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The Soils of the Western Part of the Murray Valley Irrigation Area and their Classification for Irrigation

(with particular reference to the parishes of Ulupna,
Yalca, Yielima, Picola, Narioka, Barwo, Waaia, and
Mundoona, County of Moira, Victoria)

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CONTENTS

	Page
I. Introduction	5
II. The Soils	6
III. Soils in Relation to Vegetation	13
IV. Classification of Soils as to Suitability for Irrigation Development	14
V. Soils in Relation to Irrigated Pastures and Crops	18
VI. Acknowledgments	21
VII. References	23

THE SOILS OF THE WESTERN PART OF THE MURRAY VALLEY IRRIGATION
AREA AND THEIR CLASSIFICATION FOR IRRIGATION (WITH PARTICULAR
REFERENCE TO THE PARISHES OF ULUPNA, YALCA, YIELIMA, PICOLA,
NARIOKA, BARWO, WAAIA, AND MUNDOONA, COUNTY OF MOIRA,
VICTORIA)

I. INTRODUCTION

This soil survey is a continuation of the soil surveys carried out in the Murray Valley Irrigation Area and published in Coun. Sci. Industr. Res. Aust. Bull. No. 152 (1942) and Division of Soils, Divisional Report No. 6/46, and completes the whole of the area.

Several new soil types have been encountered during the present survey, but the majority of soils in the area are similar to those mapped during previous surveys. The same relationships between soil pattern and physiography apply as are discussed in Division of Soils, Divisional Report 6/46.

In this report the soils are discussed as individual soil types and as soil associations in relation to their irrigability, probable suitability for irrigation crops, and, briefly, in relation to natural vegetation.

The soil types are defined on their features to a depth of 7 ft. Usually the uppermost layer of soil is a loam, sandy loam, or clay loam. This layer is called the "surface" soil. The lower part of this layer may be paler in colour than the upper and is referred to as the "bleached" layer. Immediately below the surface soil there is a clay layer or "clay pan" which is called the "subsoil". This layer is usually about 2 ft. thick and may have concentrations of lime and limestone rubble in the lower part of the layer. The portion of the soil below 24 or 30 in. is here termed the "deep subsoil". These various layers of soil described above are referred to as "soil horizons", which make up the "soil profile" as viewed in the side of a pit.

The physical nature of the clay in the subsoil is important in defining the soil type. This clay breaks up naturally into pieces or aggregates, which vary in hardness with moisture content. If the size of the aggregate is approximately 1 in., it is said to be "nutty". The hardness of the aggregates varies from hard or crumbly when dry to friable or sticky when moist or wet. If the clay breaks into aggregates of 2-3 in. diameter, it is said to be "coarse-nutty", whilst diameters of over 4 in. give a "lumpy" clay. When the clay shows no great tendency to break into aggregates, but is dug out in large irregular lumps of 8 in. or more in diameter, it is said to be "massive".

A soil map on which individual soil types are delineated accompanies this report. Included in this soil map is the soil map of the previously surveyed Soldier Settlement Area. A soil association map has been compiled to show the occurrence of major soil series throughout the area. It must be understood that this map is on a broader scale than the detailed map which shows individual soil types. Areas mapped as, for instance, Moira association will contain small areas of other soil types, but the soils of the Moira association predominate.

II. THE SOILS

With the exception of several new soil types and phases, the soil types occurring in the area surveyed are largely the same as those described by Butler *et al.* (1942). The Waaia loam and its sandy subsoil phase have been previously recorded in this area by Butler (1946) as also have two unnamed soil types designated by him as type 2 and type 3. These have been named Narioka silty clay loam and Barwo silty loam respectively. Other new soil types recognized and named during the survey include Waaia sandy loam, Boosey clay loam, Picola loam, Kaarimba silty loam, Nathalia fine sand, and another well-drained depression soil type E.

New phases have been distinguished in previously named soil types such as the gilgai phase of Mywee clay, the uncemented phases of the Katunga series, and the heavy profile phases of Moira and Naring loams.*

*Naring loam is an abbreviation of Naringaningalook loam as originally named. This abbreviation will be used throughout the text.

Katunga sandy loam was originally described, mapped, and named at Pine Lodge, Tocumwal, N.S.W., by Johnston and Butler (1946). It was not previously encountered in this area.

