Department of Agriculture, Victoria, Australia

SOILS AND LAND USE IN PART OF THE GOULBURN VALLEY, VICTORIA

TECHNICAL BULLETIN No. 14
MELBOURNE, 1962

Advice to Landholders on How to use the Soil Survey Report

First Locate Your Property

To find your property on the soil map first turn to the "Index to Soil Maps" at the back of this report. This is a small plan of the whole area with the soil map sheets shown as numbered rectangles. From the key features on the plan, locate the approximate position of your property and note the rectangle number. Turn to the soil map with this number. The roads, channels, and drains shown on the soil map will usually enable you to locate your property, but you should check its position by the parish allotment numbers on the plan. Mark its outline on the soil map, remembering that the scale is 1 inch to 40 chains.

Your property may lie on more than one soil map. You can make a complete plan of your property by joining the sheets together. The maps have been arranged to enable you to do this and the numbers of the adjoining maps are shown on the margins of each sheet.

Use the Legend to Soils and Crop Suitability Grouping

There are six colours and 55 different symbols altogether on the soil maps, but probably fewer than six different symbols will occur on your property. The symbols denote the various kinds of soil, and the colours denote the irrigated crops most suited to particular kinds of soil.

Note the colours, and the symbols on each colour, on the part of the soil map covering your property. Turn to the "Legend" at the back of the "Index to Soil Maps" and find your colours and symbols. This will give you the names of the soil types on your property, and the irrigated crops that can be grown more or less satisfactorily on each. The soil map will now guide you to the best positions for the irrigated crops you may wish to grow.

You will be helped further if you read the sections, "Suitability of the Soils for Various Irrigated Crops" and "Soil Features and Irrigation"; but you should remember that the soil report is not a plan of management for your farm. It will help you in planning, but, before changing your agricultural practices, you should consult your district agricultural adviser. This report is intended for his use as well as yours, and he will give you guidance having regard to all the factors involved.

Know Your Soil Types

You can learn more about your own soil types in the section, "Description of Soil Types"—it is not necessary to read about all of the other soil types in the area. In this section, you will read about the physical nature of your soils, why they are suitable or unsuitable for certain irrigated crops, and some of their problems under irrigation.

It is not essential for you to read later sections in order to use the soil survey. But landholders who do so will be helped by reading Appendix III., "Explanation of Soil Terms", and Appendix IV., "Soil Survey Methods".

The Map of Soil Associations with this report is not intended for the use of landholders. It is a generalized soil map which shows the broad soil pattern on a district basis. The scale is much too small to show farm units.

Department of Agriculture, Victoria, Australia

SOILS AND LAND USE IN PART OF THE GOULBURN VALLEY, VICTORIA

comprising the Rodney, Tongala-Stanhope, North Shepparton and South Shepparton Irrigation Areas

by

J. K. M. Skene and T. J. Poutsma

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ACKNOWLEDGMENT

The soil survey described in this Bulletin was made by the Department of Agriculture. The State Rivers and Water Supply Commission assisted by providing vehicles, field assistants, aerial photographs, plans and district office facilities. The State Rivers and Water Supply Commission also contributed half the cost of this publication.

The whole of the cartography for the soil maps was carried out by the Department of Crown Lands and Survey, as was the preparation of the plates for colour printing.

Numerous people in the three organisations have contributed much to the soil survey.

Special mention is made of the many officers of the State Rivers and Water Supply Commission; Mr. W. P. Dunk, Chief Irrigation Officer for organising the assistance provided, and the officers at the district centres of Tatura, Shepparton, Tongala and Numurkah for, either directly or indirectly, providing field assistance with the soil auger, maintaining vehicles, and providing office facilities and local information.

Officers of the Regional Mapping Section of the Department of Crown Lands and Survey who warrant special mention are Mr. S. P. Hurrey, who supervised the preparation of the soil maps, and Mr. V. K. M. Daniell who did the cartography.

Among colleagues in the Department of Agriculture who have assisted, first mention must be made of the soil surveyors listed at the beginning of the report. Others who have helped materially are the chemists and laboratory assistants responsible for the analyses. Mr. B. Cockroft, Senior Irrigation Officer at the Tatura Horticultural Research Station contributed from his knowledge of the soils in relation to irrigated horticulture.

Last, but not least, mention must be made of the landholders who, without exception, freely allowed the soil surveyors access to their properties.

To all of these people the authors extend their sincere thanks.

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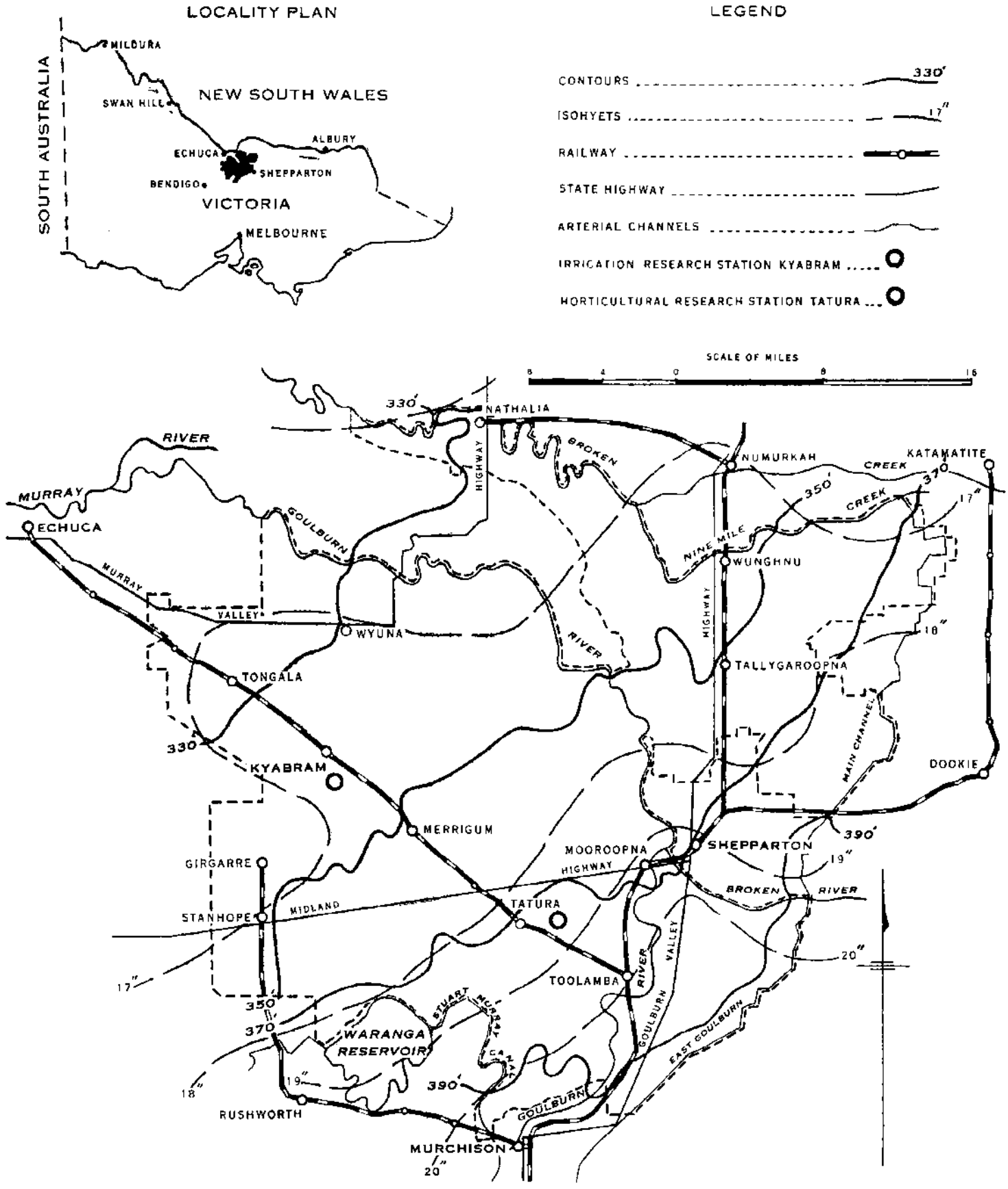

Fig. 1. Locality plan, Parts of Counties Moira and Rodney.

Soils and Land Use in Part of the Goulburn Valley, Victoria

Comprising the Rodney, Tongala-Stanhope, North Shepparton and South Shepparton Irrigation Areas

By J. K. M. Skene† and T. J. Poutsma‡

Soils Surveyed by J. D. Anderson, K. W. Double, T. R. Hansen, L. B. Harford, I. R. J. Morris, J. W. Newell, T. J. Poutsma, I. J. Sargeant, H. H. M. Sarolea, J. K. Snow, I. G. Stell, M. J. T. Troisi.

This report, "Soils and Land Use in Part of the Goulburn Valley, Victoria", concerns the detailed soil survey of about 558,000 acres in the counties of Rodney and Moira (Fig. 1). Most of the area is served by irrigation water and is used for fruitgrowing, dairying, fat lamb raising, and tomato and vegetable growing. The main horticultural crops are canning varieties of peaches, pears and apricots. Dry-farming pursuits are wheat-farming and the grazing of sheep on natural and volunteer pastures. Further information concerning the location and settlement is given in the section, "General Information about the Area."

SUITABILITY OF THE SOILS FOR VARIOUS IRRIGATED CROPS

All the soils have been classified into soil types or other units and given descriptive names. Full descriptions of these can be found in a following section, "Description of Soil Types and Miscellaneous Units."

In the present section, all the soil types with similar capabilities in regard to irrigated crops are grouped together. There are six different groups. The common crops that normally can be grown satisfactorily are listed at the head of each group, followed by the summarized features of the main soil types and the names of all the soil types in the group.

Table 1 is provided to enable the crop suitability grouping of any soil type or other mapping unit to be found readily. All the soil types, and some occurring only in adjoining areas* are listed alphabetically in the table.

TABLE 1.

Crop Suitability Grouping of the Soil Types and other Units.

Soil Types and Units	Crop Suitability Group	Soil Types and Units	Crop Suitability Group
Arkoo loam	IVB.	Wenora loam	IVB.
*Broken sand	IA.	Youanmite loam	IIA.
*Congupna loam	V.	Yuga clay	V.
Congupna clay loam	V.	Zeerust fine sandy loam	IVB.
Congupna clay	VI.	Type A	IVB.
Coomboona loam	IVB.	Type B	IVB.
Coomboona clay	V.	Type C	IVA.
Dunbulb loam	IVB.	Type D	IVB.
*East Shepparton sandy loam	IB.	Type E	IVB.
East Shepparton fine sandy loam	IB.	Type F	IVB.
Erwen loam, normal phase	III.	Type G	V.
Erwen loam, shallow phase	IVB.	Type H	V.
Goulburn loam	IVB.	Type J	IIc.
Goulburn clay loam	IVB.	Type K	III.
Grahamvale sandy loam	IB.	Type L	V.
Gupna fine sandy loam	IVB.	Type M	IVB.
Gupna loam	IVB.	Type N	IVB.
Karook loam	III.	Type O	V.
Katamatite loam	IIA.	Type P	V.
Koga clay loam	IVB.	Type Q	IVB.
Koyuga clay loam	IVB.	Type R	V.
*Lemnos sandy loam	III.	Type S	IVB.
Lemnos loam	III.	Complex I.	VI.
Lemnos loam, grey surface	IVB.	Complex II.	V.
Lemnos loam, dull variant	IVB.	Complex III.	VI.
*Orrvale sandy loam	IVB.	Complex IV.	VI.
Orrvale loam	IVB.	Erwen association	IVB.
Rooka clay loam	V.	River frontage	VI.
Sandmount sand	IA.	Unidentified flooded soils	VI.
*Shepparton sandy loam	IIB.	Soils of Prior Stream Beds—	
Shepparton fine sandy loam	IIB.	Type 1	IVA.
*Shepparton loam	IIB.	Type 1H	IVA.
		Type 2	VI.

