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SOIL SURVEY

Of Parts of the Parishes of

Nuntin and Bundalaguah
County of Tanjil
Victoria

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SUMMARY

A further area of 17,933 acres adjacent to the Maffra-Sale Irrigation District in Central Gippsland has been covered by soil survey to determine its suitability for irrigation.

The landscape of the area, generally, is one of plain, fringed by gently sloping uplands, sandy rises, and river flats.

The soils are developing under a 24 in. rainfall on fluviatile sediments ranging in age from Pliocene to late Recent. Solonisation appears to be an important process in the pedogenesis of some of the soils.

Twenty-nine soil types and four phases are described; sixteen of the types and all of the phases have not been recorded previously. Simplification of the complex soil pattern has been attained by grouping the soil types into thirteen landscape units or soil associations.

Physical differences between the principal soil types are illustrated by mechanical analyses. The data indicates differences between types in the permeability of their profiles to water.

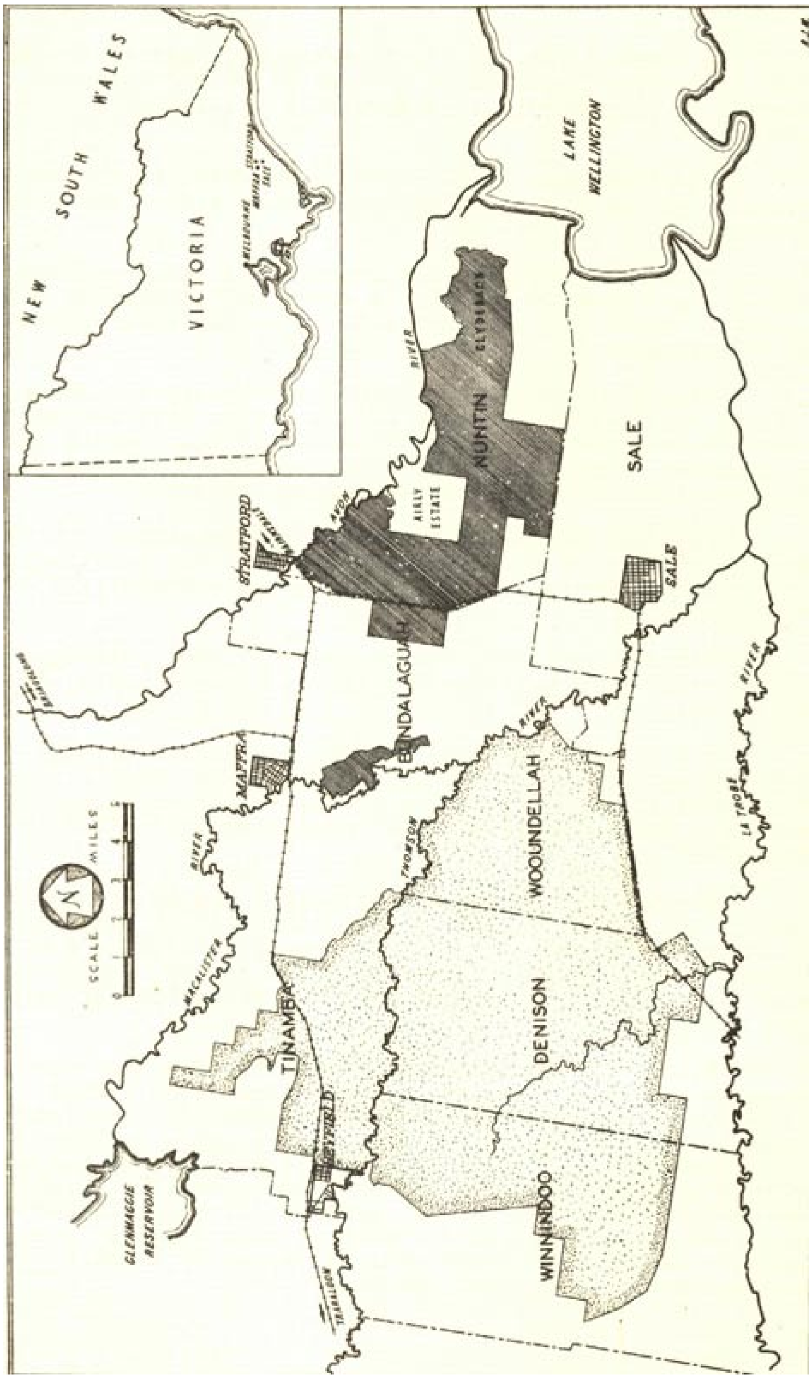
The surface soils are moderately acid; nitrogen reserves are at a satisfactory level, but available potash may be low.

The A and B horizons of five major soil types, considering their clay contents, are low in total exchangeable metal ions. Calcium is the principal exchangeable metal ion in the surface soils, magnesium and sodium in the subsoils.

Certain soil types are naturally low in soluble salts; but others include local situations of moderate salinity. One major type is inherently saline to a moderate degree. The salinity factor need not prevent irrigation of most of the area but it indicates the necessity for careful soil management.

Five soil associations provide 6,897 acres, most of which is suitable for permanent pastures under irrigation. A further seven soil associations consist of soil types of lower fertility, soils with some salt hazard, and non-commandable soils; these total 9,551 acres. Whilst some of this would be suitable for permanent pastures, light irrigation of improved annual pastures is suggested as the best form of development for much of this class of country. One soil association comprising 348 acres is largely unsuitable for irrigated pastures.

Figure 1 – Locality Plan



Soil Survey of Parts of Parishes of Nuntin and Bundalaguah, County of Tanjil, Victoria.

1. GENERAL FEATURES OF THE AREA.

1. Location.

An extension of irrigation into areas adjoining the Maffra-Sale Irrigation District is provided for under a scheme – the Central Gippsland Irrigation Project of the State Rivers and Water Supply Commission – whereby the waters of the Macalister and Thomson Rivers are to be utilised more fully than at present. Soil surveys to assess the suitability of the lands for irrigation have been carried out by the Department of Agriculture at the request of the State Rivers and Water Supply Commission, which has provided assistance in the work. The first of such surveys comprising the major area of 67,000 acres, which is referred to as the Nambrok-Denison area throughout this bulletin, has been published, while a second is the subject of this report.

The present survey concerns 17,933 acres in the parishes of Nuntin and Bundalaguah. The principal area is one of 16,991 acres between Stratford and Sale and about 7 miles east of Maffra. It includes the Clydebank district. A further 942 acres lies immediately south of Maffra and is river flats adjoining the Macalister River. Both situations and their relation to the earlier survey are shown on the locality plan (Fig. 1).

2. Agricultural Situation.

Broadly, the district is one of mixed farming, consequently very little of the original vegetation remains anywhere in the area.

The ridgeland slopes and adjoining low-lying woodland in the west and central parts of the area, and the sandy rises in the south-east, are partially developed pastoral lands, mostly utilised for the grazing of sheep and cattle. The vegetation was originally savannah woodland, with red gum (*E. tereticornis*), Danthonia, and Kangaroo grass (*Themeda triandra*) the principal species, and with the densest stands of timber in the lowest areas.

Dairying and fattening cattle are dominant on the recent alluvial soils adjoining Nuntin Creek and the Avon River in the neighbourhood of Stratford, but there is some cultivation for fodder crops. No timber remains here but there are stands of river red gum (*E. camaldulensis*) on the flats of the Avon further downstream.

On the slightly undulating plains of the Clydebank district, and on the soils adjoining the Sale irrigation district in the south-west, there is a much greater proportion of cultivation, particularly for hay, while a small amount of sugar beet was grown at one time. Dairying is associated with such farming in most instances, but sheep also take a place in the agricultural system.

3. Climate.

Except that the mean annual rainfall is nearly 2 in. higher, the climate may be regarded as similar to that of Nambrok-Denison which has been fully discussed previously, particularly in relation to Maffra data. However, the climate of the area is indicated briefly by the rainfall and temperature data given below.

The mean annual rainfalls at Stratford, Sale, and Maffra are 25.10 in., 24.10 in., and 23.28 in., respectively, while the mean seasonal rainfall at Stratford is:- Sept. – Nov., 7.12 in.; Dec. – Feb., 6.51 in.; Mar. – May, 6.07 in.; June – Aug., 5.40 in. More frequent heavy falls in spring and summer are mainly responsible for the higher mean rainfalls in these seasons compared with autumn and winter.

At Stratford, the annual temperature shows a mean minimum of 45.8^{o} F. and a mean maximum of 70.3^{o} F. Monthly mean minimum and mean maximum temperatures are above their respective annual means from November to April and below them from May to October.

4. *Geology and Physiography.*

The area is situated in the central portion of the East Gippsland Plain, which has been described by Hills as marine Cainozoic sediments overlain by fluviatile sands, gravels, and clays. The earliest of the fluviatile deposits are Middle and Upper Pliocene Torrent Gravels. Upwarping in the late Pliocene and early Pleistocene, and subsequent dissection, have left the Torrent Gravels as hill cappings, with numerous streams and extensive more recent deposits of clays and sands in the valleys.

Today, the earliest fluviatile sediments cover the western and central parts of the surveyed area. Ridge and upland between Maffra and Stratford extends south-eastwards as gentle slopes and relatively flat stretches which finally pass to slightly lower areas of restricted drainage. The last situations are comparable with the low-lying woodlands of the Nambrok – Denison area, although the timer now has been partially or wholly removed. To the north near Stratford, the uplands fall away through a series of rises and hollows to the present flood plains of Nuntin Creek and the Avon River.

A chain of more or less sandy rises in the south-east extends along the boundary of the area in an east-north-easterly direction towards Lake Wellington. These sandy rises, particularly approaching Lake Wellington, resemble dune formations and could have been formed along a lake shore-line under the influence of prevailing south-easterly winds. Actually, lacustrine conditions exist in this neighbourhood at the present time and probably were much more extensive following recession of the Cainozoic sea.

A sparsely timbered plain of clay and fine sandy clay alluvium merges with the older sediments of the low-lying woodlands in the vicinity of the Airly Estate, and extends eastward over the Clydebank district at an intermediate level between the sandy rises and the flood plain of the Avon River. In places, the topography tends to be rather undulating due to the presence of drainage lines and old stream courses and to some intermingling with the sandy rises. A somewhat similar sedimentary plain fringes older sediments in the south-west of the area.

Drainage of the area is in a generally easterly direction by way of small water courses leading to the Avon River, while run-off from high land further to the northwest reaches the Avon via Nuntin Creek. Gippsland rivers are fed by snow-waters from the Australian Alps and, although the Avon normally has a very small flow, it floods periodically and extensively over the river flats below Stratford. Further downstream the river approaches Lake Wellington through a series of saline swamplands and lagoons.

II. SOIL CLASSIFICATION AND RELATIONSHIPS.

1. *Classification and General Characteristics of the Soils.*

(a) ***Classification.*** The soils are developing on a heterogenous collection of fluviatile sediments ranging in age from Middle Pliocene to late Recent, consequently, at the present time, they are at various stages of pedological development. Prescott (3) places the area in a zonal soil group of Podsols; but none of the soils are normal podsols, although certain soil types developing on the older, coarse sediments show some degree of podsolisation. However, as in the Nambrok-Denison area, there is evidence that solonisation has been an important pedogenic process in the area generally – particularly on the lower-lying areas of fine alluvium – with the formation of intrazonal soil types. In addition, there are immature soils developing on recent river alluvium.

