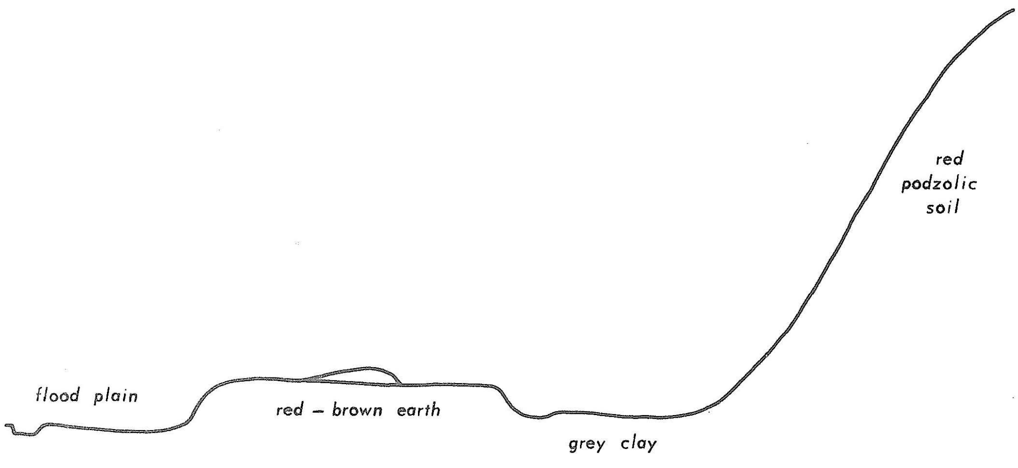


Figure 5.7 A typical section in the Solodised Red – brown Earth association.

Identification

Features used to identify this soil by the Factual Key are-:

1. Duplex texture profile.
2. Whole coloured yellow B horizon.
3. Bleached or non-bleached A_2 horizon.
4. Neutral reaction trend.

Chemical and Physical Properties

This soil is relatively fertile compared with yellow solodic soils, but it should respond to super– phosphate.

It is a moderately erodible soil requiring soil conservation structural works in most situations.

5.2.15 Hardsetting, Yellow Solonetzic Soils (Dy 3.42)

This association occupies the flat areas bordering the eastern section of Billabong Creek near Culcairn and Holbrook. It is characterised by low relief, occasional swamp and patches of gilgais. It terminates abruptly in undulating areas to the east and south, while to the west it merges with the grey and brown clay soils.

Included in the lower swampy areas are patches of grey and brown clay soils.

Morphology

This is a yellow duplex soil with a mottled (yellow-grey) B horizon and a deep bleached A_2 horizon.

Horizon	Depth (cm)	Morphology
A_1	20	Dark greyish brown (10YR 4/2 moist, 10YR 7/2 dry). Silty clay loam. Massive, very hard. pH 6. Gradual to:-
A_2	30	Light yellowish brown (10YR 6/4 moist, 5YR 7/2 dry). Silty clay loam, massive, hard. Fe–Mn nodules up to 1 cm diameter. pH 6. Abrupt to:-
B_1	100+	Yellowish brown (10YR 5/8 moist, 10YR 5/8 dry). Medium clay. Strong subangular blocky. Hard when dry. Increasing mottles of red (5YR 4/8 moist) with depth pH 6.

Identification

Identification of this soil by the Factual Key includes the following features:–

1. Duplex texture profile.
2. Yellow B horizon.
3. Bleached A_2 horizon.
4. Neutral soil reaction trend.

Chemical and Physical Properties

Soils in this map unit are of moderate to low fertility and should respond to dressings of nitrogen and superphosphate.

The soil is dispersible and hard setting. When cultivated it forms a surface crust after rain making the soil virtually impermeable to subsequent falls and excessive runoff occurs.

The soil is suitable as a construction material for soil conservation works. However, owing to the gentle nature of the terrain, few contour banks are built.

5.2.16 Yellow Solonetzic Soils (Dy5.43)

This is a sandy textured, duplex soil of low rainfall areas. Its extent is limited to a ridge of gently undulating land around Balldale.

It is differentiated from other yellow duplex soils in the district by its loose, non hard setting surface.

This soil type is used mainly for cropping and improved pastures for grazing sheep. It is moderately erodible and is prone to mild wind erosion.

Morphology

This soil appears to be formed on weathered sand. It is basically a yellow duplex soil with a mottled yellow/grey B horizon, a bleached A_2 horizon and an alkaline reaction trend.

Horizon	Depth (cm)	Morphology
A_1	10	Dark reddish brown (5YR 3/3 moist), sandy clay loam with slight blocky structure. This is a loose horizon similar to unconsolidated sand. pH 5.5. Gradual to:—
A_2	40	Brown (7.5YR 4/6 moist, 7.5YR7/3 dry) sandy loam with no structure. This horizon appears to consist of cemented sand grains and is very hard when dry. pH 7. Abrupt to:—
B	80 +	Yellowish brown (10YR 5/6 moist) with 25 percent light grey (10YR 7/2 moist) mottles. Sandy clay with a blocky structure. This also sets very hard when dry. pH 7, increasing to 8.5 with depth.

Identification

The main features used to identify this soil by the Factual Key are:-

1. Duplex texture profile.
2. Mottled yellow B horizon.
3. Bleached A_2 horizon and non hard-setting surface.
4. Alkaline reaction trend.

Chemical and Physical Properties

This soil is of moderate to low fertility and will respond to applications of phosphorus and nitrogen.

The sandy surface does not set hard so better seedling establishment is expected than of similar, hard setting soils. The characteristically loose surface will also reduce runoff during the early stages of a rainfall.

Minor sheet and slight gully erosion is evident as well as some wind erosion. The wind erosion occurs mainly during summer.

The unit is moderately erodible. The soil is suited to construction of standard banks and gully control structures.

5.3 Soil Toposequences

Throughout the district, changes in soil type occur due to topographic variation. In many instances, soil types are directly related to their topographic situation. Hence a sequence of soils dependent on topography, or a toposequence, is evident.

A range of toposequences across the major soil associations have been examined and are presented below. The diagrams are not to scale. All that is intended is a general indication of the relationship between soils and topography.

5.4 A Guide to Soil Codings

The main method of soil classification in this Manual is that of a Northcote (1971). This has been suffixed by figures that characterise the A horizon, as follows:—

Surface Texture Group/surface Structure Grade/Depth of A horizon in cm.

Surface Texture Group - The texture of the top five cm of soil, disregarding any surface litter or crust, expressed in terms of Northcote’s texture groups 1 to 6.

Surface Structure Grade –The general structural condition of the top five cm of soil, disregarding any surface crust or self, mulching characteristic, expressed in terms of Northcotes structure grades 0—3.

5.5 Soil Properties and Design Criteria

This section is concerned with soil factors which need to be considered in the design of soil conservation work in the Albury district. Details of design methods using these parameters are referred to in Section 11.

5.5.1 coefficient of runoff and soil type

The infiltration component of the coefficient of runoff 'C' varies with the following soil characteristics: —

Texture

Structure

Fabric

Surface properties

These features are used in the Northcote Factual Key, hence soils, identified by the key, can be arranged in order of potential runoff rate.

The following factors must also be considered when using this table includes cemented layers, existing erosion, and condition of the surface soil.

Increasing potential runoff rate				
0.00-0.05	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25
Um 5.22	Gn 2.15	Gn 1.22	Dy 2	Uc 2.21
Gn 2.12	Gn 2.18	Dr 2	Dy 3	
Gn 4.12		Dr 4		
		Dr 5		
		Dr 5		

5.5.2 Critical Velocities

The table below gives the critical velocities of flow to be used in bank design, depending on soil type. They must be modified according to other factors, for example, a cultivated channel requires a lower velocity than a vegetated channel.

Increasing hazard				
0.60 m/s	0.55 m/s	0.45 m/s	0.35 m/s	0.30 m/s
Ug 5	Um 5	Gn 1.2	Dy 5	Uc 2.21
	Gn 2.15	Dr 2	Dy 3	
	Gn 2.18	Dr 4	Dy 2	
	Gn 2.12			
	Gn 2.12			

The assumption is made that bank excavation will extend to the top of the B horizon. If this is not so (for example, if a soil has a particularly deep A_2 horizon) then suitable adjustment must be made allowing for the texture and structure of the material exposed after channel excavation.

Soils have been listed according to the expected detachability of their B horizons.

5.5.3 Adjustment of Stewart's 'K' for soil type

Bank spacing is principally determined by the degree of slope. However, it is also dependent on other factors such as rainfall intensity, land use, soil erodibility and infiltration.

A base value of 'K' has been calculated for erodible soils in the Albury district Section 11. This value must be modified according to the soil types nominated below.

Deduct 15% K	Deduct 10% K	No Change	add 15% K	Add 20% K	Add 30% K
Uc 2.21 Highly dispersable areas of Dy	Dy 3 Dy 2	Gn 1.2 Dy 5 Dr 2 Dr 4	Um 5 Gn 2.18	Gn 4.12	Gn 2.12

5.5.4 Erodibility

Soil erodibility is a complex parameter not easily assessed by objective means. However, basic differences between soils with respect to their resistance to erosive forces can be assessed in terms of definable soil properties.

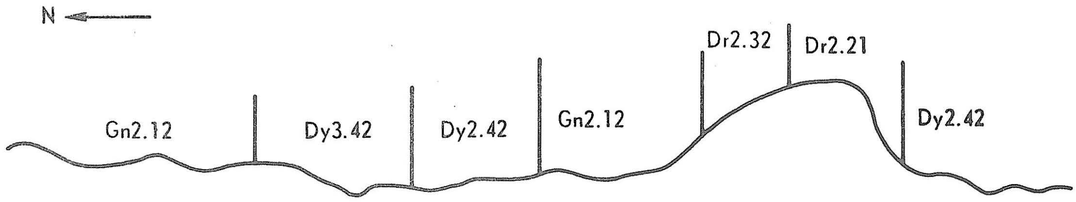
Soil erodibility is proportional to dispersibility and inversely proportional to infiltration capacity.

By assigning values to these parameters and other factors such as texture and structure, an erodibility index quantifying erodibility can be defined.

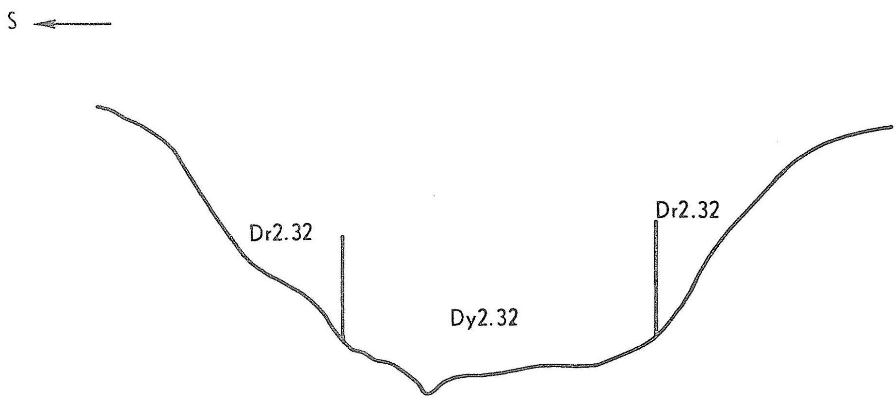
Further details are given in Charman (1975) who describes an erodibility index. Soils in the Albury district have been ranked in terms of this index in the table below:-

Low <3	Moderate 3-6	High 6-9	Very High 9-12	Extreme >12
Ug Gn 2.12 Gn 4	Gn 1 Gn 2.18	Dr Dy 2 Dy 5	Dy 3 Dy 4	Uc 2.12 Uc 2.21

GEROGERY – ALBURY



WOOMARGAMA CREEK



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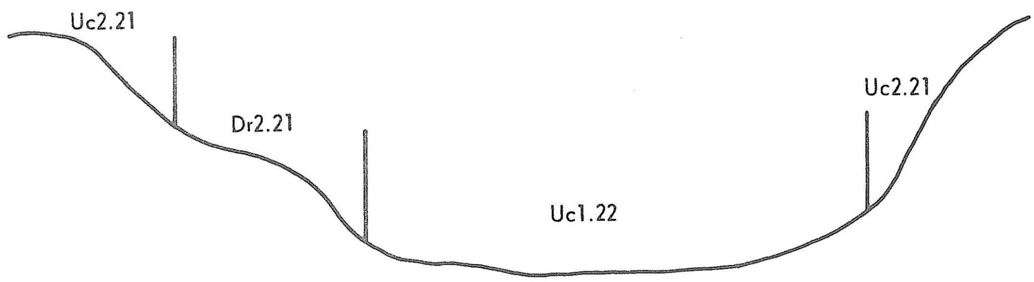
BASIN CREEK
(Uc2.21 unit)



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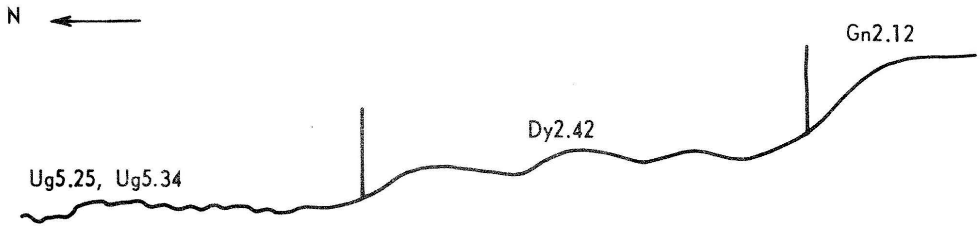
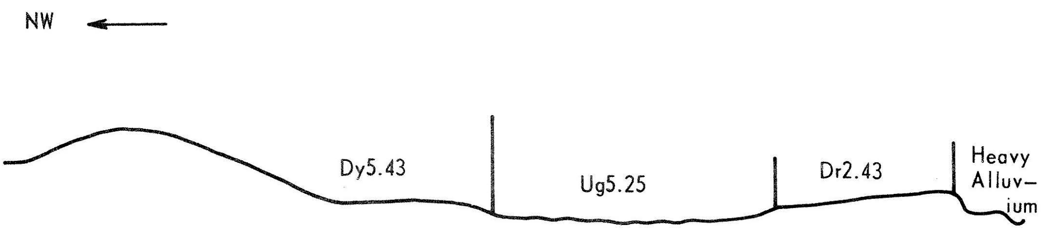
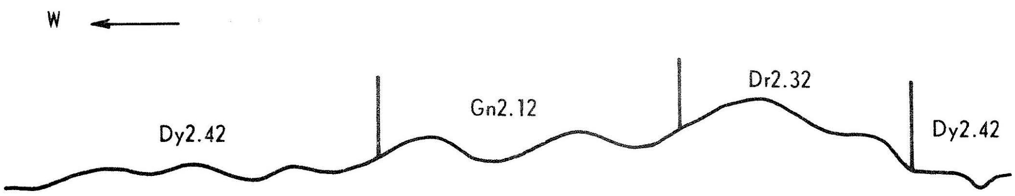
BILLABONG CREEK - BROCKLESBY



BALLDALE - HOWLONG



BROCKLESBY - BURRUMBUTTOCK



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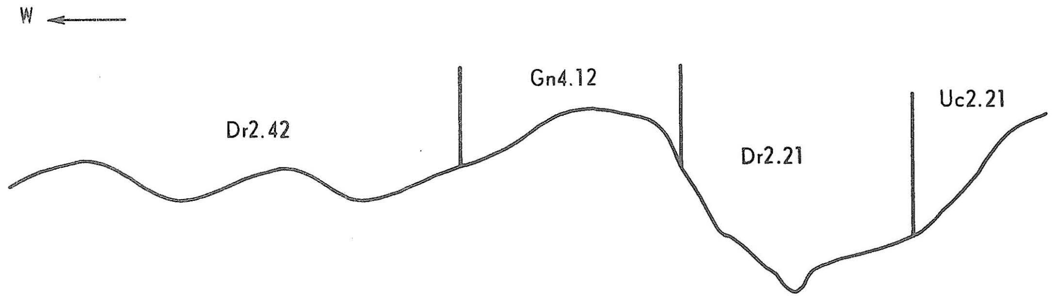
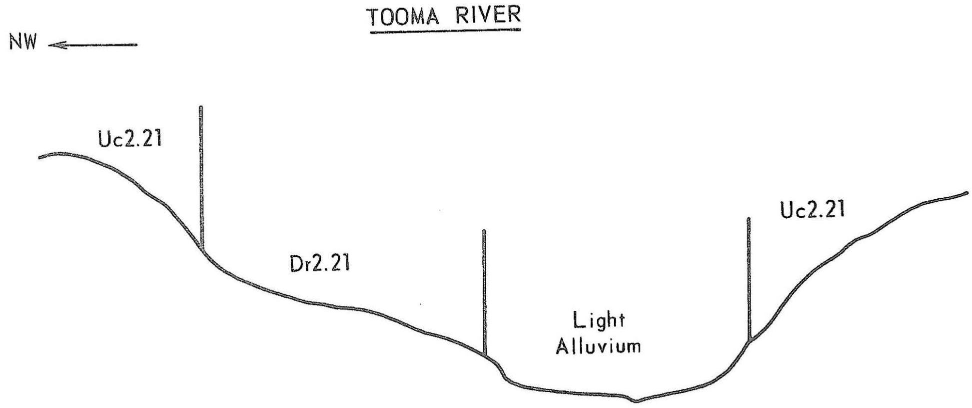
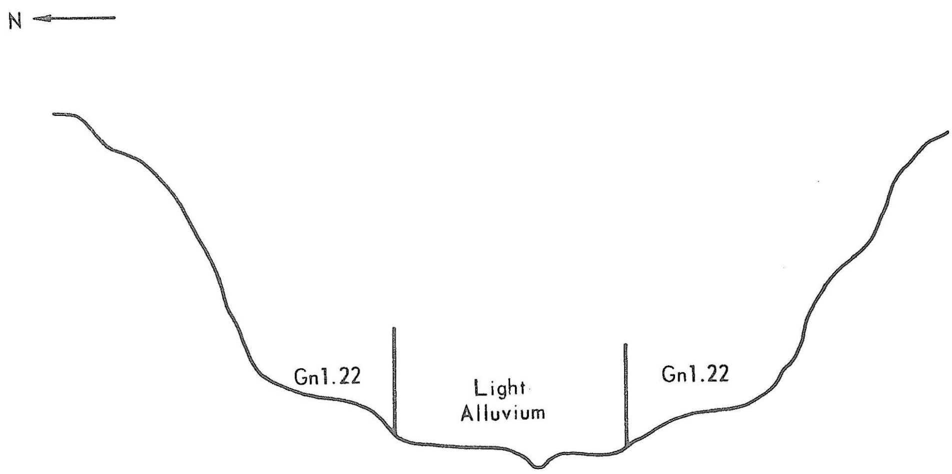
TUMBARUMBA CREEK



TOOMA RIVER



SWAMPY PLAINS RIVER



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5.6 Soil Testing and Procedures

5.6.1 Soil Tests

Wagga Research Centre provides a soil testing service primarily to aid the design and construction of earthworks in the Albury district.

The following tests are carried out as routine analyses:

- Particle size analyses
- Plastic and Liquid limits
- Dispersal Index
- Volume expansion
- Emerson crumb test

In addition the following tests are carried out on request:—

- pH
- Soluble salts total content and individual concentrations if required
- Lime requirement for acid soil.

The routine tests enable an engineering classification of the soil and together with the dispersibility tests enable the following earthwork specifications to be made:—

1. Soil compaction during construction.
2. Optimum soil moisture content for compaction.
3. Batter grades.
4. Ameliorants required (if any).
5. General suitability of the soil as a construction material.

5.6.2 Site Investigation and Soil Sampling

For some structures a visual examination of soil to one metre is sufficient to satisfy a soil conservationist of the soils suitability or otherwise as a construction material. However, deeper structures naturally require deeper sampling.

Problem sites requiring further investigation may be identified by:—

1. Seepage patches which may indicate clay or rock near the surface.
2. Deep gullies which may indicate a highly erodible soil.
3. Wormy appearance of soil on gully wall which may indicate dispersible soil.
4. Tunnels which definitely indicate dispersible soils.
5. clay disperses readily in water or fails to settle when shaken with water in a test tube may indicate dispersible soil.
6. sandy textured soil may indicate low water holding ability.
7. Red, well aggregated soil with an earthy appearance may indicate low water holding ability.

The sampling intensity required depends on the severity of the problem and the importance of the structure, in terms of the whole soil conservation design.

Ideally, about two kilograms of soil (half a sample bag) should be collected from each soil variate. over the site, to the depth of the proposed excavation.

The samples should be sent to the Officer—in—Charge at Wagga Research Centre, along with a completed soil testing request form. The accuracy and value of subsequent recommendations are directly proportional to how representative the samples are, and the detail supplied on the request form, Sampling assistance can be provided, on request, by Research Centre staff

6 VEGETATION

W.H. Johnston

6.1 Introduction

The climax vegetation of portions of the Albury district has previously been studied in the catchment of the Hume weir (Morland, 1958) and areas to the west and north–west of Albury (Moore, 1953). In both studies, the basic unit of classification was the association which Moore (loc. cit.) defined as a community with the same dominant species over the whole of its range and in general having uniform structure.

The vegetation of the Hume catchment was mapped and described in terms of plant associations, whereas Moore (loc. cit.) grouped associations into larger units termed alliances. Alliances are groups of floristically related associations of similar structure.