There are altogether 25 soil types occurring in the area with 16 soil phases of one or other of these soil types. They belong to 15 soil series and one group of variable soils which occur in the gullies of old stream beds. For purposes of further simplification the soil series are grouped into soil associations.*

There are seven of these soil associations:

- (a) Cobram association,
- (b) Katunga association,
- (c) Moira association,
- (d) Boosey association,
- (e) Ulupna association,
- (f) Barwo association, and
- (g) Sandmount association.

(a) Cobram Association

(i) Cobram Sandy Loam.- Brown sandy loam to 6 in.; light brown sandy loam to 12-18 in.; red-brown medium or heavy clay to 21-27 in. over sandy clay going to sandy clay loam, sandy loam, and sand.

(ii) Cobram Loam.- Brown loam or fine sandy loam to 4 in.; light brown loam or fine sandy loam to 9 in. overlying dark red-brown heavy clay with limestone rubble by 18-21 in. This clay is nutty and crumbly when dry, friable when moist. At 27 in. this clay rapidly gives way to fine sandy clay and may go to a fine sandy loam by 48 in.

(iii) Waaia Sandy Loam.- Brown sandy loam to loamy sand to 5 in. over light brown hard and compacted (when dry) sandy loam to 10-12 in., where a reddish brown clay occurs. This clay is somewhat hard and nutty when dry and crumbly to

* A soil association is a group of soils, with or without common characteristics, geographically situated in an individual pattern.

friable when moist. At 18-21 in. the clay has yellowish mottling and slight lime and large rubble (1-2 in. diam.) appears. At 27 in. the colour is predominantly grey with brown and yellow mottling and the texture becomes rapidly lighter, usually a fine sandy clay by 33 in. and fine sand or sand by 7 ft. The lime persists as an odd small piece of rubble.

(iv) Waaia Loam. - Brown loam or fine sandy loam to 4 in. overlying 4-6 in. of paler brown to light brown similar material which is hard when dry. At 8-10 in. a dark red-brown nutty, rather crumbly, heavy clay occurs. The colour becomes less red with depth and lime and rubble appear about 21 in. Below 27 in. the colour changes, grey predominating with yellow, brown, and black mottling and the texture falls off to light clay and then silty clay and fine sandy clay. In the sandy subsoil phase of Waaia loam the texture below 36 in. is fine sandy clay loam. Cases occurred where the texture below 5 ft. became heavier, frequently up to silty medium clay or silty clay.

(b) Katunga Association

(i) Katunga Sandy Loam. - Brown sandy loam to approximately 6 in. overlying a hard layer (when dry) of light brown compacted sandy loam to 15-21 in. This layer becomes harder and rather cemented towards the bottom. At 21 in. a thin layer (4-6 in.) of hard, brown sandy clay occurs. Immediately beneath this clay layer a heavily cemented sandy hardpan occurs. Textures vary from sandy clay loam to loamy sand and the thickness of this cemented layer varies from 2 to 4 ft. Below this layer coarse sands and gravels are usually found.

(ii) Katunga Gravelly Loam. - Shows similar characteristics to Katunga sandy loam but a large amount of gravel is found throughout the soil profile. The surface is a gravelly loam or gravelly sandy loam and the other soil layers are pronouncedly gravelly. Both Katunga sandy loam and Katunga gravelly loam have phases which are weakly cemented, but resemble the type in all other aspects. These phases are referred to as the "uncemented" phase of the type.

(iii) Katunga Loam. - Brown loam with some gravel to 9 in. overlying a dark reddish brown clay, which is nutty and

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hard when dry but crumbly when moist. At 24 in. there is a cemented layer similar to that found in Katunga sandy loam. Beneath this layer the deep subsoil consists of coarse sands and gravels.

Included in the Katunga Association are small areas of Cobram and Sandmount series.

(c) Moirra Association

(i) Moirra Loam

(1) Normal Phase.- Brown loam to 3 in. and then compact light brown loam or clay loam to 6-8 in. over a dark red-brown, coarse-nutty, heavy clay, which is hard when dry. At 21 in. the colour is grey with yellow, brown, and black mottles and the texture usually falls off to a medium clay.

(2) The light profile phase of Moirra loam is similar to the normal except that the texture is light clay at about 36 in.

(3) The friable subsoil phase of Moirra loam has a friable deep subsoil (below 27 in.) as against the hard, angular nature of the normal.

