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A Soil Survey of the Mildura Irrigation Settlement, Victoria

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SUMMARY

The Mildura Irrigation Settlement, comprising 17,150 acres of mallee country adjoining the Murray River in north-west Victoria, has been covered by a soil survey. The settlement is of considerable national importance, by virtue of its position as a pioneer and successful irrigation venture and its controlling influence on the development of the Australian dried fruits industry. At the present time, approximately 11,600 acres are in production of some kind; of this area, 10,800 acres carry vine or tree crops, sultanas being the dominant planting.

The soils of the Mildura district have been classified and mapped in 30 types and four phases. There are 17 named soil series represented: of these the Cureton, Belar, Morpung, Mildura, Koorlong and Irymple series are now described for the first time. A detailed description is given of each soil type and phase, and relations between the various types are brought out by means of a key based on colour, texture, original vegetation, and topographical occurrence. High level plain country, which originally carried mainly bluebush or mallee, is a distinctive feature at Mildura in comparison with other Murray valley settlements, and the soil types associated with these plains appear to be virtually confined to the Mildura district.

Physical and chemical analyses are recorded for 200 Mildura soil samples. Apart from river flat types, the soils conform to the characteristics of the Mallee zonal group an exceptional feature being the high silt contents of sub-soils of Mildura loam and Koorlong sandy loam. In their content of soluble carbonate, and in the relative importance of sulphate among the total soluble salts, Mildura soils resemble those of Merbein.

Some of the more extensive soil types at Mildura are inherently saline, and seepage and salinity problem have been experienced since the early years of settlement. Prospects for effective control of salinity and free water in these soils have improved notable, following the recent installation of a comprehensive drainage scheme. Emphasis therefore rests, at present, on drainage considerations, and the properties of the various soil types are reviewed with particular reference to their absorptive capacities for irrigation water, their inherent salinity, and the nature of the soil profile as a guide to drainage requirements and technique. All soil types appear capable of satisfactory production of vine fruits under good management, apart from the incidence of problems due to salt and waterlogging. As response of many of the soil types to suitable drainage measures has already been demonstrated, it is likely that the excellent facilities for drainage now available will lead, during the next few years, to appreciable increase in production.

War time economy requires reduction in the Council's expenditure on publication. It is hoped that the adoption of the photo-lithographic process will be for a brief period only.

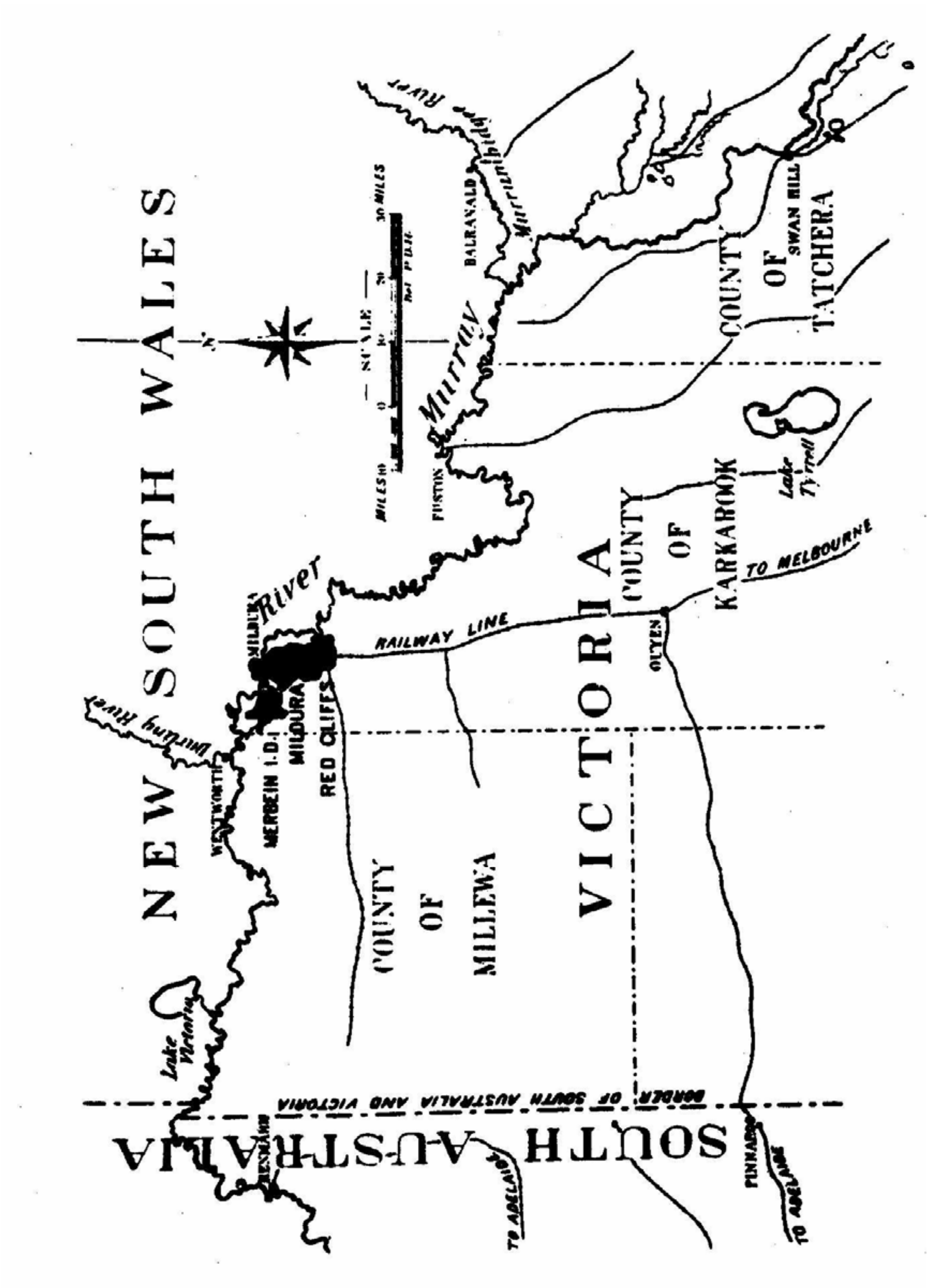

Figure 1 – Locality plan, showing position of soil survey

A Soil Survey of the Mildura Irrigation Settlement, Victoria

Note. In the Mildura district there are three centres of development – the irrigation settlements of Mildura, Merbein and Red Cliffs. These form separate entities and their soils differ to some extent. Conditions at Merbein have been discussed in "A Soil Survey of the Merbein Irrigation District, Victoria", Council for Scientific and Industrial Research (Aust). Bulletin 123, 1938. Much of the information there given on soils, agricultural position, native vegetation and climate may be applied to Mildura.

The following report marks completion of work in the Mildura settlement itself; as at Merbein, the soil survey was carried out by the Division of Soils, Council for Scientific and Industrial Research, and the Victoria Department of Agriculture. The soil survey of Red Cliffs has advanced to the stage of completion of field work.*

I. INTRODUCTION

1. *The Mildura Settlement*

Surrounding the city of Mildura is an area of 14,000 acres, controlled by the First Mildura Irrigation Trust and including the original horticultural settlement on the Murray River. The area lies in the Parish of Mildura, County of Karkarooc, in mallee country in the north-west of Victoria. As shown by the locality plan, Fig. 1, the Mildura settlement links with the younger centres of Merbein on the west, and Red Cliffs on the south, forming with them the largest single area of irrigated horticultural land in Australia. Across the river in New South Wales, are two other small settlements – Coomealla and Curlwaa, respectively 8 and 10 miles downstream from Mildura.

Mildura has great national value associated with its position as a pioneer and successful irrigation venture, and with its controlling influence on the development of the Australian dried fruits industry. The sharp contrast between irrigated lands and surrounding dry areas in this district provides a striking illustration of the latent productivity of mallee soils. Experience at Mildura gave impetus to establishment of other irrigation settlements on the mallee country, and proved that large scale pumping schemes for supply of irrigation water may be undertaken successfully when gravitation facilities are not available.

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* Field work was shared by Messrs G. D Hubble, J. K. Taylor, and P. D. Hopper, of the Division of Soils, and laboratory work was undertaken by the Victorian Agricultural Laboratory. The cartography is due to P. D. Hooper.

Recorded history of the area dates from 1846, when Mildura was taken up as a sheep run by early squatters in the north west. Although there was fair feed on the grassy plain in the wetter seasons, the carrying capacity was very low in most years. Notable deterioration followed a period of prolonged drought and infestation by rabbits, so that by 1884 the land was valued officially for annual rental purposes at only a fraction of a penny per acre. Early observers describe the country as a forbiddingly dry region, with hissing hot winds sweeping through mallee "jungle" and over dismal plains for bluebush. Today the annual produce from an average acre of irrigated sultanas at Mildura is worth about £40.

It was in August 1887 that closer settlement on irrigated land really began in Australia, with the taking over of Mildura station and surrounding country by George Chaffey under an agreement with the Government of Victoria. Chaffey had had a great deal of experience as an engineer in the United States of America in design and establishment of irrigation projects, and had conceived the idea, and planned the details, of an irrigation settlement at Mildura. Foremost among those in the political sphere whose foresight and energy made possible the development of irrigation resources in Victoria, and the implementing of Chaffey's ideas concerning Mildura, was Alfred Deakin, who later became Prime Minister of the Commonwealth of Australia.

The agreement drawn up by the Victorian Government with George & W. B. Chaffey gave a licence for 20 years for development for irrigation of a total area of 250,000 acres. Conditions were imposed concerning value and nature of improvements to be made within specified periods and volumes of water permitted for pumping during stream flow of certain rates in the Murray River. Development began on Block A of 25,000 acres, supply of water being managed by the Mildura Irrigation Company, whose system and equipment have, in large part, continued to the present time. Channelling, sub-division, and plating proceeded vigorously, so that by 1891 a small tonnage of dried fruits was marketed, and by 1894 a population of 3,000 was in occupation of more than 8,000 acres.

The growing settlement suffered a very severe reverse, in the years following 1894, associated with the national financial crisis. Lack of transport facilities for marketing fresh fruit, and inadequate drying equipment for production of dried fruits, contributed to the difficulties. In 1895, the Chaffeys and the Mildura Irrigation Company were forced into liquidation, and at the end of the same year the existing First Mildura Irrigation Trust was set up to control the water supply of the settlement. The Trust has jurisdiction over 45,000 acres, of which 13,696 acres have been made available for planting. The original sub-division into ten-acre blocks has been perpetuated, with individual ownership limited to a maximum of 160 acres.

Among regenerative influences following the depression period of the '90's, two of the most important were the completion, in 1903, of the railway link with Melbourne, and the organisation of growers and packers for marketing of dried fruits. The Mildura Fruitgrowers' Associations was incorporated later into the Australian Dried Fruits Association, a voluntary combination throughout Australia for pooling and marketing of dried fruits. The influence of W. B. Chaffey was very prominent during this reconstructive phase.

The development and prosperity of Mildura have been well sustained after the early periods of difficulty. There have been occasional big advances, such as the introduction of cincturing of the zante currant and of the cold-dipping of sultanas, and the recent installation of a comprehensive drainage scheme. Adverse effects have been due in recent years mostly to abnormal weather conditions; of these, damage by frost has been reduced to a minimum by an efficient system of frost warning and orchard heating. Steady progress has been brought to Mildura the dignity and status of a city, the first on the Murray. In the Mildura settlement there are now 701 land holders, most of whom are on holdings of 20 acres or less. The total value of produce to the growers is about £400,000 per annum.

2. Irrigation and Drainage Works

The supply of water for irrigation is diverted from the Murray River by a pump at Psyche Bend, 7 miles upstream from Mildura, into a natural storage reservoir known as King's Billabong. Two other pumps raise water from the billabong into main channels, a low lift into the 50 foot channel, and a high lift into the 90 foot channel watering the high land in the immediate vicinity. Both these channels directly command only a limited area, as the main body of the settlement is watered from three channels at the 70, 85 and 92 foot levels, filled from the 50 ft channel by the pumping system at Nichol's Point. Until recently, a fifth pumping unit was situated on the River at Mildura served from a channel at the 80 ft level, a limited area immediately south west of the city on both sides of Deakin Avenue. Water for this section is pumped now by electric power from the main 70 ft channel, which supplies the greater part of the Mildura area, at its intersection with Deakin Avenue.

The present pumping capacity is sufficient to water the whole settlement in 23 days, as compared with 45 days required with the equipment in use prior to 1927. Before that date, only three irrigations were given each season, whereas five are now available. The rate charged is 55 shilling per acre per annum, additional special irrigations being obtainable at the end of the each pumping period for 5/- per acre.

In the original scheme, no provision was made for removal of surface or underground drainage waters. Even in the first ten years of irrigation, serious water-logging and salt concentration occurred in the soil in certain areas, and it became necessary to remove excess water accumulated at shallow depth in the subsoil. Drainage schemes on individual properties, involving the laying of tile drains to shafts sunk to beds of drift sand at depths of 80 to 90 feet, have been in use in the district for more than 30 years. A certain measure of relief was obtained by such means, but they were local and temporary expedients rather than a permanent solution to the problem.

In 1934, the Victorian Government undertook the installation of a large scale drainage scheme, by which practically all the closely settled portion of the district was provided with drainage outfall into main pipe systems. Mildura settlement was divided into five drainage units totaling 10,479 acres, with independent outfalls to the river or two depressions outside the irrigation area. The scheme provided for a minimum depth of 4 feet 6 inches for internal drainage on the blocks, such a depth being usually sufficient for maintenance of suitable conditions in soils responsive to drainage. Internal drainage linking with the community system has already brought back to production certain saline and waterlogged patches.

3. The Agricultural Position

The total area surveyed, 17,147 acres, includes several hundred acres of land, mainly in the south-eastern corner of the settlement, too high to be commanded by irrigation water under present conditions. Also included is a considerable area, probably between 4,000 and 5,000 acres, of irrigable land which is not utilised for horticulture. Part of the latter area has never been planted to trees or vines; plantings on the remainder have been abandoned because of salt and seepage troubles. At present, 11,586 acres are in production of some kind; of this area 10,811 acres carry vine or tree crops. Table 1 shows how the land at present in production is utilized, the figures being based on data supplied by the First Mildura Irrigation Trust. For comparison, area of crops grown in 1894 are included.

Table 1 – Areas of Crops in the Mildura Settlement

(in acres)

Year	Sultanas	Currants	Other Vines	Citrus	Deciduous Fruits	Lucerne	Other Crops
1938	6044	2554	1511	585	117	461	314
1894	66	200	3104	1438	2676	208	524

It is evident that vines, especially sultanas, constitute the most important crop at the present time, and that, apart from an increase in the total productive area from 8,216 acres in 1894 to 11,586 acres in 1938, there has been a notable change in proportions of the various crops. Although culture of the vine was envisaged by the Chaffeys, at the time of establishment of Mildura settlement, as the probably mainstay of the district, it would appear that they expected highly diversified production to continue, including a considerable quantity of fruit for canning. The bulk of the vines in the early plantings were Gordos and wine grapes, wile apricots, together with peaches and figs, where the main deciduous fruits. Difficulties of marketing fresh fruit and the rather exacting conditions for successful growth of citrus were partly responsible for the change in crop establishment, but more important factors were the improvement in processing and marketing procedure for dried vine fruits, and recognition that the district is particularly adapted to the requirements of the sultana.

Production of dried fruits has increased greatly in volume and value with the use of improved cultural methods on larger areas. Average production figures for the Mildura settlement over the four years 1934-38 have been calculated from data supplied by the Victorian Government Statist, with the following results in tons of dried fruit: sultanas, 8,093; currants, 3,006; lexias, 1,484; muscatels, 50.26 cwts per acre for the whole settlement, with a record high production on the same basis of 32 cwts per acre in 1938. Quality of the fruit is of high standard in normal seasons. With reference to citrus, the total of 585 acres comprises 498 of oranges and 87 of lemons; it would appear, however, that the effective acreage in each case is considerably lower than that stated, total production being approximately 80,000 cases per annum.

4. Climate

Climatic conditions in the Mildura district are specified by Table 2. The data have been compiled from figures made available by the Commonwealth Meteorologist (rainfall, humidity and temperature) and the Officer-in-Charge of the Commonwealth Research Station, Merbein (wind velocity, evaporation and frost record).

Table 2 – Meteorological Data for Mildura showing Monthly and Yearly Averages

	Rain (in)	Mean Max. Temp. °F	Mean Min. temp. °F	Relative Humidity	Wind Velocity	Evaporation (in)	No. of Frosts
Jan	0.70	91.0	61.5	51	2.3	9.40	-
Feb	0.70	91.3	61.8	56	1.9	7.17	-
Mar	0.77	84.8	56.5	61	2.0	6.31	-
Apr	0.65	75.5	49.8	68	1.9	3.88	0.1
May	1.03	67.3	45.2	75	1.4	2.61	2.0
Jun	1.26	60.7	41.3	82	1.4	1.81	5.6
July	088	59.7	40.0	83	1.4	1.91	6.5
Aug	1.09	64.0	42.1	73	2.0	2.52	4.3
Sept	0.95	70.0	45.8	65	2.4	3.91	2.0
Oct	1.05	77.1	50.2	58	2.6	5.25	0.3
Nov	0.74	84.7	55.4	51	2.2	7.66	-
Dec	0.81	89.0	59.1	50	2.2	8.61	-
No. of years	**49**	**44**	**44**	**26**	**12**	**12**	**12**

Low rainfall and relatively high average temperatures and evaporation are the chief features of the climate. Together with the fact that rainfall incidence is somewhat unreliable in individual years, these conditions explain the striking contrast between irrigated land and dry farming areas in this district. Tropical depressions make an important contribution to the weather and are responsible for much of the variation from year to year. Currants, in particular, have suffered severely from tropical storms in late December or early January in some seasons.

Most of the calm forestry weather occurs from May to July, wind intensity increasing during August and September, with less likelihood of frosts. The chances of having a frost late as October in any year are about one in three. On the whole, conditions for harvest and drying of vine fruits are favourable, December to March being hot dry months in most years, an occasional season such as 1939 suffering from early and heavy rain. The table illustrates the substantial change in conditions affecting fruit drying operations as the season advances from March to April and May. Rainfall, temperature, humidity and evaporation reflect the normal break in the weather during this period.

II SOILS OF THE MILDURA DISTRICT

1. Classification

The Mildura settlement, as a whole, is not comparable with either Merbein or Red Cliffs from the soil aspect, although certain soil types are common to all three areas. Apart from the abundant water supply, and the climate, which was considered ideal, factors which influenced George Chaffey in selection of Mildura as an irrigation settlement were the nature of the soils, the elevation of the land above flood level, and the favourable topography. On the basis of his Californian experience, Chaffey preferred the heavier-textured soils, and it is a distinctive feature of the Mildura settlement that the proportion of such soils is relatively high. It is noteworthy, however, that the old Mildura homestead block is shown by the present survey to carry mainly light types of soil, and probably Chaffey was influenced to some extent by the reputation already gained along the Murray by the variety and excellence of the fruit grown in the small orchard of the old station.