There are several problems in classifying vegetation according to defined taxonomic and structural attributes.

Among the more important are:–

1. Where classification involves recognition of both structural and taxonomic attributes, it is difficult to account for a change in structure which does not involve the dominant strata.
2. The grouping of vegetation units into lower categories, e.g. from association to alliance, frequently results in a loss of sensitivity with respect to the effect of environment on plant distribution. This problem is most important where environmental factors show rapid gradation over small distances or where the magnitude of change is large. These gradients include such factors as rainfall, temperature, evaporation, soil type and slope.
3. Vegetation relationships in a survey undertaken for a specific purpose aside from pure classification, may not be distinct when taxonomic groupings are used.

The vegetation of all the Albury district has been re-surveyed. Although the information provided by Moore and Morland has been extensively used, the unit of classification has been re–defined and the various alliances and associations reorganized. (see figure 6.1)

6.2 Study Objectives

The object of studying vegetation in relation to soil erosion and conservation is threefold.

1. vegetation is a basic physical characteristic of an area. Its definition is an important item in the physical resource inventory
2. vegetation usually reflects those features of a habitat which are important for plant growth. Vegetation may therefore indicate areas of particular erosion risk or conservation problems
3. The characteristics of particular communities, either in the climax or natural state, or as influenced by man, are important in terms of land management. Although the activities of man, his domesticated livestock, pests and diseases have influenced all the plant communities of the Albury district, the effects of previous management are frequently related to the climax communities of an area.

6.3 Plant Communities and structural Organization

The basic unit of vegetation in this study is the community. The community is defined as an assemblage of plant species having similar structural features and dominant strata. Similar communities usually occupy similar habitats.

The term community is preferred because although taxonomic differences may occur within similar communities at the sub—dominant level, the effect may not be sufficient to warrant the definition of a separate community. The effect may, however, necessitate the recognition of a different plant association. The term community therefore emphasises gross differences in the vegetation pattern.

Within the Albury district, nine plant communities have been defined. The distribution of these communities is shown on the accompanying vegetation map.

Five vegetation formations have been recognised. These are also listed in Table 6.1. In general terms, the distribution of different vegetation formations is related primarily to rainfall (Prescott, 1949) or more correctly moisture availability throughout the year. The distribution or occurrence of different plant species within given formations is influenced by other factors such as soil depth and drainage, soil pH, temperature and aspect.

Figure 6.1

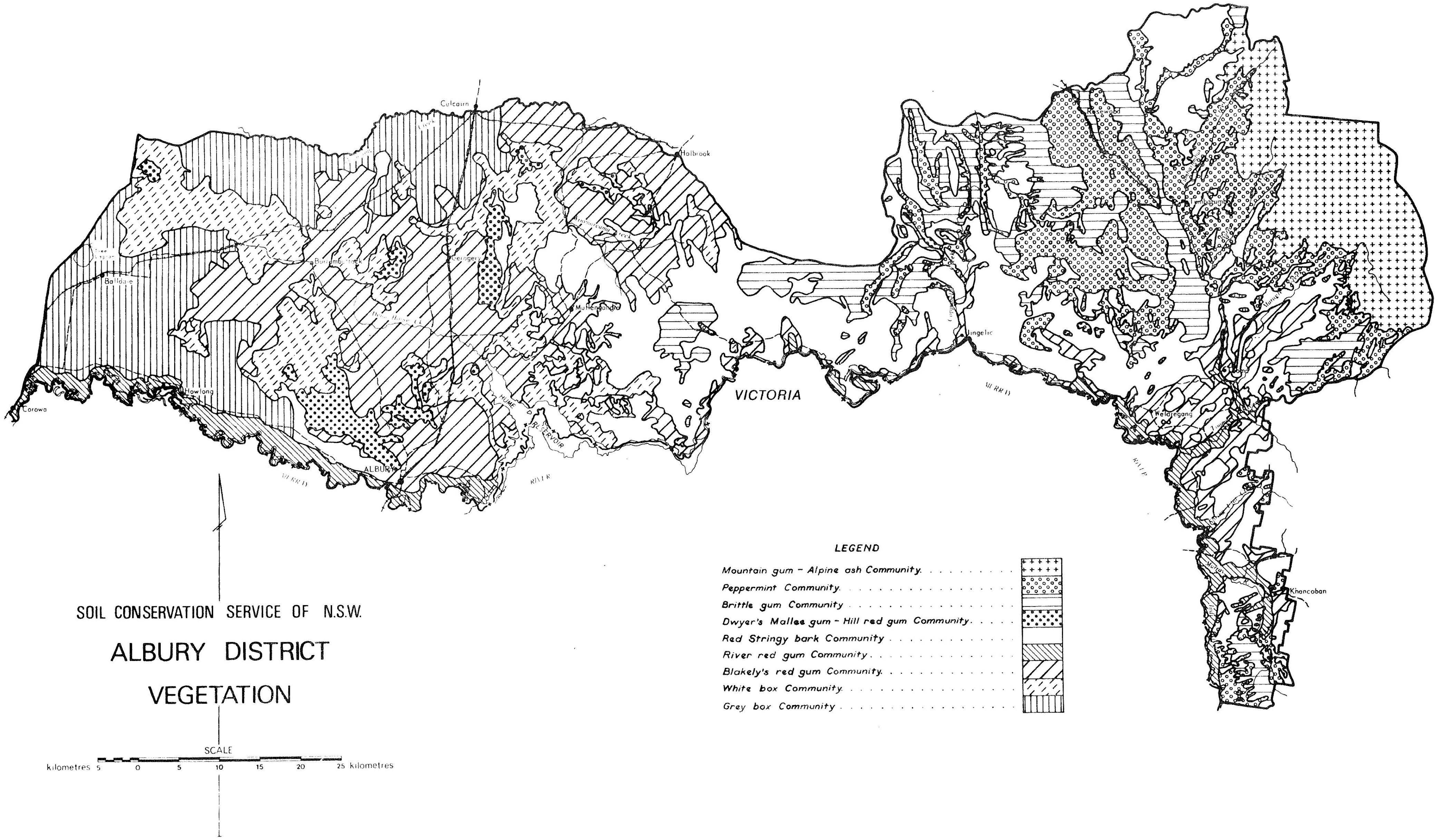

SOIL CONSERVATION SERVICE OF N.S.W.
ALBURY DISTRICT
VEGETATION
SCALE
kilometres 5 0 5 10 15 20 25 kilometres
LEGEND
Mountain gum – Alpine ash Community
Peppermint Community
Brittle gum Community
Dwyer's Mallee gum – Hill red gum Community
Red Stringy bark Community
River red gum Community
Blakely's red gum Community
White box Community
Grey box Community
Culcairn
Holbrook
Corowa
Howlong
Albury
Jingellic
Khancoban
VICTORIA
S.C.S 11084E

Table 6.1
Plant Communities of the Albury district and their Relationship with the Associations of Morland (1958) and Alliance of Moore (1953)

Formation and Community	Plant Associations (Morland)	Alliance (Moore)
Wet Sclerophyll. Forest Formation		
Eucalyptus dairympleana E. delegatensis (Mountain gum alpine ash) Community	*E. dalrympleana – ~~E. pauciflora~~ *E. delegatensis *E. fastigata (Brown barrel) *E radiata spp. robertsonii (Narrow leaved peppermint) – E. dairympleana	
Intermediate Sclerophyll Forest Formation		
E. radiata spp. robertsonii (Narrow leaved peppermint) Community	*E. radiata spp. robertsonii E. viminalis (ribbon gum) *E. radiata spp. robertsonii E. stjobnii syn. bicostata (Eurabbie; blue gum) *E. radiata spp. robertsonii E. bridgesiana (apple box) E. rubida (ribbon gum)	
E. mannifera sub sp. maculosa (Brittle gum; red spotted gum)	*E. radiata spp. robertsonii E. mannifera sub sp. maculosa *E. macrorrhyncha - E. dives E. mannifera sub sp. maculosa	
E. dwyeri – E. dealbata (Dwyers Mallee gum, Hill red gum) community		E. dealbata - E. sideroxylon

Dry Sclerophyll Forest Formation		
E. macrorrhyncha (Red Stringybark) Community	*E. macrorrhyncha - E. dives (broad leaved peppermint) *E. bridgesiana *E. macrorrhyncha - E. dives - *E. elaeophora (bundy; apple)	
	*E. macrorrhyncha - E. polyanthemos (Red box)	E. macrorrhyncha - E. rossii
	*E macrorrhyncha - E. rossii (scribbly gum)	E. macrorrhyncha - E. rossii
	*Callitris endlicheri syn. calcarata(Black Cypress Pine)	E. dealbata – E. sideroxylon (Mugga Ironbark)
Tall Woodland Formation		
E camaldulensis (River red gum) community	*E. camaldulensis	E. camaldulensis
Savannah Woodland Formation		
E. blakelyi (Blakely's Red Gum)	*E. blakelyi - E. melliodora (Yellow box) - E. bridgesiana	E. albens
E. albens (White box) Community	*E. albens	E. albens
E. woollsiana (Grey box)-		E. woolisiana

**Of insignificant occurrence

6.4 Wet Sclerophyll Forest Formation

This structural form is represented by a Eucalyptus dalrympleana E delegatensis (Mountain gum - alpine ash) community.

This tall forest community occupies extensive areas of sheltered mountain slopes in the upper Murray River catchment. Although floristically complex, it occupies largely inaccessable areas and thus is difficult to survey with accuracy. It is characterised by tall trees with a well developed mesomorphic shrub stratum and generally a well developed herbaceous ground cover. In more exposed situations, the community is replaced by E pauciflora snow gum, the areas involved, however, are small.

At lower altitudes and in less favourable situations, the community becomes gradational, with E. radiata spp robertsonii - narrow leaved peppermint, forming an indistinct boundary between the wet and intermediate sclerophyll forest formations.

6.5 Intermediate Sclerophyll Forest Formation

The intermediate sclerophyll forest was define by Story (1969) to distinguish between the true wet sclerophyll forest and a gradational form having a larger component of xeric species. Communities are characterised by tall trees of forest form - i.e. flat topped crowns whose depth is less than half the length of the bole with a closed canopy and a well developed herbaceous stratum. The shrub stratum is generally poorly developed. In the Albury district, this vegetation form is represented by an E. radiata spp. robertsonii (narrow leaved peppermint) community.

B. radiata spp. robertsonii is widely distributed in the east of the Albury district. In steep sheltered valleys, such as below Paddy’s River Falls, the species is associated with E. viminalis (ribbon gum). In sheltered, more gently undulating areas, E. St. johnii syn. bicostata (Eurabbie blue gum) assumes importance. Throughout the area of occurrence, E. bridgesiana (apple box) is the most frequent associate of B. radiata spp. robertsonii. At several locations, all four species occur together.

Although generally the shrub stratum is absent or poorly developed, examples may be found where this is not the case. In most areas where relatively undisturbed forest remains, ground cover is provided by a well developed herbaceous layer.

The intermediate sclerophyll forest formation, although not sharply defined from the wet sclerophyll forest, gives way abruptly to the dry sclerophyll forest and woodland formations. The replacement of one community by another is ascribed to changes in the pattern of moisture availability and results from a change in rainfall, modified by factors such as slope, aspect, topography and exposure.

6.6 Dry Selerophyll Forest Formation

Communities in this formation are dominated by trees of forest form. The crowns are continuous, or nearly so and there is usually a well developed stratum of xeromorphic shrubs. The herbaceous stratum is usually poorly developed and may be absent or discontinuous.

Community structure varies from the typical forest form to a community tending more towards a scrub than a forest. In some situations, they may approach a woodland form, but this is usually due to the activities of man.

Three dry sclerophyll forest communities occur in the Albury district.

(a) E. macrorrhyncha (red stringybark) community.

(b) E. mannifera sub. sp. maculosa (brittle gum; red spotted gum) community.

(c) E dwyeri - E dealbata (Dwyer's mallee gum hill red gum) community.

The latter community has been defined to overcome the problem of separating these two very similar species. In fact, it may be more correct to define this community as two separate communities, although the species frequently occur together to a variable extent.

(a) E. macrorrhyncha community

This community occurs widely in the eastern and central portions of the district on the more exposed hills and ridges. It is typically of forest form and is sharply defined in the vegetation pattern.

Both shrub and herbaceous strata are poorly developed or discontinuous. Although in some situations wattles (Acacia spp.) and black pine (Callitris endlicheri) assume importance, the areas involved are usually discrete and insignificant in extent.

E. macrorrhyncha occurs in association with E. polyanthemos (Red box) on exposed lower slopes usually at the boundary between the dry sclerophyll forest and woodland formations. In higher rainfall areas and where shelter is provided by surrounding hills, E. dives (broad leaved peppermint), elaeophora (bundy apple) and E. bridgesiana frequently occur in association with S. macrorrhyncha.

(b) E. mannifera sub spp.maculosa community

This community is characterized by a poorly developed herbaceous stratum and a moderately developed shrub stratum. It occurs either on the ridges in sheltered situations or on upper slopes within the E. macrorrhyncha community. It appears to prefer shallow soils on ridges of sedimentary origin[1] although it is also found on granite between Rosewood and Tumbarumba.

(c) E. dwyeri - E. dealbata community

This community is restricted to the rocky hills and ranges in the central and north–western portions of the district. Although considered a dry sclerophyll forest formation, the height of the dominant strata rarely exceeds six metres. In some situations, it is more like a mallee scrub than a forest.

Although E. dwyeri and E. dealbata seldom occur together in equal proportions, both species occupy similar habitats and give rise to a similar vegetation. Occurrence is related to geology in that E. dealbata prefers basic parent material, while E. dwyeri is generally found on siliceous parent rocks.

6.7 Tall Woodland Formation

Communities in this formation are characterized by tall trees in which the depth of the crown exceeds the length of the bole. The crowns are rarely continuous. A small tree or shrub layer may be poorly developed but a herbaceous stratum is always present and may be either continuous or discontinuous.

In the Albury district, this vegetation form is represented by the E. camaldulensis (river red gum) community.

E camaldulensis is restricted to the immediate vicinity of watercourses and areas subject to frequent flooding. Although it reaches maximum development along the flood-plain of the Murray River, it also occurs along the Billabong Creek in the north and in swamp areas such as Walla Walla Tank. On smaller, intermittent streams, such as the Burrumbuttock Creek and Red Creek near Culcairn, E. camaldulensis is replaced by E. blakelyi. In wet areas subject to cold air drainage in the east,it is replaced by E. stellulata (black sallee).

6.8 Savannah Woodland Formation

Savannah woodland communities are characterized by medium sized trees of woodland form in which the shrub stratum is poorly developed or absent and the herbaceous stratum is mostly continuous. Tree density may vary considerably but generally trees are scattered and their crowns rarely continuous.

Savannah woodlands occur throughout the central and western portions of the district, mainly on undulating ridges, lower slopes or flat areas. Three communities have been defined:–

(a) E. blakelyi (Blakely’s red gum) community

(b) E. albens (white box) community

(c) E. woollsiana (grey box) community.

(d) E. blakelyi community

This community prefers a more favourable moisture regime than the other savannah woodland communities. In the east it occurs on lower slopes and along drainage lines extending to the crest of lower ridges. In the central and western portions, it occurs on flatter areas which are subject to runoff from adjacent hills and along smaller watercourses.

The E. blakelyi community is a mixed community that shows considerable gradation with respect to other woodland communities. E. melliodora (yellow box) is also a frequent associate of B. blakelyi and in some situations it could be justified to delineate these two species as separate communities.

(b) E. albens conununity

E. albens occurs predominantly on better drained sites in the central and western portions of the district. It usually occurs on slight undulating ridges or around the base of hills. This community shows gradation with both the E. blakelyi and E. woollsiana communities and may also associate with E. polyanthemos.

(c) E. woollsiana community

E. woollsiana occurs on flatter areas in the central and western portions of the district. It does not occur on freely draining sites or on areas subject to waterlogging or regular flooding.

6.9 Understory Vegetation

A comprehensive list of species common in the plant communities of the Albury area is given by Moore (bc. cit.). The grasslands of the Hume Weir catchment have been mapped by Morland (loc. cit.) (Map SCS 852). A list of ground cover species common in the Albury district is given in Table 6.2.

6.10 Factors affecting the distribution of vegetation

The principal factor influencing the distribution of vegetation in the Albury district is altitude, which varies from in excess of 1800 metres near the headwaters of the Murray river to about 150 metres at Corowa. This causes a climatic change which is the main determinant factor. Locally, the effect of altitude is modified by topography and exposure, which are important in terms of seasonal moisture availability an4 rainfall effectiveness.

Relationships between the vegetation pattern and landform are shown in Figure 6.2.

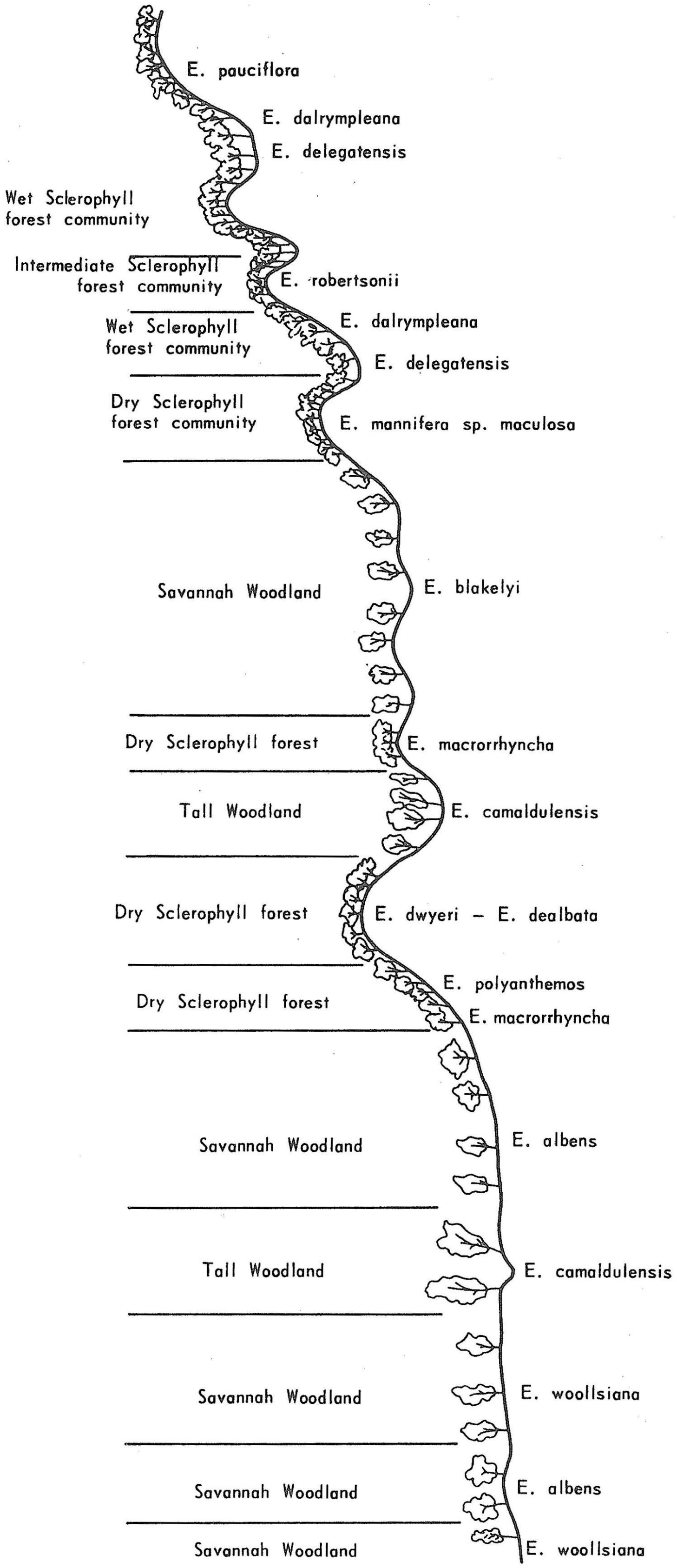


Figure 6.2 GENERAL RELATIONSHIP BETWEEN VEGETATION AND LANDFORM – ALBURY DISTRICT (Not to Scale)

S.C.S 12432/8

Table 6.2
Grasses and Legumes of particular significance
in the Albury Area

A. GRAMINEAE

Species	Common Name	Significance
Agropyron scabrum	Common Wheat grass	Occurs throughout area; perennial warm season grass susceptible to overgrazing.
Aristida behriana	Brush wire grass (Three awned spear grass)	Low productive species occurring in all communities; sharp seeds and awns Cause damage to sheep.
Bothriochloa ambigua	Red leg grass	A tufted perennial found in all communities except *E. camaldulensis* community. Unpalatable grass when rank, generally regarded as a weed in pasture.
Bromus diandrous	Brome grass or great brome	A tufted annual. Common weed of summer months on waste or cultivated ground.
Chloris truncata	Windmill grass	Occurs in all communities except *E. camaldulensis*. A tufted warm season species common in heavily grazed native pastures. Produces little leafy material.
Danthonia spp.	Wallaby grass	Occurs throughout area. A short, tufted, warm season perennial of considerable economic value, providing some feed during the cooler months as well as at other times of the year.
Enneapogon nigra	Nigger heads	A small tufted shortlived perennial found mainly in E. woollsiana and E. albens communities. Important constituent of native pastures particularly in dry woodlands.
Hordeum leporinium	Barley grass	Rapid growing winter annual providing useful feed when young but causing mechanical injury to stock as seed ripens. Found throughout district.