† Senior Soils Officer. ‡ Formerly Soils Officer, Department of Agriculture, Victoria. * Soil types marked with an asterisk in this section will not be found on the Soil Maps with this report. They occur in the adjoining Shepparton Irrigation Area (Skene and Freedman 1944).

Crops that could be grown under dry land farming have not been included in the crops listed. Practically all of the soil types and other soil units can be cultivated except some of those in Group VI.

Readers are asked to be cautious about accepting the crop suitability grouping as a rating of the soils in order of their merit. It does suggest a general order, since high return crops can be grown less successfully in descending order from Group I. But there are exceptions in the case of individual crops. For example, pastures and shallow-rooting crops are likely to do better on the medium-textured soils of Groups II. and III., because of their better moisture retaining properties and inherent fertility, than on the sandy soils of Group I.

Even where the crop suitability grouping does indicate an order of productivity, as with horticultural crops, this is not necessarily the order of economic return. Thus Group I. (*a*) soils will require extra outlay for the spray irrigation needed for these soils.

GROUP I.

Very good soils, if given careful irrigation, for all horticultural crops, vegetables, tomatoes and, in the case of sub-group (a) soils, tobacco. Summer fodder crops, cereals, lucerne, and perennial and annual pastures also can be grown successfully.

(*a*) Highly permeable, deep, sandy, brown soils without clay subsoils:

SANDMOUNT SAND.
SANDMOUNT SAND, SHALLOW PHASE.
*BROKEN SAND.

Spray irrigation is recommended for these soils. Some situations are too high for gravity irrigation and, in any case, slopes and high permeability of the soils make them generally unsuitable for furrow irrigation.

Although the soils are liable to watertables, these are usually deep, non-saline, and, in consequence, harmless to crops grown on them. Impermeable, deep clay layers, usually below 10 feet, sometimes occur at lesser depths and then there is some danger in wet years to sensitive crops such as peaches, apricots and citrus from watertables rising to near the surface.

(*b*) Brown sandy soils mostly 9 to 18 inches thick, overlying permeable, red-brown clay subsoils which are underlain by sandy layers:

EAST SHEPPARTON FINE SANDY LOAM.
*EAST SHEPPARTON SANDY LOAM.
GRAHAMVALE SANDY LOAM.

These soils can be watered by furrow and flood irrigation, but care is necessary to prevent overwatering as the soils are liable to watertables. While these watertables are not normally harmful, some situations have impermeable clay layers within 10 feet of the surface and these places are dangerous for stone fruits in wet years.

The three soil types abovementioned are not recommended for tobacco growing because of insufficient surface depth. The tendency for the surface to crust makes East Shepparton fine sandy loam, but not East Shepparton sandy loam or Grahamvale sandy loam, unsuitable for the small seeded vegetable crops, such as carrots and lettuce, sown directly in drill rows.

GROUP II.

Good soils for all horticultural crops (except citrus), pumpkins, peas, beans, tomatoes, summer fodder crops, cereals, lucerne, and perennial and annual pastures.

(*a*) Brown loams mostly 5 to 13 inches thick, overlying well-structured, permeable clay subsoils with denser, less permeable clay below 2 feet:

KATAMATITE LOAM.
YOUANMITE LOAM.

These two soil types occur only in the Dunbulbalane district. They require care in watering by flood or furrow irrigation because of the fairly high permeability of the upper 2 feet. There may be some danger to peaches and apricots in wet years from surface waterlogging, but otherwise both soil types are considered very satisfactory for stone fruits.

The soils are untried for vegetables and tomatoes, but there seems to be no reason why these crops should not do well. They support good perennial pastures in the adjoining Katandra Irrigation Area and, although lucerne has almost disappeared from there, this is probably due to reasons other than unsuitable soil.

(*b*) Brown soils mostly 6 to 10 inches thick, overlying moderately permeable, red-brown clay subsoils with lighter and more permeable layers below 2 feet:

SHEPPARTON FINE SANDY LOAM.
*SHEPPARTON SANDY LOAM.
*SHEPPARTON LOAM.

While fruit trees grown on these soils are less vigorous than those grown on Group I. and Group II. (*a*) soils, they still represent good quality horticultural land and most can be used for stone fruits.

Penetration of irrigation water is usually greater than 18 inches and adequate for reasonable growth of fruit trees and lucerne.

Water does not readily pass through the impeding clay subsoil into the more permeable layers below 2 feet, so watertables usually do not build up in years of normal rainfall. But also because of the restricting clay subsoil, some of the soils may suffer from surface waterlogging in excessively wet years with consequent danger to stone fruits.

(*c*) Grey-brown soils over-lying mottled clay subsoils with lighter textured materials beneath:

TYPE J.

Protection from flooding from the Goulburn River by levee banks enables Type J to be included in Group II.

GROUP III.

Good soils for apricots, apples, pears, plums, summer fodder crops, cereals, and perennial and annual pastures; fair soils for peaches, tomatoes, pumpkins, peas, beans and lucerne.

Brown soils mostly 4 to 8 inches thick, overlying red-brown heavy clay with variable clay layers below 2 feet:

ERWEN LOAM, NORMAL PHASE.
KAROOK LOAM.
*LEMNOS SANDY LOAM.
LEMNOS LOAM.
TYPE K.

Lemnos loam is a very wide-spread soil type used extensively for horticulture and irrigated pastures. Karook loam and Type K are minor occurrences.

Erwen loam has not been used for irrigation as it occurs on high ground above present water supply level. Its similarity to Lemnos loam suggests that it could be put to the same use should it become commandable.

The vigour of fruit trees grown on Lemnos loam is very variable because of differences in the depth of surface soil and in the permeability of the heavy clay subsoil. These features are particularly important where peaches are concerned, and these trees should not be planted on the above soil types unless the site is known to have sufficiently deep surface and satisfactory permeability. The same considerations apply to vegetables and lucerne. The grey surface and dull variants of Lemnos loam are not suitable for these crops.

Generally, it is advisable wherever stone fruits, vegetables or lucerne are contemplated on soils in Group III. to have the proposed site checked for suitability before planting.†

The soils are liable to surface waterlogging in wet years because the heavy clay subsoil does not allow sufficiently rapid downward movement of water. Unfortunately, the risk of injury to peaches and apricots under these circumstances is greatest in the best soils in this Group, i.e., those with the deepest surface. Watertables do not often develop in Group III. soils.

† Specialist officers from the Horticultural Research Station, Tatura, will check the soil and advise on horticultural plantings on request to the Manager. This service is provided free by the Department of Agriculture.

GROUP IV.

Fair soils for pears and plums; good soils for summer fodder crops, cereals, and perennial and annual pastures.

(*a*) Brown soils with permeable subsoils:

SOILS OF PRIOR STREAM BEDS: TYPE 1 AND TYPE 1H.

TYPE C.

Watertables are often present in the permeable subsoils and may persist close to the surface. Therefore, these soils should only be used for shallow-rooting crops, or for those fruit trees which can withstand appreciable waterlogging of the root-zone.

(*b*) Mainly loams and clay loams varying from 3 to 10 inches thick, overlying clays with dull or mottled colours through the soil profile:

ARKOO LOAM.
COOMBOONA LOAM.
DUNBULB LOAM.
ERWEN ASSOCIATION.
GOULBURN LOAM.
GOULBURN CLAY LOAM.
GUPNA FINE SANDY LOAM.
GUPNA LOAM.
KOGA CLAY LOAM.
KOYUGA CLAY LOAM.
LEMNOS LOAM, grey surface.
LEMNOS LOAM, dull variant.
*ORRVALE SANDY LOAM.
ORRVALE LOAM.
WENORA LOAM.
ZEERUST FINE SANDY LOAM.
TYPE A.
TYPE B.
TYPE D.
TYPE E.
TYPE F.
TYPE M.
TYPE N.
TYPE Q.
TYPE S.

With one or two minor exceptions, these soils occur on intermediate plain or in slight depressions and, since the permeabilities of their clay subsoils are mostly low, they are liable to surface waterlogging. Dunbulb loam, Goulburn loam and clay loam, Orrvale sandy loam and loam and Types A, B, D, E and M have been used for horticulture (mainly pears), and of these soil types only the Goulburn soils are extensive. Dunbulb loam and Type M are confined to the new Dunbulbalane settlement while the Orrvale soils are of more importance in the adjoining Shepparton Irrigation Area.

The remaining soil types in this Group do not occur in horticulturally developed areas and, while not particularly attractive even for pears and

plums, they could be so used if necessary. Water-tables are absent except in Orrvale sandy loam and Orrvale loam.

(*c*) Shallow, stony soils and sand sheet over clay:

ERWEN LOAM, SHALLOW PHASE.

TYPE E.

Erwen loam, shallow phase is a shallow, stony soil well above water supply level, as is most of the Erwen Association. In consequence, these soils are unlikely to be considered for irrigation.

Type E is a sandy soil of small extent. It should not be used for stone fruits because of the pronounced danger of surface waterlogging.

GROUP V.

Pears, plums and perennial pastures can be grown only if well drained; summer fodder crops, cereals and annual pastures can be grown.

Heavy textured soils, mainly in low-lying situations:

*CONGUPNA LOAM.
CONGUPNA CLAY LOAM.
COOMBOONA CLAY.
ROOKA CLAY LOAM.
YUGA CLAY.
TYPE G.
TYPE H.
TYPE L.
TYPE O.
TYPE P.
TYPE R.
COMPLEX 11.

Adequacy of drainage is the main factor determining the utilization of these soils. Congupna loam and clay loam have been used more or less successfully for pears and plums, but the trees are usually small and often are unproductive. The other soils are all minor occurrences outside the horticultural areas.

Generally the soil in this Group are best avoided for horticulture and should be so used only when there is no alternative.

Sometimes the soils are crabholey, making difficult and uneconomic the efficient grading necessary for perennial pastures. Such situations, if irrigated, should be used only for annual pastures and cereals.

GROUP VI.

Soils not recommended for irrigation because of swampiness or uneven surface features making layout for irrigation impracticable.

Low-lying, heavy textured, grey soils and mixed crabholey and pitted soils:

CONGUPNA CLAY.
COMPLEX I.
COMPLEX III.
COMPLEX IV.
SOILS OF PRIOR STREAM BEDS: TYPE 2.
SWAMPS AND INTERMITTENT SWAMPS.
RIVER FRONTAGE.
UNIDENTIFIED SOILS SUBJECT TO FLOODING.

SOIL FEATURES AND IRRIGATION

The suitability of the individual soil types for particular irrigated crops has been set out specifically in the previous section for the information of landholders. Also, passing reference is made in later sections to various attributes of particular soil types which are likely to have agricultural significance. In this section the soil features of the main soil types are considered in relation to irrigation management.

The principal soil problems of the Goulburn Valley arise from the physical characteristics of the soil profile and, in particular, from the low permeability of the top of some *subsoils*. Two quite different district problems arise from impermeable subsoils, namely, shallow penetration of irrigation water, and surface waterlogging in unusually wet autumn and winter months. Poor permeability of some *surface* soils is a particular problem of irrigated horticulture.

Poor subsoil permeability—Soil types susceptible to slow intake of irrigation water are Lemnos loam, Goulburn loam, Goulburn clay loam and Congupna clay loam, although not all occurrences of the first two soil types are slowly permeable. Perennial pastures grown on these poorly permeable soils are liable to moisture stress in mid-summer, particularly if the surface soil is shallow as is often the case. Pastures under these circumstances may require irrigation at seven to ten day intervals, while lucerne has difficulty in surviving. Fruit trees, particularly peaches, also are unthrifty. The trees are small and it is difficult to bring fruit up to size.

It is not surprising from the particle size data (see "Chemical and Physical Properties") to find that permeability is low in these subsoils. Clay contents are high, while the non-clay fraction is finely graded. In consequence, permeability is largely dependent on structural characteristics of the soil and on channels left by decayed roots and soil fauna. But once the soil is wet, many of the soil pores close and infiltration becomes very slow.

Measures aimed at increasing the effective depth of soil wetting have been attempted. These include deep ripping of pastures and surface application of gypsum. Neither has provided an answer. The

former is a temporary expedient and beneficial for only one, or at the most, two years. Gypsum has proved ineffective, possibly because it does not penetrate to the impermeable subsoil when applied to the surface.

