# *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 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 on the map with your parish allotment numbers.*

*If your property is in the Tresco or the Nyah Irrigation District, or the Long Lake or the Kangaroo Lake Settlement the scale of the soil map is 1 inch to 20 chains. Elsewhere the scale is 1 inch to 40 chains. Mark the outline of your farm on the soil map keeping in mind the scale of the map being used.*

*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 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 40 different symbols altogether on the soil maps, but probably less 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 to Soil Types and Crop Suitability Groups " following the "Index to Maps" and find your colours and symbols. This will give you the names of the soil types and other map units on your property, and the irrigated crops that can be grown more or less satisfactorily on each. The soil map of your property 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 in Relation to Irrigation". The latter section tells you of some of the things that need to be taken into account for successful irrigation of the soil types and units. It refers particularly to risks of water-tables, salting and chlorosis, and gives drainage recommendations for the horticultural soils.*

*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*

*Your can learn more about your own soil types and other map units in the section "Description of Soil Types and Miscellaneous Units"; it is not necessary to read about all the other soil types and units 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 report. But landholders who do so will be helped by reading Appendix IV, "Explanation of Soil Terms", and Appendix V, "Soil Survey Methods".*

*The Map of Soil Associations in the envelope at the back of 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. Also in the some envelope is a Salt Map. This again is a generalized map showing the broad picture of salinity in the district. It is not detailed enough to show the salt status of individual holdings. You should seek advice from your district agricultural adviser when planning new plantings which may be susceptible to salt injury.*

**Department of Agriculture, Victoria, Australia**

# SOILS AND LAND USE

## NEAR

# SWAN HILL, VICTORIA

comprising the Tresco and Nyah Irrigation Districts, Swan Hill (Part), Mystic Park and Fish Point Irrigation Areas, and Long Lake and Kangaroo Lake Irrigation Settlements.

by

J. K. M. Skene and 1. J. Sargeant

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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 organizations 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 organizing the assistance provided, and the officers at the Swan Hill and Nyah district offices for, either directly or indirectly, providing assistance with the soil auger, maintaining the survey vehicle, and providing office facilities and local information.

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Among colleagues in the Department of Agriculture who have assisted are Mr. J. H. Bird, Field Officer, who participated in the early part of the survey, and Mr. J. W. Newell, Soils Officer, whose survey of the Beverford Extension to the Woorinen Settlement has been incorporated in this report.

Others who have helped materially are the chemists and laboratory assistants responsible for the analyses. The District Horticultural Officers and Horticultural Advisers at Mildura, Nyah, Robinvale and Swan Hill provided information about irrigated horticulture in relation to the soils.

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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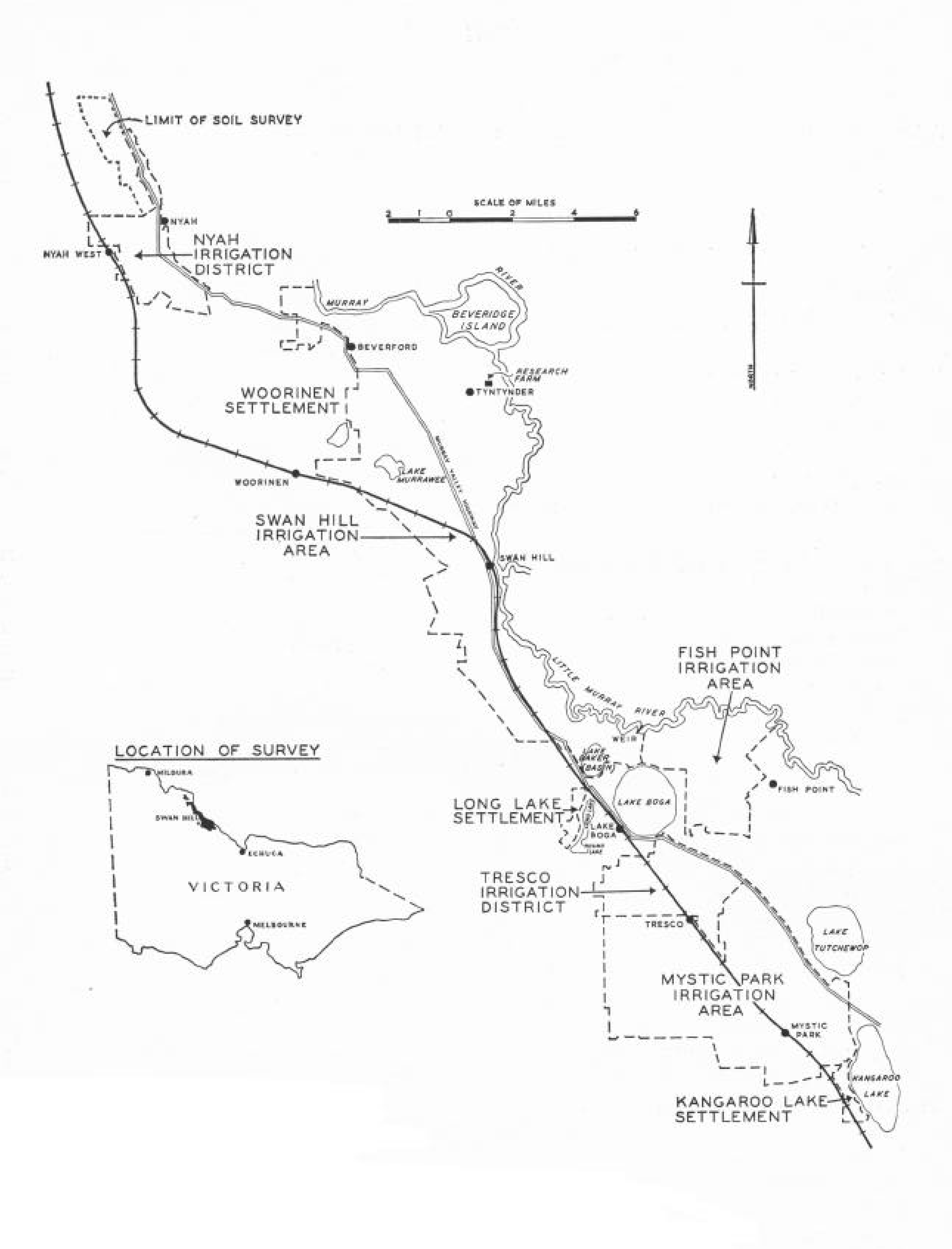

# Soils and Land Use near Swan Hill, Victoria

## Comprising the Tresco and Nyah Irrigation Districts, Swan Hill (Part), Mystic Park and Fish Point Irrigation Areas, and Long Lake and Kangaroo Lake Irrigation Settlements

By J. K. M Skene[*] and I. J. Sargeant[⊥]

Soils Surveyed by 1. J. Sargeant and J. H. Bird.

This report, "Soils and Land Use near Swan Hill, Victoria", describes a detailed soil survey of 68,400 acres in the County of Tatchera (Fig. 1). About 32,500 acres are irrigated and are mainly under pastures for dairying and fat lamb production. However, approximately 5,000 acres are devoted to horticulture, mainly vines for dried fruit production. Relatively small areas are under citrus, stone fruits, apples and market gardens. The unirrigated areas are given to wheat-farming and the grazing of sheep and cattle on native and volunteer pastures. Further information concerning the location, settlement, and present land use is given in the section, "General Information about the Area".

The present soil survey includes a re-survey of about 8,800 acres in the Nyah and Tresco Irrigation Districts and the Kangaroo Lake Settlement reported by Taylor et al. (1933). The relation of the original to the present soil types and other mapping units is given in the section, "Soil Relationships".

The areas of the individual soil types and other mapping units which are described later are given in Appendix 1 for each of the irrigation settlements.

## SUITABILITY OF THE SOILS FOR VARIOUS IRRIGATED CROPS

The soils have been classified into soil types and other mapping units[Ξ]. Most of the mapping units have been given names but some are designated by letters and numbers. Full descriptions of all of the mapping units can be found in a later section, "Description of Soil Types and Miscellaneous Units"; the present section deals with their suitability for various irrigated crops.

### *Capability Ratings*

Each mapping unit has been rated in regard to the *irrigated* crops that normally might be attempted. These ratings are given in Table 1.

[*] Senior Soils Officer
[⊥] Soils Officer
[Ξ] Refer to glossary for explanation of technical terms

*Table 1 – Capability Rating of Soils for Irrigated Crops*

| Soil Type or Mapping Unit | Citrus | Peaches | Apricots | Plums | Apples | Pears | Vines | Vegetables | Lucerne | Summer Fodder Crops | Cereals | Perennial Pastures | Annual Pastures | Crop Suitability Group |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tyntynder sand | G | D | F | F | D | | F | F | F | D | D | D | D | I |
| Murrawee sand | F | D | F | F | D | | G | G | G | D | D | D | D | I |
| Deep surface variant | F | D | G | F | D | | G | G | G | D | D | D | D | I |
| Shallow surface variant | | | F | F | D | | G | G | G | G | G | F | G | IIA |
| Shallow phase | | D | G | F | D | F | G | G | G | D | D | D | D | I |
| Murrawee sandy loam | | | G | G | F | F | G | G | G | G | G | G | G | IIA |
| Shallow phase | | | G | G | F | F | G | G | G | G | G | G | G | IIA |
| Saline phase | | | | | | | S | S | S | S | S | S | S | VA |
| Tresco sandy loam | | | G | G | F | F | G | G | G | G | G | G | G | IIA |
| Shallow phase | | | G | G | F | F | G | G | G | G | G | G | G | IIA |
| Tatchera sandy loam | | | D | D | | | G | F | G | G | G | G | G | IIIA |
| Shallow phase | | | | | | | F | F | G | G | G | G | G | IIIA |
| Deep phase | | | D | D | | | G | G | G | G | G | G | G | IIIA |
| Saline phase | | | | | | | S | S | S | S | S | S | S | VA |
| Vinifera sandy clay loam | | D | D | D | D | D | F | F | F | G | G | F | G | IIIB |
| Nyah clay loam | | | | | | | | D | D | G | G | F | G | IVB |
| Lake Baker clay | * | * | * | * | * | * | * | D | G | G | G | G | G | IVA |
| Swan Hill clay | * | * | * | * | * | * | * | D | F | G | G | G | G | IVA |
| Speewa clay | | | | | | | | | | G | G | F | G | IVA |
| Donnington clay | * | * | * | * | * | * | * | D | F | G | G | F | G | IVB |
| Fish Point clay | | | | | | | | D | F | G | G | F | G | IVB |
| Meran sandy clay loam | | | | | | | | | | S | S | | S | VB |
| Kunat sandy clay loam | | | | | | | S | S | S | S | S | S | S | VA |
| Della clay | | | | | | | | | | S | S | | S | VB |
| Boga clay loam | | | | | | | | | | S | S | | S | VB |

| Soil Type or Mapping Unit | Citrus | Peaches | Apricots | Plums | Apples | Pears | Vines | Vegetables | Lucerne | Summer Fodder Crops | Cereals | Perennial Pastures | Annual Pastures | Crop Suitability Group |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit C | | | | | | | F | F | F | F | G | F | G | IIIA |
| Unit G | | | | | | | F | F | F | G | G | G | G | IIIA |
| Unit H | | | | | | | F | F | F | G | G | G | G | IIIA |
| Unit K | | | | | | | F | | | F | F | F | F | IIIB |
| Light phase | | | | | | | F | D | D | F | F | F | F | IIIB |
| Unit L | F | G | G | G | G | G | G | G | G | G | G | G | G | IIB |
| Unit N | D | D | D | D | D | D | D | D | D | G | G | G | G | IVB |
| Type 1 | * | * | * | * | * | * | * | G | G | G | G | G | G | IVA |
| Type 2 | * | * | * | * | * | * | * | G | G | G | G | G | G | IVA |
| Type 3 | * | * | * | * | * | * | * | D | F | G | G | G | G | IVA |
| Type 4 | | | | | | | | | D | G | G | F | G | IVC |
| Type 5 | | | | | | | | D | F | G | G | G | G | IVC |
| Type 6 | | D | D | D | D | D | D | D | | F | F | * | F | IVD |
| Type 7 | | D | D | D | D | D | D | D | | F | F | * | * | IVD |
| Type 8 | | | | | | | | | | S | S | | S | VB |
| Lunette soils | | | | | | | | | | | | | | VI |
| Saline flats | | | | | | | | | | | | | | VI |
| Watercourses and swamps | | | | | | | | | | | | | | VI |

Noted: G = good; F = fair; D = doubtful; S = saline, reclamation treatment necessary. A blank space or asterisk means that the particular planting is not recommended

The assessments “good” and “Fair” mean that the soils concerned are considered to be capable of supporting economic crops *under systems of average management and non-saline conditions*. The presence of satisfactory internal drainage of soils assessed as suitable for fruit trees and vines is essential, and this means that most situations needs to be tile-drained, even when the capability rating is given as “good”.

In general, a capability rating of “fair” means that the performance of the crop specified is likely to be lower than on soils rates as “good” because of factors such as low soil fertility, low moisture retention, chlorosis, waterlogging and poor permeability. However, good crops may be possible if the restricting factors are overcome by suitable practices.

A "doubtful" rating means that the performance of the crop specified, usually, although not always, will be unsatisfactory under average management practices. The special measures necessary to raise performance to satisfactory levels may or may not be known. For example, careful attention to watering and drainage are the requirements for growing the shallow-rooting crops on the deep sandy soils, but the corrective measures necessary to bring peaches and apples to satisfactory performance on such soils are not known.

A fourth category designated "saline” comprises soils on which crop performance is likely to be severely affected by salt. Some of these soils require reclamation before worth-while production can be expected-all require careful management to combat salinity.

A blank space in Table 1 indicates that the crop concerned is not recommended for the soil type in question because of a known adverse soil factor. An asterisk means that there is uncertainty because of insufficient experience with the crops and soils concerned.

### *Crop Suitability Groups*

The soil maps with this bulletin are coloured so that they can be used directly to show broadly the capability of the soil in a particular situation for a number of irrigated crops. This has been achieved by grouping together into one crop suitability group all of the mapping units with *approximately* similar capability ratings as given in Table 1. There are six such groups and the group to which each mapping unit has been allotted is given in the last column of the Table.

The descriptions of the crop suitability groups that follow include summaries of the main soil features common to all of the mapping units included in each group. In the case of Groups II, IIII, IV and V, the mapping units are divided further into subgroups on the basis of differences in their main soil features.

Readers are asked to be cautious about accepting the crop suitability grouping as a rating of the soil types and other mapping units in order of agricultural merit, although it does suggest a general order in that high return crops usually can be grown less successfully in descending order from Group I to Group VI.

Soil salinity is a hazard over most of the surveyed area, consequently *landholders should give consideration to salinity aspects when planning the land use of specific areas, particularly if salt-sensitive crops are contemplated.* Information about salinity is given in the next section, "Soil Features in Relation to Irrigation".

### *Group I*

*Good and fair soils for citrus (except Murrawee sand, shallow phase), apricots, plums, vines, vegetables and lucerne, but doubtful soils for peaches, apples and shallow-rooting crops.*

Highly permeable, deep, sandy, brown soils grading into moderately calcareous, light-textured subsoils:

TYNTYNDER SAND.
MURRAWEE SAND.
MURRAWEE SAND, deep surface variant.
MURRAWEE SAND, SHALLOW PHASE.

The performance of peaches is doubtful because of the prevalence of nematodes and crown gall in these light-textured soils. There also appear to be nutritional deficiencies which lead to lack of fruiting and poor quality in horticultural crops other than citrus.

The depth of soil above the limey subsoil should not be less than 30 inches for citrus, and the shallow phase of Murrawee sand is not recommended for citrus for this reason. In fact, all areas proposed for citrus should be checked for suitability before planting.[*]

Group I soils have a low capacity for storing moisture and, since the surface soils dry out rapidly, shallow-rooting crops are very liable to moisture stress in summer. The soils are also highly permeable and care is necessary to prevent overwatering with consequent danger of watertables and salting developing on adjoining lower land. Watering should be light and frequent and this is best achieved by spray irrigation methods.

### Group II

*Good and fair soils for apricots, plums, apples, pears, vines, vegetables, lucerne, summer fodder crops, cereals, perennial and annual pastures; sub-group (b) is also fair for peaches.*

(a) Brown sandy soils 6 to 24 inches thick, overlying sandy clay loam or sandy clay subsoils, moderately calcareous below 16 inches, with less permeable layers commencing at variable depths greater than 3 feet from the surface:

MURRAWEE SAND, shallow surface variant.
MURRAWEE SANDY LOAM.
MURRAWEE SANDY LOAM, SHALLOW PHASE.
TRESCO SANDY LOAM.
TRESCO SANDY LOAM, SHALLOW PHASE.

Although the crops specified above usually may be grown without reservation on Group II soils, it is desirable to check the depth to the main lime horizon over sites proposed for fruit trees. This depth should not be less than 20 inches for apple plantings and 18 inches for apricots, pears and plums.

Since these soils have moderately high infiltration rates, watertables develop fairly easily. Preventative measures lie in attention to irrigation methods and, in most situations, to installation of tile drainage. With care, furrow irrigation can be used successfully, although spray irrigation wherever practicable is advisable for crops grown on Murrawee sand.

(b) Grey sandy clay grading into moderately permeable, slightly calcareous clay, with a denser layer usually commencing between 2 and 3 feet from the surface:

#### *Unit L*

Unit L is a grey, heavy-textured soil very different from other soils used for horticulture. In general, the grey, heavy-textured soils are considered unsatisfactory for horticultural crops (Anon. 1955). However, there is recent experience in the adjoining Woorinen Settlement to show that vines, peaches and apples sometimes can be grown successfully on Unit L. Such soils, therefore, are worth considering for fruit trees in the present area. Nevertheless some situations are known to be saline and all areas proposed for horticulture should be checked for suitability in regard to salinity, permeability, and lime content before planting.

### Group III

*Good and fair soils for vines, vegetables, lucerne, summer fodder crops, cereals, and perennial and annual pastures; doubtful or unsuitable for most fruit trees (Unit K is not recommended for vegetables or lucerne).*

(a) Mainly grey-brown or grey, calcareous sandy loams or sandy clay loams about 12 inches thick, overlying highly calcareous, sandy clay subsoils, with less permeable layers usually commencing between 2 and 6 feet from the surface:

TATCHERA SANDY LOAM.
TATCHERA SANDY LOAM, DEEP PHASE.
TATCHERA SANDY LOAM, SHALLOW PHASE.
UNIT C.
UNIT G.
UNIT H.

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[*] Requests for advice should be made to the Horticultural Adviser, Department of Agriculture, Public Offices, Swan Hill

Group IIIA soils are not recommended for the growing of fruit trees because of their high lime content and the consequent danger of chlorosis. The soils are moderately permeable and watertables are likely to develop in the absence of tile drainage.

(b) Brown sandy clay loams about 6 inches thick, overlying slowly permeable, red-brown clay subsoils containing calcium carbonate below 15 inches, with denser layers usually between 2 and 4 feet from the surface:

VINIFERA SANDY CLAY LOAM.
UNIT K.
UNIT K, LIGHT PHASE.

Although these soils are not so calcareous as those in subgroup (a) and there is less risk of chlorosis, indifferent permeability is a disability and they are regarded as generally unsatisfactory for fruit trees. Unit K is not recommended for vegetables and lucerne also because of the poor permeability of its subsoil. However, there are some situations of better permeability in Vinifera sandy clay loam at Nyah where fruit trees such as apricots are being grown successfully.

Watertables are slow to form in Group HIB. soils.

## *Group IV*

*Good and fair soils for lucerne (except soil types shown thus), summer fodder crops, cereals, and perennial and annual pastures; mainly doubtful for vegetables.*

(a) Grey clays and clay loams overlying non-calcareous, grey clay subsoils:

LAKE BAKER CLAY.
SPEEWA CLAY.
SWAN HILL CLAY.
TYPE 1.
TYPE 2.
TYPE 3.

The main limitation to the successful growth of pastures and lucerne on Group IVA Soi1s is the degree of salinity in the surface soil. Saline watertables are common in both Swan Hill clay and Speewa clay, even though these soil types are heavy-textured, and contribute to salting where they approach the surface. Speewa clay is rather more prone to salting than the other soil types, due to its lower situation and poorer surface drainage. It is not recommended for lucerne on this account.

Types 1 and 2 are lighter-textured and well drained, while the risk of salinity developing is low. They should be very suitable for perennial pastures and lucerne.

On present knowledge, the soils of this subgroup cannot be recommended for vines or fruit trees.

(b) Grey-brown to grey clays overlying variably calcareous, grey to brown clay subsoils:

DONNINGTON CLAY.
FISH POINT CLAY.
NYAH CLAY LOAM.
UNIT N.

The principal disabilities of the soils in this subgroup are slow permeability of the subsoils and deep subsoils, and in some situations, salinity.

(c) Grey or grey-brown heavy-textured soils overlying calcareous, brown clay subsoils with lighter textured deep subsoils.

TYPE 4.
TYPE 5.

These soils carry satisfactory irrigated pastures. Their permeability is adequate for perennial pastures while surface drainage is rarely a problem. Some windswept areas of Type 4 are less attractive.

(d) Eroded brown soils with dense subsoils.

TYPE 6.
TYPE 7.

### *Group V*

*Saline soils requiring appropriate reclamation measures and careful irrigation; when reclaimed, subgroup (a) soils should support most of the Group III crops, and subgroup (b) summer fodder crops, cereals, and annual pastures.*

(a) Grey-brown sandy clay loam 6 inches thick, overlying light clay, becoming moderately calcareous below 14 inches. Other sandy soils described under Groups IIA and IIIA:

KUNAT SANDY CLAY LOAM.
MURRAWEE SANDY LOAM, SALINE PHASE.
TATCHERA SANDY LOAM, SALINE PHASE.