(4) The heavy profile phase of Moirra loam is confined to the northern and eastern extremities of the area. There is a surface of brown loam or clay loam (3-4 in.) over a layer of material similar in texture, but light brown in colour (3-4 in.). The subsoil is dark reddish brown mottled with yellow-grey and black and is a lumpy, heavy clay. The mottling increases with depth so that yellow-grey becomes the dominant colour by 30 in. where some lime and rubble occur. The rubble usually persists to the deep subsoil which remains heavy clay.

(ii) Naring Loam

This soil has many features in common with Moirra loam. It is distinguished by the grey-brown surface colour and general drabness of colour throughout the profile. The surface soil consists of 3 in. of grey-brown loam and a further 3-5 in. of light grey-brown loam. The subsoil is dark grey-brown or dark brown and rather more coarse-nutty

than in Moira loam. Lime and rubble occur between 21 and 30 in. where the colour is yellow-grey mottled with brown and black. Naring loam has normal, light profile, friable subsoil, and heavy profile phases, which show similar distinguishing characteristics to the equivalent phases of Moira loam.

A minor proportion of the area of the Moira association consists of soils of the Cobram, Waaia, Boosey, and Muckatah series.

(d) Boosey Association

(i) Boosey Loam.- Grey or brownish grey loam surface to 3 in., then light grey compact loam or clay loam to 6 in. The clay is dark yellowish grey or dark brownish grey and very lumpy and hard when dry and sticky when wet. Yellowness increases with depth and some lime and rubble appears about 27 in. Below this depth the texture usually lightens to medium clay. As with Moira loam there are normal, light profile, and friable subsoil phases of this soil type, which are characterized as shown above.

(ii) Boosey Clay Loam.- Has a grey or brownish grey surface of clay loam to light clay to 3 in. The bottom inch is usually light grey in colour. The remainder of the profile is similar to Boosey loam except that texture usually remains heavy clay to depth.

(iii) Muckatah Clay Loam.- The surface soil, which is grey or light grey in colour, varies in texture from clay loam to medium clay. The clay occurs at 2-3 in. and is darkish grey and very massive. Lime and fine rubble usually occur at 15-21 in. and the colour of the deep subsoil is grey and yellow-grey and remains a heavy clay.

In the Boosey Association also occurred small areas of Moira, Naring, Waaia, and Ulupna series.

(e) Ulupna Association

(i) Picola Loam.- Brown loam or clay loam to 4 in. over deep brown coarse-nutty to lumpy, heavy clay. At 16-18 in. there is a rather sharp change of colour to brown. The clay becomes mottled with yellow and grey at 27 in. where

considerable quantities of crystalline gypsum occur. At 30 in. the colour is grey with yellow, brown, and black mottling and the gypsum decreases till it is totally absent by 48 in. The texture of this layer falls off rapidly and is usually a light clay by 48 in. Below this depth silty clays are usually found.

(ii) Ulupna Clay.- Has about 2 in. of brown-grey clay surface over a dark brownish or yellowish, very lumpy, heavy clay. At about 21 in. the brownness increases to almost grey-brown and crystalline gypsum appears. Below 33 in. the colour is grey with brownish, yellowish, and black mottles, gypsum disappears, and the textures become silty.

(iii) Mywee Clay.- Grey or light grey clay surface soil to 1-2 in. over very lumpy dark grey, heavy clay. At 21 in. the colour is grey and traces of lime and rubble or crystalline gypsum, or both, may occur. Below 36 in. the grey colour is mottled with rusty-brown and yellow and the texture lightens and may become more silty. There are patches of Mywee clay with strong development of gilgai formation. The profile resembles the normal, but traces of fine limestone rubble may be found on the surface of the soil and throughout the first 2-3 ft. of the puff part of the profile.

Also included in the Ulupna association are minor areas of such soil series as Moira, Boosey, and Muckatah.

(f) Barwo Association

(i) Barwo Silty Loam.- Brown silty loam or fine sandy loam to 4 in. over light grey (bleached) silty loam or fine sandy loam to 8-9 in. overlying the subsoil. The subsoil clay is brown mottled with yellow and is hard and compact when dry. There is usually a marked siltiness in the subsoil clay. There may be a trace of lime at 21 in., but usually no lime is present. At this depth the silt content increases rapidly and the clay is usually a grey silty clay by 30 in. and remains so to depth. The grey-brown phase is similar in all profile characteristics, including colour of the subsoil, but the surface is grey-brown.