Both of the above treatments have been on established pastures. Incorporation of gypsum when cultivating the land in preparation for sowing down might have some effect.

Deep subsoiling is under trial at the Tatura Horticultural Research Station. Treatments used in conjunction with subsoiling are the placement of gypsum and straw in the subsoil furrow. It is too soon yet to evaluate these effects.

Slow subsoil infiltration occurs occasionally in Shepparton fine sandy loam, but generally such problems do not arise on this soil type. Nothing is known about the behaviour of Dunbulb loam in this connexion, but compared with Goulburn loam, a somewhat similar soil type, the structure of the top of the subsoil is better and water penetration, therefore, is likely to be more satisfactory. East Shepparton fine sandy loam, Youanmite loam and Katamatite loam have moderately high infiltration rates in at least the top 2 feet. On the basis of their profile textures, this seems likely to be the case also in Zeerust fine sandy loam, Gupna fine sandy loam and Gupna loam, although there is little field experience with these soils.

Poor surface permeability—Most Goulburn Valley surface soils tend to set hard after wetting, if they have been cultivated repeatedly. This is due to the deterioration of the naturally weak soil aggregation through destruction of the soil organic matter. The soil particles, particularly in soils which have a finely graded particle size, then tend to run together when wetted. In consequence, their permeability deteriorates as time goes on. This has become a problem in many orchards, the soils becoming noticeably less permeable as the irrigation season advances. Cockroft (personal communication) states that the most prone soil types are East Shepparton fine sandy loam, Shepparton fine sandy loam, Lemnos loam and Goulburn loam. These soil types are shown later to have finely graded particles. Incidentally, these soil types comprise practically all the horticultural soils of the area with the exception of Youanmite loam and Katamatite loam in the Dunbulbalane settlement. These two soil types are better, and this is consistent with their particle size grading. East Shepparton sandy loam, Shepparton sandy loam and Lemnos sandy loam, which are confined to the adjoining Shepparton Irrigation Area, cause no trouble. These three soil types are much more coarsely graded than the first mentioned soil types and contain appreciable coarse sand in their surface horizons (Skene and Freedman, 1944).

The treatment advised by officers of the Horticultural Research Station, Tatura, is to incorporate large amounts of organic matter resistant to bacterial breakdown, by growing bulky, rather than leguminous, cover crops. It is essential to sow early enough to have the cover crop at least 1 foot high before winter cold slows down growth. Mid-February grading for winter drainage and the sowing of oats or rye grass, followed by two or three irrigations, are recommended. The cover crop should be cultivated into the soil in spring as usual, while subsequent summer weed growth should be incorporated in late December or when water penetration begins to decrease. Orchardists who experience surface penetration problems, and encounter practical difficulties in implementing this program should seek advice from the Manager, Horticultural Research Station, Tatura.

Surface waterlogging—The impermeability of the top of the subsoil has been mentioned as a principal cause of surface waterlogging. However, the extent to which such waterlogging occurs depends also on surface drainage. Thus, the soil types in the sequence—Shepparton fine sandy loam, Lemnos loam, Goulburn loam, Goulburn clay loam and Congupna clay loam—are increasingly liable to surface waterlogging passing from the lightest textured and well drained Shepparton fine sandy loam to the heavy textured and poorly drained Congupna clay loam. Other factors which determine the performance of plants on these soil types under waterlogged conditions are depth of surface soil, depth of root zone and varietal tolerance to waterlogging. These factors, together with district performance of various crops on the soil types, have been taken into account in the assessment of the suitability of the soils for the different irrigated crops (see preceding section).

Waterlogging of the surface soil can occur for other than the above reasons in East Shepparton fine sandy loam, Grahamvale sandy loam, and possibly sometimes in Shepparton fine sandy loam. This is when a watertable present in the deep subsoil builds up to the surface and stays there for some time.

Surface waterlogging has long been recognized as the principal cause of the heavy losses of stone fruits which have occurred in very wet years such as 1939 and 1956. Some of the conditions under which trees may be lost or may survive were described by Skene and Freedman (1944) following the extensive deaths of peach trees in the Shepparton Irrigation Area in 1939. The 1956 disaster engendered further investigations by officers of the Tatura Horticultural Research Station over a wider range of soil types than was affected in 1939. Cockroft *et al.* (1961) describe the following two kinds of dangerous, and two kinds of safe profiles:

(i) Soil profiles with heavy textured subsoils which prevent downward drainage of the surface water. This is the situation described above, but

not all Shepparton fine sandy loam and Lemnos loam soils have dangerous profiles. The deeper the surface soil the greater is the likely damage to tree roots in profiles of this kind.

(ii) Lighter textured profiles which have a restricting layer, either clay or cemented sand, within 10 feet of the surface. Water can penetrate the subsoil, but a watertable builds up on the impeding layer below. The risk of losing stone fruits on these soils is high. This is the situation described above for East Shepparton fine sandy loam and Grahamvale sandy loam, but not all situations in these two soil types are hazardous. Some profiles of this kind occur in the Broken sand, Shepparton fine sandy loam and Sandmount sand (shallow phase) soil types.

(iii) Soil profiles with less than 12 inches of surface soil overlying a clay subsoil which is sufficiently permeable to allow water from the surface to drain downward. Watertables do not build up because the deep subsoil is not sufficiently light in texture. These are safe profiles and occur in the Shepparton fine sandy loam and Lemnos loam soil types.

(iv) Light textured profiles which have no restricting layer closer than 10 feet to the surface. Although watertables are present, these profiles are considered to be safe for stone fruits. They occur in the Broken sand, Sandmount sand, Grahamvale sandy loam, East Shepparton sandy loam and East Shepparton fine sandy loam soil types.

It might be wondered why the four kinds of profile described, in some cases, overlap the named soil types. This is firstly because the texture of the more clayey subsoils does not reflect their permeability sufficiently well, and secondly because it was impracticable in the field survey to separate the soil types on characteristics occurring more than 6 feet below the surface.

Water use—Efficient use of water should be the aim of all irrigators. In general, this means wetting the soil only to the lower limit of the plant rootzone avoiding excessive and wasteful applications of water.

Satisfactory wetting is difficult to achieve in the soil types with poor subsoil permeability (mainly Lemnos loam, Goulburn loam and clay loam and Congupna clay loam) and can lead to excessive overflow of irrigation water into the drainage system. In the case of Katamatite loam and Youanmite loam, wetting the rootzone of pastures or fruit trees can be accomplished easily, but the deep subsoils have low permeabilities and tend to hold up water. On all the soil types mentioned above, over irrigation will accentuate surface waterlogging problems in wet years.

On the other hand, overwatering will quickly lead to watertables in the deep subsoils of the permeable soil types, Sandmount sand, Broken sand, East Shepparton fine sandy loam, East Shepparton sandy loam, Grahamvale sandy loam and some occurrences of Shepparton fine sandy loam. While these watertables are usually not harmful in normal years, they reduce the margin of safety for fruit trees in wet years and should be prevented as far as possible by giving particular attention to the amount and method of application of irrigation water.

Drainage—Any form of irrigation management, either of pastures or fruit trees, requires efficient drainage to remove surplus irrigation water. But, in the present area, there is the added need to provide for removal of excessive rainwater which periodically falls outside the irrigation season. While such drainage is important to the well-being of pastures, and particularly of perennial pastures and lucerne, it is vital to the long term survival of stone fruit trees.

Wet years will occur again and orchards need to be laid out for drainage every year and early in the season in preparation for heavy March rains should they occur. While a surface drainage layout will assist even the lightest soil types, it is essential on the medium textured and heavier soil types such as Shepparton fine sandy loam, Lemnos loam, Goulburn loam and clay loam and Congupna clay loam, if surface waterlogging is to be minimized.

Cockroft *et al.* (1961) suggest that benefit from lowering watertables will accrue only in the case of soils with restricting layers less than 10 feet from the surface. Tile drainage may be effective under these circumstances on the soil types in this category, and investigations are under way. The use of shallow underground drains on heavier soils to relieve surface waterlogging is also receiving attention.

Soil salinity—It is shown in the section, "Chemical and Physical Properties", that the soils as a whole have low salt contents. In consequence, salt problems are few in the area. It is known also, although evidence is not presented in this bulletin, that the lighter textured soil types are particularly low in salt. These are the soils in which watertables may develop, but, since salt cannot accumulate in the water, the latter is normally of good quality and harmless to plants. This places a different view on the presence of watertables in the present area to that in areas further north and west where the soils may be saline.

There are a few situations with moderately saline subsoils and the possibility of salt injury should not be ignored, particularly on the heavier soil types under pasture. Attention to surface drainage will minimize risks of salting.

Chemical fertility—The soils are known to be deficient in phosphorus and nitrogen. Superphosphate is a necessary fertilizer in all forms of agriculture in the area, while nitrogenous fertilizers are required for intensive culture such as horticulture and vegetable growing.

The analytical data show the soils to have good potassium reserves and it is difficult to see potash being of any benefit on pastures, or on the great majority of orchards.

Calcium and magnesium are normally at good levels while the soil pH is satisfactory. Under these circumstances, no benefit can be expected from using either lime or dolomite on either pastures or fruit trees. However, sulphate of ammonia is used widely in horticulture and, since this lowers both calcium and magnesium as well as making the soil more acid, lime should be used wherever necessary to counter this effect. Dolomitic limestone which supplies both calcium and magnesium can be used, but it is doubtful whether additional benefits accrue from its magnesium content on the majority of the soils.

DESCRIPTION OF SOIL TYPES AND MISCELLANEOUS UNITS

In this section, all of the soil types and other units shown on the 41 soil maps with this bulletin are described in regard to their soil profiles, occurrence and land use.

The profile features given in each case are the average for the particular soil type. The profiles of individual situations will usually depart in some respects from these averages.

Each soil type occupies a definite place in the landscape or topography. For example, some occur in depressions, others on rises. Thus, positional relationships occur between the soil types. These relationships or toposequences are shown in italics under each soil type; they are dealt with fully in the section, "Landscape Relationships."

In the first section, the soil types have been grouped in regard to suitability for particular irrigated crops. In this section, the information is elaborated for the soil types individually. In addition, reference is made to present as well as potential land use.

The 26 named soil types found in the surveyed area (Table 1) are dealt with in alphabetical order. These are followed by eighteen unnamed soil types, mainly of minor importance, four micro-complexes, three soil associations, and three types of prior stream beds.

Although a large number of soil types has been recorded, only five series* are widely distributed. These are the Lemnos, Goulburn, Congupna, Shepparton and East Shepparton series. Of these, East Shepparton fine sandy loam, although horticulturally important, is relatively small in area. By far the greatest part of the surveyed area consists of the first four series.

Soil series limited in extent, but locally important, are the Katamatite, Youanmite, Erwen, Gupna and Coomboona series.

* See Appendix III., Explanation of Soil Terms.

The overall pattern and approximate extent of the above soil series can be pictured from the Soil Association Map (see folder map); this is discussed in the section, "Soil Associations."

ARKOO LOAM.

Surface soil—

A_1 0 to 5 inches; grey-brown loam.

A_2B, 5 to 16 inches; diffusely mottled yellowish brown clay loam increasing in texture to light clay; very friable; at 14 to 24 inches, sharply separated from:

Subsoil—

B_1 16 to 27 inches; mottled yellowish brown and yellow-grey heavy clay; strong angular blocky structure; tough and intractable; grades into:

27 to 48 inches; mottled yellow-grey medium or heavy clay; more crumbly than above; slight calcium carbonate.

Occurrence.—Arkoo loam was first identified in the adjoining Deakin Irrigation Area (Skene unpublished) where it occurs as the intermediate member of the *Karook sequence.* The landscape there is one of numerous, almost treeless swamps, with intervening plain which carries grey box, yellow box and buloke.

The type is of slight importance in the present area, a few small occurrences being found south of Stanhope and east of Girgarre. Buloke is prominent on the uncleared situations.