(b) ***General Characteristics.*** Broadly, the colour range of the soils is from grey to grey-brown in the surface, although a few soils tend towards browner shades; and from yellow-grey, to yellow-brown and brown in the subsoil. Taken as a whole, there is a fairly high proportion of the area – greater than in the Nambrok-Denison area – with surface soils which show brownish influences.

Textures cover a wide range. There are large areas each of clay loam, loam, and sandy loam, while sand, fine sandy loam, and silty clay loam textures are represented also, but to a much lesser extent. In most of the soils, there is a decided increase in texture passing from the surface to the subsoil; exceptions are immature alluvial, and very sandy soils. Subsoil textures range principally from light to heavy clays, but sandy clays and sandy clay loams occur also. These frequently pass to lighter textures in the deep subsoil.

Nearly all the soils are moderately acid in their A horizons and slightly acid or neutral in their B_1 horizons. Below 3 ft. in the profile, there is considerable variation in reaction according to the soil type, and these horizons may range from fairly acid to very alkaline.

The majority of the soils do not contain lime, but it occurs fairly regularly as concretions in small amounts below 30 in. in several of the soil types.

Although soft concretions of iron oxide are present in many of the soils, they are not prominent. However, hard ferruginous concretions occur with quartz gravel in the A_2 horizon of one soil series.

There are many saline marshy soils which have been excluded from survey. Salinity is not highly developed in soils outside these areas, but a fairly high proportion of the subsoils possess moderate salt contents.

2. Relation of the Soils with Physiography.

Since topographic features and soil types over a large part of the area are similar to those found in the Nambrok-Denison area, several of the landscape categories of that area are used below to express broad relationships between soil types, topography, and parent materials, and to indicate relationships between the soil types of both area. However there are sequences of sedimentary deposits in this area which are intermingled topographically, consequently the soil pattern is more complex and not so clearly related to the physiography as in the Nambrok-Denison area. An additional category of sandy rises is included.

Ridges and Uplands. This country represents the remnants of Pliocene sediments associated with the Torrent Gravels. The parent materials of the soils are clays containing more or less sand and water-worn gravel.

Low rises are usually gravelly, but are only occasionally of Tanjil gravelly sand which is the soil type normally found on gravelly clay sediments in the Nambrok-Denison area. Here, these situations are mainly either Tanjil sandy loam “gravelly phase” or Tanjil loam “gravelly phase”. These phases merge with the normal Tanjil sandy loam and Tanjil loam soil types at slightly lower levels. The distribution of gravelly soils is difficult to determine in detail, consequently this class of country has been mapped largely as a complex of normal and gravelly phases of the Tanjil series. Type A is an unnamed type of minor significance.

Shallow drainage lines and small depressions in which the parent sediments are clays are intermingled with the Tanjil soils. The soil types are Winnindoo loam, Winnindoo clay loam and Type K.

Low-lying Woodlands. The soil types are Winnindoo clay loam and, to a lesser extent, Winnindoo loam, both of which have been recorded previously (1). These soils have developed on clay alluvium under conditions of poor surface drainage. But little of the woodland vegetation remains and this landscape category appears now as rather extensive flat areas which receive drainage from the adjacent Tanjil soils of the uplands. There is often a distinct break in slope of several feet between the Tanjil soils and the Winnindoo clay loam, but, in some parts of the area, the change is less perceptible.

A tussocky micro-relief, indicative of swampy conditions, is present in some situations, while others are slightly crabholey.

Sandy Rises. Nuntin sandy loam and its heavy phase and Type J are the principal soil types. Some rises consist mainly of Nuntin sandy loam with small areas of Type J at highest elevations, while others are almost entirely of Type J. In some situations, Clydebank sandy loam and, occasionally, Clydebank loam are found on the lower slopes.

Sparsely Timbered Plains and Associated Rises and Depressions. As well as plain, this category includes low rises and hollows resulting from past and present drainage features. The sediments are variable, but are chiefly clay containing more or less silt and fine sand with very little coarse sand.

Flat areas comparable with similar topography in the Nambrok-Denison area are of the same soil types, namely, Denison clay loam and Wandocka clay loam (1), where the alluvium is finest; but are of

Denison clay loam "light phase" and Bundalaguah clay loam, neither of which has been recorded before, where the alluvium is relatively more fine sandy. Type L occupies low rises, mainly adjoining Bundalaguah clay loam.

Undulating and relatively high situations of brown and grey-brown soils are of Clydebank clay loam and Clydebank loam, which are developing on fine sandy clay alluvium. Clydebank sandy loam usually occurs where these types adjoin the sandy rises or the lower upland slopes. The Clydebank series, , although of more variable morphological character, may be compared with Heyfield clay loam which occupies a similar situation in the Nambrok-Denison topography.

Depressions, drainage lines, and broad hollows of grey soils consist of the unnamed soil types, Types P, Q, and R according to the nature of the under-lying sediments.

River Flats. Thomson silty clay loam and Thomson silty clay have been escribed (1) as the normal soils forming on the largely silty alluvium of the Thomson River. Similar alluvium is giving rise to the Thomson series along the Macalister River near Maffra; also in the vicinity of Nuntin Creek, where this type of alluvium has been deposited until respectively recently. Type M is an associated soil type in the latter area forming on the more fine sandy sediments, while Type G, which is found on the Thomson River flats, also occurs on the Macalister flats near Maffra.

The sediments from the Avon River are distinct from the above and provide the three soil types of the Avon Suite. The alluvium of Types 1 and 2 is largely fine sand containing relatively little clay, but in Type 3 sands are overlain by silty materials. Near Stratford, Types 1 and 2 occur together with Type 2 outlying Type 1 in proximity to the river. Type 3 occurs singly further downstream towards Clydebank.

Saline Swamplands. Low-lying areas of marshy and saline soils are extensive along the lower reaches of the Avon River and around the lagoons at the eastern end of Clydebank. The soils have not been classified.

Several depressions associated with an occurrence of Wandocka clay loam in the south of the area are of a saline soil type recorded previously, viz., Type F (1).

3. Soil Association.

Owing to the complexity of the soil pattern in the area, some simplification of the detailed soil map is of help towards gaining an appreciation of the usefulness or otherwise of the area generally for irrigation. Whilst the soil types can be grouped under the broad topographic categories described in the preceding subsection, a grouping into smaller landscape units, which is based on the dominance of one or two soil types over others in a particular landscape, provides a more suitable basis for practical use. In addition to the dominant soil types, such soil associations may include one or two subordinate soil types and minor occurrences of a number of other soil types. A soil type may occur in two or even three different soil associations, assuming a different degree of significance in each. In most associations, the soil types are derived from similar, although not necessarily the same, parent materials; however, some associations may consist of mixed soil types of different origins.

Thirteen soil associations, each of which has been given the name of its principal soil series member or members, are described below, while their distribution is shown on a folder map at the back of the bulletin. Areas of the component soil types are given in a later section.

Tanjil.

Essentially light textured and gravelly soils with heavy subsoils.

Principal soil types:- Tanjil sandy loam, Tanjil sandy loam "gravelly phase", Tanjil loam, Tanjil loam "gravelly phase".

Subordinate soil types:- Winnindoo loam, Winnindoo clay loam.

Minor soil types:- Tanjil gravelly sand, Type A.

Landscape:- Ridge and gentle upland slopes.

Winnindoo – Tanjil.
Principally medium textured surface soils overlying heavy subsoil.

Principal soil types:- Winnindoo loam, Winnindoo clay loam, Tanjil loam.

Subordinate soil types:- Tanjil sandy loam.

Minor soil types:- Tanjil sandy loam "gravelly phase", Tanjil loam "gravelly phase", Nuntin sandy loam, Types K and L.

Landscape:- Lower upland slopes passing gradually to low-lying woodland.

Winnindoo.
Poorly structured, grey soils of heavy texture.

Principal soil type:- Winnindoo clay loam.

Minor soil types:- Winnindoo loam, Tanjil series, Type K.

Landscape:- Low-lying woodland of indifferent surface drainage.

Nuntin.
Principally light textured, grey brown soils, with very permeable profiles.

Principal soil type:- Nuntin sandy loam, Nuntin sandy loam "heavy phase".

Subordinate soil types:- Clydebank sandy loam, Clydebank loam, Type J.

Landscape:- Fairly extensive elevated areas running from west-south-west to east-north-east, and broadly classed as sandy rise.

The relatively heavier soils of the sandy rise landscape dominate the lighter Type J in the soil association. Clydebank sandy loam and Clydebank loam mainly occur in marginal situations.

Type J.
Mainly soils of very light texture throughout the profile.

Principal soil type:- Type J.

Subordinate soil type:- Nuntin sandy loam.

Minor soil type:- Clydebank loam.

Landscape:- Elongated, west-south-west to east-north-east, sandy rises.

Compared with the allied Nuntin association, Type J largely replaces Nuntin sandy loam and the marginal Clydebank types are less extensive.

Clydebank.
Mainly permeable soils of medium texture.

Principal soil type:- Clydebank clay loam.

Subordinate soil type:- Clydebank loam.

Minor soil types:- Denison clay loam, Clydebank sandy loam, Nuntin sandy loam, Type P

Landscape:- Low rises and gently undulating situations which are unusually included in a broader landscape of sparsely timbered plain.

Clydebank – Type J.
Rather intimately mixed, medium, light, and very light textured, permeable soils.

> ***Principal soil type:-*** Clydebank loam.
>
> ***Subordinate soil type:-*** Clydebank sandy loam, Types J and P.
>
> ***Minor soil type:-*** Nuntin sandy loam.
>
> ***Landscape:-*** Moderately undulating with some pronounced rises and drainage lines.

This soil association adjoins the Clydebank association and includes its lighter soil types as the principal members; however, soil types of the sandy rises, principally Type J, occur also. This soil type, although subordinate in area to both Clydebank loam and Clydebank sandy loam, is widespread and is a very significant member of the landscape. Type P occupies the more extensive hollows.

Type Q – Clydebank.

Principally heavy textured grey, and medium textured grey-brown soils.

> ***Principal soil types:-*** Type Q, Clydebank loam.
>
> ***Minor soil types:-*** Clydebank sandy loam, Wandocka clay loam, Types P and R.
>
> ***Landscape:-*** Low rises passing to broad flat areas, the whole occupying a low situation in the landscape of sparsely timbered plains.

Denison.
Well structured, grey soils of medium and heavy textures.

> ***Principal soil type:-*** Denison clay loam "light phase".
>
> ***Subordinate soil type:-*** Denison clay loam
>
> ***Minor soil type:-*** Wandocka clay loam.
>
> ***Landscape:-*** Sparsely timbered plain.

Wandocka.
Well structured, grey soils of heavy texture.

> ***Principal soil type:-*** Wandocka clay loam.
>
> ***Subordinate soil type:-*** Denison clay loam.
>
> ***Minor soil type:-*** Types F,Q and R.
>
> ***Landscape:-*** Sparsely timbered plain with some shallow depressions.

Bundalaguah.
Mainly well structured, grey-brown soils of medium texture, usually with lime in the subsoil.

> ***Principal soil type:-*** Bundalaguah clay loam.
>
> ***Minor soil types:-*** Denison clay loam, Types L and R.
>
> ***Landscape:-*** Sparsely timbered plain with a few low rises and shallow drainage lines.

Avon.
Fine sandy alluvial soils.

Principal soil types:- Avon Suite, Types 1 and 2.

Subordinate soil type:- Avon Suite, Type 3.

Landscape:- Avon River flood plain traversed by water courses, swamps, and lagoons.