(ii) Kaarimba Silty Loam.- Has a brown silty loam or fine sandy loam surface extending to 4 in. and overlying a light grey bleached layer of similar material which is some-

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what more compact than the surface. The clay pan occurs at 8 in. and is brown or yellowish brown, mottled with light brown and yellow-grey. This layer is hard and compact to massive when dry. At 18 in. the clay gives way suddenly to a yellow-grey and brown mottled fine sandy clay which may contain traces of limestone rubble. The texture rapidly falls off to fine sandy clay loam, fine sandy loam, or fine sand. The grey-brown phase of Kaarimba silty loam is similar in all respects, but for the surface, which is grey-brown in colour.

(iii) Narioka Clay Loam.- Light grey to grey clay loam or silty clay loam to 2 in. overlying a grey silty clay. This clay becomes less silty and darker in colour to be a darkish or dark grey (often with brownish and black mottles) heavy clay by 7 in. After 24 in. the colour is grey mottled with yellow, brown, black, and rusty-brown and is more silty, frequently becoming silty clay or silty clay loam by 5 ft.

Minor areas of Sandmount, Nathalia, Boosey, Waايا, and Moira series also occur in the Barwo association.

(g) Sandmount Association

(i) Sandmount Sand.- Brown or dull brown sand to 4-6 in., thence lightish brown sand to 21 in. where the colour becomes light brown. Below 48 in. brown or reddish brown nodules of loamy sand occur in the matrix of sand. The shallow phase of Sandmount sand goes to sandy clay loam or sandy clay after 24 in., but usually becomes sandy loam or sand again by 48 in.

(ii) Nathalia Fine Sand.- Pale brown fine sand to depths of 4-5 ft. where the colour is a light brownish yellow. The upper 2 ft. are slightly compacted.

Very small areas of Barwo and Kaarimba series may be found in this association.

(h) Well-drained Depression Soils

In all these associations, but least in the Ulupna association, the Well-drained Depression Soils occur. These soils are variable in composition, but can be described broadly as follows:

Type A.- A grey-brown soil somewhat akin to Cobram loam, but containing no lime.

Type B.- A grey-brown sandy soil varying from an undifferentiated profile like Sandmount sand to a soil similar to Cobram sandy loam in texture with no lime in the profile.

Type C.- A grey sandy soil with a sand or sandy loam surface and sandy clay subsoil. The deep subsoil is coarse-textured and may go to sand or gravelly sand. There is no lime in this soil type.

Type D.- A brown soil usually resembling Cobram sandy loam in texture and colour (with no lime), but may be similar to Sandmount sand.

Type E.- A grey or brownish grey soil usually occurring in the larger stream beds. The surface is a grey loam or sandy loam overlying a grey or yellowish grey heavy clay at 6 in. The texture becomes somewhat silty with depth and is usually a silty clay in the deep subsoil. This is the least well-drained member of the group.

III. SOILS IN RELATION TO VEGETATION

The area prior to settlement and clearing was dense savannah woodland with a small, almost treeless plain north of Nathalia. Grey box is the dominant tree occurring on all soil types, but black box is found on the heavier soil types in the north of the area, e.g. Boosey clay loam, Ulupna clay, and the heavy profile phase of Moira loam. Bull oak is usually associated with the grey box. Needlewood can be found chiefly on the low ridges where the soil type belongs to the Katunga series. Pine is fairly ubiquitous, but prefers the lighter soils, especially the sandhills. Yellow box is sometimes found on sandhills and some of the lighter soils such as Cobram loam. River red gum is found along the Broken Creek and in some depressions in the plains, but generally on heavy grey soils such as Muckatah clay loam and Narioka clay loam. The chief grass is wallaby or white top, which is largely replaced on the sandhills by corkscrew grass. There is a heavy seasonal growth of barley grass and burr medic.

IV. CLASSIFICATION OF SOILS AS TO SUITABILITY FOR IRRIGATION DEVELOPMENT

Various factors influence the use of a soil for irrigation, such as depth and permeability of the surface soil, permeability of the subsoil, presence of a cemented hardpan in the subsoil, and liability to water-table development. As the behaviour under irrigation of these or similar soils has been studied in adjacent areas, we can make a fairly sound classification as to their suitability for irrigation development.