Land use.—Arkoo loam has been cultivated successfully for cereals in the past. It is used a little for irrigated pastures, but not at all for horticulture or vegetables.

A deep friable surface makes Arkoo loam attractive for most irrigated crops. But indifferent surface drainage, coupled with an apparently poorly permeable subsoil below 27 inches, renders it liable to surface waterlogging. In consequence only Group IV. crops should be grown.

CONGUPNA CLAY LOAM.

Surface soil—

A 0 to 4 inches; grey to brownish grey (2·5Y to 10YR 4/1)* clay loam, occasionally clay, with rusty colours along root channels; weak to moderate angular blocky structure; hard and brittle when dry; variable amounts of buckshot; at 2 to 5 inches sharply separated from:

Subsoil—

B_1 4 to 21 inches; brownish grey to dark yellow-grey (2·5Y 4/2), heavy clay; moderate angular blocky structure; very hard when dry; weakly structured and more crumbly with depth; grades into:

B_2C 21 to 48 inches +; brownish yellow-grey (2·5Y to 10YR 4/4), sometimes diffusely mottled, medium clay; structureless; crumbly; slight calcium carbonate as soft concretions or in small pockets; usually continues beyond 84 inches.

Variants.—The inscription *light surface* on the soil maps denotes soils with a loam surface; this may be up to 8 inches deep. *Yellow variant* refers to soils in which the yellow-grey colour of the deep subsoil is replaced by yellowish brown or yellow-brown. Gypsum is irregularly present and the surface is moderately to strongly gilgaied. It occurs mainly in the Complex II. unit.

Occurrence.—Congupna clay loam has been described previously in the adjoining Shepparton Irrigation Area (Skene and Freedman 1944). It occupies low plain and shallow depressions in the *prior stream sequence.* Congupna clay may occur below Congupna clay loam in the more marked depressions and drainage ways. Timber, where remaining, is grey box with red gum in the lowest areas.

Land use.—Irrigated perennial and annual pastures, pears and plums are grown on Congupna clay loam. However, there is a high hazard from surface waterlogging due to its low position and impermeable profile, consequently, these crops should not be attempted unless there is adequate provision for removal of surface water. Wherever there is any doubt about the efficiency of drainage, the soils are best used for irrigated summer fodder crops, cereals, or annual pasture.

CONGUPNA CLAY.

The profile is similar to that of Congupna clay loam, except that the surface is clay (occasionally clay loam) and is usually less than 4 inches deep. The surface is more or less gilgaied. There is a *yellow variant* as in Congupna clay loam.

Occurrence.—First described by Skene and Freedman (1944), this type occupies the well defined swamps and drainage ways of the district. The timber is red gum. Some occurrences may hold water for prolonged periods; these are shown on the soil maps as intermittent *swamps.*

* Munsell colour notation of moist soil. Also see Appendix III.

Land use.—Congupna clay is not recommended for irrigation generally, because of drainage difficulties. In some circumstances these may be surmounted; then the soils can be used similarly to Congupna clay loam.

COOMBOONA LOAM.

Surface soil—

A_1 0 to 11 inches; grey-brown (10YR 4/3) to brownish grey loam or clay loam; weak subangular blocky structure, peds 1½ inches; crumbly; sharply separated from:

A_2 2 to 11 inches; diffusely mottled grey, light grey and yellowish brown fine sandy loam or clay loam; slight fine buckshot; at 4 to 10 inches grades into:

Subsoil—

B 11 to 30 inches (varies from 12 to 30 inches thick); diffusely mottled dull brown to yellowish brown (7·5YR 5/4) with shades of grey-brown, light or medium clay; less well structured and more crumbly with depth.

30 to 48 inches; moderately mottled brown and grey clay grading below 48 inches into variably coloured materials, usually clay but sometimes as light as sandy loam (micaceous).

Variant.—A red-brown deep subsoil variant has red-brown colours and friability increasing with depth below 24 inches.

Occurrence.—Coomboona loam is one of the better drained soil types of the *flooded clay plain sequence.* It occurs typically on the higher and intermediate parts of the clay plain landscape, but a few soils with similar profiles occupying distinctly lowlying areas in the southern part of the Rodney Irrigation Area have been included in the type.

Land use.—In the past, Coomboona loam has been used successfully for cereals and shows evidence of supporting good annual and perennial pastures under irrigation. It is untried for horticulture, but could be used for pears, and plums. In the absence of information about liability to waterlogging, it should be avoided for peaches, apricots and other plants sensitive to waterlogging.

COOMBOONA CLAY.

Surface soil—

A 0 to 4 inches; mottled grey light clay or clay loam, rusty colours along root channels and on ped faces; at 3 to 7 inches grades into:

Subsoil—

B 4 to 30 inches; mottled dull brown and grey clay, colours brighter and diffusely mottled with depth.

30 to 48 inches; similar to Coomboona loam.

Occurrence.—This type is a very minor component of the *flooded clay plain sequence.* It occurs as small areas in some depressions originally carrying red gum. The surface may be locally undulating, but this micro-relief is not of the usual gilgai kind.

Land use.—The poorly permeable subsoil, and the risk of flooding both locally and from the Goulburn River, limit this soil type under irrigation to summer fodder crops, cereals and annual pastures. If special provision can be made for surface drainage, perennial pastures could be grown.

DUNBULB LOAM.

Surface soil—

A 0 to 6 inches; grey-brown (7·5YR 4/2) loam or clay loam; slight buckshot; sharply separated from:

Subsoil—

B_1 6 to 33 inches; brown to dull yellow-brown (7·5YR 4/4) medium or heavy clay, colours becoming brighter and more yellow with depth; moderate subangular blocky structure; labile when moist.

B_2C 33 to 72 inches; variably mottled yellow-brown, brown and grey subplastic clay; distinct small angular blocky peds with black flecks on the faces; light calcium carbonate concretions.

Occurrence.—This soil type belongs to the *Youanmite sequence* which is found only on "high" plain in the north-eastern corner of the surveyed area. Dunbulb loam occurs on the fractionally lower parts of the plain and in some depressions. The original timber was grey box.

Land use.—Wheat has been grown extensively and successfully on Dunbulb loam, but it has not been used until recently for irrigation, except possibly for pastures in the adjoining Katandra Irrigation Area. The resemblance of Dunbulb loam to Goulburn loam—a major irrigated soil type in the Goulburn Valley—suggests that it has a similar land use potential and can be used successfully for irrigated summer fodder crops, cereals, and both annual and perennial pastures. As both permeability of the subsoil below 3 feet and surface drainage are poor, Dunbulb loam is not recommended for stone fruits but it should grow pears and plums satisfactorily.

EAST SHEPPARTON FINE SANDY LOAM.

Surface soil.

A_1 0 to 6 inches; dull brown (7·5YR 4/4) fine sandy loam; sharply separated from:

A_3 6 to 10 inches; light brown (7·5YR 5/4: dry 7/4) fine sandy loam; at 8 to 12 inches sharply separated from:

Subsoil.

B_1 10 to 20 inches; reddish brown (5YR 4/6) light clay, occasionally medium clay; grades into:

C 20 to 27 inches; mottled brown, brownish yellow and light grey fine sandy clay loam or clay loam; grades into:

27 to 36 inches; fine sandy loam; scattered calcium carbonate concretions.

36 to 72 inches; variable coarse textured (fine sand to sandy clay) and permeable materials resting on impermeable clays at depths up to about 20 feet.

Some soils with B horizons only 6 or 7 inches thick and resting on clay loam or fine sandy clay loam which extends deeper than 36 inches have also been included in this type.

Occurrence.—East Shepparton fine sandy loam is situated on the levees of the stronger prior streams that traverse the Rodney and North Shepparton Irrigation Areas. It is widely distributed, but individual occurrences are generally only a few acres in area. East Shepparton sandy loam is a similar soil type described by Skene and Freedman (1944) found on the levees of the prior streams in the adjoining Shepparton Irrigation Area. This soil type differs from East Shepparton fine sandy loam in having a deeper surface (usually from 12 to 20 inches deep) with more coarse sand present.

Land use.—East Shepparton fine sandy loam is given almost exclusively to horticulture. Experience has shown that the good permeability characteristics of the soil profile are very suitable for peach and apricot growing. While high permeability is an advantage under normal conditions, it has proved a hazard in abnormally wet seasons, and stone fruits have been lost periodically in many situations on this soil type through waterlogging. Investigations by officers of the Horticultural Research Station, Tatura indicate that the dangerous situations are those where the deep impermeable clay layer is within 10 feet of the surface. Such situations are not defined in the present survey.

Besides fruit trees, East Shepparton fine sandy loam is very suitable for most vegetables, tomatoes and lucerne. It is not recommended for small seeded vegetable crops, since the fine texture of the surface soil is conducive to crusting and consequent germination problems.

ERWEN LOAM.

Surface soil.

A 0 to 5 inches; greyish brown (5 to 7·5YR 3/2) loam, irregularly and weakly bleached in the lower part; more or less buckshot and iron-impregnated sandstone chips; at 3 to 8 inches sharply separated from:

Subsoil.

B_1 5 to 18 inches; red-brown (2·5YR 3/6) heavy clay, occasionally medium clay; grades into:

B_2 18 to 27 inches; reddish brown (5YR 4/6) heavy clay; light calcium carbonate; at 24 to 30 inches grades into:

C 27 to 48 inches; mottled red, reddish brown, brownish grey heavy clay; light calcium carbonate; at 36 to 84 inches grades into more strongly mottled clay containing sandstone fragments with calcium carbonate concentrated around them; merges into weathered Silurian rock.

Shallow [redacted] Phase.

The profile is less than 30 inches deep, weathered Silurian rock occurring before then. The red-brown clay subsoil is reduced while the deeper

mottled clay is absent or very restricted. Iron-impregnated sandstone chips are numerous on and in the surface.

Occurrence.—Erwen loam was first identified in the adjoining Deakin Irrigation Area (Skene unpublished) where it occurs on the Silurian hills which rise above the depositional plain. This landscape extends into the southern part of the Rodney Irrigation Area. There Erwen loam on the gentle lower slopes of the hills often merges with Lemnos loam on the plains, and is distinguishable from that soil type only by the occasional presence of sandstone or quartz fragments and Silurian rock within 10 feet of the surface.

Much of the soil type still carries its original tree cover of grey box and buloke, with some white ironbark.

Land use.—Cleared parts are used successfully for cereal cropping and improved pastures. Elsewhere volunteer and native pastures are used for grazing sheep.

Practically the whole of Erwen loam is above the present gravitational water supply system, and it is unlikely that it will be used for irrigation to any extent. However, some pumping may take place on to land adjoining the main channel. In such cases, perennial or annual pastures could be grown satisfactorily, and there would be fair prospects on occurrences with 6 inches or more of surface soil, for tomatoes, most vegetables, and horticultural crops.

GOULBURN LOAM.

Surface soil.

A 0 to 5 inches; grey-brown (10YR 4/2) loam; sometimes with slight buckshot and weakly bleached in lower part; at 4 to 7 inches sharply separated from:

Subsoil.

B_1 5 to 21 inches; yellowish brown (7·5 to 10YR 5/6) medium or heavy clay; massive or weak angular blocky to prismatic structure; labile or plastic when moist; grades into:

B_2C 21 to 48 inches+; yellow-brown or diffusely mottled yellowish grey (2·5YR 5/2) and yellowish brown (10YR 5/4) medium, occasionally light clay; crumbly when moist; slight soft inclusions and concretions of calcium carbonate.

Variants.—The inscriptions *light surface* and *deep surface* on the soil maps refer, respectively, to sandy loam surfaces and depths greater than 8 inches. A *bright subsoil variant* (also in Goulburn clay loam) takes in soils with brown, or even reddish brown colours below 21 inches instead of the normal yellow-brown or duller colours.

Occurrence.—Skene and Freedman (1944) have recorded both Goulburn loam and Goulburn clay loam in the Shepparton Irrigation Area where the series also is widely distributed. Goulburn loam is found on nearly level situations in the mid-flood plain position of the *prior stream sequence* of soils. The type carried grey box woodland in the original state.