Panicum effusum	Hairy panic	Found in all communities except <u>*E. camaldulensis*</u> community. A perennial drought tolerant species, providing valuable feed. May cause photosensitization in sheep when immature.
Serrafalcus mollis	Soft Brome	Occurs throughout the area; a tufted annual of erect habit. It is palatable to stock and is valuable for winter feed in both improved and unimproved pasture.
<u>B LEGUMINOSAE</u>		
Medicago spp	Medics are an important component of both native and improved pastures, particularly in the woodland communities. Most numerous species are <u>*M. polymorpha*</u> (burr medic) which, although adversely affecting wool quality, provides large quantities of green and dry feed which is readily eaten by stock. A second species of importance is <u>M. minima</u> (woolly burr medic).	
Trifolium spp	Clovers represent the most important constituent of improved pasture in the district. They are widespread and occur throughout the area. Although strictly speaking all species are exotic, some naturalised forms occur. These *are* <u>*T. arvense*</u> (haresfoot clover), <u>*T. dubium*</u> (yellow suckling clover), <u>*T. gloveratum*</u> (ball or clustered clover) and *T campestre* (hop clover). Many cultivars of subterranean clover occur but are generally restricted to improved pasture areas.	

<u>6.11 Vegetation and Land Use</u>

Relationships between vegetation and land use are confounded by the effect of landform. Land use is primarily related to accessibility, the ease of clearing, cultivation and other management practices. In the east, land use is limited by rugged terrain and significant tracts of undisturbed forest occur. Within this zone, intensive agricultural development has occurred along the flood plains of major watercourse such as the Murray River, Tooma River and Maragle Creek. Tobacco growing occurs near Tooma with minor dairying. Elsewhere, improved pasture for grazing is the principal form of land use.

Table 6.3 lists the climax communities in relation to both type and intensity of land use.

Table 6.3
Vegetation and Land Use Relationships –
Albury District

Wet Sclerophyll Forest

E. dalrympleana - *E. delegatensis* Community

As much of the area occupied by this community is of rugged terrain, it is not extensively utilized for agriculture. Land use includes catchment protection and recreation with minor forestry and grazing.

Intermediate Sclerophyll Forest

E robertsonii Community

Utilized extensively for grazing of improved pasture. In favourable areas, some winter cereals sown f or grazing; minor vegetables and other crops.

Dry Sclerophyll Forest

E. macrorrhyncha Community

Except in forest reserves, extensively cleared for grazing of both improved and native pastures. Areas generally too steep for cropping.

E. mannifera spp. *inaculosa* Community

Utilized to a moderate extent for grazing of improved pastures.

E. dwyeri - *E. dealbata* Community

Utilized to a small extent for grazing of native pastures.

Tall Woodland

E. camaldulensis Community

Extensively utilized for grazing of improved pastures with minor specialist cropping such as tobacco and millet. Much of the area subject to frequent flooding is undeveloped.

Savannah Woodland

E. blakelyi Community

Utilized mainly for grazing of improved pastures, with winter cereal production assuming importance in the central and north–western areas.

E. albens Community

Utilized extensively for both cropping and grazing. These prime wheat growing areas generally include an improved pasture ley period in the cereal rotation.

E. woolisiana Community

utilized also for both grazing and cropping.

6.12 Vegetation and Erosion

Erosion within the wet sclerophyll forest appears restricted to stream banks with minor gullying when areas have been over–cleared or over–grazed. The relatively stable nature of these areas appears to be due to inherent soil stability, together with climatic conditions which allow pasture growth throughout the warmer part of the year.

In the intermediate sclerophyll forest, gully erosion is more prevalent, particularly where steeper slopes have been cleared. Frequently, as in the case of the dry sclerophyll forest, these areas contribute runoff to lower areas occupied by woodland communities resulting in both gullying and siltation. Sheet erosion and landslips are more frequently associated with the dry sclerophyll forest.

In the central and western portions of the district, sheet and gully erosion is a problem associated with both the dry sclerophyll forest and woodland, Where areas once occupied by E. albens are cropped, gullying may be a problem. Elsewhere, uncontrolled runoff from higher land results in damage to intermediate and lower slopes.

7 LAND USE

R.J.Crouch

7.1 Introduction

Since European settlement, landuse has only fluctuated slightly, despite large changes in economic conditions. The nature of the country and extremes of climate and topography are the reasons for general stability.

The western area is predominantly under a wheat– pasture (sheep) rotation, while the central and eastern sections are either forest or sheep and cattle grazing depending on accessibility.

Orchard and vegetable crops are grown for the local market around Albury as well as between Tumbarumba and Batlow on fertile basalt soils. The areal extent and type of vegetable crops varies depending on the prevailing market.

Landuse was mapped into classes as follows

LANDUSE	MAPPING UNIT	EXAMPLE
Arable	A. Intensive cropping	Row crops, horticulture
	B. Extensive cropping	Dryland cereals summer crops
Grazing and Arable	C. Intensive farming	Dairying
	D. Mixed farming	Sheep and wheat farming
Grazing	E. improved and Semi–improved pastures	
	F. Native pastures	
Forest	G. Forestry plantations	
	H. Native timber	
Special	I. Other uses	Mining, Urban, Recreation

Mapping was based on 1:50 000 photomosaics, from aerial photography taken between 1959 and 1964 and field reconnaisance along major roads. (see figure 7.1)

7.2 Landuse Units

7.2.1 Intensive Cropping

Intensive cropping is found near the town of Albury and between Tumbarumba and Batlow.

Around Albury it consists primarily of stone fruit orchards and small market gardens supplying the local market. Intensive cropping is found on the recent alluvial deposits of nearby small creeks, while some orchards spread onto undulating areas of red and yellow earths.

With the development of Albury as a growth centre, much of this land is being subdivided for urban development. This has resulted in land not previously considered suitable being used for orchards. Consequently erosion has increased in this area.

The Soil Conservation Service has recently been involved in the establishment of orchards and vineyards in the Tabletop and Gerogery areas.

Between Tumbarumba and Batlow, there is intensive cropping of potatoes and peas as well as apple and pear orchards. The area is limited to the fertile basalt soils on the ridges, the latter providing a longer frost free period than the adjacent valleys.

The orchard area has increased 25 percent in the 22 years between 1950–51 and 1972–73.

The intensively cropped areas around Tumbarumba present a greater erosion hazard than the areas around Albury. Steeper slopes combined with a higher rainfall are conducive to gully development, despite the low inherent erodibility of the soil.

Tobacco is grown to a limited extent (32 hectares on two farms in 1972–73) on alluvial flats south of Tooma.

7.2.2 Extensive Cropping

The winter dominant rainfall of the Albury district does not generally suit extensive cropping, and since little water is available for irrigation, the total area of extensive cropping is small variable.

Summer crops, grown in conjunction with wheat, include sunflowers, sorghum, maize, lupins, safflower and soyabeans. The total area of these crops varies annually but is rarely above 1 000 hectares.

Summer cropping is scattered throughout the wheat/sheep areas of the district and therefore this unit has been included in the mixed farming unit on the map.

7.2.3 Intensive Farming

Dairying is limited to two or three farms on the flood plains west of Albury and about thirty farms on flats along the lower section of the Tooma River.

The Albury dairy farms supply milk for local consumption, while those in the Tooma River supply whole milk to a processing factory at Corryong.

Small piggeries are associated with some dairies, which rely largely on imported grain and forage crops.

West of Albury there are two large piggeries - one between Albury and Howlong, the other near Corowa. In addition, a few pigs are run on properties utilising locally or home grown wheat, oats or barley.

7.2.4 Mixed Farming

Mixed farming is primarily restricted to the flat to undulating western section of the district. Small areas also occur on the plateau areas about Tumbarumba, but these have not been mapped.

Usually, it consists of a cereal/pasture rotation, with sheep predominating in the west and cattle in the east.

Typically the rotation is three years crop followed by at least five years pasture. Cereals include wheat, oats and/or barley, depending on the area and prevailing prices.

Over the whole area wheat is grown, but barley tends to be restricted to the west of the district while oats are restricted to the east. For example, in 1972—73, barley acreages were equivalent to wheat in the Corowa Shire. In the Culcairn and Hume Shires, barley acreages were insignificant, whilst the area of oats almost equalled that of wheat.

In recent years, rapeseed has been produced as an alternative to cereals. 1 000 hectares were grown in the district during 1972—73.

This unit along with areas mapped as improved pasture present major erosion hazard. However, most farmers are aware of this and farm accordingly. Stubble burning is practised widely.

7.2.5 Improved and semi—improved pasture

Most of the Albury district which is too steep for cropping but still relatively accessible, has been cleared and improved. Much of this improvement has involved addition of large amounts of superphosphate to encourage introduced subterranean clover and ryegrass pastures.

The areas are currently used for both sheep and cattle grazing.

In intensively improved areas, the summer growing native species have been killed out by the introduced winter species. This has resulted in the soil being left bare during late summers This promotes high runoff yields and soil loss during summer storms, or serious wind erosion in the west of the district.

The land found within this unit generally requires soil conservation structural works.

7.2.6 Native Pastures

Generally, most district pastures have been improved, if only by the application of superphosphate and the natural spread of subterranean clover.

The areas mapped as native pastures have either never been improved or have not responded to the improvement. These are mainly infertile steep areas in the west and cleared but relatively inaccessible areas in the east. They all still carry a moderate tree density. Many small patches particularly on steep ridges, may also be found within areas mapped as improved.

These areas, carry only sparse vegetation. The resultant high runoff causes sheet erosion and may promote erosion on lower, more fertile slopes.

The most successful soil conservation technique is contour chisel seeding. The small furrows aid infiltration, catch fertilizer and dung in runoff water and hence improve seedling establishment and growth.

7.2.7 Forestry Plantations

Forest plantations are confined to the north - east corner of the district. They consist primarily of radiata pine (Pinus radiata) with smaller plantings of Pinus laricio and Pseudotsuga menziesii (Douglas fir). Both trials and field experience have shown that P.radiata is the most profitable species below 950 metres, with P. laricio preferred above this altitude.

Above 1 100 metres the native alpine ash (Eucalyptus delegatensis) is superior to the conifers. This is being managed for timber production by the Forestry Commission.

Timber is processed largely outside the Albury district.

There is some erosion from plantation areas during the establishment stage. The Forestry Commission now give special attention to plantation designs which minimise the erosion risk.

7.2.8 Native Timber

East of the Hume Highway, the majority of the district is covered by native timber communities of red stringybark (Eucalyptus macrorrhyncha), peppermint (E. robertsonii), mountain gum (E. dalrympleana), alpine ash (E. dele atensis), brittle gum (E. mannifera) and Blakely’s red gum E. blakelyi).

These areas have not been cleared for agricultural production mainly because of their inaccessibility.

The mountain gum - alpine ash community is the only community which can be utilized for timber production. The remaining communities have virtually all marketable timber removed.

The driest parts of the area are subject to low to moderate erosion, resulting from periodic grazing and burning. The wetter, high altitude areas have a better tree cover which provides excellent protection of the soil.

7.2.9 Other Uses

Areas around Albury and to a lesser extent around Tumbarumba and Corowa have been urbanised.

The Soil Conservation Service has been heavily involved in the development of the Albury-Wodonga Growth Centre. (See section 13)

7.3 Farm Size and Landuse

Farm sizes range from a few hectares to over 3 500 hectares.

Across the district, the average farm size changes with topography and rainfall. It is about 450 hectares in the Hume and Tumbarumba Shires, reducing to 370 hectares in the undulating country of Culcairn Shire and increasing again to 620 hectares in Corowa Shire.

Properties relying on orchard production as a major source of income are much smaller. They range from 61 to 114 hectares in the Tumbarumba Shire with an average of 11 hectares per property being used for fruit production.

7.4 Landuse potential and possible trends

The development of land in the Albury district has been dependent on the economics of the various enterprises.

The winter dominant rainfall suits the winter wheats and pastures of subterranean clover and rye grass. However, it does not suit extensive cultivation of summer growing crops such as sunflowers or sorghum. Increased irrigation facilities would increase the potential for summer cropping and may increase the area of extensive cropping at the expense of the mixed farming area. Development along these lines is not expected for some time.

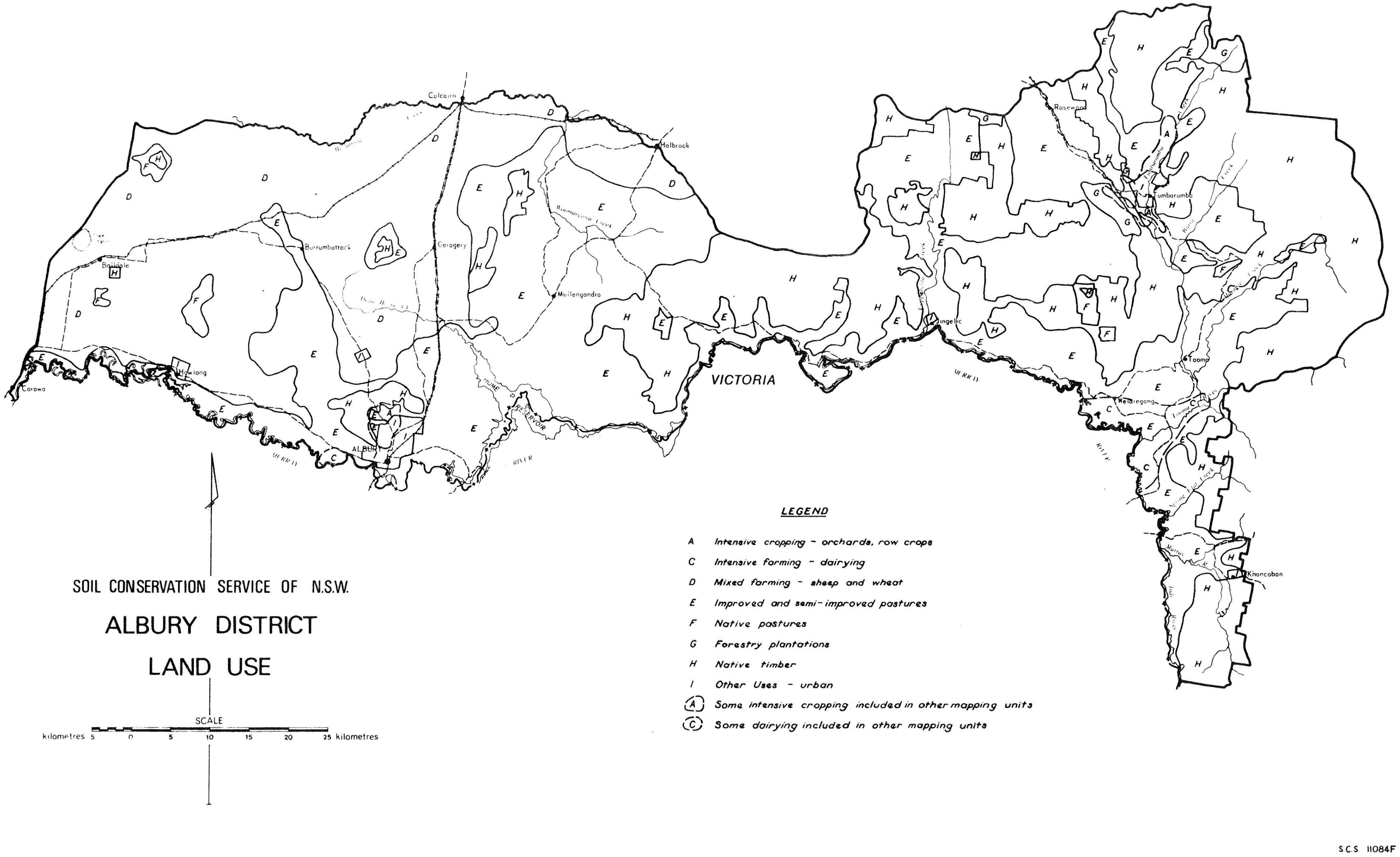
Winter growing rapeseed has gained popularity as an alternative to wheat and this trend is expected to continue.

The remaining area is generally too steep for cultivation and little cropping except for grazing oats is carried out. Sheep and cattle populations fluctuate with the viability of each enterprise.

The area of improved pasture could be increased on the steeper lands where the soil has been derived from slates and shales, providing contour chisel seeding is carried out.

In the long term, large areas about Tooma could be used for more intensive dairying, while much more intensive use could be made of the basalt soils about Tumbarumba for pome fruit and potato production.

Figure 7.1


SOIL CONSERVATION SERVICE OF N.S.W.
ALBURY DISTRICT
LAND USE
SCALE
kilometres 5 0 5 10 15 20 25 kilometres
LEGEND
A Intensive cropping - orchards, row crops
C Intensive farming - dairying
D Mixed farming - sheep and wheat
E Improved and semi-improved pastures
F Native pastures
G Forestry plantations
H Native timber
I Other Uses - urban
(A) Some intensive cropping included in other mapping units
(C) Some dairying included in other mapping units
VICTORIA
Culcairn
Holbrook
Burrumbuttock
Gerogery
Mullengandra
Howlong
Corowa
ALBURY
Rosewood
Tumbarumba
Tooma
Jingellic
Walbregong
Khancoban
S.C.S 11084F

8 **EROSION**

C.M. Adamson

8.1 General

Erosion is widespread in the Albury district. Its distribution and severity are influenced by soil type, topography, land use and annual rainfall.

The worst affected areas are located in the western and central parts of the district between Brocklesby and Holbrook. In this area annual rainfall varies from 550 to 750 millimetres.

In the east, topography becomes steeper but erosion severity decreases. This is due to the predominance of grazing and better plant growth conditions. A large proportion of this area remains under natural forest or has been reafforested.

8.2 The Erosion Map

Six erosion classes have been mapped, based on the criteria of Higginson (1970). The classes are:

- no appreciable erosion
- slight to moderate sheet erosion
- moderate to severe sheet erosion
- minor gully erosion
- moderate gully erosion
- severe gully erosion

Mapping was done in consultation with local soil conservationists and subsequent aerial photograph interpretation. (see figure 8.1)

8.3 No appreciable erosion

Fifty-eight percent of the district has been classified as having no appreciable erosion.

In the agricultural areas this includes the low slope land of the Riverina plain and the rolling grazing country around Tumbarumba.

Grey and brown clay soils and solodized red brown earths are principally associated with the Riverina plain.

Large areas of steep country that have remained under forest are also included in this unit. Apart from natural geologic erosion, accelerated erosion is not a feature of these areas. However, on clearing, heavy soil losses can be expected until revegetation is complete.

8.4 sheet Erosion

Approximately 14 percent of the district is affected by some form of sheet erosion.

This is particularly evident in hilly areas where it results from clearing and overgrazing. Soils are the shallow red podzolic soils and lithosolic soils.

Gully erosion can occur in conjunction with sheet erosion where increased runoff yields from sheet eroded areas becomes channelized on lower slopes.

8.4.1 Slight to moderate sheet erosion

Approximately 12 percent of the district is affected by slight to moderate sheet erosion, particularly in the lower rainfall, hill country where clearing and overgrazing has? occurred.

Production losses are not great but if the erosion goes unchecked serious sheeting can occur.

8.4.2 Moderate to severe sheet erosion

Moderate to severely sheet eroded country only occurs on two percent of the district. This is a sore advanced form of sheet erosion which is associated with serious soil and productivity losses. Sheet eroded areas have developed from overgrazing on shallow red podzolic soils and lithosolic hill soils.

Re—establishment of vegetative cover and proper management will reclaim many of these areas.

8.5 Gully Erosion

Some form of gully erosion affects 29 percent of the district. It is associated with both arable and grazing land and develops on a wide range of soil types.

Most common being soils with duplex profiles such as the solonetzic soils, solodic soils, podzolic soils and the granite derived siliceous sands. The severest gully erosion occurs in the central part of the district. Sheet erosion can also occur in conjunction with gullying.

8.5.1 Minor Gully Erosion

Minor gully erosion occurs over 14 percent of the district. The main areas are in the central and~ western parts on lower slopes that have been~ used for arable faming.

Reclamation of these areas is not usually difficult. Filling eliminates gullies while banks break up the length of slope.

Some areas of minor gullying on grazing land occur around Tunbarumba. Owing to better seasonal conditions, these areas can be stabilized by correct grazing management.

8.5.2 Moderate Gully Erosion

Approximately 12 percent of the district is affected by moderate gully erosion. It occurs on both arable and grazing land in the western and central parts.

The main soils affected are the less stable red podzolic soils, yellow solonetzic soils and solodic soils. On sloping land, moderate gully erosion is associated with grazing on granite derived siliceous sands.

On arable land, treatment involves gully fill and banks.

On grazing land, treatment involves banks, where possible, and ground cover improvement.

8.5.3 Severe gully erosion

Severe gully erosion occurs over 2.5 percent of the district.

The largest area occurs on the lower slopes of the Table Top Range. The affected soils are mainly red and yellow earths, with some red podzolic soils and a small area of siliceous sands.