The soils of Mildura has been classified and mapped in 30 types and four phases. Twenty-three of the types and all the phases are included in 17 named soil series, of which the Cureton, Belar, Morpung, Mildura, Koorlong and Irymple series are now described for the first time. The remaining eleven named series indicate relations between Mildura soils and those of the Berri-Moorook district in South Australia, the Coomealla-Pomona district in New South Wales and the Merbein district in Victoria. The seven un-named soil types described at Mildura are of minor importance and limited extent.

In order to facilitate interpretation of the soil map and identification of soils in the field, a key to the soil types of Mildura has been prepared. It is presented at this stage as an introduction to more detailed consideration of the soil types and their distribution.

2. The Soil Map – Distribution and Extent of Soil Types

The relative importance, with respect to total and percentage area covered, of the various Mildura soil types is shown by Table 3.

As indicated in an earlier section, a notable feature of the soil situation at Mildura is the relatively high proportion of land of which the surface soil has been classified as loam or heavier material. Table 3 shows that this proportion in 62%, the "grey mallee" soil, Sandilong loam, being prominent, together with Irymple loam and Mildura loam. These three types cover an aggregate of 5,652 acres, almost one third of the area surveyed, and it is unfortunate that these are some of the more saline types. Among the lighter-surfaced soils, which together cover 38% of the area, the very light soil of the sandy rises, Murray sand, and is the most extensive, with the Barmera, Cureton and Karadoc soils and Benetook sandy loam also important.

The distribution of soil types over the Mildura settlement is shown in detail on the soil map*. In discussion of the map, it is pointed out that the boundaries shown between individual occurrences of the soils are in many cases somewhat arbitrary, because of the presence of transition zones between soil types. Particularly does this apply to the soils of the sandy rises, where there is virtually continuous variation in profile from the top of the rise to the foot of the slope.

Table 3 – Total and Percentage Area Covered by Mildura Soil Types

Soil Type	Area in Acres	% of Total Area	Soil Type	Area in Acres	% of Total Area
Murray sand	1055	6.2	Koorlong sandy loam	371	2.2
Cureton sand	746	4.4	Koorlong loam	409	2.4
Berri sand	309	1.8	Sandilong loam	1864	10.9
Barmera sand	634	3.7	Sandilong loam (shallow phase)	296	1.7
Bamera sand (stony phase)	252	1.5	Sandilong loam (deep phase)	212	1.2
Barmera sandy loam	727	4.2	Benetook sandy loam	706	4.1
Moorook sandy loam	325	1.9	Benetok loam	1106	6.4
Nookamka sandy loam	21	0.1	Irymple loam	1815	10.6
Nookamka loam	78	0.5	Irymple clay loam	712	4.2
Coomealla loam	440	2.6	Pomona clay	402	2.3
Merbein loam	317	1.8	Type 1	200	1.2
Merbein clay loam	580	3.4	Type 2	119	0.7
Belar clay loam	255	1.5	Type 3	88	0.5
Karadoc sandy loam	574	3.3	Type 4	58	0.3
Karadoc sandy loam (heavy subsoil phase)	194	1.1	Type 5	204	1.2
Morpung loam	460	2.7	Type 6	112	0.7
Mildura loam	1465	8.5	Type 7	41	0.2

For consideration of soil distribution as set out by the map, the Mildura settlement may be divided into five geographic units with distinctive topographic and edaphic conditions: these areas will be discussed as follows:- Mildura and Koorlong, Nichol's Point, the eastern high plains section, Irymple, and the river flat and fringe or the plain.

* See map at end of bulletin

KEY TO MILDURA SOIL TYPES

<u>1. Soils associated with sandy rises characterised by the growth of pine, hopbush, sandalwood and belar</u>

Surface colour	Brown or red-brown						Grey-brown
Profile	Light No clay within 6 ft.	Light Clay deeper than 5 ft				Light Clay within 6 ft	Light Clay deeper than 6 ft
Surface texture	Sand	Sand or sandy loam	sand		Sandy loam	Sand	Sandy loam
Subsoil texture	Sandy loam	Sandy clay loam below 4 ft	Sandy clay loam within 3 ft, sandy clay or light clay usually deeper than 6 ft, never less than 5 ft.			Sandy clay loam, grey mottled clay deeper than 3 ft	Sandy clay loam within 2 ft
Lime and rubble*	Low	Low to moderate	Moderate	Stony rubble in subsoil	Moderate	Low	Variable to high
Soil type	MURRAY SAND	BERRI SAND	BARMERA SAND	BARMERS SAND (stony phase)	BARMERA SANDY LOAM	CURETON SAND	MOOROOK SANDY LOAM

* Concentrations of lime (calcium carbonate) are given in arbitrary divisions in accordance with field description. Similar terms apply to gypsum and to rubble, which is lime in a hard, more or less nodular form. The word “stony” is used for rubble when a proportion is in the form of large aggregates.

2. Soils associated with plains and undulating country characterised by mallee, belar and bluebush

Surface colour	Brown or red-brown				
Subsoil character	Brown clay				
Profile	Light. Clay more than 2 ft from surface				Heavy. Clay less than 2 ft from surface
Surface texture	Sandy loam	Loam	Loam or sandy loam	Loam	Clay loam
Lime and rubble*	Low	Low	Low	Variable to high	Low
Gypsum					
Soil type	NOOKAMKA SANDY LOAM	NOOKAMKA LOAM	MORPUNG LOAM	COOMEALLA LOAM	BEAR CLAY LOAM

Surface colour	Brown or red-brown					
Subsoil character	Grey or grey-brown clay				Greyish sandy deep subsoils	
Profile	Light. Clay more than 2 ft from surface			Heavy. Clay less than 2 ft from surface	Light	
Surface texture	Sandy loam	Loam	Loam	Clay loam	Sandy loam	
Lime and rubble*	Light clay by 3 ft becoming heavier	Light clay between 2 ft and 3 ft	Medium clay at 2 ft or more	Medium clay within 2 ft	Clay loam by 2ft sandier below	Light to medium clay sandier below
Gypsum	Low		Low		Low to high	
Soil type	BENETOOK SANDY LOAM	BENETOOK LOAM	MERBEIN LOAM	MERBEIN CLAY LOAM	KARADOC SANDY LOAM	KARADOC SANDY LOAM (heavy subsoil phase)

2. Soils associated with plains and undulating country characterised by mallee, belar and bluebush (cont)

Surface colour	Grey brown or grey								
Subsoil character	Brown clay within 6 ft				Grey-brown or grey clay within 6 ft			Sandy deep subsoils	
Profile	Light. Clay more than 2 ft from surface				Heavy. Clay by 2 ft from surface			Light	
Surface texture	Loam			Loam	Loam	Loam to clay loam	Loam	Sandy loam	Loam
Subsoil texture	Clay loam by 3 ft								
	Light clay within 5 ft	Light clay deeper than 5 ft	Light clay by 3 ft	Light clay 3 ft, then heavier	Light clay between 2 ft and 3 ft then heavier	Light clay at less than 2 ft, then heavier	Light clay by 2 ft, then heavier	Clay loam by 2 ft, then heavier	Light clay or heavier, then sandier
Lime and rubble*	Low to moderate			Lime moderate, rubble low	low		Moderate from surface to 3 ft	Variable to high	
Gypsum					Occasional	Light to moderate	occasional		
Soil type	SANDILONG LOAM	SANDILONG LOAM (deep phase)	SANDILONG LOAM (shallow phase)	TYPE 7	IRYMPLE LOAM	IRYMPLE CLAY LOAM	MILDURA LOAM	KOORLONG SANDY LOAM	KOORLONG LOAM

3. Soils of box flats and adjacent low levels

Surface colour	Grey or grey-brown			Brown			
Subsoil character	Grey to yellowish grey clay		Sandy deep subsoil	Sandy deep subsoil	Grey or grey-brown clay		
Surface texture	Clay loam	Loam or clay loam	Sand or sandy loam	Sand or sandy loam	Loam	Sandy loam	Sandy loam
Subsoil texture	Medium clay at 1 ft	Light clay at 1 ft, medium clay at 3 ft	Light clay at 1 ft, then sandier	Light clay by 2 ft, then sandier	Light clay at 1 ft, lighter below, then light or medium clays		
Lime and rubble*	Very low	Low	Very low	Low	Very low	Low to moderate	Low
Gypsum	Variable					Occasional	variable
Soil type	POMONA CLAY	TYPE 6	TYPE 2	TYPE 1	TYPE 4	TYPE 3	TYPE 5

Mildura and Koorlong. For the present purpose, Mildrua will be taken as including roughly the western half of the settlement, extending from the city to Dow Avenue, and bounded on the east by Coorong Avenue and its imaginary continuation due north to Cowra Avenue, thence along Cowra Avenue to Cureton Avenue and the City. The river flat and adjoining low lying areas are excluded from this section, but the scattered blocks south-west of Dow Avenue are included, being part of Koorlong, a further portion of which is shown as an inset in the upper left corner of the soil map.

The plain in this section is at slightly lower level than in the eastern part of the settlement, and the original vegetation was mainly bluebush and mallee, bluebush being more common round Mildura and mallee at Koorlong, particularly east of Deakin Avenue, and more or less peculiar to the Mildura settlement. Mildura loam, the Irymple and Koorlong series, Cureton sand, Benetook sandy loam, and Merbein clay loam are met here for the first time. Karado sandy loam and Benetook and Merbein loams occur more extensively in this area than at Merbein, where they were first described.

The soils of Mildura and Koorlong tend towards salinity and are characterised by greyish subsoils, often containing high proportions of micaceous fine sand or silt. At Koorlong, large amounts of limestone and rubble occur in the surface and subsoil, making cultivation difficult and even necessitating the use of explosives when trellising portions of some blocks.

In the south-west of this section is an occurrence of the parallel sand rises which are more fully developed in other section, and along the eastern boundary there is a fairly sharp change to soils with brown deep subsoils.

Nichol's Point. This are extends to the south-east from Mildura to King's Billabong, being bounded by Cureton Avenue and Cook Street on the north and east, and by a line intermediation between Eleventh and Fourteenth Streets as the south-west border.

The soil is much less variable than that of the first section; the most important type – Sandilong loam – occurs in large unbroken areas up to 30 acres in extent and originally carried a vegetation dominated by the mallees. Small occurrences of certain types important in the Mildura section, notably the Irymple series and Merbein clay loam, extend through this area from west to east, and a narrow strip of the sandy types runs north-east from the Irymple section in the south to the Nichol's Point pumping station.

The Eastern High Plain Section. Part of the 90 ft pumping lift area constitutes this section, bounded by Eleventh and Fifteenth Streets, and by Ginquam Avenue and the eastern edge of the settlement. This is high plain land, gently undulating to flat. Apart from a few isolated patches in the remainder of the settlement, the occurrence of Morpung loam is restricted to this section, with Sandilong loam and Barmera sandy loam next in extent. Smaller areas of other types are present also, but, with the exception of odd occurrences of Irymple, Mildura and Merbein loams, they all have brownish coloration in the subsoil and deep subsoil. The lower edge of the slope from the plain to the Billabong carries very mixed soils, which could not be mapped satisfactorily. These have been noted on the soil map as "mixed and unclassified soils".
Irymple. Some of the most productive soils of the Mildura district lie south of Nichol's Point, between the Mildura section on the west and the eastern high plain section, into which they extend. In the south they join the Red Cliffs area on Twenty-second Street.

The Melbourne-Mildura railway runs through this section in a north-south direction. The soils are characteristically brown to light brown in the subsoil and deep subsoil, and east of the railway consist mainly of the light sandy types, the Murray, Berri and Barmera sands and Barmera sandy loam, arranged in parallel ridges, whilst west of the line heavier types predominate, principally Coomealla loam, Nookamka sandy loam and loam, and Sandilong loam.

The River Flat and Fringe of the Plain. This section includes that area between Cureton Avenue and the river east of Mildura, and that between the Merbein railway and the river west of the city, together with a small area south of the railway. The Pomona clay, a heavy unproductive river flat type, difficult to work, and the only named type which does not belong to the Mallee Zonal group of soils, occurs in these areas. Associated with it are types 1 -6 and also some of the plain soils with grey subsoils, particularly north-west and south-east of the City. Isolated patches of the sandy types also occur in this section, notably north of Lake Ranfurly and the aerodrome, and in the vicinity of the Nichol's Point pumping station, where there is an extension of an area from the plains on the slope down to the river flat. In this position, these types are particularly liable to seepage trouble, and many acres have gone entirely out of production.

3. The relation between Soils, Topography and Vegetation

Certain relations have been noted, in the discussion on distribution of soils, between topography, native vegetation, and soil type in particular sections of the surveyed area. The Mildura settlement, considered as a whole, falls into three main topographic divisions – (a) undulating sandy rise country, which amounts to about one-third of the total area; (b) high level plains, flat or gently sloping; and (c) low level flat or gentle sloping land approaching the river. Available records of distribution of native vegetation over the area are very meager, so that relations with soil type and topography are not always clear.

(a) The sandy rises occur over a triangular section of the settlement, based on the south-west boundary and with its apex in the vicinity of the Nichol's Point pumping station. A fringe occurs along the river frontage west of the City. The ridges run roughly east and west, often very close together, separated by narrow depressions with mixed soil types. These sandy rises are seldom more than 20 feet high, with relatively steep slopes giving narrow transition strips between deep sands and quite heavy profiles.

The sand rise country centres round Irymple, extending southward into Red Cliffs and north-east towards the river. The soil map shows the long tongues of Murray sand, representing crests of the rises, flanked on the slopes by Barmera and Cureton soil types. On the more open portions of this zone occur gentle slopes of Coomealla and Nookamka soil types, with Merbein or Belar soils on the lowest levels. On the high, less sandy, ground in the vicinity of King's Billabong east of Irymple, Morpung loam occupies some elevated positions.

The typical vegetation of the zone was pine, hopbush, *Cassia* spp. and sandalwood on the crests and higher slopes, grading into mallee on lower slopes, or even on lower rises, which were sometimes notable for the presence of lime and rubble in large amounts. The intervening heavy country typically carried belar of variable size. The pine practically disappeared east of Irymple and tended to decrease notably approaching Red Cliffs settlement in favour of sandalwood and Belar, the latter then being on both light and heavy soils[*].

(b) The high level plains are the most characteristic feature of Mildura in comparison with other river settlements. They have brown or grey-surfaced soils on slight slopes characterised by their vegetation of bluebush and mallee, either alone or in combination. No other similar area of appreciable size is known near the river, so that many of these Mildura soils are apparently of localised importance. A curious feature is the presence of steps in the general level, by which two areas of plain country at different elevations are separated by a belt of typical sandy soils, on the ascending grade. At the top of the slope the soil changes directly from sandy types, as described in the first section (a) above, to the heavy plain types.

Some of the soils are very rubbly or even stony, such as the Mildura, Koorlong and Sandilong types, all associated with mallee vegetation, whilst the Benetook and Irymple types are virtually free from rubble and associated with bluebush plains.

(c) The low level flats and slopes approaching the river may be considered as falling approximately within the 125 ft contour. There are a few low sandy rises, such as those near the aerodrome west of the city and at the old Mildura homestead on the river further west, which carried trees of the Murray pine association. Some very low rises, which are less sandy and did not carry pine, occur in the same locality and also east of the town. There is no further evidence of the nature of the native vegetation of this zone, apart from the box trees on the lower flats leading down to the red gum on the river and its backwaters, and the presence of Cassia spp. and Acacia spp. on roadside areas.

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[*] Botanical name for native plants are as follows:
Pine – *Callitris robusta*
Sandalwood – *Myoporum platycarpum*
Belar – *Casuarina lepidophloia*
Hopbush – *Dodonaea attenuate*
Mallee – *Eucalyptus oleosa* and *E. Dumosa*
Blue bush – *Kochia pyramidata, K. sedifolia, K. villosa, K. brevifolia*
Box – *Eucalyptus bicolour*
Various *Cassia* spp. and *Acacia* spp. also occur

III. DESCRIPTION OF SOIL TYPES.

The more general aspects of soil classification and occurrence having been discussed in previous sections, a. detailed description of individual soil types is now given, following the same order as in the key (pp. 17-21). Several of the types have been described in other surveys, and to some existing types new phases have been added to embrace variations found at Mildura.

1. Soils Associated with Sandy Rises.

Murray sand and Berri sand. (See Bull. *73;1933, and Bull. *86,1934) Typical profiles are shown in Fig.2.

Mildura occurrences of these types conform to previous descriptions, but may be somewhat browner at the surface. Berri sand may show less tendency to sandiness with depth than in the typical profile, but is not underlain by any clay layer within 7. ft.

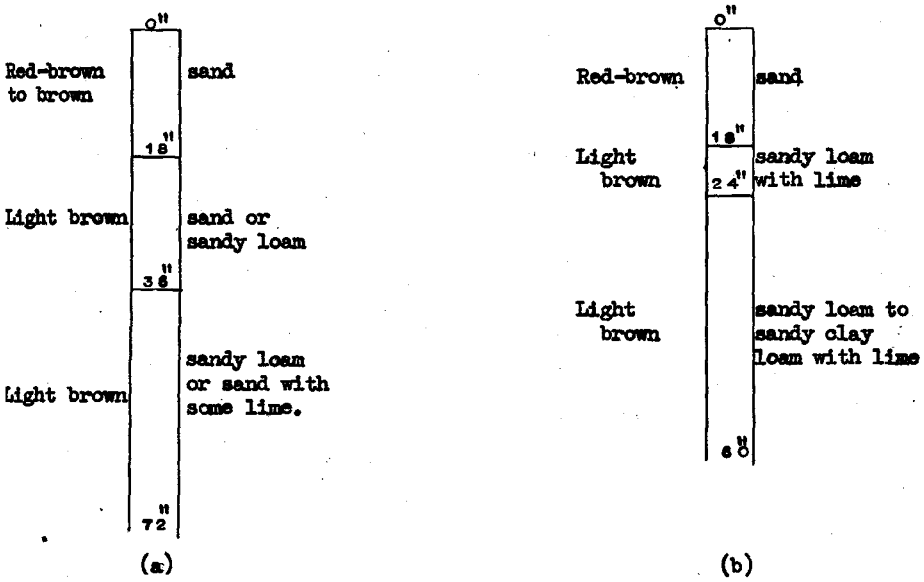

Fig. 2 - (a) Murray sand, (b) Berri sand.

Barmera series.

(a) **Barmera sand.** (See Bills. 107, 1937; and 123, 1938.)

The normal form was described from Coomealla Irrigation Area, New South Wales, a shallow phase being added to include occurrences at Merbein. Mildura soils of this type conform to the normal form, which is illustrated in Fig. 3 (a), or to a second variant which has been distinguished as "stony phase", The main feature in the latter is the presence of a layer of limestone rubble, more or less cemented mid three to eight inches thick. This lies beneath a mantle of sand 18" to 48" deep, undifferentiated apart from slight lightening of colour below the surface. Under the stony horizon, the subsoil is the usual one for the type - light brown sandy clay loam, with Blight rubble and moderate lime, continuing to below 48" before changing to a brown clay. The stony pan generally is not penetrable with an auger and only with difficulty on excavation.