Land use.—Where not irrigated, Goulburn loam is used for cereals and for grazing sheep on volunteer and improved pastures. However, most of the soil type is under irrigation and has proved satisfactory for both annual and perennial pastures. It is used extensively for most types of horticulture, but experience has shown that peach and, to a lesser extent, apricot trees tend to be of small size and low yielding. Further, the somewhat low and level situations occupied by the type frequently confer slow surface drainage and stone fruits have been lost rather extensively from surface waterlogging. In consequence, Goulburn loam is not recommended for stone fruit plantings. However, it is suitable for pears, and plums.

Goulburn loam is not generally recommended for tomatoes and vegetables because of its rather shallow surface and the waterlogging hazard.

GOULBURN CLAY LOAM.

Surface soil.

A 0 to 4 inches; grey-brown (10YR 4/2) clay loam, often with fine rusty mottling in root channels; weak angular blocky structure, 2 to 4 inch peds; slight buckshot; at 2 to 6 inches sharply separated from:

Subsoil.

B_1 4 to 18 inches; dull yellowish brown (7.5YR 4/4) sometimes mottled with grey-brown, heavy clay; weak to moderate prismatic structure, peds up to 10 inches; grades into:

B_2C 18 to 33 inches; yellowish brown (10YR 5/6) heavy clay; weak subangular blocky structure; slight calcium carbonate; grades into:

33 to 48 inches +; yellow-grey or mottled light yellowish grey (2.5Y 5/2) medium or heavy clay; slight calcium carbonate.

Occurrence.—Goulburn clay loam occurs on more definitely low situations than Goulburn loam, consequently colours tend to be duller. There is often little or no difference in particle size distribution between the loam and clay loam surfaces, but the surface is consistently shallower in Goulburn clay loam.

Land use.— The land use potential of Goulburn clay loam is similar to that of Goulburn loam.

GRAHAMVALE SANDY LOAM.

Surface soil.

A_1 0 to 8 inches; dull brown fine sandy loam or loamy fine sand.

A_2 8 to 18 inches; light grey-brown fine sandy loam or loamy fine sand; at 12 to 24 inches grades into:

Subsoil.

B 18 to 30 inches; yellow-brown clay loam to fine sandy clay; grades into:

C 30 to 72 inches; yellow-brown or mottled yellow-grey fine sandy loam and lighter textures.

Occurrence.—Grahamvale sandy loam was first described by Skene and Freedman (1944) in the Shepparton Irrigation Area as a soil type occurring directly over the channel deposits of the prior streams. In the present area, a few occurrences

adjoining prior streams have been included in the type. These soils are finer textured than the Shepparton occurrences.

Land use.—The type is quite unimportant from the land use aspect. Where necessary, it can be considered to have similar prospects to East Shepparton fine sandy loam.

GUPNA FINE SANDY LOAM.

Surface soil.

A_1 0 to 4 inches; brownish grey (10YR 5/2) fine sandy loam; friable when moist; slight buckshot at 3 to 6 inches sharply separated from:

A_2 4 to 8 inches; very light grey (10YR 7/2) fine sandy loam, strongly bleached with fine rusty colours along root channels; slight buckshot; at 6 to 12 inches grades into:

Subsoil.

B_1 8 to 27 inches; yellowish grey (2.5Y 5/2) or diffusely mottled yellow-grey light clay; plastic or labile when moist; at 21 to 33 inches grades into:

B_2C 27 to 48 inches; mottled yellow-grey, light grey, and yellow-brown light clay, fine sandy clay or clay loam; more crumbly than above; trace calcium carbonate; usually reverts to heavier textures below 48 inches.

Occurrence.—This is the lowest member of the *Zeerust sequence* which is found only between Shepparton and Tallygaroopna in the central part of the North Shepparton Irrigation Area.

There is little difference between this soil type and Gupna loam, the latter being fractionally heavier in the surface. While the distinction between the two soil types is valid in some localities, it is likely that some areas shown on the soil map as Gupna fine sandy loam are virtually similar soils to other areas shown as Gupna loam.

Land use.—Gupna fine sandy loam is cropped successfully, and where irrigated carries good pastures. It has not been used for horticulture or vegetables at all. Indifferent surface drainage constitutes a hazard to plants sensitive to waterlogging, consequently it is rated as suitable under irrigation only for Group IV. crops.

GUPNA LOAM.

The surface is a loam while the subsurface bleached horizon is either fine sandy loam or fine sandy clay loam. In other respects the profile is that described above for Gupna fine sandy loam.

Land use.—No distinction is made between this type and Gupna fine sandy loam in regard to either present or potential land use.

KAROOK LOAM.

Surface soil.

A_1 0 to 8 inches; brown loam; moderately friable; grades into:

A_2B_1 8 to 15 inches; weakly mottled dull reddish brown clay loam passing to light clay; very friable; sharply separated from:

Subsoil.

B_1 15 to 21 inches; mottled red-brown and brownish yellow heavy clay; strong angular blocky structure; tough and intractable; grades into:

B_2C 21 to 39 inches; brown heavy clay; slight calcium carbonate from 30 inches; grades into:

39 to 48 inches +; mottled brown clay; slight calcium carbonate.

Occurrence.—First identified in the adjoining Deakin Irrigation Area by Skene (unpublished), Karook loam is the upper well drained member of the *Karook sequence*.

Land use.—The very limited occurrences in the area support good irrigated perennial and annual pastures. No information is available about the performance of Karook loam under irrigated horticulture, but the deep friable surface coupled with fairly good surface drainage should make the type suitable for stone fruits. However, in view of its very small extent the question of its horticultural potential is not likely to arise here.

KATAMATITE LOAM.

There are two phases of Katamatite loam, namely, a brown phase in which the subsoil clay has brown to reddish brown colours and a yellow phase in which it is yellow-brown. Both phases are described below:

Brown phase.

Surface soil.

A_1 0 to 5 inches; brown (5YR 3/4) loam, occasionally sandy loam; scattered buckshot; sharply separated from:

A_2 5 to 13 inches; weakly bleached brown (5YR 5/4) loam or sandy clay loam; scattered to light buckshot; at 10 to 16 inches grades into:

Subsoil.

B_1 13 to 21 inches; reddish brown (5YR 4/6) or bright brown medium clay, slightly subplastic; finely vesicular; very friable when moist; grades into:

B_2 21 to 36 inches; weakly mottled brown and yellow-brown medium clay; slightly subplastic, less friable and denser than above; slight calcium carbonate from 30 inches; at 33 to 42 inches grades into:

36 to 48 inches +; mottled brown, yellow-brown and grey clay, markedly subplastic; strong small angular blocky structure with black flecks on ped faces; hard when dry; friable when moist; light calcium carbonate.

Yellow phase.

Surface soil.

A_1 0 to 5 inches; dull brown (7·5YR 3/4) loam; scattered to light buckshot; sharply separated from:

A_2 5 to 13 inches; weakly bleached greyish brown (7·5YR 5/4) sandy clay loam with light to moderate buckshot; at 10 to 16 inches grades into:

Subsoil.

B_1 13 to 19 inches; yellow-brown (7·5YR 4/6) medium clay; slightly subplastic; finely vesicular; very friable when moist; grades into:

B_2 19 to 36 inches; weakly mottled yellow-brown and yellow-grey, otherwise similar to brown phase.
36 to 48 inches; similar to brown phase.

Occurrence.—Katamatite loam, first described by Butler *et al.* (1942), occurs only in the north-east of the North Shepparton Irrigation Area where it is found on "high plain" with Youanmite loam and Dunbulb loam. The two phases are intermingled and are not readily separable in places. The phases are delineated on the soil maps only over part of the Katamatite loam occurrence. Where they have not been separated, the situation may be either phase or a mixture of both.

A woodland of grey box, yellow box and Murray pine is distinctive, although most of the land has been cleared.

Land use.—Extensive cereal cropping has been practised on Katamatite loam. In the nearby Katandra Irrigation Area, it supports good perennial and annual pasture. Lucerne has not persisted there, but this may be due to management, since the permeable upper 2 feet of the soil should provide very favourable conditions for deep rooting plants such as lucerne.

Subdivision for horticultural development of an area in the Parishes of Dunbulbalane and Youanmite was commenced in 1956, and there are now about 80 45-acre farms supporting young fruit trees under irrigation. More recently development has included the sowing of perennial pastures and subdivision into dairy farms.

Katamatite loam is the principal soil type and has been selected for plantings of peaches and apricots. The brown phase has been preferred slightly to the yellow phase for these fruit trees on the assumption that the yellow colourings in the subsoil reflect inferior internal soil drainage, and consequently a greater waterlogging hazard. However, the trees are flourishing on both soil phases at present and, given normal seasonal conditions, there is every reason to suppose that both phases of Katamatite loam will grow stone fruits very satisfactorily.

The performance of fruit trees on Katamatite loam in the wet years that recur periodically in the Goulburn Valley is quite unknown, but the possibility of tree losses from surface waterlogging must be faced. The surface and top of the subsoil to about 18 inches depth are readily permeable, but with increasing depth the subsoil becomes less permeable and offers impedance to downward drainage of water from the upper layers. Further, surface grades are flat and allow only slow run-off. These conditions are conducive to surface waterlogging. But the degree of risk is variable, since the permeability of the subsoil between 18 and 36 inches, and hence to some extent the "drainability" of the soil, varies considerably in different situations of the same soil phase. These permeability differences are not consistently predictable from observable features in the subsoil and require to be established by field permeability tests.

In order to minimize the risk of trees dying from waterlogging in wet years, permeability tests were carried out by officers of the Horticultural Research Station, Tatura prior to planting most of the fruit blocks. Final advice in regard to appropriate varieties and locations for peaches and apricots was based on the permeability of the subsoil, coupled with measurements on the thickness of the more permeable upper layers.

Irregular occurrences of hardpan layers of very low permeability below 36 inches have been recorded in both the brown and yellow phases. It is not known to what extent such layers might contribute to waterlogging.

Katamatite loam should be suitable for tomatoes and most vegetables.

KOGA CLAY LOAM.

Surface soil.

A 0 to 4 inches; diffusely mottled grey-brown or brownish grey clay loam; sharply separated from:

Subsoil.

B_1 4 to 21 inches; dark brown to dark grey-brown heavy clay; weak or moderate angular blocky structure, peds 3 to 6 inches; hard when dry; tough and intractable when moist; grades into:

B_2C 21 to 48 inches +; dull yellowish brown heavy clay; friable when moist; slight calcium carbonate; gypsum irregularly present below 30 inches.

Occurrence.—Koga clay loam was first identified by Skene (unpublished) in the adjoining Deakin Irrigation Area, where it occurs extensively on treeless plain with Koyuga clay loam and Yuga clay. The type is of small extent and is confined to the north-western part of the present area.

Land use.—While satisfactory cereal crops are grown on Koga clay loam, it has not been irrigated to any extent. Its rather shallow surface, slowly permeable clay subsoil and indifferent surface drainage suggest that, under irrigation, it would best be used for summer fodder crops, cereals, and perennial and annual pastures. It is not attractive for horticulture generally, and at the most could be used for pears and plums.

KOYUGA CLAY LOAM.

Surface soil.

A 0 to 5 inches; dull brown clay loam or loam; structureless or weak angular blocky structure; hard when dry; sharply separated from:

Subsoil.

B_1 5 to 21 inches; dark red-brown heavy clay; hard when dry, tough and intractable when moist; grades into:

B_2C 21 to 48 inches +; diffusely mottled brown or yellowish brown heavy clay; friable when moist; slight calcium carbonate; gypsum irregularly present.

Occurrence and Land use.—The remarks given about Koga clay loam apply to Koyuga clay loam except that it has slightly better surface drainage.

LEMNOS LOAM.

Surface soil.

A 0 to 5 inches; brown to dull or greyish brown (5 to 7·5YR 4/4) loam, occasionally clay loam, occasionally with weak bleaching in the lower part; at 4 to 7 inches sharply separated from:

Subsoil.