Most of the Kunat sandy clay loam has not been irrigated and little surface salting is apparent. But appreciable salt is present in the subsoils and this constitutes a hazard should the soils be irrigated. Nevertheless, pastures and lucerne might be successful provided careful attention is given to management practices. Vines are more risky, since they would require tile drainage protection, and it is not known how effectively this soil type would drain.

The saline phases of Murrawee sandy loam and, to a lesser extent, Tatchera sandy loam are largely a consequence of irrigation, either on the soils themselves, or on adjacent land. Salt has risen to the surface in many places and reclamation is necessary for irrigated crops to be grown successfully. Tile drainage, where practicable, offers prospects for reclamation of the saline phases of both Murrawee sandy loam and Tatchera sandy loam.

(b) Heavy-textured grey and brown soils overlying slightly and moderately calcareous, clay subsoils:

BOGA CLAY LOAM.
MERAN SANDY CLAY LOAM. DELLA CLAY.
TYPE 8.

The subsoils of Group VII soils are inherently saline and heavy-textured, and drain slowly, consequently the soils require very careful irrigation to avoid surface salting.

### *Group VI*

Soils generally not recommended for irrigation because of elevation above gravity supply level, liability to intermittent flooding, or high salinity.

Brown loams overlying heavy clays on lunettes; grey clays in low areas:

LUNETTE SOILS.
SALINE FLATS.
SWAMPS.
WATERCOURSES.

## SOIL FEATURES IN RELATION TO 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. In later sections, particularly, "Description of Soil Types and Miscellaneous Units", reference is made to particular attributes of the various soil types which are likely to have agricultural significance. In the present section, certain features of the main soil types are considered in relation to irrigation management and problems associated with irrigation generally. The principal soil problems in the district arise from salinity, watertables, high and low soil permeability, alkalinity and calcareousness. These are often interrelated.

### *Soil Permeability*

The permeability of the soil determines to a large degree the crops that can be grown successfully under irrigation. High infiltration rates favour deep-rooting crops such as fruit trees, but may lead to watertables, with consequent danger of waterlogging and salinity in the rootzone. On the other hand, low infiltration rates tend to limit agriculture to shallow-rooting plants such as the pasture species. Moisture stress in the hot weather and surface waterlogging in wet periods are the principal consequences of poor permeability.

All of the soil types and other mapping units at present used for horticulture, except possibly Nyah clay loam, Type 6 and Unit K, are sufficiently permeable to enable adequate wetting of the rootzone to be achieved using normal irrigation methods. Nevertheless, it may be difficult to obtain adequate penetration of water on some slopes of Vinifera sandy clay loam, Tatchera sandy loam shallow phase, and Type 7. It should be appreciated that infiltration is dependent on slope, irrigation lay-out, and rate of application of water, in addition to the permeability of the soil profile. Where it is difficult to obtain sufficient penetration of irrigation water, multi-furrow, or flood irrigation and low flow rates will give the best results.

Excessive permeability is a problem on Tyntynder sand and, to a lesser extent, on Murrawee sand. Deep penetration of water is difficult to control in these soils using furrow irrigation methods, and careful attention to layout and flow rates is necessary. Spray irrigation allows better control of water and should be used on Tyntynder and Murrawee sands wherever practicable.

Layers less permeable than the surface and immediate subsoil occur at variable depths beneath the soils on the mallee dune, mallee plain, and part of the black box woodland landscapes (see "Landscape Units and Guide to Soil Types"). The less permeable layers appear to impede the downward movement of water and, where the soils are irrigated, watertables commonly develop in the region above these layers, unless the soils are tile-drained. The soil types subject to such watertables are Tyntynder sand, Murrawee sand, Murrawee sandy loam, Tresco sandy loam and Tatchera sandy loam, mainly occurring in the horticultural settlements of Nyah, Tresco, Kangaroo Lake and Long Lake, and Kunat sandy clay loam and Boga clay loam found at Tresco and in the Mystic Park Irrigation Area. Units Q G, H, K, L, and N in the Swan Hill Irrigation Area also have impeding layers in the deep subsoil and drainage problems have occurred in these soil units in the adjoining Woorinen Settlement.

In the heavy-textured soils (Swan Hill, Speewa, Donnington, Lake Baker, Fish Point and Della clays), structural development and cracking are such that entry of water is usually adequate for the pastures which are commonly grown on these soils. However, the clays swell when wetted, and this reduces the rate of water intake such that penetration is sometimes unsatisfactory, particularly in the case of Speewa clay on which it is difficult to obtain absorption of much more than one inch of irrigation water in some situations. Nevertheless, on the Swan Hill Flats generally, irrigation water has penetrated to the light-textured layers occurring beneath Swan Hill clay and Speewa clay, with consequent formation of watertables.

Two minor soil types, Meran sandy clay loam and Type 8, appear to have low infiltration characteristics due to dense clay subsoils close to the surface.

### *Soil Salinity*

Where the rainfall is light, as in the Swan Hill district, variable amounts of soluble salts have accumulated in the soil. This accumulation which has occurred under natural conditions in the past is due, firstly, to the original parent materials which contained a certain amount of salts and, secondly, to the rain which brings in further quantities in spray from the sea. The principal salt is sodium chloride and it is estimated by Hutton and Leslie (1958) that the rainfall is responsible for bringing into Mallee areas about 10 lb of sodium chloride per acre each year. As the rainfall is insufficient to wash the salt entirely from the soil profile, more or less salt over the ages has accumulated in the subsoils at depths depending on the permeability of the soils. The highest concentrations have occurred in the heavy-textured soils, except where these have been subjected to recurrent flooding from the Murray River.

It is important to recognize that the natural distribution of salt is such that appreciable amounts may occur at variable depths in the layers beneath practically all of the soils in the area, and that some movement of salt is inevitable under irrigation. In fact, the first effect of irrigation has been to wash salt further downward, where it has been present close to the surface. Unfortunately, however, there are many situations, both in the horticultural settlements and in the areas given to irrigated pastures, where harmful amounts of salt have been brought into the rootzone with moisture rising upward under the influence of evaporation. Where high watertables have developed, such salting has been most severe. The salinity situation in various parts of the district is considered later in this section.

## Salt Survey

The salt status[*] of the soils has been investigated in some detail. Soil samples taken from both the topsoil and the subsoil were analysed from approximately 4,300 sites distributed over the whole surveyed area. In the horticultural settlements, the depths sampled were 1-2 feet (topsoil) and 3-4 feet (subsoil); elsewhere the depths were 0-1 foot (topsoil) and 2-3 feet (subsoil). Whereas the salt content of the topsoil is a guide to salted areas and to the immediate salt risk to crops, the salt level in the subsoil indicates a potential hazard, both in dryland soils should they be irrigated, and in irrigated soils should watertables develop.

## Salt Map

The pattern of salt distribution in the soils of the district as disclosed by the salt survey referred to, is shown on the Salt Map in the envelope at the back of this bulletin. The map is not detailed enough to show the salt status of individual holdings, consequently landholders requiring information about salinity on their properties should contact an advisory officer of the Department of Agriculture.

The Salt Map shows very clearly that throughout the surveyed area moderate to very high amounts of salt are present in the great majority of the subsoils below 2 feet (blue, green purple and red areas on the Salt Map). There is a potential risk of salt injury to crops developing in these situations, if it has not occurred already. Considerable areas, in fact, are indicated on the Salt Map where salt in the topsoil is at levels detrimental to irrigated crops (green, purple and red areas).

Situations with soils containing less than 0.10 per cent salt (yellow on the Salt Map) are generally free from salt problems at present, but the area shown in this category includes considerable land not under irrigation agriculture.

The salinity situation in the individual irrigation settlements is indicated below.

***Tresco Irrigation District.-***Salting has been particularly severe on the lower slopes of the mallee dunes and on the adjoining mallee plains. The salt-affected soil types are Tatchera sandy loam, saline phase (354 acres), Boga clay loam (908 acres), Murrawee sandy loam, saline phase (159 acres), and Kunat sandy clay loam (116 acres), comprising an estimated 1,537 acres (including roads and easements) of mainly very highly saline soils containing more than 0.5 per cent sodium chloride in the soil profile. Some, although not all, of this salted land was originally under horticulture.

***Nyah Irrigation District.-***Although considerable areas of the heavier low-lying soils have gone out of horticultural production, and the decline of the vines has been attributed mainly to salt and alkalinity (Anon. 1955), the salt status of the soils in the Nyah Settlement at the present time is generally satisfactory. The soils have low salt contents of less than 0.10 per cent., except for a few moderately saline areas of Nyah clay loam, Vinifera sandy clay loam and Tatchera sandy loam.

The salinity of the subsoils of unirrigated of Swan Hill known as the Swan Hill or land to the north of the Nyah Settlement is Tyntynder Flats. The decline has been low, except for an extensive flat of Vinifera attributed to salt, consequently considerable sandy clay loam and adjoining slopes of importance attaches to the present salt survey, Tatchera sandy loam, where salt contents are since, not only does it allow an accurate either moderate or high.

***Kangaroo Lake and Long Lake Settlements***.-The salt status of the soils in both of these against which future trends in salinity on the settlements is generally low. Flats can be assessed. The detailed information is not presented here. The situation as found.

***Swan Hill Irrigation Area.-***Attention has been focused on the declining productivity of the predominantly dairying area to the north of Swan Hill known as the Swan Hill or Tyntynder Flats. The decline has been attributed to salt, consequently considerable importance attaches tot he present salt survey, evaluation of the degree to which salting has occurred already,

[*] In this report the salinity of the soil (per cent. sodium chloride) is described arbitrarily as follows: Low-under 0.10 per cent.; slight-0-10-0-15 per cent.; moderate-0.16-0.30 per cent.; high-0.31-0.50 per cent.; very high-over 0.50 per cent. The degree of risk at any one of these salt levels varies with the soil type and with the salt tolerance of the crop grown.

but it provides a background against which future trends in salinity on the Flats can be assessed. The detailed information is not presented here. The situation as found in 1962 is summarized in Table 2, while the broad picture can be envisaged from the Salt Map with this bulletin.

### *Table 2 – Soil Salinity on the Swan Hill Flats, 1962*

| Colour on Salt Map | Sodium Chloride in | | Present Effect on Pastures | Risk of Salinity Increasing in Surface | Area |
|---|---|---|---|---|---|
| | Surface (0-1 ft) % | Subsoil (3-4 ft) % | | | Acres |
| Yellow, part Blue | Below 0.10 | Below 0.15 | None | Low | 3,780 |
| Blue | Below 0.10 | 0.15-0.30 | None | High | 1,970 |
| Blue | 0.10-0.15 | 0.10-0.30 | Slight | High | 1,370 |
| Green | 0.15-0.30 | 0.15-0.30 | Appreciable | High | 3,560 |
| Purple | 0.30-0.50 | Above 0.30 | Pronounced | High | 1,650 |
| Red | Above 0.50 | Above 0.30 | Pronounced | High | 70 |

The salt data show that about 54 per cent of 12,400 acres of the Swan Hill Flats is salt affected in the surface soils to a degree varying from slightly to highly saline. The soil types are principally Swan Hill clay and Speewa clay. No visible deterioration of irrigated pastures may be apparent in the slightly saline soils (1,370 acres), but some reduction in plant performance is probable, and it is concluded that agricultural production has been affected by soil salinity over about 6,700 acres in all. A further 16 per cent is not affected, but is in danger of becoming salted through salt rising from the subsoil below 3 feet. The remaining 30 per cent is sound with no immediate risk of salinity developing.

The Swan Hill Flats adjoin rising mallee dunes to the west of the Murray Valley Highway. Here the soils on the upper slopes are low in salt, but situations on the lower slopes, mainly Tatchera sandy loam, shallow phase, and on adjoining low land of Units L and N, are often highly saline. Unit K in this area is often moderately saline in the deep subsoil.

There is very little surface salting in the irrigated area between Swan Hill and Lake Boga, although there is a potential hazard, since moderate amounts of salt are present in most of the subsoils. The soil types concerned are principally Donnington clay, Speewa clay, Lake Baker clay and Unit L.

***Fish Point Irrigation Area.***- About one third of the irrigated pasture land in the Fish Point Irrigation Area is salt affected. The saline soils comprise the occurrences of Donnington clay and Swan Hill clay furthest from the Little Murray River. Nearer the river, there is little surface salting, although all of the subsoils are moderately saline and the risk of salinity developing is present.

Mystic Park Irrigation Area.- This irrigation area presents a picture of extensive soil salinity in both its irrigated and unirrigated parts. More than 80 per cent is either highly saline or potentially saline. Della clay and Boga clay loam are highly saline in all but a few situations. Other saline soils which add tot he salt-affected area are the saline phase of Tatchera sandy loam and Murrawee sandy loam, Meran sandy clay loam, Kunat sandy clay loam and Type 8. Mallee dune soils of the Murrawee and Tatchera series dominate the western fringe of the area and these soils on the whole have low salt contents to a depth of 4 feet.

Careful irrigation management has enabled subterranean clover-Wimmera rye grass pastures to be established on some of these saline soils. In particular, the reclaimed areas of Della clay stand out in striking contrast to adjoining halophytic wastelands between the Murray Valley Highway and Lake Tutchewop.

It is very evident that soil salinity is the major problem of the irrigation settlements covered by the present soil survey. The irrigated pastoral areas from Mystic Park to Tyntynder are on heavy-textured soils, all of which have a potential salt hazard and are not readily leached of salt. Salting has occurred extensively also in the horticultural settlements on the medium and heavy textured soils, but most of the soils remaining under fruit trees and vines respond to tile drainage and can be protected against rising salinity.

## *Watertables And Drainage.*

The occurrence of ground water is an almost inevitable consequence of irrigation settlement. Surplus irrigation water entering the soil, and sometimes seepage from channels, ultimately reach the district watertable causing it to rise towards the surface. Where slowly permeable layers are present in the deeper subsoil, a perched watertable may form on these. Whilst rise in the district watertable can usually be attributed to community irrigation, perched watertables can be either of district or local origin. In either case, the rate at which the watertable rises will depend largely on the permeability characteristics and arrangement of the soil layers. Crop performance will be affected if salt is present in the soil and the watertable rises into, or close to, the rootzone. Measures to prevent this rise by giving attention to irrigation practices on the farm, lining of channels, and installation of drainage structures are, therefore, an essential part of design and practice in most irrigation settlements. They are particularly important in the present area where soil salinity is so widespread.

## *Irrigation Practices*

Landholders can assist in preventing the rise of watertables by using water efficiently. This means wetting the soil only to the lower limit of the rootzone and avoiding excessive and wasteful applications of water. Even wetting of the soil can only be achieved by giving careful consideration to the length of irrigation runs, flow rates, grading, and the provision of drainage facilities inside farms to take surplus water to the district drains.

The soil types under irrigated pastures are reasonably uniform and, if well graded, can be watered efficiently provided runs are not longer than six chains for perennial, and eight to ten chains for annual, pastures. It is emphasised that, whilst district provision for surface drainage is an essential step towards control of soil salinity, this alone is not sufficient to effect reclamation of salted areas such as occur on the Swan Hill Flats. Landholders must give attention to the aspects mentioned above for success. Further, watertables need to be lowered and this will not be easy in the heavy-textured soils under pasture. The fact that these soils crack deeply and allow water to penetrate to deep layers adds to the likelihood of watertables developing, besides making the control of soil wetting in the rootzone difficult.

In the horticultural areas, the soils pass from permeable soil types in the upslope positions to more clayey and less permeable soils downslope. Furthermore, a relatively impermeable layer in the deep subsoil becomes shallower downslope. Consequently, upslope soil types such as Tyntynder sand and Murrawee sand are potential and probable contributors to watertables further downslope in soil types such as Murrawee sandy loam and Tatchera sandy loam. Wherever possible, irrigation layout should be designed to avoid irrigating dissimilar soils in the same irrigation row. If this is not practicable, flow rates need to be sufficiently high to enable rapid irrigation of the whole row.

## *Tile Drainage*

The prevalence of perched watertables in the soils of the horticultural areas has led to drainage schemes at Nyah and Tresco designed to allow internal tile drainage of the horticultural blocks. Experience in these settlements and in the nearby Woorinen Settlement has shown that the light and medium textured soils on the mallee dunes respond readily to tile drainage, but that the drainage reaction of associated heavier soils on mallee plain and blackbox woodland landscapes is poor or uncertain. These heavier soils of questionable drainage reaction are Vinifera sandy clay loam and Nyah clay loam at Nyah, Kunat sandy clay loam and Boga clay loam at Tresco, and Units G, K, L and N in the Swan Hill Irrigation Area.

Where salinity is not a problem, tile drainage is unnecessary and some horticultural crops can be grown successfully on non-saline situations of the heavier soils. This is being done with vines and, to a lesser extent, with apricots on Vinifera sandy clay loam at Nyah. Vines are also being grown on Units G, K, and L at Woorinen, and peaches and apples on Unit L. However, it is emphasised that there are risks with horticultural plantings on any soils which have poor or uncertain internal drainage of the soil profile. Nyah clay loam and Unit N are not recommended for horticulture for this reason.

It is possible to give some guidance in regard to the appropriate depth and spacing of tile drains in the common soil types of the horticultural areas (Table 3). However, it is emphasised that depths and spacings will be controlled also by the length of runs and the outfall available in addition to soil characteristics. Moreover, each specific site to be drained needs to be examined for soil variability.*

* A drainage planning service is available to irrigators on request to the Horticultural Adviser, Department of Agricuture, or the District Engineer, State Rivers and water Supply Commission, Swan Hill

*Table 3. - Depth and Spacing of Tile Drains, Horticultural Settlements.*

| Soil Type or Unit | Depth of Drains ft | Spacing of Drains ft |
|---|---|---|
| Tyntynder sand | 6 | 88-132 |
| Murrawee sand | 6 | 88 |
| Murrawee sand - Shallow phase | 5-6 | 88 |
| Murrawee sandy loam | 5-6 | 88 |
| Murrawee sandy loam - | | |
| Shallow phase | 4-5 | 44 |
| Saline phase | 4-5 | 22-44 |
| Tresco sandy loam | 5-6 | 88 |
| Tresco sandy loam - Shallow phase | 4-5 | 44 |
| Tatchera sandy loam | 4-5 | 44 |
| Tatchera sandy loam - | | |
| Shallow phase | 3½-4 | 44 |
| Deep phase | 5-6 | 88 |
| Saline phase | 3½-4 | 22-44 |
| Vinifera sandy clay loam | 3½-4 | 44 |
| Kunat sandy clay loam | 4-5 | 44 |
| Boga clay loam | 3½-4 | 22-44 |
| Unit G | 3½ | 44 |
| Unit H | 4½ | 44 |
| Unit K | 3½ | 44 |
| Unit L | 3½ | 44 |

Spacings of 88 feet for 5½ feet and deeper drains, and 44 feet for shallower drains have been found to be generally satisfactory for protective drainage of vines in the Swan Hill district. Such spacings readily allow the installation of drains in intermediate rows at appropriate distances should drainage reaction indicate that closer spacing is necessary. For example, areas which need to be reclaimed from salt damage require closer spacings and, in such cases, spacings of 44 feet or 22 feet instead of the normal 88 and 44 feet may be required initially.

The depths at which tiles should be laid may be based on recognition of a restricting layer where this occurs within 6 feet of the surface. The setting of the drains into the layer is considered desirable, particularly when it is shallow, as this gives added depth and, in any case, the less permeable layer can seldom be regarded as completely impermeable. Drainage possibilities are regarded as poor where drains are set at depths of less than 4 feet, and the presence of apparently restricting layers at less than 3 feet in Tatchera sandy loam, shallow and saline phases, Vinifera sandy clay loam, Nyah clay loam, Boga clay loam, and Units G, K, L and N makes the drainage reaction of these soils uncertain.

Subsoil drainage in the horticultural areas is based mainly on district experience, and few measurements have been made of the hydraulic conductivity of the various soil layers. Such data are needed to provide a sounder basis for drainage advice. Recently, the State Rivers and Water Supply Commission has become active in this field and, with further knowledge of the drainage properties of different soil layers, the agricultural potential of soil types considered doubtful for horticulture or in need of reclamation from salt (see Table 1) will become better known.

Although salting of irrigated pastures in the Swan Hill district is associated with rise in the ground water, alleviation by tile drainage has not been entertained as an economic proposition for pastures. In any case, tile drainage has been considered impracticable since the soil types concerned, principally Swan Hill, Speewa, Donnington, Fish Point and Della clays appear to be too heavy textured to drain satisfactorily. However, measurements of hydraulic conductivity by Bridley (personal communication) suggest that Swan Hill clay, at least, has some drainage potential, and studies which should indicate the feasibility of economically tile-draining this soil type for pastures are in progress on the Swan Hill Research Farm.

*Pumping from Aquifers*

Whilst the present soil survey has not been concerned with the, nature of the layers below 7 feet, deeper bores on the Swan Hill Flats have demonstrated the presence of underlying sands. The possibility of lowering the district watertable, and so reducing soil salinity, by pumping from these deep aquifers has received some attention on the Swan Hill Research Station, but the results have not been promising in that locality. Nevertheless, it is likely that sands also underlie other parts of the Swan Hill district and further investigations are warranted. Requirements for success are, (i) the sands underlying the salt-affected areas must be sufficiently coarse-textured to yield a reasonable flow of water on continuous pumping, (ii) the hydraulic conductivity of the overlying strata must be sufficiently high to allow downward drainage, and (iii) drainage facilities must be available for disposal of the pumped saline water without detriment to the irrigation supply system.