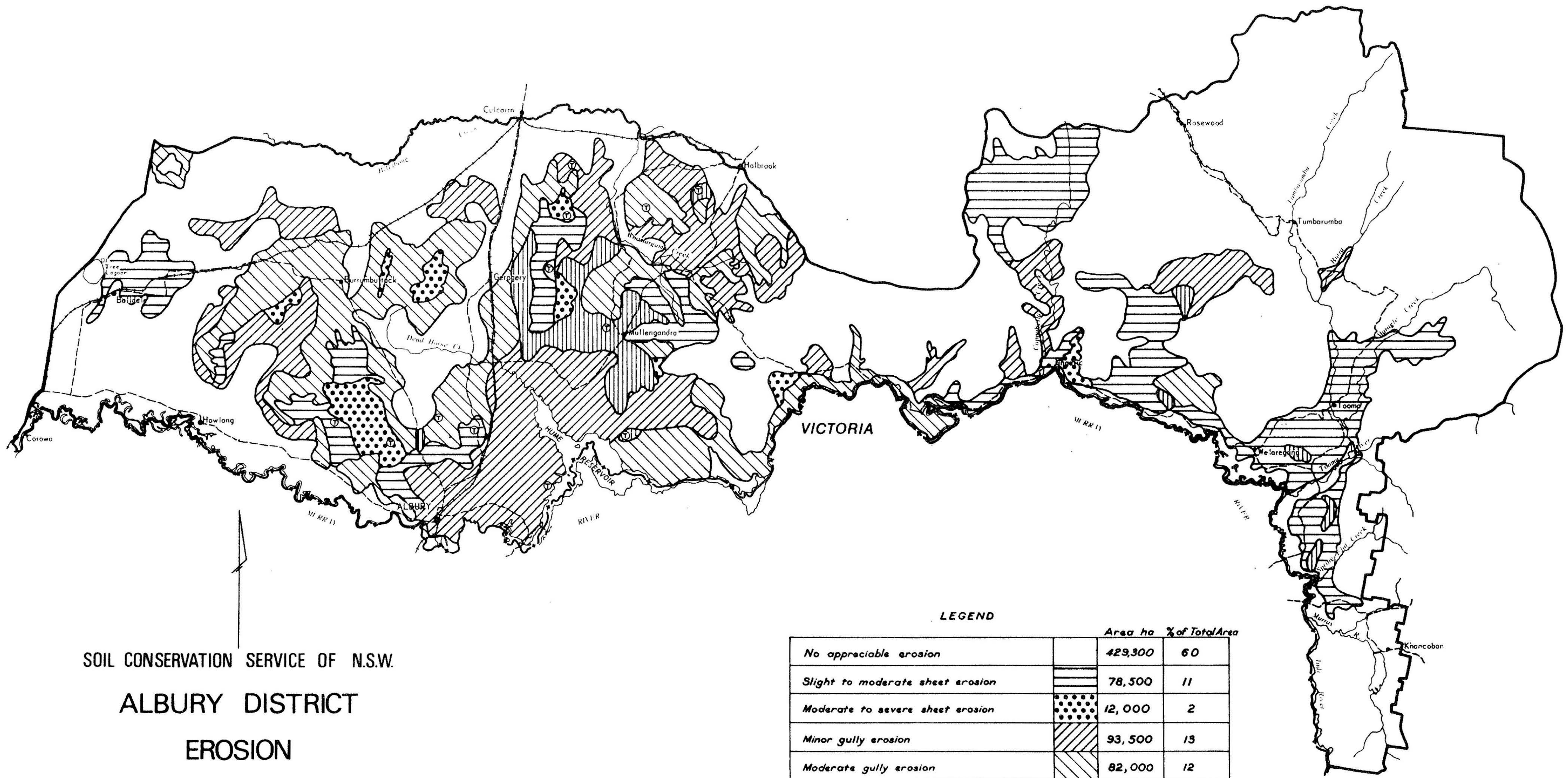
Elsewhere, severe gullying occurs in isolated pockets. A pocket at Jindera is on yellow solonetzic soils. Associated with the gullies is some severe sheet erosion.

In high rainfall areas, peristent trickle discharges over granite siliceous sands have created some very deeply incised gullies. These occur in only a few localities situated within an otherwise stable landscape.

Reclamation is generally very expensive with structural earthworks and revegetation being required.

In higher rainfall areas gullies can be reclaimed by fencing and tree planting with willows, pines and poplars.

Figure 8·1



SOIL CONSERVATION SERVICE OF N.S.W.

ALBURY DISTRICT EROSION

LEGEND

	Area ha	% of Total Area
No appreciable erosion	429,300	60
Slight to moderate sheet erosion	78,500	11
Moderate to severe sheet erosion	12,000	2
Minor gully erosion	93,500	13
Moderate gully erosion	82,000	12
Severe gully erosion	16,500	2

Ⓣ – Tunnel erosion site

SCS 11084G

9 GENERAL SOIL CONSERVATION PRACTICES

R.S. Junor

Because of the diversity of landform, soils, rainfall pattern and landuse in the Albury district, the district has been divided into two sections for discussion of soil conservation practices these are:

(1) East of the Hume Highway

(2) West of the Hume Highway

The area east of the Flume Highway contains steep hilislopes, receives higher rainfall and is used predominantly for grazing. It includes most of the Hume Reservoir Catchment.

The area west of the Hume Highway is gently undulating to flat. The predominant land use is mixed farming.

9.1 Soil Conservation Practices East of the Hume Highway

Overgrazing and rabbit infestation of hilly lands are the major erosion hazards of this area.

A grazing management programme should aim at maintaining complete ground cover. This can be achieved as follows:—

(a) On steep hill lands, stocking should be controlled in the late spring to allow native grasses to reseed. Stock can be held on better undulating country to utilise the nonnally abundant spring pasture growth.

(b) Light applications of superphosphate to maintain pasture density and subterranean clover component.

(c) Heavy applications of superphosphate on hill tops and ridges in steep areas should be avoided. This practice has led to winter annuals dominating the sward resulting in extensive bare ridge tops in the summer and early autumn. The bare ridge tops generate excessive runoff and cause erosion of drainage lines.

(d) Location of subdivision fences. These should be located on ridgetops to form natural subcatchment boundaries in steep country thereby reducing erosion damage resulting from stock tracks. Location of fences on land class boundaries particularly between Class V and VI lands is desirable to reduce erosion hazard.

(e) Access tracks should be located on ridge lines or well drained areas of red earths or podzolic soils. Solodic soils should be avoided as they have a low wet strength and will erode readily once the surface is disturbed. Access tracks may cause soil slumps where the track is formed by a side cut across a hillslope.

(f) Where a permanent road formation is necessary adequate pipe drains should be provided, together with surface drainage of the road to avoid runoff accumulation. This is particularly necessary where springs or soakages occur. Where tracks cross drainage or gully lines, rock groynes located on the downstream side of the track have been most successful in providing a stable section.

Owners or occupiers of land within the Hume Reservoir Catchment who intend to clear a slope in excess of 18 degrees are required to make an application to the Catchment Areas Protection Board for an authority to destroy trees. Clearing of steep slopes particularly those facing south and south east has created land slip problems.

Owners or occupiers of land who wish to destroy trees from within twenty metres of the banks of prescribed streams are similarly required to seek an authority under Section 260 of the Water Act.

Structural soil conservation treatment in the eastern section of the Albury district is restricted by steep slopes. The main works include gully control structures, diversion banks, flumes and contour ripping. The following guidelines should be adhered to when designing works.

(a) Gully control structures should be built with trickle pipes to carry winter seepage flows to the floor of drainage lines. Soil tests prior to construction are desirable.

(b) Steep slopes with shallow or sheet eroded soils should be contour ripped when planting a perennial pasture to increase moisture absorption. There is a wide potential for this treatment in the area.

(c) Generally, diversion banks are used in association with gully control structures or located on the boundary between Class V and Class VI lands to provide runoff control onto Class V land.

(d) Flumes require a well prepared site and must be vegetated prior to water being diverted onto them.

(e) Water disposal areas, including flumes, should be fenced to exclude stock. Stock traffic during the winter contributes significantly to the high failure rate of unfenced water disposal areas.

9.2 Soil Conservation Practices West of the Hume Highway

This section includes gently undulating lands, typical of the western slopes, grading to the plains surrounding Corowa. A mixed farming land use is practised. Westward the area cultivated for cereals increases.

A soil conservation management programme should be directed towards maintenance of a good vegetative cover. This can be achieved by:

(1) Avoiding overgrazing.

(2) Rotational grazing of paddocks.

(3) Removal of stock from steep hill lands in late spring to allow native grasses to reseed.

(4) A fodder conservation programme to conserve the normal heavy pasture growth of winter annuals in the late spring.

Depletion of ground cover by overgrazing or summer fallowing on light sandy textured soils in the Balldale area can result in wind erosion occurring in late summer.

Intensive soil conservation structural works are not common in this part of the district because the main arable lands are not normally under crop for more than three consecutive seasons. Fallowing of paddocks for moisture conservation and weed control is not a usual practice, and thus soils are not left exposed for a long time. Nitrogen buildup from subterranean clover pastures rapidly rejuvenates soil fertility. By comparison with other areas of the State intense rainfalls are not common and also the arable slopes relatively short. Hence the erosion hazard is reduced.

A most important soil conservation practice is to make the landholder aware of natural drainage lines so that they are not cultivated. Drainage lines must be clearly shown on farm plans.

The main structural soil conservation works required are gully control structures, graded banks, diversion banks and gully fill.

Treatment of gullied drainage lines frequently requires inclusion of a gully control structure as a major component. Dispersible soils are a problem throughout the region. Soil sampling and testing should be a standard procedure prior to designing structures. The replacement of topsoil over the completed structure is also essential.

Where slopes permit, broad based graded banks are favoured. When constructed on solodic and solonetzic soils they are less prone to tunnel erosion. The channels should be revegetated as quickly as possible. Cropping the entire bank and channel area, with large additions of fertilizer, helps revegetation during the pasture phase of the rotation.

Gully filling following soil conservation treatment is recommended in most cases in this region. It is essential to conserve as much topsoil as possible when carrying out the work. This can be done by deep cutting back the sides of gully walls and using this subsoil material to form the bulk of the fill. Topsoil and subsoil mixture from adjacent areas is then spread across the filled area from side to side until the desired cross section is achieved. A grass and fertilizer mixture should be sown immediately. Cropping over protected and newly filled areas during the appropriate part of the rotation assists complete rehabilitation.

10 LAND CLASSIFICATION AND FARM PLANNING

R.S. Junor

10.1 Introduction

The soil conservation farm plan is an important land management tool to help the farmer achieve satisfactory returns without damaging his soil resource. It is an excellent extension aid for the soil conservationist, providing a basis for a comprehensive erosion control programme as well as encouraging communication with the farmer.

Essential considerations in preparation of the plan are:—

- Classifying the land according to its capability and need for protection from erosion.
- Location of water disposal areas and necessary erosion control works.
- Planning of subdivision fencing within the property.
- Recommendations for future land use according to the physical capabilities of the land.

These considerations will be modified by individual paddock requirements for stock management, stock water availability, access and location of existing or proposed buildings, yards and shelter belts.

10.2 Land Classification

The Soil Conservation Service land classification system is set out below.

Land Suitable for Cultivation

Class I	No special soil conservation practices necessary.
Class II	Simple soil conservation practices, such as contour cultivation, adequate crop rotation and good soil management are necessary.
Class III	Intensive soil conservation measures such as graded banks, waterways and diversion banks are necessary, in addition to the practices for Class II.

Land Suitable for Grazing

Class IV	Simple soil conservation practices such as pasture improvement, stock control, application of fertilizer and contour chisel ploughing may be necessary on these lands, which are generally less than 15% slope.
Class V	Intensive soil conservation measures such as pasture furrows, absorption banks, diversion banks and deep contour ripping are necessary, in addition to the practices for Class IV. Land generally less than 33% slope.
Class VI	Good management practices are necessary.

These include limitation of stock, broadcasting of seed and fertilizer, prevention of fire and destruction of vermin, together with the retention of green timber on slopes above 33%. Structural soil conservation measures are impracticable on this type of steep or broken or rocky land.

Land Best Suited to Timber

Class VII — Land best suited to green timber for any of the following reasons: erosion hazard, steepness, shallowness or infertility. Generally stock should be excluded.

Other Land

Class VIII — Cliffs, lakes, swamps and other land unusable for agricultural or grazing purposes.

In this system, land must be classified according to its potential when fully developed rather than its present use.

10.3 Identification of Land Classes

In classifying the land according to the above system the following aspects are considered:

- Climate
- Topography particularly degree and length of slope.
- Soil type.
- Other physical factors which may hinder cultivation, or affect plant growth.
- Past erosion.

10.3.1 Climate

The climate of the Albury district varies from cool and moist conditions in the east to warm and dry conditions in the west. This variation has a marked effect on overall land use pattern and is a major consideration in land classification.

10.3.2 Topography

Slopes in excess of 15% are not suitable for cultivation in this district, since it is impracticable to manipulate conventional farm machinery.

Degree and length of slope are the main factors that determine erosion potential. They must be considered in association with other primary factors such as soil type and rainfall intensity.

10.3.3 Soil Type

Soils of the Albury district differ considerably due to diverse lithology, variation in climate and topography.

The present agricultural use of these soils has created areas of land degradation. For example, the extensive cultivation of yellow solonetzic soils south of Culcairn. Soil type is used as the first variable in a scheme of land classification presented later in this section.

10.3.4 other Physical Factors

A variety of other physical factors may affect potential land use by hindering cultivation or affecting plant growth. They include stoniness, wetness, salinity and effects of past erosion.

10.4 A Scheme for Land Classification in the Albury District

In this scheme soil type is the first element considered by the planner. Identification of major soil types is essential, together with an understanding of their physical properties.

A modal land class is given for each soil type, togethet with a list of those factors which may alter this classification.

10.4.1 Siliceous Sands and Sandy Earths

These soils occupy a large area of the steeper lands in the Hume Reservoir catchment. They are weakly structured soils which break down with cultivation.

The modal classification is Class V. This may vary over limited areas as described below:–

- On slopes between 3% and 10% soils may be cultivated using a broad rotation of two years cropping followed by four years pasture - Class III.
- Gently sloping land below 15% generally affected by a high seasonal water table or seepage areas – Class IV.
- Land capable of pasture development on slopes up to 20%. Pasture management aimed at maintaining a surface vegetative cover is the basis of erosion control. Soil conservation earthworks are desirable to control runoff from steeper land above, to protect lower arable land or to control existing erosion - Class V.
- Land steeper and stonier than Class V but still capable of supporting good pasture. The scope for earthworks is limited to gully control structures. Soil conservation consists of maintenance of a complete ground cover by strict stock management and rabbit control. Large areas will often require subdivision if the desired level of management is to be attained - Class VI.
- Very steep land on which maintenance of productive pasture cover is not possible. These areas should be left under natural timber or managed as forest Class VII.

10.4.2 Red and Yellow Podzolic Soils formed on Granite

This soil association occurs on undulating slopes with soils becoming shallower as degree of slope increases. It is found south west of Tumbarumba and east of Burrumbuttock. Class III is the modal land class but slope should be used as a guide to classification as follows:

Below 3%	ClassII
3 - 10%	Class III Banks are required if the length of slope is above 250 metres.
10 - 20%	Class V Soils are too shallow or steep for cultivation, some banking is normally required to protect lower land. Small areas with short lengths of slope may be Class IV.
Above 20%	Class VI Land too stony or steep for protection by banks.

Other limiting factors include:—

Wetness

Major drainage lines should be grassed and they may be of sufficient area to delineate as Class IV.

Stoniness

Frequent rock outcrops may cause Class II or Class III land to be classified as Class IV or Class V.

10.4.3 Red and Yellow Earths

These are good agricultural soils located in the Gerogery and Brocklesby areas. The modal classification is Class II. A rotation comprising two to three years cropping followed by two years pasture ley has proved adequate without the need for intensive erosion control works. There are limited areas where the following restrictions apply.

Slope

Degree of slope exceeding 4% for a length of more than 250 metres - erosion hazard Class III.

Stoniness

Ridge tops and outcrops too rough for cultivation usually Class IV but possibly Class V if length of slope is considerable.

Past Erosion

Dissected areas requiring extensive gully fill may need the protection of graded banks - Class III.

10.4.4 Yellow Solodic and Solonetzic Soils

This association of highly dispersible soils occurs to the north—west of Albury and around Jindera. They are of moderate to low fertility, highly erodible and very difficult to work in wet or dry seasons. The best soils occur on land classified as Class III but frequently, cultivation has extended to areas better treated as Class V, usually with disastrous long term results.

The modal land class for this soil association is Class V. However, there are large expanses of Class III south of Billabong Creek.

The Class III classification should be reserved for land with sufficient soil depth for cultivation and shows evidence of reasonable fertility. There may be limited areas of flat, Class II land.

Major drainage lines and poorly drained areas should be classified as Class IV.

10.4.5 Grey and Brown Clay Soils

These soils are located north of Walla Walla and between Howlong and Corowa.

The modal classification is Class II.

This soil type is often subject to run-on from adjoining areas and an erosion potential exists in areas undergoing frequent cultivation. Protection by soil conservation banks on higher land may be required.

Wetness is frequently a constraint on land use. Flatter land with poor drainage and high seasonal water table is best left under permanent pasture - Class IV.

10.4.6 Red Brown Earths

This soil association contains two soils differentiated by the physical characteristics of the surface. One is hard setting when dry, the other is soft.

The hard setting red brown earths are located north of Howlong. They are heavier textured and have a higher runoff potential. The soft red brown earths occur north of Balldale.

The modal classification is Class II but large areas will fall into other classes, particularly Class III. The limiting factors to be considered are:—

Slope

In excess of 3% for lengths greater than 250 metres Class III.

Wetness

Flat areas or run—on areas are best suited to permanent pasture - Class IV.

Stoniness

Ridge tops and outcrops too rough for cultivation usually Class IV.

Past Erosion

Dissected areas requiring extensive gully fill may need the protection of graded banks -Class III.

10.4.7 Red Podzolic Soils developed on Metamorphic Rock

This soil association is located west of Albury and Burrumbuttock. The soils are of moderate fertility, highly erodible and difficult to work in wet or dry seasons. The best soils in the group are on land classified as Class III.

The modal classification in Class V.

The main erosion problem is in drainage lines where highly dispersible solodic soils predominate.

Very steep slopes with shallow and stony soils, for example the hills surrounding Albury, should not be cleared – Class VII.

10.4.8 Chocolate Soils

These soils have been formed on basalt and are found around Tumbarumba. They are well structured and of low erodibility.

The modal land class is Class IV.

Well drained hill crests are frequently cultivated for grazing crops and horticulture and require some soil conservation treatment Class III.

Steep rocky areas also occur and should be placed in Class VI. More rugged areas are best retained under green timber Class VII.

10.5 Soil Conservation Earthworks and Waterways

Identification of the drainage pattern of a property is the first step in providing a safe runoff disposal system. Natural flow lines should be used when available. Constructed waterways should be located to use natural level cross–sections so they require only retaining banks.

Banks can be located so as to feed these disposal areas. The data necessary for the design of these works is referenced in Section 11.

Suitability of soils for earthwork construction should be considered at the planning stage and tests made when doubt exists.

10.6 Fencing

Fences located to separate land classes and to protect natural and constructed waterways provide a basis for further subdivision. In arable areas particularly, it is advisable to locate further subdivision on, or at right angles to the contour. Close consultation with the landholder is essential.

Factors to be considered include:–

- A sufficiency of paddocks of an appropriate size to permit effective management of rotations and livestock.
- Availability of stock water in each paddock.
- Placement of farm tracks and laneways to minimise erosion risk.

- Location of existing and proposed buildings and stock yards.
- Provision of adequate timber for shade and shelter. Many older agricultural holdings near Albury have been overcleared. Inadequate or badly placed shelter areas often lead to a concentration of stock tracking which can initiate gully erosion. The p~ovision of well placed shelter areas 4n each paddock is a desirable planning goal.

10.7 General Remarks regarding the Farm Plan

This section has been designed to set out the elements of farm plan development in the Albury district, in a sequence which can be roughly followed in the actual planning operation.

The bulk of the section has been devoted to land classification. It is not the most important element involved, but it is the element about which the newcomer to the Albury district will need most information.

The completed plan should be supplemented with a brief text in which the management needs of each land class are stated. Much of this information is obtainable from other sections of this manual along with information on the establishment of waterways, re-vegetation of earthworks and similar matters.

11 DESIGN OF SOIL CONSERVATION STRUCTURES

C.M. Adamson

11.1 Introduction

Soil conservation earthworks in conjuction with improved agronomic practices provide the best control and prevention of water caused erosion.

Earthworks are used to control existing soil erosion or to prevent erosion as a result of unstable land use practices or conditions. They are designed to detain runoff and prevent its concentration in unstable natural drainage lines. Runoff velocity and its ability to transport soil particles is reduced. Control is achieved by the use of graded stable channels and storage structures.

Earthworks must be adequately designed to cope with the expected storm discharge. Overdesign will make earthworkcs unnecessarily expensive, while underdesign can lead to earthwork failure. Therefore, reliable estimates of storm runoff from small catchments are necessary.

Two methods of flood estimation are used.

Where channel capacity is the critical design factor, an estimate of peak discharge is required. Where channel storage is the critical design factor, an estimate of runoff volmue is required.

For soil conservation channels with even cross sections and gradients, e.g., graded banks and waterways, conditions of uniform open channel flow exist. The rate of the flow in channels for these conditions is solved using Mannings formula to estimate velocity.

For banks with no gradients channel storage capacity is the principal design factor.

The principles and procedures for the design of soil conservation works in the Riverina and Southern soil conservation Districts, including the Albury district, are contained in a series of Wagga Research Centre publications as detailed below;

11.1.1 Determination of Rainfall Intensity

Refer to Wagga Research Centre technical bulletin No. 5, “A Simple Method for Determining Rainfall Intensities for the Riverina and Southern Soil Conservation Districts” by CM. Adamson.