The soils of the western part of the Murray Valley Irrigation Area may be placed in six categories according to the various factors influencing their irrigability.* These may be indicated on the soil map by the use of six distinct colours.

(a) Carminé.- Soils of very high permeability with no impeding layers and very permeable deep subsoils. High topographical positions and low water-retaining capacity. Liable to over-watering, but water-tables develop only in lowest positions. Salting negligible.

(b) Yellow.- Soils of high permeability with permeable deep subsoils. Subsoil forms a layer of lower permeability between surface and deep subsoil. Slightly high to level topography and moderate to high water-retaining capacity. Liability to water-table development and salting is moderate.

(c) Brown.- Soils containing a cemented horizon.

(d) Purple.- Soils of moderate to low permeability in both subsoil and deep subsoil. Level topography, high

*These six categories are best shown on the map and referred to in classification by colour names which have been used for a considerable time in denoting soil groups of specified nature and irrigation characteristics. These colours, which have been used extensively in colouring land-use maps, and hence are understood by land settlement authorities, are carminé, yellow, brown, purple, grey, and green. Although the groups are numbered (a) to (f) they are in no sense in order of usefulness or irrigation value.

water-retaining capacity, and moderate to low liability to salting due to water-table development.

(e) Grey.- Soils of low permeability in low topographic positions liable to seasonal flooding. Liability to water-table and salting troubles low.

(f) Green.- Soils with thin dispersed surfaces, and dense clay subsoils and deep subsoils. Level topography, high water-retaining capacity, and low risk of water-table development or salting.

It must be emphasized that salting is largely dependent on water-table development. The salt content of the deep subsoil has, however, some bearing on the risk of salting. It is arbitrarily considered that soils containing less than 0.05 per cent. sodium chloride (salt) are in no danger of salt troubles, whereas soils containing more than 0.2 per cent. salt have a strong liability to salting. In Table 1 the average salt content at 4 ft. is given for each soil type. It will be seen that the Katunga series are very liable to water-table development but are not likely to be affected by salt owing to the low (less than 0.02 per cent.) salt content of the deep subsoil.

The majority of the remaining soil series contain less than 0.1 per cent. salt, which is not appreciable unless there is a definite likelihood of water-table development. Mywee clay has 0.16 per cent. salt at 4 ft. but the low permeability of the clay renders the formation of a water-table most unlikely. However, Barwo silty loam may give rise to salt troubles with 0.20 per cent. salt in the deep subsoil and a moderate likelihood of water-table development.

Table 1 summarizes all the above points. The accompanying soil map is not published in colour, but interested parties may find it to be more explicit if they colour the map according to the colour categories in Table 1. It must be stressed that these colours bear no relationship to colours used on soil maps previously published by C.S.I.R.O.

Table 2 shows the area in acres and the percentage of total area of each colour category. It is interesting to note that the two most useful categories (yellow and purple) comprise 62.25 per cent. of the total area.