## *Lime-Induced Chlorosis.*

Fruit trees are susceptible to lime-induced chlorosis to varying degrees, but vines are very much more resistant. The condition is manifest by pronounced yellowing of the leaves, leading to defoliation in severe cases. The effect of lime (calcium carbonate) in the soil, in some circumstances, is to cause malnutrition of the tree, by preventing the movement of iron, either from the soil of within the tree, such that formation or the green chlorophyll necessary for photosynthesis is inhibited.

All of the soil types in the horticultural settlements contain more or less lime, and the chlorosis hazard is high for very susceptible trees such as citrus and peaches. Tyntynder sand is the least, and Tatchera sandy loam the most, calcareous soil type. The former has small amounts of lime below 3 feet, whereas the latter may be highly calcareous from the surface. Murrawee sand, Murrawee sandy loam, and Tresco sandy loam are intermediate, with moderately calcareous horizons commencing between 18 and 36 inches in the first soil type and between 16 and 24 inches in the last two soil types. Vinifera sandy clay loam, Kunat sandy clay loam and Boga clay loam are somewhat less calcareous while the main lime horizon commences at about 14 inches in these types.

The depth of soil containing little or no lime above the main lime horizon, and. the rooting habits of the fruit trees grown are important factors determining chlorosis. Observations suggest that the desirable minimum depths of essentially, lime-free soil for the principal fruit trees grown in the district are as follows:

| | |
|---|---|
| Citrus | 30 inches |
| Peaches | 24 inches |
| Apples | 20 inches |
| Apricots | 18 inches |
| Pears | 18 inches |
| Plums | 18 inches |

The relationship between chlorosis and lime, however, is not simple, nor is it clearly understood. Water relationships are involved. Trees in freely draining soils appear to tolerate lime in some circumstances. On the other hand, waterlogging of calcareous soils certainly is conducive to chlorosis. Salinity may also play a part as also may soil texture. Calcareousness in heavy-textured soils seems to be less hazardous than in light-textured soils. Also, the form and distribution of the lime in the soil may be concerned. For these reasons, the above depths may not always be critical.

## *Chemical Fertility Aspects.*

Fertilizers containing phosphorus, nitrogen and potassium are commonly used in the area on citrus, deciduous fruit trees and vegetables. Only superphosphate is used on pastures and on vines, but this is to assist with the cover crop in the latter case. The need for phosphorus and nitrogen has been well substantiated by field experimentation, but the Benefit to be derived from application of potassium fertilizer is less certain. The analytical data show that the soils, except Tyntynder sand and Murrawee sand, have good potassium reserves in both the surface and the subsoil horizons. It is unlikely under these circumstances that benefits would derive from potash on the majority of the soils. In the case of Tyntynder sand and Murrawee sand, however, low levels of soil potassium may occur and potash possibly would benefit citrus, deciduous fruit trees, and vegetables grown on these soil types.

Calcium and magnesium are normally at satisfactory levels. Under these circumstances, no benefit can be expected from using lime, dolomite, or other magnesium-containing materials on either horticultural crops or pastures. However, should sulphate of ammonia be used consistently, as in horticulture and vegetable-growing, very sandy soils may become sufficiently acid to warrant liming to counter the soil acidity produced. Soil tests* are useful to indicate whether liming is warranted in such cases.

Of the trace elements, zinc is the most important deficiency. The soils of the mallee dunes are low in zinc, and it is usual to spray with zinc compounds to correct zinc deficiency in citrus, vines and deciduous fruit trees grown on these soils. Zinc has not been found necessary for vegetables or pastures grown in the area. Occasionally, molybdenum deficiency occurs in watermelons and rock melons, but this condition is not widespread. The deficiency can be corrected with molybdenum sprays. Boron injury to citrus from excessive amounts of boron in the soil has been recorded in the Swan Hill district (Penman and McAlpine 1949). The condition has occurred mainly on soils with impeded drainage, and provided citrus are planted on deep, free-draining soils, boron poisoning is unlikely to be a problem in the area. There is no evidence of copper deficiency in horticultural crops, or that levels of copper in pastures are insufficient to maintain stock in good health.

Iron deficiency induced by the high alkalinity associated with calcareous soils leads to chlorosis in susceptible horticultural crops. This has been referred to earlier. There is no economic treatment for the condition and susceptible crops should not be planted on soils which are calcareous in the rootzone.

High amounts of exchangeable sodium occur in the subsoils of nearly all of the soil types. Where this is associated with calcareousness, as in the soil types of the mallee dunes and plains, the subsoils do not become dispersed when leached of salts and their drainage is not impaired.

The surface soils of Boga clay loam, Della clay, and the saline phases of Murrawee sandy loam and Tatchera sandy loam contain appreciable exchangeable sodium. When reclamation of these soils is attempted, dispersion of the clay occurs in the surface and the permeability of the soil may be greatly reduced. However, if gypsum is incorporated in the surface, dispersion is prevented and leaching can proceed.

## DESCRIPTION OF SOIL TYPES AND MISCELLACEOUS UNITS

In this section, all of the soil types and other mapping units shown on the ten soil map sheets with this bulletin are described in regard to their 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.

Six landscape patterns, each with its own distinctive topography and vegetation, can be recognized in the area. These have been designated landscape units and are indicated by italics in ensuing parts of this section. Each soil type occupies a definite place in the landscape pattern, consequently positional relationships occur between the soil types in each landscape unit. These aspects are dealt with in the section, "Landscape Units and Guide to Soil Types" which is also a help to the identification of the soil types in the field.

Sixteen named soil types have been recorded in the surveyed area. Several of these have one or more phases and variants. A further eight soil types of minor extent have not been named, while six units described by Churchward (1960) at Woorinen have been mapped elsewhere in the Swan Hill Irrigation Area. In all, 43 units have been used in the mapping of the soils; these are listed in Table 1 and described in this section.

The names given to five of the soil series have been used before in the early soil surveys of the Woorinen Settlement (Taylor and Penman 1930), and the Nyah, Tresco and Kangaroo Lake Settlements (Taylor et al. 1933). These settlements have all been re-surveyed, Woorinen by Churchward (1960), and the others in the present soil survey. It should be remembered that the new soil types are not identical with the original types of the same name, although they are similar. The relationships between the mapping units of the various soil surveys are described in a later section, "Soil Relationships".

### *Boga Clay Loam*

*Surface soil-*

A 0 to 6 inches; grey-brown (7.5-IOYR 3/2)* clay loam or sandy clay loam; powdery dry, sticky wet; clear transition to:

*Subsoil-*

$B_1$ 6 to 14 inches; yellowish grey-brown (10YR 4/3) medium clay; weak medium angular blocky structure; with or without slight calcium carbonate; gradual transition to:

$B_{L1}$ 14 to 30 inches; similar with light to moderate soft calcium carbonate and concretions; gradual transition to:

$B_{L2}$ 30 to 66 inches; mottled yellowish grey and brown medium clay; light to moderate soft calcium carbonate and concretions; gradual transition to:

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

66 to 84 inches; mottled brown, red-brown and yellow-grey dense heavy clay; slight calcium carbonate decreasing with depth.

***Variant.-***The inscription deep surface on the soil maps denotes soils which have more than 12 inches of surface soil.

***Occurrence.-*** Boga clay loam is a grey saline soil type occupying broad, shallow depressions and low plain in the mallee plain landscape unit which occurs extensively in the western parts of the Tresco and Mystic Park areas. The original vegetation was predominantly mallee with black box a minor component.

***Land U*se.-**In the Tresco Irrigation District, large areas of Boga clay loam support little more than halophytic species and generally the soils are too saline to allow establishment of good pastures. However, there are situations in the Mystic Park Irrigation Area where annual irrigated pastures might be attempted, provided careful attention is given to layout, watering methods, and surface drainage. There is no experience with tile drainage in Boga clay loam, but its rather high clay content and alkalinity due to sodium suggest that it would be difficult to drain.

## *Della Clay*

*Surface soil-*

A — 0 to 8 inches; brownish grey (2.5Y 4/2) cracking heavy clay; weak to moderate medium subangular blocky structure; very hard dry, moderately sticky moist; at 4 to 12 inches clear transition to:

*Subsoil-*

B — 8 to 24 inches; yellowish grey (5Y 5/2) heavy clay; weak medium subangular blocky; very hard dry, moderately sticky moist; slight soft calcium carbonate and fine concretions, gradual transition to:

C — 24 to 84 inches; yellowish grey, or yellowish grey brown, occasionally passing to brown, heavy clay; calcium carbonate usually present; occasionally traces of gypsum.

***Variant.-***The inscription sandy loam surface on the soil map refers to areas with about 4 inches of wind blown sandy loam on the surface.

***Occurrence.-***Della clay is the soil type of the almost level plains of the black box woodland landscape unit which occurs extensively in the Mystic Park irrigation area.

**Land Use.-**Most areas of Della clay are either saline, or potentially saline, and appropriate reclamation measures, including attention to the control of irrigation water, are required to establish satisfactory pastures. Only annual pastures should be attempted.

A large part of Della clay has been retained as State Forest, and is timbered with black box.

## *Donnington Clay*

*Surface soil-*

A — 0 to 8 inches; dark brownish grey (10YR 3/1) cracking medium clay; moderate coarse angular blocky structure; very hard dry, moderately sticky moist; clear transition to:

*Subsoil–*

B — 8 to 24 inches, yellow grey (5Y 5/3); weakly mottled with dark grey and rusty brown; heavy clay; very hard dry; moderately sticky moist; with or without slight soft calcium carbonate from about 15 inches; gradual transition to:

C — 24 to 84 inches; brownish grey (2.5Y 5/2), often mottled with pale shades of brown, heavy clay; slight calcium carbonate and/or gypsum irregularly present.

***Variants.-*** Variations in surface texture are noted on the soil map by appropriate inscriptions. A *deep sandy clay surface* variant has more than 14 inches of surface. The inscription bright sub-soil denotes soils possessing a dominantly brown clay deep subsoil which is generally calcareous.

***Occurrence*.-** Donnington clay is a component of the *river flat landscape* unit and is the dominant soil type on the flats between Swan Hill and Fish Point. It occurs to a much smaller extent on the river flats to the north of Swan Hill. Donnington clay probably carried no tree cover originally, apart from scattered box adjoining the mallee landscape.

***Land Use.-*** Donnington clay supports fair to good irrigated pastures. The soil profile is heavy-textured, but cracking assists water penetration. Salting has occurred on a few situations of Donnington clay in the Fish Point Irrigation Area, but generally the surface soils have low salt contents. However, there is risk of salt rising from the subsoils which are usually moderately saline, and careful attention to irrigation practices is necessary to prevent this.

## *Fish Point Clay*

*Surface Soil-*

A — 0 to 10 inches; brownish grey (2.5Y 4/2) cracking medium clay; moderate coarse angular blocky structure; hard dry, moderately sticky moist; at 8 to 14 inches sharp transition to:

*Subsoil-*

$B_1$ — 10 to 20 inches; brown (7.5YR 4/4), mottled with grey, heavy clay; moderate coarse angular blocky structure; hard dry, moderately sticky moist; gradual transition to:

$B_L$ — 20 to 30 inches; greyish brown heavy clay; usually light amounts of calcium carbonate and/or gypsum; gradual transition to:

C — 30 to 48 inches; pale yellowish grey, diffusely mottled with brown, medium clay; light or moderate calcium carbonate.

***Occurrence and Land Use***.-Fish Point clay is a soil type of small extent found on the slightly higher parts of the river flat landscape unit in the Fish Point Irrigation Area. It can support fair to good irrigated pastures, but is liable to salting and careful attention to irrigation practices and drainage are necessary. Like Donnington clay, the soil profile is heavy-textured and water entry is assisted by cracking.

## *Kunat Sandy Clay Loam*

*Surface soil-*

A — 0 to 6 inches; dull brown (7.5YR 3/4) sandy clay loam; structureless; hard dry, slightly friable moist; sharp transition to:

*Subsoil-*

$B_1$ — 6 to 14 inches; greyish brown (10YR 5/4) medium clay, weak medium subangular blocky structure; hard and brittle dry, moderately sticky moist; gradual transition to:

$B_L$ — 14 to 40 inches yellowish brown (10YR 5/5) light clay; light to moderate soft calcium carbonate and concretions; gradual transition to:

C — 40 to 66 inches; brown, mottled with yellow-grey, medium clay; light to moderate soft calcium carbonate and concretions, clear transition to:

66 to 84 inches; strongly mottled brown, yellow-brown and yellow-grey dense medium clay; moderate small angular blocky structure; black flecks on ped faces, light calcium carbonate decreasing to none with depth.

***Occurrence***.-Kunat sandy clay loam occurs extensively on the slightly higher parts of the mallee plain landscape unit in the Mystic Park and Tresco areas. The original vegetation was principally mallee.

**Land Use.-**Most of the Kunat sandy clay loam is not irrigated and supports wheat-growing and the grazing of sheep on volunteer pastures.

The subsoils are moderately to highly saline and there is considerable risk of the surface becoming salt-affected should Kunat sandy clay loam be irrigated. Nevertheless, annual pastures could be grown successfully with careful attention to irrigation practices. There would be greater risk with permanent pastures and lucerne, because of the likelihood of watertables developing, and the suitability of individual situations would need to be assessed before contemplating either of these crops.

It is unlikely that Kunat sandy clay loam would be considered for vines, except possibly in localized areas. Protection by tile drainage against rising salinity would be necessary, but the effectiveness of such drainage in Kunat sandy clay loam is unknown at present. The outlook for effective tile drainage is not promising, however, because of the moderately high clay content of the subsoils.

### *Lake Baker Clay.*

*Surface soil-*

A — 0 to 8 inches; dark grey (N 3/0) medium clay; strong crumb structure; friable; clear transition to:

*Subsoil-*

B — 8 to 15 inches; dark grey (N 3/0) heavy clay; moderate medium angular blocky structure; gradual transition to:

C — 15 to 30 inches; yellowish grey (5Y 5/1) with dark grey, heavy clay; gradual transition to:

30 to 84 inches; yellowish grey (5Y 5/1) heavy clay; slight amounts of small calcium carbonate concentrations usually present.

***Occurrence***.-This is a minor soil type occupying the drained bed of Lake Baker and a smaller unnamed lake east of Lake Boga.

***Land Use.***-The subsoils are moderately saline and salting has occurred in places. However, the surface soil has a particularly good structure due to a high organic matter content, and, where salting is not a problem, good irrigated annual and perennial pastures and summer fodder crops can be grown. There may also be possibilities for vegetables, vines and fruit trees, but there is no experience with these crops and there could be drainage problems.

### *Meran Sandy Clay Loam.*

*Surface soil-*

A — 0 to 3 inches; brown (M 4/4) sandy clay loam; structureless; brittle dry; slightly friable moist; surface often badly eroded and at variable depths sharp transition to:

*Subsoil-*

$B_1$ — 3 to 14 inches; dark reddish brown (5YR 4/3) heavy clay becoming paler and brighter in colour with depth; medium subangular blocky structure; hard dry, tough moist; gradual transition to:

$B_L$ — 14 to 20 inches; brownish yellow-grey medium clay; slight to light soft calcium carbonate and fine concretions; gypsum irregularly present; gradual transition to:

C — 20 to 48 inches; similar; slight gypsum usually present.

***Occurrence.***-This soil type occupies the slightly higher, better drained positions in the treeless plain landscape unit which is found in the southern part of the Mystic Park Irrigation Area. Meran sandy clay loam is widespread outside the surveyed area.

***Land Use***.-The dry-land agriculture practised on Meran sandy clay loam is cereal-farming and grazing of sheep on volunteer pastures. If irrigated, Meran sandy clay loam should support annual pastures, but, owing to its shallow surface and the poor permeability of its subsoil, Meran sandy clay loam is unattractive for perennial pastures.

### *Murrawee Sand*

*Surface soil-*

A — 0 to 18 inches; brown (5YR 4/4) sand; structureless; slightly coherent; at 12 to 24 inches sharp transition to:

*Subsoil-*

$B_1$ — 18 to 24 inches; reddish brown (2.SYR 4/6) sandy clay loam or sandy clay; weak medium angular blocky structure; slightly hard dry, friable moist; gradual transition to:

$B_L$ — 24 to 72 inches; brown sandy clay loam, occasionally sandy loam; variable amounts of soft, panned, and concretionary calcium carbonate; clear transition to:

C — 72 to 84 inches; red-brown, often mottled with yellow-grey, dense sandy clay.

***Variants.***-Inscriptions on the soil maps of shallow surface and deep surface denote soils which have, respectively, less than 12 inches and more than 24 inches of surface sand. The inscription eroded is used when much or all of the surface has been stripped off as a result of contemporary wind or water erosion.

***Occurrence.***-Murrawee sand occurs on the crests and eastern slopes of the mallee dune landscape unit and is found throughout the surveyed area.

***Land Use.***-Murrawee sand is capable of supporting a wide range of crops under irrigation. It is a reliable soil type for vines and apricots, although it has disabilities for citrus, peaches and apples. For example, it is rated as being only fair for citrus because of the variable incidence of lime in the subsoils and, consequently, the doubt about chlorosis developing. It is desirable for longevity in citrus that lime should not occur visibly in the rootzone. Soils with more, than 36 inches of soil above the layer containing visible lime are regarded as safe and capable of supporting good citrus. Such situations in the Murrawee sand soil type are most likely to be found in its deep surface variant. Normally, the depth to the main lime horizon is about 30 inches and this is about the minimum permissible depth for citrus plantings. Areas of Murrawee sand shown as shallow surface are unlikely to have this depth above the lime and should not be considered for citrus.

In the Goulburn Valley, peaches do well on deep sandy soils texturally similar to Murrawee sand, but, when grown in light-textured soils in the Swan Hill district, they are shy-bearing and subject to crown gall and nematodes. Apples also, when grown on light-textured soils, tend to be unsatisfactory, mainly because of their poor colour and quality. The reasons for the poor performance of peaches and apples on light-textured soils such as Murrawee sand are not clear.

The low capacity of the topsoil for storing moisture limits the usefulness of Murrawee sand for shallow-rooting crops. Pastures will be satisfactory only if watered frequently in summer. This applies also to vegetables, but lucerne should be less difficult because of its ability to exploit moisture reserves at depth.

Murrawee sand is highly permeable and preferably should be watered by spray irrigation methods. Even so watertables may develop; these can be controlled by tile drainage in most circumstances.

### *Shallow phase*

The shallow phase is distinguished from the normal phase of Murrawee sand by the occurrence of dense, red-brown sandy clay commencing between 4 and 6 feet from the surface instead of below 6 feet.

***Land Use.***-The shallow phase of Murrawee sand is not recommended for citrus because lime usually occurs within 30 inches of the surface. Otherwise it is suitable for the same crops as the normal phase, but tile drains may need to be placed slightly shallower in some situations.

## *Murrawee Sandy Loam*

*Surface soil-*

A — 0 to 6 inches; brown (5YR 3/3) sandy loam or sandy clay loam; weakly cemented dry, friable moist; at 4 to 10 inches sharp transition to:

*Subsoil-*

$B_1$ — 6 to 16 inches; reddish brown (2.5YR 4/6) sandy clay; weak medium angular blocky structure; hard dry, firm moist; gradual transition to:

$B_L$ — 16 to 60 inches; brown (5YR 4/4) with pockets of light brown (7.5YR 7/4), sandy clay; variable amounts of soft, panned, and concretionary calcium carbonate; at 48 to 72 inches gradual transition to:

60 to 84 inches; red-brown or brown, often mottled with yellow-grey, dense clay or sandy clay; little or no visible calcium carbonate.

***Occurrence.***-Murrawee sandy loam occurs throughout the area on the gentle slopes of the *mallee dune landscape unit*.

***Land Use.***-Except in the western part of the Mystic Park Irrigation Area, Murrawee sandy loam is mainly under vines and has proved very satisfactory for that crop. It is also regarded as a good soil for apricots and plums, but it is only fair for apples and pears. It is not recommended for citrus and peach tree plantings because of the incidence of lime in the rootzone and consequent danger of chlorosis developing in those fruit trees.

Murrawee sandy loam is suitable for cultivated crops, lucerne, and pastures. Furrow irrigation can be employed, but careful attention to watering practices is necessary to minimize excessive entry of water, since watertables develop readily. The soils respond to tile drainage and the installation of tile drains is desirable for the protection of horticultural plantings from rising watertables and salinity.

### *Shallow Phase*

In the shallow phase of Murrawee sandy loam, the dense red-brown sandy clay layer which normally appears between 4 and 6 feet commences between 3 and 4 feet.

***Land Use.-***The same irrigated crops can be grown as on the normal phase, but shallower and more closely spaced tile drains are required for satisfactory drainage of the shallow phase.

### *Saline Phase*

The surface and subsoil horizons of the saline phase of Murrawee sandy loam contain appreciable amounts of soluble salts, mainly sodium chloride; otherwise the profile is similar to that of the shallow phase.

***Occurrence and Land Use.-***The saline phase occurs only in the Tresco Irrigation District and the Mystic Park Irrigation Area. It is found in situations of Murrawee sandy loam where irrigation has been responsible for bringing salt to the surface. Vines have died where planted originally and, for the most part, the present vegetation consists of native halophytic species.

Irrigated annual pastures can be established provided careful attention is given to irrigation lay-out and watering methods. The subsoils are sufficiently permeable for tile drainage to be effective, and reclamation for vine-growing may be possible where tile drainage installations are practicable.