11.1.2 Estimation of Runoff

Refer to Wagga Research Centre technical bulletin No. 11, “A Manual of Soil Conservation Design for the Riverina and Southern Soil Conservation DIstricts”, Part 1, by C.M. Adamson.

The contents of this publication are;

(a) Estimation of Peak Discharge

Rainfall Intensity

Rainfall Return Period

Time of Concentration

Determination of Rainfall Intensity

Runoff Coefficient

Adjustment of Runoff Coefficient for Area

Procedure for Calculating Peak Discharge using the Rational Formula

(b) Estimation of Runoff Volume

Short Duration Storms

Long Duration Storms

11.1.3 Design of Earthworks

Refer to Wagga Wagga Research Centre technical bulletin No. 12, “A Manual of Soil Conservation Design for the Riverina and Southern Soil Conservation Districts,” Part II, by C.M. Adamson.

The contents of this publication are;

(a) Uniform Open Channel Flow

Rate of flow in channels

Estimation of velocity of flow

Design of Banks with Graded Channels

Velocity of flow in channels

Channel capacity

Channel dimensions

Bank spacing

Design of Graded Banks on Arable Land with Bare Soil Channels

Velocity of flow for channels with bare soil conditions

Determining channel dimensions for broad based banks

Design procedure

Graded Banks with Vegetated Channels

Flow within vegetated channels

Solution of Mannings formula for vegetated channels.

Design of graded banks with vegetated channels

Velocity of flow in vegetated channels

Channel dimensions

Design procedure

Bank Outlets

Waterways

Calculation of waterway dimensions

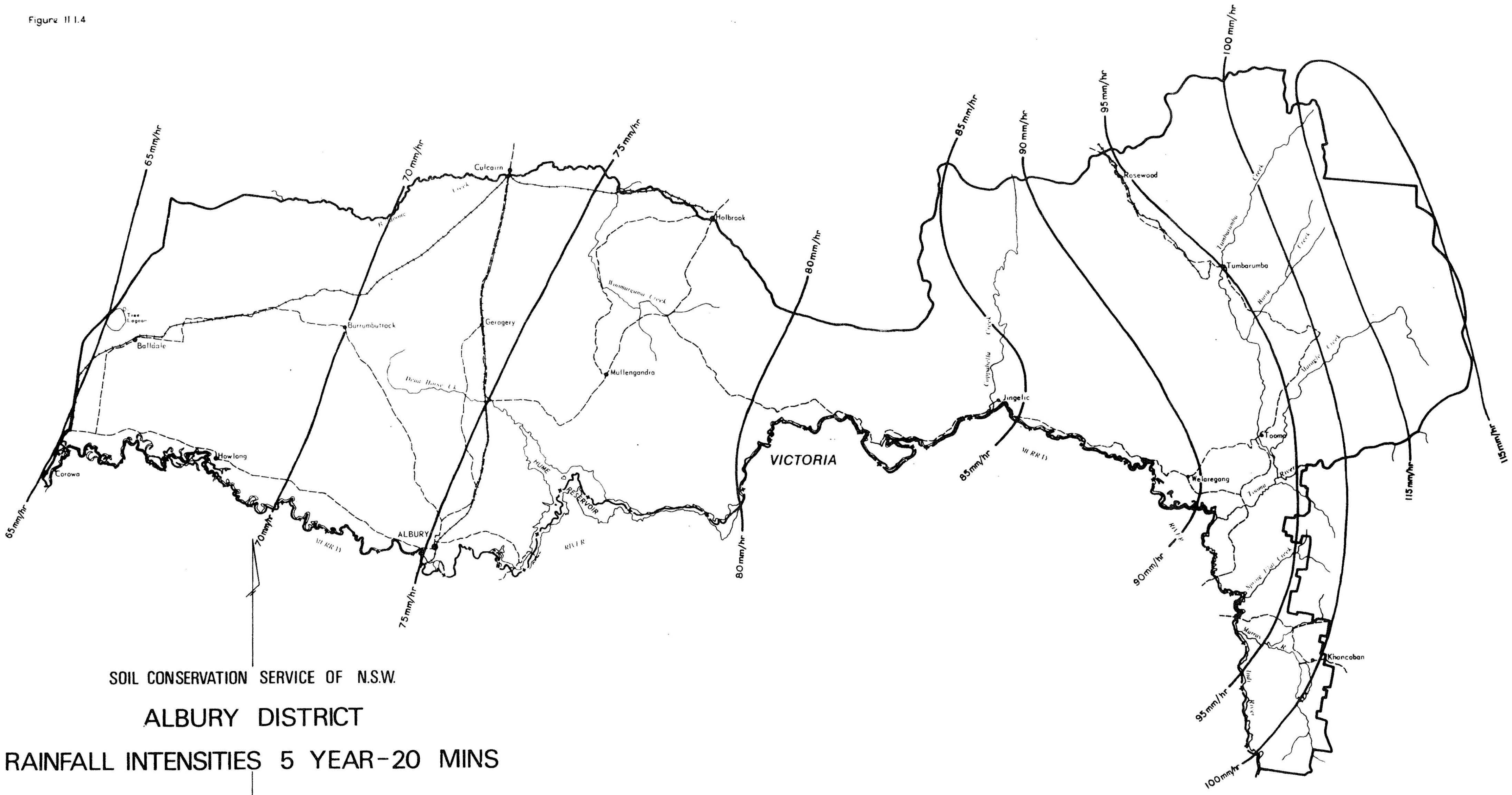
Procedure for determining waterway dimensions – variable vegetative retardance

(b) Design of Banks with Level Channels

When calculating rainfall intensity and bank spacing in the Albury district Figure 11.1 and Figure 11.2 will be useful adjuncts to Figures 3 in bulletins 5 and 12.

When determining drop inlet spiliway pipe sizes. Table 11.1 should be used in place of Figure 16 in bulletin 12.

Figure 11.4



SOIL CONSERVATION SERVICE OF N.S.W.

ALBURY DISTRICT

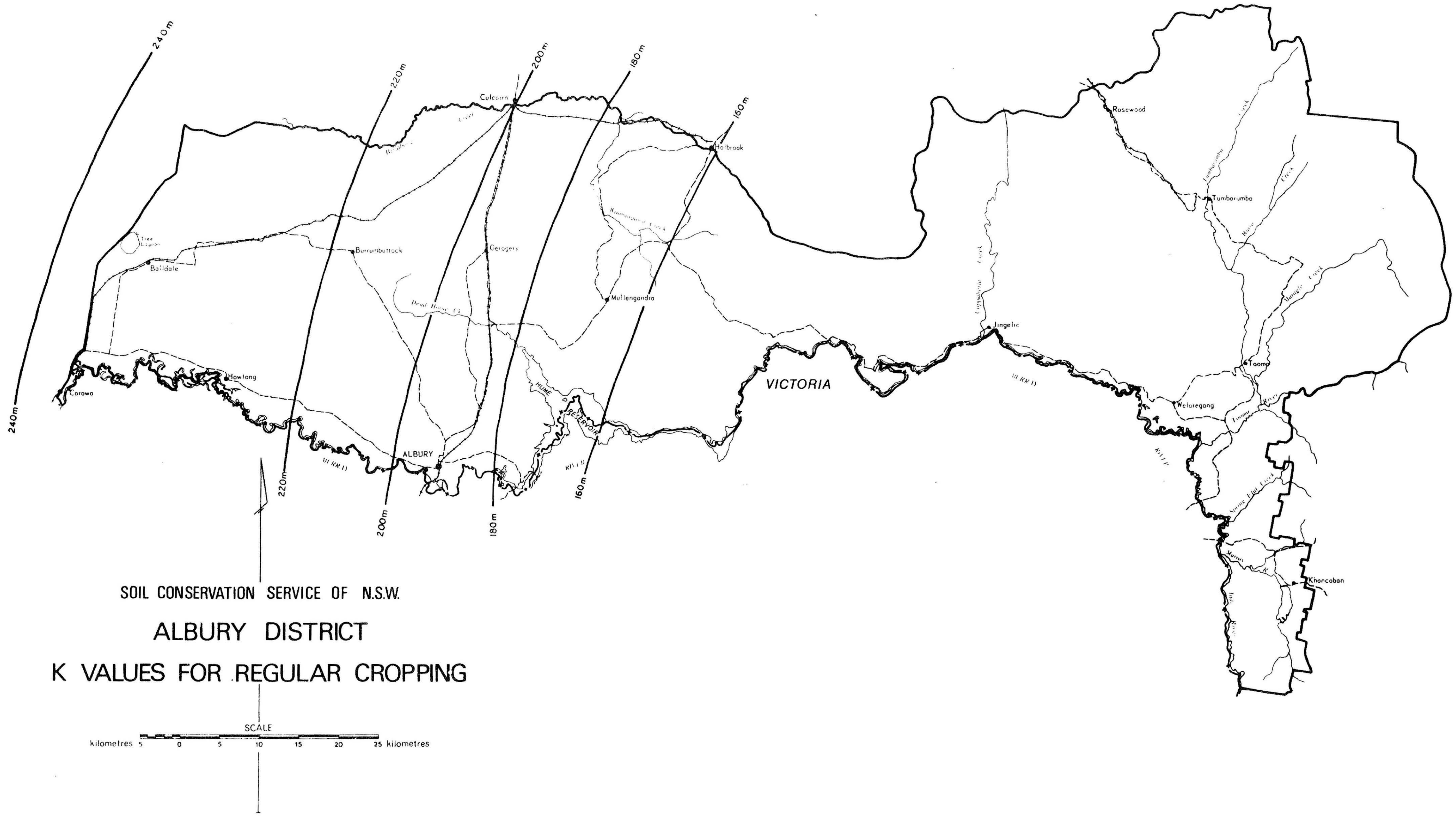
RAINFALL INTENSITIES 5 YEAR-20 MINS

SCALE

kilometres 5 0 5 10 15 20 25 kilometres

S.C.S 1108

Figure 11.23



SOIL CONSERVATION SERVICE OF N.S.W.

ALBURY DISTRICT

K VALUES FOR REGULAR CROPPING

SCALE

kilometres 5 0 5 10 15 20 25 kilometres

S C S 11084 I

Table 11.1

Discharges in litres/sec for Drop Inlets for Various Pipe Sizes

	Pipe	size	inlet	Outlet in mm		
Total Head Metres	150 : 100 PVC	200 : 150 AC	250 : 200 AC	300 : 250 AC	375 : 300 AC	600 : 375 AC
2.00	32	74	150	270	440	800
2.50	33	76	155	280	460	840
3.00	34	79	160	300	480	880
3.50	36	83	170	310	500	910
4.00	38	86	180	320	520	950
4.50	40	89	190	340	540	1000
5.00	42	92	200	350	560	1050

PVC = PVC pipe

AC = Asbestos cement

Pipe length determined for embankment with 3:1 front and 2.5:1 back batters with specified top widths.

Total head includes 0.3 metres of head on inlet riser to make pipe flow full.

Actual inlet rise pipe length = Total head – 0.3 metres

12 AGRONOMIC RECOMMENDATIONS

W.H. Johnston

12.1 Principles of Revegetation

12.1.1 Introduction

Pastures are usually established to improve the fertility and hence long term yields from arable lands or to increase production from grazing lands. Their effect on the chemical and physical fertility of the soil and the direct protection they provide for the soil surface are most important in terms of soil conservation.

Pasture plants are also used to revegetate newly constructed earthworks, waterways and other water disposal areas.

Successful revegetation requires a basic understanding of the general principles of pasture establishment. These principles can then be adapted to suit particular situations.

Pasture establishment is only the first step in a revegetation programme. Long term success depends on post establishment management.

The purpose of this section is to present the basic concepts of pasture establishment and management as they relate to soil conservation practice. Specific recommendations are given in section 12.2.

12.1.2 Species Selection

Basic Criteria of Selection

The commercial availability of pasture plants is determined largely by their usefulness for grazing. Apart from climatic suitability, factors such as palatability, digestibility and toxicity are the main determinants.

For erosion control purposes, habit, perenniality, persistence and performance under adverse conditions are equally if not more important.

Soil conditions at eroded sites are generally more unfavourable to plant growth than those found in normal agricultural situations. The seed bed usually consists of subsoil which is prone to surface sealing and fertility and moisture relations are usually poor.

The clay soils pose particular problems; they are relatively impermeable and hence light falls of rain may not be effective in terms of plant growth.

It is also important to remember that the growth period on earthworks may be much shorter than in the field. This is because runoff rates are usually higher, the soil is less fertile and usually contains appreciably more clay.

Consequently, species not normally used in an area maybe recommended.

In southern New South Wales, the first constraint is the mediterranean type of climate of cool moist winters and hot dry summers. This means that the most commonly used improved pasture species grow during the cooler months of the year.

Species Mixtures

Seed mixtures are usually preferred to the sowing of a single species. This is because plants differ in their tolerance to variations in local environmental influences, such as soil pH, texture, fertility, moisture and temperature.

Depending on the extent and type of erosion present, site variation can be considerable. For example, an absorption bank presents three separate soil environments for plant growth. There is the normal paddock, the subsoil environment of the channel and the elevated, mixed, subsoil and topsoil environment of the bank. Thus it is necessary to select species with a sufficient range of tolerance to all three microenvironments.

The Role of Legumes

The importance of the legume lies in its ability to fix atmospheric nitrogen and thus provide a means for this nutrient to enter the nutrient cycle of the pasture.

Legumes as a group are generally more sensitive to nutrient deficiencies than grasses. In eroded situations, and on earthworks, where subsoils have been exposed or disturbed, soil fertility is low. Thus special attention must be given to legume nutrition.

The “Climax” Pasture

Following establishment of a mixed grass and legume pasture and the application of fertilizer -usually superphosphate, there is usually a period of legume dominance. This is due to the stimulatory effect of the fertilizer on the legume and poor grass growth because of low soil nitrogen.

After one or two seasons, this trend should reverse because increasing levels of soil nitrogen tend to favour grasses.

In the long term, the composition and relative productivity of the legume and grass components will follow this cyclic pattern, provided phosphate nutrition remains adequate. If available soil phosphate declines, the legume component will decline and the pasture will become grass dominant.

In soil conservation practice, the establishment of a protective vegetative cover which will persist in the long term is most important. This cover can be provided with equal effectiveness by either grasses or legumes as well as mixtures. In situations where productivity is of little concern, the most stable cover in the long term will often be provided by indigenous species.

Sowing Times

Sowing time of both annual and perennial species, is important in terms of short term performance and long term persistence.

In the case of annual species, persistence from one season to another depends on plants setting seed. This means that sowings should not be made later than the time taken to set seed before the onset of summer drought. Some latitude is provided by choosing progressively earlier varieties as sowing time extends into the winter.

In perennial species such as phalaris, summer survival depends on summer dormancy. This is dependant on plants reaching the reproductive stage at the commencement of the summer drought. In the case of phalaris, a growing period of about five months is required and sowings should be planned accordingly.

12.1.3 Fertilizers

The use of fertilizers is the most readily available means of substantially altering the productive potential of land. In conjunction with improved pasture species, fertilizers, mainly superphosphate, have resulted in large increases in pasture productivity in southern New South Wales.

Erosion of the surface soil represents a considerable loss of plant nutrients and this loss must be at least partially offset before plants can be re–established.

The mixing of subsoil and topsoil as frequently occurs in earthworks results in a dilution of the available nutrient “pool”.

In normal agricultural practice superphosphate is the main fertilizer applied to pastures and crops. It is usual to apply superphosphate when sowing crops at rates of between 100 and 200 kg per hectare and to topdress pastures with an equivalent amount either every two to three years or in some cases even less frequently. Consequently, where topsoil has been removed, these rates should be increased.

Where large scale improvement of plant cover is undertaken, the effect of fertilizer application on botanical composition of a sward must be considered. The response of grass dominant native pasture to increased fertility is relatively small. Thus in order to realise the full benefit of fertilizer addition, it is usually necessary to sow species with a high fertility requirement.

On eroded areas, other plant nutrients such as nitrogen, molybdenum, potassium, and trace elements may be important.

In general, fertilizer requirements are assessed by one of three methods, namely:–

- chemical soil tests
- subjective appraisal
- field trials

The results of chemical soil tests should, in most cases, be interpreted with caution. The correct application of these results often varies depending upon laboratory technique, soil type, variation in soil type and degree of field correlation.

Assessing fertilizer requirements using field trial results – either fully replicated research plots or simple “test strips” – is the most satisfactory method, but especially for revegetation work, a subjective appraisal must be made. Subjective appraisal is based on site conditions, past fertilizer history and amount of topsoil removed.

Wherever possible, landholders should be encouraged to lay out simple “test strips” of fertilizer. This, together with careful record of the outcome of subjective appraisal recommendations will result in more precise fertilizer use.

Phosphate fertilizers

Phosphorus is one of the major essential elements for plant growth. It is of special importance in the germination of seeds, seedling metabolism, the ripening processes of seeds and fruits and the development of roots. Phosphorus stimulates early root growth, increases leaf size, tiller number and grain yield in Cereals, and in legumes it is essential for nodulation and early growth.

In the soil, phosphorus is present in both mineral and organic forms. The organic forms are largely unavailable to plants. The mineral phosphorus occurs either in an available or unavailable form, although the available phosphorus pool is relatively smaller than the unavailable pool, despite the addition of phosphatic fertilizer. Reversion to sparingly soluble forms may limit fertilizer effectiveness in the long term.

The phosphate content of fertilizers is expressed as a percentage by weight of elemental phosphorus.

Fertilizers containing phosphorus are listed in Table 12.1, together with their elemental phosphorus content.

In subsoils, fertilizer phosphorous is more likely to be “fixed”, or converted to an unavailable form. Consequently, application rates even higher than those needed to offset erosional losses are required.

Nitrogen fertilizers

Like phosphorus, nitrogen is also an essential plant nutrient. Unlike phosphorus, the available pool of nitrogen is not fixed in the soil, but is in continual flux, depending on biological activity, with atmospheric nitrogen.

Nitrogen is usually present in the soil as either nitrite, nitrate or ammonia. The nitrate form is most readily used by plants and the conversion of others such as nitrite and ammonia to nitrate depends on the action of bacteria which obtain energy from the breakdown.

Legumes provide the chief source of nitrogen in Australian pastures. The use of fertilizer nitrogen is not widespread, mainly because of its relative cost. Future price variations may alter this picture.

The nitrogen content of fertilizers is expressed as a percentage by weight of elemental nitrogen.

Table 12.1 lists the more common fertilizers, together with their nitrogen content.

Generally, legumes are more sensitive to phosphorus deficiency than grasses, whilst grasses are more sensitive to nitrogen deficiency. Consequently, in revegetation, there is a need for nitrogenous fertilizer to stimulate early grass growth. However, the application of phosphorus and nitrogen must be balanced, otherwise the subsequent grass/legume balance may be affected. Nitrogenous fertilizers are also recommended in areas subject to inundation, where the activity of denitrifying organisms is favoured.

Table 12.1

Nutritive Values of Common Fertilizers*

(Percentage of total weight)

FERTILIZER		ELEMENT ANALYSIS				REMARKS
TYPE	NAME	N	P	K	S	
PHOSPHATE	Single Superphosphate		9.3		12 0	For pasture establishment and topdressing of pastures. Can be used to increase clover content of grass dominant swards.
	Double Superphosphate		17.5		4.5	
	**Tri-phos		19.7		2.0	
Main advantage of concentrated phosphate fertilizers is reduced freight and handling costs.						
NITROGEN	**Nitram	34.0				For topdressing.
	Urea	46.0				For pre–planting and surface application on moist soils
	Sulphate of Ammonia	21.0			24.0	For topdressing, prolonged use may lower soil pH.
Because nitrogen is not fixed in soil significant losses can occur if it is applied when conditions are not suitable, i.e. too dry or too wet. Do not mix sulphate of ammonia with lime, this will immediately release ammonia gas.						
POTASSIUM	Muriate of potash			49.8		Do not use on saline areas or chloride sensitive crops.
	Sulphate of potash			39.8	16.0	Can be used on saline areas.

Table 12.1 (Cont'd)

MIXES	**Starter 12 (12:52:0)	12.4	22.3		3.0	used on low phosphate low nitrogen areas or where nitrogen can be applied separately.
	**Starter 15 (15:30:0)	15.0	13.1		10.0	Low to medium phosphate soils where moderate nitrogen required.
	**Starter 18 (18:18:0)	17.5	8.0		16.9	Used where both phosphate and nitrogen are deficient.
	**Greentop (20:11:0)	19.6	4.8		21.1	Low nitrogen, medium phosphate soils.

* From Fertilizer Handbook A.F.L. (1974)

** Registered trade name.

Mixed fertilizers and trace elements

Mixed fertilizers are often a more convenient means of applying these elements than two separate applications.

The use of trace elements, apart from molybdenum, is not widespread unless specific nutritional disorders are noted. It is unusual to find serious trace element deficiencies in subsoils when they are not already present in the topsoil.

Molybdenum is used more widely because of its role in nitrogen fixation. It has been found deficient in many soils in the State, and is more likely to be deficient in acid soils. It is usually applied mixed with superphosphate.