Thomson.
Silty alluvial soils.

Principal soil type:- Thomson silty clay loam.

Subordinate soil type:- Type M.

Minor soil type:- Thomson silty clay.

Landscape:- Flats traversed by Nuntin Creek and the Macalister River.

III. THE SOIL TYPES.

1. Summary of the Soil Types.

Twenty-nine soil types and four phases have been recorded in the area. Thirteen of the soil types, viz., Tanjil gravelly sand, sandy loam, and loam, Winnindoo loam and clay loam, Nambrok clay loam, Denison clay loam, Wandocka clay loam, Thomson silty clay loam and silty clay, and Types A, F and G occur in the Nambrok-Denison area and have been described previously. Five soil types and one phase in the Clydebank, Nuntin, and Bundalaguah series, two gravelly phases in the Tanjil series and a light phase of Denison clay loam have not been recorded before; nor have three recent alluvial soils – grouped as an Avon Suite – and eight unnamed soil types.

The principal morphological characteristics and occurrences of all the soil types are summarised in Table 1 in order to present these features collectively. The table is intended to serve as a ready means of reference to main differences between the soil types.

The significance of the abbreviations used in Table 1 are as follows:-

L. and l. = light; D. = dark; yell. = yellow; y.ish = yellowish; Br. = brown; gr. = gravel; c. and cl. = clay; si. = silty; s. and sdy = sandy (f = fine); / = over or passing to; + = and.

Table 1 – Summary of the Soil Types

Soil Type	Profile			Occurrence
	Surface and subsurface	Subsoil	Deep subsoil	
Tanjil gravelly sand	Grey-brown sandy loam /l.brownish grey gravelly sand 0-16"	Brownish yellow heavy clay with gravel 16-30"	Yellow-grey-red clay with heavy gravel 30-60"	Crests of ridges and upland; associated with Tanjil sandy loam
Tanjil sandy loam	Grey-brown sandy loam /1.brownish grey sand with some gravel 0-10"	Brownish yellow heavy clay 10-36"	Brownish yellow gritty medium clay 36-72" or sandy clay from 48"	Ridges and gently sloping upland; may be slightly crabholey
" " gravelly phase	Grey-brown sandy loam /1.brownish grey sand with much gravel 0-12"	Brownish yellow heavy clay 12-25	Brownish yellow-red-grey clay with gravel 25-60"	Low rises on gently sloping upland
Tanjil loam	Brownish grey loam/1. grey sandy loam 0-8"	Brownish yellow heavy clay 8-36"	Brownish yellow medium clay 36-72"	Gently sloping and flat areas of upland; crabholey
" " gravelly phase	Br.ish grey loam, much gr.in subsurface 0-10"	Brownish or greyish yell. heavy clay 10-30"	Brownish yell.-red-grey clay with gr. 30-42"	Low rises on gently sloping upland
Winnindoo loam	Grey loam/1.grey+rusty flecked clay loam 0-7"	Light clay 7-10" Yell-grey heavy clay 10-30"	Greyish yellow clay 30-72"	Broad areas of indifferent drainage merging with uplands
Winnindoo clay loam	Grey/light grey+rusty flecked clay loam 0-6"	Yellow-grey heavy clay 6-21"	Greyish yellow clay 21-72"	Broad depressions of poor surface drainage
Nuntin Sandy loam	Grey-brown sdy loam/1. Grey-brown sand 0-24"	Brown+yell.br.sdy clay loam or sdy clay 24-39	L.yell-brown sdy clay loam or lighter 39-72"	Upper slopes and crests of sandy rises
" " heavy phase	Grey-brown sandy loam or loam/1. Grey-brown sand or sdy loam 0-21"	Brown and yellow-brown medium clay (sandy) 21-33"	Brown and yellow-brown sandy clay 33-48" Deeper strata variable	On lower slopes and on less pronounced sandy rises
Clydebank Sandy loam	Grey-brown sandy loam /1.grey-brown sand or sandy loam 0-24" A fine sandy influe	Brown or yellowish brown sandy clay or light clay 24-36" nce is strong compared w	Light brown sandy clay passing to lighter textures 36-72" ith the Nuntin series.	On rises and gentle slopes with Clydebank loam and clay loam

Soil Type	Profile			Occurrence
	Surface and subsurface	Subsoil	Deep subsoil	
Clydebank loam	Grey-brown loam/1.br. fine sandy loam 0-21"	Br. Or yell.-br. f. s. clay or light clay 21-36"	L.brown+brown f. sandy clay or lighter 36-72"	On low rises associated with the sparsely timbered plains
Clydebank clay loam	Grey-brown clay loam 0-18"	Brownish or yellowish brown light or medium clay 18-30"	Mottled fine sandy or light clay/light brown +brown f. s. clay 30-72"	On low rises ad gentle undulations associated with the sparsely timbered plains
Bundalaguah clay loam	Dark grey-brown clay loam/grey-brown light clay 0-16"	Brown or yellow-brown medium clay 16-30"	Mottled fine sandy or light clay with lime 30-48", lighter 48-72"	On sparsely timbered plain
Nambrok clay loam :- See Dept. Agric. Vic. Tech. Bull. No.3				Unimportant in this area
Denison clay loam	Grey/grey with 1.grey+ yellow clay loam 0-14"	Dark y.ish grey/yell. – grey heavy clay 14-30"	Greyish yellow medium clay, lime, 30-60"	Gentle slopes and flat areas of sparsely timbered plain
" " light phase	" 0-15"	Dark yellowish grey medium clay 15-30"	Greyish yellow light clay, or with fine sandy clay, lime, 30-72"	As above
Wandocka clay loam	Grey clay loam/grey, 1. Grey and rusty flecked light clay 0-12"	Dark yellowish grey/ yellow-grey heavy clay 12-27"	Greyish yellow heavy clay, lime, 27-60"	On low-lying sparsely timbered plain
Thomson silty clay loam	Grey, brown stained, silty clay loam 0-15"	Grey, with yellowish grey mottling, silty clay, becoming yellower with depth, 15-72"		Flats adjoining the Macalist-er River and Nuntin Creek
Thomson silty clay	Grey, brown stained, silty clay 0-12"	As for Thomson silty clay loam, 12-72"		On shallow depressions on river flats
Avon Suite Type 1	Strata of yellowish and greyish brown fine sand and fine sandy loam 0-42:84"		D. grey si. c. loam/grey + yell. si. clay 42:84-108"	On flats adjacent to Avon River
Type 2	Strata of f. sdy clay loam + f. sdy loam 0-18:42"		" 18:42-72"	On flats outlying Type 1
Type 3	Yellowish grey-brown silty loam 0-12"	D. grey si. c. loam/grey + yellow si. clay 12-30"	Strata of yellow and grey sands 30-72"	On flats along lower reaches of the Avon River

Soil Type	Profile			Occurrence
	Surface and subsurface	Subsoil	Deep subsoil	
Type A	Grey-brown/light brown -ish grey sand 0-15”	Yellow and grey sandy clay 15-30”	Yell. sandy clay pass-ing to variable strata	On uplands, as small rises adjacent to drainage ways
Type F	Grey, with rusty stain-ings, clay 0-8"	Yellowish grey heavy clay, lime, 8-48”	Mottled yellow and grey heavy clay	On low badly drained areas in a topography of plain
Type G	Brownish grey clay loam passing to light clay 0-20”	Brown or greyish yell. fine sandy clay or f. sdy clay loam 20-42”	Similar to subsoil, or grey and yellow silty clay, 42-72”	On banks above Thomson series near the Macalister river
Type J	Grey-brown/yellowish brown sand 0-54”	Yellowish brown sandy loam 54-60”	Light yellowish brown sand 60-84”	On crests of sandy rises; as knolls with Clydebank series
Type K	Grey loam/1.grey fine sdy clay loam/l.y.ish grey light clay 0-18"	Mottled yellow-brown, yellow-grey, red heavy clay 18-36”	Yellow + grey, or yellow-light grey-brown clay, lime, 36-72”	With, but slightly above, Winnindoo clay loam in a gen-erally low-lying topography
Type L	Grey-brown loam/brown clay loam 0-18”	Brown heavy clay/light clay, lime, 18-48”	Brown-yellow-red-grey, fine sandy clay 48-72”	As low rises between plain and low-lying woodland
Type M	Grey clay loam 0-18”	Yellowish grey clay 18-33”	Grey-yell-brown light clay/f. s. clay 33-72”	On river flat between Thomson and Clydebank series
Type N	Grey sand to sandy clay loam textures 0-48			As very small depressions
Type P	Grey/light grey sandy clay loam 0-16”	Yellow and grey sandy clay 16-27”	Yell + grey sdy cl. loam/ lighter textures 27-72”	On low-lying areas adjoining Clydebank or Nuntin series
Type Q	Grey clay loam/grey + yell-grey clay 0-12”	Yell-grey, rusty + l. grey heavy clay 12-30”	Grey-yell-red sdy clay or light clay 30-48”	“
Type R	Grey clay loam/grey-rusty-l. grey clay 0-10”	Grey + yellow-grey heavy clay 10-30”	Greyish yell. + l. grey clay, lime, 30-48”	As depressions on sparsely timbered plains

2. *Description of the Soil Types.*

Descriptions of the soil types in more detail than is provided by the summary are set out below, while the occurrence in the topography is indicated also for each type. In the case of the soil types recorded previously, their morphologies as described originally (1) are reproduced and are followed by the addition of notes, when necessary, to describe variations found in the present area.

Tanjil gravelly sand.

Upland: small knolls.

A_1 0-4 in. Grey-brown or brownish grey sandy loam or sand, with slight gravel; loose when dry, slightly coherent when moist.

A_2 4-12/18 in. Light brownish grey gravelly sand, with iron concretions and cemented gravel at junction with the B horizon; loose when dry, incoherent when moist.

B 12/18-30 in. Brownish yellow with slight red mottling, heavy clay, with slight to moderate gravel and slight iron concretions; massive structure; hard when dry, stiff when moist.

30-60 in. Yellow and grey with some red mottling, gravelly clay, or medium clay with sand and gravel increasing with depth.

Tanjil sandy loam.

Upland: gentle slopes

A_1 0-4 in. Grey-brown or brownish grey sandy loam; loose when dry, slightly coherent when moist.

A_2 4-10 in. Light brownish grey sand, with slight to moderate gravel and iron concretions, sometimes cemented at the junction with the B horizon; loose when dry, incoherent when moist.

B 10-36 in. Brownish yellow with slight red mottling, heavy clay; massive structure; hard when dry, stiff when moist.

36-72 in. Brownish yellow, gritty medium clay, sometimes sandy clay below 48 in.

Variations are "deep surface" in which the surface is the normal sandy loam but exceeds 12 in. in depth, and "deep sand surface", applied to small rises, in which the surface is a sand exceeding 12 in. An area of "light and deep surface" includes both deep sand and deep sandy loam surface.

Tanjil sandy loam "gravelly phase".

Upland: low rises.

A_1 0-4 in. Grey-brown or brownish grey sandy loam, sometimes with slight water-worn gravel and large stone; loose when dry, slightly coherent when moist.

A_2 4-8 in. Light brownish grey sand, with large amounts of gravel and stone, sometimes iron cemented at the junction with the B horizon; loose when dry, incoherent when moist.

B_1 12-25 in. Brownish yellow with slight red mottling, heavy clay, with slight gravel; massive structure; hard when dry, stiff when moist.