* Of the Council for Scientific and Industrial Research

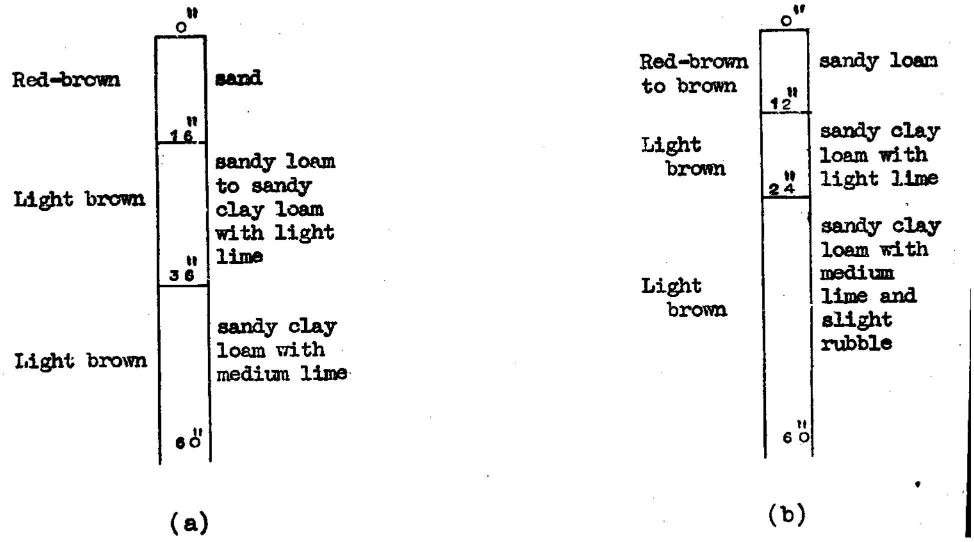

Fig. 3 - (a) Barmera sand, (b) Barmera sandy loan.

(b) **Barmera sandy loam** (See Bulls. 86, 1934; 107, 1957; 123, 1938.)
The normal type, as shown in a representative profile in Fig. 3 (b) is mapped at Mildura, and, as at Merbein, contains limestone rubble up "light" concentration.

Cureton sand. An average profile of this sandy-surfaced type is illustrated in Fig. 4 (a). The appearance of the deep subsoil suggests that the clay subsoil of the heavier plains types has been overlaid by sand drift and that the profile has matured with a predominantly greyish clay below 4 ft., sharply differentiated from the soil above. Cureton sand is distinguished in this way from Barmera and other sandy types. Because of its topographic position, flanking ridges, and its profile character, Cureton sand is subject to temporary waterlogging following irrigation, but it appears to clear the excess water readily and in any case may be drained easily. Lime content may be moderate in the sandy clay loam horizon, but always decreases notably in the heavier horizons at greater depth.

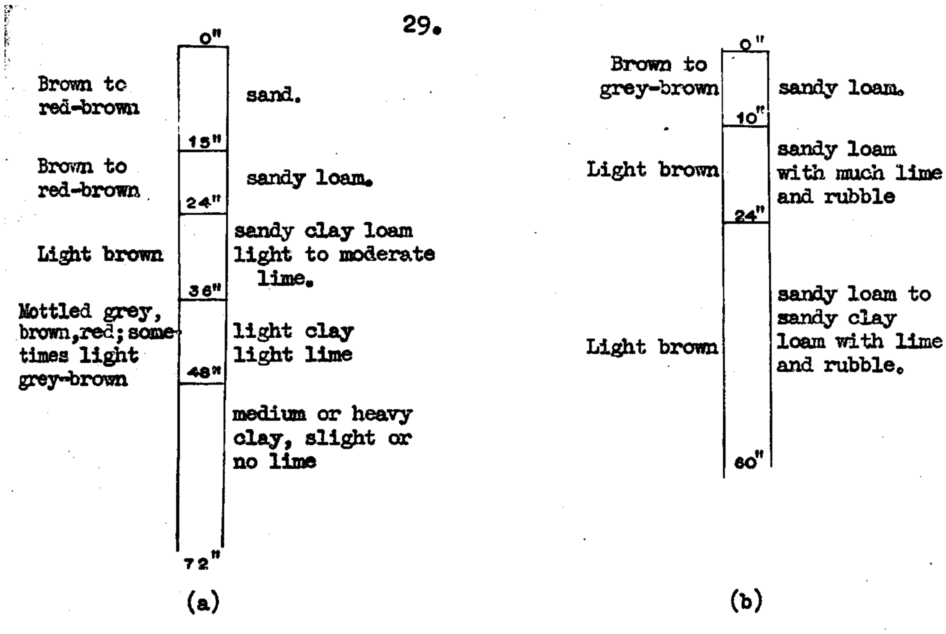

Fig.4 — (a) Cureton sand, (b) Moorook sandy loam.

Moorook sandy loam. (See Bulls. 86, 1934; and 107, 1937.)

This soil type associated with low sandy rises and slopes has a characteristic greyish surface and highly calcareous subsoil, otherwise resembling Barmera sandy loam to a depth of 6 ft. At about that depth frequently occur black, apparently manganiferous, inclusions, and the clay layer at greater depth may be grey and friable. Under irrigation, soils of this type are often waterlogged and suffer considerably from salt accumulation. Response to drainage is satisfactory when drains can be laid on a suitable bottom. The content of lime and rubble in the subsoil is usually rather less at Mildura than in the type as described at Berri. South Australia, and illustrated in Fig. 4 (t). Another tendency at Mildura is towards slightly heavier texture in the subsoil and deep subsoil than at Berri.

2. Soils Associated with Plains and Undulating Country.

Nookamka series. (See Bulls. 86,1934; 107,1937;123,1938)

The occurrences of **Nookamka sandy loam** and **Nookamka loam** at Mildura conform to the types as previously described and as illustrated in Fig. 5.

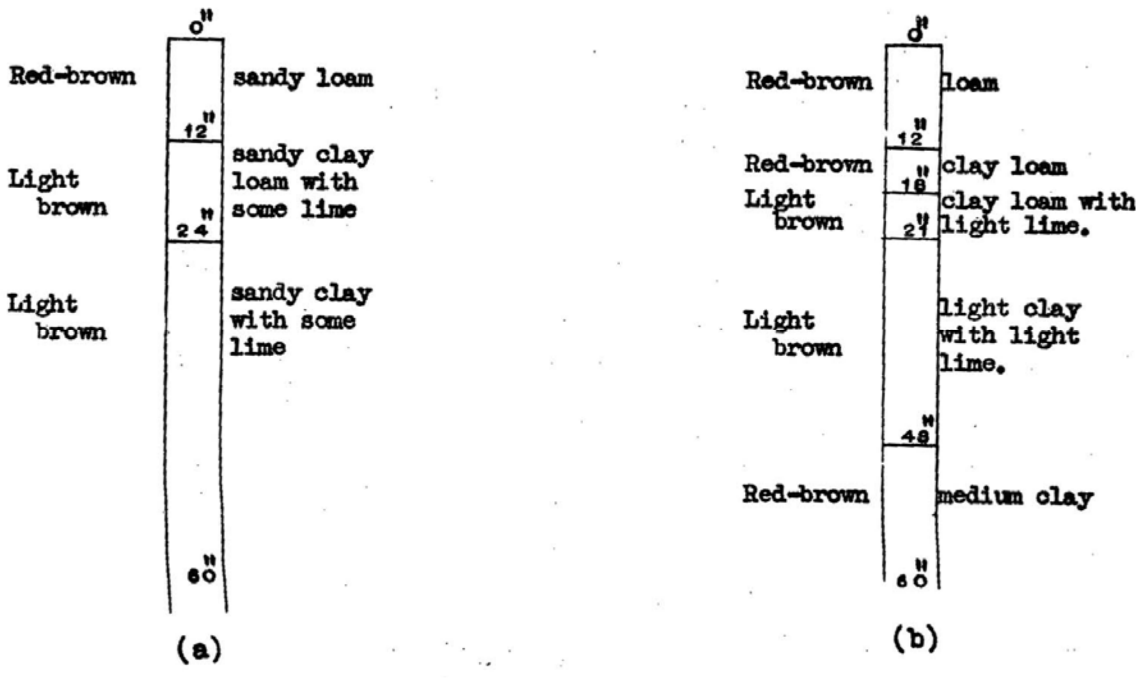

Fig. 5 – (a) Nookamka sandy loam, (b) Nookamka loam

Morpung loam The outstanding feature of this soil type is the brown, or even red, colour of the profile, especially prominent in the deep subsoil. Lime content is usually low and texture not at all heavy to 3 feet. The typical profile to 6 feet is shown in Fig. 6 (a).

Below 6 feet the colour continues brown or red-brown with some black inclusions, while texture may become more sandy or heavy clay, which persists to at least 9 feet. Under irrigation this soil type is considered safe, not particularly liable can be effectively to surface salinity, and if necessary drained.

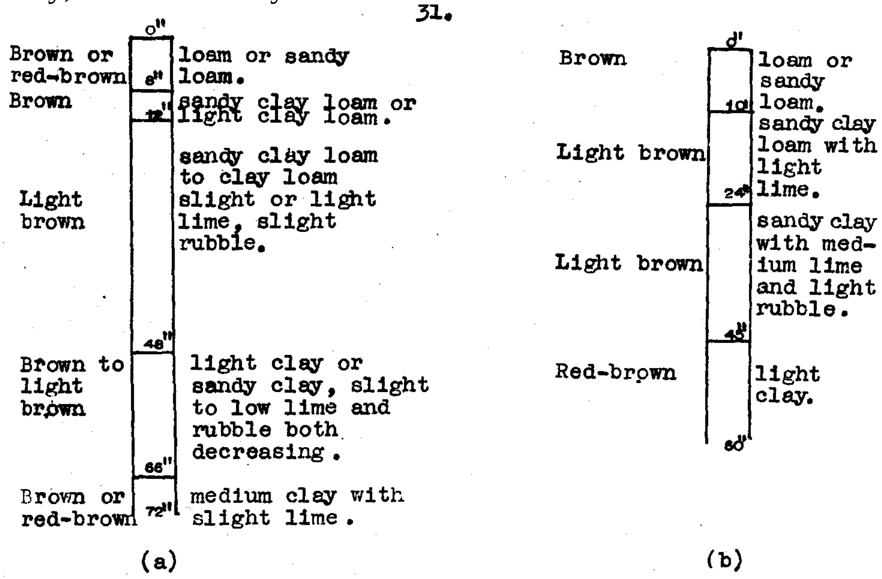

Fig. 6 - (a) Morpung loam, (b) Coomealla loam.

<u>Coomealla loam.</u> (See Bulls.107, 1937; and 123,1938.)

Occurrences of this soil type at Mildura conform with the original description, which is illustrated in Fig. 6 (b). In some cases, the underlying clay may be shallower and heavier than normal, as in the profile 8491- 8495 (see Appendix, Table IV).

<u>Belar clay loam.</u> The main features of this soil type are the heavy texture throughout the profile and the redness of the deep subsoil. The latter is a point of distinction from Merbein clay loam, which this type resembles in texture and in its occurrence in similar locations, although confined to the eastern part of the settlement. Belar clay loam in its natural state carried belar interspersed with open,more or less grassy, areas.

The features of a typical profile are shown in Fig. 7. Small amounts of gypsum are frequently present. The heavy profile restricts water penetration, so that the chief difficulty experienced with this soil is lack, rather than excess, of water, and drainage is not necessary.

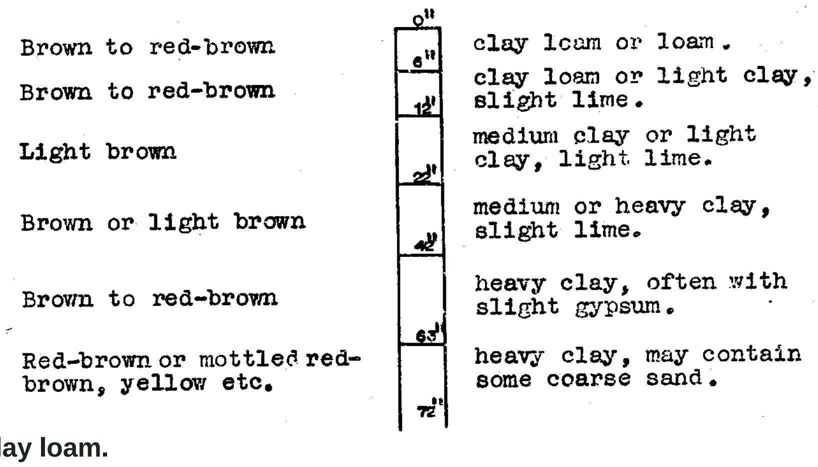

Fig. 7 - Belar clay loam.

Benetook series.

(a) **Benetook loam.** (See Bull. 123,1938.)

Recorded as a minor occurrence at Merbein, this soil is widespread at Mildura, particularly in the western half of the settlement. It is the typical soil of the mallee-bluebueh plain country having a brown to red-brown surface.

A representative profile is shown in Fig. 8 (a), the heavy clay shown at 6 feet persisting to at least 9 feet. In a number of cases, no gypsum was observed and the lime continued instead to 5 feet. Despite the heavy nature of the profile, there is often need for underground drainage, particularly when gypsum is present in large amounts.

(b) **Benetook sandy loam.**

This type has a sandier surface and rather lighter profile to about 40" than Benetook loam, but the colour sequence is similar and the deep subsoil consistently heavy. This is typically a soil of the plains with gentle slope.

As shown in an average profile in Fig. 8 (b), the surface is always light and deep, while the subsoil seldom contains much lime or rubble and continues brown in colour down to the medium clay horizon. Lime decreases with the appearance of grey colour in the deeper subsoil, which persists as a heavy clay below six feet.

A variant of the type, marked "light profile", has been mapped near the western fringe of the settlement. This is of minor importance and is distinguished by, its greater depth of light surface and subsoil; the clay horizon usually lies at about 5 feet, below which there is a rapid change to heavy clay.

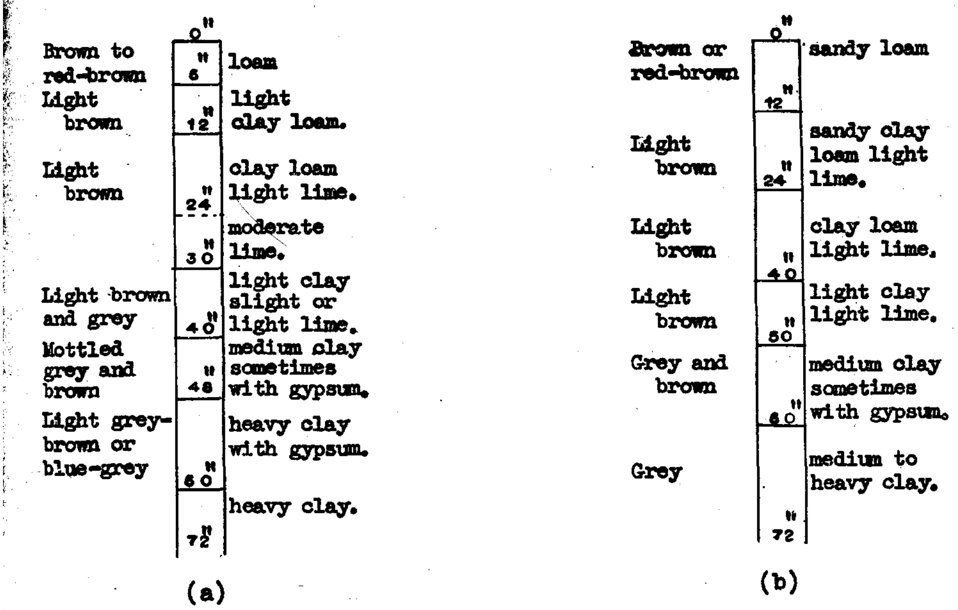

Fig. 8 ...(a) Benetook loam, (b) BenetoOk sandy loam.

Merbein series.

Merbein loam. (See Bull. 123, 1938.)

The profile conforms with the type as described at Merbein and illustrated in Fig. 9 (a). Clay content increases steadily in the profile to medium clay by 30 inches. This type occurs to only minor extent at Mildura.

Merbein clay loam.
Soil of this type occurs typically on lower ground, either on plains or between sandy rises. The profile, as shown in Fig. 9 (b), is heavy throughout, lime content being ,unusually low and rubble either slight or absent. Light clay occasionally may occur at the surface or within a depth of 4 inches, in which case the medium clay appears within 20" of the surface. Soil salinity is not a problem of any importance in this soil type, and drainage is not necessary because of the slow rate of absorption of water.

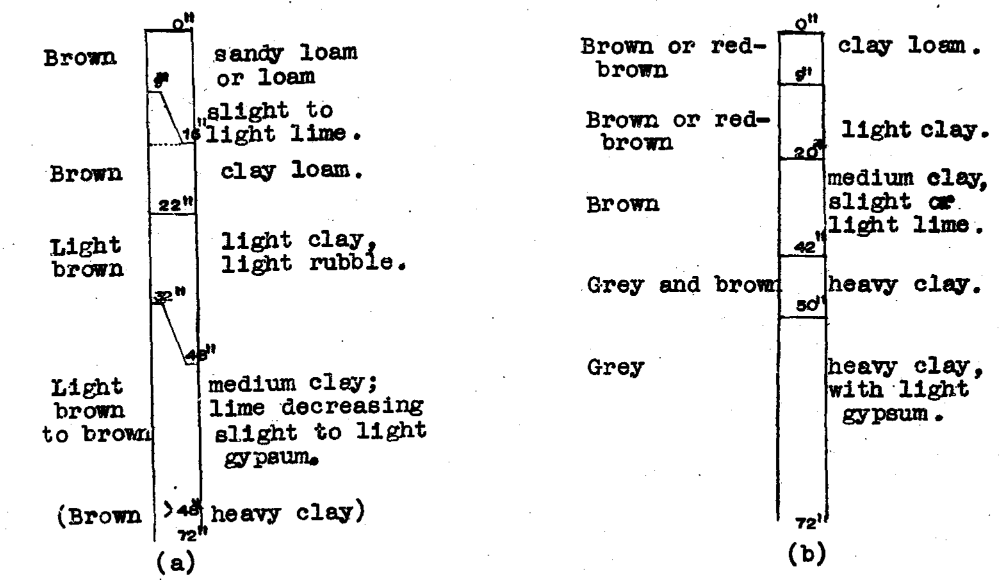

Fig. 9 - (a) Merbein loam (b) Merbein clay loam.

Karadoc sandy loam. (See Bull. 123, 1938.)

Both in topographic situation and profile character, occurrences of this type at Mildura agree closely with those at Merbein. The normal form is represented in Fig. 10 (a). Appreciable amounts of rubble may occur in the surface soil, and considerable amounts, often somewhat stony, are found in the subsoil. Characteristic changes in the deeper subsoil are decrease in lime content and notable increase in sand, occasionally to a coarse gritty sand, more generally to a fine micaceous sand.