## *Nyah Clay Loam*

*Surface soil-*

A — 0 to 6 inches; grey-brown (10YR 4/2) clay loam or light clay; weak medium angular blocky structure; hard dry, sticky wet; with or without calcium carbonate; clear transition to:

*Subsoil-*

$B_L$ — 6 to 24 inches; yellowish grey-brown (7.5YR 5/3) light or medium clay; weak medium angular blocky structure; hard dry, tough moist; light soft calcium carbonate, occasionally light concretions; gradual transition to:

C — 24 to 48+ inches; grey-brown medium clay becoming brighter with depth; light calcium carbonate; gypsum irregularly present.

***Occurrence***.-Nyah clay loam occurs as a component of the black box woodland landscape unit in the Nyah Irrigation District. The original timber of black box has largely been removed.

***Land Use.-***Vines have declined on Nyah clay loam, reputedly because of salinity and poor response of the soils to tile drainage. Little now remains under vines and the soil type is not recommended for horticulture. However, cultivated crops and pasture may be grown successfully under irrigation.

## *Speewa Clay*

*Surface soil-*

A — 0 to 18 inches; grey (5Y 4/1) often with fine rusty mottling, cracking heavy clay; moderate coarse angular blocky structure; hard and brittle dry, tough and plastic moist; gradual transition to:

*Subsoil-*

B — 18 to 30 inches; grey (5Y 5/1) with rusty mottling heavy clay; hard dry, plastic moist; gradual transition to:

C — 30 to 48 inches; grey, often steely grey, with dull rusty mottling, heavy clay.

48 to 84 inches; as above, but light clay and fine sandy clay sometimes occur before 84 inches.

***Occurrence.-***Speewa clay generally occupies the lower parts and depressions on the river flat landscape unit. It is found widely over the Swan Hill Irrigation Area and occurs also in the Fish Point Irrigation Area.

***Land Use.-***Speewa clay supports good perennial and annual pastures where water penetration is satisfactory and surface drainage is efficient. However, in some situations infiltration of irrigation water is poor due to swelling of the clay when wetted. Also, much of the Speewa clay has become saline to varying degrees. These two factors have led to low productivity of pastures on many situations of Speewa clay.

Watertables are frequently present as in Swan Hill clay, and comments made in relation to these apply also to Speewa clay.

### *Swan Hill Clay*

*Surface soil-*

A — 0 to 10 inches; dark grey (5Y 3/1) cracking medium clay, occasionally light clay; moderate coarse angular blocky structure; hard dry, plastic moist; at 8 to 14 inches clear transition to:

*Subsoil-*

B — 10 to 26 inches; grey (2.5Y 5/2), weakly mottled with dark grey and rusty brown, medium clay; moderate medium angular blocky structure; hard dry, plastic moist; gradual transition to:

C — 26 to 48 inches; mottled light grey and yellow-brown light or medium clay, passing to light clay and occasionally to fine sandy clay; slight calcium carbonate irregularly present:

48 to 84 inches; mottled light grey and yellow-brown light clay or fine sandy clay generally becoming more fine sandy with depth.

***Variants.-***The inscription sandy profile on the soil map denotes soils containing obvious amounts of sand. Dull deep subsoil refers to soils which have a grey light clay in the deep subsoil.

***Occurrence***.- Swan Hill clay is the principal soil type of the river flat *landscape unit.* It occurs extensively in the Tyntynder area to the north of Swan Hill, but is found also on the flats adjoining the Little Murray River between Swan Hill and Fish Point.

***Land Use.-***Swan Hill clay is given almost wholly to irrigated perennial pastures devoted to dairying. It has earned a high reputation for its productive capacity in the past, both in regard to pastures and lucerne, but declining productivity due to rising soil salinity has become increasingly evident over the last 25 years or so. Pastures have degenerated and lucerne plantings on Swan Hill clay have almost entirely disappeared.

Watertables present problems in Swan Hill clay. At present, there are no known economic ways of lowering these, such as by tile drainage, and efforts must necessarily be directed towards preventing their further development. This is largely a matter for irrigators. Overwatering should be avoided and provision also should be made for the removal of surplus water from blocks into the district drainage scheme.

### *Tatchera Sandy Loam*

*Surface soil-*

A — 0 to 12 inches; dull brown to grey-brown (7.5-10YR 4/2) sandy loam or sandy clay loam; structureless; friable when moist; moderate calcium carbonate in the fine earth, light concretions; at 8 to 16 inches clear transition to:

*Subsoil-*

$B_L$ — 12 to 18 inches; yellowish brown (5YR 5/6) sandy clay loam; very weak medium subangular blocky structure; very friable dry, friable moist; moderate or heavy soft, panned, and concretionary calcium carbonate; gradual transition to:

$B_LC$ — 18 to 40 inches; brown (2.SYR 5/6) with light brown pockets, sandy clay loam or sandy clay; moderate soft, panned, and concretionary calcium carbonate; clear transition to:

40 to 84 inches; red-brown or brown, often mottled with yellow-grey dense clay or sandy clay; light calcium carbonate decreasing to none with depth..

***Variants.-***Inscriptions on the soil map denote sandy overlays, and gravel and sandstone where these occur in the deep subsoils.

In the Kangaroo Lake Settlement, the profile of Tatchera sandy loam is usually somewhat heavier than that described above, the surface often being clay loam and the subsoil light clay. A further difference is that much of the occurrence is underlain by sandy strata which may commence before 6 feet. This is denoted on the soil map by an inscription, with areas of light sub-strata.

***Occurrence.***-Tatchera sandy loam is the principal soil type of the *mallee dune landscape* unit and is found throughout the surveyed area from Nyah to Kangaroo Lake. It occurs extensively on the northern, western and southern slopes of the dunes. Tatchera sandy loam also occurs as a component of the mallee plain landscape unit in the Tresco and Mystic Park areas.

***Land Use***.-Tatchera sandy loam is easily the most widespread soil type under horticulture in the district. Vines are grown almost exclusively, since fruit trees usually develop chlorosis as a consequence of the high lime content of the soils. The subsoils are frequently saline and tile drainage is necessary to protect vines from salinity as watertables develop readily in Tatchera sandy loam. A dense layer commonly commences between 3 and 4 feet and this means that drains should not be set deeper than 5 feet and need to be located in every fourth row.

Cultivated crops, lucerne, and pastures can be grown successfully with normal care in irrigation methods. Subsoil salinity is the principal hazard and care should be taken to avoid overwatering leading to watertables.

## *Deep Phase*

In the deep phase of Tatchera sandy loam, the red-brown dense clay which normally commences between 3 and 4 feet occurs deeper than 4 feet.

***Occurrence and Land Use.***-The deep phase of Tatchera sandy loam is as common as the normal phase and occurs throughout the surveyed area on the mallee dune landscape unit except in the Kangaroo Lake Settlement.

The deep phase is more attractive for vines than the normal phase, because of the greater depth to the underlying dense clay. There is slightly less risk of waterlogging and drains can be set deeper and be more widely spaced.

## *Shallow Phase*

The layer of low permeability which commences between 3 and 4 feet in the normal phase appears between 2 and 3 feet in the shallow phase.

***Occurrence and Land Use.***-The shallow phase of Tatchera sandy loam occurs on the lower slopes of the mallee dune landscape unit. it is less extensive than the normal and deep phases, but substantial areas are present in the Nyah Irrigation District and the Swan Hill Irrigation Area.

The shallow phase is regarded as being only fair for vines because of its susceptibility to shallow watertables. Drains may need to be set at depths as shallow as 31 feet and at this depth the recommended spacing of 44 feet may not be fully effective.

## *Saline Phase*

The profile of the saline phase is similar to that of the shallow phase except that the former contains appreciable sodium chloride.

***Occurrence and Land Use.***-The saline phase of Tatchera sandy loam occurs in the Tresco Irrigation District and to a small extent in the Mystic Park Irrigation Area. At Tresco, irrigation has been responsible for bringing salt to the surface in some occurrences of Tatchera sandy loam and these areas comprise most of the saline phase recorded.

Vines have died out and for the most part the saline phase now carries native halophytic species. Reclamation for vine-growing will depend on the efficiency of tile drainage. The subsoils appear to be drainable, but spacings as close as 22 feet may be necessary for reclamation to be effective.

***Occurrence.***-This soil type occurs on the crests and upper eastern slopes of the mallee dune landscape unit. It is widespread but the total area is small.

**Land Use**.-Tyntynder sand is a deep, free-raining soil low in lime, and is the only soil type in the area regarded highly for citrus. Other fruit trees and vines are not so successful. Crops tend to be light and the quality poor while nematodes and crown gall are prevalent.

A disability of Tyntynder sand it its low water-holding capacity. This makes the soils unsuitable for shallow-rooting crops such as pastures unless they can be watered very frequently in summer. Deep-rooting crops such as lucerne should do reasonably well.

## TRESCO SANDY LOAM

*Surface soil-*

| | |
|---|---|
| $A_{11}$ | 0 to 6 inches; dull brown (5YR 4/4) sandy loam, occasionally loamy sand; slightly hard dry, friable moist; calcium carbonate in the fine earth irregularly present; gradual transition to: |
| $A_{12}$ | 6 to 24 inches; brown (5YR 4/6) sandy loam or sandy clay loam; slightly hard dry, friable moist; calcium carbonate in the fine earth; at 18 to 30 inches clear transition to: |

*Subsoil-*

| | |
|---|---|
| $B_L$ | 24 to 60 inches; brown (2.5-5YR 4/6) with p6ckets of pale brown, sandy clay loam or sandy clay; very weak medium subangular blocky structure; very friable dry, friable moist; moderate soft, panned, and concretionary calcium carbonate; clear transition to: |
| | 60 to 84 inches; red-brown, often mottled with yellow-grey, dense sandy clay; light calcium carbonate decreasing to none with depth. |

***Occurrence.***-Tresco sandy loam occurs on the middle and upper slopes of the mallee *dune* landscape unit and is found throughout the surveyed area.

***Land Use.***-Vines grow well on Tresco sandy loam. It is considered to be a good soil also for apricots and plums, but is only fair for apples and pears. Peaches are not recommended as they frequently are shybearing as well as being liable to chlorosis on soils of this character.

Although Tresco sandy loam is mainly given to horticulture, cultivated crops, lucerne, and pastures also can be grown satisfactorily on it under irrigation.

### *Shallow Phase*

In the shallow phase of Tresco sandy loam, the dense red-brown sandy clay which normally occurs below 4 feet from the surface, commences between 3 and 4 feet.

***Occurrence and Land Use***.-The shallow phase is of very small extent and occurs almost exclusively in the Nyah Irrigation District. It can he included with the normal phase in regard to its land use.

## *Tyntynder Sand*

*Surface soil-*

| | |
|---|---|
| $A_{11}$ | 0 to 10 inches; dull brown (5YR 5/4) sand; weakly coherent; gradual transition to: |
| $A_{12}$ | 10 to 40 inches; reddish brown (2.5YR 5/6) sand; incoherent; gradual transition to: |

*Subsoil-*

| | |
|---|---|
| $B_1$ | 40 to 50 inches; reddish brown (2.5YR5/6), often weakly mottled with yellow-grey, clayey sand or sandy clay loam; gradual transition to: |
| $B_L$ | 50 to 84 inches; reddish brown clayey sand or sandy loam; variable soft, panned, or concretionary calcium carbonate. |

***Occurrence.-*** This soil type occurs on the crests and upper eastern slopes of the *mallee dune landscape* unit. It is widespread but the total area is small

Land Use.- Tyntynder sand is a deep, free draining soil low in lime, and is the only soil type in the area regarded highly for citrus. Other fruit trees and vines are not so successful. Crops tend to be light and the quality poor while nematodes and crown gall are prevalent.

A disability of Tyntynder sand is its low water-holding capacity. This makes the soils unsuitable for shallow-rooting crops such as pastures unless they can be watered very frequently in summer. Deep-rooting crops such as lucerne should do reasonably well.

### *Vinifera Sandy Clay Loam*

*Surface soil-*

A — 0 to 6 inches; dull brown (5YR 4/4) sandy clay loam; weak medium angular blocky structure; brittle dry, friable moist; at 4 to 8 inches sharp transition to:

*Subsoil-*

$B_1$ — 6 to 14 inches; reddish brown (2.5YR 3/2) medium clay; moderate medium angular blocky structure; hard dry, tough moist; gradual transition to:

$B_L$ — 14 to 30 inches; brown or reddish brown (5YR 4/6) light clay or medium clay; light to moderate soft calcium carbonate in pockets, slight concretions; gradual transition to:

30 to 72 inches; reddish brown, dull brown, or grey-brown dense medium clay; light soft calcium carbonate decreasing with depth, with or without slight concretions; gypsum irregularly present.

***Variant.-***A grey surface variant shown by inscription on the soil map comprises brownish grey surface soils overlying normal reddish brown subsoils.

***Occurrence.-***Vinifera sandy clay loam is a component of the *black box woodland* and the mallee plain *landscape units*. Most occurrences originally carried black box, but the higher situations carried typical mallee, vegetation. Vinifera sandy clay loam has been recorded only in the Nyah Irrigation District.

**Land Use.-**Vinifera sandy clay loam is mainly under vines and supports fair crops. There is evidence that stone fruits and apples might be grown satisfactorily on some occurrences, but there are risks involved and generally Vinifera sandy clay loam is regarded as a doubtful soil for fruit trees. The hazards are chlorosis due to excessive lime in the rootzone, and salinity. Soil examinations should be made to assess whether these hazards are likely to be significant before planting particular situations to fruit trees.

Heavy textures in the deep subsoil engender doubt as to the effectiveness of tile drainage should this be necessary to counteract soil salinity. This is a further reason why caution should be exercised in the planting of fruit trees on Vinifera sandy clay loam.

Generally, infiltration of water is not rapid and watertables are slow to develop. In some situations, efficient wetting of the rootzone of vines may even be difficult and measures to increase soil wetting, such as multi-furrow irrigation, should be employed.

Vinifera sandy clay loam is a satisfactory soil for cultivated crops, lucerne and pastures grown under irrigation.

## SOIL UNITS

The following soil units have all been recorded previously by Churchward (1960) in the Woorinen Settlement. The descriptions given here, however, are based mainly on the occurrences as found within the present surveyed area.

### *Unit C*

*Surface soil-*

A — 0 to 12 inches; brownish grey sandy loam; sharp transition to:

*Subsoil-*

$B_1$ — 12 to 18 inches; grey-brown, usually diffusely mottled with brown, sandy clay; gradual transition to:

$B_LC$ — 18 to 48 inches; diffusely mottled yellowish brown and grey sandy clay; light calcium carbonate; at 3 to 5 feet clear transition to:

48 to 72 inches; grey mottled with brown, dense clay.

***Occurrence.-***Unit C is a minor occurrence and generally occupies the lower eastern slopes of the *mallee dune landscape unit*.

**Land Use.-**As Unit C is liable to waterlogging and salting, tile drainage is necessary before planting to vines. With careful attention to watering, it should carry satisfactory cultivated crops, lucerne, and annual and perennial pastures.

## *Unit G*

*Surface soil-*

A — 0 to 12 inches; brownish grey sandy clay loam; weak medium angular blocky structure; slightly hard dry, friable moist; moderate calcium carbonate in the fine earth; clear transition to:

*Subsoil-*

$B_L$ — 12 to 18 inches; brownish grey sandy, clay; very weak medium subangular blocky structure; very friable dry, friable moist; moderate to heavy soft, panned, and concretionary calcium carbonate; gradual transition to:

C — 18 to 30 inches; grey-brown, usually mottled with brown, sandy clay; moderate soft calcium carbonate, light concretions; clear transition to:

30 to 72 inches; mottled grey and brown dense clay; light calcium carbonate decreasing to none with depth.

***Variant.-***The inscription dark grey surface refers to occurrences which have a much darker grey surface than normal. This variant appears to have been subjected to more inundation than the normal type.

***Occurrence.-***Unit G is a minor component of the mallee dune landscape unit where this occurs in the northern part of the Swan Hill Irrigation Area. It occupies lower-lying and nearly level situations adjoining the dune masses.

***Land Use***.-Unit G is unsuitable for horticulture except vines, but is capable of supporting satisfactory cultivated crops, lucerne and pastures, where salt is not a problem.

Watertables readily form on a relatively dense layer which occurs within 3 feet of the surface. Tile drains need to be laid at less than 4 feet and the soils are considered to be marginal for effective tile drainage.

## *Unit H*

*Surface soil-*

A — 0 to 12 inches; brownish grey sandy clay loam or sandy clay; slightly hard dry, friable moist; calcium carbonate in the fine earth; clear transition to:

*Subsoil-*

$B_L$ — 12 to 18 inches; brownish grey sandy clay; very weak medium subangular blocky structure; very friable dry, friable moist; light to moderate soft, panned, and concretionary calcium carbonate; gradual transition to:

C — 18 to 48 inches; grey-brown, mottled with brown, sandy clay; moderate soft calcium carbonate. light concretions; at 3 to 5 feet gradual transition to:

48 to 84 inches; mottled brown and grey dense clay; light calcium carbonate decreasing to none with depth.

***Variant***.-A bright subsoil inscription on the soil map denotes soils possessing a brown subsoil.

***Occurrence***.-Unit H is a minor component of the mallee dune landscape unit in the northern part of the Swan Hill Irrigation Area. It usually occurs on the lower part of the landscape adjoining the dunes.

***Land Use***.-Type H has the same land use capabilities as Type G, although the occurrence of the dense layer at a slightly greater depth allows more effective tile drainage.

### *Unit K*

A — 0 to 6 inches; dull brown (7.5YR 3/3) sandy clay loam; brittle dry, friable moist; at 4 to 10 inches sharp transition to:

*Subsoil-*

$B_LC$ — 6 to 30 inches; reddish brown (2.5YR 4/6) medium clay; moderate medium angular blocky structure; hard dry, tough moist; light soft calcium carbonate and concretions appear from 9 to 18 inches; at 24 to 36 inches gradual transition to:

30 to 72 inches; mottled yellow-grey and brown dense medium clay; light soft and concretionary calcium carbonate decreasing to none with depth.

***Variants.-***The presence of various overlays are denoted by inscriptions on the soil maps. Other inscriptions are *rubbly* referring to appreciable calcium carbonate concretions in the lime-rich zone, heavy surface for textures heavier than sandy clay loam, and grey surface.

***Occurrence.-***Unit K is a brown soil component of the black box *woodland land*scape unit in the Swan Hill Irrigation Area.

***Land Use.-***Unit K is one of the heavier soils under vines at Woorinen. It is regarded rather unfavourably because of water penetration difficulties. Poor permeability makes it unsatisfactory for lucerne, but it supports reasonable irrigated pastures.

The potential of Unit K for effective tile drainage is poor.

#### *Light Phase*

In the light phase, the reddish brown subsoil clay passes to sandy clay or lighter textures, and the underlying dense medium clay commences at variable depths between 3 and 6 feet from the surface.

**Land Use.-**The light phase is more attractive for vines than the normal phase and has better drainage possibilities.

### *Unit L*

*Surface soil-*

A — 0 to 8 inches; brownish grey (10YR 4/1) sandy clay; moderate coarse angular blocky structure; hard dry, friable moist; at 6 to 12 inches gradual transition to:

*Subsoil-*

$B_LC$ — 8 to 36 inches; yellowish grey (2.5Y 6/2), often mottled with shades of brown medium clay with sand in cracks and pockets; weak medium angular blocky structure; hard dry, friable moist; light soft calcium carbonate commences from 10 to 18 inches; at 30 to 48 inches gradual transition to:

36 to 72 inches; light yellowish grey with yellow-brown mottling, dense medium clay; light calcium carbonate decreasing to none with depth.

***Variants***.-The inscriptions fine lime in *surface, light* surface and bright subsoil denote respectively, lime detectable by acid, sandy loam or sandy clay loam textures, and dominately brown colours in the subsoil below 15 inches.

***Occurrence.-***Unit L is a component of the *black* box *woodland landscape unit* in the Swan Hill Irrigation Area.

***Land Use.-***A survey of horticultural plantings in the Mid-Murray area in 1954 (Anon. 1955) indicated that soils similar to Unit L were unsuitable for fruit trees because of salinity and chlorosis hazards. It is evident however, from current successes with peaches and apples on some occurrences of Unit L at Woorinen that consideration can be given to this unit for horticultural plantings. But caution is necessary since saline subsoils are common. Only non-saline situations should be considered since the potential of the soils for effective tile drainage is not good. Highly calcareous occurrences are risky for peaches, although possibly satisfactory for vines.

Soils heavier in texture than described above for Unit L may be encountered within areas shown on the soil map as Unit L. Such situations are unsuitable for horticultural crops.

Unit L is suitable for cultivated crops, lucerne and pastures.

### *Unit N*

*Surface soil-*

| | |
|---|---|
| A | 0 to 8 inches; brownish grey light or medium clay; moderate coarse angular blocky structure; hard dry, very firm moist; at between 6 to 12 inches gradual transition to: |

*Subsoil-*

| | |
|---|---|
| B | 8 to 24 inches; yellowish or brownish grey medium clay; structure and consistence as above; light soft calcium carbonate at 18 to 30 inches; gradual transition to: |
| | 24 to 72 inches; yellowish grey, often mottled with brown, dense heavy clay; with or with out light calcium carbonate decreasing with depth. |

***Variants***.-The inscription on the soil map fine lime in surface is used to denote invisible lime detectable with acid. The presence of various overlays is denoted also by inscriptions on the map.

***Occurrence.-***Unit N is a component of the *black box* woodland landscape unit in the Swan Hill Irrigation Area.

***Land Use.-***Irrigated perennial and annual pastures may be grown satisfactorily on Unit N where surface drainage is effective and salinity has not developed.