B_1 5 to 18 inches; reddish brown (2·5 to 5YR 4/6) medium or heavy clay; weak to moderate angular blocky structure, peds 1 to 3 inches; consistence varying from friable to hard; grades into:

18 to 24 inches; brown or yellowish brown (7·5YR 4/6) medium clay; less well structured and more friable than above; sometimes slight calcium carbonate; grades into:

B_2C 24 to 48 inches; mottled brown, yellow and grey light, occasionally medium, clay; friable when moist; slight soft and concretionary calcium carbonate; grades into:

48 to 72 inches +; variably mottled; textures usually clay, but occasionally micaceous fine sandy clay or clay loam.

Variants.—The inscription *light surface* covers a few occurrences where the surface texture is sandy loam. *Deep surface* refers to surface soils deeper than 8 inches. These usually have a weakly bleached A_2 horizon and may contain small amounts of buckshot. *Grey surface* as the name indicates comprises soils with grey or brownish grey A horizons, but the subsoil clay is always reddish brown. A *dull variant* on the other hand has a dark dull brown (10YR 3/4) subsoil clay which becomes brighter and normal with depth.

Occurrence.—The Lemnos series was first described by Skene and Freedman (1944) in the adjoining Shepparton Irrigation Area where both loam and sandy loam members occur. In the present survey, only Lemnos loam has been recorded, but it is widespread over the whole area and, with Goulburn loam, is the principal soil type of the Goulburn Valley. Lemnos loam is one of the upper members of the *prior stream sequence.* The original tree cover was grey box woodland.

Land use.—Where not irrigated, Lemnos loam is used for cereal cropping and for grazing sheep on volunteer and improved pastures. Under irrigation, it supports good perennial and annual pastures, but is variable in regard to lucerne, vegetables and fruit trees. Such variability is due to differences within the type in permeability of the subsoils and in depth of surface soil. Peaches and apricots are not vigorous on the less permeable occurrences. These are often soils with less than 6 inches of surface depth. Apples, pears and plums can be grown satisfactorily on these situations, although naturally they do better on the more permeable Lemnos loam soils.

Lemnos loam does not develop subsoil watertables, but many peach and apricot trees have been lost on this soil type from surface waterlogging in abnormally wet autumn and winter months. Surface run-off is only moderate, consequently drainage of the root-zone may depend largely on the rate at which water can soak into the subsoil. Where soakage is slow, there is the possibility of prolonged saturation of the surface layer. Risk of tree injury in such cases is greatest in the soils of deepest surface, since trees on these situations have the greatest root development in the saturated zone. Incidentally, these are often the best producing and most vigorous trees.

Because of the above considerations, Lemnos loam is not always suitable for peaches and apricots and should be checked for suitability before planting.* The grey surface and dull variants and soils with only 3 or 4 inches of surface should always be avoided for peaches, apricots, vegetables and lucerne.

ORRVALE LOAM.

Surface soil.

A 0 to 7 inches; grey-brown to grey loam or sandy loam, weakly bleached in the lower part; slight buckshot; sharply separated from:

Subsoil.

B_1 7 to 30 inches; yellowish brown to brownish grey (sometimes mottled) medium clay passing to light clay; grades into:

B_2C 30 to 48 inches +; mottled brown, yellow, grey clay loam, fine sandy clay or lighter textures; slight calcium carbonate. Below 48 inches the light textures may continue or more usually revert to impermeable clay before 72 inches.

Occurrence.—Orrvale loam and Orrvale sandy loam have been described previously in the adjoining Shepparton Irrigation Area (Skene and Freedman, 1944). In the present area, the Orrvale series is of very minor importance and both types are included in Orrvale loam. The type occurs on the lower parts of the levees and near-flood plain of the *prior stream sequence.* It originally carried grey box woodland.

Land use.—Since Orrvale loam occupies situations of restricted surface drainage and is moderately permeable in the subsoil, it develops watertables under irrigation. In consequence, peaches, apricots, vegetables and lucerne should not be attempted on this soil type, but pears, plums, summer fodder crops, cereals, and perennial and annual pastures can be grown.

ROOKA CLAY LOAM.

Surface soil.

A_1 0 to 4 inches; grey clay loam, fine mottling in root channels;

* See footnote, page 7.

A_2B_1 4 to 10 inches; mottled grey and yellowish brown clay loam passing to light clay; sharply separated from:

Subsoil.

B_1 10 to 27 inches; grey mottled with yellowish brown, heavy clay; when moist tough and intractable but increasingly friable with depth; grades into:

B_2C 27 to 48 inches +; mottled yellow-grey and grey-brown, heavy clay; more friable than above; slight calcium carbonate.

Occurrence.—This is the lowest member of the *Karook sequence.* There are no individual occurrences of Rooka clay loam shown on the soil map. It occurs only in very small areas denoted by inscription and in Complexes II. and III.

SANDMOUNT SAND.

Surface soil.

A_1 0 to 7 inches; dull or greyish brown (5 to 7·5YR 4/3) sand, variably coarse; weakly coherent; sharply separated from:

A_2 7 to 42 inches; brown (5YR 5/4) or light brown sand; incoherent; grades into:

Subsoil.

B_1 42 to 48 inches; red-brown (2·5YR 4/6) sand, sandy loam or sandy clay loam.

C 48 to 84 inches +; yellowish brown sand or variably mottled red, yellow and brown, slightly clayey sand, often cemented and compacted.

Shallow Phase.

This occurs on the lower slopes of the more pronounced dunes and on the less pronounced rises. The B_1 or subsoil horizon is usually sandy clay loam, sometimes sandy clay, and occurs before 36 inches; in extreme cases it occurs by 15 inches. At all times it grades back into lighter textures.

Occurrence.—Sandmount sand was first recorded by Butler *et al.* (1942) in the Murray Valley Irrigation Area. It occurs on dunes and low rises adjoining the prior stream beds. These are thought to have arisen from the re-sorting of the riverine deposits by wind action. The depth of sand is very variable and depends on the prominence of the dune formation. The type is of very small extent in the present area.

Land use.—Sandmount sand is almost always above gravity irrigation supply level, consequently it can only be utilised for irrigated crops where pumping is feasible. This, and the fact that the soils are extremely permeable, mean that spray irrigation is the most suitable type of water distribution for crops grown on Sandmount sand. Watertables develop, but are too deep to be harmful, except perhaps on some occurrences of the shallow phase.

The soils are suitable for citrus, although climatically the area is not particularly good. Other fruit trees can be grown as can tobacco, vegetables and lucerne. The high cost of spray irrigation seems to limit the use of Sandmount sand to high return crops.

SHEPPARTON FINE SANDY LOAM.

Surface soil.

A_1 0 to 5 inches; brown (5YR 4/4) fine sandy loam or loam; sharply separated from:

A_2 5 to 7 inches; weakly bleached light brown fine sandy loam (this horizon may be absent); sharply separated from:

Subsoil.

B_1 7 to 20 inches; red-brown (2·5YR 4/6) medium clay; grades into:

20 to 27 inches; brown or yellowish brown light clay; grades into:

B_2C 27 to 48 inches; mottled brown, yellow-grey fine sandy clay, clay loam or fine sandy clay loam; moderate subangular blocky structure; friable when moist; slight soft concretionary calcium carbonate; grades into:

48 to 72 inches +; textures as above or lighter: these rest on dense, poorly permeable clay at depths ranging from 4 feet to more than 25 feet.

Light phase.

In this phase, clay loam or fine sandy clay loam, instead of light clay, occurs between 20 and 27 inches and continues beyond 36 inches. Thus the light phase is transitional between the normal phase of Shepparton fine sandy loam and East Shepparton fine sandy loam. The latter soil type also has fine sandy clay loam between 20 and 27 inches, but this passes to fine sandy loam before 36 inches.

The principal occurrences of the light phase which are shown on the soil maps are in the Toolamba area, but there are other areas of Shepparton fine sandy loam where it has not been separated from the normal phase. The principal of these are between Bunbartha and Nathalia and north-west of Kyabram.

Variants.—The inscription *sandy surface* refers to surface soils which show the influence of coarse sand. They are sandy loams or loamy sands instead of fine sandy loams. *Sandy profile* denotes soils in which the coarse sandy influence extends throughout the soil profile. *Deep surface* refers to surface soils deeper than 12 inches. A *grey surface variant* comprises soils with a brownish grey surface over normal red-brown subsoils. A *dull variant* on the other hand has a brown (5YR 4/4) clay subsoil which becomes reddish brown with depth. These colour variants appear to be due to slight flooding from the Goulburn River. They are of very slight extent.

Occurrence.—The Shepparton series has been recorded previously in the Shepparton Irrigation Area (Skene and Freedman, 1944). There, two types were defined, Shepparton sandy loam and Shepparton loam. The former has a significant amount of coarse sand which is almost absent in Shepparton loam and Shepparton fine sandy loam. No distinction has been made between the last two soil types in the present area, consequently Shepparton fine sandy loam may also include loam textures.

Shepparton fine sandy loam is the typical soil of the levees of the *prior stream sequence* and is widespread over the whole area. It originally supported grey box woodland.

Land use.—Shepparton fine sandy loam is almost entirely devoted to irrigation. It supports good fruit trees, and perennial and annual pastures. Experience has shown that it is a satisfactory soil for peaches and apricots, although the trees are often less vigorous than on East Shepparton fine sandy loam. It has proved a good soil for most vegetables, and there seems to be no reason why lucerne should not do well on it.

As has occurred on most other soil types, stone fruits have died extensively on Shepparton fine sandy loam from autumn and winter waterlogging in abnormally wet years. Whether trees survive or not depends largely on the permeability of the subsoil clay. Where this is of low permeability and the slope is slight, the surface tends to become saturated and the risk of trees dying is great. However, the permeability of the subsoil clay is variable, and, where it is sufficiently high to allow water to drain through from the surface in a reasonable time, trees will usually survive, unless a shallow watertable is present in the lighter materials beneath the subsoil clay.

As a whole Shepparton fine sandy loam soils are not prone to shallow watertables because of the impeding nature of the subsoil clay. But they have developed in some horticultural situations and, more particularly, under irrigation systems involving high watering rates, such as on perennial pastures. In consequence, much of the Shepparton fine sandy loam under pasture in the more intensively developed parts has a high watertable.

Before planting to peaches, it is advisable to have Shepparton fine sandy loam checked for general suitability and the most appropriate peach varieties.* The grey surface and dull variants should not be used for stone fruits.

WENORA LOAM.

Surface soil.

A_1 0 to 4 inches; dark brownish grey to grey-brown loam or clay loam; grades into:

A_2 4 to 6 inches; weakly bleached grey-brown loam or clay loam; slight to moderate buckshot and iron-impregnated sandstone chips; sharply separated from:

Subsoil.

B_1 6 to 18 inches; yellowish brown to grey-brown heavy clay; tough and intractable when moist, hard when dry; grades into:

B_2C 18 to 45 inches; mottled grey, yellow, brown clay; isolated iron-impregnated sandstone floaters; light soft calcium carbonate; grades into:

45 to 84 inches; mottled grey and brown silty clay; sandstone fragments increasing with depth and merging with weathered sandstone at depths varying from 48 inches to more than 84 inches.

* See footnote, page 7.

Occurrence—Wenora loam was first identified in the adjoining Deakin Irrigation Area (Skene unpublished). It occurs on the Silurian hills, usually but not always, in situations which receive run-off from Erwen loam on higher country.

Land use.—Where cleared of grey box and buloke the soil type is used for cereal cropping. Sheep are grazed on the native and volunteer pastures.

As Wenora loam is of small extent and is largely above water supply level, it has very little potential for development under irrigation It would only be suitable for Group IV. crops.

YOUANMITE LOAM.

Surface soil.

A 0 to 5 inches; brown (5YR 3/4) loam, occasionally fine sandy loam; scattered buckshot; weakly bleached in lower part; at 3 to 7 inches sharply separated from:

Subsoil.