A "heavy subsoil phase" has been mapped, indicating a subsoil horizon of light to medium clay, underlain by sandy horizons almost as light as in the normal type. Below 6 feet there is a clay layer, varying widely in its depth of occurrence. In the Karadoc sandy loam soils generally, waterlogging of the sand horizon in the subsoil is very common, and the type frequently gives trouble with salt accumulation. For these reasons, drainage is often required, but an unfortunate feature of the soil profile from this aspect is that there is no satisfactory base for laying of drains within reasonable depth.

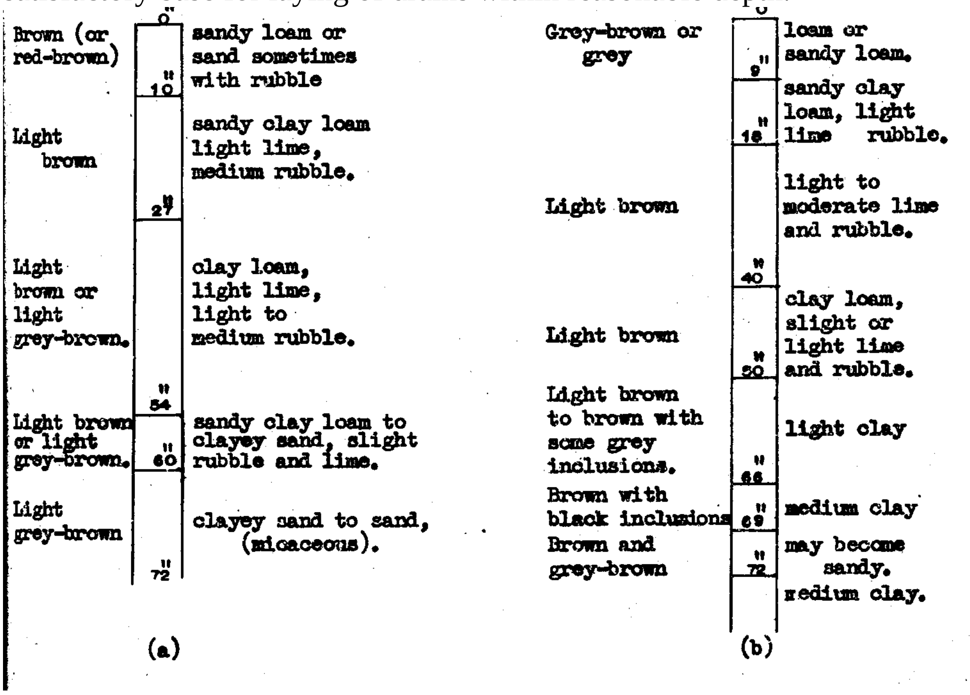

Fig. 10 — (a) Karadoc sandy loam, (b) Sandilong loam,

Sandilong loam. The main features of this type, which is associated with flatter country naturally covered with dense mallee, are the greyish surface colour and the considerable thickness of light subsoil continuing brownish in colour to the clay, which may be somewhat mottled. Black manganiferous inclusions occur almost invariably in a band a few inches thick at a depth of about 6 feet and may be succeeded by a narrow zone of rather coarse Sandy clay.

The content of lime and rubble is variable, but usually moderate. Fig. 10 (b) illustrates the typical profile.

A **"shallow phase"** was separated on the basis of depth to the clay horizon; in other respects it follows the normal form in most respects. From the surface loam there is a change to clay loam at an average depth of 20 inches, then to light clay at 33 inches and to medium clay at about 4 feet, at which depth some gypsum may be present. Small areas of even heavier soils were included with this shallow phase when the general profile was similar to that described ed, but heavier from 2 feet downward.

Deep phase. A lighter form of Sandilong loam was mapped as "deep phase" where the underlying clay occurred at more than 5 feet from the surface (average, 70 inches). In all other profile features, as well as in topographic position and native vegetation, this phase conforms with the normal type.

All the Sandilong loam soils appear to have been inherently saline, and under irrigation large, areas have gone out of production as the result of surface accumulation of salt. Subsoil drainage at close intervals has been successful in many instances in combatting soil salinity in this type.

Irymple series.

(a) **Irymple loam,** Soil of this type is predominantly grey, although brown-surfaced areas were included if grey colour occurred at shallow depth. The absence of sandy influence throughout the profile, which is illustrated by Fig. 11. (a), is a point of distinction from most other Mildura types with grey profiles. Lime content is low and there is little, if any, rubble. A resemblance to Benetook loam lies in the progressive increase in heaviness to the clay at 2 to 3 feet. Irymple loam is associated with the bluebush plains, particularly in the western part of the settlement. In this locality blue-grey clay is the characteristic deep subsoil, in contrast with grey or grey-brown colours elsewhere in the Mildura area.

Irymple loam has not proved a highly productive type, and it has been necessary to provide drainage in many cases because of salt accumulation. The soil profile indicates that tile drains should be laid at the lower limit of the gypsum horizon, if gypsum is present, otherwise on the blue-grey clay.

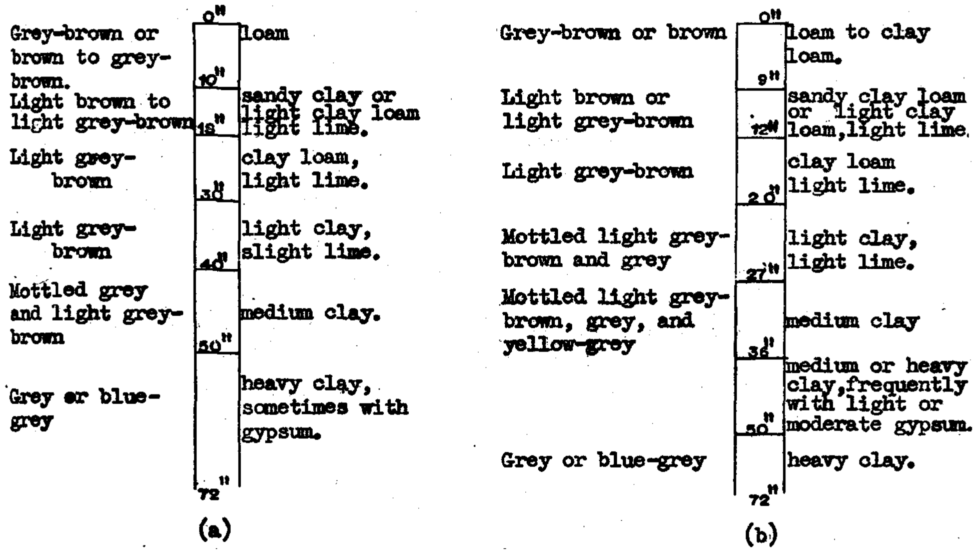

Fig. 11 - (a) Irymple loam, (b) Irymple clay loam.

(b) **Irymple clay loam.** As shown by the typical profile set out in Fig. 11 (b), this type is similar to Irymple loam, but the surface soil As a light clay loam and the texture changes to a medium clay by 30 inches, the profile then remaining grey and heavy to more than 6 feet. In several places, a heavy variety of Irymple clay loam has been mapped, with a uniformly heavy and grey profile.

Soil salinity is oftenhigh in this type. Despite the slow rate of movement of water associated with such a heavy profile, drainage is likely to prove beneficial when much gypsum is present. In other cases, improvement following drainage would take place very slowly and probably would be unsatisfactory.

Mildura loam. This is one of the "grey mallee" types intermediate between Irymple loam, and Sandilong loam and occurring mainly in the western half of the area. It differs from the former in its notable content of rubble and from the latter in its definitely grey deep subsoil. In two respects it is allied with the Koorlong series, with regard to rubble content and exceptionally high silt content, but Mildura loam has no sandy substratum. A representative profile is shown in Fig. 12.

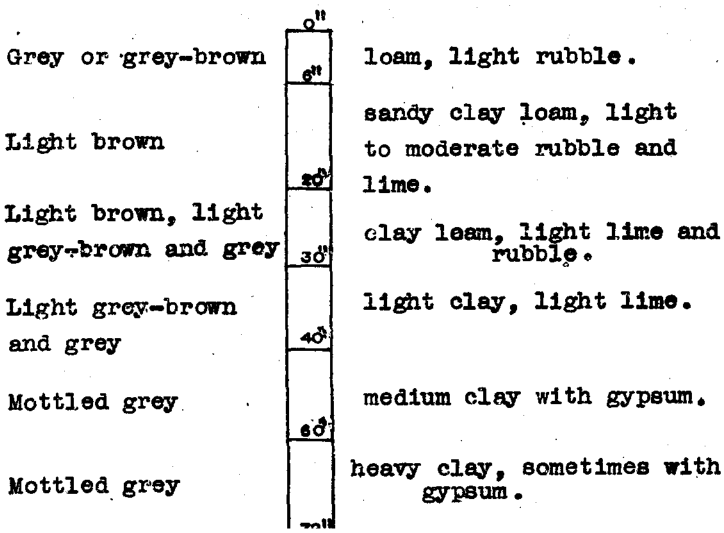

Fig. 12 — Mildura loam.

The presence of rubble in the surface soil is characteristic, and it persists to depths of 2 or 3 feet, often in large amounts. Gypsum is not always present in the deeper subsoil, which is mottled and dense. In the absence of gypsum, these subsoils appear only slowly permeable to. water Temporary waterlogging of the upper soil often occurs following irrigation, and salt accumulation has been frequent, so that drainage usually is necessary on this soil type.

Koorlong series.

(a) **Koorlong sandy loam.**

This soil is similar to Karadoc sandy loam in sequence of horizons, texture, and lime content, but tends to greyish colour throughout the profile, which is illustrated by Fig. 13 (a). The surface soil is usually deep, with considerable rubble or stone, the rubble diminishing with depth and virtually disappearing below 4 fee‘ Below about 3 feet the characteristic light substrate appears, typically with a high content of micaceous fine sand, often with an appreciable proportion of silt. The deeper subsoil is very variable in texture but may be as heavy as a fine sandy clay, changing to medium clay by 6 feet, the latter feature being responsible for waterlogging under irrigation and making provision of drainage necessary for satisfactory results.

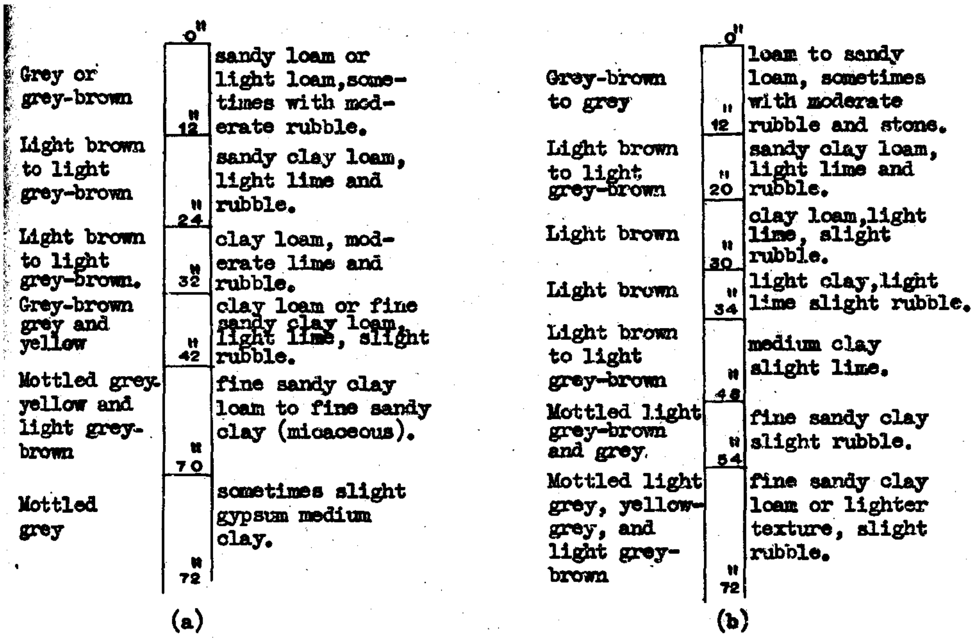

Fig. 13 - (a) Koorlong sandy loam, (b) Koorlong loom.

(b) **Koorlong loam**

Soils of nature similar to Koorlong sandy loam, but of heavier profile, have been separated into the Koorlong loam type, the features of which are shown in Fig. 13 (b). The surface soil is usually a loam, the subsoil changing to medium clay before lightening to a fine sandy clay at about 4 feet. Below that depth, the profile may continue as fine sandy clay or may become fine sandy clay loam, but has always a notable content of find sand and silt.

At Koorlong, the deep subsoil is frequently as light as clayey fine sand.

3. Soils of Box Flats. Pomona play. (See Bull. 107, 1937.)

While there are several variants of this type, all have definite resemblance to the soil described earlier at Pomona. A representative profile is shown in Fig. 14, the chief features being the general grey or yellow—grey colour, the low content of lime, and the almost uniform heaviness throughout.

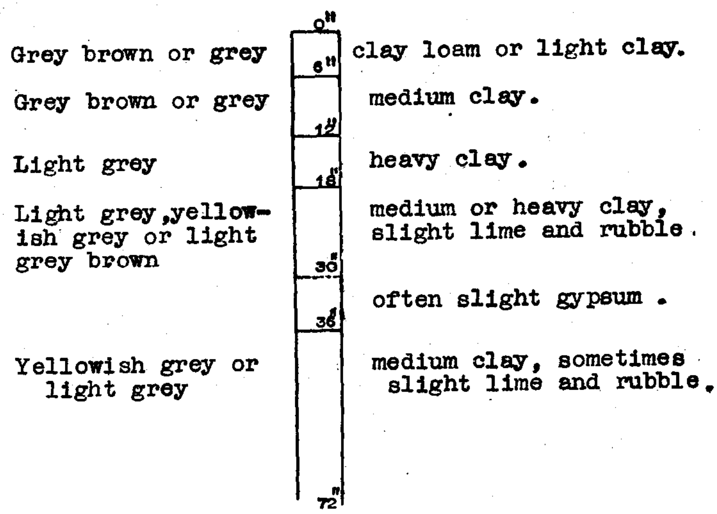

Fig. 14 — Pomona clay

Considerable variation occurs in the surface layer, which often is a brownish sandy loam accumulated as blown material to a depth of 1 to 12 inches, averaging about 4 inches. Such an occurrence is noted on the soil map as "light surface". A second variant becomes increasingly sandy below about 50 inches of the usual heavy clay, the substratum being micaceous and varying from a silty clay to fine sandy clay loam below 5 feet.

The Pomona clay type, which in the virgin state carried a moderate stand of box trees, is not a useful soil for horticulture because of its low absorption rate for water and the difficulty of effective cultivation.

The light-surfaced variety is materially better if the surface soil extends to a depth of 6 inches or more.

4. Unnamed Minor Types.

Most of these soils were found on the lower ground adjacent to box flats. They have been.separated as a group of minor types, occurring in positions of low elevation as compared with the main settlement and in areas in which soil Variability is very great.

Type 1. This soil 'has many features, apart from elevation, in common with Karadoc sandy loam. The type has a brown sandy surface which has probably been windblown, and its typical occurrence is in the form of patches at slightly higher level than the adjacent greyer soils. Type 1 was mapped east and west of the city of Mildura, and round. the Old-Mildura Station homestead, in all cases adjoining box flats. The profile is as follow:-

Brown to red-brown	- sand to sandy loam	0-6"
Brown	- sandy loam	6-12"
Light brown	- clay loam	12-18"
Light brown	- clay loam or light clay, slight lime from 24"	18-36"
Light brown to light grey-brown	- sandy clay loam, slight lime and rubble	36-50"
Light brown to light grey-brown	- sandy clay loam to sandy loam	50-72”

The marked change in texture from sandy loam to clay loam may occur at rather greater depth than 12". The sandy horizons of the deeper subsoil are micaceous, and lime is not a prominent feature in the profile. Natural drainage is very good and little damage appears on these soils from waterlogging or salinity.

Type 2. A grey soil closely related to Type 1 and occurring in a similar topographic position on the eastern and western sides of the settlement has been Classified, as Type 2. The surface is often a sand and the whole profile may be sandy, as indicated in the average profile.

Grey or grey-brown	- sand	0-12"
Grey or light grey	- sandy clay or light clay	12-18”
Grey or light grey	- light clay or medium clay	18-24”
Light grey	- sandy clay, slight lime	24-36”
Light grey or light grey-brown	- sandy clay to sandy clay loam, slight lime	36-50”
Light grey to yellowish grey	- sandy, clay loam to clayey sand slight lime	50-72”

The sandy material of the deep subsoil is often micaceous, but the sand generally appears coarse rather than fine. The colour profile is similar to that of Pomona clay, in fact this type probably, grades into Pomona clay although the variant of the latter which is underlain by sand.

Type 3. Occurrences of this type are restricted to the north-west portion of the settlement in the vicinity of Mildura aerodrome. The surface horizon consists of red-brown sandy loam windblown in comparatively recent times into its present position overlying a "box flat" profile. Accumulation of similar sandy material may be as much as 3 feet deep along fences or channels. A representative profile is as follows:

Red-brown	- sandy loam	0-10”
Grey-brown	- light clay	10-18”
Light grey-brown or light brown	- clay loam or sandy clay loam	18-36”
Grey or light grey-brown	- sandy clay or light clay, slight lime	36-45”
Grey or light grey-brown	- light clay to medium clay, low lime	45-60”

The lime content is low, often tending to increase slightly with depth to moderate amounts, and occasionally slight gypsum is present at about 4 feet. The lightening of texture in the zone 18-36", as shown in the typical profile, is characteristic of this type.

Very little development has taken place on this soil, which adjoins. Pomona clay at slightly higher elevation.

Type 4. Soil of this type has certain affinities with the Merbein series and represents a transition between mallee-belar soils and the box flats. A representative profile is as follows:

Brown	- loam (or sandy loam)	0-6”
Brown	- clay loam (or sandy clay loam)	6-9”
Light brown	- light clay	9-18”
Light brown or light grey-brown	- clay loam, slight lime	18-30”
Light brown to light-grey brown	- light clay, slight lime	30-40”
Light grey-brown to grey	- medium clay, slight lime (no lime from 54”)	4-72”

It is a feature of this type that a lightening of texture occurs at 18 or 24 inches, followed by a progressive increase in heaviness. Lime content is usually slight and never more than light.

Type 5. Type 5 is a red brown soil on the lower slopes to the grey flats in the north-west portion of the settlement. The main characteristics are a definitely reddish and light upper zone, and definitely greyish and heavy lower zone in the profile. The subsoil shows lightening in texture before reaching the grey clayey horizons at 2 or 3 feet. A representative profile is as follows:

Red brown	- sandy loam	0-8”
Light red-brown	- clay loam to light clay	8-18”
Light red-brown (or light brown)	- sandy clay loam	18-30”
Grey brown	- light clay or sandy clay, light lime	30-40”
Grey or light grey-brown	- medium clay, light medium lime	40-60”
Mottled grey, brown, yellow	- medium clay, light lime	60-72”

Considerable variation from this profile has been permitted in mapping, while preserving the general sequence of colour and texture. Some difficulty was experienced in separating areas of Type 5 from the deep Phase of Benetook sandy loam, which occurs in the same section of the settlement. The essential difference is the clay band immediately below the surface soil in Type 5.