Costs

When comparing fertilizer costs, price per tonne is of little significance without considering the amount of nutrients present. Consequently, the price per kilogram of nutrient should be compared. This is obtained by dividing the price per tonne by 1000 (the number of kilograms in a tonne) multiplied by:-

$$\frac{100}{\text{\% nutrient content}}$$

For example, if the following assumptions - based on prices as at 22.3.76 - are made regarding the cost of fertilizer:-

Starter 18* (17.5%N, 8.0%P)	$167.35 per tonne
Single Superphosphate (9.25%P)	$67.75 per tonne
Urea (46.0%N)	$165.00 per tonne

Then the cost per elemental unit (1 kg) would be:-

(a) Starter 18: $\frac{167.35}{1000} \times \frac{100}{8}$

= $2.09 (per unit of phosphorus)

Amount of fertilizer required to supply 1 kg P is 12.5 kg. This supplied in addition, 2.18 kg of Nitrogen and 2.11 kg of sulphur

(b) Superphosphate: $\frac{67.75}{1000} \times \frac{100}{9.25}$

= $0.73 (per unit of phosphorus)

Equivalent to 10.81 kg of fertilizer supplying in addition 1.29 kg of sulphur.

(c) Urea: $\frac{165.00}{1000} \times \frac{100}{46}$

= $0.36 (per unit of nitrogen)

Equivalent to 2.17 kg of fertilizer.

The cost of single and mixed fertilizers can be compared as follows:—

Starter 18* To supply 1 kg of phosphorus and 2.2 kg of Nitrogen requires 12.5 kg fertilizer at a cost of $2.09.

This is equivalent to a separate dressing of superphosphate at a rate of 10.81 kg and cost of $9.73; and Urea at a rate of 4.78 kg (equivalent to 2.2 kg Nitrogen). This would cost $0.79.

The total cost of the alternative would be $1.52, with a total fertilizer application of 15.6 kg.

The benefits of the mixed fertilizer in this case arise from savings in labour and the weight of fertilizer used. The cost of this saving is $0.75 per kg which would have to be balanced against the handling and spreading costs of the separate fertilizers.

12.1.4 Site Preparation

There are two basic requirements for successful pasture establishment. Firstly, the seed bed must provide suitable conditions for germination, emergence and growth and secondly, competition from other species must be reduced or removed.

In soil conservation practice, seed bed conditions are usually more important because ground cover is frequently poor or absent.

Where improvement of an existing sward is required such as waterway establishment or land improvement on a broad acre basis, competition by existing species may be important. However, in these situations there is a difference between detrimental competition, that is, competition from existing or invading species which reduce the quality or desirable characteristics of ground cover, and competition which will supplement the objective.

Topsoiling

Because of its superior chemical and physical fertility, only small quantities of topsoil are required to markedly improve the subsoil environment.

Trials near Wagga have shown that topsoil, even at a depth of a few centimetres, greatly improves establishment and long term persistence of sown species.

It should be the aim to spread topsoil over all major soil conservation structures and whenever possible, over critical water disposal areas.

Where topsoil is not used, heavier applications of seed and fertilizer are necessary for satisfactory establishment.

Ripping and cultivation

Deep ripping and contour cultivation of land to reduce runoff or after earthwork construction, is desirable, particularly where a hard pan or impermeable soil horizon is present.

Tunnel eroded areas should only be deep ripped when all tunnels can be broken. Where tunnels are too deep, ripping may increase the erosion hazard by allowing water to concentrate in deeper soil horizons. For effective control in tunnel cultivation and sowing, it is important that the final working should be done on the contour, so that an even water penetration will occur.

The use of cultivated seed beds and seed sowing machinery is the most effective means of establishing pasture. Where this is not possible, it is necessary to increase sowing rates to compensate for seedling mortality and germination failure.

Landholder co-operation

Harrowing of banks and channels and the routine sowing of all disturbed areas is a vital part of an erosion control scheme. The use of wheeled tractors improves soil compaction beyond that possible with tracked equipment.

These matters, together with post construction cultivation, sowing, fencing and general management, should be discussed with landholders during the planning stage of the work.

In some situations for example, the construction of a waterway, it is desirable to achieve control over an area well in advance of actual construction, Such control depends entirely upon co-operation with the landholder.

Where erosion is due to runoff from elevated land, improved management, coupled with pasture improvement) will be as important as earthworks in erosion control. Details should be discussed with all landholders involved, and technical information provided, Such details include species and fertilizer recommendations.

12.1.5 Pasture Establishment and Improvement

In many situations, a satisfactory ground cover can be obtained merely by fencing to exclude stock. However, where a complete ground cover is required quickly, or where conditions are so adverse that natural reclamation would be a slow process, pasture establishment or improvement is necessary.

Two factors need to be considered, namely:-

1. The role of the pasture in terms of whole farm management and production.
2. The role of individual species in promoting a stable, long term ground cover.

Broad acre land improvement for erosion control must also consider management requirements with respect to overall productivity. it is possible to maintain a productive sward of improved species in the long term, with adequate grazing management.

Where specific areas are revegetated, productivity is often not important. In these situations, it is often best to sow a species or species mixture which will dominate in the short term and provide an environment suitable for colonization by native plants.

The location, extent and potential productivity of a pasture will determine when and how it will be sown and will influence sowing rates, fertilizer rates, insect and weed control and species selection.

Sowing rates

Several factors are important, namely:—

1. Seed size and weight.
2. The number of species in the mixture.
3. Ease of establishment of species in the mixture which will influence competitive ability. It will also be influenced by germination rate in relation to any stress which may occur during germination.
4. Seedling mortality and seed viability; which will be influenced by site characteristics, environmental factors and seed quality.
5. Time of sowing; under conditions where false germination could occur, seeding rates should be increased to compensate.

The effect of seed size and weight on seeding density is shown in Table 12.2 for selected species.

Table 12.2
The effect of seed size and weight on seeding density for selected species

Species	Seeds per kg	Approximate seeding density per square metre with 1 kg ha^{-1} sowing rate
Couch grass	3,970,000	384
Cocksfoot	990,000	96
Perennial Veldt grass	749,000	75
Lovegrass (*Eragrostis* spp)	3,300,000	336
Wimmera ryegrass	550,000	55
Phalaris	701,000	71
Oats	28,600	3
Barley	31,000	3
Cereal Rye	40,000	4
Lucerne	440,000	48
Barrel Medic	232,000	19
Strawberry Clover	772,000	77
Subterranean Clover	154,000	19
Vetch	17,000	2

Seedling establishment density will depend on other factors such as seed viability and mortality.

- When sowing under adverse conditions, normal broad acre seeding rates should be increased by a factor of four or five.

- When surface sowing into standing vegetation, a factor of two should be adequate.
- When sowing onto bare ripped ground in early summer, a factor of three or four should be
- applied to counter a false germination which may occur before opening rains the following autumn.
- When sowing out of season or in particularly harsh environments, such as gravel pits, it is often best to sow relatively high seeding rates of one or two species, then over-sow at a later stage when conditions are more favourable.

Sowing Techniques

Sowing technique will be determined by the availability of machinery, site characteristics such .as topography and amount of stone and rubbish present and the type of structure to be revegetated.

The most successful means of establishing plants is the use of a combine in a prepared seedbed. Frequently, such machinery is not available or the site is unsuitable. When relatively small areas are being revegetated, sowing by hand immediately after construction, followed by harrowing either with diamond harrows or a light chain is most satisfactory.

Establishment problems are likely, particularly when species are sown out of season and where site characteristics are adverse.

During mid winter to early spring, the use of a winter cereal, such as oats, may provide sufficient protection and standing stubble by the next autumn to allow a reasonably successful strike of oversown species. During spring, the use of millet would be more satisfactory.

Sowing of disturbed areas directly following construction should be attempted whenever possible.

Pasture and ground cover improvement on a broad acre basis should only be attempted in the early autumn.

Under these conditions, sowing can be done using a variety of techniques, including cultivation and drilling, sod seeding, scratch seeding and aerial sowing.

A prepared seedbed and conventional sowing is usually best, although under some conditions this may result in prolific weed problems. Adverse seasonal conditions may result in a costly failure which would be offset using less intensive techniques.

Scratch and sod seeding techniques overcome many of the problems associated with surface seeding, whilst not incurring the expense associated with full seedbed preparation and conventional sowing. Scratch seeding has been used successfully on Wagga Research Centre to improve the botanical composition and productivity of hill pastures.

Fertilizer rates and application

The condition of the area will indicate likely fertilizer rates needed for satisfactory growth. A normal application, of standard superphosphate at a rate of 125 kg/ha contains 12.1 kg of phosphorus. In subsoil situations, rates of the order of 22-44 kg of phosphorus per hectare may be required.

It should be remembered that seeding and fertilizing earthworks is by far the cheapest part of the operation.

Fertilizer is best applied when seed is sown. It can be broadcast by hand or drilled if a combine ‘is available. It is not advisable to mix seed and fertilizer as fertilizer may adversely influence germination or nodulation.

The availability of nutrients from fertilizer lying on the soil surface is low and exposure may decrease availability further. If an area is ripped following earthwork construction, fertilizer and seed can be applied prior to ripping.

Particular attention should be paid to areas of high erosion risk, especially bank outlets, flow lines and points of water re-entry.

It is important to note that some fertilizers are not compatible in mixtures and therefore as a general rule it is best to apply different fertilizers separately.

Legume inoculation

When sowing legumes, in subsoil or areas where no natural or naturalized legumes OF THE SAME SPECIES can be found, the seed must be inoculated with the appropriate strain of Rhizobia. Seed can be purchased inoculated and lime pelleted, but inoculum viability decreases with storage, therefore it is usually best to inoculate just prior to sowing.

Table 12.3 lists the inoculum requirements of commonly used pasture species. The correct inoculum must be used because the various types are host specific.

Method

The simplest way of inoculating and lime pelleting legume seed is to use a cement mixer and gum arabic or other adhesive. Adhesives specifically made for inoculating seed are available through most seed merchants.

Seeds are placed in a mixer and sufficient adhesive added to make them glisten. If too much is added, or if it is added too rapidly, seeds will tend to clump together.

The required quantity of inoculum should be then added, but only in small quantities at a time. After further mixing, micro fine lime or plasterers whiting - not hydrated lime should be added in sufficient quantity to coat the seeds and absorb excess adhesive.

If a cement mixer is not available, seeds can be inoculated in small lots using a sheet of plastic. The seeds are mixed by alternately lifting opposite corners of the sheet.

When inoculating seeds, it is advisable to commence with small quantities until the technique is mastered.

Insect and weed control

Insect activity may be important under certain climatic conditions. Where seed is surface sown, particularly grass seed, it should be dusted with an insecticide to discourage seed harvesting ants.

Table 12.3
Inoculum Requirements of Commonly used Pasture and Other Legumes*

GROUP	USED FOR INOCULATING	SIZE Each size inoculates up to the weight of seed indicated in the columns below	
		Small Pack(kg)	Standard Pack(kg)
A	Lucerne and Barrel, 173 Harbinger and Cyprus Medics	15	50
B	Red, Strawberry and all White Clovers	7	25
C	Crimson and all Subterranean Clovers	15	50
D	Pea, Vetch, Tares, Broad Beans, Tick Bean	30	100
G	Lupin	30	100
	Serradellas	7	25
H	Soybean	30	100
I	Cowpea, Velvet and Mung Bean	30	100
	Siratro, Phasey, Puero, Calopo	15	50
	Glycine, Stylosanthes, Townsville Stylo	7	25
Centro	Centrosema	15	50
Desmodium	Desmodium	7	25
Lotononis	Lotononis	2	7
Dolichos	Dolichos lablab	30	100
	Dolichos uniflorus	3	10
	Dolichos axillaris	1	5

*Original data for inclusion in this Table was supplied by New South Wales Department of Agriculture, Horticultural Research station, Narara.-January, 1975.

The control of insect pests such as lucerne flea and red earthmite may also be necessary during autumn. Locusts and grasshoppers may be a problem during summer. Table 12.4 gives details of current recommendations.

Weed control, where necessary, is best undertaken using techniques other than chemical weed–killers. These include strategic grazing and slashing, pasture improvement and the use of fertilizers to stimulate competition by more desirable species. Preventing an annual weed from setting seed should provide eventual control.

Many weed-killers are strongly residual and continued applications in the long term may lead to toxicity problems. They should only be used where no alternatives are available.

When using both weedicides and pesticides, it is important that all safety precautions be observed. Many of these substances are systemic, so that prolonged or continued exposure may cause illness or death of the operator. When using spray equipment which is also used for firefighting purposes, all equipment should be appropriately labelled.

12.1.6 Specific Applications and Special Techniques

Waterway establishment

Where fair ground cover is provided by native or naturalised species, the best means of improving this cover is to exclude stock and apply fertilizer.

Where sparse cover is provided by native or naturalised grasses, oversowing with an annual legume and topdressing with superphosphate may be all that is required.

In other situations, oversowing in the autumn following grazing or slashing can be a satisfactory alternative o cultivation and conventional sowing.

Oversowing waterways or other water disposal areas with a “shot–gun” type seed mixture is generally less successful than using one or two selected species. Unfortunately, many perennial species do not establish easily from surface sown seed, but Wimmera ryegrass, subterranean clover and vetch can be established satisfactorily by this means.

Where a waterway is to be cultivated and sown several years prior to use, the area must still be fenced to exclude stock. In this case, it is preferable to utilize the advantages of both annual and perennial plants, so the sowing of a seed mixture is recommended.

Flumes

The principles which apply to the revegetation of flumes apply also to spillways and other areas where prolonged flows are expected. The main danger is that trickle flows may cause erosion at the point of water exit. This results in rills and gullies which further concentrate flow.

When constructing flumes and spillways or when assessing the suitability of sites for water re–entry to a gully floor, careful attention must be paid to the stability of the outlet point.

The outlet can be stabilized by building a level sill using posts or railway sleepers and vegetatively stabilizing both above and below this sill.

All flumes should be fenced to exclude stock.

If minor ruling occurs, jute bags filled with soil, or dung, and seed can be used to repair the damaged area.

Gully control structures and dams

Where structures are topsoiled after construction, subsequent sowing is often not necessary. However, it may be desirable to establish a vigorous short term stand of improved pasture to control weeds.

Where topsoil is not available, the exposed batters should be sown.

Depending on soil type and degree of compaction achieved during construction, some settling and cracking may occur during the first few years of operation. Gypsum applied along these cracks will often cause them to close up; additional seed should also be sown.

In dams with a large surface area, erosion caused by wave action may be a problem. Sowing or sodding kikuyu grass 30—50 cm above top water level is recommended. Kikuyu has no specific soil temperature requirements for germination and hence can be sown throughout the year at a rate of 1—2 kg/ha. When sodding, it is best to wait until the structure is full and space sods about two metres apart around the wall and exposed batters, just above top water level. Sods should be about 20 cm square and placed so that the surface is slightly below the surrounding soil.

Banks

Narrow—based banks can be revegetated by broadcasting seed and fertilizer directly after construction. It is inadvisable to sow annual cool season pasture species during mid to late winter because they may not set seed. If banks are constructed during this period, oats should be sown at a rate of 100-150 kg/ha to provide temporary cover.

The treatment of broad based banks is more dependent on current paddock management. Under pasture, they should be treated as above but in the arable situation, sowing in conjunction with the next crop may be more convenient.

Revegetation of bank channels is particularly difficult, especially in the case of graded banks where channel disturbance may lead to scouring. Broadcasting seed and fertilizer prior to finishing off the chanrr~1 will often result in a satisfactory establishment.

Gravel Pits

Gravel pit restoration and management should be done at three levels;

1. Planning and layout of mining activity.
2. Progressive restoration of mined areas as material is exhausted.
3. Final restoration and management of the closed pit.

Pits should be located across the slope where possible, and runoff from adjacent areas diverted from the workings. Undisturbed natural flowlines will simplify water disposal. Commencing operations as high on the slope as possible will permit the correct location of access tracks as mining and restoration proceed. As each pit is exhausted, it should be closed and restored as quickly as possible.

The object of quarry restoration is to reestablish vegetation as rapidly as possible. This is greatly facilitated by spreading of topsoil and this should be. stockpiled when mining starts. Deep ripping, banking and in some cases mulching and sodding may be an advantage. The use of absorption banks may be advantageous in improving water availability.

In areas likely to be returned to grazing, sowing an improved pasture mixture is essential and is recommended in all other cases. Trees and shrubs should also be planted where possible.

The quarry should be fenced out when mining begins so that grazing can be prevented on areas which are progessively restored.

After final restoration, management of the area must be conservative to permit development of a protective pasture sward. Full production cannot be expected for several years after quarrying has ceased.

12.1.7 Gully fill areas

The main problems which arise as a result of gully filling are subsidence and deep cracking. They are more likely to occur following work under very wet or very dry conditions, and in duplex and dispersible soils. In the latter case, excessive cracking and subsidence may lead to tunnel erosion.

Cultivation for several years following filling has been found to promote stability. By filling in surface cracks and eliminating irregularities, more even water penetration is promoted. In addition, cultivation following cropping assists organic matter build up and inhibits the formation of the surface crust.

In arable areas, sowing a permanent pasture immediately following gully filling should be avoided where possible. Several years of cropping followed by a pasture ley is the best method. Where possible, gully fill areas should not be fallowed, but should be cultivated once or twice just prior to sowing.

Table 12.4

Recommendations for Control of Common Insect Pests of Pasture*

INSECT	CONTROL **(all rates per hectare)	NOTES
Red–legged Earth Mite and Blue Oat Mite	A. Establishment of new pasture and crops on infested ground. apply before seedlings appear DDT at a rate of 280 g active ingredient1120 ml 25% emulsion concentrate2.8 kg 10% dust B. Control of infestation in established pasture or crops following emergence. DDT at a rate of 140 g active ingredient560 ml 25% emulsion concentrate1.4 kg 10% dust May be applied with superphosphate top dressing, mixtures of superphosphate and DDT are commercially available Azinphos ethyl–Gusathion A (R) at a tate of 560 ml of 40% concentrate Phosmet-Imidan CR) or Imicide (R) at a rate of 230 ml of 15% concentrate	Small grey to black mite with red legs The blue oat mite can be distinguished by a small red spot on its back In the adult stage, mites are about 1 mm long. Both species are active only during the winter. Eggs hatch after the first autumn rains and under favourable conditions, pass through a succession of generations which may give rise to large populations Mites die off with the advent of warmer weather The mites infest a wide range of plants, including lucerne, clovers, peas, young cereal crops as well as vegetables ornamental plants and broad leafed weeds.
Sitona Weevil	DDT at a rate of 1.12 kg active ingredient 4.5 litres of 25% DDT emulsion concentrate Dust not recommended Azinphos ethyl-Gusathion CR) at a rate of700 ml of 40% emulsion. Fenitrothion at a rate of 1.1 litres of 50% emulsion	The preferred host of this insect is lucerne but it will also attack other legumes such as burr medic, subterranean clover and vetch. The adult weevil feeds on the aerial part of the plant, resulting in characteristic υ shaped notches in the leaf margin The larvae are soil dwellers and feed on root nodules. This pest is most active during spring and early summer.
Cutworms and Armyworms	DDT at a rate of 560 to 1120 g active ingredient depending on the size of the caterpillars The low rate is recommended	Cutworins attack a wide range of plants, feeding on stems at ground level, making the plants topple over.

	for caterpillars up to 1.5 cm in length. 2.25 – 4.5 litres of 25% emulsion concentrate Trichiorphon at a rate of 560 g active ingredient 700 g of 80% soluble powder (Dipterex (R)) Cabaryl at a rate of 1.1 kg active ingredient 2 litres of 55% emulsion (Lebaycid (R))	Armyworms, under certain climatic conditions, may suddenly appear in vast numbers and cause widespread damage. They move in a constant direction across a field, eating plant in a face leaving bare ground behind.
Seed Harvesting Ants	The basic recommendation is 3 oz. of 10% gamma DDT wettable powder (or Lindane) per bushel of dried seed. This is equivalent to approxi mately 85 grams per 25 kq of barley or 85 qrams per 20 kg oats, or an approximate rate of 4 grams per kg for cereal grains. The application rate must be increased for species with smaller and heavier seeds. For example, a satisfactory rate for Winmera rye grass would be 6 grams per kg seed, or about7 grams per kg for Phalaris and about 10 grams per kg for Cccksfoot An alternative to mixing the powder with the seed, is a seed pelleting procedure involving 1 part of 10% wettable powder plus 200 parts of basic superphosphate on 40 parts of moist seed.	May be a problem in the autumn particularly when grass seeds are sur face sown. There is currently no official recommendation for the control of seed harvesting ants in New South Wales. The recommendations given here are from the Queensland Department of Primary Industries.

* Original data for inclusion in this Table was supplied by the N.S.W. Department of Agriculture – Division of for Science Services

** In all cases, directions and precautions on manufacturers labels should be strictly folled
(R) Registered trade name.

In cases where immediate protection for a revegetated area is required or where control of runoff using conventional earthworks is not possible, temporary surface stability can be achieved using one of a number of special techniques.

Straw mulching

A protective mulch of at least 3–5 cm and preferably 6-10 cm of cereal hay or straw may be used to control erosion while sown species become established. The site should be prepared normally, fertilized, sown and then covered with straw which should be tied down by wire netting as described below.

Bitumen mulch

Instead of using straw mulch, bitumen emulsion may be sprayed on the surface. This is a highly satisfactory alternative and is widely used on large areas. The bitumen provides a complete surface seal through which sown species readily establish.

