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A Soil Survey of the Nyah, Tresco, Tresco West, Kangaroo Lake (Vic.), and Goodnight (N.S.W.) Settlements

BY

J. K. TAYLOR, BA., M.Sc.,
Soil Survey Officer,
Division of Soils, C.S.I.R.

F. PENMAN, M.Sc.,
Assistant Research Chemist,

Department of Agriculture,
Victoria.
T. J. MARSHALL, B.Sc. (Agr.),
Assistant Field Officer,
Division of Soils, C.S.I.R.

G. W. LEEPER, M.Sc.,
School of Agriculture,
Melbourne University.

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SUMMARY.

Soil surveys have been carried out on five settlements in the region of the Murray Valley, aggregating 9,300 acres mainly planted to horticultural crops. The areas are scattered over about 60 miles of typical mallee country in the vicinity of Swan Hill, ranging from Goodnight (N.S.W.) in the north to Kangaroo Lake (Vic.) in the south. Considerable decreases in cropped area have occurred on one settlement (Tresco), and a proportion of each has been rendered unproductive by an excessive increase in soil salinity.

Six soils belonging to five types have been defined and given the names Murray sand, Tyntynder sand, Tatchera sand, Tatchera sandy loam, Vinifera loam, Nyah clay loam. A full description is given of the character of each type, with the exception of the first named.

The soil position on the settlements has been outlined, mentioning the distribution and extent of the several soils, irrigation and drainage necessities, the importance of soil salinity, and its sphere of influence on each area.

Full details of the analytical data for a range of 112 samples covering all the soil types are given, with a discussion of the salient chemical and physical characteristics of the soils.

A general discussion of the problems connected with the soils of the areas is given from the aspects of horticultural development, climatic influence on crops, improvement of soils and possible increase in yield, irrigation and drainage requirements, and soil salinity.

A Soil. Survey of the Nyah, Tresco, Tresco West, Kangaroo Lake (Vic.), and Goodnight (N.S.W.) Settlements.*

I. INTRODUCTION.

The chief problems in the horticultural areas of the Murray Valley are concerned with the raising of the productivity of the poorer soils to a profitable level, and the possibility of controlling other factors partly responsible for low yield. The generally accepted statement that an average minimum yield of 1 ton of sultanas per acre is necessary to maintain an area under dried fruit crops is a matter for-concern, as there is no doubt that the average on some soils is below this figure. This is due, in part at least, to disease, seasonal conditions, and in some cases to salinity and partial waterlogging. The diminution in area of citrus at Nyah and Tresco has converted the former into what is essentially a sultana settlement, and in the latter has caused a steady decline in total irrigated area. The changes which have occurred indicate the need for the study of such problems as the relative fertility of soil types in comparison with other Murray Valley soils yielding higher returns, the specific requirements of a citrus soil, the improvement of the present vine soils, irrigation and drainage necessities of the several soil types, and the presence of salt or the danger of its excessive accumulation.

The scope of the soil investigations discussed in this Bulletin covers five irrigation areas, forming part 'of the chain of settlements in the vicinity of the Murray Valley which have come into prominence, particularly in the last decade, for dried fruits and citrus production. The settlements are scattered over about 60 miles of relatively uniform country in the County of Tatchera, Victoria, and in New South Wales, with a typical vegetation of Murray pine, mallee, sandalwood, and belar. The geographical relationship of the areas is shown in Fig. 7. They are discussed as a unit since, as a general rule, they face the same problems in the same soil types. From Swan Hill as a centre, Goodnight settlement is 34 miles north on the New South Wales bank of the river, Nyah 17 miles north on the Victorian bank, Tresco and Tresco West together about 14 miles south, and the Kangaroo Lake Estate a further 14 miles in the same direction, adjoining the township of Mystic Park. The Woorinen area, to which reference is made, lies between Swan Hill and Nyah.

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* The soil survey of the five settlements mentioned in the title was undertaken jointly by the Division of Soils, Council for Scientific and Industrial Research, the Victorian Department of Agriculture, and the Melbourne University School of Agriculture, the former being responsible for the field work and the two latter for the bulk of the analytical data. The investigation was conducted in accordance with the plan to study the soils of the horticultural areas in the Murray Valley with a view to correlating and defining the soil types, evaluating them in terms of present and possible productivity, and elucidating the soil problems confronting the fruit growers.

The field work, including field salt estimation, was carried out by Messrs. T. J. Marshall, J. K. Taylor, and P. D. Hooper, and the laboratory work for Nyah and Kangaroo Lake by Mr. V. Penman, for Tresco and Tresco West by Mr. G. W. Leeper, and for Goodnight by Mr. T. J. Marshall.

The original planting on each settlement has been modified by failures, and the present distribution of crops is the result of an elimination of the unsuitable plants, with or without replacement by others. A summary of the approximate extent of individual crops at Nyah and Tresco is shown in Table 1.

TABLE 1.—DISTRIBUTION OF CROPS IN NYAH AND TRESCO SETTLEMENTS.

Settlement	**Citrus.**	**Sultanas.**	**Currants.**	**Gordos.**	**Dora-dillos.**	**Table Grapes.**	**Deciduous Trees.**	**Lucerne and Fodder Crops**	**Total**
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Nyah	250	1,975	250	125	80	40	..	40	2,760
Tresco	438	140	..	..	298	63	110	135	1,182

There is a marked dominance of sultanas at Goodnight, Nyah, and Tresco West, and of citrus at Kangaroo Lake and Tresco, with doradillos grapes also occupying a strong position in the latter.
Climatic Features.

The official meteorological data for Swan Hill, as a central station among the areas investigated, are given in Table 2, and also for comparison the mean monthly temperatures of Mildura, which may he taken as a climatically reliable settlement for dried fruit. Proceeding eastward from Mildura, the order of reliability of the settlements may be taken as Goodnight, Nyah, Swan Hill, Tresco, and Kangaroo Lake. The rainfall increases slightly but definitely; the mean temperature decreases similarly, and in particular the fruit-drying period of February to April is more subject to unseasonable breaks, with consequent interference with the drying process.

TABLE 2.—OFFICIAL METEOROLOGICAL DATA FOR SWAN HILL (VIC.).

Month.	**Jan.**	**Feb.**	**Mch.**	**Apl.**	**May**	**June.**	**July.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Total.**
Rainfall in inches	0.60	0.72	0.85	0.95	1.40	1.84	1. 13	1.36	1.35	1.12	0.95	1.11	13.8
Temperature Mean°F	74.2	74.9	68.2	61.8	54.8	49.5	48.2	50.5	55.1	61.0	67.7	72.2	..
Temperature Mildura °F. Mean	76.7	76.8	70.2	62.8	56.2	51.2	49.6	52.8	57.5	63.7	70.2	74.4	..

The ripening season also is later, further limiting the suitable weather for processing, and with atmospheric drying this means a low grade for the fruit picked late in the harvest. Frost danger is unimportant in general, with the exception of occasional extreme cases, when great damage may be done. Local damage on lower lying ground may occur more frequently, but even for citrus the five settlements are regarded as safe from ordinary frost damage.

II CLASSIFICATION AND DESCRIPTION OF THE SOILS.

A study of the soils in the areas under review shows a reasonable grouping into five soil types, exclusive of three unclassified soils of minor importance. One of the types is subdivided into two varieties. Each type has been given a name of local geographical significance qualified by a class name to indicate the texture of the surface soil; this follows the binary system developed in America. The application of the system in Australia has been described by Prescott and Taylor (4). Names for the main types concerned in the present survey were allotted as follows, the types being arranged in increasing order of heaviness—Murray sand, Tyntynder sand, Tatchera sand, Tatchera sandy loam, Vinifera loam, Nyah clay loam. A full description of each type is given below.

The mechanical analyses confirm the apparent field textures. The relative heaviness in texture of the types, as observed at Nyah, where all occur, is correlated to some extent with elevation, as the Murray sand and Tyntynder sand occupy the highest, and the Nyah clay loam the lowest, levels. In the discussion of textures, as indicated by mechanical analysis, recalculated figures for the mineral fractions on the basis of + sand + silt + clay = 100 per cent have been used. This appears to be the soundest method of treating soils such as these, containing variable and often large amounts of lime, so that the comparison rests on the absolute texture of the soil matrix. The lime rubble exceeding 2 mm. in diameter is removed before analysis, but is a very important feature in many of the soils.

The distribution of the soil types in the different areas is shown in Table 3. It will be seen that the Tatchera soil types predominate except in the Goodnight settlement, and that the Nyah and Vinifera types are only important in the Nyah district. Murray sand is unimportant owing to its restricted extent and its occurrence above the level of community irrigation channels.

TABLE 3.—DISTRIBUTION OF SOIL TYPES IN SURVEYED AREAS.

Soil Type	Goodnight I.T.D.	Nyah I.S.	Tresco I.S.	Tresco W. I.S.	Kangaroo Lake East
	Acres	Acres	Acres	Acres	Acres
Murray sand	377	182	..	65	..
Tyntynder sand	..	192	84	28	38
Tatchera sand	..	421	813	413	..
Tatchera sandy loam	..	1,585	1,630	103	592
Tatchera sandy loam (saline phase)	..	..	684	459	..
Vinifera loam	17	869	36	..	..
Nyah clay loam	128	416	..	..	..
Unclassified	47	52	114	..	..
Total surveyed area	569	3,717	3,361	1,068	630

In the survey of the Woorinen settlement(8), four soils were described, of which one, designated Type 8, has distinct affinities with the Tatchera type. It is probable that Type 8 covers both classes of the latter soil type, mainly conforming to Tatchera sandy loam, and there is also a definitely lighter form, probably best classed with Tyntynder sand. Type 8 and the Tatchera type are separated in elevation by a contour interval of 30 to 40 feet, although they occur only a few miles apart. The two soils have points in common in their chemical and physical characters, as well as a profile relationship in the

1. Murray Sand.

The occurrence of this type is very restricted, the main area being in the Goodnight settlement. It is characteristic of the true pine ridge country which constitutes the best citrus land in the Murray Valley. It has typically a very open texture, very good drainage, and freedom from salt troubles; its main drawback is its elevation, which necessitates a high lift, and in most cases, as at Nyah, places it above normal irrigation level. The red or red-brown deep sandy soil with a calcareous sandy loam subsoil presents no difficulty of cultivation, but is very liable to over-irrigation resulting in the formation of seepage patches at lower levels. The soil has been described in full elsewhere(6), and analytical details of a sample are given in Appendix Table 1.

2. Tyntynder Sand.

This soil type, in texture and profile, occupies a position between the Tatchera sand and the Murray sand, with a tendency towards the character of the latter. Originally, it carried a good growth of Murray pine; it is found only on the highest levels, and is outstanding among surrounding heavier types in its permeability to water and free drainage. It is only of limited extent, but occurs consistently at Nyah, Tresco, and Kangaroo Lake.

The distinctive features of the typical profile (Fig. 1) are the general lightness of texture throughout, and the definite sandiness in the deep subsoil allowing satisfactory drainage. The lime content is high, often exceeding 20 per cent in the fine earth, and the amount of rubble is equally large on some occasions. The clay content is low except in the subsoil, where it may rise to about 28 per cent.; the silt fraction is very small, and coarse sand equals or exceeds fine sand in amount in almost every case. The approximate composition of the soil is shown by the average figures for four profiles summarized in Table 4.

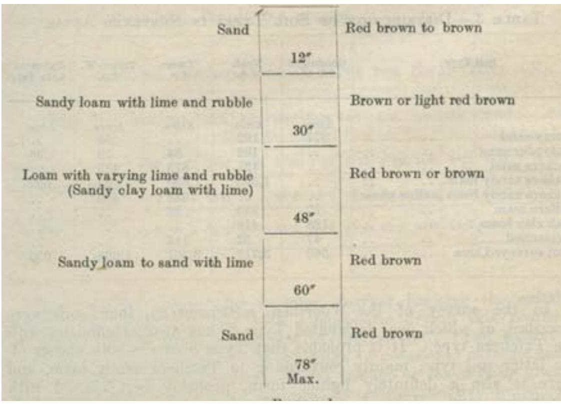


Figure 1

TABLE 4.—AVERAGE MECHANICAL ANALYSES OF SOIL TYPES.

Figures recalculated from analyses on the basis clay + silt + sand = 100 per cent.

Soil Type	Number Samples	Surface				Subsurface				Subsoil			
		Coarse sand	Fine sand	Silt	Clay	Coarse sand	Fine sand	Silt	Clay	Coarse sand	Fine sand	Silt	Clay
Murray sand	1	34	53	2	11	29	53	2	16	33	49	2	16
Tyntynder sand	4	46	38	5	11	39	36	4	21	41	34	5	20
Tatchera sand	4	60	25	4	11	47	24	5	24	38	23	8	31
Tatchera sandy loam	14	43	27	9	21	35	24	7	34	32	23	7	38
Vinifera loam	3	32	26	13	29	20	19	9	52	25	17	6	52
Nyah clay loam	3	26	27	7	40	21	25	6	48	21	24	7	48

3. Tatchera Soil Type.

The most important soils encountered in the survey of the settlements were grouped under the titles of Tatchera sand and Tatchera sandy loam. The sequence of layers in the profile, the occurrence of pockets of soft and rubbly lime, certain details of mechanical analysis, and the topography of the occurrences, point to a similarity between these two soils, and justify their classification under a common type name. Both occur on the same contour levels, but generally the lighter form occupies the crests of the ridges, and for this reason, perhaps, there is often more sand accumulated on the surface. The topography of the Tatchera soil type is characterized by moderately sloping ridges with more or less flat land between them; at Tresco all the flat land is of this type, but at Nyah other heavier soils are sharply defined on the lower levels. The vegetation of the ridges was a mixture of Murray pine (*Callitris glauca*) and large and small mallee, while on the flat land of this type, mallee, belar (*Casuarina lepidophloia*), and sandalwood (*Millyoporum platycarpum*) occur. There was very little true pine country on the settlements, as even the higher ridges carried a mixed mallee and pine vegetation, with the former mainly dominant. This indicates less surface sand and the presence of more rubble and limestone than in the ridge formation of the Murray sand soil type. It is probable that Tatchera sand represents the areas with originally more pine than mallee, and Tatchera sandy loam those with mallee dominant.