Type 6. At Nichol's Point and also north of the aerodrome, this type occurs in small areas intermixed with Pomona clay. It has a somewhat lighter profile than the latter, and is not as definitely grey in the upper 4 feet. The average profile is as follows:

Grey-brown	- loam or clay loam	0-6”
Grey brown	- clay loam	6-12”
Light grey-brown	- light clay	12-27”
Light grey-brown becoming grey	- medium clay, slight lime and rubble	27-60”
Grey or yellowish	- medium or heavy clay	60-72”

The surface is occasionally a light loam and the light clay may come in at less than 12 inches and continue to 36 inches without change. Lime is present in only very small amounts. The grey an yellowish-grey colouration of the deep subsoil is typical of this soil, as with Pomona clay and Types 2 and 3. Type 6 is somewhat easier to handle than Pomona clay but water absorption is slow and drainage unnnecessary.

Type 7. This soil occurs only on a restricted area immediately west of the town. It does not lie on the lower levels like Types 1 - 6, although not greatly removed from them in actual eleeation. It has some features in common with Mildura loam, but is distinguished by the redness of the subsoil below 2 or 3 feet and its low silt content as shown by mechanical analysis. Under irrigation, this soil suffers in a similar way to grey-brown loam and drainage usually is necessary for continued good results.

A representative profile is as follows:

Grey-brown	- loam to slight light rubble	0-8”
Light brown or light grey-brown	-sandy clay loam light rubble and medium lime	8-25”
Light brown or light grey-brown	- sandy clay or light clay slight rubble, medium lime	25-44”
Light red-brown	- medium clay, slight rubble, light lime	44-72”

The texture of the subsoil may vary in sandiness, and clay may not appear within 4 feet of the surface; below 6 feet there is often a mottled red, brow ,and grey heavy clay without lime or rubble.The content of lime in other horizons is usually moderate, with rubble content varying from, ight to moderate from the surface to a depth of about 3 feet.

5. Variants of Soil Types,

Variants of some of the Mildura types have been discussed in description of the soil types themselves. A certain amount of variation within a soil type is normal, but where it exceeds the usual limit without being sufficiently important or extensive to warrant separation as a phase, the departure from the normal type has been indicated by lettering on the soil map. The terms used are in most cases self-explanatory, some of the more important being as follows:

* "***Light profile***" - used for a number of types to indicate soils of lighter textures generally, or of greater depth to the clay horizon, than the normal for the type.
* "***Heavy profile***" - indicates soil of heavier texture, or less depth to the clay horizon, than the normal for the type.

* "***Sandy clay subsoil***" - this variation occurs mainly in Mildura loam, which normally has- a high silt content in the subsoil.
* "***Silty subsoil***" - a few small areas of Sandilong loam contain even finer micaceous material than in Mildura loam. The soils had a very smooth, silty character, and the visible flakes of mica were very small.
* "***Rubbly profile***" - or "***Rubble in profile***" - some areas of types which normally contain little or no rubble had sufficient to make necessary an indication of its presence.
* "***Deep sandy surface***" - a variant of several types indicating a greater depth of, and frequently a lighter textured, surface soil than is normal for the type.

IV. LABORATORY EXAMINATION OF SOIL

1. Mechanical Analysis.

Soils of the Mildura district cover a wide range of physical composition, varying from wind-blown sands to clay types. This is illustrated by Table 4, which presents weighted average clay contents to 60" for representative soils, the figures being derived from those given in the Appendix for mechanical analysis by the International method.

Table 4 - Average Clay Content to GO" for Mildura Soils.

Soil type	Clay%	Soil type	Clay%
Murray Sand	9	Mildura loam	24
Barmera sand	13	Benetook sandy loam	26
Moorook sandy loam	16	Koorlong loam	26
Berri sand	17	Irymple loam	28
Karadoc sandy loam	18	Coomealla loam	30
Koorlong sandy loam	18	Benetook loam	33
Sandilong loam	20	Belar clay loam	35
Barmera sandy loam	21	Merbein clay loam	41
Cureton sand	22	Irymple clay loam	47

The main features of the various soil types from the physical aspect are summarized in this tabulation, which expresses relative heaviness in the soil depth of chief interest in connection with plant growth, irrigation, and drainage. The light nature is shown of the red-brown sandy rise soils of the Murray, Berri, and Barmera series, especially Murray sand, Sandilong loam, together with Karadoc sandy loam, Koorlong sandy loam, and Morpung loam are of moderate average clay content, while the figure for Cureton sand reflects the influence of the heavy subsoil characteristic of this sandy-surfaced type, Among the heavier soils, Belar clay loam, which gives the impression in the field of being the heaviest type, is noted as lighter on analysis than the clay loam members of the Merbein and Irymple series. Merbein loam, as represented in the Merbein district, had a corresponding figure of 35% clay, The Benetook series shows the influence of lighter subsoils than those found in the related Merbein series, a similar relation holding between Mildura loam and the Irymple soils. It should be noted, however, that one profile of Mildura loam with very heavy subsoil has not been considered in compiling Table 4.

Details of mechanical analyses, as listed in the Appendix for 200 samples, indicate that the Mildura soils in general conform to the normal features of the Mallee group. The properties of the soils are determined chiefly by relations between contents of sand, calcium carbonate, and clay, and the nature of the latter. Silt seldom contributes more than 7% to the mechanical composition, notable exceptions being Mildura loam, in which silt contents as high as 37% occur in the subsoil, and Koorlong sandy loam in which figures of similar order were found. Certain subsoils of other types, such as Irymple clay loam below 22" and Benetook loam below 50", contain up to 14% of silt.

The coarser soil constituents, listed in the Appendix as "rubble and gravel", consist usually of limestone rubble, although stone is included in some cases. Apart from the subsoil band of sheet limestone in the stony Phase of Barmera sand, rubble occurs in varying quantities up to 42% of the field sample, the higher proportions of rubble being associated chiefly with the Koorlong series. More moderate proportions of rubble are present in the Barmera, Coomealla, Karadoc, Sandilong, and Mildura types, the chief occurrences being in the subsoils in these cases, except for Mildura loam, which gave figures up to 16% for surface samples. Soils in which rubble contents are comparatively slight include Merbein clay loam, the Irymple series, Pomona clay, Type 5, and Murray and Berri sands. In certain subsoils, much of the material noted in the Appendix as "rubble and gravel" is coarse gypsum. The samples concerned, which are marked appropriately in the column for "total soluble salts" in the Appendix, occur in the Irymple, Merbein, Benetook, and Mildura series. Contents of gypsum in this form vary up to 21% of the field sample for the soils examined. Together with the gypsum in the finer condition, often also present, the occurrence of this material in appreciable quantity exerts considerable influence on physical properties of the soil, particularly with regard to local accumulation of free water.

The composition of the fine earth, remaining after separation of the coarser materials just described, has been discussed to some extent already with reference to clay and silt. The relations of these constituents to coarse and fine sand and to calcium carbonate may be illustrated by reference to Fig. 15, which shows variations in the proportions of the soil fractions at different depths in representative profiles of the four main loam soils of Mildura, which together cover 36% of the total area.

Generally in the Mildura soils, fine sand predominates over coarse sand, often to considerable degree, and coarse sand tends to diminish with increasing depth: these points are evident in Fig. 15. Coomealla loam is exceptional, coarse sand content being well sustained throughout the profile and predominating over fine sand at all depths. As indicated by Fig.15, fine sand is an important feature in all soil types at Mildura at all depths except in some of the heavier subsoil clays. It attains particular significance in certain subsoils, notably those of Karadoc sandy loam, where figures up to 66% were found, and in the Koorlong series, which includes a sample with 82% fine sand.

Fig. 15 illustrates the small proportions of silt fraction typical of Mallee soils in general, showing as an exception the high content of silt throughout the profile of Mildura loam. Also evident in the figure is the definite increase in silt content in the deeper horizons of Irymple loam. As noted previously, certain other soil types exhibit one or other of these exceptional features with regard to silt content.

In accordance with a general principle of soil formation, variations in distribution of clay with depth in Mildura soils are related to changes in content of calcium carbonate. Lime in the form of rubble has been discussed above, but it is calcium carbonate in the soft form, as present in the fine earth, which is now under consideration.

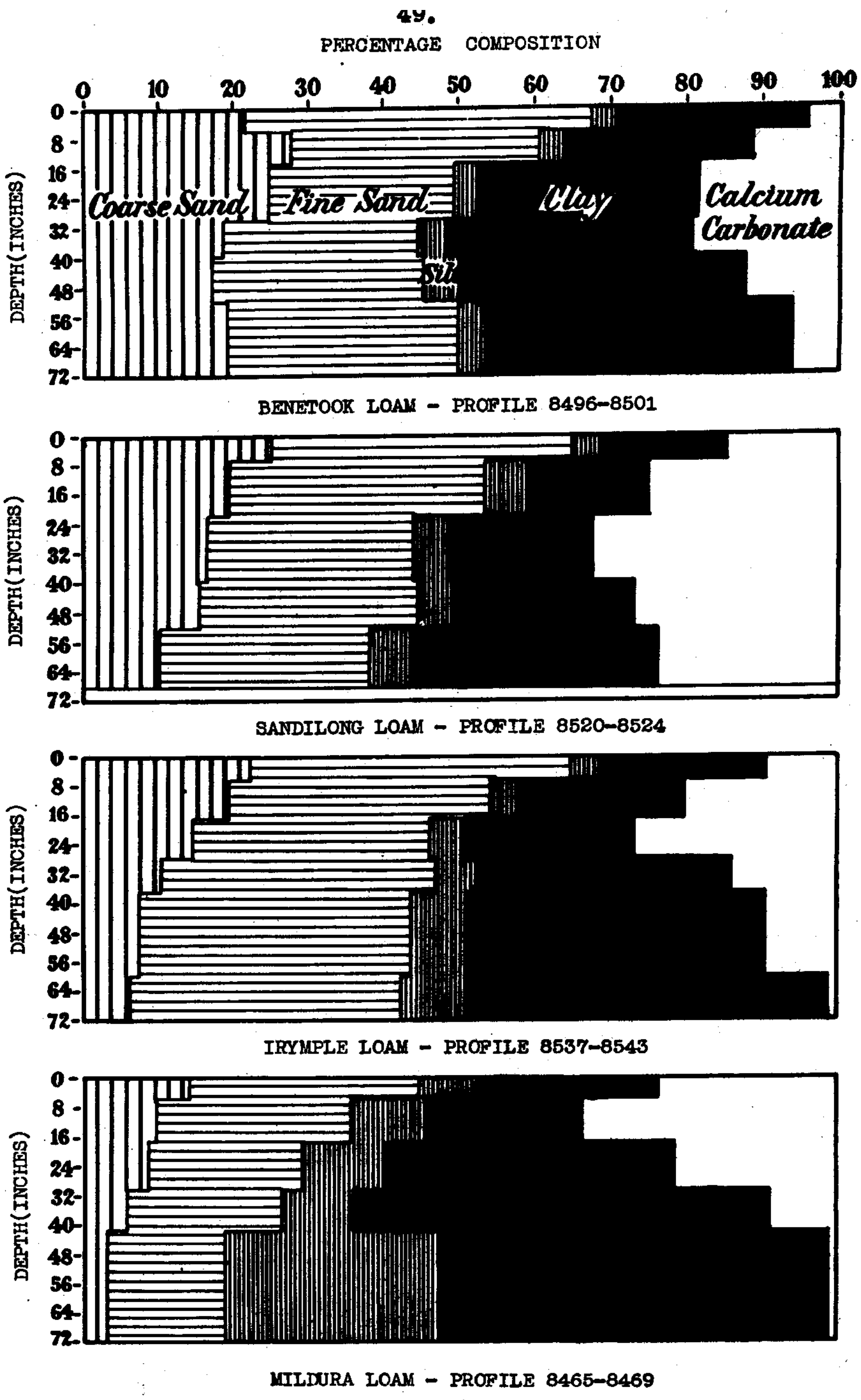

Fig. 15 - Showing physical constitution of soil at different depths in four representative Mildura soils. The diagrams are based on recalculations to a total of 100 per cent for the five constituents shown.

Variations in amounts of the two forms of lime throughout the soil profiles are usually related, as may be noted in the Appendix. Most of the Mildura soils show the usual tendency towards increasing clay content with depth, the analyses disclosing that a well-defined increase in clay at about 30" depth is succeeded at about 40" by diminution of lime, each change progressing further with greater depth. In the heavier types, such as the Irymple series, Merbein clay loam, and Mildura loam, these changes tend to occur at shallower depths; exceptions are the box flat soil Pomona Clay, and Type 5. In the lighter soils, the distribution of soft lime may be fairly diffuse; in the "sand" types, for example, and in Sandilong and Moorook loams, lime is very persistent with depth, variations in clay content being relatively slight in most of these types.

The Chief points in the variations of clay and calcium carbonate are illustrated in Fig. 15, which shows also that lime may be present in considerable quantity even in surface soils. For Mildura and Sandilong loams, figures up to 22% of soft lime in surface soils are recorded in the Appendix, while Corresponding figures for Koorlong and Irymple loams are of the order of 10%. Apart from Murray and Berri sands, Merbein, Belar, and Irymple clay loams, Pomona clay, and Type 5, contents of soft lime greater than 20% occur in the subsoils of all types. Koorlong, Mildura, Sandilong, and Karadoc loams are particularly notable in this respect, the Appendix showing figures up to 38% soft lime in subsoils of these types.

With regard to the order of clay content, none of the samples examined is a very heavy clay: the highest clay content recorded in the Appendix is 59% for the deep subsoil of Irymple clay loam. Figures approaching this magnitude are given for subsoils of Merbein loam, Benetook sandy loam, Irymple loam, Merbein clay loam, and for a sample at a depth of 9 feet in Sandilong loam. Among the surface soils, Merbein clay loam is outstanding in clay content, with figures up to 40%. In general, agreement is good in these soils between field estimates of texture and mechanical analysis; soils which give the field impression of greater heaviness than their analyses would suggest, include the subsoil horizons of Cureton sand, while the reverse effect is shown by subsoils of Type 5 and the stony phase of Barmera sand.

2. Reaction.

After irrigation for about 50 years on soils of this nature, high reaction values are likely to be prevalent. That this is the case is demonstrated by Table 5, which presents reaction values as determined by the glass electrode method of Heintze (J. Agric. Sci.24:28, 1934), on 1:5 soil suspensions. In this tabulation. samples are separated into surface, subsoil, and deep subsoil groups, the divisions representing approximately 0 - 7 inches, 7 - 42 inches, and 42 72 inches, respectively.

Table 5. Frequency Distribution of Reaction r in Mildura Soils.

pH	Less than 7.3	7.3-7.6	7.7-8.0	8.1-8.4	8.5-8.8	8.9-9.2	9.3-9.6	9.7-10.0	No. of soils
Surface				4	26	6	2		38
Subsoil		1		2	28	30	22	7	90
Deep subsoil	2	3	5	5	6	15	23	13	72

The typical change in reaction with depth over the three divisions mentioned is very similar to that found at Merbein, namely pH 8.6 to 9.2 to 9.6. Most of the figures less than pH 8.5 for the lower horizons are for samples containing gypsum, although other, and more soluble, salts are in some cases partly responsible for lowering of reaction, as in the subsoil of Irymple clay loam, where reaction pH 7.6 is found in the presence of 0.85% soluble salts. The two lowest reactions found in the whole series, listed as "less than pH 7.3" in Table 5, are pH 6.4 for mottle heavy clay at a depth of 9 ft. in Sandilong loam and pH 6.2 for similar clay at 54-78 inches in Irymple loam. As soluble salts are present in these samples, and in others like the Merbein clay loam subsoil 8507, to only moderate extent, the indications are that some of the deeper subsoils are inherently of definitely lower reaction than the usual Mildura subsoils in the root zone.

The general position as shown by Table 5 is that most of the soils are highly alkaline. Some of the types, namely Koorlong and Coomealla loam and Moorook sandy loam are specially notable for very high alkalinity throughout the profile, except where gypsum may occur in the deeper subsoils. Details of reaction for individual samples are given in the Appendix, figures ranging for surface samples up to the rather remarkable figure of pH 9.5, and for subsoils up to 10.0. Sultanas on Koorlong sandy loam with reaction pH 9.5 at the surface are definitely poor, but it is difficult to evaluate any possible adverse effect of such high reaction on the vines in view of the fact that the land is rather salty. Fair growth of sultanas is carried on Coomealla loam and Moorook sandy loam with reactions in the range ph 9.1 to 9.5 in all horizons from the surface to 6 feet.

The soil mapped as Pomona Clay at Mildura is evidently an older soil than the original type, (Coun. Sci. Ind. Res., Bull. 107,1937) in that the reactions for the representative Mildura profile examined are alkaline at all depths, the surface soil having pH 8.4 and containing a small amount of free lime. At Pomona, this type of soil is slightly acid at the surface and more definitely acidic in the upper subsoil.

3. Nitrogen.

An average of 38 determinations of the nitrogen surface soils of Mildura, listed in the Appendix, is 0.070g. This figure is rather higher than that found in certain other settlements along the Murray River, but is influenced considerably, as shown below, by the proportion of heavier-textured soils included. The distribution of values for total nitrogen is shown in Table 6.

Table 6. Frequency Distribution of Nitrogen in Mildura Surface. Soils.

No. of soils	Nitrogen percentage					
	0.02-0.04	0.04-0.06	0.06-0.08	0.08-0.10	0.10-0.12	0.12-0.14
38	3	8	17	5	4	1

One of the factors associated with such a distribution is the soil texture, the lighter soils tending to lower contents of nitrogen. The operation of this factor at Mildura may be noted in the average figures for nitrogen in different classes as set out in Table 7.

Table 7. Nitrogen in Mildura Sols

	No. of soils	Nitrogen percentage
Sands	5	0.043
Sandy loams	10	0.058
Loams	19	0.080
Clay loams and clays	4	0.088

4. Hydrochloric Acid Extracts.

As in the case of nitrogen, some of the constituents which may be extracted from soil by strong hydrochloric acid vary according to texture. This may be noted in the analyses for soils given in Table 8, particularly with respect to the low values for phosphoric acid and the bases given by the two light soils, Murray and Cureton sands, compared with the remainder of the soils examined.

Potash is present in moat of these soils in considerable quantity, rising to 1.5% in the heaviest sample examined, Merbein clay loam. Lime and magnesia show the wide range of variation usually found in Mallee soils, this effect being dependent largely on the presence of varying amounts of carbonates of calcium and magnesium.

Table 8. Chemical Analysis of Boils.