## UNNAMED SOIL TYPES

Five of the unnamed soil types occur in the river flat landscape unit. Types 1, 2 and 3 are found on the coarser riverine sediments adjacent to the Murray and Little Murray Rivers and extend from Tyntynder to Fish Point. Types 4 and 5 appear to represent remnants of a parna plain and are similar to soils found on the present aeolian landscape to the west of the river flats.

Types 6 and 7 are minor occurrences in the *mallee dune landscape unit* in the Nyah Irrigation District, and Type 8 is a soil of small extent in the treeless plain landscape unit in the Mystic Park Irrigation Area.

### *Type 1.*

0 to 5 inches; brownish grey (2.5Y 5/2) clay loam, strong medium angular blocky structure; hard dry, friable moist; clear transition to:

5 to 48 inches; moderately mottled light brownish grey (2.5Y 6/2) and yellow-brown (5YR 5/8) fine sandy clay loam; at variable depths after 3 feet, gradual transition to:

48 to 84+ inches; grey with dull rusty mottling light clay passing to grey medium clay.

***Occurrence and Land Use***.-Type 1 is situated on low levees adjacent to the Murray River and its anabranches on the Swan Hill Flats. It is used successfully for irrigated perennial pastures and also should be a very suitable soil for lucerne and cultivated crops.

#### *Shallow Phase*

A shallow phase of Type 1 has grey medium clay commencing between 20 and 36 inches instead of below 36 inches.

***Land use.-***The possibility of watertables developing is greater than in the normal phase and this makes the shallow phase less attractive for lucerne.

### *Type 2*

0 to 26 inches; grey with rusty mottling clay loam; at 20 to 30 inches, clear transition to:

26 to 48 inches; grey often steel grey, with rusty mottling, medium clay.

***Variant.***-A *heavy surface* variant has a light clay instead of a clay loam surface. Generally the variant occurs in the lower-lying parts.

***Occurrence and Land Use***.-Type 2 occurs at slightly lower levels than Type 1. It is a satisfactory soil type for irrigated perennial pastures and lucerne. The heavy surface variant is less suitable for lucerne.

### *Type 3*

0 to 14 inches; brownish grey with rusty mottling light clay; at 10 to 24 inches, sharp transition to:

14 to 28 inches; grey medium clay; at 24 to 36 inches, gradual transition to:

28 to 48 + inches; brownish grey, occasionally mottled light grey and yellow-brown, medium clay.

***Land Use.***-Type 3 soils are satisfactory for perennial pastures.

### *Type 4*

A — 0 to 4 inches; dull brown sandy clay loam or sandy clay; sharp transition to:

$B_LC$ — 4 to 20 inches; reddish brown medium clay; light calcium carbonate in pockets from about 12 inches; gradual transition to:

20 to 48+ inches; yellowish brown light clay; usually slight calcium carbonate; grades into mottled light grey and yellow-brown fine sandy clay or fine sandy clay loam.

***Occurrence and Land Use***.-Type 4 is a minor type found on the higher positions of the western extremity of the Swan Hill Flats. Satisfactory irrigated pastures may be grown on this soil type.

### *Type 5*

*Surface soil-*

A — 0 to 10 inches; grey (N 4/0) light or medium clay; moderate medium angular blocky structure; clear transition to:

*Subsoil-*

$B_L$ — 10 to 26 inches; brown (7.5YR 4/4) medium clay; light calcium carbonate irregularly present; diffuse transition to:

C — 26 to 48 inches; mottled yellow-brown and light grey medium clay grading into fine sandy clay;

48 to 84 inches; as above, fine sand increasing with depth

***Occurrence and Land Use.***-Type 5 occurs on the Swan Hill Flats at slightly higher elevations than Swan Hill clay. Most occurrences carry good annual and perennial pastures under irrigation.

### *Type 6*

A — 0 to 4 inches; dull brown sandy clay loam; calcium carbonate irregularly present in the fine earth; clear transition to:

BC — 4 to 48 inches; reddish brown dense clay or sandy clay; slight calcium carbonate irregularly present in the upper part of the horizon; sand generally increasing with depth.

## LANDSCAPE UNITS AND GUIDE TO SOIL TYPES

Six broad physiographic features are recognizable; they are the *mallee dune, mallee plain, black box woodland, treeless plain, river flat,* and the *lake-lunette landscape units.* The distribution of these features is shown in Figure 2.

Each of the landscape units has its own array of soil types, each type occupying a definite position in the landscape. The illustrative diagrams presented in Figures 3 and 4 show idealized arrangements; each member of the sequence is not necessarily present, and a soil type as found in the field may not occur next to the soil type shown adjoining it in the diagram.

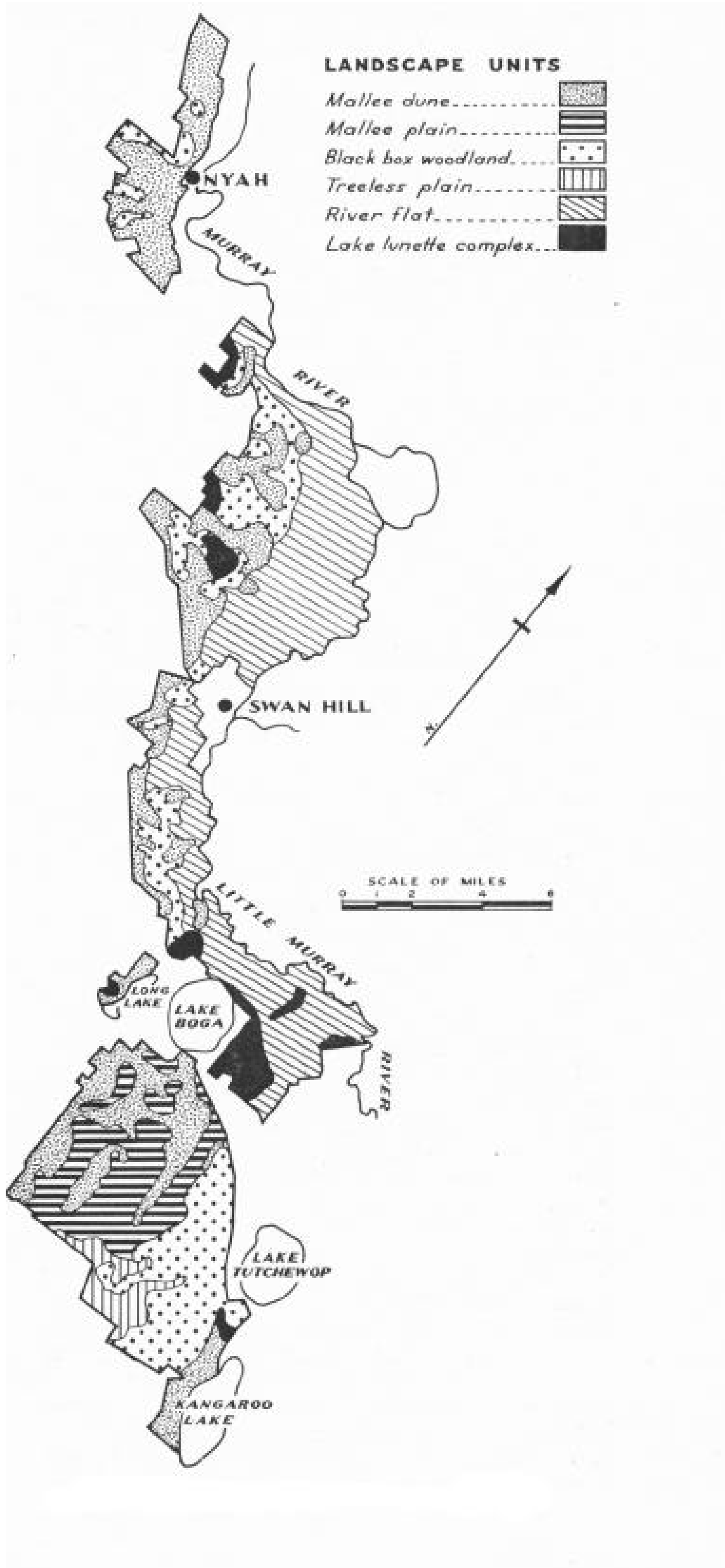
Recurring soil patterns are evident in each of the landscape units. These are the soil *associations* described in the following section and shown on the Soil Association Map in the envelope at the back of this bulletin. The relationships between the landscape units and the soil associations, and the areas of each are given in Table 4.

### *Table 4 - Relation between Landscape Units and Soil Associations.*

| Landscape Unit | Soil Association | Area (acres) | |
|---|---|---|---|
| *Mallee dune -* | | | 18,900 |
| | Tatchera | 18,900 | |
| *Mallee plain -* | | | 7,400 |
| | Boga | 7,400 | |
| *Black box woodland-* | | | 14,800 |
| | Beverford | 5,900 | |
| | Nyah | 900 | |
| | Della | 8,000 | |
| *Treeless plain-* | | | 1,700 |
| | Meran | 1,700 | |
| *River flat* | | | 20,700 |
| | Donnington | 5,700 | |
| | Swan Hill | 11,000 | |
| | Unnamed | 3,800 | |
| *Lake-Lunette-* | | | 2,900 |
| | Lake-Lunette | 2,900 | |
| | Total | 66,400 | 66,400 |

In the description of each landscape unit that follows, the component soil types are shown in italics, and the main profile features distinguishing the soil types are given.

*Fig 2 – Landscape units in the Swan Hill district*



## MALLEE DUNE

The aeolian landscape consists of several layers of windblown material superimposed on an older land surface which is generally more dense and less permeable to water than the material above. This windblown material originally contained sand, clay particles, and finely divided lime, but over thousands of years the clay and lime have been leached downward from the upper layers to a varying extent and concentrated into definite horizons. At the same time, stripping of soil material from certain parts of the landsurface and its deposition elsewhere have occurred. The resulting soil pattern is quite complex, especially on the broad, north-south ridges (see "Geology and Physiography").

The simplest landform is the mallee dune which exhibits an approximately east-west longitudinal orientation due to prevailing north-westerly winds. The idealized sequence of soil types on an east-west dune is illustrated in Figure 3. The same soil types occur throughout the mallee dune landscape and it is considered that the soils have been formed similarly on erosional and depositional surfaces, but in a less regular pattern. The soils comprise the *Tatchera soil association.*

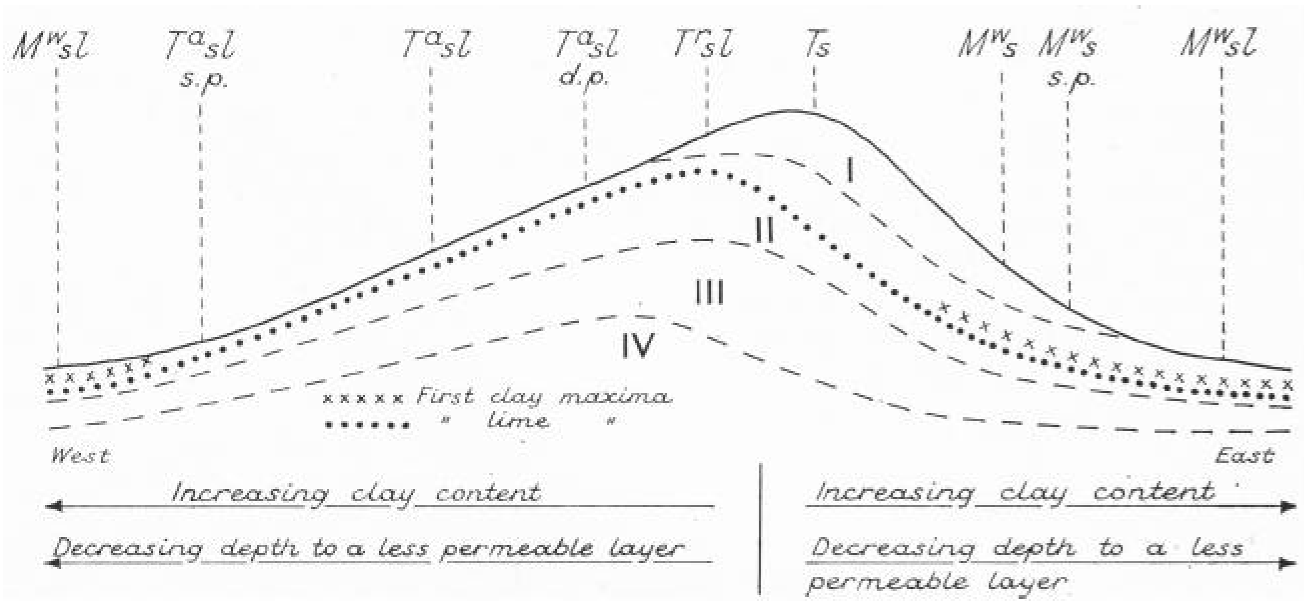
On the eroded western and northern slopes, both the topsoil and clay horizons may be stripped off leaving the lime horizons only a few inches below the surface. *Tatchera sandy loam* and *Tresco sandy loam* occur in these situations, the latter where erosion has been less pronounced. In the former soil type, the main lime horizon is shallower and occurs within 15 inches from the surface, whereas it is always below 15 inches in Tresco sandy loam. Other differences are in the colour and calcareousness of the surface soils. Tatchera sandy loam is always appreciably calcareous and varies in colour from dull brown to grey-brown. Tresco sandy loam also is dull brown, but is never grey-brown, and calcium carbonate is not always present in the surface. Normally, a dense less permeable layer commences between 3 and 4 feet from the surface in Tatchera sandy loam, but where it commences before 3 feet, or after 4 feet, *shallow* and *deep phases,* respectively, are recognized. In Tresco sandy loam, the dense layer normally commences after 4 feet, and the *shallow phase* refers to situations where it is encountered before 4 feet.

On the steeper eastern slopes where little erosion has occurred, and on the crests of the dunes, additional material blown from the western slopes and elsewhere has been deposited. Both *Tyntynder sand* and *Murrawee sand* are found in these situations, but where they occur together, Tyntynder sand occupies the higher place in the topography. In both free of calcium carbonate, overlying reddish brown sandy clay loam. Tyntynder sand differs from Murrawee sand in that the depth of surface sand is always more than 36 inches, and textures below it are not heavier than sandy clay loam; in Murrawee sand the surface depth is always less than 36 inches, while the subsoil sandy clay loam may contain a zone of sandy clay. Both subsoils contain calcium carbonate, but Tyntynder sand usually is less calcareous than Murrawee sand, although this is not a consistent point of distinction. The underlying dense and less permeable layer occurs below 6 feet except in a *shallow phase* of Murrawee sand. This is distinguished by having such a layer commence between 4 and 6 feet from the surface.

*Murrawee sandy loam* occurs in slightly elevated and gently sloping situations where little erosion or deposition has taken place. It is always below Murrawee sand where the two types occur together. A shallow, brown surface soil overlies a reddish brown sandy clay or light clay followed by a lime rich layer. Visible lime is absent from the zone of clay accumulation and this distinguishes Murrawee sandy loam from both Tatchera sandy loam and Tresco sandy loam. A *shallow phase is* distinguished from the normal Murrawee sandy loam by having a dense, less permeable layer before 4 feet.

Minor soils in the mallee dune landscape unit are *Unit C, Type* 6 and *Type 7.* The first is a grey sandy loam overlying mottled clay, calcareous from 18 inches. It occurs on the lowest parts of the eastern slopes of the dunes. Types 6 and *7* occur only in the Nyah Irrigation District. Type 6 occurs on steep slopes adjoining the river frontage where intense erosion has removed the more recent aeolian layers, leaving dense clay at, or very close to, the surface. Type *7 is* associated with the lower slopes in the same locality and overlies riverine sediments.

*Fig 3 – Sequence of soil types on the mallee dune landscape unit*




Layers: I, Kyalite; II, Speewa; III, Bymue; IV, Tooleybuc
Soil types: $M^{w}s$ – Murrawee sand; $M^{w}sl$ = Murrawee sandy loam; $T^{a}sl$ = Tatchera sandy loam; $T^{r}sl$ = Tresco sandy loam; s.p. = shallow phase; d.p. = deep phase.

## MALLEE PLAIN

Interdune plain carrying mallee vegetation is a feature of the aeolian landscape in the Tresco-Mystic Park area. The soils which are visibly salt-affected, especially in the lower-lying parts and adjoining the mallee dunes, comprise the *Boga soil association.*

*Murrawee sandy loam saline phase, Kunat sandy clay loam* and *Boga clay loam* form a topographical and colour sequence. Murrawee sandy loam saline phase occurs on the few incipient rises on the plain. The soil profile is identical with that of the shallow phase, but the surface shows evidence of salinity, either by the presence of halophytic vegetation or by chemical analysis.

Where the surface of the low rises has been eroded as is frequently the case, the lime horizon occurs at or near the surface and Murrawee sandy loam saline phase is then replaced by the *saline phase* of *Tatchera sandy loam.* This is identical with the shallow phase of Tatchera sandy loam, except for evidence of salinity.

Kunat sandy clay loam occupies intermediate positions on the mallee plain and has dull profile colours. The B horizon typically is greyish brown compared with reddish brown in Murrawee sandy loam saline phase; also the texture is medium clay instead of sandy clay or light clay. Kunat sandy clay loam is readily distinguished from the saline phase of Tatchera sandy loam by the presence of lime in the surface and immediate subsoil of the latter soil type.

Boga clay loam occupies the lowest parts of the plain. In addition to being slightly heavier, it is distinguished from Kunat sandy clay loam by having yellowish grey-brown to grey colours in the profile instead of dull brown. Both soil types are saline and the surface of Boga clay loam typically is powdery when dry.

As in the mallee dune landscape unit, dense layers which restrict downward movement of water underlie the mallee plain soils. The layers commence between 30 and 48 inches in Kunat sandy clay loam and between 20 and 36 inches in Boga clay loam.

### BLACK BOX WOODLAND.

This landscape unit delineates areas of low plain which formerly carried black box and, in places, a little mallee. The depositional layers are principally aeolian, although it is probable that riverine layers are intermingled in some parts at least. Occurrences at Nyah and adjoining Woorinen are not now subject to inundation from the Murray River, but an extensive expanse of black box woodland in the Mystic Park area is very occasionally inundated by waters moving overland from the Avoca River.

The pattern of soil types is different in each of the three localities mentioned. At Nyah the situation is one of swale and interdune plain with no evidence of riverine deposition in the upper layers at least. The soils which comprise the *Nyah soil association* are dominantly brown and grey-brown. Vinifera sandy clay loam is the brown soil type. It is distinguished from Murrawee sandy loam which occurs on the lower slopes of adjoining mallee dunes by having generally heavier textures in the subsoil layers. In Vinifera sandy clay loam a brown surface soil passes at 6 inches to reddish brown medium clay, with the underlying dense clay layers commencing before 36 inches. Nyah clay loam occurs on fractionally lower situations than Vinifera sandy clay loam. The surface soil is grey-brown and passes to a yellowish grey-brown medium clay at 6 inches. Some situations are greyer and calcium carbonate is irregularly present above 18 inches. Nyah clay loam resembles Boga clay loam but is not markedly saline like the latter.

Adjoining the Woorinen Settlement, black box woodland occurs between the mallee dunes and the river flats. The unit is primarily in the aeolian landscape, although the lower elements which comprise the major part of the occurrence may have been subjected to periodic flooding from the Murray River in the past. The soils comprise the Beverford soil association, the principal components of which are the grey soils, Unit L and Unit N, and the brown soil Unit K. Unit L has a sandy clay surface and a sandy influence through its yellowish grey medium clay subsoil which commences about 8 inches from the surface. It is arbitrarily separated from Unit N which lacks this distinct sandy influence. Unit L is better drained internally then Unit N due to the sand in veins and pockets in the subsoil. The subsoils of both units are lightly calcareous from about 12 inches. Unit K is found on very slightly higher situations and is very similar, if not identical, to Vinifera sandy clay loam. In common with that type, Unit K has about 6 inches of sandy clay loam surface overlying reddish brown medium clay, with calcium carbonate appearing below 9 inches, and a denser, less permeable layer commencing at about 30 inches. A light phase of Unit K differs in having lighter textures beneath the reddish brown medium clay B horizon. This phase resembles Murrawee sandy loam which is a minor component of the landscape, but is distinguished from that type by having a medium instead of a light clay B horizon. Unit G and Unit H are minor occurrences, usually found where the black box woodland adjoins mallee dunes. Both units have grey sandy clay loam overlying grey sandy clay and are strongly calcareous from the surface. A dense clay layer commences before 36 inches in Unit G and after that depth in Unit H.

The Mystic Park occurrence of black box woodland corresponds to the Della soil association. There is only one important soil type, Della clay. This is a grey, cracking clay which becomes yellowish or brownish, and slightly calcareous, between 4 and 12 inches. Most of the soils are saline.

## TREELESS PLAIN

A great part of the Riverine Plain which extends over much of northern Victoria and southern New South Wales is almost featureless and devoid of trees, except for black box and red gum in some of the shallow drainage ways. The treeless areas constitute a landscape unit commonly referred to as treeless plain. The soils occurring on treeless plains both in Victoria and in New South Wales, have been recorded previously in a number of publications. In Victoria, occurrences extending from Koyuga, near Tongala, to Kerang have been described by Baldwin et al. (1939), Skene and Poutsma (1962), Skene (1963), and Skene and Harford (1964).

The treeless plain landscape unit encroaches into the southern part of the Mystic Park Irrigation Area, but, as may be seen from Figure 2, it is a comparatively minor component of the general landscape pattern of the area. the soil types have not been recorded previously. Meran sandy clay loam and Type 8 are the only components of the soil pattern which is referred to as the Meran soil association. Meran sandy clay loam occupies the fractionally higher and better drained parts of the plain. A shallow dull brown sandy clay loam overlies dark reddish brown heavy clay, but the surface is frequently windswept and the clay may be exposed. Calcium carbonate occurs below 14 inches, but usually only in small amounts. Gypsum is commonly present. Type 8 is the duller member of the sequence and takes in grey-brown and grey profiles. It is of very small extent.