The relationship and distinction between the two soil profiles is shown in Fig. 2. The essential difference is that the sandy loam profile is heavier throughout in average texture.

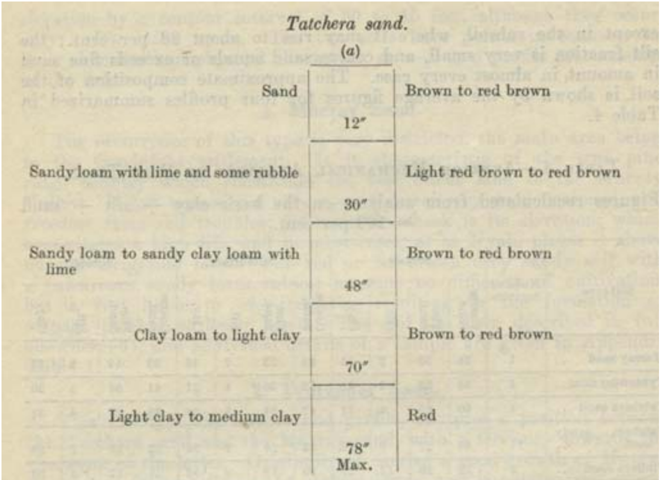


Figure 2a

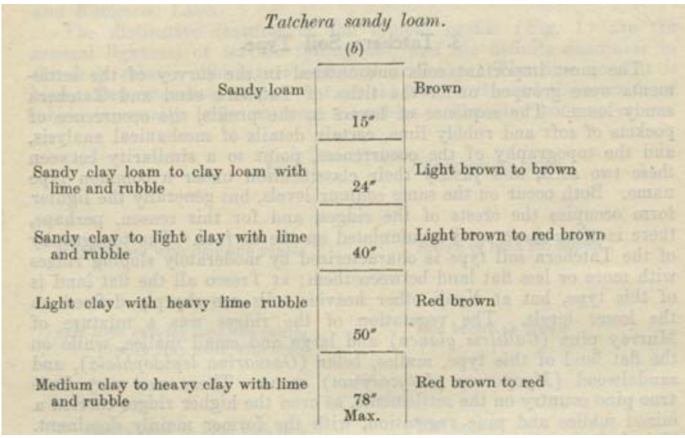


Figure 2b

(a) *Tatchera sand* (Fig. 2A) is brown to red-brown, with a darker shade of colour at the surface due to organic matter, and a distinct redness in the deep subsoil at 6 feet. The feature deciding the separation of this soil from related types was the depth to the clay loam layer, which was arbitrarily fixed at not less than 48 inches. The lime content is low in the surface sand, moderate in the subsurface sandy loam, and very high in the subsoil, where it averages more than 20 per cent of the fine earth in addition to the original rubble present. This undoubtedly has a modifying effect on the permeability of the subsoil to water. The predominance of coarse over fine sand tends to emphasize this feature. The silt content is too small to have any appreciable effect on the texture. An average mechanical analysis of the profile is given in Table 4.

A stony phase was observed, but apart from a few well defined areas no boundaries were fixed.

Some soils contained large amounts of nodular limestone, and a number of spots have been marked "heavy rubble" or "stony" according to the nature of the occurrence.

(b) *Tatchera sandy loam* is a heavier form of the type, particularly in the subsurface layer. The surface colour is browner than that of Tatchera sand, and varies to grey-brown, while the subsoil colour is red-brown, becoming redder with depth. The average profile is sketched in Fig. 2b, and an average mechanical analysis given in Table 4.

The apparent field texture is considerably lighter than the analysis indicates owing to the high content of lime, which, although variable, is seldom low. An indication of the wide limits of the lime content is given in the following summary of analyses of ten profiles of this soil type:-

		Surface	Subsurface	Subsoil	Deep Subsoil
		Per cent	**Per cent**	**Per cent**	**Per cent**
Lime in fine earth	{ Min	Tr.	1	2	2
	{ Max	10	35	31	25
Rubble lime in field	{ Min	<2	<2	<2	<2
	{ Max	3	47	24	19

It is manifestly impossible to deal with average field textures under such conditions, and in extreme cases the field texture and water relations may be quite different from those indicated by the analytical figures, which require cautious interpretation. Another important factor governing the apparent texture is the high proportion of coarse to fine sand. In Nyah and Tresco soils, coarse sand invariably equals or exceeds fine sand in amount, in some cases reaching a 5:1 ratio. At Goodnight and Kangaroo Lake the tendency is for fine sand to dominate. Silt is generally low, and the clay content of the layers in the soil profile varies within wide limits.

Saline Phase.
On the Tresco and Tresco West settlements occurs a modification of the Tatchera sandy loam, which has been denoted as the "saline phase" of the type. The profile is essentially the same as for the normal soil in colour and texture, although it may appear heavier from field observations, but it is highly saline throughout, and the surface soil is grey or grey-brown. The immediate surface is frequently powdery and salt-encrusted when dry, and the sodium chloride content exceeds 200 parts per 100,000 of soil in the 0 to 36 inch depth. It is considered that, in its present state, the whole area of this phase is unsuitable for any agricultural crop, and that reclamation could not be effected economically.

4. Vinifera Loam

The Vinifera loam is associated with the slightly lower land of the valleys between ridges of the Tatchera soil type, where it appears in a strip often a few chains wide. It is found in larger areas in the Vinifera section of the Nyah settlement, but still on the lower ground approximately between the 245 and 260 feet contours. The original vegetation was probably box (*Euc. Bicolor*), mallee, and sometimes belar.

The profile (Fig. 3) is definitely heavy compared with the soil types described above, and as a rule there is less lime present. The surface soil normally is a red-brown loam, although the analyses indicate that is may be heavier, with very little lime present in any form. The texture changes between 6 inches and 12 inches, where a light clay with increasing amounts of soft and rubbly lime appears; the lime content rises to moderately high figures in a light red-brown medium clay between 2 and 4 feet. The deep subsoil is heavy, sometimes appearing to become lighter with depth. The lime is present in large amounts, reaching a maximum of 17 per cent of the soft form and 22 percent of rubble in the 24 in to 50 in layer of the heaviest soil. The average analysis for three profiles of this group is given in Table 4. Field data do not indicate great variation in lighter than the figure show. Silt in most cases is low, one case along being outstanding with 21 per cent in surface soil. The coarse sand in three Nyah profiles was equal to, or greater than, the fine sand in amount, while the fine sand was definitely higher in the Goodnight sample.

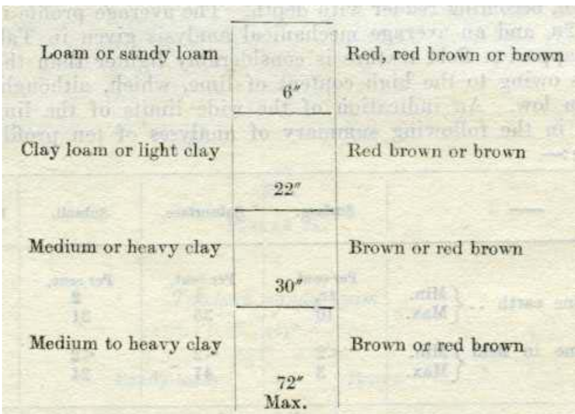
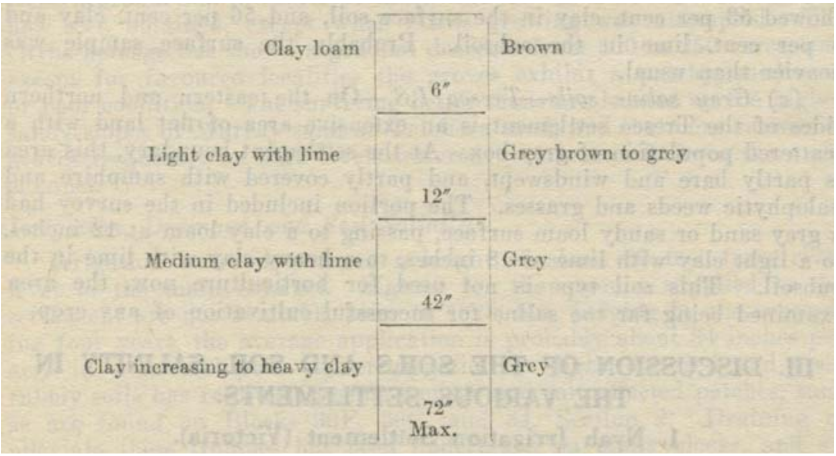


Figure 3

The colour of the type is somewhat variable, and although normally red or red-brown, in certain areas it is brown. In general, the brown-surfaced variant contains less lime, but closely resembles the common form.

5. Nyah Clay Loam.

The major occurrence of Nyah clay loam is in the southern portion of the Nyah settlement, although it is also found generally throughout that area and to a small extent at Goodnight. It represents the heaviest soil encountered, and the lowest in lime content; it is strikingly uniform in subsoil texture, and is predominantly grey, except for the surface layer. As a rule, it occupies the lowest levels at Nyah, occurring mainly between the 245-ft. and 250-ft. contours. All the occurrences are adjacent to, and lower than, areas of Vinifera loam, and it is associated with the main drainage system of the settlement. The original vegetation was probably box and mallee. A sketch of the profile is given in Fig. 4, and the average mechanical analyses calculated from three profiles, in Table 4. The analyses of three profiles showed a wide variation in surface texture, which, however, was always heavier than that recorded in the field observations; this may be due to the low silt content and high proportion of coarse to fine sand.



Certain areas of the type show a crab-holey condition, necessitating some grading before planting, so that an uneven soil has resulted. Instances of such patchy soils occur on Block 15A of Section 1, and 27B of Section 2, Nyah. The normal variety is a uniform soil of very fair productive capacity, and although irrigation difficulties are experienced initially, the vines appear to do well after heavy gypsum dressings have been applied.

6. Unclassified Soils.

Three soils, different in character from those described above, occur in small areas on three settlements, and are more representative of the surrounding country not suitable for horticulture.

(a) *Red gum flat soils—Goodnight I.D.*-These occur on the open low-lying plain country carrying red gums on the north-western and south-western sides of the Goodnight settlement. The profile consists of a grey clay loam surface, passing to a light clay at 10 inches, and containing some lime at 20 inches ; the subsoil is a medium clay, ultimately passing gradually to a sand. On the eastern side of the area is some heavy textured grey box country, similar to the Nyah clay loam. Both these soils are difficult to work and irrigate, and at present are not giving satisfactory results. In the surveyed area their extent is limited.

(b) *Gypsum-bearing clay—Nyah I.S.* - the north-western corner of the Nyah settlement, and to a smaller extent south of Nyah West township, occurs a heavy uniform-textured soil with a gypsum-bearing layer in the subsoil. It is circumscribed fairly well by the 240-ft. contour and carries stunted box, and on lower ground samphire and dillon bush (*Eremophila maculata*) as the main cover. The land surface is flat, or with shallow crab-holes, and the soil is heavy right to the surface. It is a brown to grey clay on the surface, becoming greyer and apparently heavier with depth, and containing some lime; the gypsum appears at about 42 inches. The soil surrounding a crab-hole seemed browner in colour, lighter in texture, and more calcareous than in the hollow itself. A mechanical analysis of a typical profile showed 53 per cent clay in the surface soil, and 56 per cent clay and 5 per cent lime in the subsoil. Probably the surface sample was heavier than usual.

(c) *Grey saline soils—Tresco I.S.* - On the eastern and northern sides of the Tresco settlement is an extensive area of flat land with a scattered population of grey box. At the settlement boundary, this area is partly bare and windswept, and partly covered with samphire and halophytic weeds and grasses. The portion included in the survey had a grey sand or sandy loam surface, passing to a clay loam at 12 inches, to a light clay with lime at 18 inches, to a heavy clay with time in the subsoil. This soil type is not used for horticulture now, the area examined being far too saline for successful cultivation of any crop.

III. DISCUSSION OF THE SOILS AND SOIL SALINITY IN THE VARIOUS SETTLEMENTS.

1. Nyah Irrigation Settlement (Victoria).

The real development of the Nyah settlement began in 1909 with the establishment of a large pumping scheme by the State Rivers and Water Supply Commission. Prior to that year, there was only a small planted area under irrigation privately, which then expanded rapidly to a total of about 2,000 acres. The area was not extended further until 1919, when 45 additional blocks were opened in the portions known as Vinifera and North Nyah Extension, bringing the total to the present figure of 2,760 acres. All but 400 acres of this area is concerned with the production of dried fruits, sultanas forming 70 per cent of the gross planting. The area surveyed was 3,717 acres, divided among the soil types as shown in Table 3. The distribution of the soil types is shown in the soil map.*

The principal soil at Nyah is Tatchera sandy loam, found mainly on the intermediate slopes of the ridges, and the remaining types conform fairly closely to the topography of the country. Vinifera loam soils are located in the valleys between the slopes of Tatchera sandy loam, and associated with the main drainage system; an extensive area is found at Vinifera. Higher on the slopes and near the irrigation channels lies Tatchera sand, and while a few patches of Murray sand occur on the highest ridges, they are usually above normal irrigation level, and if planted are supplied with water by private lift from the main channels. Soils not included in the four major types appear in the box country on the lower flats of the settlement, being grouped either with Nyah clay loam, or as an unclassified type, discussed in section II. as a grey "gypsum bearing clay" (p. 14). The latter is of small importance and extent, and has, so far, not been utilized for horticultural purposes. Nyah clay loam differs from this soil in having a grey brown, rather than a grey surface soil, and a superiority in textural conditions seems associated with the difference. Should salty conditions supervene, as in Blocks 32 and 33 of Section 2, it appears from experience with these soils under more favorable circumstances, that attempts at reclamation would be difficult, and not warranted.