B_1 5 to 21 inches; red-brown (2·5YR 3/6) medium clay; moderate small subangular blocky structure; very friable when moist; grades into:

B_2 21 to 36 inches; reddish brown, or reddish brown diffusely mottled with yellow-grey, heavy clay; moderate small subangular blocky structure; moderately friable; slight calcium carbonate from 30 inches; grades into:

C 36 to 84 inches; brown or mottled reddish brown and yellow-grey clay; moderately subplastic; strong small angular blocky structure, black flecks on ped faces; hard when dry, friable when moist; slight to light calcium carbonate.

Deep Surface Phase.

Surface soil.

A_1 0 to 5 inches; brown loam or fine sandy loam; scattered buckshot; sharply separated from:

A_2 5 to 12 inches; weakly bleached reddish brown loam or fine sandy loam; light to moderate buckshot; at 8 to 14 inches grades into:

Subsoil.

B 12 to 21 inches +; similar to normal surface phase.

Occurrence.—Youanmite loam occurs only in the north-east of the North Shepparton Irrigation Area where it is found on "high plain". The deep surface phase is often associated with the brown phase of Katamatite loam, grades into it and is difficult to distinguish from it. The normal surface phase is more distinctive, but is of small extent in the surveyed area. Hard pan below 36 inches occurs irregularly as in Katamatite loam. Most of the original woodland of grey box, yellow box and Murray pine has been cleared.

Land use.—Cereal cropping in conjunction with grazing sheep on volunteer pasture is practised under dry-farming. Yields of wheat on the normal phase are reputed to be lower than on the deep surface phase.

Youanmite loam is regarded very favourably for irrigated pastures and fruit trees, and is being utilized along with Katamatite loam in a new irrigation settlement in the Parishes of Dunbulbalane and Youanmite (see Katamatite loam). The type is considered to have possibly a very slightly better potential for stone fruits than Katamatite loam, brown phase.

For the same reasons as those given for Katamatite loam, there is risk of peaches and apricots dying from waterlogging in abnormally wet years. Perhaps the risk is slightly less for Youanmite loam because of better surface run-off. Also, the normal phase may be safer than the deep surface phase, since shallow surface is held to reduce the effects of surface waterlogging.

Youanmite loam should be suitable for most vegetables, tomatoes and lucerne, the deep surface phase being preferred to the normal phase.

YUGA CLAY.

Surface soil.

A 0 to 3 inches; grey, diffusely mottled with rusty colours, clay loam or light clay; sharply separated from:

Subsoil.

B_1 3 to 15 inches; dark brownish grey or yellow-grey heavy clay; moderate angular blocky structure; hard when dry, tough and intractable when moist; grades into:

B_2 15 to 22 inches; yellow-grey heavy clay; weak structure; slight calcium carbonate; grades into:

C 22 to 48 inches +; yellow-grey medium clay; friable when moist; slight calcium carbonate; gypsum irregularly present below 30 inches.

Occurrence.—Yuga clay was first identified in the adjoining Deakin Irrigation Area (Skene unpublished), where it occurs on low plain and in shallow depressions in a virtually treeless landscape. It is the lowest member of the Koyuga catena, The type is of very minor extent in the present area.

Land use.—Provided there is adequate surface drainage, Yuga clay can be used for irrigated summer fodder crops, cereals and annual pastures. It is best avoided for horticulture and perennial pastures, unless there is no alternative. Pears and plums are the only fruit trees that should be attempted.

ZEERUST FINE SANDY LOAM.

Surface soil.

A_1 0 to 5 inches; greyish brown or grey-brown fine sandy loam; sharply separated from:

A_2 5 to 12 inches; moderately to strongly bleached, light brownish grey fine sandy loam; sharply separated from:

Subsoil.

B_2 12 to 27 inches; mottled yellow-brown and grey-brown light or medium clay; weak to moderate subangular blocky structure; friable when moist; grades into:

B_2C 27 to 48 inches +; mottled yellow-brown, light grey and reddish brown clay or sandy clay, sometimes with sandy loam in the deep subsoil; slight calcium carbonate.

Occurrence.—The *Zeerust sequence* is found only in the area between Shepparton and Tallygaroopna in the North Shepparton Irrigation Area. Zeerust fine sandy loam occupies the fractionally higher positions on a level or barely undulating plain. It is a relatively minor soil type.

Land use.—Zeerust fine sandy loam is given to cereal cropping and the grazing of irrigated pastures. It has not been used for horticulture. It is rated as a good soil for irrigated summer fodder crops, cereals, and both annual and perennial pastures, but is not recommended for vegetables, tomatoes, apples or stone fruits because of doubt about its surface drainage. However, its permeability appears to be good, and there may be situations where these crops could be grown. It should be suitable for pears and plums.

UNNAMED SOIL TYPES.

The following soil types are all of relatively small extent and are agriculturally unimportant. In some cases, the type descriptions given are based on only a few observations.

Type A

A_1 0 to 5 inches; grey-brown loam.

A_2 5 to 9 inches; light brownish grey fine sandy loam or loam; light buckshot; sharply separated from:

B_1 9 to 21 inches; yellow-brown or greyish brown medium clay; grading into:

21 to 48 inches +; mottled yellow-grey clay; slight calcium carbonate.

Occurrence and Land Use.—Type A occurs in small depressions on the flood plain of the *prior stream sequence,* often in areas of Lemnos loam and Goulburn loam. It can be used for Group IV. crops. Lemnos loam should not be planted with peaches and apricots where Type A occurs intermingled with it.

Type B

A_1 0 to 5 inches; grey or brownish grey loam.

A_2 5 to 11 inches; light grey loam; moderate buckshot; at 7 to 15 inches sharply separated from:

BC 11 to 48 inches +; grey or mottled grey medium clay; slight calcium carbonate below 30 inches.

Occurrence and Land use.—Type B occurs in depressions like Type A, but is more poorly drained. It can be used for the same irrigated crops as Goulburn loam with which it frequently occurs.

Type C

A_1 0 to 9 inches; dull brown sandy loam, slightly gritty.

A_2 9 to 13 inches; light brown loamy sand.

B_1 13 to 25 inches; diffusely mottled light brown sandy clay.

25 to 36 inches; mottled brown, yellow, light grey gritty coarse sand; cemented; grading into:

36 to 48 inches; mottled sandy clay loam; slight calcium carbonate.

Occurrenee and Land use.—This soil type is found on the levees and near-flood plain part of the landscape. Similar soils are Katunga sandy loam (Johnson, 1952), and Purdanima sand in the Deniboota Irrigation District, N.S.W. (Johnson, 1952a).

Because of the doubt about drainage and the possibility of shallow watertables, this type should only be used for Group IV. crops.

Type D

A 0 to 9 inches; grey-brown or greyish brown loam with weakly bleached A_2 horizon; light buckshot.
B 9 to 36 inches; weakly mottled brown medium clay.
36 to 48 inches; moderately mottled clay, slight calcium carbonate.

Occurrence and Land use.—Only one situation of Type D near Kyabram has been recorded. It is considered suitable for Group IV crops.

Type E

A_1 0 to 5 inches; dull brown to dark grey-brown sand; structureless and loose.
A_3 5 to 20 inches; light brown or light grey-brown sand; buckshot irregularly present; compact at junction with B horizon; at depths from 9 to 36 inches sharply separated from:
B 20 to 36 inches; variably mottled red-brown, grey and yellow-brown sandy clay; moderate angular blocky structure.
36 to 48 inches +; mottled material ranging from medium clay to fine sandy clay loam; slight calcium carbonate.

Occurrence and Land use.—This is one of the more extensive of the unnamed soil types. It occurs on or near the levees of the prior streams in association with rises of Sandmount sand, extending from that type as a sandsheet of variable depth over the finer alluvial deposits of the plain.

Type E is liable to shallow watertables, consequently it is not suitable for stone fruits and may not be satisfactory for pears. It can be used for irrigated summer fodder crops, cereals, and perennial and annual pastures.

Type F

A_1 0 to 5 inches; grey-brown loam.
A_3 5 to 11 inches; diffusely mottled and weakly bleached brown loam; light buckshot; sharply separated from:
B 11 to 27 inches; reddish brown passing to brown medium clay.
27 to 48 inches; mottled light clay, slight calcium carbonate.

Occurrence and Land use.—The only occurrences are in the vicinity of Tatura. Many areas are too small to be shown on the soil maps. It is found with Lemnos loam where it is distinguished by its thicker surface and A_2 horizon, duller colours and the presence of buckshot.

Type F is best avoided for stone fruits, but pears and plums can be grown. It is suitable for irrigated perennial and annual pastures.

Type G and Type H

Strongly gilgaied soils occur over small areas on the plain adjacent to the Silurian hills in the southern part of the area. Type G identifies such soils with grey clays and Type H soils with brown or red-brown clays. The two types occur closely associated and grade into one another, and both contain scattered iron-impregnated sandstone fragments. The gilgai micro-relief is of the shelf-puff type.

Type G, shelf profile.
0 to 3 inches; diffusely mottled grey clay loam; irregularly bleached in lower part; sharply separated from:
3 to 18 inches; dark brownish grey (10YR 3/1) medium clay; coarse angular blocky structure; grades into:
18 to 48 inches +; brownish yellow-grey clay, mottled with depth; light fine calcium carbonate below 30 inches.

Type G, puff profile.
0 to 14 inches; grey clay; strong small angular blocky structure; light soft and fine concretionary calcium carbonate; grades into:
14 to 48 inches; similar to 18 to 48 inches of shelf profile.

Type H, shelf profile.
0 to 4 inches; grey-brown (10YR 4/2) loam; sharply separated from:
4 to 11 inches; dark brown (5YR 3/4) medium clay; moderate angular blocky structure, peds ⅛ to ½ inch; grades into:
11 to 23 inches; bright brown (5YR 4/6) clay; weak structure; light soft and fine concretionary calcium carbonate; grades into:
23 to 48 inches +; mottled brown, grey, red clay; decreasing calcium carbonate.

Type H, puff profile.
0 to 4 inches; dull brown (7·5YR 5/4) medium clay; moderate subangular blocky structure, 1 inch peds; slight calcium carbonate.
4 to 40 inches; dark brown (5YR 4/3) clay; moderate subangular blocky structure; light calcium carbonate; grades into mottled clay with decreasing calcium carbonate.

Land use.—The gilgai micro-relief makes efficient grading for irrigation difficult consequently these soil types are not suitable for horticulture or for perennial pastures, but they could be used for irrigated summer fodder crops, cereals and annual pastures.

Type J

A 0 to 8 inches; diffusely mottled grey loam; vesicular and brittle; at 6 to 12 inches grades into:
B 8 to 26 inches; mottled greyish brown and yellowish brown medium clay passing to light clay; coarse angular blocky structure; grades into:
26 to 48 inches +; mottled brownish grey and yellowish brown clay loam or fine sandy clay loam, often micaceous.

Occurrence and Land use.—This is a relatively coarse textured soil found on the highest parts of the landscape of the *flooded clay plain sequence.* The dull colours in the profile are considered to be

due to past flooding from the Goulburn River. However, these soils are protected from flooding, and, since they occur relatively high in the landscape and have good surface slopes, they could possibly be used for horticulture, including peaches and apricots, tomatoes and most vegetables.

Type K

A 0 to 8 inches; brown or diffusely mottled grey and brown loam; sharply separated from:

B_1 8 to 30 inches; red-brown (2·5YR 4/6) medium clay; massive or coarse angular blocky structure; grades into:

B_2C 30 to 48 inches; brown (5YR 4/4) clay; strong small angular blocky structure, 1/10 to ¼ inch peds; slight soft and concretionary calcium carbonate.

Occurrence and Land use.—Type K has been found only in association with Lemnos loam which it closely resembles, and Shepparton fine sandy loam. It can be utilised in the same manner as Lemnos loam.

Type L

0 to 15 inches; diffusely mottled grey silty clay loam or silty loam, often becoming light grey with depth; grades into:

15 to 48 inches; strongly mottled light grey, rusty colours and yellow-brown silty clay loam or silty light clay.