TABLE 1
CHARACTERISTICS OF INDIVIDUAL SOIL TYPES IN RELATION TO THEIR SUITABILITY FOR IRRIGATION

Soil Type	Surface Depth (in.)	Thickness of Subsoil (Clay Pan)	Texture of Deep Subsoil	Liability to Water-table Development	Average Salt Content at 4 ft. (%)	Topographical Position	Colour Category
Sandmount sand	48	Nil	Sand	Nil	0.007	Very high	Carmine
Sandmount sand - Shallow phase	24	Thin	Sand	Nil	0.025	High	Carmine
Nathalia fine sand	48-60	Nil	Fine sand	Nil	0.008	Very high	Carmine
Katunga sandy loam	15-21	Thin	Cemented hard pan	High	0.015	High	Brown
Katunga gravelly loam	15-21	Thin	Cemented hard pan	High	0.024	High	Brown
Katunga uncemented phases	15-21	Thin	Sandy or gravelly	High	0.015	High	Carmine
Katunga loam	9	Moderate	Cemented hard pan	High	0.015	Slightly high	Brown
Cobram sandy loam	12-18	Thin	Sandy	Moderate	0.100	Slightly high	Yellow
Waaia sandy loam	10-12	Moderate	Fine sandy	Moderate	0.043	Slightly high	Yellow
Cobram loam	9-12	Moderate	Fine sandy	Moderate	0.115	Slightly high	Yellow
Waaia loam - Sandy subsoil phase	8-10	Moderate	Fine sandy	Moderate	0.106	Slightly high to level	Yellow
Normal phase	8-10	Moderate	Light clay	Moderate	0.114	Slightly high to level	Yellow
Moirra loam - Friable subsoil phase	6-8	Moderate	Medium clay	Moderate	0.066	Level	Yellow
Light profile phase	6-8	Moderate	Light clay	Moderate	0.113	Level	Purple
Normal phase	6-8	Moderate	Medium clay	Low	0.086	Level	Purple
Heavy profile phase	3-4	Very thick	Heavy clay	Low	0.066	Level	Purple
Naring loam - Heavy profile phase	3-4	Very thick	Heavy clay	Low	0.073	Level to slightly low	Purple
Normal phase	6-8	Very thick	Medium clay	Moderate	0.091	Level to slightly low	Purple
Light profile phase	6-8	Thick	Light clay	Moderate	0.088	Level to slightly low	Purple
Friable subsoil phase	6-8	Thick	Medium clay	Moderate	0.076	Level to slightly low	Purple
Boosey loam - Normal phase	6	Very thick	Medium clay	Low	0.092	Low	Grey
Light profile phase	6	Thick	Light clay	Low	0.078	Low	Grey
Friable subsoil phase	6	Thick	Medium clay	Low	-	Low	Grey
Muckatah clay loam	2-3	Very thick	Heavy clay	Low	0.105	Low	Grey
Boosey clay loam	3	Very thick	Heavy clay	Low	0.110	Low	Green
Picola loam	4	Thick	Light clay	Moderate	0.138	Level	Green
Ulupna clay	2	Very thick	Heavy clay	Low	0.105	Level to slightly low	Green
Mywee clay	1-2	Very thick	Heavy clay	Low	0.160	Level to low	Green
Kaarimba silty loam	4	Moderate	Fine sandy	High	0.079	Slightly high	Yellow
Barwo silty loam	4	Thick	Silty clay	Moderate	0.200	Slightly high to level	Purple
Narioka silty clay loam	2	Thick	Silty clay	Low	0.095	Low	Grey
A, B, C, and D	10+	Thin or Nil	Sandy	Low	0.010	Low	Carminc
E	6	Moderate	Sandy or silty	Low	0.020	Low	Yellow

TABLE 2

AREAS OF COLOUR CATEGORIES

Colour Category	Soil Types or Series	Area (acres)	Total Area (acres)	Percentage of Total Area
Carmine	Sandmount series	1,950	6,074	7.80
	Nathalia fine sand	162		
	Well-drained depression soils, A, B, C, and D	3,493		
	Katunga series - uncemented phase	469		
Brown	Katunga series	2,645	2,645	3.40
Yellow	Cobram series	4,619	22,018	28.30
	Waaia series	15,409		
	Moirra loam - friable subsoil phase	424		
	Kaarimba silty loam	594		
	Well-drained depression soil E	972		
Purple	Moirra loam	7,421	26,426	33.95
	Moirra loam - light profile	8,601		
	heavy profile	463		
	Naring series	8,561		
	Barwo silty loam	1,380		
Grey	Boosey loam	7,404	12,116	15.57
	Muckatah clay loam	3,841		
	Narioka silty clay loam	871		
Green	Picola loam	1,720	8,546	10.98
	Ulupna clay	2,623		
	Mywee clay	949		
	Boosey clay loam	3,254		
TOTAL			77,825	100.00

V. SOILS IN RELATION TO IRRIGATED PASTURES AND CROPS

Most of the soils encountered in the area surveyed have been previously mapped in the eastern portion of the Murray Valley Irrigation Area, where they have been used for some years to produce pastures and crops under irrigation. Much information is therefore available as to their response to irrigation and suitability in this regard. Several new soil types were discovered which do not occur in the previously surveyed area and about which no information is available. Their probable suitability for irrigation may be fairly reliably forecast by correlating their characteristics with similar soils of known irrigation potential.