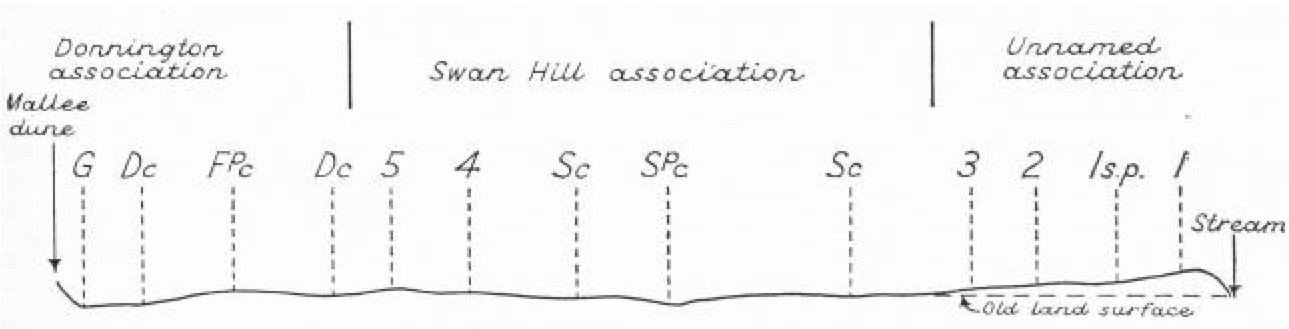
## RIVER FLAT

The alluvial plains of the Murray and Little Murray Rivers constitute the river flat landscape unit. In most situations, this may be clearly recognized below the lower elements of the aeolian landscape. The river flats are below high flood level of the rivers and once were subject to recurrent flooding. Greater exploitation of the rivers for irrigation and installation of flood protection works now prevent this. The river flats have always been treeless except for scattered black box where they adjoin the aeolian landscape.

The surface of the flats is generally level, except for a few shallow depressions and low rises. Certain of the rises form discontinuous and indistinct natural levees adjoining the Murray River, its anabranch, and Little Murray River. Other very low rises further removed from the rivers represent remnants of aeolian deposits superimposed on the alluvial layers.

The positional relationships of all of the soil types encountered in the river flat landscape are illustrated in Figure 4. The soil pattern varies over the length of the unit and three soil associations can be recognized. These are the Swan *Hill,* *Donnington,* and *unnamed soil* associations indicated in the diagram. However, all three associations only occasionally occur together.

***Fig 4 – Sequence of soil types on the river flat landscape unit.***




Soil types: Dc = Donnington clay; FPc = Fish Point clay; SPc = Speewa clay; Sc = Swan Hill clay; G = Unit G; 1 to 5 = Types 1 to 5; s.p. = shallow phase.

*Swan Hill clay* is the most extensive soil type on the river flat landscape. This is a dark grey cracking medium clay which first becomes mottled with rusty shades, and then grades into strongly mottled yellow-brown and light grey light clay or fine sandy clay before 4 feet. Speewa clay is a somewhat similar clay soil, but occupies slightly lower situations. It differs from Swan Hill clay in that dominantly grey clay continues to 4 feet, although the mottled lighter textures found in Swan Hill clay may occur before 7 feet. Calcium carbonate is only occasionally present in these soil types and then as concretions in the deep subsoil. Donnington clay is an extensive soil type and also is a dark grey cracking clay. A yellowish or brownish grey heavy clay in the subsoil continuing to 7 feet distinguishes it from Speewa clay. Also slight calcium carbonate may be present throughout the subsoil. Donnington clay resembles Unit N, but is heavier-textured and less calcareous. It is probably formed on mixed aeolian and alluvial materials.

Fish Point clay is a minor occurrence where the river flats are intermingled with lunette ridges in the Fish Point Irrigation Area. It occurs with Donnington clay, but on slightly higher levels, and aeolian deposition has made a greater contribution to its profile features. The main difference is a brown subsoil clay and the more common occurrence of calcium carbonate and gypsum below 30 inches in Fish Point clay.

Type 4 and Type 5 are formed on remnants of the aeolian landscape. Type 4 has about 4 inches of brown sandy clay loam over reddish brown medium clay becoming calcareous below 12 inches. This is similar to Unit K, but the presence of mottled grey and yellow-brown alluvium below 20 inches distinguishes it from that unit. Type 5 is similar to Type 4 except that alluvial deposition has modified the surface to a grey clay. Unit G which has been described in the black box woodland landscape unit is a minor occurrence adjoining the mallee dune, landscape.

The soils on the levees of more recent alluvium are Type 1, Type 2 and Type 3. Type 1 occupies the highest parts and is a strongly structured grey clay loam which passes to fine sandy clay loam. Grey clay representing an older landsurface normally occurs below 3 feet, but it is encountered before this depth in a *shallow phase*. Type 2 occupies intermediate levels and is a grey clay loam superimposed on grey clay at about 2 feet. Type 3 is associated with levees along the Little Murray River and is heavier and shallower than soils occupying similar positions on the flats north of Swan Hill. The surface is brownish grey light clay about 14 inches thick, with a sharp transition to darker grey and heavier clay representing the older landsurface.

## LAKE-LUNETTE COMPLEX

Lakes and drainage basins with associated crescentic ridges or lunettes on their eastern perimeters are conspicuous features of the landscape in the Lake Boga locality. Here the lunettes extend into the Fish Point Irrigation Area. There are also several smaller occurrences of lunettes in the north of the Swan Hill

Irrigation Area. The lunette soils which, in general, are moderately heavy brown soils have not been classified.

The soils of two drained lake beds near Lake, Boga have been classified as *Lake Baker clay.* The surface is a dark grey clay, characteristic. ally strongly structured and friable due to a high organic matter content. This passes to yellowish grey clay.

## SOIL ASSOCIATIONS

A soil association is a grouping of adjoining soil types which occurs in a pattern that is repeated in different parts of the area. The soils grouped in this way occupy a particular and usually distinctive part of the landscape. Thus the pattern of soils in each of four of the six landscape units described in the section, "Landscape Units and Guide to Soil Types" may be regarded as a soil association. In two of the units, the soil pattern is not the same throughout the unit and each includes three soil associations. The distribution of the ten soil associations is shown on the Soil Association Map contained in the envelope at the back of this publication. This map enables the overall soil pattern of the area to be seen readily. It also indicates in a broad way the potential land use in different parts of the area.

The soil associations, in alphabetical order, are described below in terms of their dominant, subdominant, and minor soil types, and general agricultural use. A soil type may occur in more than one soil association assuming a different degree of importance in each.

## *Beverford Association*

This association comprises part of the *black box woodland landscape unit.* It occurs along the western boundary of the Swan Hill Irrigation Area from Woorinen to Lake Boga.

*Dominant soil types*-

Unit K.
Unit L.
Unit N.

Whilst this association comprises grey plain (Units L and N) and, to a lesser extent, brown plain (Unit K) originally supporting black box, small areas of the subdued elements of the mallee dune landscape are minor components of the association. The minor soil types are Murrawee sandy loam Unit G and Unit H.

The Beverford soil association defines areas mainly suitable for irrigated pastures, although they have some potential for horticulture.

However horticultural development should be approached cautiously in view of experience at Woorinen where vines have declined on the soils of this association, mainly because of their salinity and poor reaction to tile drainage.

## *Boga Association*

The Boga soil association is one of dominantly medium-textured saline soils. It corresponds to the *mallee plain landscape unit* in the Tresco and Mystic Park localities where it occupies a broad, interdune plain carrying remnants of the original mallee vegetation.

*Dominant soil types:*-

Boga clay loam.
Kunat sandy clay loam.

*Subdominant soil type*.-

Tatchera sandy loam, saline phase.

Murrawee sandy loam, saline phase is a minor component of the association.

The Boga association defines an area where soil salinity is a hazard to the successful establishment of irrigated crops. Most of the association is given to dry-farming pursuits or has been rendered unproductive through salting arising from irrigation. Some annual irrigate pastures are grown and, in general, this is the type of land use most likely to succeed under irrigation.

## *DELLA ASSOCIATION*

The Della soil association corresponds to the *black box landscape unit* in the Mystic Park Irrigation Area. The soils are saline, grey clays.

*Soil type:-*
Della clay.

Similarly to the Boga association, the Dell association defines an area where soil salinity is the principal hazard to the establishment ( irrigated crops, and irrigated annual pasture are most likely to be successful.

### *Donnington Association*

This is one of the three soil associations found in the *river flat landscape unit*. It occupies situations furthest from the river adjoining the higher aeolian landscape. Although found throughout the Swan Hill Irrigation Area, the principal occurrences are on the flats of the Little Murray River to the south of Swan Hill.

*Dominant soil type:-*
Donnington clay.

*Minor soil types-*
Fish Point clay.
Unit G.

Small areas of Swan Hill clay may be present while Fish Point clay is a component of the association only in the Fish Point Irrigation Area.

The Donnington association defines areas suitable for irrigated pastures and lucerne. Most of the occurrence is under annual pastures, but is capable of supporting satisfactory perennial pastures.

### *Lake-Lunette Association*

This soil association corresponds to the *lake-lunette landscape unit*.

*Soil types:-*
Lake Baker clay.
Unclassified soils on lunettes.

The lake-lunette occurrences define areas which have only slight agricultural significance for irrigation. Two relatively small drained lakes carry irrigated pastures, but there appear to be no other lake beds suitable for agricultural development. The lunettes vary from being sparsely grazed to cultivated for wheat-growing. Their high elevation precludes them from gravity irrigation, but there are a few instances of lucerne being grown under spray irrigation on the more sandy occurrences.

### *Meran Association*

This is a relatively minor association of heavy-textured soils corresponding to the *treeless plain landscape unit* in the southern part of the Mystic Park Irrigation Area.

*Dominant soil type:-*
Meran sandy clay loam.

*Subdominant soil type-*
Type 8.

The Meran association is mainly used for the grazing of sheep on native pastures. Irrigated annual pastures can be grown, but the subsoils are saline and careful attention to irrigation practices is necessary.

### *Nyah Association*

This soil association corresponds to the *black box woodland landscape unit* where it occurs in the Nyah Irrigation District. It is an association of moderately heavy-textured soils occupying interdune swales and plains.

*Dominant soil types:-*
Nyah clay loam.
Vinifera sandy clay loam.

Minor areas of Tatchera sandy loam and Murrawee sandy loam occur on the fringe of the association.

The Nyah soil association delineates areas where problems in horticultural crops are likely under irrigation. Vines and fruit trees have declined due to salinity and poor drainage reaction of the soil where grown on Nyah clay loam. Fewer troubles have occurred on Vinifera sandy clay loam, but it still is a doubtful soil type for fruit trees, Generally, the soils of the association are best suited to irrigated pastures.

### *Swan Hill Association*

The Swan Hill association is the principal soil association in the *river flat landscape unit.* It occurs extensively in the northern part of the Swan Hill Irrigation Area.

*Dominant soil type:*-
Swan Hill clay.

*Subdominant soil type:*-
Speewa clay.

Minor components of the association are Type 4, Type 5 and Donnington clay.

The Swan Hill association delineates areas generally suitable for irrigated perennial pastures, although there has been an appreciable decline in the productivity of established pastures over much of the occurrence due to increasing salinity.

### *Tatchera Association*

The Tatchera soil association comprises the soil types found in *the mallee dune landscape unit.* It is found throughout the area from Nyah to Kangaroo Lake.

*Dominant soil type:*-
Tatchera sandy loam.

*Subdominant soil types:*-
Murrawee sand. Murrawee sandy loam.

*Minor soil types:*-
Tresco sandy loam. Tyntynder sand. Unit C Type 6. Type 7.

The proportion of the principal soil types in the association varies in different parts of the area. Tatchera sandy loam is always clearly dominant and Murrawee sandy loam sub-dominant, except in the Long Lake Settlement where Murrawee sand is the most extensive soil type. On the other hand, Murrawee sand is insignificant and Murrawee sandy loam is only of slight extent in the Kangaroo Lake Settlement. Tresco sandy loam assumes sub-dominance in the Tresco Irrigation District, but is a minor occurrence elsewhere.

The Tatchera soil association defines areas either under horticulture, or suitable for horticultural crops if irrigated. However, most of the association is above the pre-irrigation system, consequently a proportion is not irrigated and is given to cereal cropping and the grazing of sheep. Nevertheless, water is lifted to supply large the irrigation settlements of Ny Kangaroo Lake and Long Lake , mainly on soils of the Tatchera association.

### *Unnamed Association*

This association occurs in the *landscape unit.* It takes in the unnamed soil types found on the discontinuous, levees adjoining the Murray and Little Murray Rivers in the Swan Hill and Fish Point Irrigation Areas.

*Soil types:*-
Type 1
Type 2
Type 3

Type 1 is dominant and Type 3 is absent where this association occurs on the Swan Hill Flats. In the Fish Point Irrigation Area the reverse is the case.

This soil association defines areas generally suitable for irrigated perennial pastures and lucerne.

## SOIL RELATIONSHIP

### *Relation to earlier Surveys*

The first soil surveys in this area concerned the horticultural settlements and were made by Taylor and Penman (1930) and Taylor *et al*. (1933). These surveys were among the first carried out in Australia at a time when the factors determining the soil pattern and soil formation were less well understood than is the case today. It is to be expected, therefore, that those who compare the earlier with the latest soil maps will see little outward resemblance. That this is so is evident from Table 5 which illustrates the confused relationships between the present soil types and those of the first soil surveys.

The earlier soil types were derived from arbitrarily grouped profiles with similar textural characteristics, whereas in the present soil survey, colour, texture, depth and distribution of calcium carbonate, and depth to less permeable layers were the criteria used in defining the soil types. Perhaps the most important difference is the emphasis now placed on the depth to lime and its distribution in the profile. In the earlier surveys, all of the soil types allowed variable distribution of lime in the profile, but in the recent surveys the distribution of lime and depth to the main lime horizon are characteristic for each of the soil types. This attribute has considerable horticultural ficance.

Of the soil types recorded by Taylor and Penman (1930) and Taylor *et al.* Tyntynder sand, Tatchera sandy loam, Nyah clay loam, Vinifera loam and Swan Hill clay have been redefined and the names retained, except that the surface texture of Vinifera loam is now described as sandy clay loam. New soil types introduced with redefinition of the soil types occurring on the mallee aeolian are Murrawee sand, Murrawee sandy loam, Tresco sandy loam, Kunat sandy clay loam and Boga clay loam.

Definition of the above soil types has been assisted greatly by information and concepts arising from a re-survey of the Woorinen Settlement by Churchward (1960). He has described the soils rather broadly in 13 units. Six of these (Units, C, G, H, K L and N) have been used directly in the present classification, except that more precise definition has been given to their profile features; and other units coincide with some of the above named soil types. The relationship between Churchward's mapping units and those of the present soil survey are included in Table 5.

### *Table 5 – Relation between Soil Types and Units of Various Surveys*

| **Skene and Sargeant (1966)**<br>**Nyah, Tresco, Swan Hill, Kangaroo Lake** | **Churchwood (1960)**<br>**Woorinen** | **Taylor and Penman (1930)*, Taylor *et al* (1933)**<br>**Nyah, Tresco, Woorinen, Kangaroo Lake** |
|---|---|---|
| Tyntynder sand | Unit A | Tyntynder sand, Murray sand |
| Murrawee sand (including shallow phase and surface variants) | Unit B | Tyntynder sand, Murray sand, Tatchera sand |
| Murrawee sandy loam (including shallow phase0 | Unit J | Tatchera sand, Tatchera sandy loam, Vinifera loam (Nyah), Woorinen loam |
| Murrawee sandy loam, saline phase | No equivalent | Tatchera sandy loam, saline phase |
| Tresco sandy loam (including shallow phase) | Unit D | Tatchera sand, Tatchera sandy loam |
| Tatchera sandy loam (including deep phase) | Unit E | Tatchera sand, Tatchera sandy loam |
| Tatchera sandy loam, shallow phase | Unit F | Tatchera sandy loam, Nyah clay loam |
| Tatchera sandy loam, saline phase | No equivalent | Tatchera sandy loam, Nyah clay loam |
| Boga clay loam | No equivalent | Tatchera sandy loam, saline phase |
| Kunat sandy clay loam | No equivalent | Tatchera sandy loam |
| Nyah clay loam | No equivalent | Nyah clay loam, Vinifera loam |
| Vinifera sandy clay loam | No equivalent | Vinifera loam, Nyah clay loam |
| Swan Hill clay | No equivalent | Swan Hill clay |
| Unit C | Unit C | Tatchera sandy loam |
| Unit G | Unit G | Tatchera sandy loam |
| Unit H | Unit H | Tatchera sandy loam |
| Unit K | Unit K | Woorinen loam |
| Unit L | Unit L | Tatchera sandy loam, Woorinen loam, Beverford loam |
| Unit N | Unit N<br>Unit P | Beverford, Beverford clay loam<br>Beverford clay loam |

* The soil types described in this publication were named subsequently as follows: Type 1 – Tyntynder sand and Tatchera sand; Type 7 – Woorinen loam; Type 8 – Tatchera sandy loam; Type 9A – Beverford loam; Type 9 – Beverford clay loam; Type 10 – Swan Hill clay

### *Classification*

The Swan Hill area lies in the zone of solonized brown soils originally defined by Prescott (1944) and later modified by Stephens (1961). However, other great soil groups are present.

The soils of the mallee dunes, Tyntynder sand, Murrawee sand, Tresco sandy loam and Tatchera sandy loam fit the generalized description of solonized brown soils given by Stephens (1962). Some of the soils on the lower slopes and plains of the aeolian landscape are in this great soil group also. Such soils are Nyah clay loam and Units G, H and L. Other soils in these situations have more strongly contrasting textural A and B horizons. The brighter coloured of these soils, namely, Vinifera sandy clay loam, Murrawee sandy loam and Unit K have affinities with the red-brown earths, but the duller soils, Kunat sandy clay loam and Boga clay loam, for the most part are saline and may be regarded as solonchaks**.** The saline phases of Tatchera sandy loam and Murrawee sandy loam, and most of the Della clay, are in this category also.

The soil types on the treeless plain part of the area are Meran sandy clay loam and Type 8. The former is a shallow red-brown earth and the latter a grey soil of heavy texture.

The soils forming on the fine alluvium of the river flats, namely, Swan Hill clay, Speewa clay, Donnington clay and Fish Point clay are grey clays which exhibit pedologic horizons, and therefore are considered to be grey soils of heavy texture. However, Swan Hill clay and Speewa clay both depart from the normal grey soil of heavy texture in that calcium carbonate is absent from the profile.

Della clay and Unit N found on black box woodland areas are normal grey soils of heavy texture.

Sheet I of the Atlas of Australian Soils compiled by Northcote (1960a, 1960b) using different concepts of soil classification and mapping shows the surveyed area as overlapping three landscape map units in which the soils are dominantly grey-brown highly calcareous loamy earths (Gc1.12), brown calcareous earths (Gc 1.12 and Gc 1.22), and cracking grey clays (Ug 5.2). A complex soil pattern is recorded in each of the landscape units, and soils with duplex profiles (D), as well as other soils with gradational (G) and uniform (U) profiles, are stated to be present also.

The classification of the soils in the surveyed area according to the criteria of Northcote (1960a) is as follows:

| | | |
|---|---|---|
| Gn 2.23 | | Tyntynder sand |
| Gc 1.12 | | Tatchera sandy loam, Unit G, Unit H |
| Gc 1.22 | | Tresco sandy loam, Nyah clay loam |
| Gc 2.22 | | Unit L (some profiles) |
| Dr 4.53 | | Murrawee sand |
| Dr 2.53 | | Murrawee sandy loam |
| Dr 2.13 | | Vinifera sandy clay loam, Meran sandy clay loam, Unit K |
| Db 1.53 | | Kunat sandy clay loam, Boga clay loam (some profiles) |
| Db 3.53 | | Boga clay loam |
| Ug 5.25 | | Fish Point clay |
| Ug 5.28 | | Swan Hill clay, Speewa clay |
| Ug 5.28 | } | Donnington clay, Della clay |
| Ug 5.29 | } | |

### *Chemical and Physical Properties*

Forty-two profiles taken from the principal soil types have been examined in the laboratory. The locations of these are shown by numbers on the soil maps while their analyses are presented in Appendix II. This appendix, therefore, provides references to the more important measurable characteristics of the principal soil types. The analytical methods employed are given in Appendix III.

### *Particle Size Distribution*

The analyses in Appendix II relate particle size distribution to assessments of field texture, and their main purpose is to enable a better appreciation of the textures given in the morphological descriptions of the soil types. But it should not be overlooked that the analyses in some cases represent only single profiles, whereas the soil types each cover a range of textures. However, some idea of the range in mechanical composition of the more common soil types can be gained, since several profiles are illustrated in these cases. The following comments also arise from consideration of the particle size data.

The characteristically sandy nature of the principal soil types occupying the mallee dunes is evident from the particle size distribution of the twenty profiles of Tyntynder sand, Murrawee sand, Murrawee sandy loam. These analyses also indicate that the dunes at Tresco (including Long Lake) and in the Swan Hill Irrigation Area have a generally coarser sand grading than is the case at Nyah and Kangaroo Lake. For example, the coarse to fine sand ratio in Tresco and Swan Hill profiles ranges from 1.3 to 2.0, whereas the range is 0.7 to 1.0 for five of the six Nyah profiles. The coarse-fine sand ratio is 0.6 in the surface soil of the Tatchera sandy loam profile from the Kangaroo Lake Settlement. This is in accordance with the recognition in the field of the heavier and less sandy nature of the extensive occurrence of Tatchera sandy loam in that area.