25-45 in. Brownish yellow with red and grey mottling, heavy clay, usually with moderate to large amounts of water-worn gravel.

45-60 in. Mottled brownish yellow, red, and grey sandy and gravelly clay.

The gravel may be large, with odd stone in the A horizon reaching flattened tennis ball size. The gravelly horizons of the Tanjil series vary over a wide range, both in the actual amount of gravel present and in the thickness of the horizons; consequently, the profile features of Tanjil sandy loam "gravelly phase" merge with Tanjil gravelly sand on one side and with the normal Tanjil sandy loam on the other. Compared with Tanjil gravelly sand, in general, the A horizon of Tanjil sandy loam "gravelly phase", besides being less gravelly, does not extend below 12 in. from the surface; it always exceeds this depth in Tanjil gravelly sand. Compared with the normal Tanjil sandy loam, the A horizon is more gravelly, although approximately of similar thickness, and is more frequently associated with a gravelly lower subsoil. However, the distribution of gravel in the lower subsoil tends to be erratic in both the normal type and the gravelly phase.

Tanjil loam.

Upland: flat areas, usually crabholey.

A_1 0-4 in. Brownish grey loam; loose when dry, coherent when moist.

A_2 4-8 in. Light grey with slight rusty-brown flecks, sandy loam or loam; loose when dry, coherent when moist. Iron concretions at junction with B horizon. (These frequently occur on the surface of clay banks). This horizon may be very restricted.

B 8-36 in. Brownish yellow heavy clay; massive structure; hard when dry, stiff when moist.

36-72 in. Brownish yellow medium clay, becoming sandier with depth.

Tanjil loam "gravelly phase".

Upland: low rises.

A_1 0-5 in. Brownish grey loam, with slight gravel and odd waterworn stone; loose when dry, coherent when moist.

A_2 5-10 in. Brownish grey loam, with large amounts of water-worn gravel and stone; loose when dry, coherent when moist.

B 10-30 in. Brownish yellow or greyish yellow, heavy clay, with slight gravel; massive structure; hard when dry, stiff when moist.

30-42 in. Brownish yellow with red and grey mottling, heavy clay, with moderate to large amounts of water-worn gravel.

The gravelly phase of Tanjil loam has been recorded in the Nambrok-Denison area as the unnamed Type C.

Winnindoo loam.

Low-lying woodland: broad, flat areas of indifferent surface drainage.

A_1 0-3 in. Grey, occasionally brownish grey, loam; cloddy structure; compacted and brittle when dry. Coherent when moist.

A_2 3-7 in. Grey and light grey with rusty flecks, clay loam or sandy clay loam, with slight iron concretions; massive structure; hard when dry, plastic when moist.

A_2B_1 7-10 in. Yellow-grey with light grey and rusty flecks, clay loam to medium clay, with slight iron concretions. Transitional between the A_2 and B_1 horizons with the texture gradually increasing.

B_1 10-30 in. Faintly mottled yellow-grey heavy clay, with decreasing iron concretions; massive structure; hard when dry, sticky when moist.

B_2 30-42 in. Greyish yellow heavy clay, sometimes with limestone rubble.

42-72 in. Greyish yellow heavy clay or mottled yellow-grey-red stratified clay.

In this area, lime is found in the profile only on very rare occasions; also, sandy clay or light clay may replace heavy clay below 42 in.

Winnindoo clay loam.

Low-lying woodland: broad depressions of poor surface drainage.

A_1 0-3 in. Grey clay loam; cloddy structure; brittle when dry, plastic when moist.

A_2 3-6 in. Grey and light grey with rusty flecks, clay loam, with slight iron concretions; hard when dry, plastic when moist.

B_1 6-21 in. Faintly mottled yellow-grey heavy clay, with slight iron concretions; massive structure; hard when dry, sticky when moist.

B_2 21-42 in. Greyish yellow heavy clay, sometimes with limestone rubble; massive structure; hard when dry, sticky when moist.

42-72 in. Mottled yellow and grey heavy clay; massive structure; hard when dry, sticky when moist.

As in Winnindoo loam, lime occurs infrequently and deep subsoil textures are often light clay or sandy clay. Areas in which sandy clay comes in at 36 in. to 48 in. are inscribed "light deep subsoil".

Nuntin sandy loam.

Sandy rise: upper slopes and crests except where occupied by Type J.

A_1 0-15 in. Grey-brown or dark grey-brown sandy loam; slightly coherent when dry, coherent when moist.

A_2 15-24 in. Light grey-brown sand; slightly compacted when dry, incoherent when moist.

B_1 24-39 in. Brown and yellow-brown sandy clay loam or sandy clay; structureless; brittle when dry, strongly coherent when moist.

39-72 in. Light yellow-brown sandy clay loam, sandy loam, or sand.

Characteristic features of all soil profiles of the Nuntin series are their relatively coarse sandy nature and somewhat bright colours.

Nuntin sandy loam "heavy phase".

Sandy rise: lower slopes and the less pronounced rises.

A_1 0-12 in. Grey-brown or dark grey-brown loam or sandy loam; slightly coherent when dry, coherent when moist.

A_2 12-21 in. Light grey-brown sandy loam or sand; slightly compacted when dry, incoherent when moist.

B_1 21-33 in. Brown and yellow-brown medium clay, usually with a coarse sandy influence; structureless; brittle when dry, plastic when moist.

33-48 in. Brown and yellow-brown sandy clay.

The heavy phase shows considerable variation. Loam surface textures occur slightly more frequently than sandy loam; however, the heavier nature of the B_1 horizon is the main distinguishing feature from the normal form. From a limited number of borings, it appears that the profile from 18 in. to 72 in. either may have light textures similar to the normal profile or may revert to heavier textures. On a few occasions, these heavy textures appear before 48 in.; in the normal profile, they are usually below 72 in. Such horizons are not necessarily related to the soil profile.

Clydebank sandy loam.

Sparsely timbered plain and associated rises and depressions: rises and some gently slopes.

A_1 0-14 in. Grey-brown sandy loam; coherent when dry or moist.

A_2 14-24 in. Light grey-brown sand or sandy loam; coherent when dry, incoherent when moist.

B 24-36 in. Brown or yellowish brown sandy clay or light clay; small nutty structure; brittle when dry, plastic when moist.

36-72 in. Light brown sandy clay, passing to lighter textures before 72 in.

Profiles of this soil type generally show the influence of fine sand. The deep subsoil horizons below 48 in. are variable in colour and texture and are not necessarily related, pedologically, to the soil profile.

Clydebank loam.

Sparsely timbered plain and associated rises and depressions: low rises and gently slopes.

A_1 0-14 in. Grey-brown loam; crumbly when dry, coherent to mellow when moist.

A_2 14-21 in. Light brown fine sandy loam; crumbly when dry, coherent when moist; diffuse junction with B horizon.

B 21-36 in. Brown or yellowish brown fine sandy clay, sometimes passing to lighter textures before 72 in.

Although the average colour of the surface is grey-brown, many occurrences are only greyish brown, while, on the lower situations at the eastern end of Clydebank, grey influences are strong and have produces colours in the surface soils within the brownish grey range.

Clydebank clay loam.

Sparsely timbered plain and associated rises and depressions: low rises and gentle undulations.

A 0-18 in. Grey-brown clay loam; granular structure; friable when dry, mellow when moist; diffuse junction with B horizon.

B 18-30 in. Brown or yellowish brown light or medium clay; small nutty structure; friable when dry, plastic when moist.

30-48 in. Faintly mottled brown, yellow-brown, and light grey light clay or fine sandy clay; nutty structure; brittle when dry, plastic when moist.

48-72 in. Light brown and brown fine sandy clay, sometimes passing to lighter textures before 72 in.

Variation from the normal surface colour is mainly towards greyish brown and dark grey-brown shades.

An occurrence adjoining river flats near Stratford has been inscribed "light profile" on the soil map; the average profile textures are:- 0-16 in., clay loam; 16-24 in., light clay; 24-30 in., fine sandy clay; 30-48 in., fine sandy clay loam, sometimes passing to fine sandy loam. In the same area, the presence of a coarse sand drift below 30 in. is denoted by the inscription "underlain by sand".

Bundalaguah clay loam.

Sparsely timbered plain: almost flat with a few shallow depressions.

A_1	0-9 in.	Dark grey-brown or dark brownish grey clay loam; small nutty structure; friable when dry, mellow when moist.
A_2	9-16 in.	Grey-brown light clay; small nutty structure; friable when dry, mellow when moist.
B_1	16-30 in.	Brown or yellow-brown medium clay, with dark staining on cleavage planes; nutty structure; brittle when dry, plastic when moist.
B_2C	30-48 in.	Mottled light shades of brown, red, yellow, and grey light clay or fine sandy clay, with limestone rubble; small nutty structure; friable when dry, mellow when moist.
	48-72 in.	ditto, fine sandy clay and/or lighter textures.

Nambrok clay loam.

Sparsely timbered plain.

A_1	0-7 in.	Brownish grey clay loam; nutty structure; brittle when dry, mellow when moist.
A_2	7-14 in.	Grey, light grey, and rusty yellow and brown, mottled clay loam or light clay; nutty structure; brittle when dry, plastic when moist.
B_1	14-20 in.	Mottled yellow-grey, brown, and red heavy clay, with moderate iron concretions; small nutty structure; friable when dry, stiff when moist.
B_2	20-42 in.	Greyish yellow heavy clay, with decreasing iron concretions and with slight small inclusions of gypsum; blocky structure; hard when dry, stiff when moist.
	42-72 in.	Mottled grey-yellow-brown medium clay, sometimes with limestone rubble and slight inclusions of gypsum.

Denison clay loam.

Sparsely timbered plain: very gentle slopes and flat areas.

A_1	0-8 in.	Grey or brownish grey clay loam; crumb structure; friable when dry, mellow when moist.
A_2	8-14 in.	Grey with light grey and greyish yellow flecking, clay loam, occasionally light clay; compacted and brittle when dry, mellow when moist.
B_1	14-30 in.	Dark yellowish grey with slight red mottling, heavy clay with black staining on cleavage planes, passing to yellow-grey heavy clay; large nutty to blocky structure; hard when dry, stiff when moist.
	30-60 in.	Greyish yellow medium or heavy clay, sometimes with limestone rubble.

Denison clay loam "light phase".

Sparsely timbered plain: very gentle slopes and flat areas.

A_1	0-8 in.	Grey or brownish grey clay loam; crumb structure; friable when dry, mellow when moist.
A_2	8-15 in.	Grey with light grey and greyish yellow flecking, clay loam; slightly compacted and brittle when dry, mellow when moist.
B_1	15-30 in.	Dark yellowish grey with slight red mottling, medium clay with black staining on cleavage planes; nutty structure; brittle when dry, plastic when moist.
	30-48 in.	Greyish yellow, or mottled greyish yellow, yellow, light grey, and brown light clay, sometimes passing to fine sandy clay, with concretionary limestone.

48-72 in. Mottled yellow-grey, yellow, and light grey light clay, with concretionary limestone.

Although the whole profile is generally lighter, the principal difference compared with the normal profile is in the presence of light clay to fine sandy clay textures, instead of medium or heavy clay, between 30 in. and 48 in.

Wandocka clay loam.

Sparsely timbered plain: low-lying situation.

A_1 0-6 in. Grey clay loam; small cloddy structure; brittle when dry, plastic when moist.

A_2 6-12 in. Grey with light grey, yellow-grey and rusty flecking, light clay; cloddy structure; hard when dry, plastic when moist.