(expressed as percentages of air-dry soil)

Soil Type	Soil No.	Depth (in)	P_2O_5	K_2O	CaO	MgO
Murray sand	8454	0-15	0.02	0.27	0.09	0.07
Barmera sandy loam	8508	0-9	0.07	0.66	1.65	0.25
Cureton sand	8525	0-12	0.07	0.36	0.21	0.24
Morpung loam	8350	0-8	0.23	0.88	1.19	0.57
Coomealla loam	8491	0-8	0.24	0.65	7.03	0.23
Benetook sandy loam	2137	0-7	0.16	0.51	5.36	0.42
Benetook loam	2127	0-6	0.04	0.61	0.32	0.09
Merbein clay	2148	0-9	0.16	0.49	1.35	0.58
loam	8470	0-4	0.18	1.45	1.88	0.72
Karadoc sandy	8485	0-6	0.09	0.76	0.82	0.25
loam	2152	0-11	0.08	0.88	0.23	0.33
Sandilong loam	8520	0-7	0.11	0.59	8.50	0.73
Irymple loam	2133	0-9	0.13	0.66	6.58	0.54
	8537	0-6	0.20	0.84	6.37	0.57
Mildura loam	2143	0-8	0.14	0.54	8.08	0.75
	8465	0-5	0.18	0.74	13.96	1.04
	8458	0-10	0.08	0.73	11.64	0.51
Koorlong sandy	8398	0-7	0.16	0.83	4.26	0.52
loam	8544	0-6	0.07	0.56	9.42	049
Type 5	2157	0-10	0.13	0.52	0.28	0.27
Type 7	2161	0-9	0.16	0.58	8.92	0.61

It was noted in Merbein soils that several samples contained 0.1% or more of phosphoric acid, In the present examination of Mildura soils, 14 out of 22 samples conform to the standard mentioned, three having 0.2% or more of phosphoric acid. Judged against typical phosphate contents of virgin mallee soils, figures of this order indicate considerable accumulation of phosphate reserves in the soil following years of fertilizer treatment.

5. Gypsum

Reference has already been made to the proportions of gypsum in the form of coarse crystals found in certain subsoils at Mildura. In several cases, determinations were made of the amounts of gypsum present in the fine earth fraction. Results are listed in Table 9.

Table 9. Gypsum in Mildura

Soil No.	Soil type	Depth (in.)	Percentage gypsum in fine earth
8462	Mildura loam	50 - 63	4.82
8463	Mildura loam	70 - 84	1.49
8469	Mildura loam	42- 72	6.35
8474	Merbein clay loam	42-54	7.78
8535	Merbein clay loam	33-48	17.15
8536	Merbein clay loam	48-72	20.50
8549	Koorlong sandy loam	54-63	30.87

Although the major zone of gypsum accumulation at 63-70" was discarded in sampling the profile containing the two first samples, it is noted that gypsum content approached 5% in the overlying horizon, falling to 1.5% below. The last sample listed is representative of the heavier occurrences of relatively fine gypsum, approximately 31% of fine gypsum being associated with nearly 2% of gypsum in coarse form.

6. Soluble Salts.

Contents of chloride, and of total soluble salts as estimated by the conductivity method, are given in the Appendix for all samples. In most cases these figures are low to moderate throughout the root zone, but in certain profiles examined, concentration of soluble salts has proceeded to serious extent. The worst area examined is represented by the Koorlong sandy loam profile 8544-8549.

This is an area of waste land showing high concentration of salt in the upper 18 inches of soil, figures approaching 3% for total salts and 0.2% for chloride (as chlorine). Details of two other profiles representing areas abandoned for horticulture are given under Mildura loam 2143-2147 and Karadoc sandy loam 2152-2156. In these cases, total salts are of the order of 0.3% in surface soils and the salts are fairly well distributed through the profiles. The Mildura loam profile is typical of a number of cases of salt-affected land in the Mildura district in which the proportion of chloride in the total soluble salts is low.

For several of the profiles examined, there were indications of adverse effect of salt on vines in the vicinity. In most of these cases, the chief concentration of salt is in the surface horizon, as in Koorlong sandy loam (8393-8402), Mildura loam (8458-8461), and Sandilong loam (8374-8379, 8513-8519). For surface horizons in these cases, total soluble salts cover the range 0.16 to 0.52% and chloride 0.030 to 0.053%. More even distribution of salt is shown in the Karadoc sandy loam profile 8481-8484, which has chloride 0.054 and total salts 0.21% in the surface horizon and figures of similar order to 60". In the Irymple clay loam profile 8394-8397, apparent salt injury to vines is associated with comparatively low salt concentrations from the surface to 22", salt content rising sharply below that depth to figures approaching 0.9% for total salts and 0.3% for chloride below 4 feet.

It was indicated above, and was noted in the Merbein area, that chloride may contribute a relatively small proportion of the total soluble salts in many soils in this district, in contrast to its position of chief importance among the soluble salts in most other Murray

Valley areas. For further examination of this phase of the subject, analyses of soluble salt extracts of 15 Mildura soils are given in Table 10.

Consideration of the equivalent proportions of the anions, particularly chloride and sulphate, and the cations, particularly sodium and calcium, shown in Table 10, indicates that sodium sulphate may be regarded as an important constituent in several cases, confirming results obtained from Merbein. In the badly salted Koorlong sandy loam sample, in which sulphate is the chief salt, sodium predominated over calcium to the extent of almost three to one. In soils with more moderate salt content, such as 8506 and 8543, the ratio of equivalents of sodium to calcium may be very wide. Most of the surface soils, notably 8454, sandy loam 8458, show more favourable ratios, calcium being approximately equal to sodium in these cases. It is evident, also, that magnesium salts are important in some of the surface soils, while soluble potassium content is small in all cases.

Table 10. Analysis of Soluble Salts in Mildura Soils.

Soil Type	Soil No.	Depth (in)	Total soluble salts %	Mg equivalents per 100 gm soil							
				Cl	SO_4	HCO_3	CO_3	Na	K	Ca	Mg
Murray sand	8454	0-15	0.036	0.1	0.0	0.4	Nil	0.1	0.1	0.1	0.1
Benetook loam	2131	34-50	0.298	1.2	2.6	0.9	0.2			0.3	0.5
Merbein clay loam	8471	4-10	0.046	0.2	0.1	0.6	Nil	0.2	0.1	0.4	0.2
	8505	22-38	0.340	0.5	3.7	0.8	Nil	3.9	0.1	0.3	0.4
	8506	38-63	0.321	0.9	3.2	1.6	Nil	4.5	0.2	0.2	0.2
Sandilong loam	8520	0-7	0.116	0.6	0.5	0.7	Nil	0.7	02	0.6	0.5
	8513	0-8	0.528	1.5	5.4	0.5	Nil	4.2	0.3	2.2	1.1
	8519	108	0.248	1.9	1.6	0.3	Nil	3.0	0.0	0.2	0.3
Irymple loam	8543	75-84	0.336	2.6	1.6	1.4	0.4	4.4	0.1	0.1	0.2
Mildura loam	2143	0-8	0.314	0.2	4.0	0.6	Nil	2.8	0.1	0.7	0.6
	8458	0-10	0.334	1.0	3.3	0.6	Nil	1.8	0.2	1.5	1.2
	2147	54-68	0.872	3.1	9.3	0.9	Nil			1.6	1.5
Koorlong sandy loam	8544	0-6	2.863	5.4	36.5	0.7	Nil	28.7	0.3	10.6	2.9
	2160	42-66	0.150	0.5	1.0	1.4	0.9			0.1	0.4
	2164	36-52	0.215	0.2	0.6	0.9	Nil			0.2	0.5

Table 10 shows that bicarbonate content in Mildura soils is of similar order to that found elsewhere, and that it varies over a somewhat restricted range: on that account it is often present in greater amount than the other anions in the less saline soils, its magnitude relative to chloride and sulphate tending to decrease with increasing total salts. The rather infrequent occurrence of carbonate in the samples listed in Table 10 does not give a true impression of the prevalence of soluble carbonate in the soils of Mildura. Apart from a number of surface soils and the subsoils of comparatively low reaction, most of the samples, as examined in a 1:5 suspension, contain soluble carbonate. This is in accord with the high alkalinity usually found, long-continued irrigation having caused in most cases some leaching of soluble salt and hydrolysis of sodium clay, thus intensifying the natural alkalinity of these soils.

7. Replaceable Bases

Determination of replaceable bases by the Hissink method has been carried out on 23 representative Mildura soils, with the results listed in Table 11.

The proportions of the various bases as presented in Table 11 are of normal character for Mallee soils. Variations in total amounts of replaceable base are dependent largely on texture in this series, although organic matter in surface soils is an important factor. More than half the soils examined contain replaceable sodium to the extent of 10% or more of the total bases. The Irymple loam subsoil 2136, with almost 35% of clay, and sodium 38% of total replaceable bases, is representative of a fairly common type of subsoil in the Mildura district. Such subsoils restrict water penetration, thereby making desirable the provision of drainage if the overlying horizons are of much greater permeability. The Benetook loam subsoil 2131 is essentially similar, with a lower proportion of replaceable sodium but a higher clay percentage.

The change in proportions of the bases with increasing depth, typical of Mallee soils, is illustrated in several profiles. In general, calcium falls from proportions varying from 50 to nearly 80% in the upper horizons to figures as low as 22% in the subsoils, magnesium and sodium increasing in a corresponding manner. In the Koorlong sandy loam profiles, however, replaceable calcium forms only 37% of the total bases in the surface soil, while replaceable sodium constitutes more than 20% of the bases at all depths examined. Magnesium makes an important contribution to the total replaceable bases even in the surface soils and rises as high as 55% of the total in the subsoils. Replaceable potassium covers a similar range to that found for Merbein soils, varying from 5 to 24% of the total bases in the present series. Expressed as potash K_20, replaceable potash averages approximately 0.070 per cent in these soils, the lowest figures being 0.019 per cent, for the surface Murray sand and 0.023 per cent for the sub-surface sample of Karadoc sandy loam. Although no definite criteria exist for interpretation of such figures in relation to nutrition of vines and citrus, it would appear from the order of these results, and those for water-soluble, and acid-soluble, potash, that adequate amounts of this nutrient are present in available condition in Mildura soils.

In addition, it is known that ample water supply, such as is assured by efficient irrigation, promotes availability of soil potash.

Table 11. Replaceable Bases in soils.

Soil type	Soil no	Depth (in)	pH	Total soluble salts %	Clay %	Total bases	Percentage of total bases			
						mgm equivalents per 100 gm soil	Ca	Mg	Na	K
Murray sand	8454	0-15	8.6	0.04	8.7	5.6	69	21	3	7
Barmera sand (stony phase)	8407	26-57	8.9	0.07	24.5	12.2	44	38	5	13
Barmera sandy loam	8509	9-18	8.5	0.08	21.8	11.0	29	55	2	14
Morpung loam	8352	19-42	9.3	0.08	19.1	13.3	34	33	9	24
Benetook sandy loam	2141	47-58	9.1	0.10	45.7	29.7	41	43	11	5
	2130	24-34	9.2	0.20	32.2	19.7	35	41	19	5
	2131	34-50	9.1	0.30	41.3	27.1	36	35	23	6
Merbein clay loam	8532	3-8	8.6	0.12	41.8	25.8	61	25	6	8
	8472	10-22	8.8	0.08	33.8	16.3	46	46	3	5
Karadock sandy loam	8486	6-14	8.7	0.08	24.6	14.7	76	14	2	8
	8487	14-27	8.9	0.08	22.7	10.1	52	38	5	5
Sandilong loam	8520	0-7	8.8	0.13	15.7	11.9	45	32	14	9
	8522	22-40	9.0	0.12	18.6	10.1	35	43	10	12
Irymple loam	2135	0-9	8.7	0.13	18.5	13.6	60	16	10	14
	8539	17-27	9.5	0.18	20.7	13.5	35	44	13	8
	2136	33-63	9.6	0.15	34.6	18.4	22	34	38	6
Mildura loam	2143	0-8	8.8	0.23	19.1	16.4	49	28	16	7
	8468	30-42	8.8	0.20	50.6	32.7	56	31	8	5
	8461	40-50	8.8	0.38	30.1	19.6	34	41	20	5
Koolong sandy loam	8398	0-7	9.5	0.16	16.0	12.2	37	17	27	19
	8399	7-12	9.6	0.12	13.6	11.8	37	22	24	17
	8400	12-33	9.8	0.10	11.7	7.2	24	32	29	15

V. IRRIGATION DRAINAGE AND SALINITY OF MILDURA SOILS.

In an irrigation area such as the Mildura settlement, practical problems of vital importance include those associated with the handling of irrigation water, and with provision of drainage when it is rendered necessary by water-logging or by accumulation of soluble salts. Knowledge of the soil types which occur in different portions of a holding, and of the properties of each type, is obviously of great value in this connection, particularly with regard to the absorptive capacity for water of the various soils as a guide to irrigation practice, and the nature of the soil profile in relation to depth and spacing of subsoil drains.

Some information along these lines has been given in the section concerned with description of Mildura soil types, and a discussion on the subject, including soil amendments, was included in a previous publication dealing with the Merbein district, (Coun. Sci. Ind. Res., Bull. 123, 1938) to which reference should be made. The two settlements adjoin, and many of the Mildura soil types occur also at Merbein in similar topographic situations, so that similar principles apply in both cases. While existing data make it unnecessary to discuss these matters in detail for Mildura, the main features of the major Mildura soil types from the present aspect are assembled in Table 12.

In all cases, the logical approach is to reduce to a minimum the accumulation of free water in particular areas, and the consequent necessity for drainage, by adjustment of water application in accordance with absorptive capacity of the soil and the requirements of the crop. Factors affecting this adjustment include the length of irrigation run, time of soakage, head of water, the furrow or other system of application, and efficiency of grading.

Table 12. Salinity Water Absorption and Approximate Drainage Depth for Mildura Soils.

Soil Type	Liability to salt damage	Rate of water absorption	Probable drainage requirement	Approximate depth for drains
Murray sand	Not liable	Very high	Occasional	6’
Berri sand	Very slight	Very high	Occasional	6’
Barmera sand	Slight	Very high	Variable	5’9”
Barmera sandy loam	Liable	High	Variable	5’9”
Moorook sandy loam	Very liable	High	General	6’
Cureton sand	Slight	High	Occasional	4’
Karadoc sandy loam	Liable	High	General	5’6”
Koorlong sandy loam	Very liable	High	General	5’6”
Koorlong loam	Liable	Moderate	Frequent	5’6”
Nookamka sandy loam	Slight	Moderate	Occasional	5’
Benetook sandy loam	Slight	Moderate	Variable	5’
Sandilong loam	Very liable	Moderate	General	5’
Nookamka loam	Very slight	Moderate	Rare	4’
Morpung loam	Slight	Moderate	Occasional	5’6”
Coomealla loam	Liable	Moderate	Occasional	4’
Benetook loam	Slight	Low	Occasional	
Irymple loam	Liable	Low	Frequent	4’ or below
Mildura loam	Very liable	Moderate	Frequent	Gypsum layer
Merbein loam	Slight	Low	Rare	
Irymple clay loam	Liable	Low	Variable	
Merbein clay loam	Slight	Very low	None	
Belar clay loam	No liable	Very low	None	
Pomona clay	Not liable	Very low	None	

The approximate drainage depths shown in the table are determined by the changes in the character of the soils which occur with increasing depth in the profile. In most cases, the depth to the drainage layer coincides with that to a definite clay horizon so slowly permeable to water that notable restriction of natural water movement occurs at this point in the profile. The influence of gypsum in the profile has been mentioned previously, and frequently it is desirable to provide by means of drains for the removal of free water which collects in the gypseous horizon. In Murray and Berri sands, and Moorook, Karadoc, and Koorlong sandy loams, no clay horizon to provide a satisfactory bed for laying of tile drains occurs within 6 feet of the surface. In such soils, when conditions suggest that drainage may be desirable, tiles are usually laid at approximately 6 feet deep, limitation to that depth being due chiefly to economic considerations, although some areas have been drained at greater depth.

The depth at which drains are laid and the character of the soil profile are two be the chief factors which influence the lateral spacing of the drains. The general conclusion is that for moderately heavy soils, such as Benetook, Irymple, and Sandilong loams, with drains laid at a depth of 4 to 5 feet, a spacing of 44 feet between laterals within the blocks is quite satisfactory. For lighter and more permeable soils with drains at 6 feet depth, drainage may be equally satisfactory at spacings of 66 or 88 feet.

As a pioneer in large-scale irrigation, Mildura had a number of disadvantages, including lack of experience in the use of irrigation water and the fact that there was a large portion of inherently saline land in the area first developed. Under these conditions it was inevitable that much land depreciated markedly for horticultural purposes even during the first ten years of settlement. As an indication of the range of salt concentrations in the :soil at the time of the survey, figures obtained for an area in the northwest of the settlement are of interest. Referring to the soil depth 12-24", results for chloride expressed as sodium chloride showed 37, out of a total of 263 soils, higher than 0.2%, these being for areas which have gone completely out of production, or have never been planted. Good or very fair growth of vines was associated with salt content on the same basis up to 0.07%, the corresponding figure for fair or patchy growth being 0.10%. Of the total number of determinations, about two-thirds are below 0.06%, which was indicated as the limit above which dangerous conditions for vines are likely to occur in Merbein soils (Coun. Sci. Ind. Res., Bull. 123, 1938). These figures were obtained in an area of relatively heavy soils including the Irymple and Benetook series and Mildura and Koorlong loams; all of these types are liable to some extent to salt damage, as shown by Table 12.

It is likely that the majority of Mildura soils which suffer from high water tables and salinity can be improved by standard methods of drainage proved effective on the settlement. It has been demonstrated in practice that noticeable improvement in growth of vines is achieved with, in two years of draining on the more responsive types. These include all the sand types and Barmera sandy loam, in which low productivity is due to accumulation of excess water rather than to salt injury. Early improvement is shown also by the Moorook, Karadoc, Koorlong, and Benetook sandy loams, and the Sandilong, and, to a lesser extent, Koorlong loams. The light permeable profiles of these types give facility for water movement, and therefore for leaching of salt, following the laying of tile drains. Response has: been particularly notable with Sandilong loam, a very saline type, of which large areas have gone out of production due to surface accumulation of salt following irrigation. Mildura loam also responds fairly readily to drainage, although improvement is neither as rapid nor as marked as with lighter types. The heavier, less permeable, Benetook and Irymple loams respond even more slowly, though drainage is frequently necessary and ultimately profitable. Of the heavier types, Irymple clay loam is often unproductive because of salt accumulation, but its permeability is so poor that draining is very slow and in many cases likely to be unprofitable.

Effective control of excess water and salinity in all soil types at Mildura brings them to a profitable cropping condition under good management. Excluding these factors, there would not appear to be any material differences between the various soil types with respect to cropping capacity. Some are obviously more difficult to handle, such as the heavy variety of Irymple clay loam, and Merbein and Belar clay loam, among heavy types, and Moorook and Koorlong sandy loams together with Sandilong loam among lighter types.

As far as citrus growing is concerned, only the sandy rises are continuously profitable, and most of them require drainage on lower slopes. There is very little citrus grown successfully on soils other than Murray and Berri sands and the Barmera series.