Most of the twenty profiles referred to show a decreasing coarse to fine sand ratio with depth. This is illustrated in Figure 5 for three of four sites in Tatchera sandy loam. If the sand fractions were wholly stable to weathering and movement, or weathered equally, the decreasing ratio trend would suggest that the aeolian parent material increased in coarseness during deposition over the depth of the decrease in CS/FS. This may have occurred in fact, since Churchward (1963a) studying dune formation in the Swan Hill district considers that mixing of a coarse component, moved mainly by saltation, with a finer suspended materia (parna) occurred in the moulding of dunes. However, there are at least two other factors which could explain a decrease in the coarse sand-fine sand ratio. Firstly, coarse sand may have weathered more rapidly than fine sand and, secondly, fine sand may have moved downward through the profile. It is understandable, therefore, that the particle size analyses do not assist greatly in the recognition of the horizons representing the parent materials of the superficial soil profiles. In fact, it is likely that unaltered parent material does not occur in most profiles on the mallee dunes. For this reason, the C horizons for these soil types given in the section, "Description of Soil Types and Miscellaneous Units" should be regarded only as approximations of the parent materials of the horizons above them.

The particle size data do, however, enable unrelated depositional layers to be recognized in a number of the profiles. This is the case in Tatchera sandy loam profiles 2 (Nyah) and 32 (Tresco) illustrated in Figure 5. Breaks in the continuity of the coarse sand/find sand trend at 49 inches and 54 inches, respectively, suggest the presence of pedologically unrelated horizons above and below these depths. In both instances the breaks in continuity are associated with decline from high to low calcareousness. Other profiles, not illustrated, which exhibit discontinuities on the evidence of the coarse sand/fine sand trend are profile 5 (Murrawee sand at Nyah) at 54 inches, profile 9 (Tresco sandy loam at Nyah) at 72 inches, profile 31 (Murrawee sandy loam at Tresco) at 60 inches, and profile 42 (Murrawee sandy loam at Kangaroo Lake) at 34 inches.

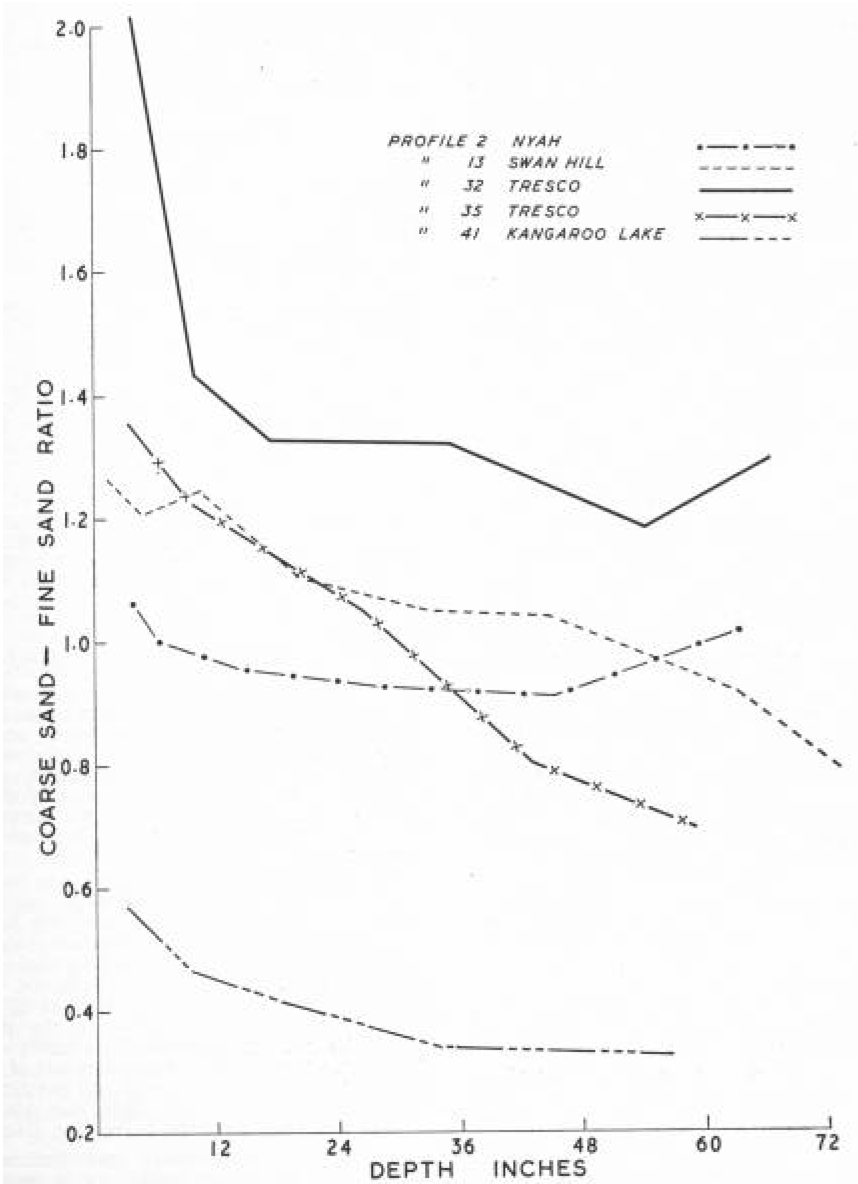
In addition to decline in calcareousness, the discontinuities referred to are associated with increased compactness in the deeper deposits. Such layers have been identified in the field as less permeable layers and are considered to have important significance in the drainage of the soils. The layers appear as dense sandy or medium clays, although the analyses do not always show a marked clay increase.

The aeolian deposits become finer with distance from the dunes. The clay fraction increases and coarse sand, although significant, ceases to be the dominant component of the sand fraction. Coarse to fine sand ratios in the soil profile are usually in the range, 0.5 to 0.9. Profiles 33 and 36 representing Boga clay loam and Kunat sandy clay loam, respectively, illustrate this situation on the mallee plain landscape in the Mystic Park area. Both profiles indicate a discontinuity in the depositional pattern at about 40 inches.

Profiles 1 and 6 (Vinifera sandy clay loam), profile 7 (Nyah clay loam) and profile 16 (Unit L) from the black box woodland landscape in the northern part of the area show coarse to fine sand ratios and low silt and moderately high clay contents comparable with those in profiles from the mallee plains. This places these soils with the aeolian landscape, although the possibility of riverine influence on some soils (Unit N) contiguous with the river flats has not been investigated. Certainly alluvial, as well as aeolian, deposition has contributed to the parent materials of the soils on the black box woodland landscape in the Mystic Park area. This is evident from the proportions of coarse sand, fine sand and silt in Della clay profiles 38 and 40.

The silt fraction is low in all horizons of the profiles of dominantly aeolian origin. The amounts are always less than 10 per cent. and commonly are less than 5 per cent. In contrast, the soils on the river flats (Swan Hill clay and Speewa clay) have moderately high silt contents (15 to 30 per cent.), but have insignificant amounts of coarse sand. Lower silt (10 to 15 per cent.) and the presence of small amounts of coarse sand (up to 8 per cent.) in the Donnington clay and Fish Point clay profiles reflect the proximity of these soil types to the aeolian landscape.

*Fig 5 – Trend in the coarse to fine sand ratio in Tatchera sandy loam profiles.*




## *Calcium Carbonate*

The analyses presented in Appendix II illustrate the highly calcareous nature of the aeolian deposits. The calcium carbonate has been leached from some horizons and concentrated in others and may be present as hard concretions, soft lime in pockets, panned lime or as finely divided lime detectable only with acid. The concretionary lime is expressed as gravel, but the other forms are all included in the analysis of the fine earth. Calcium carbonate reaches maximum concentrations in Tatchera sandy loam, concretionary and fine earth lime below about 12 inches each ranging from 15 to 40 per cent. The surface soils commonly contain about 10 per cent. of finely divided lime, but concretions are few.

Tresco sandy loam is calcareous at the surface also, but the amount of fine earth lime is usually less than 5 per cent and lime may even be absent. However, large amounts of concretionary and fine lime comparable with those in Tatchera sandy loam occur below 24 inches.

Calcium carbonate is absent from the surface horizons of the Murrawee sand and Murrawee sandy loam profiles, but 12 to 20 per cent of fine earth lime is usual in the main lime horizons. These commence below 30 inches in Murrawee stand and below 16 inches in Murrawee sandy loam. Associated concretionary calcium carbonate is usually slight in the former soil type, but amounts up to 15 per cent are present in Murrawee sandy loam.

The soils on the plain and lower parts of the aeolian landscape all contain lime, but the amounts are variable. Kunat sandy clay loam, Boga clay loam and Nyah clay loam are strongly calcareous from the surface or just below it. Unit K and Unit L are less calcareous, but some horizons may contain as much as 10 per cent. of lime in the fine earth. On the other hand, the two profiles of Vinifera sandy clay loam illustrated contain smaller amounts of fine earth lime (about 5 per cent) and practically no concretionary lime. The Della clay profiles also demonstrate a relatively low lime status.

Studies of the vertical and horizontal distribution of calcium carbonate in aeolian depositional systems have assisted in the recognition of cycles of groundsurface development, and in an understanding of soil development on these exposed and buried groundsurfaces. Reference may be made to the work of Churchward (1961, 1963a, 1963b) in the Swan Hill district for information on this aspect.

The soils derived from alluvium contain comparatively little lime. Some profiles of Swan Hill clay and Speewa clay have up to 2 per cent as small concretions in the deep subsoil horizons, but many profiles have no lime. Calcium carbonate is present below 15 inches in Donnington clay and Fish Point clay profiles, but the amounts are usually less than one per cent. and rarely more than 2 per cent.

### *pH*

The profile data show that the soils fall into two groups, viz., soils which are neutral to slightly alkaline in the surface, and those which are moderately to strongly alkaline. The first group comprises the majority of the alluvial soils on the river flats and the second all of the soils on the aeolian landscape.

The surface pH values of the alluvial soils are mainly within the limits 7.1 to 7.8, although profiles 15 and 24 (pH 8.2, 8.4) illustrate that some situations on the flats are moderately alkaline. Alkalinity increases with depth and pH values usually exceed 8.0 before 24 inches. Profile 10 (Type 1) however, does not conform to this pattern and demonstrates an acid trend in the profile.

High pH is common in the sandy loam surfaces of the mallee dune soils. The pH range is 8.0 to 9.2 in fourteen profiles of Murrawee sandy loam, Tatchera sandy loam and Tresco sandy loam, but ten of these have values ranging from 8.8 to 9.2. Lighter textured soils tend to be slightly lower in pH and four profiles in Murrawee sand range from 7.7 to 8.4. The surface soils on mallee plain and black box woodland conform to the same pattern of moderate to strong alkalinity, ten such profiles exhibiting values which range from 8. 0 to 9.2. The subsoils of the aeolian soil types are always more alkaline than their surface soils and usually are very strongly alkaline. Most of the profiles sampled demonstrate subsoil pH values in the range 9.0 to 10.0, the high alkalinity continuing to 6 feet.

High pH often reflects an influential amount of exchangeable sodium on the exchange complex. However, the present data indicate that pH is not a reliable guide to high sodium until pH values exceed about 9.6. With one exception, ten horizons (profiles 2, 5, 11, 12, 19, 30, 34 and 35) with pH values of 9.6 to

10.0 contain appreciable exchangeable sodium (saturation percentages of 12 to 39). A further ten horizons (profiles 2, 9, 30, 34 and 35) have pH values of 9.1 to 9.7 in association with low exchangeable sodium percentages (2 to 9), but, on the other hand, exchangeable sodium percentages may be high at lower pH. For example, profiles 6, 20, 31 and 38 have horizons with exchangeable sodium percentages of 19 to 42 in association with pH values of 8.0 to 8.9. In these cases, soluble salts are present in sufficient amounts to depress the pH values.

## *Exchangeable Cations*

The exchangeable calcium, magnesium, potassium, sodium and hydrogen, and the sum of these cations representing the total cation exchange capacity, are given in Appendix 11. for selected horizons in fifteen profiles.

The cation exchange capacity of the clay fraction is a broad guide to its mineralogy and may be calculated for the subsoil horizons which do not contain organic matter. The values for the horizons between 2 and 4 feet tend to fall into two groups based not on soil type but on locality. The four profiles from the Nyah area provide the highest values, three ranging from 72 to 74 m.e. per 100 g of clay, whereas the range in the 2 to 4 feet depths of all profiles from other areas is 52 to 61 m.e. per 100 g. These values are comparable with exchange capacities reported for clays from similar depths in solonized brown soils at Robinvale (Skene 1951) and Walpeup (Newell 1961) and suggest that the clay minerals are dominantly illite and montmorillonite types. No difference is apparent between the exchange capacities of clays from the alluvial and aeolian deposits.

Calcium is the dominant cation in the surface soils on the aeolian landscape, comprising 58 to 73 per cent of the exchange capacity in all profiles except those of the saline soil types. In these, sodium partly replaces calcium so that the proportion of calcium is 30 to 37 per cent, and magnesium approximately equals calcium. Hydrogen partly replaces calcium in profiles 14 and 20 from the river flats but calcium clearly remains dominant over magnesium.

In accordance with common experience in solonized brown soils, the proportion of calcium declines markedly with depth in the profile, while magnesium and, to a lesser extent sodium, increase. Generally magnesium is the dominant exchangeable cation in the B and deeper horizons. The relatively immature profiles 14 and 20 from the river flats do not conform, however, to this pattern. In profile 14, there is little change in the proportion of any of the exchangeable cations to a depth of 40 inches, while in profile 20 the only change is an increase in sodium at the expense of hydrogen.

The main agricultural interest is in the exchangeable sodium, as a percentage of the exchange capacity, since this has a marked influence on the physical properties of the soil. It is generally recognized that significant dispersion of the clay occurs in non-saline soils when irrigated if the exchangeable sodium percentage exceeds 15. Under these circumstances, water movement through the soil becomes slow and infiltration and drainage may be affected adversely. However, in saline soils, dispersion of the clay tends to be prevented by the salt present. As the salt is leached out, reclamation becomes more difficult. The presence of calcium carbonate in the soil or addition of gypsum assists reclamation in these circumstances.

Soils with exchangeable sodium percentages of 15 or more are commonly referred to as alkali soils. Profiles 31, 37 and 38 show values ranging from 19 to 42 per cent and, therefore, are in this category. As these profiles are also saline, the data illustrate that the saline phase of Murrawee sandy loam, Boga clay loam and Della clay are saline alkali soils. Although exchangeable cations have not been determined, the saline phase of Tatchera sandy loam is in this category also. The remaining profiles except only profiles 5, 9 and 14, demonstrate that alkali subsoils may be common below 2 or 3 feet in most of the soil types. However, adverse effects due to the high sodium are unlikely in most of these subsoils because of associated high lime contents.

Exchangeable potassium contents are high in the surface (0.8-4.0 m.e.%) and subsoils (0.7-2.6 m.e.%) of all but the most sandy soils, consequently potash fertilizer is unlikely to benefit the majority of horticultural crops and pastures. The circumstances where potash may be of benefit are with vegetables and fruit trees grown on situations of Tyntynder sand and Murrawee sand which have received substantial past fertilizing with sulphate of ammonia.

### *Organic Matter*

The general level of organic matter in the soils can be appreciated from the total nitrogen and organic carbon values reported in Appendix II.

Total nitrogen in the aeolian soils ranges from 0.04 to 0.09 per cent in the sands, 0.05 to 0.15 per cent in the sandy loams and sandy clay loams, and 0.07 to 0.21 per cent in the clay loams. Corresponding organic carbon, ranges are 0.37 to 0.91 per cent, 0.53 to 1.28 per cent and 0.69 to 2.99 per cent, while average carbon-nitrogen ratios are 14, 11 and 11. The heavier soils from the river flats have higher values, viz., 0.11 to 0 .28 per cent for total nitrogen and 1.02 to 2.89 per cent for organic carbon. The average carbon-nitrogen ratio is 10.

The organic matter content of Lake Baker clay is remarkably high and this is responsible for a friable consistence and strong structure in this soil type. Total nitrogen is 0.66 per cent, organic carbon 5.94 per cent and the carbon-nitrogen ratio 9.

Organic matter in the B horizons varies from one-third to two-thirds of the amount in the surface. The average carbon-nitrogen ratio is about 8.

The range of organic matter contents in the surface soils is wide since the soils analysed were drawn from irrigated as well as from dryland areas.

### *Soluble Salts*

#### *Total Soluble Salts*

The profile data for soluble salts in Appendix II illustrate that the subsoils of the majority of the soil types contain sufficient salts to constitute a salinity hazard under irrigation.

Soluble salts usually are low in the mallee dune soils, although there is a tendency for the amounts present to increase passing downslope from the lightest soils on high situations to the mallee plains. Thus, all of the Murrawee sand, Tyntynder sand and Tresco sandy loam profiles, except profile 19, contain less than 0.1 per cent of soluble salts, while further downslope Murrawee sandy loam and Tatchera sandy loam profiles usually have between 0.1 and 0.2 per cent in the horizons below 2 feet. However, considerable amounts of soluble salts have accumulated in some situations of the last two soil types. This is illustrated by Tatchera sandy loam profile 13 which contains nearly 0.5 per cent, and profiles 28 and 31 representing the saline phases of Tatchera sandy loam and Murrawee sandy loam respectively. These two profiles contain between 1 and 2 per cent of soluble salts.

The high salinities of Boga clay loam, Della clay and Meran sandy clay loam are illustrated by the analytical data. Total soluble salts range from 1 to 2 per cent in the three profiles representing these soil types, and approximately to 0.5 per cent in two others.

Moderate to appreciable amounts of soluble salts are present in practically all of the profiles from soil types on the river flats. The amounts present range from approximately 0.2 to 1.0 per cent.

The constituent cations and anions are shown in Table 6 for a number of selected subsoil horizons. Apart from differences in the total amounts of soluble salts present, the data illustrate a difference in the composition of the salts between soils from the aeolian landscape and the river flats. The soluble salts in the six examples from the former situation consist very largely of sodium salts, calcium and magnesium slats being present in only small amounts. The anions in relative order of quantity usually present are chloride, sulphate and bicarbonate. Most of the profiles also exhibit small amounts of soluble carbonate.

### *Table 6 – Analysis of Soluble Salts*

| Soil type | Sample No. | Depth (in) | Ca | Mg | K | Na | Cl | $SO_4$ | $HCO_3$ | $CO_3$ | Total salts % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Milliequivalents per 100 g of soil | | | | | | | | |
| Murrawee sandy loam | 26173 | 43-63 | 0.20 | 0.03 | 0.09 | 4.11 | 2.00 | 0.97 | 1.12 | 0.18 | 0.29 |
| Murrawee sandy loam saline phase | 28158 | 7-18 | 1.06 | 1.73 | 0.32 | 21.30 | 20.00 | 4.10 | 0.46 | 0.00 | 1.52 |
| Tatchera sandy loam | 26180 | 14-26 | 0.30 | 0.58 | 0.11 | 9.04 | 8.09 | 0.88 | 0.54 | 0.01 | 0.59 |
| Vinifera sandy clay loam | 19652 | 11-20 | 0.43 | 0.08 | 0.05 | 4.35 | 1.03 | 1.68 | 1.23 | 0.35 | 0.33 |
| Nyah clay loam | 19667 | 16-30 | 0.09 | 0.12 | 0.06 | 6.57 | 2.62 | 1.90 | 1.24 | 0.32 | 0.42 |
| Boga clay loam | 23651 | 22-36 | 0.43 | 0.08 | 0.11 | 7.13 | 4.10 | 1.86 | 0.92 | 0.10 | 0.47 |
| Swan Hill clay | 26219 | 30-40 | 11.20 | 3.41 | 0.10 | 6.17 | 1.55 | 17.90 | 0.35 | 0.00 | 1.46 |
| Speewa clay | 28142 | 0-6 | 7.93 | 5.06 | 0.26 | 8.91 | 14.80 | 6.92 | 0.27 | 0.00 | 1.54 |

In the two soils (Swan Hill clay and Speewa clay) from the river flats, calcium and magnesium, as well as sodium, are important components of the total soluble salts present. Sulphate and chloride are the principal anions, and either may be dominant. Bicarbonate is less than in the soils from aeolian landscape, while soluble carbonate is not present.

### *Sodium Chloride*

Chlorides have been estimated in all of the profiles shown in Appendix II and are reported as sodium chloride. Levels in general parallel the total salt values. In most horizons sodium chloride comprises from one-third to two-thirds of the total salts, the lower proportions being common where the total salt levels are low.

The salt data indicate that sodium chloride is present in significant quantities in many of that soil samples analysed for chloride from the 3 to 4 feet depth, as has been done in the general salt survey of the whole area, are appropriate to evaluate potential salinity hazards. These hazards, and details of the salt survey are dealt with in the section “Soil Features in Relation to Irrigation”.

## GENERAL INFORMATION ABOUT THE AREA

### *Location*

While the location and outline of the surveyed area can be found from the locality plan (Fig. 1), and the “Index to Soil Maps”, additional information about locality references is given below.

Swan Hill is a city 210 miles by road north-west of Melbourne, while Nyah West and Lake Boga are township 17 miles to the north-west and 10 miles to the south-east of Swan Hill, respectively. The settlements at Tresco, Kangaroo Lake and Long

Lake are without local business centres, although railway facilities are nearby. Mystic Park is a hamlet, but other locality references are mainly districts identified by post offices, schools etc.

Woorinen which is not included in the present soil survey is an important dried fruit settlement between Swan Hill and Nyah West.