B_1 12-27 in. Dark yellowish grey passing to yellow-grey, heavy clay, with slight small iron concretions; large nutty passing to blocky structure; hard when dry, stiff when moist.

27-60 in. Greyish yellow heavy clay, sometimes with limestone rubble and odd small inclusions of gypsum.

There may be some variation from this profile in the deep subsoil. Frequently, a mottled grey and yellow and rather silty type of clay is encountered below 36 in. Such soils have been included with the normal form. Occasionally, light clay, or more rarely fine sandy clay, occurs before 48 in.; the inscription “light deep subsoil” has been used to cover these minor occurrences.

Thomson silty clay loam.

River flat: on a generally flat topography dissected by drainage ways and lagoons.

0-15 in. Grey silty loam with rusty stainings of organic matter; nutty structure; friable when dry, mellow when moist.

15-72 in. Grey with yellowish grey mottling, becoming more yellow with depth, silty medium clay, with occasional small soft iron concretions; blocky structure; hard when dry, stiff when moist.

Thomson silty clay.

River flat: occupying the lower situations.

0-12 in. Grey silty clay with rusty stainings of organic matter; cloddy structure; brittle when dry, plastic when moist.

12-72 in. Grey with yellowish grey mottling, becoming more yellow with depth, silty medium clay, with occasional small soft iron concretions; blocky structure; hard when dry, stiff when moist.

Avon Suite.

River flat: generally flat topography but dissected by drainage ways.

Yellowish alluvium from the Avon River has been deposited over a grey clay, which represents an earlier soil profile. The Avon deposits are sequences of predominantly fine sandy and silty materials, which vary in fineness and in depth to the grey clay according to distance from the river.

Type 1.

0-9 in Yellowish grey-brown fine sand, occasionally fine sandy loam; slightly coherent when dry and when moist.

9-42/84 in. Variable strata of yellowish or greyish, light brown sand, fine sand, and fine sandy loam, with rusty mottling in the deeper horizons.

42/84-108 in. Dark grey with rusty mottling, silty clay loam, passing to mottled grey and yellow-grey silty clay.

This type occurs only adjoining the river. It usually has a hummocky micro-relief. Textures in the profile are never heavier than fine sandy loam above the grey clay, which usually occurs at a depth greater than 4 ft.

Type 2.

0-8 in. Yellowish grey-brown fine sandy clay loam, occasionally fine sandy loam; slightly coherent when dry or moist.

8-18/42 in. Variable strata of yellowish or greyish light brown fine sandy loam and fine sandy clay loam.

18/42-72 in. Dark grey with rusty mottling, silty clay loam, passing to mottled grey and yellow-grey silty clay.

Compared with Type 1, Type 2 occurs further from the river; also, textures are heavier above the grey clay and this occurs before 4 ft.

An area in which a coarse sandy wash has covered Types 1 and 2 recently is marked by inscription.

Type 3.

0-12 in. Yellowish grey-brown silty loam; granular structure; friable when dry, mellow when moist.

12-30 in. Dark grey silty clay loam, passing to yellow-grey silty clay; large nutty structure; hard and brittle when dry, plastic when moist.

30-72 in. Strata of yellow and grey sand.

Type 3 occurs along the lower reaches of the Avon River where flooding is dissipated through marshes and lagoons and the fine sandy materials of higher upstream are replaced by predominantly silty alluvium. The depth to the grey clay is much shallower than in Types 1 and 2, while the underlying yellow and grey sands are not encountered in either of these types.

Unnamed Soil Types.

Because of the related nature of this and the Nambrok-Denison soil survey, the lettering of the minor soil types adopted in the latter survey has been retained. Thus Types A to H refer to soil types recorded previously – actually only Types A, F and G are found in the present area – while suitable letters from J to R have been given to eight new minor types.

Type A.

Upland: small rises adjacent to drainage ways. Very restricted occurrence.

A_1 0-7 in. Brownish grey to grey-brown sand.

A_2 7-15 in. Light brownish grey sand.

B 15-30 in. Yellow and grey mottled sandy clay.

30-48 in. Yellow sandy clay loam or sandy clay.

48-72 in. Variable strata of sand and clay textures.

Type F.

Saline swampland: small depressions. Very restricted occurrence.

A 0-8 in. Grey (black when moist) with rusty stainings, light or medium clay.

B 8-48 in. Grey and yellowish grey, becoming more yellow with depth, heavy clay, with limestone rubble; massive structure; hard when dry, very sticky when moist.

Type G.

River flat: restricted to banks adjoining the Macalister River.

0-12 in. Dark brownish grey clay loam; small nutty structure; friable when dry, mellow when moist.

Gradual transition to :

12-20 in. Brownish grey light clay; nutty structure; brittle when dry, plastic when moist.

20-42 in. Brown or greyish yellow light clay or fine sandy clay; large nutty structure; hard when dry, plastic when moist.

42-72 in. ditto, or more rarely passing to mottled grey and yellow silty clay.

Variation from this profile towards browner colours on banks and greyer colours in hollows is a normal feature of Type G soils. A rather brown subsoil is usual in the soils within the present area, while textures between 24 in. and 48 in. are almost invariably fine sandy clay or fine sandy clay loam.

Type J.

Sandy rise: on crests; also as small knolls associated with Clydebank loam and sandy loam near Stratford and in the Clydebank district.

A_1 0-24 in. Grey-brown, passing to brown sand; loose when dry or moist; diffuse junction with A_2 horizon.

A_2 24-54 in. Light yellowish brown sand; loose when dry or moist.

B_1 54-60 in. Yellow-brown and brown sandy loam or sandy clay loam.

60-84 in. Light yellowish brown sand.

Generally, these soils are derived from wind-piled coarse sediments; however, all very light profile, sandy soils found on rises, whatever their origin, have been included in this soil type. Such inclusions are those with waterworn quartz gravel in the profile and inscribed “gravelly”. They occur adjoining the Tanjil series, and are developing on accumulations of sandy materials over-lying the gravelly deposits associated with that series.

Most Type J soils have at least 48 in. of sand above the B_1 horizon, which is very weakly developed and unusually occurs as clayey lumps anywhere within the sandy zone between 48 in. and 72 in. A clay “bed” is only encountered occasionally before 72 in.

Type K.

Low-lying woodland: at very slightly higher levels than Winnindoo clay loam. Restricted occurrence.

A_1 0-6 in. Grey or brownish grey loam, occasionally fine sandy loam.

A_2 6-12 in. Light grey fine sandy clay loam.

A_3 12-18 in. Light yellowish grey light clay.

B_1 18-36 in. Yellow-brown and yellow-grey with red mottling, heavy clay.

36-72 in. Mottled yellow and grey heavy clay, or mottled light grey, brown, and yellow light clay, sometimes with limestone rubble.

Type K frequently occurs adjoining Winnindoo clay loam on situations normally occupied by Winnindoo loam; also, the surface soil may be indistinguishable from the surface of the latter soil type. Characteristic features are the deep A horizon, very bleached in the lower depths, and the mottled B_1 horizon. The nature of the deep subsoil appears to be related to the adjoining soil types, e.g., it is usually yellowish grey heavy clay when near Winnindoo clay loam, and mottled brown-grey light clay when adjacent to Bundalaguah clay loam.

Type L.

Sparsely timbered plain: restricted to low rises situated between plain and low-lying woodland in the south-west of the area.

A_1 0-12 in. Grey-brown loam.

A_2 12-18 in. Brown clay loam.

B_1 18-30 in. Brown with slight red and yellow-grey mottling, heavy clay with black staining on cleavage planes; nutty structure; crumbly when dry, plastic when moist.

B_2 30-48 in. Brown light clay, sometimes passing to fine sandy clay, with limestone rubble.

48-72 in. Mottled light shades of brown, red, yellow, and grey fine sandy clay.

Type M.

River flat: outlies the Thomson series at levels between it and adjacent undulating rises of the Clydebank series. Restricted to the vicinity of Nuntin Creek.

0-18 in. Grey clay loam; small nutty structure; friable when dry, mellow when moist.

18-33 in. Yellowish grey light or medium clay, occasionally heavy clay; large nutty porous structure; brittle when dry, plastic when moist.

33-48 in. Mottled light shades of grey, yellow, and brown light clay, usually passing to fine sandy clay.

48-72 in. ditto, or occasionally yellow-grey silty clay.

The surface is sometimes a silty clay loam, but siltiness gives way to a fine sandy influence in the subsoil horizons. Type M occupies a similar situation in the topography to Type G in the Nambrok-Denison area, but differs from that type in the dominant greyness of the profile and in the heavier texture of the 24 in. to 36 in. zone.

Type N.

Low-lying grey soil: very light profile. Occurrence very restricted.

In some small low-lying areas, the soil profile is grey with sand to sandy clay loam textures above 48 in.; gravel may be present. The average profile has not been determined.

Type P.

Low-lying grey soil; light subsoil and deep subsoil. Associated with the soil types of the sparsely timbered plains and sandy rises as well defined, small depressions, and as broad, flat areas between pronounced rises.

A 0-16 in. Grey passing to light grey, sandy clay loam or clay loam.

B 16-27 in. Mottled yellow and grey sandy clay, occasionally heavier.

27-72 in. Mottled yellow and grey sandy clay loam, passing to lighter textures.

Type Q.

Low-lying grey soil: heavy subsoil and light deep subsoil. Principally restricted to broad, low situations in the extreme east of the area.

A_1 0-6 in. Grey clay loam or light clay.

A_2 6-12 in. Grey and yellow-grey light clay to heavy clay.

B 12-30 in. Yellow-grey with light grey and rusty mottling, heavy clay, usually with iron concretions.

30-48 in. Mottled light grey – yellow-red sandy clay or light clay, usually with iron concretions.

Type R.

Low-lying grey soil: heavy profile. Depressions and drainage lines in the sparsely timbered plain topography.

A_1 0-6 in. Grey clay loam.

A_2 6-10 in. Grey with light grey and rusty brown staining, light to heavy clay.

B 10-30 in. Grey and yellow-grey heavy clay.

30-48 in. Greyish yellow and light grey heavy or medium clay, occasionally with limestone rubble.

This soil type includes minor depressions of the Type 3 variety of the Nambrok-Denison area.

3. The Soil Maps.

The soil maps accompanying the bulletin are, (i) a map of the soil associations, (ii) two maps of the soil types.

The map of the soil associations shows, at a scale of 1 inch to the mile, the distribution of the thirteen soil associations described in a previous section. The area adjoining the Macalister River near Maffra is not included.

The maps of the soil types show the situations of the individual occurrences of each soil type. The smaller map is of the Macalister flats, while the larger is of the principal area in the parishes of Nuntin and Bundalaguah; both are at a scale of 1 inch to 40 chains. In some areas shown on the map by diagonal hatching and double symbols, two soil phases or two soil types occur together, but the individual situations of each are not delineated.

Situations of mixed gravelly and normal phases of the Tanjil series are the principal areas in this category.

The inscriptions on the maps relating to soil variations have been explained under the appropriate soil type descriptions; abbreviations of these have been used in some instances, viz., "l. p." = light profile, "l. s." = light surface, "l.d.s." = light deep subsoil, "d.s." = deep surface, "d.s.s." = deep sand surface, "gr." = gravelly.

Certain areas have been excluded from soil survey because of their obvious unsuitability for irrigation; however their natures are indicated by self-explanatory inscriptions. The terms used are:- sandy knoll, river frontage (abbreviated R.F.), and swampy and saline soils.