(a) Cobram Association

The Cobram series provides the best lucerne-growing soils of the area. The sandy subsoil phase of Waaia loam should be equal to or better than the Cobram series, but the normal phase of Waaia loam has a heavier deep subsoil and may not be quite so suitable. Most of the soils in the association are excellent for pastures, fodder crops, cereals, and horticultural crops such as peaches, apricots, and pears. Both these soil types occur in small areas and should be reserved for lucerne. They are quite suitable for summer pastures and fodder crops but, owing to rather low water-retaining capacity, require frequent waterings during the summer months. Most of the soils in the Cobram Association are in the yellow colour category.

(b) Katunga Association

The outstanding feature of these soils is the presence of the cemented hardpan at approximately 2 ft. Provided that the hardpan is not completely impermeable, lucerne should do reasonably well on Katunga sandy loam. Winter pastures and cereals should be fair on all the Katunga series, but summer pastures and crops would require too frequent applications of water on Katunga sandy loam and Katunga gravelly loam. Certain areas of these latter soil types have been mapped as "uncemented". In these both lucerne and citrus should do well. Both in these uncemented types and in the event of the hardpan being permeable, the coarse-textured deep subsoil will quickly dispose of any surplus water. In this association the Katunga series belongs to the brown colour category.

(c) Moira Association

The soils of this association are all characterized by a "clay pan" near the surface which hinders the downward movement of irrigation water. All phases of Moira loam are recommended for pastures and cereals and all except the heavy profile phase for pears. The friable subsoil phase should give good results with lucerne, peaches, and apricots, owing to the permeable nature of the friable deep subsoil. The light profile phase should give reasonably good results with lucerne and apricots.

All phases of Naring loam should give good results for irrigated cereals and be fairly well suited to pastures, but only the friable subsoil phase can be recommended for lucerne. The Naring series occurs in slightly lower topographical positions than the Moira series and is less well drained.

Most of the soils in the Moira Association are in the purple colour category.

(d) Boosey Association

Boosey loam and its various phases should produce good winter cereal crops and fair to good pastures and summer cereals. However, this soil type occurs as areas of occluded drainage or depressions in the plain and displays all the features of seasonal swamps. Local conditions in this respect should be taken into account before this soil is used for irrigation. Established pastures could be quickly destroyed by local flooding due to heavy rains.

Boosey clay loam occurs in more extensive areas than Boosey loam, but is low-lying, and numerous depressions, which hold water after rain, render it rather unsuitable for pastures and crops. Providing that they are not flooded for lengthy periods, both winter and summer cereals and pastures should give fair results.

Muckatah clay loam occurs as crabhole depressions that are usually seasonal swamps. Expense in grading and great risk of flooding render this soil unsuitable for irrigation.

Most of the soils in the Boosey association are in the grey colour category, but Boosey clay loam is in the green colour category.

(e) Ulupna Association

With the exception of Muckatah clay loam these soils are the least attractive irrigation soils of the area. They all possess shallow surfaces which tend to set after irrigation and depress brairding. The subsoil and deep subsoil are very impermeable in Ulupna clay and Mywee clay. The gilgai phase of Mywee clay is rough and swampy and quite unsuitable for irrigation.

Picola loam has a somewhat deeper surface and more permeable subsoil. With the exception of the gilgai phase of Mywee clay, all soils in this association should give good results with winter cereals, fair summer cereals, and winter pastures, but are not recommended for permanent pastures. They are more salty than the other soils in the area but, owing to their low permeability, should not be prone to salt deterioration.

Most of the soils in the Ulupna association are in the green colour category.

(f) Barwo Association

Little is known of the behaviour of these soils under irrigation, but it is possible that the rather compact nature of the clay pan may restrict water penetration.

Barwo silty loam should give good results under pastures or cereal crops and should be fairly well suited to pears. Owing to the light sandy deep subsoil, Kaarimba silty loam should be excellent for winter pastures, cereals, and pears, whilst lucerne should also thrive on this soil type. Excess water usage may prohibit its use for permanent pastures but peaches, apricots, and even citrus should do well.

Narioka clay loam occurs mainly in low areas but where suitable contours are available fair pastures and cereals should be produced.

Soils in this association belong mainly to the yellow, purple, and grey colour categories.

(g) Sandmount Association

These soils occur as sandhills which are invariably too high to be irrigated from the gravity channel system. However, they are excellent citrus soils and could be irrigated by pumping water from the channel to higher levels. They are also well suited to apricots and peaches. Nathalia fine sand can be expected to give even better results than Sandmount sand. Owing to expense of irrigation, these soils are not used for other irrigated crops.