To ensure success, the site must be carefully prepared. It should be cultivated to a fine tilth, smoothed and rolled to remove surface irregularities, watered thoroughly with at least 13 litres of water per square metre and seed and fertilizer broadcast. A slow breaking anionic bitumen emulsion should then be applied to ensure even penetration of the emulsion. An additional light watering immediately before the bitumen is applied may be required.

Any area treated this way must be fenced to exclude stock as they will damage the seal.

Nets and netting materials

Netting materials are frequently necessary to prevent removal of straw mulch by wind or running water. They can also be used to increase the durability of a bitumen emulsion seal.

With straw mulch, wire netting, pinned to the soil using staples made from 4 mm fencing wire is most satisfactory.

With bitumen, jute mesh is best. This is because jute will not pull away from the soil surface. The mesh should be laid after the application of seed and fertilizer but prior to the bitumen. “Soilsaver” jute mesh has been found satisfactory. It is available in six feet wide rolls from A. Abraham and Son, Cnr. Canal and Burrows Road, Alexandria.

Other netting materials are available including paper and plastic weave fabrics. Trials have shown these are not as good as jute mesh, nor are they as easy to lay. Light fabrics are difficult to lay in wind, usually deteriorate rapidly and are prone to wind damage following laying. Heavy materials which do not roll flat will easily pull out securing staples, especially when the soil is wet.

Sodding

Laying complete grass sods is the most successful method of preventing erosion on water disposal areas. However, it is limited by the availability of sods, the labour required in their placement and the desirability of subsequent watering to ensure optimum development.

Kikuyu grass is the most successful species. It is easily cut and readily establishes from sods. Couch grass may be used as a less satisfactory alternative.

For complete sodding, cut sods are placed over the entire surface of the site which should be fertilized prior to placement and then watered. Wire netting should then be placed over the sodded surface and pinned to the soil to prevent runoff penetrating beneath the sods and washing them away. 4 mm fencing wire makes satisfactory pins which should be pushed into the soil on 0.5 - 1.0 m centres. Closer pinning, or stapling, is required to join adjacent strips of netting. The upstream edge of any netting should be buried to prevent the sod being peeled back by flowing water.

Alternatively, kikuyu or couch may be laid in strips across the slope or sprigged on 50 cm centres. If these methods are used, it is more desirable to have sites watered to ensure a rapid stabilisation.

If sodding is carried out when a species is actively growing, sods will rapidly attach themselves to the soil and spreading rhizomes and stolons will hasten the attainment of complete ground cover. In favourable situations, areas can be satisfactorily established if sods are placed at 1 to 1.5 m intervals during the early summer.

Cover crops

The use of winter and summer growing cereals as cover crops is advantageous where either a rapid ground cover or a temporary or pioneer species is required.

In eroded situations, cover crops are used to improve the micro-environment and hence conditions for establishment of other sown species. Cover crops reduce surface sealing of the soil, promote even infiltration and reduce evaporation. Additionally, they provide a mulch following seeding and haying off. Mowing with a slasher or reciprocating mower following seeding assists this process. Sowing rates are generally about half those used for paddock sowing.

Hydromulching

This process consists of mixing either wood pulp or hammer-milled hay, seed and fertilizer with water in a large tank and spraying this on the area to be treated. The hydromulcher is a machine specially designed for this purpose.

The method is particularly suited to sowing very steep and high road batters or inaccessible areas which cannot be traversed by conventional seeding equipment.

The wood pulp or hay acts as a vehicle to distribute the seed, and also adheres to the batter holding the seed in place until it germinates.

The method is very convenient and quick. It does not represent such a hazard to passing traffic as bitumen spraying.

Seeded pellets and pelleted seed

Various types and combinations of pelleted seed and seeded pellets are commercially available. These products are designed to enhance the physical and/or chemical environment immediately adjacent to the germinating seed and young plant.

Trials have shown they perform reasonably well compared to uncoated single seeds when surface sown. Their specific application in this environment for the sowing of eroded areas and earthworks, has not yet been fully evaluated.

12.1.8 Post Establisbment Management

Grazing management

Because of the dynamic nature of pastures, management plays a major role in determining long term stability of the system. Grazing management is particularly important. Ungrazed pastures will become rank and stemmy with a consequent reduction in ground cover, productivity and soil nutrient availability. The effects of overgrazing are of course even more deleterious.

All critical areas and particularly water disposal areas should be fenced and grazed only to control rank growth. Grazing should therefore be infrequent, using large numbers of stock for short periods only when the area is dry.

Broad acre grazing management is also important in soil conservation practice. Where ground cover can be maintained on steeper land, either as a result of grazing by cattle rather than sheep, or grazing only during the most productive months of the year, the erosion risk can be considerably reduced. At the same time, where grazing pressures are too light, species selection by stock may adversely affect the botanical composition of the sward. Selective grazing of oversown pasture on steep lands may result in a complete failure of the sown species if they are more palatable than the existing plants.

Fertilizer management

The use of fertilizers, together with sound grazing management, is another essential part of post establishment management.

Fertilizers, apart from their effect on general vigour, can also be used to influence botanical composition. To maintain a legume component in a sward, regular applications of superphosphate are required. In a sward consisting primarily of native grasses, fertilizer management is less critical.

Fertility improvement of less accessible country is usually the first step in improving ground cover. The usual method is to apply fertilizer and seed, usually a legume.

It must be remembered that improvement of grazing land does not necessarily mean grazing rates can be immediately increased. Where ground cover has deteriorated as a result of long periods of poor grazing management, permanent improvement may take a number of seasons.

The use of techniques such as rotational and deferred grazing may be necessary to allow annual species to set seed and to allow the build up of less palatable dry stubble to provide protection over the summer. At the same time, excessive dry pasture will greatly increase the bush fire hazard. Firebreaks, on the contour, will greatly assist fire control.

Waterways and flumes

Post—establishment management of these areas is particularly important.

Regular inspections should be made, particularly after heavy rains so that obstructions can be removed and damage repaired. Experience has shown that although waterways and flumes may operate successfully for several years, cover deterioration and development of rills and tunnels may occur at any time.

Following successful establishment or ground cover improvement, waterway swards require careful management. Infrequent grazing by large numbers of stock for short periods is recommended. The complete exclusion of stock is undesirable, long term dominance of the sward by native species is probably best.

Table 12.5
Fertilizer Conversion Chart
All rates in kilograms per hectare (to nearest 5 kg)

Kg elemental phosphorus per Hectare	Equivalent Fertilizer Application Rates kg ha^{-1} (to nearest 5 kg)													Kg elemental Nitrogen per Hectare	Equivalent application rate kg ha^{-1}		
	Single Super Phos-phate	Double super-phos-phate	Hi-phos® or Tri-phos® Triple Super	Starter l2® (12:52:0)		Starter 15® (15:30:0)		Starter l8® (18:18:0)		Greentop® (20:11:0)		Multigrow® (10:9:8)			Urea	Sulphate of ammonia	Nitram
				Rate	Addnl N (kg)	Rate	Addnl N (kg)	Rate	Addnl N (kg)	Rate	Addnl N (kg)	Rate	Addnl N/K (kg)				
6	65	35	30	25	3	45	7	75	13	125	25	155	16/10	15	30	70	45
8	85	45	40	35	4	60	9	100	18	165	32	205	21/13	20	45	95	60
10	110	60	50	45	6	75	11	125	22	210	41	255	26/16	25	55	120	75
12	130	70	60	55	7	90	14	150	26	250	49	305	31/19	30	65	140	90
14	150	80	70	65	8	105	16	175	31	290	57	360	36/22	35	75	165	105
16	170	90	80	70	9	120	18	200	35	335	66	410	41/25	40	85	190	120
18	195	105	90	80	10	135	20	225	39	375	74	460	46/29	45	100	215	130
20	215	115	100	90	11	150	23	250	44	415	81	510	51/32	50	110	240	145
22	240	125	110	100	12	165	25	275	48	460	90	565	57/35	55	120	260	160
24	260	140	120	110	14	185	28	300	53	500	98	615	62/38	60	130	285	175
26	280	150	130	115	14	200	30	325	57	*		665	67/41	65	140		190
28	300	160	140	125	16	215	32	350	61			720	72/45	70	150		205
30	325	170	150	135	17	230	35	375	66			770	77/48	75	165		220
40	430	230	205	180	22	305	46	500	88			1025	103/64	80	175	Higher rates of appli-cation not recom-mended	235
50	540	285	255	225	28	380	57	625	109					85	185		250
60	650	345	305	270	34	460	69	*						90	195		265
70	755	400	355	315	39	535	80							95	205		280
80	865	460	405	360	45	*								100	215		295

* Rates in excess of 100 kg ha^{1} N are not recommended

® Trade name

This table may be used to formulate fertilizer application recommendations. It may be seen that the value of mixed fertilizers lies in being able to apply phosphate and nitrogen at varying rates. Thus 500 kg ha^{-1} Starter 18 will supply kg P and 88 kg N per hectare. If a higher rate of P is desired, Starter 15 at 535 kg ha^{-1} will supply 70 kg P and about the same quantity of Nitrogen.

12.1.9 seed and Fertilizer Application Rate Tables Metric Equivalents

1	lb/acre	=	1.1 kg ha^{-1}
1	cwt/acre	=	125 kg ha^{-1}
1	hectare	=	2.471 acres
1	kg ha’	=	1 gram per 10 square metres
10	kg ha^{1}	=	1 gram per square metre

1 metre is slightly longer than one pace.

1 lb per acre is approximately equivalent to 1 kg per hectare.

It is possible using these conversions to work out the total quantity of seed and fertilizer required for specific areas.

Examples:

The recommendation for a batter 20 metres x 9 metres includes fertilizer at a rate of 250 kg ha^{-1} (2 cwt per acre) and a seeding rate of 20 kg ha^{-1}.

Area of the batter is 180 square metres.

The fertilizer dressing of 250 kg ha^{-1} is equivalent to 25 g per square metre, so the total requirement is 4500 g or 4.5 kg.

The seed requirements are equivalent to 2 g per square metre, so that the total requirement is 360 g or 0.36 kg.

Figure 12.1 is included to aid the computation of seed and fertilizer requirements for small areas.

Table 12.5 lists some of the common single and mixed fertilizers in terms of their equivalent application rates.

12.1.10 Approximate Measures for Field Use

The weight of a closed handful of seed of some common grasses, legumes and fertilizers is presented in tabular form below. Although a very approximate measure, this estimate will frequently be satisfactory for field use.

Species or Fertilizer	Weight (grams)
Subterranean clover	50
Woollypod vetch	80
Wimmera ryegrass	40
Ryecorn (black winter)	60
Phalaris	20
Cocksfoot	90
Superphosphate (single)	80
Starter 18*	40
Urea	50
Sulphate of ammonia	80

Thus a sowing rate of 10 kg ha^{-1} of Wimmera rye grass is approximately equal to a handful per 40 square metres. An application rate of superphosphate at 125 kg ha^{-1} is approximately equal to one handful per six square metres.

To obtain a reasonably uniform coverage when applying by hand, measure out and sow appropriate reference area, then attempt to achieve the same ground coverage over the rest of the site.

12.2 District Recommendations

In this section specific species, fertilizer and sowing recommendations are given for the Albury district.

The district has been divided into various agronomic zones on the basis of differences in land use, soils, vegetation and climate. (refer figure 12.2)

12.2.1 Agronomic Zones

Zone 1

Land use, except for Crown Land, consists of grazing with minor vegetable growing and cropping. Topography is undulating to steep. Soils are predominantly sandy, including sandy yellow earths and siliceous sands with minor occurrence of red podzolic soils and red earths.

The zone is characterized by a relatively long growing season with adequate rains expected from March to October.

Zone 2

Similar to Zone 1, except the growing season is shorter. Topography is steep to undulating with areas of river flats and sheltered valley floors, Soils are mainly siliceous sands.

The area is used primarily for grazing and includes considerable tracts of Crown Land. Some cropping including tobacco growing, is undertaken near Tooma.

Zone 3

Land use consists principally of grazing with minor cereal cropping. Topography is variable. Soils vary from podzolic soils and red and yellow earths to yellow solodic soils.

Zone 3 is differentiated from Zone 2 chiefly on the length of growing season and more gentle terrain.

Zone 4

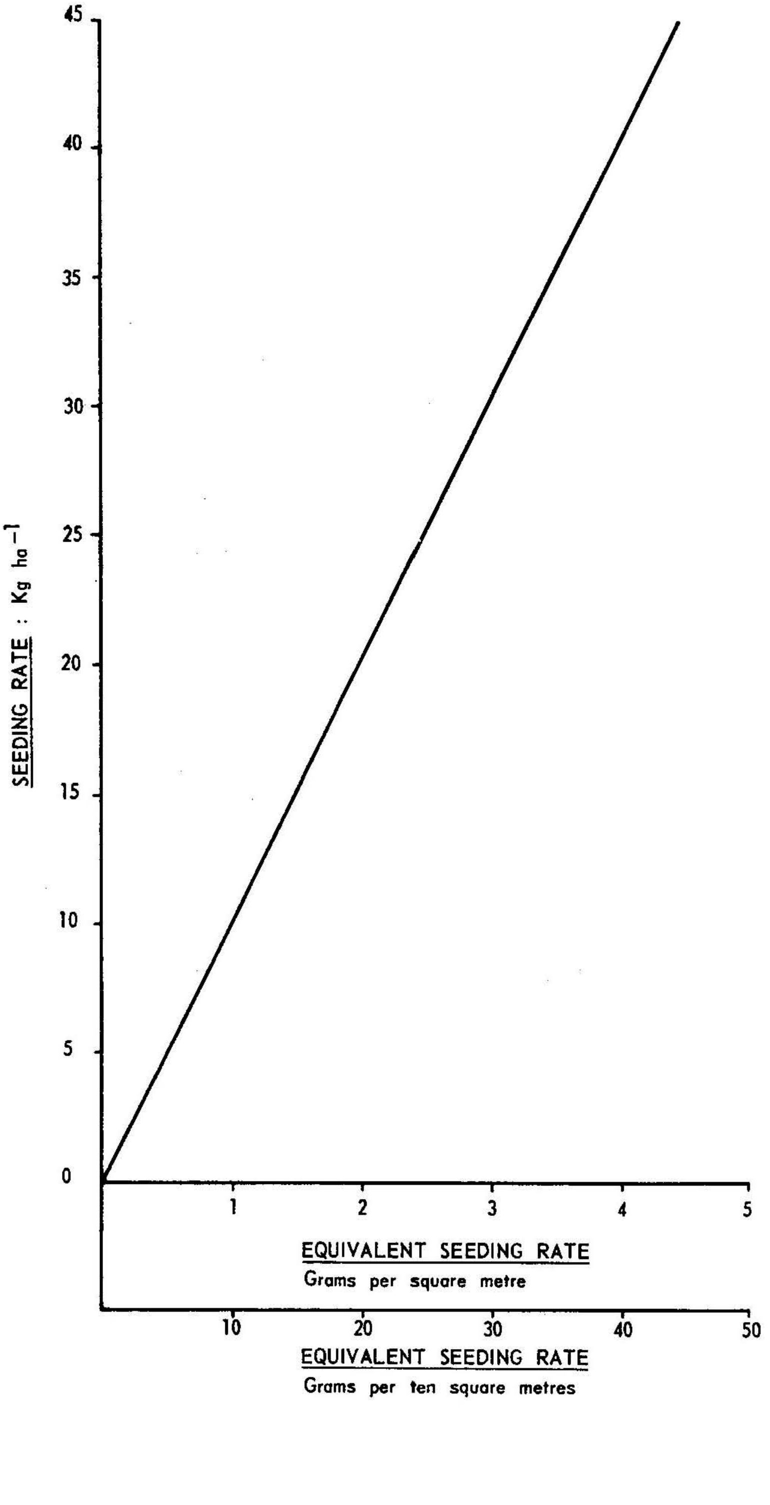
Consists principally of flat to undulating land. The area is used mainly for cool season cereal cropping and grazing. Soils are variable, including areas of grey and brown clay soils, yellow solodic soils and solodized red brown earths.

Zone 5

Flat to undulating land used primarily for winter cereal cropping and grazing of annual pastures. Soils are similar to those of Zone 4.

Zone 5 is differentiated from Zone 4 by climate and length of growing season.

Figure 12.1 Relationship between Seeding Rates in Kilograms per Hectare and Grams per square Metre and ten square Metres.



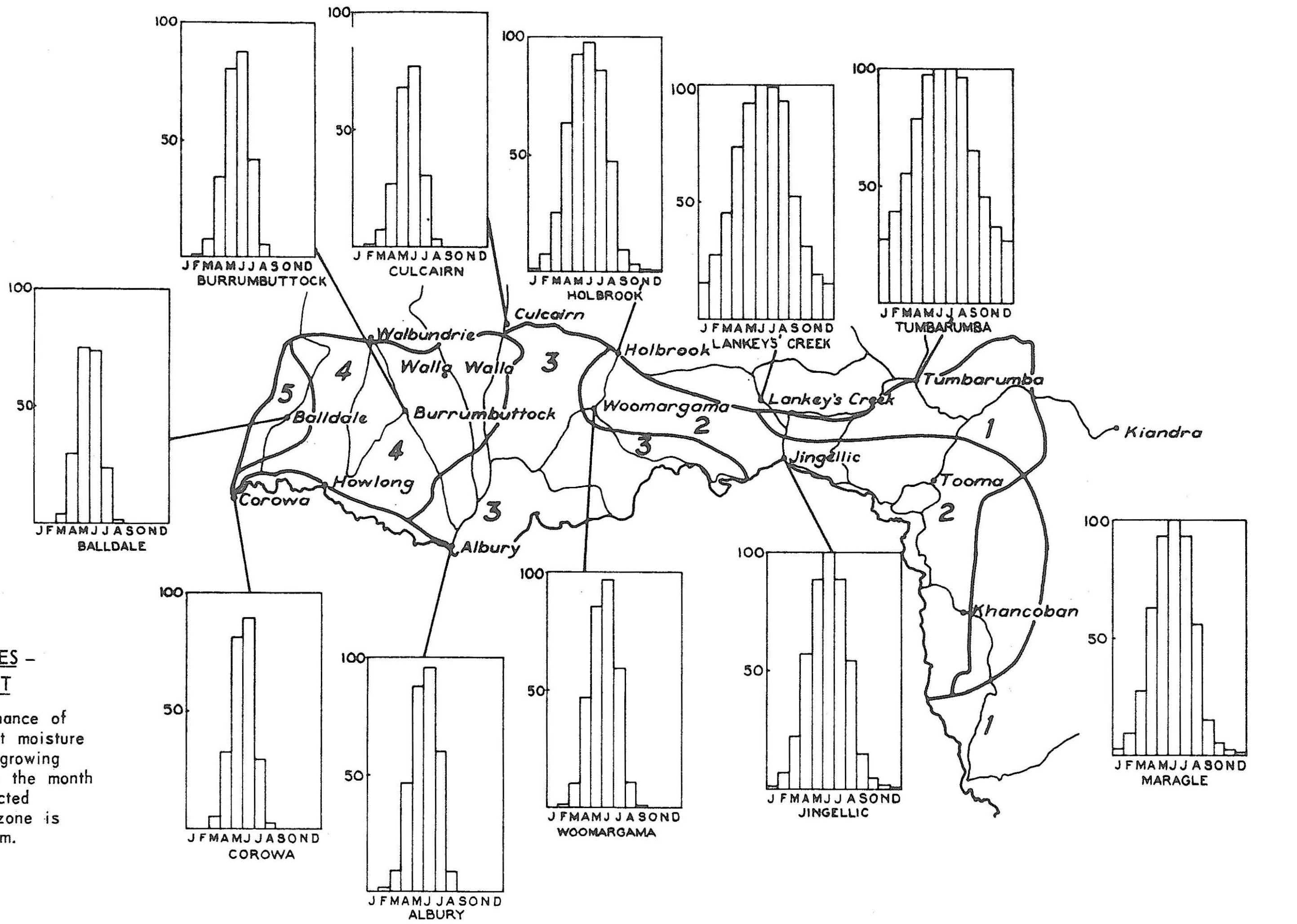


FIGURE 12.2

AGRONOMIC ZONES – ALBURY DISTRICT

The percentage chance of receiving sufficient moisture for a five month growing season starting in the month indicated for selected stations in each zone is shown by histogram.

12.2.1 Species Notes

Grasses

Grasses suitable for erosion control in the area are listed below in tabular form. The cereals, oats barley, cereal rye and millet are suitable as cover crop species or for a short term cover pending the sowing of a permanent pasture.

Annual Grasses

Wimmera ryegrass (Lolium rigidum)	A naturalized species popular as a cool season grazing plant. Free seeding, it is considered a weed in arable country where it may appreciably reduce crop yields. It can be sown on banks, batters, beneath straw mulch and bitumen and generally on disturbed areas, Compatible with most legumes.
Algerian oats (Avena byzantina)	Commonly grown as a cereal or to provide supplementary grazing during late winter to spring. Closely related to the common oat (A. sativa) which is also grown in the area. (e.g. cv. Cooba). Both these species are useful for erosion control either as a cover crop or to provide temporary protection for earthworks over winter.
Barley (Hordeum spp.)	Grown commercially for both malting and grain. Particularly useful as a primary colonizing species in saline and low fertility situations.
Cereal Rye or Ryecorn (Secale cereale)	Not widely grown as a crop. for either grain or grazing. a useful species for erosion control, will withstand periodic waterlogging, but flourishes in well drained soils. Particularly value— able for wind erosion control and as a primary colonizer on infertile soils. Drought resistant and cold tolerant.
Japanese millet (Echinocloa crusgalli var. frurnentacea)	Although not commercially grown in the area, this species is the only recommended summer growing annual. It is suitable for providing temporary cover during summer. Requires moderately fertile soil and a prepared seedbed.