The Vinifera loam is planted in practically every block on which it occurs, but has not generally proved highly productive. The use of gypsum would undoubtedly result in improved textural condition and increased production in course of time. On the lighter soils, better success has been obtained, except when citrus growing was attempted. The citrus acreage has shown a gradual decrease from 500 to 250 acres, and except for favoured localities the groves exhibit a patchy, mediocre, or poor condition. The surviving better areas are located on the higher sandy slopes of Murray sand or Tatchera sand, and the more successful groves frequently on high levels watered by private lift from the main channel.

Irrigation, Drainage, and Soil Salinity.

Irrigation water is pumped a height of about 80 feet from river level to the main channel. Figures for the amount supplied to the settlement are not available prior to 1928, but, judging by the succeeding four years, the average application is probably about 34 inches per acre in a normal year. Over-irrigation on light textured and open rubbly soils has resulted in some seepage and salt affected patches, such as are found on Blocks 30F, 30C, and 34, Section 2. Draining to alleviate these troubles has been undertaken on many blocks, and an extensive open

* See folders at back.

cut main system laid out to carry off water from the private tile drains. Under-drainage has been used by settlers to improve the condition of their orange groves, with results which are not always successful. Citrus injury on the slopes of the sand ridges was due mainly to excessive subsoil water, and not to salt concentration in the root zone. The peculiar uneven surface of the subsoil clay by which water was impounded in pockets probably caused the trouble, and drainage lines cutting across the obstructing clay bars have largely alleviated this condition. Citrus trees are much more susceptible to injury from waterlogging than vines, and to this cause rather than to salt accumulation is ascribed the decline in acreage of that crop.

Excessive amounts of salt are not common in Nyah soils, except in some of the heavier varieties, where frequently more than 100 parts of sodium chloride per 100,000 parts of soil were encountered. Estimations made during the survey showed that Nyah clay loam includes the greater portion of the dangerously saline soils, most of the remainder occurring in Vinifera loam. The settlement is not regarded as in danger of any major extension of the known saline areas, as has occurred at Tresco. Localized patches occur in many places readily recognized from the condition of the trees or vines. It is significant that soils known to have been heavily watered in the past, and on which drainage was necessary, have not shown an accumulation greater than 50 parts of sodium chloride per 100,000 parts of soil. Seepage from main channels has not produced salty effects in the sandier soils.

The most seriously affected area lies north-east of Nyah West township, where a strip of land running through Blocks 30F to 34 north of and along the drain has been abandoned as far as vine growth is concerned, or is producing only a poor crop. Further injury has appeared south of the drain in Blocks 28C and 27C, and in 30E, 30B, and 31B, having either killed the trees and vines, or rendered them unprofitable.

The crabholey, box-flat land in the north-west corner of the settlement, especially in Blocks 4B, 4C, 5, 5A, and 5B, has a fairly high salt content, which is not so obvious in the absence of a crop. Definite signs appear, however, in Blocks 1B, 5, and 5C. A similar soil formation, with salt accumulation, occurs in parts of Blocks 16B and 17, of Section 1, and Blocks 15C, 15B, 15A, and 14C are affected in lesser degree. Actually, many of the drains in the main system show signs of the presence of salt, and sometimes in their vicinity end vines in rows may be affected. Generally, the heavier soils of the Nyah and Vinifera types occurring in such places show a relatively high toxic limit of salt concentration for vine growth. There does not appear to have been any seriously high salt content in the virgin Nyah soils, except perhaps in some of the lower ground between the ridges, and consequently the main source of danger lies in the creation of high water tables rather than in soil salinity.

2. Tresco Irrigation Settlement (Victoria).

1. General Description.

The Tresco area abuts on Lake Boga, the last of a string of inter- connected lakes stretching from Reedy Lake, near Kerang, to the Little Murray River, water being circulated through the series, and maintained in a relatively fresh condition for use in irrigation. The settlement, unlike Nyah, is 8 to 10 miles from the Murray River, and is dependent entirely on the lake for its water supply. In the early stages of development, possibilities of injury were introduced by the use of water which was often more salty than the average reached in 1922-23, namely 62 parts of sodium chloride per 100,000. During the past six years, it has averaged 20 parts of sodium chloride per 100,000, which is regarded as satisfactory.

Prior to subdivision in 1913 by Australian Farms Limited, the area was a wheat-farming property, some parts of which, even at that time, showed signs of salt trouble. The two main ridges on the eastern and western sides, and the flat between, were originally covered with malice scrub of varying density and size, associated with pine on the higher parts, and with some sandalwood on the lower. The nature of the topography split the irrigation system into three parts—the first lift of 20 feet commanding 2,565 acres, the second of 14 feet and the third of 11 feet, together commanding 660 acres. In addition, about 135 acres of higher land were irrigated in the northern and western portions of the area by private pumping from the first lift main channel. About 2,500 acres out of a total of 3,360 acres within the settlement boundary were planted, or prepared for planting, with citrus and doradillos grapes, the former covering about two-thirds of the total area.

In the early stages, trees and vines prospered, but after some five years, evidence of salt trouble became apparent, and the area has since declined progressively in production and effective extent. The first part to go out of cultivation was the flat land on the first lift, and very little of it remains under any kind of crop at the present time. The second lift and the areas irrigated by private pumps are in various stages of abandonment, while at present the third lift is probably more secure. As shown in Table 1, there remains under irrigation a total of 1,182 acres, including 438 acres of citrus, the bulk of which is still classed as good; 140 acres of sultanas, producing moderate amounts of medium to low grade fruit; 296 acres of doradillos in various stages of neglect; and 135 acres of fodder crops which are found to do quite well in some soils excised for horticultural purposes.

The causes of the failure of the citrus area may be summarized as follows :---(i) The original irrigation system of unlined main channels allowing seepage on a large scale, and inadequate ditches on individual blocks, which were not always graded satisfactorily; (ii) the former use of saline water for irrigation; (iii) the application of excessive amounts of water, causing development of a high water table; (iv) the presence of large amounts of salt in the deep layers of the soil, ascending to the surface consequent on the raising of the water table; (v) on the lower ground the added effect of excessive seepage from the ridge soils; and (vi) the semi-impervious nature of the subsoil of most of the soils at a, depth of about 4 feet. Some of these points will be discussed in more detail. The general nature of the troubles and causes has been dealt with by Read (5), (6).

(2) Distribution, of Soil Types.

The extent of the various soils in the Tresco area is shown in Table 3, and their distribution in the soil map.* It will be seen that the order of importance in gross area is Tatchera sandy loam (49 per cent.), Tatchera sand (24 per cent.), Tyntynder sand (2.5 per cent.), the remainder being grey saline phase of the Tatchera sandy loam (20.5 per cent.), none of which, however, is under cultivation, and unclassified saline soils (3 per cent.) on the fringe of the settlement. On the map, the eastern ridge has a backbone of Tatchera sand with three patches of Tyntynder sand on definitely high portions, and with Tatchera sandy loam flanking both on each side. A similar distribution, though not so marked, occurs on the western ridge. There is a central mass of the saline phase of Tatchera sandy loam, and the northern extremity of the settlement is a composite of this and the normal phase with Tyntynder sand. Surrounding the ridge land on the east and north is the lower, highly saline ground of the grey box flats, which fortunately were never

* see folders at back

devoted to horticulture. There is one fairly marked area of the stony phase of Tatchera sand in Blocks 28, 40A, 41, 42, and 47, and a few isolated observed occurrences of heavy rubble in this and Tatchera sandy loam, such as in Blocks 26, 27, 62, &c. These are not the only occurrences, nor is the extent indicated, as it was not possible to deal in the survey with this detail, which in any case is a highly variable feature of the soil profile over even small areas. The predominant type of profile contains moderate amounts of rubble, and somewhat more soft lime in the subsoil, although cases of many subsoils were frequently observed.

On the eastern slope of the main ridge, some mixed soils were found on small areas, particularly on Blocks 36, 37, 38, and -28, not conforming definitely to any type described and denoted on the soil map as varieties of the Tatchera type. At the present time, the productive capacity of these blocks is low, and salt accumulation liar reached a dangerous level.

Read (6) distinguished three soil types—Type I corresponds to the Tyntynder sand, Type II to the Tatchera sandy loam, and Type III to the saline phase of the same type. The first is associated with the higher levels, but not in this case with the highest level; the second occupies the lower ridge slopes, but sometimes, as in Blocks 40, 64, 67, 69 is much higher; the third is typical only 'of the flat land between the ridges. It is significant that in Read's selection of soils, based on the health of the citrus trees, the good examples are Tyntynder sand or Tatchera sand, the fair examples divided between the two Tatchera types, the poor and bad are all in the Tatchera sandy loam, and the dead groves in the saline phase of the same soil type.

(3) The Salt Problem at Tresco.

A full account of an investigation into soil salinity problems on three typical properties at Tresco has been given by Read (5) and (6), and his conclusions on the origin of the salt, waterlogging of the soil, and the best method of irrigation are endorsed from a study of the whole settlement. The distribution and extent of the saline and non-saline soils are shown in Fig. 8, and in Table 5. Borings for salt estimation were carried down to 3 or 6 feet over the whole area, with special attention to the planted portions. In general, the significant depth as far as maximum concentration was concerned was 24 inches to 36 inches, but obviously there can be no exact measurement of the sodium chloride concentration in soils when sampling is limited to a single series of determinations and to a restricted depth. The salt map therefore cannot be interpreted rigidly, but the outstanding feature is the frequency with which figures less than 50 parts of sodium chloride per 100,000 of soil were obtained on the main ridge in blocks both cultivated and abandoned. This leads to the general conclusion that there is not at the present time a seriously high concentration in many areas carrying dead or inferior citrus trees. The amount may have been higher in the surface few inches, but in the last resort the average figure to a depth of 3 feet, representing also an approximation for 6 feet, is a better index of salinity, and an important factor in reclamation for citrus or other crop. In all discussions of reclamation, it is assumed that the best practical method of handling the blocks and the irrigation system is adopted, no consideration being given to cases where inadequate methods are practised.

The figures selected for the divisions on the salt map were chosen on the basis of crop tolerance to sodium chloride, assuming that 50 parts per 100,000 of soil is the maximum possible for citrus, 100 parts per 100,000 the maximum for vines, and 200 parts per 100,000 an arbitrary limit for the purpose of reclamation. It was shown that, after a furrow irrigation, the salt content of the soil between the furrows was not materially changed, and there was little tendency to distribute the salt to greater depths. The winter of 1931 had been wetter than the average, and there was an improved surface condition from the salt point of view compared with recent years, accounting for such vegetation anomalies as the growth of spear grass (Stipa sp.) on a soil averaging 600 parts of sodium chloride per 100,000 of soil, while the trefoil and weed growth in moderately saline areas was diverse and thick.

TABLE 5.—APPROXIMATE DISTRIBUTION OF SALINE AND NON-SALINE SOILS.

Sodium Chloride Concentration	**Area**			**Proportion of -**	
	1st Lift	**2nd + 3rd Lift**	**Total**	**Total Area**	**2nd + 3rd Lift**
	Acres	Acres	Acres	Per cent	Per cent
<50 pp 100,000 soil	650	640	1,290	38	81
50-100 pp 100,000 soil	475	115	590	18	15
100-200 pp 100,000 soil	105	30	135	4	4
>200 pp 100,000 soil	1,335	..	1,335	40	..

A study of the salt-affected areas in Table 5 and Fig. 8 shows that there is a very small acreage on the second pumping lift, and none on the third lift, where there is more than 50 parts of sodium chloride per .100,000 of soil in the 0-3 ft. layer, whereas the figures for the lower levels are generally much higher. Numerous blocks on the first lift have been able to carry on by privately pumping water from the main channel to higher ground. The large proportion of highly saline land, with more than 200 parts of sodium chloride per 100,000 of soil, is mainly due to areas not planted to crops, although within the Tresco drainage system. Areas such as these on the eastern and northern sides of the settlement, and in the vicinity of Tresco township are obviously not reclaimable at the present time. For practical irrigation purposes, this portion may be disregarded. The two remaining areas of special importance are the eastern and the western ridges. The third and sixth columns of Table 5 show the area watered on the higher pumping lift, and the proportion affected by salt. Over 81 per cent was in a satisfactory condition at the time of the investigation, and 96 per cent in a state probably allowing a successful growth of horticultural crops other than citrus. In considering the western ridge, the important fact is that almost all the original planting and the present cropped area has been irrigated by private pumping plants from the first lift main channel. From Read's investigations, it is quite likely that salt occurs at considerable depths in the soils, but except in a few instances of very heavy irrigation, the watering system has been such as to prevent the formation of a dangerously high water table and the rise of salt.