The soils of the Sandmount association are in the carmine colour category.

The soils of the well-drained depressions are, with the exception of type E, suitable for lucerne growing and winter pastures and could be used for all other crops except permanent pastures and summer cereals, owing to excess water usage by these latter crops. Type E could be used for irrigated cereals. However, in the majority of cases, these soils will be unsuitable for irrigation because of their occurrence in low areas or gullies.

The above suggestions as to the suitability of the various soils to specific irrigation crops are summarized in Table 3.

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TABLE 3
PROBABLE SUITABILITY OF SOILS TO THE PRODUCTION OF IRRIGATION CROPS AND PASTURES

CROP	Soil Profile	Suitability	
Citrus	Sandmount Sand	G	
	Nathalia Fine Sand	G	
	Katunga Sandy Loam	G	
	Katunga Gravelly Loam	D	
	Katunga Loam	D	
	Cobram Sandy Loam	G	
	Cobram Loam	G	
	Waia Loam	D	
	Waia Loam - Sandy Subsoil	D	
	Moira Loam	D	
	Moira Loam - Light Profile	D	
	Moira Loam - Friable Subsoil	D	
Peaches	Naring Loam	D	
	Naring Loam - Heavy Profile	D	
	Naring Loam - Light Profile	D	
	Naring Loam - Friable Subsoil	D	
	Boosey Loam	D	
	Boosey Loam - Light Profile	D	
	Boosey Loam - Friable Subsoil	D	
	Muckatah Clay Loam	D	
	Picola Loam	D	
	Ulupna Clay	D	
	Mywee Clay	D	
	Kaarimba Silty Loam	G	
Apricots	Barwo Silty Loam	D	
	Narlaka Clay Loam	D	
	Well-drained Depression Soils	G	
	A, B, C, and D	D	
	Well-drained Depression Soil E	D	
	Pears	Sandmount Sand	D
		Nathalia Fine Sand	D
		Katunga Sandy Loam	D
		Katunga Gravelly Loam	D
		Katunga Loam	D
		Cobram Sandy Loam	G
		Cobram Loam	G
Waia Loam		D	
Waia Loam - Sandy Subsoil		D	
Moira Loam		D	
Moira Loam - Light Profile		D	
Moira Loam - Friable Subsoil		D	
Lucerne (hay)	Naring Loam	D	
	Naring Loam - Heavy Profile	D	
	Naring Loam - Light Profile	D	
	Naring Loam - Friable Subsoil	D	
	Boosey Loam	D	
	Boosey Loam - Light Profile	D	
	Boosey Loam - Friable Subsoil	D	
	Muckatah Clay Loam	D	
	Picola Loam	D	
	Ulupna Clay	D	
	Mywee Clay	D	
	Kaarimba Silty Loam	F	
Winter pastures	Barwo Silty Loam	F	
	Narlaka Clay Loam	F	
	Well-drained Depression Soils	F	
	A, B, C, and D	D	
	Well-drained Depression Soil E	D	
	Permanent pastures	Sandmount Sand	D
		Nathalia Fine Sand	D
		Katunga Sandy Loam	D
		Katunga Gravelly Loam	D
		Katunga Loam	D
		Cobram Sandy Loam	G
		Cobram Loam	G
Waia Loam		D	
Waia Loam - Sandy Subsoil		D	
Moira Loam		D	
Moira Loam - Light Profile		D	
Moira Loam - Friable Subsoil		D	
Irrigated cereals (summer)	Naring Loam	F	
	Naring Loam - Heavy Profile	F	
	Naring Loam - Light Profile	F	
	Naring Loam - Friable Subsoil	F	
	Boosey Loam	F	
	Boosey Loam - Light Profile	F	
	Boosey Loam - Friable Subsoil	F	
	Muckatah Clay Loam	F	
	Picola Loam	F	
	Ulupna Clay	F	
	Mywee Clay	F	
	Kaarimba Silty Loam	F	
Irrigated cereals (winter)	Barwo Silty Loam	F	
	Narlaka Clay Loam	F	
	Well-drained Depression Soils	F	
	A, B, C, and D	D	
	Well-drained Depression Soil E	D	

Key: G = good, F = fair, D = doubtful.

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