The more important drainage features such as swamps, lagoons, and pronounced drainage ways are shown on the maps.

4. Extent of the Soil Types.

In Table 2 are shown the areas of the principal and subordinate soil types in each soil association, and the acreages and proportions of the soil types in the total area surveyed.

Table 2 – Areas of Soil Types

Soil Association	Soil Type	Acres	Total Acre age	As % of area
Tanjil	Tanjil sandy loam[X]	727	933	5.6
2,519 ac.	Tanjil loam[X]	1,031	1,415	8.4
	Winnindoo loam	414	885	5.3
	Winnindoo clay loam	233	2,794	16.7
Winnindoo –	Winnindoo loam	446		
Tanjil	Winnindoo clay loam	482		
1,656 ac.	Tanjil sandy loam	167		
	Tanjil loam	326		
Winnindoo	Winnindoo clay loam	2,054		
2,191 ac.				
Nuntin	Nuntin sandy loam[X]	390	598	3.6
694 ac.	Clydebank + J types	266		
Type J	Type J	200	439	2.6
348 ac.	Nuntin sandy loam	113		
Clydebank –	Clydebank sandy loam	152	228	1.4
Type J	Clydebank loam	277	1,378	8.2
848 ac.	Types J (152), P (171)	323	346	2.1
Type Q-Clydebank	Type Q	184	199	1.2
599 ac.	Clydebank loam	199		
Clydebank	Clydebank clay loam	1,204	1,239	7.4
2,148 ac.	Clydebank loam	699		
Denison	Denison clay loam[X]	735	1,308	7.8
896 ac.				
Wandocka	Wandocka clay loam	934	1,124	6.7
1,502 ac.	Denison clay loam	457		
Bundalaguah	Bundalaguah			
818 ac.	clay loam	666	666	4.0
Avon	Avon Suite Type 1	553	553	3.3
1,134 ac.	“ “ Type 2	359	359	2.2
	“ “ Type 3	197	197	1.2
Thomson[φ]	Thomson si. cl. loam	370	374	2.1
591 ac.	Type M	192	208	1.2
Various minor soil types			538	3.2
Unclassified areas (swamps, lagoons etc.)			980	5.9

[X] Including phase [φ] Excluding 942 ac. of Macalister River flats

IV. PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS.

The methods used in the laboratory examination of the soils are essentially those described by Piper (4).

All estimations were carried out on the air-dried fine earth, i.e., material passing a 2 mm. Round hole sieve. In the case of calcium carbonate, nitrogen, and organic carbon estimations, the samples were weighed from subsamples which had been ground all passed through an eighty mesh sieve.

1. Mechanical Analysis.

The mechanical compositions of 103 soils from 18 profiles representative of the more important soil types and phases are given in Appendix 2, while the summation curves in Fig. 2 illustrate graphically the proportions of sand, silt, and clay particles in significant A and B horizons of 15 of the soil types.

In the gravelly phases of the Tanjil series, gravel, from little or nothing in the A_1 horizon, increases to maximum concentrations in the A_2 horizon. Values recorded in this horizon are 48% and 66% if the fine earth; however, percentages have little significance owing to the wide variation in the size of the gravel and stone. Gravel falls off in the B_1 horizon but reappears in quantity below 30 in. The influence of the large mineral fragments in the parent alluvium is reflected by high proportions of coarse and fine sands in the A horizons. Silt is at a relatively low level throughout the whole profile. The big difference in clay contents between the A and B horizons which is typical of the Tanjil series is well illustrated in Fig. 2.

Type J and Nuntin sandy loam are also soil types in which coarse sand is significant. In Type J, coarse and fine sand together contribute well over 90% of the mineral particles to a depth of 3 ft. or more. The profile sampled does not reveal the weak B horizon of clay accumulation of this type. Fig. 2 illustrates a general similarity in mechanical composition between the A horizons of Type J and Nuntin sandy loam, but shows a definite increase in clay content in the B horizon of the latter soil type. However, this horizon is not nearly so strongly developed as in the more mature Tanjil sandy loam.

Winnindoo clay loam and Wandocka clay loam have very similar summation curves. Both soil types are developing on alluvium which is approximately 90% clay and silt. They appear to be well advanced towards maturity, since their A and B horizons are distinctly differentiated texturally (Fig. 2), although the fine nature of their sediments is not conductive to eluviation of clay.

The two profiles of the light phase of Denison clay loam recorded, show that this soil is appreciably lighter in mechanical composition that the normal Denison clay loam described in the Nambrok-Denison area. This fact is not entirely evident from field observations of the A and B horizons, although the lighter nature of the deep subsoil is readily apparent. Silt exceeds fine sand in the normal Denison clay loam profile, but the reverse is the case in the A and B horizons of the light phase illustrated in Fig. 2. Largely for this reason, the summation curves indicate that the light phase of Denison clay loam has textural affinities with the Clydebank and Bundalaguah series, soils with which it is associated in this area.

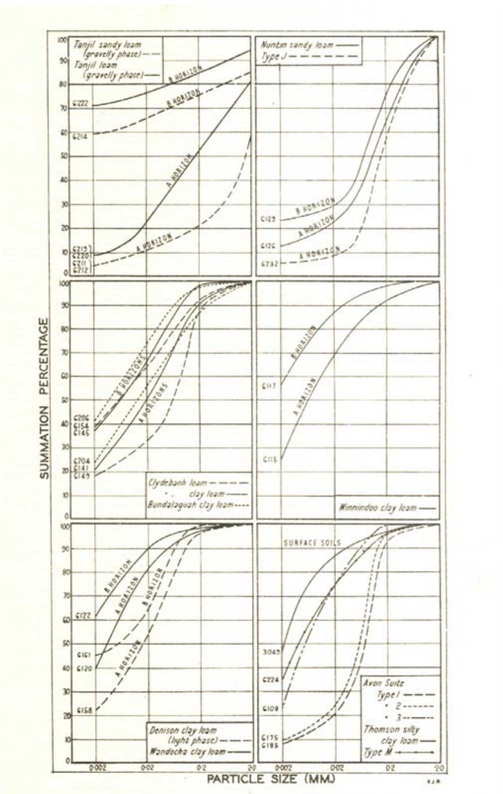


Figure 2 – Summation Curves of A and B Horizons of Soil Types

Although Clydebank clay loam and Bundalaguah clay loam are not found contiguously, the summation curves reveal a distinct textural similarity between these two types, both in the A and in the B horizons. However, the fuller data in Appendix 2 suggest that pedogenic processes have proceeded further in the Bundalaguah clay loam. In the profile illustrative of this type, there is a sharp rise in clay content from 21.3% in the A horizon (0-15 in.) to 37.6% in the B_1 horizon (16-26 in.), whereas, in the Clydebank clay loam profile, clay accumulates gradually from 19.6% in the A (0-14 in.) to 35.0% in the B_1 horizon (21-35 in.) through intermediate horizons of 21.4% (14-18 in.) and 28.9% (18-21 in.). Further, there is a B_2 horizon of lime accumulation in the Bundalaguah clay loam which is not found in the Clydebank clay loam.

A textural similarity is evident between Clydebank clay loam and Heyfield clay loam, although the sand/silt ratio is wider in the A horizons of Clydebank clay loam. These two soil types have some morphological characteristics in common and occupy rather similar situations in their respective topographies.

Clydebank loam exhibits a slightly lighter profile than Clydebank clay loam, accompanied by an increase in fine sand at the expense of silt. This is carried a stage further in the Clydebank sandy loam.

Profile 3049 – 3052 illustrates the essentially silty and clayey nature of the alluvium giving rise to the Thomson silty clay loam, and also shows that there has been but little profile development. Soils 3053 and 3054 represent increasingly fine sandy sediments underlying the more recent alluvium. The Type M profile suggests an affinity with Thomson silty clay loam, but indicates that fine sand is a rather more significant constituent of the alluvium.

Fine sand is very much the dominant constituent to beyond 4 ft. in the profiles of both Types 1 and 2 of the Avon Suite. Silt and clay fractions are each low. Such sediments are in accordance with deposition from the fast-flowing flood waters of the Avon River in this region. Soil 6184, by comparison with series 3049 – 3052, suggests that these sediments are resting on fine alluvium of the Thomson type. The profile of Type 3 differs considerably from Types 1 and 2 in that silt and not fine sand is the dominant sediment in the immediate deposits, while the underlying Thomson type alluvium is quite close to the surface (12-28 in.). In addition, coarse sandy strata occur below 32 in., an indication of a further alteration of stream activity in this vicinity.
In Table 3, the detailed data of Appendix 2 is summarised in respect to clay content of all horizons from the surface to the lower limit of the zone of maximum clay accumulation. This makes possible a ready appreciation of the major textural change between surface and subsoil in each of the principal soil type, an important factor contributing to the water relationships of the soils. But it should not be overlooked that penetration of water depends on other soil factors besides mechanical composition. However, the data enable the following generalisations to be made:- Type J and Types 1 and 2 of the Avon Suite are very light textured to 4 ft. or more and will absorb water very readily. Both Tanjil types are light on the surface and will probably take water readily enough to a depth of about 10 in., but penetration may then be impeded by the heavy subsoil (60-70% clay). On the other hand, the light surface soil types, Nuntin sandy loam and its heavy phase, and Clydebank sandy loam, are deeper, and possess much lower clay contents in their subsoils (24-34%), features which suggest easy permeability throughout the profiles of these soil types. A group of soils comprising Clydebank loam, Clydebank clay loam, Bundalaguah clay loam, and Denison clay loam "light phase" posses good depths of medium textured soil overlying subsoils with moderate clay contents (33-45%). Satisfactory water penetration is expected in these soils under irrigation. Two soil types, Winnindoo clay loam and Wandocka clay loam, have rather shallow, heavy surface soils (29% ad 40% clay) and heavy subsoils (56% and 65% clay). Movement of water in such soils is usually slow and penetration of irrigation water may be restricted to shallow depths. However, Wandocka clay loam has been included previously (1) with Denison clay loam in possessing structural and other advantages in the subsoil which are conductive to better penetration of water than in the Winnindoo series. Thomson silty clay loam and Type M are characterised by heavy surface soils which increase but little in clay content with depth. Good structural qualities in these soil types are expected to favour water absorption.

Table 3. - Clay Contents of Soil Types.

(Clay percentages are weighted averages compiled from data in Appendix 2 on the basis of gravel + coarse sand + fine sand + silt + clay = 100%).

Soil Type	Surface and Sub-surface		Subsoil	
	Depth in.	**Clay %**	**Clay %**	**Depth in.**
Tanjil sandy loam				
gravelly phase	0-10	4	60	13-22
Tanjil loam				
gravelly phase	0-7	9	70	8-28
Winnindoo clay loam	0-7	29	56	8-24
Type J	0-22	5	4	22-66
Nuntin sandy loam	0-27	12	24	27-37
" " heavy phase	0-18	9	34	18-34
Clydebank sandy loam	0-16	10	25	16-32
" loam	0-18	17	33	18-42
" clay loam	0-18	21	36	18-35
Bundalaguah clay loam	0-15	23	40	16-26
Denison clay loam				
light phase	0-17	23	45	17-28
Wandocka clay loam	0-10	40	65	10-22
Thomson silty clay loam	0-10	45	48	10-33
Type M	0-16	35	36	17-34
Avon Suite				
Type 1	0-18	8	8	18-46
" 2	0-21	9	11	21-48
" 3	0-12	29	48	12-28

Small amounts of lime in the fine earth, usually less than 0.2%, are present in the deep subsoil horizons of the Denison clay loam, Bundalaguah clay loam, and Wandocka clay loam. Concretionary calcium carbonate of gravel size is present in two profiles, viz., 20% at 45-62 in. in the light phase of Denison clay loam and 3.8% at 34-46 in. in the Bundalaguah clay loam.