Emphasis at present rests on consideration of drainage properties of Mildura soils, as a result of the completion of the community scheme referred to in the introductory section of this bulletin. Facilities thus provided for efficient drainage have been utilized widely, with rapid progress in internal block drainage. With responsiveness of many of the more important soil types already known, it is likely that this development will lead during the next few years to appreciable increase in average productivity.

VI. ACKNOWLEDGMENTS.

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APPENDIX. Mechanical Analyses and Other Data for Mildura

All figures are shown as percentages of fine earth, except those for reaction, depth, and "rubble and gravels" the latter being percentages of the field samples. As indications of field texture, S signifies sand; SL, sandy loam; Cl S, clayey sand; Cl FS, clayey fine sand; SCL, sandy clay loam; FSCL, fine sandy clay loam; L, loam; CL, clay loam; SC, sandy clay; FSC, fine sandy clay; LC, light clay; MC, medium clay; HC, heavy clay.

An asterisk entered against "Total soluble salts" indicates the presence of gypsum.

TABLE I. MECHANICAL ANALYSES AND OTHER DATA FOR MURRAYSAND AND BOLA SAND PROFILES.

	Murray Sand				**Berri Sand**			
Lab No.	8454	8455	8456	8457	8355	8356	8357	8358
Depth (inch)	0-15	15-36	36-60	60-80	0-9	9-33	33-63	63-72
Texture	S	S	S	S	S	S-SL	SCL	SCL
Rubble & gravel	-	-	-	-	-	-	0.4	
Coarse sand	43.4	39.7	35.5	31.2	32.5	31.9	22.3	27.5
Fine sand	47.5	50.4	53.1	55.1	52.7	49.7	47.0	44.6
Silt	0.4	0.7	0.4	0.5	1.5	2.9	2.4	1.3
Clay	8.7	8.2	9.4	12.5	12.2	14.7	19.8	16.5
Moisture	0.6	0.7	0.9	1.4	1.0	1.5	2.0	1.4
Loss on acid treatment	0.5	0.5	1.5	1.3	1.7	0.8	8.4	9.2
Loss on ignition	1.0	1.0	1.5	1.3	1.9	1.8	5.1	5.3
Calcium carbonate	0.0	0.1	0.9	0.7	0.1	0.1	7.0	7.1
Total soluble salts	0.04	0.06	0.06	0.07	0.04	0.05	0.07	0.06
Chlorides (as Cl)	0.004	0.003	0.012	0.006	0.003	0.003	0.010	0.002
Nitrogen	0.049				0.034			
Reaction (pH value)	8.6	8.9	9.0	9.1	8.7	8.7	9.0	9.1

Table II. MECHANICAL ANLAYSES AND OTHER DATA FOR PROFILES OF BARMERA SERIES

	Barmera sand				**Barmera sand (stony phase)**						
Lab No.	8359	8360	8361	8362	8403	8404	8405	8406	8407	8408	8409
Depth (inch)	0-12	12-23	23-54	54-80	0-9	9-17	17-23	23-26	26-57	57-68	68-78
Texture	S	L-SCL	SCL	SCL	S	S	SL-S		SCL	CL-LC	MC
Rubble & gravel	-	-	-	6.9	0.2	-	-	50.0	18.9	9.3	4.5
Coarse sand	29.1	27.1	22.7	15.5	26.9	30.9	28.5		12.4	9.3	9.9
Fine sand	50.5	47.2	39.3	32.8	54.3	520	50.5		33.2	33.3	40.1
Silt	1.8	1.6	1.6	2.3	3.7	2.1	1.2		2.5	3.0	4.0
Clay	13.1	14.3	13.1	14.1	12.6	13.5	13.4		24.5	41.2	40.3
Moisture	1.1	1.4	1.3	1.3	1.8	1.3	1.2		2.7	3.5	3.4
Loss on acid treatment	4.8	9.7	23.1	36.2	1.6	1.0	5.5		27.0	11.5	4.7
Loss on ignition	3.6	5.4	11.2	17.2	2.6	1.7	3.6		13.7	7.7	4.8
Calcium carbonate	3.2	8.7	21.3	33.8	0.7	0.3	4.4	34.1	25.0	10.2	3.2
Total soluble salts	0.06	0.06	0.06	0.7	0.07	0.06	0.07		0.07	0.10	0.14
Chlorides (as Cl)	0.004	0.002	0.002	0.004	0.004	0.004	0.004		0.005	0.002	0.005
Nitrogen	0.036				0.067						
Reaction (pH value)	8.7	9.3	9.1	8.9	8.6	8.7	8.7	8.7	8.9	9.2	9.5

TABLE II – Cont'd

	Barmera sandy loam									
Lab No.	8345	8346	8347	8348	8349	8508	8509	8510	8511	8512
Depth (inch)	0-9	9-13	13-24	24-60	60-78	0-9	9-18	18-48	48-63	63-84
Texture	S-SL	SCL	SCL	SCL	SC	SL	SL-SCL	SCL	SL	SL-SCL
Rubble & gravel	-	-	-	11.7	1.8	-	1.2	-	1.3	3.1
Coarse sand	39.3	37.1	31.7	23.1	22.0	39.4	31.7	36.0	42.8	43.5
Fine sand	36.3	34.0	34.4	23.9	25.3	34.1	28.9	25.8	34.0	28.8
Silt	4.1	4.7	3.5	2.6	2.6	4.3	2.1	0.9	1.9	0.8
Clay	16.4	20.6	22.8	15.4	17.8	15.5	21.8	22.1	17.3	20.5
Moisture	32	4.1	2.8	1.5	1.8	2.0	2.6	2.5	1.7	1.8
Loss on acid treatment	1.5	1.7	4.9	34.5	31.6	4.3	13.3	12.9	3.3	6.4
Loss on ignition	2.8	2.9	4.0	16.4	13.9	3.8	7.9	7.3	2.6	4.2
Calcium carbonate	0.3	0.3	3.8	33.5	31.4	2.9	11.5	12.3	2.4	4.8
Total soluble salts	0.07	0.06	0.07	0.10	0.11	0.07	0.08	0.07	0.07	0.10
Chlorides (as Cl)	0.006	0.004	0.009	0.009	0.008	0.011	0.006	0.004	0.005	0.006
Nitrogen	0.056					0.042				
Reaction (pH value)	8.5	8.7	9.1	9.5	9.6	8.6	8.5	8.9	9.0	9.5

TABLE III. MECHANICAL ANALYSES AND OTHER DATA FOR CURETON SAND AND MOROOK SANDY LOAM

	Morpung loam						Coomealla loam			
Lab No.	8525	8526	8527	8528	8529	8530	8385	8386	8387	8388
Depth (inch)	0-12	12-24	24-34	34-44	44-54	54-72	0-8	8-18	18-40	40-72
Texture	S	SL	SCL	LC	MC	HC	SL	SL-SCL	SL-SCL	SCL
Rubble & gravel	0.1	-	0.1	0.4	2.0	0.1	-	-	1.5	3.6
Coarse sand	41.8	35.4	26.0	18.5	17.3	19.0	29.5	26.1	21.2	20.1
Fine sand	42.4	35.9	30.1	26.6	27.3	30.8	43.7	41.2	33.3	31.0
Silt	2.2	1.5	1.2	3.3	2.7	1.2	4.3	5.3	2.0	2.9
Clay	12.6	23.5	23.2	23.4	23.3	27.7	14.0	15.7	17.6	15.5
Moisture	1.6	3.4	3.3	3.2	3.0	3.7	1.9	2.7	1.6	1.4
Loss on acid treatment	0.6	2.3	17.1	27.1	26.1	16.6	7.5	11.0	26.3	30.4
Loss on ignition	1.4	2.8	9.2	13.2	13.1	9.1	5.2	6.5	12.8	11.5
Calcium carbonate	0.1	1.3	14.9	23.7	22.6	15.3	5.9	9.4	21.6	28.2
Total soluble salts	0.10	0.07	0.09	0.12	0.14	0.17	0.06	0.06	0.07	0.09
Chlorides (as Cl)	0.004	0.004	0.005	0.012	0.014	0.014	0.004	0.004	0.004	0.004
Nitrogen	0.027						0.061			
Reaction (pH value)	8.3	8.8	9.0	9.5	9.7	9.9	9.1	9.1	9.3	9.5

TABLE IV. MECHANICAL ANALYSES AND OTHER DATA FOR MORPUNG LOAM AND COOMEALLA LOAM

	Cureton sand						Moorook sandy loam			
Lab No.	8525	8526	8527	8528	8529	8530	8385	8386	8387	8388
Depth (inch)	0-12	12-24	24-34	34-44	44-54	54-72	0-8	8-18	18-40	40-72
Texture	S	SL	SCL	LC	MC	HC	SL	SL-SCL	SL-SCL	SCL
Rubble & gravel	01	-	0.1	0.4	2.0	0.1	-	-	1.5	3.6
Coarse sand	41.8	35.4	26.0	18.5	17.3	19.0	29.5	26.1	21.2	20.1
Fine sand	42.4	35.9	30.1	26.6	27.3	30.8	43.7	41.2	33.3	31.0
Silt	2.2	1.5	1.2	3.3	2.7	1.2	4.3	5.3	2.0	2.9
Clay	12.6	23.5	23.2	23.4	23.3	27.7	14.0	15.7	17.6	15.5
Moisture	1.6	3.4	3.3	3.2	3.0	3.7	1.9	2.7	1.6	1.4
Loss on acid treatment	0.6	2.3	17.1	27.1	26.1	16.6	7.5	11.0	26.3	30.4
Loss on ignition	1.4	2.8	9.2	13.2	13.1	9.1	5.2	6.5	12.8	11.5
Calcium carbonate	0.1	1.3	14.9	23.7	22.6	15.3	5.9	9.4	21.6	28.2
Total soluble salts	0.10	0.07	0.09	0.12	0.14	0.17	0.06	0.06	0.07	0.09
Chlorides (as Cl)	0.004	0.004	0.005	0.012	0.014	0.014	0.004	0.004	0.004	0.004
Nitrogen	0.027						0.061			
Reaction (pH value)	8.3	8.8	9.0	9.5	9.7	9.9	9.1	9.1	9.3	9.5

TABLE V. MECHANICAL ANALYSES AND OTHER DATA FOR OF THE BENETOOK SERIES

	Benetook sandy loam						Benetook loam					
Lab No.	2137	2138	2139	2140	2141	2142	2127	2128	2129	2130	2131	2132
Depth (inch)	0-7	7-14	14-39	39-47	47-58	58-72	0-6	6-12	12-24	24-34	34-50	50-66
Texture	SL-L	SL	SL-SCL	CL	LC-MC	MC	L	L-CL	CL	LC	HC	HC
Rubble & gravel	0.7	0.5	1.0	0.3	02	0.2	0.1	-	0.2	-	-	16.1
Coarse sand	23.9	20.3	23.8	11.3	7.0	4.4	16.5	16.9	13.5	10.9	8.8	2.9
Fine sand	44.0	36.7	34.7	22.5	18.9	12.2	40.2	36.5	27.1	23.7	22.8	13.7
Silt	4.2	4.2	3.1	6.4	8.5	12.4	4.2	5.1	4.2	5.1	8.1	11.6
Clay	16.1	18.5	17.0	31.6	45.7	54.0	26.5	23.7	25.0	32.2	41.3	36.6
Moisture	1.6	2.0	2.0	4.7	5.9	7.2	2.1	2.9	3.2	4.0	5.4	10.4
Loss on acid treatment	11.9	19.1	21.4	25.5	15.8	4.1	10.6	15.6	8.6	25.2	14.3	24.5
Loss on ignition	7.3	10.4	9.8	13.8	8.6	5.3	7.2	9.0	8.8	12.9	9.1	5.1
Calcium carbonate	9.5	16.6	17.1	20.5	13.3	2.1	8.7	12.2	26.1	20.8	11.3	2.1
Total soluble salts	0.07	0.08	0.06	0.09	0.10	0.12	0.07	0.09	0.13	0.20	0.30	*
Chlorides (as Cl)	0.011	0.014	0.008	0.019	0.010	0.010	0.016	0.017	0.025	0.038	0.043	0.042
Nitrogen	0.055						0.067					
Reaction (pH value)	8.8	8.5	9.0	8.9	9.1	8.9	8.9	8.8	8.9	9.2	9.1	8.1

TABLE V. Cont'd

	Benetook loam cont'd										
Lab No.	8476	8477	8478	8479	8480	8496	8497	8498	8499	8500	8501
Depth (inch)	0-8	8-12	12-27	27-45	45-72	0-6	6-15	15-30	30-40	40-52	52-72
Texture	L-SL	SCL	CL	LC-MC	HC	L	SCL-CL	CL	LC	MC	HC
Rubble & gravel	-	-	0.1	5.7	0.3	2.6	6.2	5.4	6.5	5.2	1.9
Coarse sand	29.1	27.1	22.4	13.6	11.0	28.9	25.5	21.5	17.6	16.6	18.2
Fine sand	36.8	34.3	27.3	22.9	22.9	32.9	31.2	21.7	24.7	27.1	28.3
Silt	5.2	2.4	2.0	4.8	5.1	2.9	3.8	2.8	3.8	5.2	3.7
Clay	24.9	31.5	29.8	36.9	50.0	23.2	23.2	26.0	31.5	36.4	37.7
Moisture	2.6	3.4	3.4	4.1	5.3	2.5	2.7	3.2	4.0	4.2	4.8
Loss on acid treatment	2.0	2.5	16.7	18.3	7.7	7.9	15.3	24.1	20.5	12.2	7.6
Loss on ignition	3.8	3.6	9.8	10.8	6.5	6.4	9.1	12.8	10.9	7.8	5.8
Calcium carbonate	0.4	0.9	13.1	15.9	5.0	3.8	10.3	16.4	18.6	11.7	5.7
Total soluble salts	0.11	0.07	0.11	0.16	0.22	0.16	0.10	0.10	0.12	0.17	0.20
Chlorides (as Cl)	0.007	0.009	0.012	0.013	0.018	0.029	0.015	0.009	0.012	0.013	0.012
Nitrogen	0.121					0.111					
Reaction (pH value)	8.5	8.6	9.1	9.6	9.8	8.6	8.8	9.1	9.4	9.4	9.5

TABLE VI. MECHANICAL ANALYSES AND OTHER DATA FOR MERBEIN CLAY LOAM AND BELAR CLAY LOAM

	Merbein clay loam											
Lab No.	8531	8532	8533	8534	8535	8536	8470	8471	8472	8473	8474	8475
Depth (inch)	0-3	3-8	8-20	20-33	33-48	48-72	0-4	4-10	10-22	22-42	42-54	54-72
Texture	L-CL	CL-LC	LC	MC	HC	HC	CL-LC	LMC	MC	HC	HC	HC
Rubble & gravel	-	-	0.1	-	1.4	4.8	-	-	0.1	-	-	-
Coarse sand	10.7	9.7	7.9	7.1	4.3	1.7	19.3	19.9	18.2	13.3	7.8	10.8
Fine sand	32.8	32.0	26.7	31.3	29.5	26.0	27.5	27.7	25.2	27.0	25.8	28.5
Silt	8.8	7.7	6.3	6.6	7.6	10.2	4.4	5.7	4.1	5.5	5.2	4.8
Clay	40.3	41.8	34.7	38.7	36.3	43.2	39.5	39.4	33.8	41.5	46.8	49.0
Moisture	5.0	6.0	5.2	5.4	7.4	8.1	4.5	4.8	4.2	4.8	7.3	5.6
Loss on acid treatment	4.7	4.3	19.2	11.1	17.2	13.2	5.2	4.0	16.2	9.9	8.3	1.8
Loss on ignition	5.7	5.5	10.8	7.1	4.7	3.5	6.3	5.4	9.9	7.5	5.0	4.5
Calcium carbonate	1.7	2.1	15.8	7.4	2.2	0.2	2.7	1.4	13.4	7.4	1.4	0.1
Total soluble salts	0.15	0.12	0.17	0.20	*	*	0.11	0.05	005	0.15	*	0.28
Chlorides (as Cl)	0.012	0.020	0.013	0.027	0.005	0.030	0.010	0.006	0.007	0.004	0.008	0.006
Nitrogen	0.076						0.095					
Reaction (pH value)	8.5	8.6	9.7	9.4	8.2	8.0	8.4	8.5	8.8	8.9	7.9	8.6

TABLE VI – Cont'd

	Merbein clay loam – cont'd				Belar clay loam					
Lab No.	2148	2149	2150	2151	8502	8503	8504	8505	806	8507
Depth (inch)	0-9	9-20	20-36	36-60	0-6	6-12	12-22	22-38	38-63	63-84
Texture	SL	LC	MC	HC	L	CL	LC	MC-HC	HC	HC
Rubble & gravel	0.1	-	-	16.4	-	0.1	0.1	-	-	-
Coarse sand	20.6	10.2	7.5	2.5	25.0	17.5	17.6	20.6	25.2	30.3
Fine sand	41.6	25.2	23.2	9.2	34.2	25.9	23.4	22.6	24.6	22.3
Silt	4.7	5.2	5.9	6.3	9.0	2.8	5.8	4.2	2.8	4.8
Clay	26.1	412	42.8	48.6	26.4	40.8	32.5	36.6	40.9	36.3
Moisture	3.2	5.5	6.3	11.6	3.7	5.7	4.4	4.6	4.9	4.1
Loss on acid treatment	5.3	13.1	13.5	23.8	2.5	6.8	18.0	11.5	2.6	1.4
Loss on ignition	4.3	9.1	9.2	5.5	4.6	6.6	10.5	7.3	4.0	3.2
Calcium carbonate	2.0	8.8	11.0	2.7	0.8	4.2	16.2	9.3	1.0	0.2
Total soluble salts	0.09	0.11	0.17	*	0.10	0.13	0.20	0.34	0.32	0.29
Chlorides (as Cl)	0.010	0.012	0.014	0.013	0.008	0.008	0.013	0.018	0.032	0.040
Nitrogen	0.049				0.075					
Reaction (pH value)	8.6	9.1	9.3	8.2	8.6	8.8	9.6	9.1	8.7	7.6

TABLE VII. MECHANICAL ANALYSES AND OTHER DATA FOR KARADOC SANDY LOAM

Lab No.	8481	8482	8483	8484	8485	8486	8487	8488
Depth (inch)	0-7	7-27	27-2	42-60	0-6	6-14	14-27	27-38
Texture	SL	SCL	SCL	SCL	SL	L	SCL	CL
Rubble & gravel	2.9	12.3	2.5	1.4	0.4	0.8	9.5	12.5
Coarse sand	27.8	20.6	13.4	8.0	33.5	31.2	26.0	25.2
Fine sand	44.3	37.5	47.6	60.4	37.7	33.6	26.9	25.1
Silt	4.7	4.1	5.5	7.1	4.2	5.1	4.1	3.5
Clay	15.0	16.4	18.0	18.9	211	24.6	22.7	18.0
Moisture	1.7	1.9	2.0	2.0	2.4	3.1	3.0	2.3
Loss on acid treatment	8.5	21.1	15.2	5.3	2.5	4.1	19.8	28.2
Loss on ignition	5.3	10.7	8.0	3.7	3.3	4.0	10.5	13.8
Calcium carbonate	5.8	19.8	15.8	3.5	0.9	3.0	18.3	32.0
Total soluble salts	0.21	0.20	0.16	0.16	0.10	0.08	0.08	0.08
Chlorides (as Cl)	0.054	0.054	0.030	0.025	0.005	0.006	0.006	0.006
Nitrogen	0.063				0.076			
Reaction (pH value)	8.9	9.4	9.7	9.8	8.6	8.7	8.9	9.0