A study of the contour lines indicates that there is very little land with less than 200 parts of sodium chloride per 100,000 of soil below the 233-ft. level, and a low proportion only within the 240-ft. line; between 240 feet and 246 feet representing the first lift main channel, the figure vary considerably, with a maximum of 200 parts of sodium chloride in the planted area. With regard to this lower ground in the centre of the settlement, the question arises as to the causes contributing to its present state. From the evidence available, it is highly probable that the excessive watering of the eastern ridge, in addition to seepage from the huge unlined main channels, caused a steady leaching movement down the slope, ultimately raising the water-table, and carrying salt to the surface. This effect was aided by irrigation of the flat land, by the large amounts of salt initially present in the deep sub-soil, and by the texture of the soil profile which is not conducive to deep leaching or sub-drainage. It was commonly found that, in the Tatchera sandy loam soil irrigated within the preceding two week, the soil from 2 to 4 feet was waterlogged, and beneath was a dry stiff clay – a clear case of a perched, though temporary, water-table. This is attributable to the chemical nature of the clay affecting the permeability of the sub-soil, a condition modified to some extent by the lime pockets. The laying of tile drains in the clay horizon is a useless expedient for relieving water accumulation in summer, or for the removal of salt. The question of the amount and method of application of water has been dealt with adequately by Lyon (2). The optimum application would appear to be five or six acre-inches under normal circumstances in soils of the average texture at Tresco, applied by the flooding system on short rows. This method has the dual effect of evenly distributing the water through a minimum depth of soil, and also evenly distributing the salt in the profile.

A large proportion of the ridge soils appear to be still in a satisfactory state for vines, and undoubtedly could be brought into a moderately productive condition. There is not the same justification for replanting citrus, although it is not clear whether this judgement should be based on soil defects, salt trouble, waterlogging, parasitical attacks, or a combination of them.

3. Tresco West Irrigation Settlement (Victoria)

The Tresco West settlement was opened some years after the main Tresco area, and when the results of seepage and salt injury were becoming plain on the lower ground. In consequence, the planting was wisely restricted to those parts above a critical contour level, and the justification for this policy is seen in the present saline condition of the lower ground. The effective area is now 609 acres out of the gross total of 1,068 acres. The planting is mixed, consisting, in order of importance, of sultanas, citrus and fodder crops.

The conformation of the area shows a main ridge, with further small rises of recent windblown sand, sloping to low ground on the east and west sides. The irrigation system leading from Lake Boga involves a double or triple lift to the main channels. The drainage scheme finds an outlet to a lagoon in the south-west corner, and private sub-drainage systems have been laid on most of the blocks.

The soils* are similar to the common types of Tresco, namely Tatchera sand (413 acres), Tatchera sandy loam (103 acres), Tyntynder sand (28 acres), and Murray sand (65 acres). The latter is a poor, brown loose sand; it is non-coherent, blow readily, is extremely poor chemically, and although grouped, for convenience, with the Murray type, is inferior in all ways to the standard form.

The salt accumulation is shown in Fig. 9, which illustrates the sodium chloride content in the 0-3 ft depth, in a series of 81 borings on the settlement. Borings to 6 feet did not define the salt position more clearly in the cases examined. The shaded portion on the eastern side comprises 47 per cent of the total area, and is disregarded as being too saline for agricultural use. An analysis of the borings on the remaining part gives the following distribution:-

Sodium Chloride Content in parts per 100,000 of soil	**<20**	**21-30**	**31-40**	**41-50**	**51-74**	**76-100**	**>100**
Number of borings	34	13	13	5	11	2	3

The higher parts of the ridge are low in sodium chloride, mainly less than 20 parts per 100,000 of soil. No real difference between the two forms of the Tatchera type is recorded, but the sandy loam is more liable to waterlogging with excessive application of water. About one

* For the soil map of the area see folders at back

quarter of the planted area contains more than 50 parts of sodium chloride per 100,000 of soil, but while almost the whole could be used for some horticultural purpose, the planting of citrus is not recommended.

4. Kangaroo Lake Estate (Victoria)

The irrigated area at Kangaroo Lake is situated on the eastern bank of the lake, and comprises 630 acres of land which is almost entirely utilised for the production of citrus fruits; vines, mainly doradillos, covering a comparatively small portion of the total area.

The soils of the estate are unusually uniform in general type and area classed chiefly as Tatchera sandy loam with only minor areas of Tyntynder sand. A notable feature of the soils is their high rubble content which is consistently higher than normal in the Tatchera sandy loam. Although no area of heavy soil is defined, some borings revealed a distinctly heavy profile for the Tatchera soil type, and these localized patches are probably more difficult to handle and may form the nuclei of dangerously saline spots in the future.

The classification of Kangaroo Lake soils as Tatchera sandy loam, which occurs so extensively at Tresco, necessarily emphasizes the vulnerability of the estate to the troubles which have overtaken the older settlement. A large number of estimations of chlorides in the soil have been made, and the results are recorded on the soil map[†] as parts of sodium chloride per 100,000 pars of soil. Determinations were made at each foot depth to three feet, and in addition a sample at five to six feet was frequently taken. The following table shows the distribution of soils of different chloride concentrations, and is based on the average content to a depth of 3 feet, as determined in November, 1931.

Sodium Chloride Content in parts per 100,000 of soil	**<20**	**21-30**	**31-40**	**41-50**	**51-74**	**76-100**	**>100**	**Total soils sampled**
Number of borings	24	28	17	12	8	4	7	100

The results show definitely that Kangaroo Lake Estate cannot be considered free from danger from this source, since nearly 50 per cent of the borings disclose a content greater than 30 parts per 100,000. On the other hand, very high concentrations are comparatively few in number, and the absence of any permanent water-table within dangerous limits indicates that little damage has yet been done to the soils, and that, provided due care is taken in subsequent handling, decline of the orange trees should be avoidable. Of the total area of 630 acres, approximately 556 acres contain less than 50 parts, 7 acres 50 to 100 parts, and 67 acres more than 100 parts of sodium Chloride per 100,000 parts of soil. The irrigation runs, which originally were excessively long and at the present time are generally more than the five or six chains considered a safe maximum, have laid the foundation of salt troubles in some blocks; a spray irrigation system has been adopted by a number of growers to overcome the difficulty. Spray systems, being the ideal method of water application, are of particular value in citrus groves where watering problems exert such a marked influence on the health of the trees. The facility with which water may be obtained on the lake frontage blocks and applied at the time when it is required, has brought the method into some favour at Kangaroo Lake despite the higher costs.

[†] For the soil map of the ara see folders at back

5. Goodnight Irrigation Settlement (New South Wales).

The Goodnight Irrigation Trust District is situated on the New South Wales side of the River Murray, 17 miles north of Nyah (Victoria). It was prepared for intensive irrigation purposes after the war, and subdivided into about thirty holdings, comprising in all a developed irrigable area of some 300 acres. The total area controlled by the Trust is 1,364 acres, including a considerable portion of flat unimproved country.

The section on which development has proceeded consists principally of a wide sand ridge on which water for irrigation is pumped from the river through two lifts, and circulated by channel and pipe systems running along the contours from both pump levels. Owing to the sandy nature of the soil at the higher lift, pipe lines and concrete channels were provided for the distribution of the water from this level. However, most of the lower level channels were formerly unlined, and seepage trouble in various parts of the settlement has doubtless been aggravated by leakage from them. Since the formation of the Trust in 1926, a good deal has been done toward improving this system.

Below the lower lift channels, the slopes of the ridge pass into the grey or brown soils of the flats which were timbered in their virgin state with box trees, and on which, up to the present, but little horticultural development has taken place. The ridge itself, which originally carried Murray pine and mallee, is now used almost entirely for horticultural purposes, sultanas being quite the most extensive planting. Oranges, mandarins, and apricots are the principal fruit crops on the remaining planted area.

The Soil Types.

In the irrigated section of the settlement, three soil types were encountered—Murray sand, 377 acres; Vinifera loam, 17 acres; and Nyah clay loam, 128 acres, while the surrounding flat land consists of a grey heavy uniform soil similar to some of the box flat country at Nyah. The distribution of the types is shown in the soil map.*

Soils of the Murray sand type form the bulk of the irrigated land, and are the most productive and satisfactory soils in the settlement. A variant of the normal form was found in Blocks 28 and 29, where heavy rubble was present, in some places right to the surface. The comparatively high fine sand fraction contributes to the good working quality of such a light soil, (vide analysis Appendix Table 1).

The Vinifera loam type is restricted in occurrence to two localities of small extent. In Block 31, it appears as a narrow strip of land in a basin between sandy slopes. These red, heavy-textured soils are not at present very productive. The usual profile, having a loam or clay loam surface and changing to a medium clay in the sub-surface layer, does not allow a ready penetration of water, and causes a shallow root system to develop. It is a common complaint that drying out occurs between irrigations, and as a consequence the fruit is not carried successfully to the ripening stage. On similar soils at Nyah, applications of gypsum have been used with success to overcome this trouble.

Nyah clay loam occurs frequently in a strip below the sand ridge slopes. These soils are rather greyer than the soils of the same type at Nyah and the clay content higher. The productive capacity for vines is generally low, and gypsum applications are necessary before a satisfactory condition in the surface can be obtained. The effect of poor water absorption by the soil is even

* See folders at back

more marked than in the Vinifera type. The lower-lying, unclassified, grey flat soils cover a very small area on the horticultural settlement. The original vegetation included box trees, resembling the box flat formation at Nyah, but the soil profile shows no gypsum bearing layer. It is an unattractive soil for development.

Seepage and Soil Salinity.

The extremely light texture of Murray sand makes overwatering very easy, and while, owing to its good drainage, it is not affected itself and produces high grade fruit, the lower slopes of the hills are liable to show seepage patches, with or without salt accumulations. The trouble has already manifested itself in Blocks 9, 10, 35B, and 36, which have badly seeped patches due to drainage water accumulating in basins. Blocks 2, 3, 10, 12, and 34B provide examples of seepage to lower ground from the first lift channels, although the neighbouring hill ground has probably contributed in these cases.

The lining of the channels above Blocks 12 and 34B should largely check the spread of the affected area. Increased attention to irrigation practice, involving lighter watering in shorter furrows, will alone remove the cause of these troubles.

The difficulties in the heavier soils, unless affected by seepage from adjoining hills, are confined largely to heavy working surface soils and slow penetration of water. It is almost impossible to overwater these soils, in contrast with Murray sand. Texture can be definitely improved with gypsum, which is readily procurable locally, and with green manure crops.

IV. LABORATORY EXAMINATION OF SOILS.

1. Mechanical Analysis.

In physical character the soils from all areas under discussion are essentially similar. They conform to the general nature of soils of the irrigation districts in the Murray Valley, apart from the river flat soils, in their low content of silt (7), (8). The dominant factors determining the properties of these soils are the relation between sand and clay, the nature of the clay complex, and the presence of varying amounts of calcium carbonate.

Detailed results of mechanical analyses, which were carried out according to the International method, are set out in the Appendix. The salient features of the various types are shown by summation curves (Fig. 5) and distribution triangles (Fig. 6 (a) and 6 (b)). Fig. 5 is based on the data of Table 4, average values of all the available figures for each type, including the profiles given by Read (6) being plotted. Curves are shown for surface soil and subsoil of each type, "subsoil" representing weighted averages of all horizons below the surface soil to the maximum depth of sampling, or to 60 inches. The distribution triangles show individual points for surface, sub-surface, and subsoil samples of the various types. "Sub-surface" figures are weighted means for horizons included from below the surface zone to approximately 30 inches, "subsoil" representing underlying soil to a maximum depth of 60 inches.

Comparison of texture of the various types is brought out in the summation curves. The relative heaviness of Nyah clay loam and the gradation through Vinifera loam, Tatchera sandy loam, and Tatchera sand to Tyntynder sand is shown. There is a well-defined concentration of clay in the subsoil, as is usual with soils of this character.

Fig. 6 (*a*) shows the relations between Tatchera sand, Tatchera sandy loam, and Woorinen Type 8[*] from the physical aspect. The distribution of Tatchera sandy loam analyses shows the heavier character of this type and its tendency toward higher silt figures, as compared with Tatchera sand. The figure confirms field impressions that Woorinen Type 8 and Tatchera sandy loam probably conform to the same type.

Fig. 6 (b), which shows the remaining classified soils encountered, supports the field distinction between Tyntynder sand and Murray sand, based on the heavier character of sub-surface soil and subsoil in the former, and expresses the tendency toward a higher silt content in the Vinifera loam.

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[*] Council for Scientific and Industrial Research, Australia. Bulletin 45.

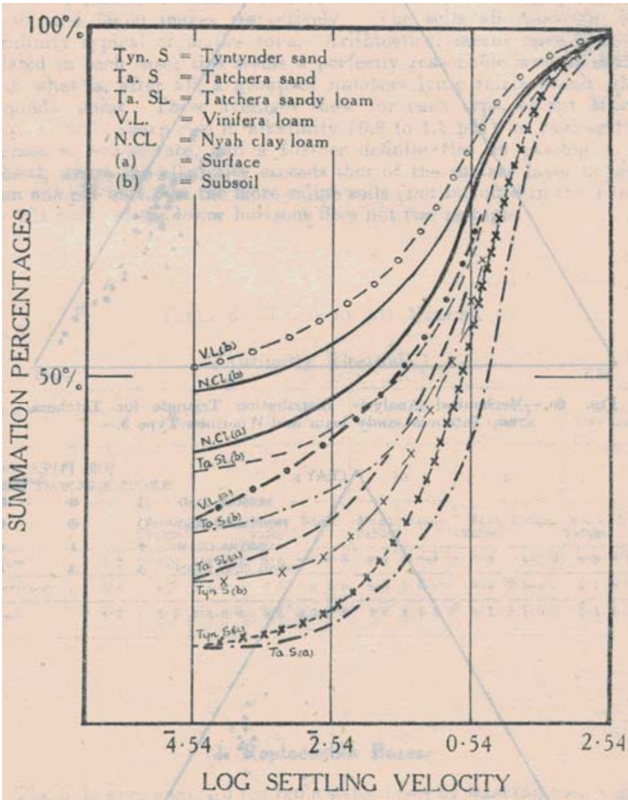

Fig. 5 – Summation Curves illustrating Average Mechanical Analyses of Surface Soils and Subsoils

2. Reaction of Soils.

Table 6 shows the pH values of the various soil types determined in soil-water suspensions (1:2.5) by means of the antimony electrode method described by Best (1). Potentiometer readings were taken while the suspension was stirred with the electrode. The horizons named surface, sub-surface, and subsoil, correspond roughly to 0-10, 10-30, and 30-60 inches respectively. The soils all show the high alkalinity typical of mallee soils. Arithmetical means have been calculated in each case; this seems a perfectly reasonable way of dealing with what is, after all a group of numbers lying fairly evenly about a middle point. These averages show for each type, except Murray sand, a fairly sharp rise in alkalinity (0.6 to 1.1 pH) on passing from surface to sub-surface, and a further definite rise on passing to the subsoil, where the alkalinity exceeds that of the surface layer by more than one pH unit. In the more saline soils (not included in the Table), the pH value of the lower horizons does not rise as high.