Perennial Grasses

Phalaris (Phalaris tuberosa)	The most widely used perennial grass in the district. Two cultivars are generally available, Australian and Sirocco. The latter cultivar was specifically bred to extend the usefulness of the species to lower

rainfall areas. Phalaris is strongly summer dormant, making good growth during the cooler months. Valuable for erosion control, particularly on waterways, spillways and gully fill.

Cocks foot (Dactylis glomerata cv. Currie)	A strongly tufted deep-rooted perennial generally used for grazing particularly in the spring. Drought resistant, this species can be sown as an alternative to Australian commercial phalaris. Useful for erosion control on waterways, flumes and spillways. Not recommended for bank or batter sowings.
Fescue (Festuca arundinacea)	Although a cool season perennial it is capable of good growth during summer if moisture conditions are adequate. Cultivar Demeter may make better growth than Australian Commercial phalaris in high rainfall areas during the cooler months. Maybe slow to establish.
Perennial ryegrass (Lolium perenne)	This species has strong autumn and spring growth and under conditions of high fertility produces abundant high quality pasture during the cool season. It is also capable of withstanding periods of summer moisture stress. In some areas it may fail to persist beyond three or four seasons.
Reed canary grass (Phalaris arundinacea)	A robust coarse perennial, spreading by creeping rhizomes. Prefers wet areas. A good species for soil conservation.
Prairie grass (Ehrharta calycina cv. Unarlee)	A deep-rooted tufted perennial bunch grass adapted to lighter soils. Very palatable and susceptible to high grazing pressures. Slow to establish but of value for erosion control, particularly in gravel pits and similar situations. Seed viability is variable.
Tall Wheatgrass (Agropyron elongatum)	A coarse tufted species particularly adapted to saline situations, alkaline soils and areas susceptible to inundation. The main growing period is spring and autumn and it remains green well into the summer. Normally sown as a pure stand, it is compatible with other species
Paspalum (Paspalum dilatatum)	Strongly tufted deep-rooted bunch grass, spreading by short rhizomes. Although specifically adapted to sub-tropical areas, will perform satisfactorily where above average

	water supply can be provided. Useful species for road drains, some flumes and waterways. Not suitable for areas with infrequent flows, during summer.
Kikuyu (Pennisetum clandestinum)	A deep-rooted turf–forming species spreading by stolons and rhizomes. Not utilized as a grazing plant in the district. A very valuable species for erosion control. It is particularly useful for stabilization of inlet batters of structures and for preventing erosion by wave action. Useful for gully stabilization and on flumes and waterways. The seed is now commercially available. Previously establishment was by vegetative means.
Couch grass (Cynodon dactylon)	A variable fine-leaved turf-forming perennial spreading by rhizomes and stolons. Although often a troublesome weed in arable land, it is valuable for erosion control. Establishment from seed is difficult and more reliable results can be obtained from sodding using an ecotype common to the area. May be used for waterways and flumes. Local strains are usually more drought resistant and frost tolerant than commercial material.

Legumes

Features of recommended legumes are listed below in tabular form.

Subterranean clover (Trifolium subterraneum)	The agronomic features of common strains of subterranean clover are given in Table 12.6.
Lucerne (Medicago sativa cv. Hunter River	Adapted to a wide range of environments in the Mediterranean climate zone. Little winter dormancy and good frost resistance. High degree of tolerance to hot dry summers but prefers intermittent grazing. May be selectively grazed and eaten out under continuous grazing
Barrel medic (Medicago truncatula cv. Jemalong)	Adapted to a Mediterranean climate with an annual rainfall of 250–500 mm. Seeds germinate with autumn rains and a dense sward is developed during winter an early spring. Commences flowering in early September. Prefers neutral to alkaline soils.
Woollypod vetch (Vicia dasycarpa cv. Namoi	Although early growth is fine and prostrate, later growth is very vigorous resulting in dense, bulky stands. It regenerates well, but must be allowed to set adequate seed. A

	cool season annual, this species performs well under a cover crop and can be successfully established from surface sown seed. Namoi is of value particularly on low fertility acid soils between 380–635 mm annual rainfall isohyets. Can be used to increase the quality of ground cover when surface sown into an existing sward.
White clover (Trifolium repens)	A highly valued cool season perennial adapted to areas with mild to cool winters but having a relatively short summer drought. Not persistent under close grazing, grows well where fertility conditions are adequate to good.
Strawberry clover (T. fragiferum cv.Palestine)	Adapted to temperate areas. Tolerant of a wide range of soil pH including acid soils, peats and black clays (pH 5.5 to 9.0). Has a high phosphate and potash requirement. Also tolerant of moderately high soil and repeated inundation. Not adversely affected by submergence for up to three months provided the water is flowing.

Table 12.6
Agronomic Features of Various Cultivars of
Subterranean Clover
(Trifolium subterranean)

Cultivar	**Flowering time**	**Time from sowing to flowering** *	**Effective rain requirement** **	**Oestro genic rating** ***	**Remarks Special features**
Geraldton	Jul-Aug	128 days	5–6 mths	L-M	Wide range of soil types, pH 6-7.5
Dwalganup	Aug	124 days	6-6½ mths	M-H	Poor spring growth, popular strain
Daliak	Aug-Sep	Approx.130 days	6½ mths	L	Good field qualities
Yarloop	Aug-Sep	132 days	6½ mths	M-H	Adapted to moist situations pH 6-7.5
Seaton Park	Sep		6½–7 mths	M	
Dinninup	Sep	130–140 days	6½–7 mths	H	Not recommended

Cultivar	Flowering time	Time from sowing to flowering *	Effective rain requirement **	Oestro genic rating ***	Remarks Special features
Howard	Sep	130–140 days	6½–7 mths		Resistant to clover stunt virus
Woogenellup (Marrar)	Aug-Oct		7 mths	M-H	Popular strain. Good persistence
Bacchus Marsh	Sep–Oct	140 days	7 mths	L-M	Lacks persistence
Clare	Sep–Oct	151 days	7-8 mths	L-M	Tolerant to alkaline soil conditions
Mt. Barker	Sep–Oct	148 days	7-8 mths	L-M	Susceptible to rust
Tallarook		171 days	7-7½ mths	L-M	Late rains important - produces into summer.

* From Cameron (1961). Where data was not avilable, figures were interpolated.

** Lazenby and Swain (1973) and interpolation.

***L – Low potency

M – Medium potency

H - High potency

The climate of the Albury district is characterised by a high probability of summer and early autumn drought. If the probability of drought exceeds 50 percent, the risk to species likely to be actively growing at this time is considered too great.

Figure 12.2 shows the length of growing season for cool season species is between 7 and 8 months in the east of the district and S to 6 months is the west.

Drought probability does not take into account local factors such as aspect or topography which may influence moisture availability at specific locations.

When sowing structures such as banks and batters, use earlier strains of available species. When sowing areas subject to prolonged flows or seepage, late maturing varieties should be used, When sowing areas where frequent flows can be expected over summer, tropical or sub–tropical grasses may be included.

If early maturing cultivars of subterranean clover are to set seed successfully, they should not be sown later than June or earlier than November. For later varieties such as Seaton Park, Howard and Woogenellup, sowings should be made no later than the end of May.

If phalaris is to reach reproductive age, it should not be sown later than early June.

Warm season species such as kikuyu, and paspalum should be sown in the early spring and sowing completed by the end of November.

Sowing method will depend on the site and availability of machinery. Large seeded legumes such as woollypod vetch and subterranean clover can be established by surface sowing, provided that some protection is given the seed. Harrowing, following surface sowing is an advantage, particularly with small seeded grasses. Partial or complete seed burial will reduce problems caused by seed harvesting ants.

Seed theft by ants, lower germination potential due to adverse soil conditions and out of season sowings can be compensated for by increasing sowing rates. Some guidelines are listed in table 12.7.

Table 12.7

Factorial Increases in Sowing Rate under Adverse Conditions

Condition	Factorial increase
Surface sowing small seeded grass	x4
Surface sowing subterranean clover	x3
Surface sowing woollypod vetch	x2
Out–of–season sowing grasses	Inadvisable
Out–of–season sowing legumes	x4
Hard surface, 5–10% ground cover	x5
Hard surface, 50–100% ground cover	x2
Hard surface bare	Inadvisable
Surface ripped, sown and harrowed	x1.5
Surface ripped, sown not harrowed	x2

12.2.2 Zone recommendations

Basic pasture mixtures for all agronomic zones are given in table 12.8. The sowing rates given are those recommended for use following optimal site preparation, sowing conditions and methods at the most favourable time of year. Adjustments should be made where necessary by consulting Table 12.7. Notes which should be read in conjunction with these recommendations are presented in a tabular form below.

Site Characteristic	Remarks
Less favourable site, such as steeper slopes, shallow soil areas, compact surface	Use earlier maturing strains of subterranean clover, such as Daliak or Geraldton. Use Sirocco phalaris in place of Commercial phalaris where recommended. Use a cover crop such as oats or barley sown at 80 kg ha^{-1} to promote establishment and water penetration.
Moist areas, areas subject to prolonged flows during the winter.	Use Yarloop subterranean clover or Palestine strawberry clover in high rainfall areas, in place of other recommended varieties. Omit Hunter River lucerne, where recommended. Use grasses such as Tall Wheatgrass, kikuyu and couch grass sown at rates of 9 and 4 kg ha^{-1} respectively.
Areas subject to prolonged flows during the summer.	Use adapted grass species above. Paspalum sown at 3 kg ha^{-1} may be satisfactory.
Areas which have failed to establish or where cover improvement is desirable.	Surface sown Namoi woollypod vetch at 10-15 kg ha^{-1} or subterranean clover at 8 kg hal. Sod seed the recommended pasture mixture. Surface sow the recommended pasture mixture and cover with straw mulch or topsoil.
Self–mulching soils.	Include Jemalong barrel medic at a sowing rate of 2–3 kg ha^{-1}.
Sandy sites such as silt fans, creek banks, fenced waterways on granite country.	Use perennial veldt grass (obtain fresh seed supplies) sown at a rate of 3–5 kg ha^{-1}, in combination with Hunter River lucerne (at 2 kg ha^{-1}). Ryecorn is a good stabilizing species sown at a rate of 100 kg ha^{-1}, but if used as a cover crop reduce this rate to 60 kg ha^{-1}. In moist situations, Tall wheatgrass, kikuyu, paspalrnn and couch grass may be satisfactory. In waterways, sow Namoi woollypod vetch at 15 kg $ha-^{1}$ in addition to the above species.

Gravel Pits	Use perennial veldt grass (obtain fresh seed supplies) sown at 3-5 kg ha^{-1}, Merridin Wimmera ryegrass at 8 kg hal, barley or ryecorn at 80 kg ha^{1}, Narnoi woollypod vetch at 10 kg ha^{-1}, Daliak or Geraldton subterranean clover at 6 kg ha^{-1}. All areas should be ripped and where possible topsoiled prior to sowing.
Cereal Cover Crops.	Oats sow at a rate 80 kg ha^{-1}. Barley sow at a rate of 60 kg ha^{-1}. Ryecorn sow at a rate of 60 kg ha^{-1} Japanese Millet 10 kg ha^{-1}.

12.2.3 Fertilizer Recommendations

Owing to site variability and other factors, it is not possible to provide specific fertilizer recommendations for use throughout the district.

The notes in Section 12.1.3, and Fertilizer rates and applications and the data in Table 12.5 provide basic data from which recommendations can be formulated. The following examples are intended as guidelines only.

Example 1

Broad based bank in Zones 4 or 5 on cropping land:

Usual application rate with crop 100 to 150 kg ha^{-1} superphosphate.

Where paddock has a long fertilizer history,double this rate on bank and channel areas.

Where previous applications have been infrequent, a rate of 2.5 times the normal may be required.

Example 2

On sheet eroded areas having little cover, use a mixed fertilizer such as 18:18:0 (starter 18) or 20:11:0 (Greentop)® at 200 kg ha^{-1} respectively. An annual follow up application of superphosphate at 100 to 150 kg may be necessary for several years after sowing.

Example 3

On gravel pit and other areas of large scale topsoil removal, superphosphate at 200 kg ha^{-1} and a mixed fertilizer such as 18:18:0 (starter 18®) at a rate of 200 kg h^{-1} may be necessary. This would be equivalent to 12:52:0 (Starter 12®) at 155 kg ha^{-1} (supplying 19 kg ha^{-1} N) or 15:30:0 (Starter 15*) at 270 kg ha^{-1} (supplying 41 kg ha^{-1} N). The latter alternative would be more satisfactory.

Table 12.8
Basic Sowinq Recommendations - Albury District

Situation/ Zone	Zone 1	Rate kg/ha	Zone 2	Rate kg/ha	Zone 3	Rate kg/ha	Zone 4	Rate kg/ha	Zone 5	Rate kg/ha
Paddock Sowing										
a) Long Term Ley	perennial ryegrass	6	Currie Cocksfoot	5	Aust. Comm phalaris	2	Aust. Comm phalaris	3	Sirocco phalaris	3
	Currie Cocksfoot	3	Hunter River lucerne	5	Currie Cocksfoot	2	Hunter River lucerne	5	Hunter River lucerne	5
	White clover	2	Mt. Barker sub–clover	4	Hunter River lucerne	5	Woogenellup or Mt. Barker sub clover	4	Seaton Park sub–clover	4
					Woogenellup or Mt. Barker sub–clover	4				
b) Short Term Ley	Does not apply		Does not apply		Wimmera ryegrass Mt. Barker sub–clover		Wimmera ryegrass woogenellup sub–clover		Wimmera ryegrass Seaton Park sub–clover	

Table 12.8 (Cont'd)
Basic Sowinq Recommendations - Albury District

Situation/ Zone	Zone 1	Rate kg/ha	Zone 2	Rate kg/ha	Zone 3	Rate kg/ha	Zone 4	Rate kg/ha	Zone 5	Rate kg/ha
Bank sowing a)Agricult -ural bank	Sow with a crop or suitable ley mixture as given above									
b)Narrow based Bank and Gully Control Structure (surface sown in Autumn)	perennial ryegrass	9	perennia ryegrass	3	Wimmera ryegrass	9	Wimrnera ryegrass	9	Wimmera ryegrass	9
	White clover	1	Wimmera ryegrass	3	Woogenellup sub—clover	6	Seaton park sub—clover	6	Geraldton or Daliak sub clover	6
	Mt Barker Tallarook sub-clover	5	Mt Barker sub-clover	5						

Table 12.8 (Cont'd)
Basic Sowinq Recommendations - Albury District

Situation/ Zone	Zone 1	Rate kg/ha	Zone 2	Rate kg/ha	Zone 3	Rate kg/ha	Zone 4	Rate kg/ha	Zone 5	Rate kg/ha
Waterways and flumes										
Cultivated and sown	Long term ley mixture given above. Additions/deletions depending on site characteristics as per notes following table 12.7									
Uncultivated	Mt Barker or Tallarook sub-clover	8	Mt Barker sub-clover	8	Woogenellup sub–clover	8	Woogenellup sub–clover	8	Seaton park sub–clover	8
(oversown in Autumn)					Namoi Woolypod Vetch	15	Namoi Woolypod Vetch	15	Namoi Woolypod Vetch	15
Species Suitable for Use in Wet Areas	Reed Canary grass	3-4	Same as Zone 1 also		Kikuyu	2-3	Kikuyu	2-3	Kikuyu	2-3
	Demeter fescue	4-6	Tall Wheatgrass*	9-12	Paspalum	3-4	Paspalum	3-4	Paspalum	3-4
	Palestine strawberry clover	2-3	Couch grass*	2-4	Tall Wheatgrass*	9-12	Tall Wheatgrass*	9-12	Couch grass*	2-3
	Lotus Major*	2-3			Yarloop sub-clover	5-6	Yarloop sub-clover	5-6	Seaton Park and Yarloop sub-clover	5-6

Moderately salt tolerant. Where salting is an obvious problem, use Tall wheatgrass at a rate of 15 kg ha-1 and Palestine strawberry clover at 2–3 kg ha-1

13 URBAN CAPABILITY PLANNING

R.S. Junor

13.1.1 Introduction

The Soil Conservation Service’s urban capability programme provides a detailed inventory of the natural features and resources of an area and an interpretation of this data in terms of the erosion and instability hazard subsequent urban development may create.

Also, it provides guidelines for reducing erosion damage during urban development and associated sedimentation and turbidity of waterways downstream. Development, planned to minimize erosion hazard, is generally consistent with an aesthetically pleasing land-scape and minimizes long term repair and maintenance costs.

The main considerations in the preparation of an urban capability report are:

- Detailed soil survey and laboratory analysis of samples from selected areas.
- Detailed slope and landform survey using aerial photographs and field reconnaissance.
- Urban capability classification using the above data (see 13.2).
- Specific recommendations for each urban capability class.

13.2 Urban Capability Classification

Class	Erosion/Instability Hazard	Interpretation of Urban Capability
A	Low	Extensive building complexes (Commercial or industrial complexes).
B	Moderate	Suitable for extensive building complexes or for residential develop ment (600 sq. metre blocks)
C	High	Suitable for residential development ‘(600 sq. metke blocks). Specific site recommendations given to overcome erosion hazard
D	Very High	Suitable for low density residential or recreation al use: Specific constraints determine the type and intensity of development.
E	Extreme	Not recommended for development because physical constraints are too severe

The following subclasses are used to indicate the major physical constraints to development, they are:—

0 No constraints.

1 Slope.

2 Flooding.

3 Soil Characteristic.

4 Extraction or disposal site.

5 Topographic feature (run—on, seepage, swamp, wave erosion, rock outcrop, rock fall, avalanche)

6 High water table.

For example, classification of B - 1, 3, indicates a moderate erosion hazard and development constraints involving land slope and soils.

13.3 Identification of Urban Capability Classes

The following features are used to define the urban capability class.

- Climate
- Slope
- Landform
- Geology and Soils
- Drainage
- Other physical factors which affect development such as flooding, salinity and rock outcrop.

13.3.1 climate

The main considerations are annual rainfall, rainfall intensity and seasonal variation of rainfall and temperature. These factors provide a guide to the ease of revegetation or the persistence of vegetation to control erosion in the urban area and associated drainage reserves.

Specific rainfall intensity and frequency data is required because storms create a major erosion threat to extensively exposed areas of a subdivision.

13.3.2 Slope

Six slope classes are used to describe the degree of land slope, they are:—

Slope Class

a	0 - 2%	Drainage problems may occur here.
b	2 – 5%	These slopes are best suited for industrial, commercial or education complexes that normally require large scale site disturbance.
c	5 – 10%	Recommended upper limit of commercial or industrial development owing to the extent of site excavation required. Land best suited for residential development.
d	10 – 20%	Slopes generally suited for residential development (600 sq. metre blocks), 20% slope recommended as the upper limit of development.
e	20 – 30%	Slopes not suited to intensive residential development, use determined in association with other physical constraints.
f	> 30%	Slopes not suited for urban development.

13.3.3 Topography

Topography is described using seven slope facet classes, they are:—

1. Crests and Ridges.
2. Sideslopes.
3. Footslopes.
4. Floodplain.
5. Drainage Plain.
6. Incised drainage channel.
7. Disturbed landform.

These landform components are detailed together with the slope classes for ease of interpretation.

13.3.4 Geology and Soils

The geology of an area is considered in relation to soils and natural slope stability. Areas of mass movement or seepage, arising from a particular rock type or geological formation are identified.

The soils of the area are classified In terms of major soil types and a detailed laboratory analysis of physical properties is provided. Soil problems that would be a constraint to development are identified.

13.3.5 Drainage

The location of an area is considered in relation to the surrounding catchments.

The internal natural drainage pattern is defined and its effect on urban growth and the potential erosion danger of increased runoff is explained. Hydrological investigations may be required to provide drainage reserve recommendations.

13.4 Application of the Urban Capability Classification

The classification is made from an objective assessment of the main physical parameters discussed above.

In the Albury district soils and slope are considered the major parameters.

Slopes below 5% are normally placed in Class A. However, where poor drainage or problem soils occur, such as those with a very high volume expansion, these lands are placed in Class D.

Slopes between 5% and 20% are classified as Class B or Class C depending on the physical soil constraint, drainage, or other site features. Class C indicates greater erosion/instability hazard.

Slopes in excess of 20% are not considered suitable for urban development owing to the erosion hazard. They are classified as Class D, suitable for recreation reserves, grazing, backyard space for low density residential development.

Slopes in excess of 30% are Class E - not suitable for any development.

The flood plain of the Murray River is classified as Class E. Similarly, areas affected by mass movement, and extensive seepage are placed in this class.

Main drainage lines are placed in Class D. These may be developed as waterways to carry storm runoff and used as open space for recreation or backyards.

13.5 Soil Conservation Recommendations for Urban Development

Specific recommendations are provided to assist design engineers in reducing the erosion hazard during and after urban development. They include:—

- Batter slope recommendations.
- Stripping and stockpiling of topsoil.
- Revegetation of general disturbed areas,waterways, and batter slopes.
- Recommendations for location of temporary diversion banks and sediment basins.
- Provision of permanent drainage works and their stabilisation
- Recommendations for location of borrow areas.
- Maintenance of revegetated areas.

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