2. Reaction.

The reactions of the individual horizons in the profiles of the soil types sampled are given in Appendix 2. Considering all values, the reactions lie within a very wide range, viz., pH 3.9 – 9.4. On the other hand the surface soils are remarkably uniform in reaction, 78% being within the narrow range of pH 5.5 – 5.9, while all are within the range 5.3-6.2.

Table 4. - Frequency Distribution of Reaction Values of Soils.

Horizon	4.0-4.4	4.5-4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	7.0-7.4	7.5-7.9	8.0-8.4	8.5-8.9	9.0-9.4	No.
Avon Suite, Thomson silty clay loam, Type M.												
Surface				5								5
Subsur.		1		3	1							5
1-2 ft.	1			1	3							5
2-3 ft.	1			1	3							5
3-4 ft.	1			2	1				1			5
Tanjil, Winnindoo, Nuntin, Clydebank series, Type J.												
A_1			2	6	1							9
A_2				2	4	3						9
B_1			1	1	2	5						8
2-3 ft.				1	2	3	1					8
3-4 ft.					2	2	3					7
Bundalaguah, Denison, Wandocka Series.												
A_1				4								4
A_2				3	1							4
B_1						2	2					4
2-3 ft.							1		2	1		4
3-4 ft.									1	2	1	4

In Table 4, the data have been assembled to show the frequency distribution of the pH values for different zones of the soil profile. The soil types are grouped in three different categories in this table. The first group comprises all the river flat soil types. In general, these soils are moderately or slightly acid and the reaction alters very little with depth to 4 ft. or lower. The pH's of the majority of the soils are between 5.5 and 6.4, but exceptions are Type 3 of the Avon Suite, which passes to strongly acid reactions in the subsoil, and the deep subsoil of the Thomson silty clay loam, which is strongly alkaline below 3 ft.

In the second group, there is a slight trend towards less acid reactions with depth in the profile. As a rule the B_1 horizons are only slightly acid, while deeper zones either may be slightly acid also or may be approximately neutral. The soil series included in this group are of various ages and have been derived from a variety of sediments under several topographic situations. Pedogenesis under combinations of these factors has given rise to broadly similar pH profiles in these soil series; however, this does not indicate that they are otherwise morphologically related.

The third group includes the principal soil types of the sparsely timbered plains. Reaction pass from acid in the A to neutral in the B_1 horizons, and then frequently increase to values above pH 8.0 before 3 ft. Deeper horizons may be even more alkaline. Although lime is often found in the deep subsoils of these soil types, sodium and magnesium ions contribute also to the high reactions.

3. Nitrogen and Organic Carbon.

Table 5 shows the average nitrogen, organic carbon, and C/N values for three textural classes of surface soils.

Table 5. - Average Nitrogen and Organic Carbon in Surface Soils.

Textural Group	No. of Soils	N %	C %	C/N
Sandy loam	7	0.119	1.45	12.2
Loam	3	0.152	2.11	13.9
Clay loam	8	0.259	3.36	13.0

For the soils as a whole, these figures indicate that the organic matter and nitrogen content of the clay loam soils are good, while those of the loams and sandy loams are satisfactory. The relationship of organic matter with texture and the C-N ratio are normal.

Individual values for organic carbon, nitrogen, and C-N ratio in the surface soils of the soil types sampled are given in Appendix 2. Apart from the normal influence of texture, these do not show any significant difference between soil types except in the Thomson silty clay loam. A nitrogen value of 0.583% denotes a particularly good organic matter status in this soil type.

4. *Exchangeable Cations.*

The exchangeable metal ions present in the surface and other horizons of five of the principal soil types are given in Table 6.

The data for Winnindoo clay loam and Wandocka clay loam are in agreement with those reported previously for these soil types, while that for the light phase of Denison clay loam is similar to the normal profile of this soil type (1). Total exchangeable metal ions are low in both surface and subsoils when clay contents are taken into consideration. In the A and B_1 horizons, the low values are due partly to a fairly high degree of unsaturation[×] of the absorbing complex (pH range 5.5 – 6.4), but previous data (1) suggest that a rather low exchange capacity of the clay colloid is also a factor in the soils of the area generally. In this connection, the total exchangeable metal ions of the fully saturated subsoil 6125 (pH 8.7), when calculated on a clay basis, is 29.1 m.e. per 100 g. of clay. Compared with soils from Northern Victoria this is a moderate value, e.g., values for base saturated subsoils (pH 8.5 – 8.7) from Kerang (5) and Shepparton (6) are, respectively, 61.5 and 55.6 m.e. per 100 g. of clay. Although calcium is the dominant exchangeable metal ion in the surface soils, magnesium is also an influential ion.

In the subsoils, exchangeable magnesium and sodium increase at the expense of calcium, the high proportion of sodium affording evidence of a solonising process in the pedogenesis of these three soil types. Exchangeable potassium is particularly low in all horizons and indicates the possibility of deficiencies of available potash.

Table 6. - Exchangeable Metal Ions.

Soil Type	Soil No.	Depth (in.)	pH	Clay %	Total Ex.Me. ions. [X]	% of total metal ions as			
						Ca	Mg	K	Na
Clydebank loam	6149	0-8	5.3	16.8	4.3	64	21	12	3
Clydebank	6141	0-9	5.7	19.3	8.6	72	23	3	2
clay loam	6145	21-35	6.5	35.0	9.4	37	57	2	4
Denison	6158	0-8	5.7	20.6	8.1	65	29	2	4
clay loam	6161	17-28	6.5	42.5	13.6	30	58	1	11
“light phase”									
Wandocka	6120	0-6	5.9	35.5	9.4	59	33	3	5
clay loam	6122	10-15	6.4	57.3	13.4	36	52	1	11
	6125	30-48	8.7	64.3	18.7	20	55	1	24
Winnindoo	6115	0-3	5.9	23.0	8.0	45	45	3	7
clay loam	6117	8-24	5.5	53.0	11.9	14	70	1	15

[X] Total exchangeable metal ions as milligram equivalents per 100g. of air dried soil.

[×] Saturation refers to equilibrium with excess calcium carbonate. The pH of such soils is about 8.4.

The two Clydebank soil types also have low total exchangeable metal ions, but the rations of calcium to magnesium in the surface soils are wider than in the other soil types illustrated. Potassium is low except in the surface soil of Clydebank loam. Subsoil 6145 indicates that magnesium is the influential exchangeable ion in the B horizon of Clydebank clay loam, while sodium is not an important ion.

5. *Soluble Salts.*

Specific conductivity, as a convenient measure of total soluble salts, and chloride values are given in Appendix 2 with the other data for the representative profiles of the soil types.

Chlorides are insignificant in all horizons of the Nuntin and Clydebank series, Type 1 of the Avon Suite, and Types J and M. Values are also low in the surface horizons of the Thomson, Tanjil, Bundalaguah, Wandocka, and Denison series, and Type 2 of the Avon Suite, but increase in the subsoil horizons, usually to between 0.05% and 0.10%. One profile of Denison clay loam shows higher concentrations. In the Winnindoo clay loam profile – an inherently more saline soil type – chlorides exceed 0.25% in the subsoil horizons, reaching a maximum of 0.33% at 2-3 ft. Type 3 of the Avon Suite shows high concentrations above 30 in. in the profile.

For soils of this area, it has been determined that, except for low concentrations (specific conductivity below 20), the approximate percentage of total water-soluble salts in the soil may be arrived at by multiplying the specific conductivity as reported by 0.0035. In the soil type profiles, the total soluble salts follow the same general trend as the chlorides.

Analyses of the total water-soluble salts in selected horizons of four of the main soil types are given in Table 7.

Table 7. - Analysis of Soluble Salts.

Soil Type	Soil No.	Depth (in.)	K^X	Total Soluble Salts %	Milliequivalents per 100 g. of air dried soil.						
					Cl	SO_4	HCO_3	CO_3	Ca	Mg	Diff.$^+$
Winnindoo clay loam	6115	0-3	15	0.085	0.79	0.33	0.33	Nil	0.05	0.21	1.19
Bundalaguah clay loam	6204	0-8	7	0.067	0.45	0.27	0.20	"	0.15	0.25	0.52
	6206	16-26	17	0.081	0.82	0.38	0.15	"	0.15	0.12	1.08
Denison clay loam	6195	0-5	23	0.097	0.90	0.46	0.25	"	0.15	0.37	1.09
Wandocka clay loam	6120	0-6	12	0.081	0.51	0.52	0.21	"	0.10	0.12	1.02
	6122	10-15	14	0.100	0.65	0.79	0.23	"	0.30	0.12	1.25
	6124	22-28	32	0.139	1.41	0.63	0.23	"	0.05	0.16	2.06

^{X} K = Specific conductivity of 1 : 5 soil : water suspension at 20°C in mhos x10^5

$^+$ Difference between sum of anions and cations – mainly sodium and potassium, principally the former.

Chloride is the principal anion except in the two upper horizons of the Wandocka clay loam, where sulphate is slightly dominant. Bicarbonate is not an important ion. Sodium was not determined directly, but appears to be the most significant cation in all horizons examined. Calcium and magnesium are at low levels. The data suggest that the water-soluble salts consist largely of sodium chloride with some sodium sulphate, and that the chloride content alone is a sufficiently good indication of the presence of injurious salts in the soils.

The distribution of salt throughout the area has been investigated by systematic soil sampling during the survey. About 1,300 samples from all soil types have been analysed for chloride content. These data are summarised in Table 8 for the 3-4 ft. zone which is most frequently the zone of maximum salt content in the soil profile. In the table, soil types, when their salt levels are similar, are grouped in their soil series. The Winnindoo clay loam is listed separately from the Winnindoo loam since the former type shows an appreciably higher salt status. Minor soil types are included with the soil type or series with which they principally occur in the topography.

Table 8. - Frequency Distribution of Salt (NaCl) for 3-4 ft. Depth.

Soil Group	Proportion of samples in which percentage of salt was :-						No. Of Samples
	below .050	.051-.100	.101-.150	.151-.200	.201-.300	above .300	
Tanjil series	33	30	20	12	4	1	110
Nuntin Sandy loam Type J	69	21		7	3		29
Winnindoo loam Type K	25	29	29	14	3		63
Winnindoo clay Loam	16	18	22	22	21	1	142
Clydebank series	50	35	10	5			186
Bundalaguah Clay loam Type L	26	37	23	10	3	1	62
Denison clay Loam	13	36	22	20	6	3	94
Wandocka clay Loam	12	27	29	17	14	1	66
Low-lying Grey soils (Types P, Q, R)	33	31	17	13	6		54
Avon Suite	44	23	12	6	6	9	34
Thomson series Types M and G.	37	36	19	6	2		160

The data indicates that moderately saline subsoils (0.15 – 0.30% NaCl) may be expected in many situations irrespective of soil type. However, certain soil groups, notably Clydebank and Nuntin, are more satisfactory than others. A number of the groups, viz., Tanjil, Winnindoo loam, Bundalaguah, and Thomson show a fairly high proportion of subsoils with salinity in the 0.15 – 0.20% range, but with very few more saline. With adequate drainage facilities, soil salinity should not be a factor in preventing successful irrigation of these soil types; similarly with the majority of the Denison clay loam, Wandocka clay loam, Avon Suite, and Types P, Q and R occurrences, although salt contents above 0.20% are more frequent in the subsoils of these latter types. It may be advisable to exclude certain of the more saline situations from irrigation. Winnindoo clay loam shows the highest proportion of subsoils (22%) with salt contents above 0.20% and some such situations are not regarded favourably for irrigation; however, with careful handling most other situations could be irrigated satisfactorily.