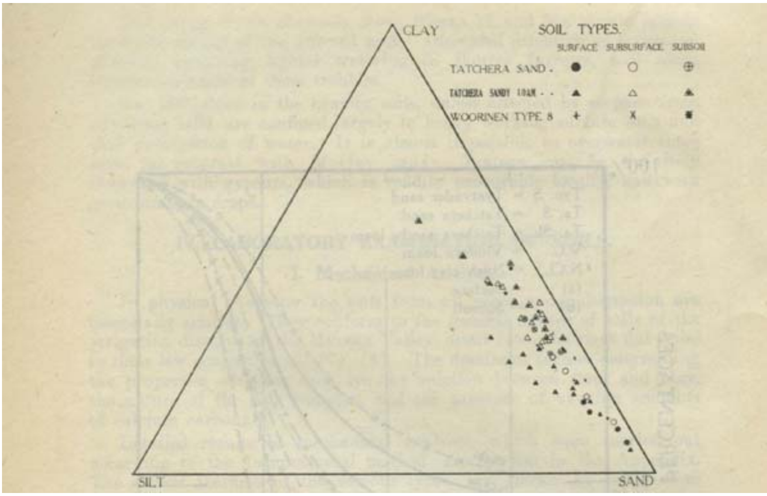

Figure 6a – Mechanical Analysis Distribution Triangle for Tatchera sand, Tatchera sandy loam and Woorinen Type 8

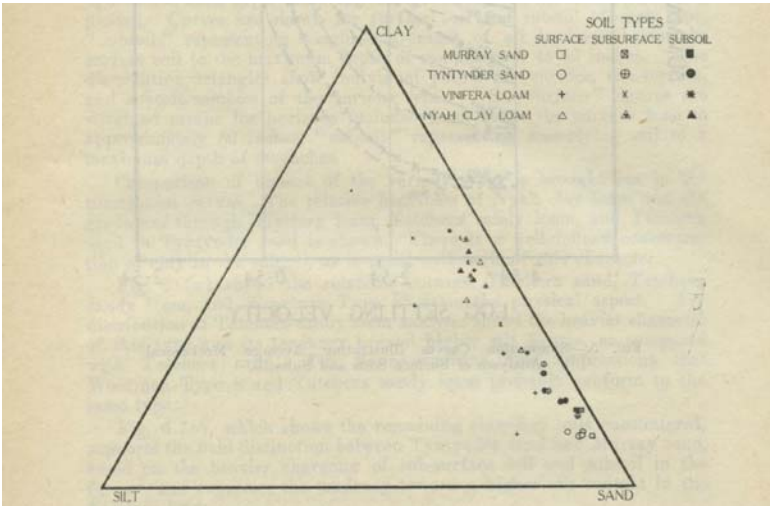

Figure 6b – Mechanical Analysis Distribution Triangle for Murray sand, Tyntynder sand, Vinifera loam, and Nyah clay loam

TABLE 6.—TABLE OF pH VALUES.

(Antimony Electrode.)

Soil Type	Murray Sand	Tyntynder sand		Tatchera sand		Tatchera sandy loam		Vinifera loam		Nyah clay loam	
Number of sample	**1**	**3**		**4**		**10**		**4**		**3**	
		Mean Value	**Range**	**Mean Value**	**Range**	**Mean Value**	**Range**	**Mean Value**	**Range**	**Mean Value**	**Range**
Surface	8.2	8.0	7.4-8.5	8.4	8.1-8.8	8.2	7.3-8.7	7.6	7.4-7.9	8.3	8.0-8.9
Subsurface	8.4	8.9	8.5-9.2	9.0	8.4-9.5	8.8	7.9-9.5	8.7	7.9-9.1	9.1	8.9-9.5
Subsoil	8.7	9.2	8.6-9.9	9.5	9.0-9.8	9.4	8.9-9.9	9.1	8.2-9.5	9.4	9.2-9.6

3. Replaceable Bases.

The soils were analysed for replaceable bases by leaching with sodium chloride and ammonium chloride, according to standard methods (3). The results are shown in Table 7. The proportions of the four chief cations are very similar for the various soil types, with the exception of one Nyah sample, which is not quite typical. In general, there is a predominance of calcium, or of calcium and magnesium, in the surface soil, and of sodium and magnesium, with low calcium, in the subsoil. This change is correlated with the considerably higher pH values of the subsoils and their impermeability, which is greater than is accounted for by increase in clay content alone. These results, and the values of total exchangeable bases, are similar to those found previously at Tresco (6), and at Woorinen (8).

4. Chemical Analyses.

Nitrogen.

Table 8 shows the total nitrogen content of surface samples of the various types. The values lie around a mean of about 0.06 per cent., rising above 0.1 per cent in only two of the 26 samples analysed. These figures are of the same order as those found on similar soils at Woorinen, and are in the normal range for soils under these climatic conditions.

TABLE 8.—DISTRIBUTION TABLE OF NITROGEN IN SURFACE SOILS.

Nitrogen %	0.021-0.040	0.041-0.060	0.061-0.080	0.081-0.100	0.101-0.120
Tyntynder sand	..	2	1	..	..
Tatchera sand	..	3	2	1	..
Tatchera sandy loam	1	3	4	2	2
Vinifera loam	1	1	1	..	..
Nyah clay loam	..	1	1	..	..

TABLE 7.-REPLACEABLE BASES IN SOIL TYPES.

Soil Type.	Location.	Sample No.	Depth Inches.	Field Description.	pH.	Clay. %	Total Replaceable Bases mg. eq. %	Percentages of Total Bases.			
								Ca.	Mg.	Na.	K.
Tyntynder sand	Tresco West	T 13 A	0–14	SL	8·5	10	11·6	48	41	6	5
		T 13 B	14–30	CS	9·2	13	8·9	31	47	14	8
		T 13 C	30–48	SCL	9·7	14	9·0	29	39	22	10
		T 13 D	48–72	SCL	10·0	17	8·8	13	32	42	13
Tatchera sand	Tresco	T 1 B	9–16	SL	9·2	23	14·2	49	34	10	7
		T 1 C	16–28	L	9·6	25	11·8	40	46	8	6
		T 1 D	28–50	SCL	9·7	25	10·4	18	33	41	8
	Nyah	526/31/26	0–5	SL	8·1	12	14·5	57	18	5	20
		526/31/29	36–66	CL	9·5	21	15·3	23	24	42	11
Tatchera sandy loam	Tresco	T 4 B	10–24	SCL	8·6	25	16·3	43	44	9	4
		T 4 C	24–40	CL	9·6	27	13·3	27	47	20	6
		T 4 D	40–63	LC	9·7	29	13·2	16	48	26	10
	Tresco	T 7 A	0–10	SL	8·6	16	11·5	28	37	25	10
		T 7 B	10–36	SCL	8·8	22	10·2	41	42	10	7
		T 7 C	36–60	SC	9·6	23	12·3	21	51	22	6
		T 7 D	60–72	SCL	9·7	21	9·1	20	35	36	9
	Nyah	526/31/22	0–10	SL	8·1	15	14·9	65	18	8	9
	Nyah	526/31/30	0–6	SL	8·2	20	23·8	70	17	5	8
	Nyah	526/31/9	0–12	S	7·3	5	7·2	56	33	..	11
	Nyah	526/31/32	26–45	CL–LC	8·6	44	36·3	18	56	21	5
	Nyah	526/31/24	34–48	CL–LC	8·8	21	18·7	21	38	34	7
	Nyah	526/31/4	36–64	LC	9·9	23	14·4	18	36	35	11
	Nyah	526/31/55	40–66	LC	9·7	23	15·3	17	31	43	9
	Kangaroo Lake	637/31/2	10–26	CL–LC	8·9	30	22·6	43	34	19	4
		637/31/3	26–40	CL–LC	9·5	34	25·3	13	40	42	5
	Kangaroo Lake	637/31/8	24–45	CL–LC	9·1	30	17·5	20	40	32	8
Vinifera loam	Nyah	526/31/13	0–6	CL	7·6	19	16·6	60	30	3	7
	Nyah	526/31/18	0–8	CL	7·5	37	28·3	72	20	1	7
		526/31/19	8–24	MC	7·9	50	34·1	71	20	4	5
Nyah clay loam	Nyah	526/31/34	0–6	L	8·0	29	20·4	68	23	2	7
	Nyah	526/31/38	0–10	CL	8·9	35	27·9	38	31	26	5
	Nyah	526/31/36	13–27	MC	9·2	37	25·8	28	38	28	6
Unclassified	Nyah	526/31/42	8–38	MC	8·8	56	39·8	34	27	34	5

Abbreviation of field description in column 5: S = Sand; CS = Clayey sand; SL = Sandy loam; L = Loam; SCL = Sandy clay loam; CL = Clay loam; LC = Light clay; MC = Medium clay.

Hydrochloric Acid Extract.

There is no unusual feature in the results of analyses of hydrochloric acid extracts of these soils. Table 9 presents the information obtained on the present surveys, and includes figures for two Tresco profiles given by Read (6). Phosphoric acid is definitely low, the highest value obtained being 0.1 per cent. Potash is present in ample quantity, the replaceable base figures indicating that a reasonable proportion of the total potash is in a relatively available form. Lime and magnesia are high in general, and vary very considerably in accordance with variations in carbonate concentration of these constituents. Results of chemical analyses of similar soils at Woorinen are comparable with those listed in Table 9.

Soluble Salts.

Figures for total soluble salts and for chlorine are listed with the mechanical analyses in the Appendix. "Chlorine" represents chlorine in the form of chloride. Except for special samples which were taken from areas known to be saline, the total soluble salts from all areas sampled were relatively low, and chlorine seldom rose to 20 parts per 100,000 of soil. The distribution of chlorine in salty areas has been discussed in a previous section. As in the case of Woorinen soils, chloride was the dominant acid radicle in the soils containing the higher amounts of total salts, but in the general case, bicarbonate formed the bulk of the soluble salt. This is shown in Table 10, which presents detailed analyses for soluble salts of certain typical samples. Carbonates, calcium, and magnesium were of little importance, the analyses indicating that sodium bicarbonate in most cases, and sodium chloride in those with high total salt figures, constituted the bulk of the soluble material. Sulphate was of importance in certain Nyah soils, reaching 0.08 per cent in one saline soil, while in Tresco soils it was of relatively low magnitude, exceeding 0.01 per cent in only one case.

TABLE 9.—CHEMICAL ANALYSIS OF SOILS.

(Figures represent percentages of air-dry soil.)

Soil Type	Location	Sample No.	Depth in inches	P_2O_5	K_2O	CaO	MgO
				%	%	%	%
Tatchera sand	Nyah	526/31/26	0-5	0.08	0.53	3.59	0.47
Tatchera sandy loam	Nyah	526/31/9	0-12	0.03	0.13	0.16	0.12
	Nyah	526/31/22	0-10	0.10	0.42	2.86	0.62
	Nyah	526/31/30	0-6	0.05	0.61	9.53	0.64
	Nyah	526/31/4	36-64	0.01	0.62	14.21	0.93
	Kangaroo Lake	637/31/1	0-10	0.04	0.90	5.62	1.04
		637/31/2	10-26	0.05	1.66	11.45	2.10
		637/31/6	0-12	0.05	0.92	3.00	0.66
	Tresco	273/27/1	0-6	0.06	0.68	3.78	0.73
		273/27/2	6-24	0.04	0.75	8.24	1.21
		273/27/3	24-48	0.03	1.46	9.50	2.56
Tyntynder sand	Kangaroo Lake	637/31/10	0-12	0.03	0.47	0.90	0.32
	Tresco	273/27/4	0-6	0.06	0.58	0.51	0.43
		273/27/5	6-24	0.05	1.62	3.15	0.63
		273/27/6	24-48	0.04	0.54	9.22	1.61
Vinifera loam	Nyah	526/31/13	0-6	0.08	0.35	0.40	0.48
		526/32/18	0-8	0.07	0.67	0.82	0.77
		523/31/19	8-24	0.04	0.61	2.29	0.73
Nyah clay loam	Nyah	526/31/34	0-6	0.10	0.70	0.99	0.63
		526/31/38	0-10	0.08	1.00	6.12	1.37
Grey gypsum soil (unclassified)	Nyah	526/31/41	0-8	0.03	1.18	0.62	0.79

TABLE 10 – ANALYSES OF SOLUBLE SALTS (EXPRESSED AS PARTS PER 100,000 OF AIR-DRY SOIL)

Soil Type	Location	Sample No.	Depth in inches	Total So. Salts	Cl	SO_4	HCO_3	CO_3	Na	K	Ca	Mg
Tyntynder sand	Tresco West	T 13 B	14 -30	100	19	10	54	0	24	9	Nd	nd
		C	30-48	130	14	6	79	2	28	7	6	2
		D	48-72	150	8	Nd	124	4	46	3	4	2
Tatchera sand	Tresco	T 2 B	9-15	122	14	6	54	0	30	8	9	1
		C	15-33	123	26	10	54	0	35	13	Nd	Nd
		D	33-52	180	34	4	83	2	38	14	4	1
		E	52-72	188	17	4	110	4	40	7	3	1
	Nyah	526/31/28	16-36	95	6	12	41	0	nd	nd	7	6
Tatchera sandy loam	Tresco	T 4 A	0-10	140	20	20	43	0	nd	nd	18	2
		B	10-24	111	12	Nd	57	1	nd	nd	11	2
		C	24-40	150	11	5	91	3	31	10	4	1
		D	40-63	152	10	4	112	7	43	11	6	1
	Nyah	526/31/1	0-10	125	5	17	64	0	nd	nd	5	4
		526/31//2	10-16	140	17	42	40	0	nd	nd	7	4
	Nyah	526/31/24	34-48	110	8	14	56	0	nd	nd	4	5
	Kangaroo Lake	637/31/7	12-24	230	26	15	37	0	nd	nd	21	8
Nyah clay loam	Nyah	526/31/40	24-36	255	31	37	120	5	nd	nd	1	2
	Nyah	526/31/44	0-8	175	29	20	76	0	nd	nd	2	4
		526/31/45	8-30	360	94	61	88	0	nd	nd	4	3
		526/31/46	30-50	430	124	76	93	0	nd	nd	3	4
Vinifera loam	Nyah	526/31/47	0-5	105	11	10	43	0	nd	nd	9	5
	Nyah	526/31/51	54-76	165	23	30	44	0	nd	nd	2	2
Unclassified	Nyah	526/31/42	8-38	195	36	26	84	0	nd	nd	1	2

V. GENERAL DISCUSSION OF SOIL PROBLEMS.

In summarizing the findings of the soil survey of the five settlements dealt with in this Bulletin, the discussion of the present situation and future improvement is viewed from the following aspects :— (*a*) the horticultural position, (*b*) climatic influence, (*c*) improvement of soils and increase in yields; (*d*) irrigation and drainage problems, and (*e*) soil salinity.