Occurrence and Land use.—This is the main soil type developed on the recent alluvium of the lower terraces along the Goulburn River. The type carries a forest of river red gum which is largely intact. The surface is often irregular and hummocked. Regular flooding excludes Type L from any form of agricultural use other than for sparse grazing of cattle in summer. The forest is used by apiarists and as a source of timber and firewood.

Type M

A_1 0 to 5 inches; grey loam; slight buckshot; sharply separated from:

A_2 5 to 18 inches; light grey fine sandy loam or fine sandy clay loam; moderate to heavy buckshot; at 13 to 24 inches grades into:

B_1 18 to 36 inches; mottled yellow-brown and grey light clay grading into medium clay.

36 to 48 inches +; mottled grey and yellow-brown clay; markedly subplastic; strong angular blocky structure, black flecks on ped faces.

Occurrence and Land use.—Type M is associated with Youanmite loam and Katamatite loam in the Dunbulbalane area where it occurs as small, usually landlocked, depressions. It is used for pears and plums and irrigated perennial and annual pastures.

Type N

A 0 to 6 inches; grey loam or clay loam with rusty colours along root channels; scattered fine buckshot; at 4 to 9 inches sharply separated from:

B 6 to 24 inches; dark brownish grey (10YR 4/2) grading into dull yellowish brown (7·5YR 4/4) heavy clay; tough and intractable when dry or moderately moist; grades into:

24 to 36 inches; yellowish brown clay; more friable than above; slight calcium carbonate; grades into:

36 to 48 inches mottled brown and grey clay; occasionally gypsum.

Occurrence and Land use.—Type N is one of the soil types of moderate surface drainage found in the *flooded clay plain sequence.* Under irrigation it would be suitable for Group IV. crops.

Type O

A 0 to 4 inches; dark grey-brown (10YR 4/2) clay or clay loam; moderate angular blocky structure; cracked and very hard when dry; scattered buckshot and iron-impregnated sandstone chips.

B_1 4 to 15 inches; grey-brown (10YR 6/3) to dark grey heavy clay; grades into:

B_2 15 to 24 inches; olive (2·5Y 6/4) heavy clay; calcium carbonate concretions.

24 to 48 inches; mottled shades of grey and red, clay; below 36 inches grades into strongly mottled light grey silty clay; occasional sandstone fragments.

Occurrence and Land use.—This soil type is the grey, but not always the lowest member of the toposequence found on the Silurian hills. Under irrigation it would be suitable only for Group V. crops.

Type P

0 to 24 inches; dark grey or dark grey-brown clay loam or silty loam; at 18 to 36 inches or more grades into:

24 to 48 inches; grey-brown to yellow-grey, sometimes mottled, clay.

Occurrence.—There are no individual areas of Type P. It is one of the depression components of Complex I. which describes a characteristic area of "pitted" country in the Murchison district.

Type Q

A 0 to 5 inches; diffusely mottled grey-brown (10YR 4/3) to grey silty clay loam to light clay, sometimes weakly bleached in lower part; at 3 to 7 inches sharply separated from:

B 5 to 30 inches; yellowish brown (10YR 4/4) to yellowish grey (2·5Y 4/2) medium clay; labile or plastic when moist; at 24 to 36 inches grades into:

30 to 84 inches; dull yellowish brown (7·5YR 4/4) to reddish brown (5YR 4/6) clay; strong small angular blocky structure, 1/10 inch peds; light soft calcium carbonate.

Occurrence.—Type Q is not found in areas large enough to be shown on the soil maps. It occurs on intermediate parts of the landscape as a component of Complex II. a micro-association of soil types on the flooded clay plain It may be slightly gilgaied.

Type R

0 to 27 inches; diffusely mottled grey clay loam or light clay with rusty colours along root channels and diffuse grey-brown colours more prominent with depth; structureless and finely vesicular; at 18 to 36 inches or more sharply separated from:

27 to 84 inches +; diffusely mottled yellowish brown clay; denser and better structured than above; slight calcium carbonate.

Occurrence and Land use.—Type R is the lowest component of the *flooded clay plain sequence.* It occurs in depressions, both as individual areas and in the Complex III. and Complex IV. micro-associations. Under irrigation, it would be suitable only for Group V. crops.

Type S

A_1 0 to 5 inches; grey-brown or brownish grey fine sandy loam or loam.

A_2 5 to 12 inches; light grey, variably bleached, fine sandy loam or fine sandy clay loam; at 8 to 15 inches sharply separated from:

B_1 12 to 24 inches; moderately mottled yellow-brown and yellow-grey clay.

24 to 48 inches; light clay passing to sandy clay (sometimes textures are lighter).

Variant.—Textures below 12 inches are fine sandy clay loam in a *light subsoil variant.*

Occurrence and Land use.—Type S occurs only in the vicinity of Seven Creeks in the South Shepparton Irrigation Area. The type is untried under irrigation, but it appears suitable only for Group IV. crops.

MICRO-ASSOCIATIONS.

In some areas, two or more soil types are so closely intermingled that they cannot be shown individually on the soil map. Soil changes may occur within a few yards in which case the soil types form a complex or association. This is usually associated with a characteristic micro-landscape. Four complexes of this kind have been used as compound mapping units. They are described below.

Complex I.

This is a complex of soil types associated with "pitted country" in the southern part of the Rodney Irrigation Area. It occurs over small areas both on the levees alongside a strong prior stream, and on the near- and mid-flood plain, close to but not necessarily adjacent to the Silurian hills.

The land is marked by distinct pits, usually roughly circular in shape, and from 10 to 20 yards across. The pits mostly vary from 1½ to 4 feet in depth but some are as deep as 6 feet. The pits may cover as much as 60 per cent of the total area or as little as 15 per cent.

The soils in the level areas or "shelves" range from Shepparton fine sandy loam and Orrvale loam to Lemnos loam and Goulburn loam. The soil types in the pits are Type P, Goulburn clay loam or Congupna clay loam. A considerable proportion of transitional and marginal profiles are present.

Land use.—This complex is unsuitable for irrigated agriculture because of the impossibility of grading it adequately. Where the pits are numerous, it is doubtful whether it can be cultivated effectively even for dry-land farming.

Complex II.

This is a component of the *flooded clay plain sequence.* It occurs on level, intermediate areas and, where gilgai micro-relief is present, the gilgaies are no more than moderately developed.

The soil types in the complex are Goulburn loam, Goulburn clay loam and their bright deep subsoil variants, Type Q and Rooka clay loam and, occasionally, small areas of Coomboona loam. Where the complex is gilgaied, the Goulburn soils and Type Q occupy the level or "shelf" situations, while Rooka clay loam and sometimes Type Q occupy the depressions.

Land use.—Complex II. is reputed to grow good cereal crops in the absence of protracted floods. If put to irrigation, it should be suitable only for Group V. crops.

Complex III.

This unit occupies the intermediate and lower positions on the *flooded clay plain sequence.* Its surface is moderately to strongly gilgaied.

The component soil types are Congupna clay loam, Congupna clay, their yellow variants, Goulburn clay loam and its bright deep subsoil variant, together with smaller and varying proportions of Type R, Rooka clay loam and very occasionally some Coomboona loam. The main soil types, the Goulburn and Congupna soils, are marked by the irregular presence of gypsum in the deep subsoil.

Goulburn clay loam, Congupna clay loam and their variants occupy the shelves and puffs of the gilgaies, while Congupna clay and its yellow variant, Type R and Rooka clay loam occupy the depressions.

Land use.—This unit can be used for cereal cropping and grazing. It is not recommended for irrigation because of poor surface drainage, poor permeability of the subsoils, grading difficulties, and the risk of flooding from the Goulburn River. However in situations where these difficulties can be overcome the soils have the same irrigation potential as those of Complex II.

Complex IV.

The soils of this complex are found in the wettest and lowest parts of the *flooded clay plain sequence.* Some parts are intermittent swamps, but the complex is principally one of broad shallow depressions. The surface is moderately to strongly gilgaied.

The soil types are mainly Congupna clay, Congupna clay loam, their yellow variants and smaller areas of Type R and Goulburn clay loam. Gypsum is irregularly present in the deep subsoils of the Congupna and Goulburn soils.

Land use.—Complex IV. is not recommended for irrigation for the same reasons as Complex III. It has some value for grazing purposes.

ERWEN ASSOCIATION.

Unlike the micro-associations described above, this is a large landscape unit and the component soil types are capable of being mapped individually. In fact, this has been done in some parts of the area. However, as the soils are mainly above present irrigation supply level, and are unlikely to be utilized for irrigation, a broad grouping has been adopted over parts of the Silurian hills.

The component soil types are mainly Erwen loam, its shallow phase, Wenora loam, and small areas of Goulburn loam, Goulburn clay loam, Types G, H, and O, and Complex I.

Land use.—Cereal cropping and the grazing of sheep on native, improved and volunteer pastures are the agricultural pursuits.

SOILS OF THE PRIOR STREAM BEDS.

The soils in this group are found in the beds of the more or less continuous depressions running through the higher parts of the country. These are old, non-functional streams.

The soils vary considerably, not only along and across the stream beds, but also with depth. The soil changes are too frequent to map, consequently the depressions have only been broadly separated into three types, mainly on differences in the permeability of their soils.

Type 1

This is a well drained depression and water normally moves away rapidly through and over the soil. Surface textures are usually sandy loam or sand, while subsoil textures are never heavier than sandy clay. These light textures frequently persist beyond 15 feet, but in some situations pass to clay before 4 feet. Colours are commonly brown or grey-brown in the surface and dark brown or dark reddish brown in the subsoil, with brownish yellow in the deep subsoil.

Land use.—Where these depressions are capable of being laid out to irrigation, they can be used for Group IV. crops. They should be avoided for stone fruits. Watertables are present where the soils are under irrigation.

Type 1H

This also is a well drained depression of dominantly brown and grey-brown soils, but textures are a degree heavier than in Type 1 depressions. The surface is sandy loam or loam and the subsoil light or medium clay. The clay may occur either within the first foot or at greater depths; it overlies lighter textured materials in the deep subsoil. These materials vary below 4 feet similarly to those in Type 1 depressions.

Land use.—Type 1H depressions are less permeable than Type 1 and therefore they drain more slowly. Situations capable of being laid out to irrigation are suitable for Group IV. crops. The deep subsoils are usually highly permeable and watertables are present where irrigation is practised.

Type 2

These depressions have restricted downward drainage and water may lie on the surface for extended periods. The surface soil is from 2 to 12 inches thick and ranges from grey to grey-brown in colour and from loam, or even sandy loam, to light clay in texture. The subsurface is commonly bleached to light grey in the deeper soils and is separated sharply from the clay subsoil beneath. This is usually medium or heavy clay, with colours varying from mottled brownish grey to yellow-grey. The clay may extend downward for more than 6 feet, but eventually it grades into sandy materials.

Sometimes the soils in the upper 4 feet of the profile resemble those of the Goulbourn or the Congupna series. Such occurrences are inscribed on the soil map "Goulburn profile" and "Congupna profile".

Early in the survey, Type 1H was not separated from Type 2 depressions, consequently Type 2 depressions recorded in the North Shepparton irrigation Area and in the northern part of the Rodney Irrigation Area may include a small proportion of Type 1H.

Land use.—Since Type 2 depressions are liable to hold water for prolonged periods, they are not suitable for irrigation. Some are used for sites of constructed drains.

MISCELLANEOUS UNITS.

River Frontage.

This unit delineates areas which are subject to recurrent flooding adjoining the rivers and creeks. It comprises the lower terraces flanking the Goulburn River, but also includes some adjacent low land in the northern part of the Rodney Irrigation Area and along the Broken River, Nine Mile Creek and Seven Creeks. The soil types have not been investigated fully; those recorded are given in the section on "Soil Associations".

The original cover of red gum is mostly intact and the larger areas are reserved as State Forest. The unit has no agricultural value other than for sparse grazing when it is not inundated.

Unidentified Soils Subject to Flooding.

A fairly extensive area of land in the northern part of the Rodney Irrigation Area has been placed in this unit. It is not protected from flooding by the Goulburn River, consequently it is unsuitable for irrigation. It provides rather sparse grazing for sheep and cattle.