TABLE VII – Cont'd

Lab No.	8489	8490	2152	2153	2154	2155	2156
Depth (inch)	38-54	60-84	0-11	11-32	32-42	42-54	54-62
Texture	SCL	S	SL	SCL	SCL	CIS	SCL-SC
Rubble & gravel	13.0	2.6	-	2.7	6.0	7.7	7.9
Coarse sand	34.4	45.0	18.9	11.7	7.1	4.8	4.0
Fine sand	30.7	37.6	54.8	45.6	59.5	66.2	60.0
Silt	3.0	2.7	4.6	3.1	3.6	2.6	3.9
Clay	17.0	11.6	20.2	20.7	18.4	20.3	25.7
Moisture	2.1	1.4	1.6	2.7	2.8	2.3	3.8
Loss on acid treatment	14.2	3.3	1.6	16.9	9.1	5.5	3.8
Loss on ignition	7.3	2.1	3.0	9.1	5.4	3.9	3.1
Calcium carbonate	12.0	1.8	0.3	15.1	7.6	4.3	3.0
Total soluble salts	0.08	0.09	0.28	0.17	0.15	0.15	0.17
Chlorides (as Cl)	0.005	0.010	0.070	0.048	0.036	0.038	0.037
Nitrogen			0.054				
Reaction (pH value)	9.2	9.5	8.6	9.1	9.4	9.4	9.4

TABLE VIII. MECHANICAL ANALYSES AND OTHER DATA FOR PROFILES OF THE SANDILONG SERIES

	Sandilong loam (deep phase)					Sandilong loam					
Lab No.	8380	8381	8382	8383	8384	8374	8375	8376	8377	8378	8379
Depth (inch)	0-6	6-19	19-48	48-68	68-78	0-8	8-19	19-27	27-36	36-60	60-72
Texture	L-SL	SL-SCL	SCL	SCL	CL	L	SCL	CL	LC	MC	HC
Rubble & gravel	1.1	1.8	0.7	8.9	1.5	3.0	5.3	0.2	0.4	-	-
Coarse sand	23.0	18.7	21.1	15.4	11.7	14.7	12.7	11.9	12.0	11.1	9.2
Fine sand	39.5	36.0	35.4	30.5	27.6	37.8	29.0	27.8	28.9	29.7	32.1
Silt	4.0	2.7	3.5	3.8	5.1	5.9	3.9	2.1	4.6	4.9	7.7
Clay	15.7	16.1	14.9	19.2	24.5	17.2	17.3	21.0	23.1	29.8	33.2
Moisture	2.4	1.7	1.4	2.0	2.7	2.5	3.4	2.5	2.5	3.1	3.2
Loss on acid treatment	16.0	25.5	24.5	30.4	30.4	22.1	35.5	35.0	30.1	21.8	16.1
Loss on ignition	9.0	12.4	12.0	14.9	15.3	12.0	10.6	15.7	14.6	11.4	9.1
Calcium carbonate	13.5	23.8	21.9	28.8	27.8	20.6	32.3	30.9	26.5	20.0	14.3
Total soluble salts	0.15	0.07	0.07	0.10	0.11	0.23	0.15	0.16	0.16	0.18	0.20
Chlorides (as Cl)	0.018	0.004	0.003	0.003	0.004	0.048	0.021	0.023	0.017	0.015	0.020
Nitrogen	0.070					0.074					
Reaction (pH value)	8.7	9.2	9.5	9.4	9.5	8.6	8.9	9.0	9.0	8.8	8.7

TABLE VIII. – Cont'd

	Sandilong loam – cont'd											
Lab No.	8513	8514	8515	8516	8517	8518	8519	8520	8521	8522	8523	8524
Depth (inch)	0-8	8-22	22-42	42-60	60-72	72-76	at 108	0-7	7-22	22-40	40-52	52-69
Texture	L-SL	SL-SCL	SCL	CL	LC-MC	LC	HC	L	SL-SCL	SCL	CL	LC
Rubble & gravel	0.4	0.6	1.7	1.3	1.1	0.1	-	1.3	12.9	3.7	1.3	0.4
Coarse sand	22.5	19.8	14.7	17.1	21.0	26.4	12.1	23.6	18.3	15.7	15.0	9.7
Fine sand	40.3	36.9	29.6	28.4	28.6	34.8	20.1	37.7	32.4	25.9	27.3	26.7
Silt	4.9	2.9	2.0	2.7	4.7	8.2	11.1	3.9	5.6	4.4	5.0	5.8
Clay	15.5	17.0	16.8	18.2	20.2	25.6	52.2	15.7	15.4	18.6	22.6	30.8
Moisture	2.1	2.4	2.0	2.2	2.5	3.3	5.1	2.4	2.4	2.5	3.3	4.5
Loss on acid treatment	15.2	22.4	35.4	31.7	24.0	2.6	1.4	16.9	27.6	34.9	29.1	24.6
Loss on ignition	8.7	11.4	16.3	15.4	12.0	3.7	3.7	9.7	13.2	16.6	14.5	12.8
Calcium carbonate	11.9	20.5	35.8	28.6	21.4	1.4	0.3	13.7	23.6	30.6	25.6	22.7
Total soluble salts	0.52	0.14	0.13	0.15	0.16	0.20	0.25	0.12	0.11	0.12	0.14	0.17
Chlorides (as Cl)	0.053	0.016	0.007	0.016	0.012	0.015	0.068	0.023	0.011	0.011	0.011	0.014
Nitrogen	0.082							0.071				
Reaction (pH value)	8.6	9.4	9.7	9.7	9.8	9.5	6.4	8.8	8.7	9.0	9.0	9.5

TABLE IX. MECHANICAL ANALYSES AND OTHER DATA FOR PROFILES OF THE IRYMPLE SERIES

	Irymple loam										
Lab No.	8537	8538	8539	8540	8541	8542	8543	2133	2134	2135	2136
Depth (inch)	0-6	6-17	17-27	27-37	37-60	60-75	75-84	0-9	9-24	24-33	33-63
Texture	L	SCL	CL	LC	MC-HC	HC	HC	L	SCL	CL	LC-MC
Rubble & gravel	0.8	2.2	1.3	0.3	0.1	-	-	0.7	4.5	0.9	1.6
Coarse sand	21.1	18.3	13.1	9.7	7.1	6.1	3.3	21.0	17.5	13.5	11.0
Fine sand	39.7	32.8	28.2	32.1	33.2	33.2	28.7	37.5	28.8	26.9	31.3
Silt	4.0	3.8	4.0	6.0	7.4	8.4	9.7	6.5	2.8	3.4	6.2
Clay	20.6	21.1	20.7	29.8	36.7	44.2	52.3	18.5	21.4	24.9	34.6
Moisture	2.6	2.8	2.9	4.0	4.9	5.8	6.7	2.5	2.2	3.2	4.1
Loss on acid treatment	13.0	22.9	32.0	20.6	11.7	3.6	1.7	14.2	28.9	29.3	14.5
Loss on ignition	7.9	11.9	15.7	10.7	7.3	4.4	3.9	8.5	14.6	14.4	7.7
Calcium carbonate	8.7	19.0	24.3	12.6	8.7	0.8	0.0	11.6	26.4	26.1	12.7
Total soluble salts	0.12	0.13	0.18	0.21	0.27	0.28	0.34	0.13	0.13	0.12	0.15
Chlorides (as Cl)	0.006	0.011	0.03	0.016	0.026	0.040	0.092	0.031	0.019	0.015	0.014
Nitrogen	0.068							0.081			
Reaction (pH value)	8.7	8.9	9.5	9.8	9.8	9.7	9.4	8.7	8.7	9.6	9.6

TABLE IX. – Cont'd

	Irymple loam – cont'd						Irymple clay loam			
Lab No.	8368	8369	8370	8371	8372	8373	8394	8395	8396	8397
Depth (inch)	0-6	6-16	16-27	27-32	32-48	54-78	0-7	7-22	22-48	48-72
Texture	L	SCL	CL	LC-MC	MC	HC	L-CL	LC-MC	HC	HC
Rubble & gravel	0.2	1.1	1.4	0.6	20.6	-	0.2	0.3	-	-
Coarse sand	22.3	17.6	16.0	15.5	13.8	13.9	13.6	8.2	6.6	4.9
Fine sand	39.6	32.5	30.1	31.8	27.5	26.0	36.1	22.7	19.7	16.4
Silt	3.9	2.9	3.6	5.9	4.7	7.0	7.4	11.5	13.4	14.6
Clay	16.5	17.8	20.4	27.8	30.9	46.5	24.9	38.7	52.7	58.7
Moisture	2.7	2.1	2.3	3.3	7.1	4.6	3.4	5.3	4.6	5.0
Loss on acid treatment	15.4	27.2	27.9	16.2	18.3	2.2	14.7	13.9	4.9	2.1
Loss on ignition	8.4	13.7	13.8	9.4	3.6	3.5	9.6	8.7	5.9	4.9
Calcium carbonate	13.0	25.3	25.8	14.3	0.8	0.3	12.0	11.4	3.2	0.0
Total soluble salts	0.10	0.08	0.12	0.13	*	0.21	0.07	0.17	0.39	0.85
Chlorides (as Cl)	0.004	0.008	0.004	0.004	0.010	0.13	0.004	0.016	0.074	0.258
Nitrogen	0.073						0.102			
Reaction (pH value)	8.9	8.8	8.7	8.5	7.6	6.2	8.9	9.5	9.3	7.6

TABLE X. MECHANICAL ANALYSES AND OTHER DATA FOR PROFILES OF MILDURA LOAM

Lab No.	8465	8466	8467	8468	8469	2143	2144	2145	2146	2147
Depth (inch)	0-8	5-18	18-30	30-42	42-72	-8	8-24	24-42	42-54	54-68
Texture	L	SCL	LC	MHC	HC	L	SCL	CL	LC	LC-MC
Rubble & gravel	10.6	14.1	3.0	0.3	1.0	15.7	10.5	7.5	1.7	-
Coarse sand	13.0	9.5	8.7	5.8	2.8	17.0	12.9	6.8	5.7	3.1
Fine sand	28.1	24.6	22.0	183	14.0	32.8	24.6	24.1	20.7	18.4
Silt	7.0	9.3	7.0	8.8	25.0	10.3	9.4	17.8	32.9	37.1
Clay	22.5	20.3	36.0	50.6	45.4	19.1	16.0	24.0	29.2	35.8
Moisture	3.0	2.9	4.6	6.5	7.3	2.0	1.9	2.9	4.8	3.8
Loss on acid treatment	27.4	35.3	22.3	11.2	7.8	19.7	35.7	26.0	8.8	2.8
Loss on ignition	14.4	17.5	127	8.6	4.5	11.6	17.0	12.7	4.7	3.8
Calcium carbonate	21.6	32.5	20.3	8.2	0.9	16.2	31.5	23.0	4.6	0.6
Total soluble salts	0.11	0.10	0.12	0.20	*	0.31	0.28	0.44	*	0.87
Chlorides (as Cl)	0.011	0.007	0.006	0.014	0.010	0.007	0.045	0.092	0.067	0.110
Nitrogen	0.086					0.059				
Reaction (pH value)	8.8	8.9	9.0	8.8	7.9	8.8	8.9	8.6	8.3	8.5

TABLE X. – Cont'd

Lab No.	8458	8459	8460	8461	8462	8463	8464
Depth (inch)	0-10	10-22	22-40	40-50	50-63	70-84	84-108
Texture	L	SCL	CL-FSC	LC	MC	HC	HC
Rubble & gravel	4.3	5.0	6.2	4.6	0.2	0.6	-
Coarse sand	10.6	7.4	4.2	2.9	2.4	0.9	1.7
Fine sand	32.6	25.0	24.0	24.9	20.0	10.2	15.2
Silt	11.2	9.4	23.4	26.1	31.3	23.0	32.8
Clay	20.2	18.7	20.5	30.1	34.7	55.7	45.8
Moisture	3.0	2.6	2.8	3.9	5.0	7.1	5.2
Loss on acid treatment	23.4	38.6	27.3	14.1	7.4	2.7	1.6
Loss on ignition	13.2	18.6	13.4	8.3	4.3	4.7	3.8
Calcium carbonate	20.0	34.2	23.1	10.6	1.4	0.1	0.1
Total soluble salts	0.33	0.17	0.18	0.38	*	*	0.39
Chlorides (as Cl)	0.035	0.017	0.013	0.011	0.024	0.037	0.026
Nitrogen	0.105						
Reaction (pH value)	8.7	9.3	9.4	8.8	8.1	7.4	7.8

TABLE XI. MECHANICAL ANALYSES AND OTHER DATA FOR PROFIELS OF THE KOORLONG SERIES

	Koorlong sandy loam							
Lab No.	8398	8399	8400	8401	8402	8544	8545	8546
Depth (inch)	0-7	7-12	12-33	33-60	60-72	0-6	6-18	18-28
Texture	L-SL	L-SL	SCL	FSCL	FSCL	L	SCL	CL
Rubble & gravel	4.0	41.5	20.1	9.3	3.2	0.9	8.0	3.5
Coarse sand	18.7	17.4	8.5	2.6	1.5	13.2	10.2	6.9
Fine sand	50.2	47.5	55.5	67.5	70.2	32.9	29.0	24.3
Silt	4.8	5.3	3.1	4.3	8.6	11.0	9.4	12.4
Clay	16.0	13.6	11.7	14.6	16.0	19.3	17.5	20.0
Moisture	1.4	1.8	1.2	1.2	1.6	3.2	2.9	2.8
Loss on acid treatment	8.7	15.0	20.8	10.5	3.7	21.5	32.2	35.5
Loss on ignition	5.8	12.2	10.2	6.0	2.6	10.1	15.0	16.2
Calcium carbonate	7.5	12.7	19.1	9.5	2.6	11.1	27.5	31.6
Total soluble salts	0.16	0.12	0.10	0.13	0.15	2.86	1.90	0.43
Chlorides (as Cl)	0.030	0.010	0.007	0.015	0.027	0.191	0.151	0.027
Nitrogen	0.067					0.063		
Reaction (pH value)	9.5	9.6	9.8	99	9.9	9.0	9.2	8.7

TABLE XI. – Cont'd

	Koorlong sandy loam			Koorlong loam				
Lab No.	8457	8548	8549	8389	8390	8391	8392	8393
Depth (inch)	28-42	42-54	54-63	0-9	9-17	17-30	30-50	50-72
Texture	CL	CL	FSC	L	CL	LC-MC	MC-HC	CLFS
Rubble & gravel	2.5	0.4	1.6	2.6	26.4	1.3	-	4.0
Coarse sand	4.4	3.5	1.6	16.8	14.4	7.5	4.4	7.1
Fine sand	29.8	28.0	19.6	39.5	38.4	23.6	31.3	82.4
Silt	20.4	34.8	23.4	5.5	5.1	4.9	8.6	0.9
Clay	23.3	25.0	21.1	25.3	21.3	21.7	40.7	7.3
Moisture	3.3	3.9	8.8	2.5	2.4	3.1	3.4	0.7
Loss on acid treatment	20.3	7.1	27.0	10.8	18.8	40.4	13.0	2.4
Loss on ignition	10.5	4.9	2.7	7.3	10.4	18.1	8.8	1.6
Calcium carbonate	16.9	3.5	0.5	8.8	17.7	37.6	11.6	1.8
Total soluble salts	0.18	0.23	*	0.06	0.07	0.10	0.20	0.12
Chlorides (as Cl)	0.009	0.009	0.004	0.003	0.003	0.004	0.008	0.007
Nitrogen				0.074				
Reaction (pH value)	8.6	8.3	7.9	8.8	8.8	9.6	9.8	10.0

TABLE XII. MECHANICAL ANALYSES AND OTHER DATA FOR POMONC CLAY, TYPE 5, AND TYPE 7

	Pomona clay				
Lab No.	8363	8364	8365	8366	8367
Depth (inch)	0-9	9-20	20-36	36-54	54-75
Texture	SC-MC	MC	MC	MC	MC
Rubble & gravel	-	-	0.9	3.1	1.0
Coarse sand	22.8	18.2	15.9	9.6	19.7
Fine sand	43.3	35.2	32.1	33.8	33.3
Silt	3.9	3.7	2.9	9.2	6.4
Clay	26.1	39.0	38.6	36.3	35.9
Moisture	8	4.1	4.7	3.3	2.9
Loss on acid treatment	1.3	1.7	6.6	8.9	3.3
Loss on ignition	2.7	3.4	5.3	6.3	3.7
Calcium carbonate	0.1	0.1	5.2	7.3	2.0
Total soluble salts	0.05	0.07	0.19	0.25	0.24
Chlorides (as Cl)	0.003	0.004	0.015	0.036	0.044
Nitrogen	0.081				
Reaction (pH value)	8.4	9.2	9.7	9.6	9.5

TABLE XII. – Cont'd

	Type 5				Type 7				
Lab No.	2157	2158	2159	2160	2161	2162	2163	2164	2165
Depth (inch)	0-10	10-20	20-42	42-66	0-9	9-13	13-36	36-52	52-78
Texture	SL	CL-LC	Cl-SCL	LC	L	L	SCL	LC	MC
Rubble & gravel	-	-	1.2	1.6	2.6	3.4	5.5	5.1	4.2
Coarse sand	21.2	12.0	12.0	16.0	18.1	15.0	9.5	14.8	18.1
Fine sand	55.5	27.7	25.0	33.2	32.5	31.2	22.3	26.0	31.2
Silt	6.2	3.8	1.5	3.2	3.1	3.7	3.6	3.5	5.4
Clay	16.0	52.1	52.5	37.4	22.6	21.6	24.7	30.6	35.1
Moisture	2.1	4.0	7.3	5.1	2.4	3.3	2.9	4.7	4.3
Loss on acid treatment	0.7	1.8	3.4	6.8	20.9	26.4	37.8	21.6	7.8
Loss on ignition	2.2	5.0	4.5	4.6	12.2	14.1	16.7	9.8	6.2
Calcium carbonate	0.1	0.1	2.1	5.7	18.4	24.7	35.2	21.1	4.9
Total soluble salts	0.07	0.07	0.09	0.15	0.06	0.06	0.07	0.22	0.22
Chlorides (as Cl)	0.007	0.013	0.008	0.017	0.009	0.008	0.010	0.009	0.008
Nitrogen	0.041				0.075				
Reaction (pH value)	8.1	8.1	9.2	9.8	8.7	8.6	8.9	9.2	9.6