(*a*) *The Horticultural Position*.—The stability of the industry depends on the quantity and quality of the fruit grown. These features require investigation in the light of soil variations, soil improvement, and suitability of specific crops to certain soils. Descriptions have been given of six soil types which cover a wide range in texture, lime content, and permeability to water. Their locations vary from valley bottoms to ridge slopes, through an elevation range of 40 feet. All these factors —physical, chemical, and topographical— point to the need for different treatments and selection of crops. Assuming normal cases, the descending order of cropping value of the soils for a crop which can be grown satisfactorily on all, such as sultanas, is Murray sand, Tyntynder sand, Tatchera sand, Tatchera sandy loam, Vinifera loam, and Nyah clay loam, the four latter following in close sequence. The first and second are very suitable for citrus-growing, the fifth and sixth definitely unsuitable. The Tatchera types offer an interesting problem, as, while they indicate by topographical position and surface a satisfactory soil for citrus, the general opinion of horticulturists is to the contrary. A study of their field characteristics, and the laboratory examination of samples, seem to show that, in a majority of cases, there is not a serious danger of water-logging and salt troubles arising if irrigation and drainage practice is good, and that the adverse judgment is due, at least in part, to a lack of appreciation of the primary irrigation requirements of the soil in the early years of planting. The saline phase of Tatchera sandy loam on the lower ground at Tresco was initially a hopeless case whatever the methods used, as there was undoubtedly a highly saline subsoil influencing the root zone almost from the first irrigation. On the higher ground, the issue is complicated by the introduction of the citrus nematode as a pathological controlling factor, the importance of which has not been gauged. Murray sand and Tyntynder sand have shown themselves well suited to citrus-growing, even though on some occasions a large amount of lime rubble may be present.

Nyah clay loam and Vinifera loam have given moderately high yields of sultanas, and are even said to be superior in this regard to the Tatchera type at Nyah. All the soil types will grow vines if treated properly, but the proportion of lower grades of fruit is too great. Other factors besides the soil are partly responsible for this result, mainly adverse climatic conditions in the drying season and the incidence of disease.

(*b*) *Climatic Influence*.— This factor requires stressing, in view of the later maturing of fruit and the uncertainty of satisfactory harvesting weather, compared with conditions at Mildura. In consequence, unless some means of hastening maturity is found, or sufficient drying space is made available for handling the crop quickly, there is not a great hope of improving the average quality of the dried-fruit pack, and the prospect diminishes with the more easterly settlements. Recent developments in dehydrator construction in the Woorinen-Nyah district provide partial insurance against the effects of unfavorable harvest weather.

(*c*) *Improvement of Soil Types*.— The weight of evidence from analyses of samples tends to show that the soils themselves, excluding saline areas, are not necessarily inferior to those of other settlements yielding better returns. The average productive capacity of the Tatchera soil type for sultanas appears lower than might be expected, and it is considered that a more efficient cultivation practice, including thorough ploughing in the late winter, the growing of green manure crops annually in alternate rows, the use of adequate dressings of fertilizers, especially phosphates, and, if necessary, nitrogen and potash, would increase profitably the production of dried fruit. Nitrogen is essential if there is weakness in cane growth or in foliage production, and potash, despite the high total content in the soil, may effect an improvement in quality, and should, therefore, be tried experimentally. On the heavier soils, moderate to heavy dressings of gypsum are necessary to facilitate tillage and irrigation operations.

(*d*) *Irrigation and Drainage Problems* — It has been shown in practice that the lighter soils, as the Murray, Tyntynder, and Tatchera types, are liable to over-watering. The first and second, with very good under-drainage, do not suffer themselves, but tend to cause seepage patches on lower levels, especially on the boundary of heavier adjoining soils. Examples may be seen on the Good-night and Nyah settlements. Artificial drainage is not required on these soils, but they do need cautious irrigation if neighbouring blocks are likely to be affected. Drainage measures are also unnecessary on the Vinifera and Nyah soil types, and the difficulty with them is rather to secure sufficient penetration of the water to avoid drought effects in hot, dry seasons.

Irrigation on the Tatchera type is very liable to produce a water table, and in course of time frequently salt trouble also. Careful irrigation practice, involving short runs, a good head of water in the head ditch, quick and relatively light watering by multi-furrow, semi-or border-flooding methods, materially assists in preventing this condition. Read has shown that the heaviest irrigation required, 6 acre inches, can be applied effectively on Tatchera sandy loam by border flooding in three hours. In combination with a shallow drainage system, such methods obviate excessive accumulation of water and salt. Probably 5 acre inches would be ample at any one time. The policy of reducing amounts applied, and if necessary increasing in certain seasons the number of irrigations, is worthy of consideration.

The depth of the tile drains in the drainage system employed generally at Tresco and Nyah varied between 3 feet and 6 feet, and while the latter figure may be adequate, if uneconomical, under some conditions for free watering soils, the shallow depth is preferable in the majority of cases. On no account should the tiles be laid in the less permeable layer of the clay subsoil, a feature which may be overlooked in laying at some arbitrary standard depth, irrespective of the nature of the soil. Drainage is designed to remove excess water and salt, and as both are likely to be present in Tresco soils in serious amounts, a proper functioning of the drains is essential in the Tatchera soil types.

Laboratory studies of the soil-water relations of small samples of soil showed that in some cases blocks of soil, when allowed to absorb water freely from below, reached a waterlogged condition and developed a glazed surface appearance- These blocks on draining lost water very slowly, and in one case remained in the liquid mud stage. Two out of six samples of Tatchera sand, and three out of five samples of Tatchera sandy loam, behaved abnormally in this way. These are typical cases of the slow-draining subsoils which are very liable to cause temporary water tables to develop, and in the field can usually be recognized by the glazed appearance of the soil in the furrow after an irrigation. Such cases would probably show a more or less hard, cloddy condition on drying, and require careful handling; they would benefit considerably by gypsum applications.

(*e*) *Soil Salinity*.— The productivity of all the settlements under discussion has been lowered to some extent by excessive salt accumulations in the soil. It is considered that the saline areas on all settlements can be confined to the present limits, and that there is no reason to expect any extension but rather restriction if sound irrigation practice is followed. Read (6) found in unirrigated sand ridges at Tresco a high concentration of chlorides in the deep subsoil below 5 or 6 feet, although no water-table was encountered in 20 feet. It is easy to picture a steady and dangerous increase in salinity in the soil closer to the surface with the establishment of a water-table, as undoubtedly occurred in the past at Tresco with heavy irrigation. This is naturally intensified if saline water is applied. The salt problem is clear cut on the settlements themselves; the next question is the relationship of soil salinity to the development of further irrigable land. It is fairly certain that no unavoidable danger attaches to the irrigation of the higher country in the Murray Valley between Swan Hill and Goodnight, but the matter is more obscure south-east of Lake Boga. For this district, evidence has been presented to show a significantly high salt content at shallow depths in the lower land, and at greater depths in the rising ground. The salinity of the water in the extensive lake system in this area prior to the introduction of the water circulation scheme demonstrates the considerable movement of water and salt in the Tresco district, the lakes acting as natural foci for surface and sub-drainage waters. It is concluded that the nature of this country is against horticultural development, and that the ridge slopes offer the only possible areas for experiment, with close attention to irrigation and drainage requirements. The uncertainty of dried fruit production under the adverse climatic conditions, and the susceptibility of citrus to salt injury and water-logging, emphasize the conclusion that it is not advisable to develop further the red sandy soils of this district.

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APPENDIX

TABLE 1 – MECHANICAL ANALYSES OF TYNTYNDER SAND AND MURRAY SAND PROFILES

Soil Type.	Tyntynder Sand.											Murray Sand.		
Location.	Tresco West.				Nyah.			Kangaroo Lake.				Goodnight.		
Sample No.	T13 A.	B.	C.	D.	526/31/6.	7.	8.	637/31/10.	11.	12.	13.	2405.	2406.	2407.
Depth, Inch.	0–14.	14–30.	30–48.	48–72.	0–6.	6–36.	36–60.	0–12.	12–21.	21–42.	42–60.	0–24.	24–42.	42–72.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	40·6	22·8	26·2	36·6	48·5	35·7	45·5	46·7	40·0	29·1	31·6	32·9	26·0	28·8
Fine sand	27·7	23·4	22·0	26·0	35·8	23·4	29·8	33·0	36·6	32·4	32·8	51·7	47·6	43·7
Silt	5·2	3·5	6·0	3·4	3·5	2·9	3·3	4·5	2·5	2·1	3·6	1·9	1·8	1·6
Clay	9·9	12·9	13·8	17·5	11·6	22·2	17·7	10·2	10·8	12·7	15·6	10·8	14·2	14·0
Loss on acid treatment ..	13·1	33·4	30·6	11·6	0·7	16·5	4·3	2·0	7·6	21·2	15·2	0·5	9·3	10·6
Loss on ignition	8·6	16·7	15·6	7·1	2·3	9·8	3·9	3·7	5·1	11·7	8·7	2·0	5·7	6·0
$CaCO_3$ (fine earth) ..	11·5	28·0	24·6	11·3	0·0	14·7	3·7	1·1	7·4	19·1	13·2	n.d.	8·3	10·4
$CaCO_3$ rubble (field sample)	9	20	9	1	..	..	4	..	..	6	12	..	..	..
Total salts	0·08	0·10	0·13	0·15	0·07	0·11	0·11	0·08	0·08	0·08	0·08	0·04	0·05	0·04
Chlorine	0·010	0·019	0·014	0·008	0·004	0·003	0·003	0·008	0·005	0·010	0·009	0·005	0·010	0·005
pH	8·5	9·2	9·7	10·0	7·4	8·9	9·2	8·0	8·3	8·5	8·6	8·2	8·4	8·7

TABLE 2 – MECHANICAL ANALYSES OF TATCHERA SAND PROFILES

Location.	Tresco.					Tresco.					Nyah.			
Sample No.	T1 A.	B.	C.	D.	E.	T2 A.	B.	C.	D.	E.	526/31/26.	27.	28.	29.
Depth, Inch.	0–9.	9–16.	16–28.	28–50.	50–72.	0–9.	9–15.	15–33.	33–52.	52–72.	0–5.	5–16.	16–36.	36–66.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	55·7	44·0	31·2	22·7	22·3	72·7	59·6	41·3	25·0	23·1	45·0	35·4	33·3	32·7
Fine sand	17·9	15·5	16·3	15·6	15·4	14·4	23·4	17·5	13·4	13·2	28·8	24·5	17·8	18·6
Silt	5·5	5·9	6·8	4·7	7·9	1·9	2·1	4·4	6·3	9·7	5·3	4·8	3·0	3·6
Clay	15·0	22·8	25·3	24·6	25·1	6·6	10·6	25·6	24·5	16·2	12·4	19·2	19·8	20·5
Loss on acid treatment ..	1·8	6·3	16·1	28·7	29·1	0·5	1·0	5·8	27·4	31·4	7·5	16·6	25·4	24·4
Loss on ignition	3·8	5·4	9·6	15·2	16·0	2·2	2·0	5·4	14·8	17·7	6·2	9·5	12·8	12·9
$CaCO_3$ (fine earth)	0·6	4·5	13·6	25·1	26·5	0·2	0·3	4·4	24·7	29·0	5·6	13·5	22·2	21·4
$CaCO_3$ rubble (field sample) ..	..	1	5	6	5	..	..	3	9	21	..	..	..	5
Total salts	0·08	0·09	0·14	0·17	0·43	0·07	0·12	0·12	0·18	0·19	0·09	0·10	0·10	0·11
Chlorine	0·002	0·002	0·007	0·020	0·174	0·005	0·014	0·026	0·034	0·017	0·005	0·007	0·012	0·007
pH	8·6	9·2	9·6	9·7	9·9	8·8	9·0	9·1	9·4	9·7	8·1	8·3	8·4	9·5