The parishes covered by the soil maps, either wholly or in part are: Bael Bael, Castle Donnington, Kunat Kunat, Tyntynder, Tyntynder North and Tyntynder West, all in the County of Tatchera.

The soil maps accord with the standard mapping areas of the Military Map Series. However, for convenience, parts of more than one standard mapping area have been placed on a few of the soil map sheets. The Military Map grid lines are shown on the "Index to Maps" and this can be used to locate the military sheet references for any of the soil maps.

The survey area of 68,400 acres includes about 2,000 acres of unirrigated land outside the Nyah Irrigation District on the Murray Valley Highway to the north of Nyah.

### *Settlement, Water Supply and Government Centres*

The Swan Hill, Mystic Park and Fish Point Irrigation Areas, and the Nyah and Tresco Irrigation Districts are all administrative divisions set up by the State Rivers and Water Supply Commission for the control and distribution of water in particular, defined locations. The Fish Point and Mystic Park Irrigation Areas and the Tresco Irrigation District are administered from the Swan Hill district office of the Commission.

With the exception of the Nyah settlement which is irrigated by water pumped locally from the Murray River, the surveyed area occupies the most northern part of the River Murray Irrigation System. Water is diverted by the Torrumbarry Weir on the Murray River near Echuca and gravitates as far north as Woorinen through a natural system of lake and swamp storages. Water is also diverted to the Swan Hill Irrigation Area from the Murray River by a weir near Lake Boga on the Little Murray River, an anabranch of the former river. Recently, supplies tot he Tyntynder and Woorinen areas have been supplemented by pumping from the Murray River at Swan Hill.

Land settlement in the area commenced in 1846 when Andrew and Peter Beveridge "squatted" at Tyntynder and Curlewis and Campbell at Lake Boga. The Tyntynder run extended from Swan Hill to north of Piangil. Swan Hill itself was started by surrounding squatters, and rose to prominence with the river trade inaugurated by Captains Cadell and Randell.

The subsequent history of the area up to the introduction of irrigation is a story of progressive subdivision of land and increasing important of wheat-growing, especially following the invention of the stump-jump plough and the advent of superphosphate.

Irrigation was introduced tot he district in 1887 with the formation of the Swan Hill Irrigation Trust. Many such Trusts were founded after the *Irrigation Act* of 1886, and in 1895 there were thirty Irrigation Trusts in Victoria financed by the State Government. The financial situation of most of the Trusts became most unsatisfactory, and in 1906 the State Rivers and Water Supply Commission was constituted and took over their activities. The history of the various settlements is outlined below.

***Swan Hill Irrigation Area*** – In 1887 John Wyse and other successfully petitioned the State Government to inaugurate the Swan Hill Irrigation Trust. Water was pumped from the Murray River immediately north of Swan Hill to irrigate 15,000 acres of river flats previously used for cereals. After the completion of the Little Murray Weir, pumping was discontinued and the whole district was irrigated by gravitation. In 1965, following complaints of water quality, pumping from the Murray River was resumed at the old pump site.

Much of the old irrigated pasture lands are north of Swan Hill on an area known as the Swan Hill or Tyntynder Flats. This area supports mainly dairy cattle, although beef cattle and fat lambs are also produced. The flats were most productive in the past, with lucerne widely grown. At the Swan Hill sitting of the Royal Commission in 1936 into the administration of water supplies for irrigation, it was stated by the irrigators' representative that an abundance of water could be used on the Flats without fear of causing salting or seepage problems. This prediction unfortunately proved wrong and the productivity of the Swan Hill Flats has gradually declined. This has been referred to in the section, "Soil Features in Relation to Irrigation".

After departmental investigations of the Flats in 1947, it was reported that a free water table occurred very generally, and great care in management of pasture cover and irrigation methods was necessary. In 1952 the State Rivers and Water Supply Commission gave approval to irrigators to pump surplus water into irrigation channels and, whilst this gave some relief in regard to surface flooding, it was not effective in reducing the watertable level. A surface drainage scheme was unanimously accepted by irrigators in November 1960, and construction of drainage works commenced in January, 1962.

***Nyah Irrigation District*** – Irrigation at Nyah was introduced by James Thwaites in 1896 by pumping from a 73 ft shaft fed by the Murray River through a 1,500 ft tunnel. The tunnel was destroyed by flood in 1903 and, in 1906, the State Rivers and Water Supply Commission provided steam pumps to supply water directly from the river.

The Nyah settlement proper was begun in 1910 as the Sir John Taverner Village Settlement, with 50 acre blocks under lucerne. By 1912 these holdings were being subdivided for the planting of fruit trees such as peaches, apples and citrus. Mainly because of marketing difficulties, most of these planting were replaced by vines in 1919. The Vinifera section was opened to Soldier Settlement in 1919 and the Nyah Extension in 1920.

Nyah remains primarily a viticultural area, mostly planted to sultanas for dried fruit production. Citrus, apricots and plums are the principal orchard crops, although apples and pears are also grown. Commercial seed-growing including lettuce, onion and pumpkin is becoming an important industry.

Water is supplied by pumping from the River Murray, a lift of 78 ft being required. Irrigation commenced in late August or early September and the usual interval between irrigations is about four weeks. Six irrigations are usually taken.

***Tresco Irrigation District*** – The Tresco settlement was commenced in 1913 by a private company, Australian Farms Limited, on wheat-farming land purchased from Cornish and Angus. By 1918, about 2,500 acres had been planted to vines and citrus. Waterlogging and salt troubles soon appeared, and the planted area steadily decreased until 1930, when only 750 acres remained. This area has since increased, and limited expansion is still taking place.

Owing to the financial difficulties of the Company and the settlers, the control of the settlement was transferred to the State rivers and Water Supply Commission in 1922.

The Tresco West settlement began after salt and seepage troubles had become apparent at Tresco. Consequently planting were limited to selected higher land and these troubles have been largely avoided. This settlement became included in the Tresco Irrigation District in 1951.

Water is supplied to Tresco by pumping from Lake Boga, a lift of 20 ft being necessary with a re-lift of 25 ft for approximately one-third of the settlement. Generally, six irrigations are given in one season and the shortest period between successive irrigations is 21 days.

***Mystic Park and Fish Point Irrigation Areas*** – These were constituted as irrigation districts by the State Rivers and Water Supply Commission in 1922 and 1926 respectively. Most of the irrigation land supports only annual pastures while unirrigated saline areas are widespread.

***Long Lake and Kangaroo Lake Settlements*** – Citrus-growing developed in these areas following the first world war through private diversion of irrigation water from the Long Lake and Kangaroo Lake storages. However, there has been a gradual decline and the area of citrus is now little more than half that planted in the 1920's. Grapes, mainly table varieties, are grown to a small extent, but there has been little planting of alternative irrigated crops where citrus have been removed.

## Irrigated Culture

The area of land in the Swan Hill district under various types of irrigated culture is given in Table 7 (Anon. 1965).

### *Table 7 – Area of Land under Irrigated Culture in the Swan Hill District, 1964-65*

| | Swan Hill IA* acres | Nyah ID acres | Tresco ID areas | Mystic Park IA acres | Fish Point IA acres | Kangaroo and Long Lake Settlments acres | Total acres |
|---|---|---|---|---|---|---|---|
| Pastures - | | | | | | | |
| Annual | 4,691 | 94 | 35 | 2,582 | 2,514 | | 9,916 |
| Perennial | 13,608 | 52 | 2 | 424 | 413 | | 14,499 |
| Native | 401 | 302 | 10 | 3 | 247 | | 963 |

| | Swan Hill IA* acres | Nyah ID acres | Tresco ID areas | Mystic Park IA acres | Fish Point IA acres | Kangaroo and Long Lake Settlments acres | Total acres |
|---|---|---|---|---|---|---|---|
| Lucerne | 905 | 228 | 12 | 392 | 68 | | 1,608 |
| Cereals | | 60 | | 121 | 20 | | 201 |
| Summer fodder crops | 21 | | | 128 | 17 | | 166 |
| Orchards | 520 | 152 | 192 | 11 | | 480 | 1,355 |
| Market gardens | 757 | 85 | 48 | 5 | | | 895 |
| Vineyards | 3,379 | 1,991 | 1,283 | 22 | | 80 | 6,755 |
| Fallow and miscellaneous | | 199 | | 120 | | | 319 |

* includes the Woorined Settlement

There has been recognition for many years that there are problems associated with the irrigation of both pastures and horticultural crops in the Swan Hill district. The salinity of the heavy-textured soils of the plains in the Mystic Park and Fish Point Irrigation Areas clearly presents difficulties to the establishment of irrigated pastures, and the risks involved in the irrigation of these lands have long been recognized. The place of annual subterranean clover-Wimmera rye grass pastures in the development under limited water supply of lands in northern Victoria is well-known. The marked dominance of annual pastures in these two Irrigation Areas is evident from Table 7, though the areas given also include pastures dominantly of barley grass.

More recently, it has been realized that the soils on the Swan Hill river flat supporting perennial pastures and, for many years, considered to be highly fertile and free from salinity hazards, are deteriorating from encroaching soil salinity. This has been referred to previously in this section, and also in the section “Soil Features in Relation to Irrigation.”

In addition to soil problems of waterlogging, salinity, and chlorosis evident in the Nyah, Woorinen and Tresco settlements from the 1920’s onward, horticulturists have had to contend with difficulties arising from marketing and climate. Realization that all was not well with the dried vine fruits industry generally led to an economic survey of the industry by the Bureau of Agricultural Economics and, as a consequence of its report in 1951, the setting up of a Committee of Enquiry in 1953 to investigate in detail the problems of the Mid-Murray Area adjacent to Swan Hill. The Committee reported (Anon. 1955) on aspects of soil salinity, drainage, climate, frequency of irrigations, prospects for alternative crops, size of holdings, resettlement, adjuncts to production and marketing, and the financial status of growers. Relevant conclusions regarding soil aspects were that, although soil salinity was a major factor responsible for the decline of horticulture, a substantial area of land in each settlement could be expected to remain productive provided drainage was adequate and management sound. Heavy-textured soils were usually unsatisfactory for horticulture and new land should not be considered for such crops unless it would respond to tile drainage.

## *Research Centres in the District*

Research activities are strongly established with community owned research farms at Woorinen, Tyntynder and Kerang.

Following the initial soil surveys published in 1930 and 1933, Block 38H was established at Woorinen by local dried fruit growers as a site for investigations by the Council for Scientified and Industrial Research and the Department of Agriculture into viticultural practices and soil management. Block 38H is administered by the Nyah-Woorinen Enquiry Committee and has set the pattern for community owned research farms. These ventures although primarily directed towards stimulating research into district problems, aim to be self-supporting in the long term.

The Swan Hill Research Farm is a dairy farm purchased in 1954 and located on the river flats about 7 miles from Swan Hill in the Tyntynder area. It is administered by the Swan Hill Irrigators’ Research Committee under the guidance of the Tyntynder Investigation Committee. This committee consists of representatives of the Department of Agriculture, State Rivers and Water Supply Commission, Commonwealth Scientific and Industrial Research Oranization and the Swan Hill Irrigators’ Research Committee. Portion of the Research Farm is made available for investigations by the Government organizations into the irrigation and management of perennial pastures and the reclamation and drainage of the soils.

Research staff of the State Rivers and Water Supply Commission, operating from the Swan Hill office, are active in investigating the distribution of underground water and the hydraulic conductivity of soils in relation to their drainage potential.

*Advisory Services*

The Department of Agriculture provides advisory services from its district offices at Swan Hill and Kerang. The State Rivers and Water Supply Commission at Swan Hill combines with the Department to provide advice on the drainage of fruit blocks. The service includes inspection to study the drainage problem, provision of working plans and survey levels, and advice on costs.

## Climate

The average rainfall varies from 13.1 inches at Swan Hill to 11.2 inches at Nyah. Table 8 shows that the winter rainfall is a little higher than summer rainfall, 7.39 inches falling on the average in the period April to September, and 5.70 inches in October to March. The rainfall varies considerably from year to year, the recent highest and lowest values being 23.76 inches in 1956 and 6.67 inches in 1944. Data are not given, but the rainfall in summer and autumn is more erratic than in winter and spring.

### *Table 8 – Meteorological Data – Swan Hill*

| Month | Rainfall (30 years) | Temperature (35 years) | | | Evaporation (24 years) in | P/E |
|---|---|---|---|---|---|---|
| | | Average Maximum in | Average Minimum °F | Average Mean °F | | |
| January | 0.68 | 89.1 | 59.1 | 74.1 | 9.27 | 0.07 |
| February | 1.13 | 89.3 | 59.7 | 74.5 | 7.24 | 0.16 |
| March | 0.77 | 83.3 | 54.9 | 69.1 | 6.14 | 0.13 |
| April | 0.79 | 73.9 | 49.2 | 61.5 | 3.90 | 0.20 |
| May | 1.31 | 65.7 | 44.1 | 54.9 | 2.45 | 0.54 |
| June | 1.46 | 58.5 | 40.3 | 49.4 | 1.75 | 0.84 |
| July | 1.19 | 58.1 | 39.0 | 48.5 | 1.64 | 0.73 |
| August | 1.29 | 61.5 | 40.5 | 51.0 | 2.38 | 0.54 |
| September | 1.35 | 67.3 | 43.7 | 55.5 | 3.72 | 0.37 |
| October | 1.28 | 74.4 | 48.0 | 61.2 | 5.29 | 0.24 |
| November | 0.83 | 82.1 | 53.0 | 67.6 | 7.06 | 0.12 |
| December | 1.01 | 87.0 | 56.9 | 71.9 | 8.63 | 0.12 |
| Year | 13.09 | 74.2 | 49.0 | 61.6 | 59.47 | |

Evaporation figures for Merbein are quoted as there are no reliable figures available for Swan Hill. Annual evaporation calculated from humidity and temperature data using a formula proposed by Prescott (1938) is 60-53 inches for Merbein and 60-23 inches for Swan Hill, indicating that the actual evaporation should be very similar at both places.

The ratio of rainfall to evaporation (P/E) is useful to illustrate the general aridity of the climate. The P/E figures show a complete dominance of evaporation over rainfall in all months of the year. The highest ratios are for June and July when the rainfall is about three-quarters of the potential evaporation. From November to April, rainfall is only one-fifth of the potential evaporation.

Temperatures fall below 32°F (heavy frost) on an average of 1.8 days in August and 0.5 days in September. Temperatures between 32°F and 36°F (light frost) occur on an average of 5.6 days in August, 3.2 days in September and 0.8 days in October.

## Geology and Physiography

*Geology*

The surveyed area occupies a plain of deposition and represents the eastern portion of the ancient Murray Gulf, which reached its greatest development in Miocene times. Limestones, marine sands and clays associated with the Miocene sea are overlain by lacustrine, fluviatile and aeolian deposits laid down during the alternatively wet and dry periods of the Pleistocene and later. Bores sunk by the Mines Department show that these deposits are more than 300 feet thick within the Swan Hill district. The formations are loosely compacted and represent the landsurface of today.

## *Physiography*

The western part of the area, commonly referred to as the Mallee, is dominantly an aeolian landscape comprising plains, east-west dunes, north-south ridges and lunettes. Lunettes are crescentic ridges associated with the eastern peripheries of playas and lakes, generally between 15 and 30 feet high.

The eastern part of the area is a riverine plain traversed by the Murray River and its anabranch, the Little Murray River. The present flood plain of the Murray River extends to the mallee fringe and in places is several miles wide.

The rivers have cut themselves steep sided channels about 20 feet deep, and are essentially "rivers of transit" as, owing to the low rainfall and absence of defined watercourses, the area contributes little to their flow. In general, runoff after heavy rain occurs only on steeper slopes and is locally contained. Erosion from surface runoff is particularly severe on some lunettes.

## *Depositional Layers*

Detailed studies by Churchward (1961, 1963a, 1963b) have shown that the aeolian landscape has been built up by a succession of depositional layers, marking cycles of stable and unstable periods in the history of the landscape. These layers provide groundsurfaces on which soils have developed. Each cycle involved in groundsurface development comprised an unstable phase of erosion, deposition and burial, followed by a stable phase of landsurface conditions during which soil development occurred. The materials of the layers comprise sands moved by saltation, mixed with variable amounts of a finer fraction moved in atmospheric suspension. The latter is a more or less calcareous, clayey material called parna by Butler (1956). Five aeolian depositional layers have been recognized and given local names by Churchward.

The uppermost layer is the *Piangil.* This is a contemporary deposit directly related to wind erosion and deposition following the clearing of vegetation. It shows no pedogenetic features.

The youngest layer at the advent of European settlement is the *Kyalite* which conforms to the present shape of the dunes and ridges, although it is mainly associated with the dune crests and depositional slopes. Soil development is weakly expressed. There is little change in clay content with depth, and calcium carbonate, if present, is only slightly leached and not concentrated in segregations.

The *Speewa* layer extends as a continuous sheet over all elements of the aeolian landscape and, where it is not covered by the Kyalite layer, it occurs on the present surface. Pedogenetic features are evident and both clay and lime maxima have developed in the layer. Subsequent erosion has exposed the lime in many places.

The *Bymue* underlies the Speewa layer and has not been found exposed at the surface. It shows similar profile development to the Speewa although rather more leached and organized.
The *Tooleybuc* layer underlies the Bymue and is continuous, following in a general way the contours of the present landscape. It is strongly organized, lime-free, and generally very slowly permeable to water.

The above layers are evident in the lunettes but the greater thickness of one or more of the layers indicates that parna deposits have been supplemented by material blown from the dry bed of the lake.

The riverine landscape also is built up by a succession of depositional riverine layers, with or without interposed aeolian layers. The riverine layers from the surface downward are the *Coonambidgal, Mayrung, Quiamong* and *Katandra* (Butler 1958).

## ***Vegetation***

The landscape units described earlier originally carried their own distinctive vegetation. However, this has been greatly modified by clearing for agricultural purposes and now only remnants remain.

The dominant tree cover on the mallee dune and plain landscape consisted largely of the small eucalypts, oil mallee *(Eucalyptus oleosa)* and dumosa mallee *(E. dumosa).* Belar *(Casuarina cristata)* and needlewood *(Hakea vittata),* as well as shrubs such as blue bush *(Kochia spp.)* and various acacias *(Acacia* spp.), occurred on the flatter and gently sloping situations. Murray pine *(Callitris* spp.) and mallee were the dominant species on the lighter soils of the dunes. Other common species in these situations were sandalwood *(Myoporum platycarpum),* cattle bush *(Heterodendron oleifolium),* hop bush *(Dodonaea attenuata),* tea-tree *(Leptospermum laevigatum* var *minus),* and grevilleas *(Grevillea spp.).* Spear grass *(Stipa spp.)* and wallaby grass *(Danthonia spp.)* mainly comprised the sparse ground cover.

Woodland, dominantly black box (*E. largiflorens)* but with some buloke *(Casuarina Leuhmannii),* belar, and needlewood, was associated with much of the flatter country adjoining the mallee dunes.

The river flats near Swan Hill contrast with river flats elsewhere along the Murray River in that the former were always treeless, except for a few scattered red gum *(E. camaldulensis)* along the river banks. The ground cover consisted of native grasses and sedges, with nardoo *(Marsilea drummondii)* growing in seasonally waterlogged areas.

The present plant cover variously reflects the hand of man. Much of the area now receives water from irrigation and carries sown pastures or horticultural crops. The sown pastures are either annual pastures of subterranean clover *(Trifolium subterraneum)* and Wimmera rye grass *(Lolium rigidum),* or perennial pastures based on perennial rye grass (*L. perenne*), white clover *(T. repens)* and strawberry clover *(T. fragiferum).* Paspalum *(Paspalum dilatatum),* even if not actually sown, soon appears in most perennial pastures and often becomes the dominant species.

The volunteer pastures mostly comprise native grasses, rye grasses, barley grass *(Hordeum murinum)* and various medics such as burr medic *(Medicago polymorpha* var. *vulgaris)* and barrel medic *(M. truncatula).*

Halophytic species commonly found on the very saline areas are seablite *(Suaeda maritima),* black roly poly *(Bassia quinquecus*pis), samphire *(Crithmum maritimum),* salt bush *(Ariplex spp.)* ice plant *(Mesembryanthemum crystallinum)* and pigface *(M. aequilaterale).* Sea barley grass *(Hordeum hystrix)* occurs on the moderately salt-affected soils.

Dillon bush *(Nitraria schoberi)* occurs on the treeless plain, with lignum *(Muehlenbechia cunninghamii)* in swampy depressions.

*Weeds.-On the* unirrigated mallee dunes, one of the most extensive weeds is onion-weed *(Asphodelus fistulosus).* Other common weeds on the dune soils are saffron thistle *(Carthamus lanatus),* skeleton weed *(Chondrilla juncea),* hogweed *(Polygonum aviculare),* paddy melons *(Cucumis myriocarpus),* wild melon *(Colocynthis citrullus),* and heliotrope *(Heliotropium europaeum).*

Love grass *(Eragrostis* spp.), capeweed *(Cryptostemma calendula),* spiney emex *(Emex australis)* and fat hen *(Chenopodium album)* are among the common weeds in the horticultural areas.

Black rush *(Juncus polyanthemus) and* docks *(Rumex spp.)* are widespread in perennial pastures on the river flats. Bathurst burr *(Xanthium spinosum)* occurs throughout the district, but is most common along the Murray and Little Murray Rivers.

Cumbungi *(Typha spp.)* forms tall, dense stands in irrigation channels and drains. Other water-weeds which present a continual threat to efficient water distribution are water couch *(Paspalum distichum),* eel weed *(Vallisneria spiralis)* and cat tail *(Myriophyllum elatinoides).*

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