TABLE 3 – MECHANICAL ANALYSES OF TATCHERA SANDY LOAM PROFILES

Location	Nyah.					Nyah.				Nyah.			
Sample No.	526/31/1.	2.	3.	4.	5.	526/31/9.	10.	11.	12.	526/31/22.	23.	24.	25.
Depth, Inch	0–10.	10–16.	16–36.	36–64.	64–84.	0–12.	12–33.	33–60.	60–93.	0–10.	10–33.	33–48.	48–68.
	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	39·2	31·9	27·4	27·3	33·1	61·1	28·0	35·0	26·0	40·6	24·2	24·0	27·5
Fine sand	24·2	23·5	18·6	17·1	19·5	30·6	19·6	25·6	18·2	33·4	22·7	20·0	22·6
Silt	5·4	5·7	3·8	3·4	3·6	2·1	8·8	3·7	3·5	4·1	4·8	4·3	4·0
Clay	15·8	16·9	21·0	22·9	25·6	4·9	41·2	33·7	26·6	14·8	21·6	20·9	22·8
Loss on acid treatment	12·0	20·1	28·7	27·7	16·2	0·6	2·2	2·9	25·5	6·4	24·2	31·0	22·3
Loss on ignition	9·0	11·9	15·1	14·8	10·0	1·7	5·3	4·0	13·4	5·4	13·4	16·2	16·2
$CaCO_3$ (fine earth)	10·5	17·6	26·8	25·5	12·3	0·0	1·2	1·9	23·6	4·4	22·5	28·8	20·8
$CaCO_3$ rubble (field sample)	..	3	10	11	6	..	..	3	7	..	3	2	2
Total salts	0·13	0·14	0·15	0·16	0·17	0·06	0·15	0·13	0·13	0·08	0·09	0·11	0·10
Chlorine	0·005	0·020	0·020	0·013	0·009	0·004	0·006	0·004	0·005	0·002	0·007	0·012	0·006
pH	8·6	8·6	9·5	9·9	10·0	7·3	9·0	9·2	9·3	8·1	8·5	8·8	9·1

TABLE 3 (*continued*) – MECHANICAL ANALYSES OF TATCHERA SANDY LOAM PROFILES

Location	Nyah.				Nyah.				Kangaroo Lake.				
Sample No.	526/31/30.	31.	32.	33.	526/31/52.	53.	54.	55.	637/31/1.	2.	3.	4.	5.
Depth, Inch	0–6.	6–26.	26–45.	45–66.	0–10.	10–17.	17–40.	40–66.	0–10.	10–26.	26–40.	40–56.	56–75.
	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	22·9	13·1	10·0	9·2	48·5	34·1	28·4	31·1	23·0	17·8	12·2	12·3	12·8
Fine sand	24·2	15·9	13·7	12·9	32·1	19·6	18·2	21·8	22·1	18·6	16·4	21·4	22·7
Silt	12·4	6·4	14·0	15·3	3·9	12·4	2·9	2·3	13·9	5·9	8·2	11·3	10·2
Clay	19·7	26·4	44·2	53·4	12·6	27·9	27·7	23·4	25·6	30·4	34·1	43·2	49·2
Loss on acid treatment ..	18·3	37·9	17·1	8·2	1·6	4·3	22·1	20·1	13·0	25·3	25·8	8·5	2·3
Loss on ignition	12·7	20·0	12·7	9·8	3·0	5·8	12·3	11·0	10·5	14·6	14·3	8·9	6·5
$CaCO_3$ (fine earth)	15·0	35·2	15·2	5·8	0·3	2·8	20·5	18·0	9·5	22·4	24·3	8·7	2·1
$CaCO_3$ rubble (field sample) ..	3	17	7	..	..	..	11	7	3	26	20	6	..
Total salts	0·08	0·09	0·10	0·13	0·07	0·11	0·16	0·16	0·09	0·09	0·12	0·15	0·15
Chlorine	0·005	0·009	0·006	0·006	0·006	0·006	0·010	0·011	0·010	0·007	0·006	0·007	0·006
pH	8·2	8·4	8·6	9·1	8·0	8·7	9·5	9·7	8·3	8·9	9·5	9·6	9·6

TABLE 3 (*continued*) – MECHANICAL ANALYSES OF TATCHERA SANDY LOAM PROFILES

Location	Tresco.				Tresco.				Kangaroo Lake.			
Sample No.	T4 A.	B.	C.	D.	T7 A.	B.	C.	D.	637/31/6.	7.	8.	9.
Depth, Inch	0–10.	10–24.	24–40.	40–63.	0–10.	10–36.	36–60.	60–72.	0–12.	12–24.	24–45.	45–60.
	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	38·6	26·9	21·0	20·1	47·8	33·8	40·8	45·0	26·7	17·5	20·9	25·0
Fine sand	19·9	14·3	13·8	14·8	19·2	13·8	16·5	21·2	31·9	23·2	24·6	25·2
Silt	11·2	5·8	3·8	3·0	5·8	3·6	3·4	3·1	7·8	4·7	4·4	4·2
Clay	17·5	25·2	27·5	29·2	15·9	22·0	22·8	21·2	25·4	22·8	30·0	32·2
Loss on acid treatment	7·7	22·2	29·2	26·4	8·4	24·0	10·8	3·5	5·6	28·3	17·9	10·9
Loss on ignition	7·2	12·6	15·6	14·7	6·9	12·4	7·4	2·9	7·7	16·1	11·5	8·1
$CaCO_3$ (fine earth)	5·4	14·2	28·5	24·9	6·1	21·4	9·6	1·8	3·7	27·0	17·4	10·6
$CaCO_3$ rubble (field sample)	2	10	4	8	..	10	6	2	..	47	24	19
Total salts	0·14	0·11	0·15	0·15	0·08	0·09	0·14	*	0·19	0·23	0·14	0·15
Chlorine	0·020	0·012	0·011	0·010	0·003	0·013	0·016	0·009	0·028	0·031	0·011	0·010
pH	8·3	8·7	9·6	9·7	8·6	8·8	9·6	9·7	7·7	7·9	9·1	9·5

* Clear filtrate not obtainable.

TABLE 4 – MECHANICAL ANAYSES OF TATCHERA SAND, TATCHERA SANDY LOAM AND UNCLASSIFIED SOIL PROFILES

Soil Type	Tatchera Sand.			Tatchera Sandy Loam.			Unclassified.		
Location	Tresco.			Tresco West.			Nyah.		
Sample No.	T5 A.	B.	C.	T14 A.	B.	C.	526/31/41.	42.	43.
Depth, Inch	0–14.	14–24.	24–42.	0–10.	10–20.	20–40.	0–8.	8–38.	38–50.
	%	%	%	%	%	%	%	%	%
Coarse sand	64·6	47·5	39·2	39·6	30·7	27·9	11·4	11·3	12·3
Fine sand	20·6	28·5	24·0	13·0	12·8	11·2	20·1	16·9	18·6
Silt	2·4	4·2	6·4	10·4	6·4	5·5	9·6	7·7	5·9
Clay	8·8	16·5	24·8	19·6	21·6	27·6	53·2	55·7	45·5
Loss on acid treatment	0·8	0·9	1·5	9·6	20·6	22·5	3·0	7·1	12·7
Loss on ignition	2·4	3·0	3·9	8·6	12·7	13·4	6·4	8·3	8·3
$CaCO_3$ (fine earth)	0·0	0·1	0·2	5·1	17·5	19·2	0·3	4·9	6·0
$CaCO_3$ rubble (field sample) ..	..	..	..	2	27	8	..	..	..
Total salts	0·07	0·09	0·09	3·20	2·40	2·80	0·10	0·20	1·80*
Chlorine	0·005	0·008	0·10	1·45	1·15	1·17	0·006	0·040	0·121
pH	8·2	9·0	9·0	7·7	8·0	n.d.	8·5	8·8	8·5

* Contains 1·42 per cent. gypsum.

TABLE 5 – MECHANICAL ANALYSES OF VINIFER LOAM PROFILES

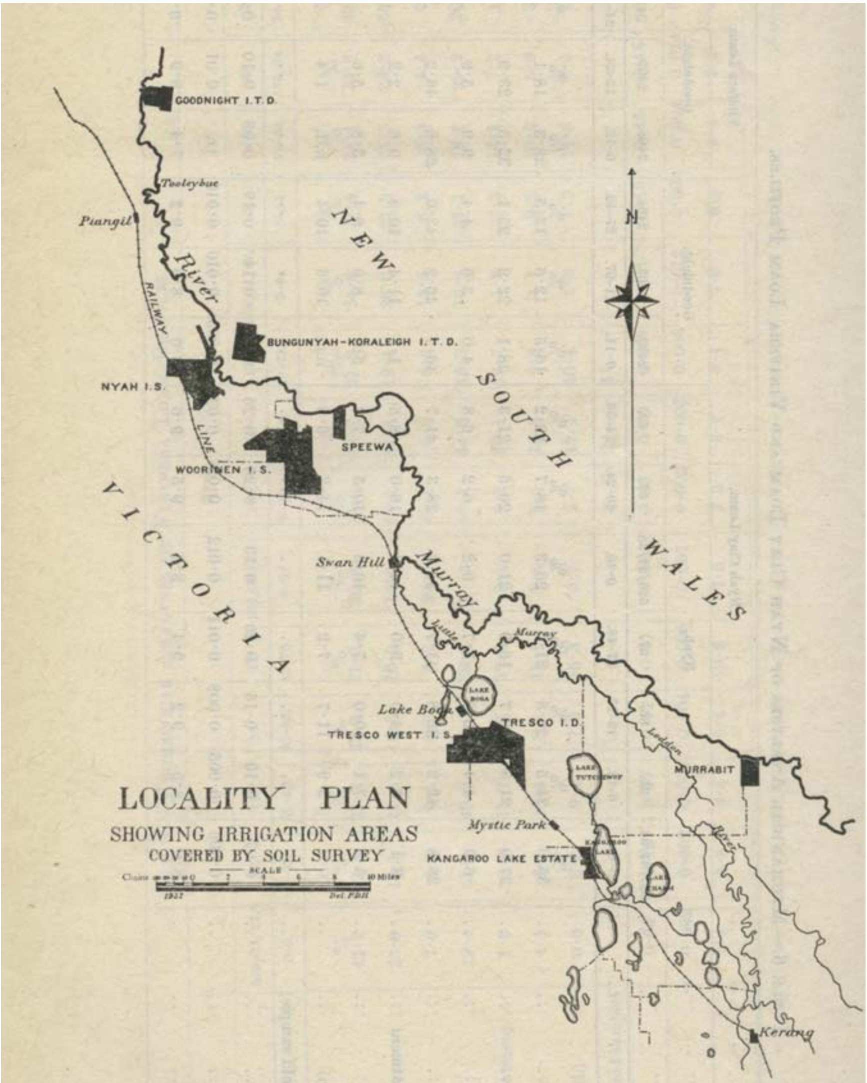
Location ..	Nyah.													
Sample No. ..	526/31/13.	14.	15.	16.	17.	526/31/18.	19.	20.	21.	526/31/47.	48.	49.	50.	51.
Depth, Inch ..	0–6.	6–21.	21–40.	40–48.	48–75.	0–8.	8–24.	24–50.	50–72.	0–5.	5–14.	14–34.	34–54.	54–76.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand ..	42·7	22·5	21·7	23·3	21·9	20·8	16·0	16·9	21·8	34·6	27·4	24·1	33·8	40·5
Fine sand ..	25·9	16·1	17·5	19·5	16·9	15·9	13·1	11·8	12·4	36·0	23·3	25·5	25·2	25·1
Silt ..	7·9	4·8	6·1	6·2	4·7	20·1	13·1	6·5	4·2	15·8	8·2	5·3	4·4	6·2
Clay ..	19·4	51·9	40·8	41·0	38·9	37·2	50·1	44·6	48·2	10·8	37·1	28·2	29·2	26·7
Loss on acid treatment ..	1·2	5·0	13·7	9·7	17·0	3·1	5·3	20·1	12·7	1·8	3·3	16·1	7·2	1·2
Loss on ignition ..	4·1	8·1	10·4	8·2	11·1	7·6	8·5	12·8	9·8	4·1	6·2	10·2	5·9	3·4
$CaCO_3$ (fine earth) ..	0·0	2·8	9·4	7·9	15·3	0·1	2·7	17·4	10·4	1·8	1·3	14·3	6·1	1·0
$CaCO_3$ rubble (field sample)	..	..	..	..	4	..	3	22	11	..	..	..	..	..
Total salts ..	0·06	0·13	0·17	0·17	0·17	0·08	0·08	0·09	0·09	0·11	0·10	0·15	0·18	0·17
Chlorine ..	0·002	0·002	0·007	0·004	0·006	0·007	0·005	0·003	0·008	0·012	0·005	0·004	0·014	0·030
pH ..	7·6	8·8	9·4	9·4	9·6	7·5	7·9	8·2	8·1	7·9	8·4	9·4	9·5	8·2

TABLE 6 – MECHANICAL ANALYSES OF NYAH CLAY LOAM AND VINIFERA LOAM PROFILES

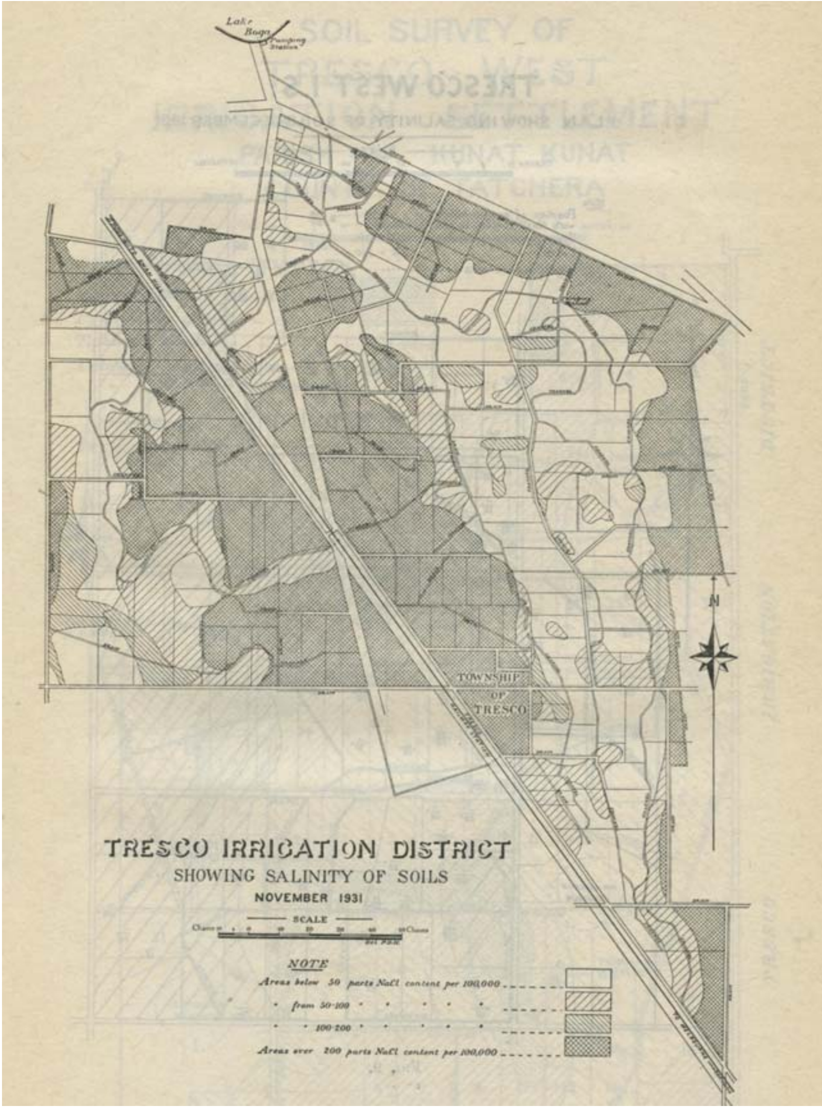
Soil Type	Nyah Clay Loam.										Vinifera Loam.		
Location	Nyah.							Goodnight.			Goodnight.		
Sample No.	526/31/34.	35.	36.	37.	526/31/38.	39.	40.	2402.	2403.	2404.	2408.	2409.	2410.
Depth, Inch	0–6.	6–13.	13–27.	27–48.	0–10.	10–24.	24–36.	0–11.	11–27.	27–42.	0–12.	12–24.	24–48.
	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	35·0	24·5	23·8	21·9	20·3	18·7	22·2	16·5	12·6	12·5	28·3	18·1	..
Fine sand	27·0	21·8	19·7	16·9	21·0	20·5	21·3	28·1	22·9	25·1	32·5	23·9	..
Silt	6·0	4·4	5·2	7·7	9·2	6·2	6·8	4·0	3·6	4·4	9·9	5·9	..
Clay	28·8	42·2	36·8	41·7	34·6	38·3	41·7	46·2	46·2	43·9	28·6	46·2	..
Loss on acid treatment	3·1	6·2	14·0	9·0	14·4	16·0	8·5	1·3	11·4	10·9	0·6	2·2	..
Loss on ignition	5·5	7·1	10·0	7·4	10·5	10·5	7·3	5·0	8·9	8·4	3·8	5·6	..
$CaCo_3$ (fine earth)	0·7	3·9	11·7	7·2	11·1	14·2	6·8	n.d.	10·6	10·4	n.d.	1·4	..
$CaCO_3$ rubble (field sample) ..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total salts	0·07	0·10	0·15	0·20	0·13	0·20	0·26	0·07	0·14	0·19	0·08	0·10	0·16
Chlorine	0·006	0·005	0·008	0·011	0·012	0·027	0·037	0·005	0·010	0·010	tr.	0·01	0·02
pH	8·0	8·5	9·2	9·4	8·9	9·5	9·6	8·0	8·9	9·2	7·4	8·9	9·3

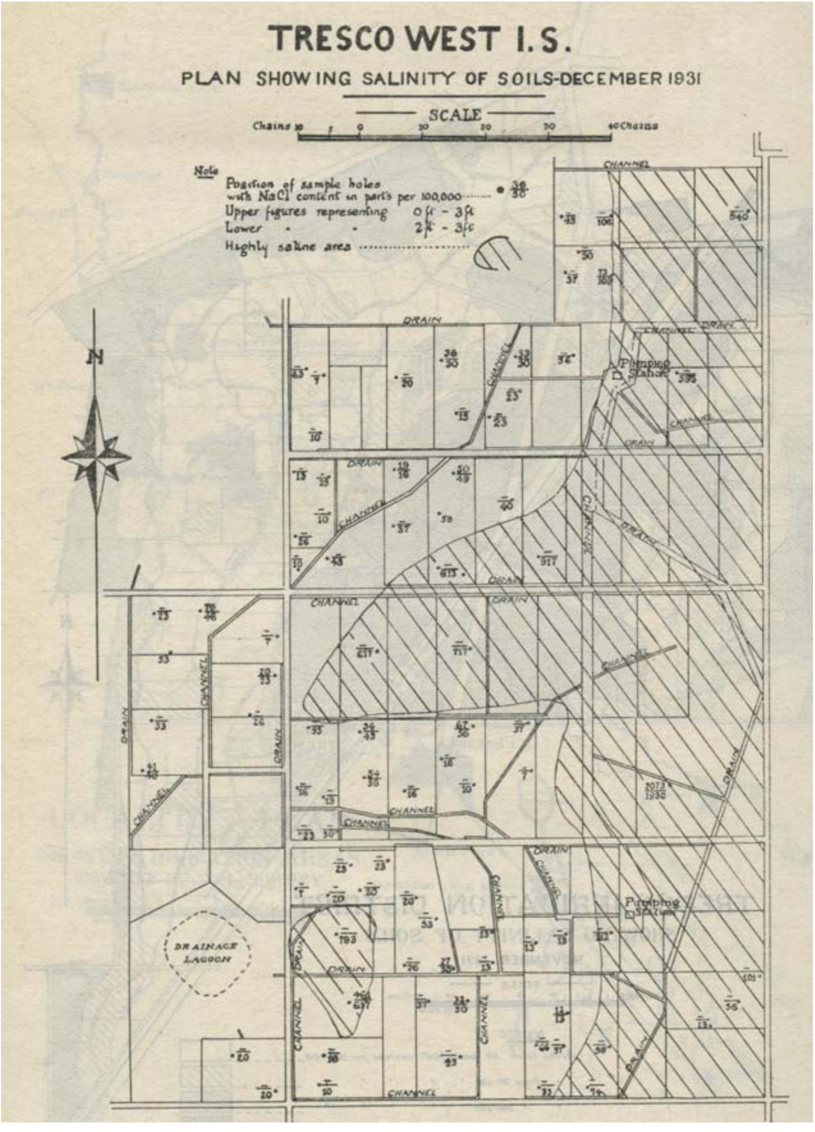
TABLE 6 (continued) – MECHANICAL ANALYSES OF NYAH CLAY LOAM AND VINIFERA LOAM PROFILES

Soil Type	Nyah Clay Loam.										Vinifera Loam.		
Location	Nyah.							Goodnight.			Goodnight.		
Sample No.	526/31/34.	35.	36.	37.	526/31/38.	39.	40.	2402.	2403.	2404.	2408.	2409.	2410.
Depth, Inch	0–6.	6–13.	13–27.	27–48.	0–10.	10–24.	24–36.	0–11.	11–27.	27–42.	0–12.	12–24.	24–48.
	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	35·0	24·5	23·8	21·9	20·3	18·7	22·2	16·5	12·6	12·5	28·3	18·1	..
Fine sand	27·0	21·8	19·7	16·9	21·0	20·5	21·3	28·1	22·9	25·1	32·5	23·9	..
Silt	6·0	4·4	5·2	7·7	9·2	6·2	6·8	4·0	3·6	4·4	9·9	5·9	..
Clay	28·8	42·2	36·8	41·7	34·6	38·3	41·7	46·2	46·2	43·9	28·6	46·2	..
Loss on acid treatment	3·1	6·2	14·0	9·0	14·4	16·0	8·5	1·3	11·4	10·9	0·6	2·2	..
Loss on ignition	5·5	7·1	10·0	7·4	10·5	10·5	7·3	5·0	8·9	8·4	3·8	5·6	..
$CaCo_3$ (fine earth)	0·7	3·9	11·7	7·2	11·1	14·2	6·8	n.d.	10·6	10·4	n.d.	1·4	..
$CaCO_3$ rubble (field sample) ..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total salts	0·07	0·10	0·15	0·20	0·13	0·20	0·26	0·07	0·14	0·19	0·08	0·10	0·16
Chlorine	0·006	0·005	0·008	0·011	0·012	0·027	0·037	0·005	0·010	0·010	tr.	0·01	0·02
pH	8·0	8·5	9·2	9·4	8·9	9·5	9·6	8·0	8·9	9·2	7·4	8·9	9·3

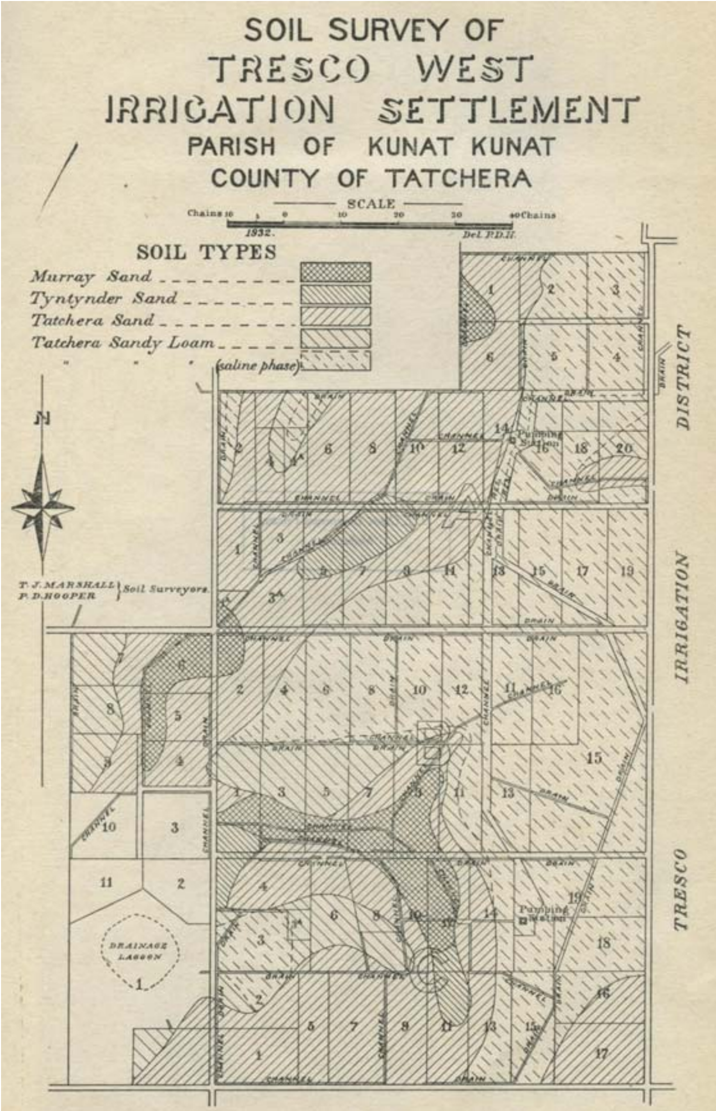


GOODNIGHT I.T.D.
Tooleybuc
Piangil
NEW SOUTH WALES
River
RAILWAY
LINE
BUNGUNYAH-KORALEIGH I.T.D.
NYAH I.S.
SPEEWA
WOORINEN I.S.
VICTORIA
Swan Hill
Murray
Little
Murray
Lake Boga
TRESCO I.D.
TRESCO WEST I.S.
Loddon
MURRABIT
Mystic Park
KANGAROO LAKE ESTATE
Kerang
LOCALITY PLAN
SHOWING IRRIGATION AREAS
COVERED BY SOIL SURVEY
SCALE
10 Miles


TRESCO IRRIGATION DISTRICT
SHOWING SALINITY OF SOILS
NOVEMBER 1931
SCALE
NOTE
Areas below 50 parts NaCl content per 100,000
" from 50-100 " " " " "
" " 100-200 " " " " "
Areas over 200 parts NaCl content per 100,000
TOWNSHIP OF TRESCO
Lake Boga
N



TRESCO WEST I. S.
PLAN SHOWING SALINITY OF SOILS-DECEMBER 1931
SCALE
Chains 10 5 0 10 20 30 40 Chains
Note
Position of sample holes with NaCl content in parts per 100,000
Upper figures representing 0 ft - 3 ft
Lower 2 ft - 3 ft
Highly saline area
N
DRAIN
CHANNEL
Pumping Station
DRAINAGE LAGOON



SOIL SURVEY OF
TRESCO WEST
IRRIGATION SETTLEMENT
PARISH OF KUNAT KUNAT
COUNTY OF TATCHERA
SCALE
Chains 10 0 10 20 30 40 Chains
1932.
Del. P.D.H.
SOIL TYPES
Murray Sand
Tyntynder Sand
Tatchera Sand
Tatchera Sandy Loam
" " " (saline phase)
N
T. J. MARSHALL
P. D. HOOPER
Soil Surveyors.
TRESCO IRRIGATION DISTRICT
DRAINAGE LAGOON
Pumping Station