V. RELATION OF THE SOILS TO IRRIGATION.

The soil associations described earlier afford a convenient basis for assessing the potential usefulness of the soils generally to irrigation. The influences of such factors as topography, salinity, and soil type in relation to the irrigation of each of the soil associations are discussed below.

Tanjil. In the Nambrok-Denison area this class of country has been recommended only for restricted irrigation (1). The soil types are inferior to the Thomson, Denison, Wandocka, Clydebank, and Bundalaguah series and the associated minor soil types, and would only warrant development under irrigation after these better soils have been utilised. At present the natural pastures are used for grazing sheep and cattle, but are capable of improvement with subterranean clover, rye grass, and superphosphate under light irrigation. The total water requirements for this purpose would not be large. The gravelly nature of some of the surface soils may be a hindrance to cultivation and grading for irrigation purposes.

Winnindoo-Tanjil. For developmental purposes, this soil association can be included with the Tanjil, provided consideration is given to a rather higher incidence of inherent salinity in the lower-lying soils. However, no situations need be excluded on this account.

Winnindoo. Most of this association is Winnindoo clay loam which has been regarded adversely for general irrigation in the Nambrok-Denison area (1). Disabilities of this soil type are its low fertility, shallow surface, low-lying situation, and the relatively high salt content of the subsoils. The soils would require careful handling under irrigation having regard to these factors, but some at least should respond to good management. This association can be developed best along with the Tanjil and Winnindoo-Tanjil associations, except for a few situations of high salinity.

Nuntin. The soils generally are light and deep and can be expected to absorb water very readily under irrigation and to dry out rapidly during the summer months. For these, as well as for topographic reasons, the very light Type J is regarded as an unsuitable soil type for irrigation. The principal soil type, Nuntin sandy loam, appears better suited for annual pastures developed under light irrigation than for the permanent type of pasture. Soil salinity is at a satisfactory level. The association can best be compared with the Tanjil in its usefulness to irrigation, although much of the country appears to be above possible water-supply level.

Type J. The soil s in this association are mainly unsuitable for irrigated pastures, and, in any case, are largely not commandable.

Clydebank. The soils should be suitable for the irrigation of permanent pastures, while lucerne can be expected to do well in the rather permeable Clydebank loam and clay loam. Minor occurrences of other soil types are numerous in this association and some situations are less attractive soils; however, these should not interfere with the general development of this association under irrigation. Soil salinity is at a generally low level and will not be a hazard to successful irrigation.

Clydebank – Type J. This is a patchy soil association from the aspect of general irrigation owing to the erratic distribution between the very sandy and unsuitable Type J, the relatively light types Clydebank sandy loam and Type P. In addition, contours in some situations may not be favourable for irrigation lay-out. Soil salinity is not a problem. The association is not entirely useless for irrigation, but development would depend on local circumstances such as the topography, detailed pattern of soil types, proximity to better class country, and water available.

Type Q – Clydebank. Future development of salinity appears to be the hazard associated with irrigation of Type Q and the adjoining Clydebank loam; otherwise the soils are suitable for general irrigation with the exception of parts of Type Q which are heavy textured and very low-lying and swampy. At present, the soils are not saline to a degree detrimental to the establishment of irrigated pastures, although there are several minor areas of fairly high salinity. However, this country is low and at the extremity of the area, and subsoil water is present in some situations of Type Q; consequently, it may be difficult to prevent development of salinity if irrigation is extended into this area.

Denison. The soils are mostly suitable for permanent pastures under general irrigation. Subsoil salinity reaches moderate levels in a number of areas and odd situations may need to be excised from irrigation. Adequate attention to the use of irrigation water and to drainage from the outset is indicated on this account.

Wandocka. The Wandocka association is probably equal to the Denison except that salinity is rather more extensive. But it should be possible to put a fair proportion of this soil association under general irrigation if treated similarly to the Denison association.

Bundalaguah. Bundalaguah clay loam is an attractive soil type for irrigation and appears to support permanent pastures satisfactorily in the adjoining Maffra-Sale Irrigation District. It appears to be a suitable soil for lucerne. Some situations are moderately saline in the subsoil, but, in general, the salt status of the soils is satisfactory.

Avon. Exclusive of saline situations, this association comprises soils more or less suitable for irrigation. Type 2 of the Avon Suite is an attractive soil for general irrigation, but Type 1 is very light in texture – particularly when in close proximity to the river – and is unattractive on this account. Type 3 is too saline for development under irrigation. Flooding of all three soil types is a hazard, and Type 1 is typically hummocky due to turbulent water action on the light surface soil.

Thomson. Near Stratford this association of highly fertile soils should be excellent for general irrigation; but on the Macalister River flats south of Maffra, salinity in the subsoils is at a higher level and the soils are less attractive for this reason. However, the soils should respond well apart from one fairly extensive situation which appears too saline for irrigation. Generally, the topography is suitable for irrigation lay-outs, but flooding from the Macalister may be a drawback in the vicinity of that river.

Summarised, the relation of the soils in the district to irrigation is as follows:-

The Thomson, Clydebank, and Bundalaguah soil associations are neatly wholly suitable for the general irrigation of permanent pastures capable of supporting dairy cattle and fattening stock; the Denison and Wandocka associations also are suitable except for certain areas with saline subsoils; and it may be possible to utilise parts of the Avon and Clydebank-Type J associations for this purpose.

The Tanjil, Winnindoo-Tanjil, Winnindoo, and Nuntin associations consist of inferior soils, non-commandable soils, and those requiring a special approach towards establishment of irrigated pastures. Light irrigation of subterranean clover-rye grass pastures is suggested as the best treatment for some of these soils.

There are hazards connected with irrigation for the Type Q – Clydebank association, while the Type J association and portions of the Avon association are generally unsuitable for irrigation.

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APPENDIX I. - Soil Terms and Definitions.

The ***morphology*** of the soil is the physical constitution of the various and their arrangement in the soil profile.

The soil profile is the succession of soil horizons down to the parent material or substrata. It embodies all the processes of soil formation and is the unit of soil study.

A soil horizon is a layer of soil with similar characteristics. The horizon may be distinguished by differences in one or more of the following soil characters :- colour, texture, structure, organic matter content, and the presence of visual products of weathering such as calcium carbonate and iron concretions. The sequences of horizons from the surface downwards in the soils described is :-

A_1 – The surface layer in which organic matter has accumulated, and partly leached of clay and soluble material.

A_2 – A lighter coloured layer, poor in organic matter. This is the zone of maximum leaching.

B_1 – A zone of accumulation of some materials, chiefly clay, from A1 and A2 horizons.

B_2 – A zone of accumulation of calcium carbonate leached from upper horizons.

C – A layer representing unchanged material from which the above horizons have formed.

Illuvial material is material deposited as the result of translocation during soil weathering processes. It is customary to refer to the A horizons as ***eluvial*** horizons, and to the B horizons as ***illuvial*** horizons, the whole process being one of eluviation

Lime is calcium carbonate and may occur as illuvial material in the B and C horizons, both in a soft form and in concretions described as rubble.

Gypsum is illuvial calcium sulphate.

Ferruginous concretions are more or less rounded nodules of variable size and composition formed by the deposition of iron oxide (sometimes with other materials) in the lower A_2 and the B horizons.

A soil type is a group of soils derived from similar parent material under similar conditions of development, giving rise to the same general profile characteristics. It is the unit of soil mapping.

A soil series consists of one or more soil types of the same general profile form, but differing in the texture of the surface soil. Such a series is named after the locality of its most common occurrence within the area in which it was first described.

A phase is a modification of a soil type in which one feature is accentuated without altering the main profile form.

A variation is a minor modification of a soil type and is usually indicated by suitable notation on the soil map.

The structure of the soil refers to the morphology of the soil aggregates. The types of structure in the soils described are crumb, granular, nutty, cloddy, blocky, and massive.

The consistency of the soil refers to the stability of the soil aggregate in both the dry and the moist state. The terms used are :- in the dry state; loose, friable, compacted, brittle, and hard :- in the moist state; coherent, mellow, plastic, sticky, and stiff.

APPENDIX 2. - Mechanical Analyses and other Data for the Soil Types.

Gravel, concretionary iron oxide, and limestone rubble are expressed as percentages of the field samples, and specific conductivity as that of a 1:5 soil:water suspension at 20^{o}C in reciprocal ohms x10^{5}; while all other figures, except those for depth, reaction, and C:N ratio, are percentages of air dried soil passing a 2 m.m. sieve.

The following abbreviations are used to describe field texture:-

S	-	sand
SL	-	sandy loam
L	-	loam
CL	-	clay loam
SCL	-	sandy clay loam
SC	-	sandy clay
FS	-	fine sand
FSL	-	fine sandy loam
FSCL	-	fine sandy clay loam
FSC	-	fine sandy clay
LC	-	light clay
MC	-	medium clay
HC	-	heavy clay
Cl	-	clayey
Gr	-	gravelly
Si	-	silty

SOIL TYPE	TANJIL SANDY LOAM GRAVELLY PHASE						TANJIL LOAM GRAVELLY PHASE				
Soil No.	6211	6212	6214	6215	6216	6218	6219	6220	6221	6222	6223
Depth (in.)	0-4	4-10	13-22	22-25	25-32	48-54	0-5	5-7	8-12	12-28	32-40
Texture	SL	GrS	HC	HC	GrC	S+GrC	L	L	HC	HC	GrC
Gravel	28	48	14	23	23	32	0	66	1	5	42
Coarse sand	44.5	47.5	10.6	11.4	21.1	49.3	33.6	37.0	15.7	9.8	26.9
Fine sand	32.1	33.3	11.0	12.9	16.4	23.7	35.7	32.7	14.9	7.9	14.3
Silt	12.7	10.3	6.8	8.0	7.1	7.6	15.8	14.4	8.1	6.4	5.8
Clay	7.1	6.7	65.6	62.9	51.2	18.4	10.4	12.4	55.3	69.4	49.5
Moisture	0.8	0.4	5.0	5.0	3.8	1.3	1.2	1.2	4.2	6.1	3.4
Loss on acid treatment	0.6	0.4	1.4	0.8	0.5	0.4	0.9	0.6	1.8	1.0	0.7
Loss on ignition	3.1	1.6	9.0	8.0	6.6	2.2	4.3	3.7	7.9	8.5	5.5
Specific conductivity	4	4	26	32	30	12	6	6	14	55	61
Chlorides (Cl)	.003	.004	.033	.049	.045	.014	.005	.006	.014	.075	.073
Nitrogen	.095						.118				
Organic carbon	1.47						2.02				
C-N ratio	15.5						17.1				
Reaction (pH)	5.4	6.2	6.5	6.1	6.1	6.2	5.9	5.9	6.6	6.6	5.9

SOIL TYPE	NUNTIN SANDY LOAM					NUNTIN SANDY LOAM HEAVY PHASE						TYPE J		
Soil No.	6126	6127	6128	6129	6130	6133	6134	6135	6136	6137	6138	6232	6234	6236
Depth (in.)	0-5	5-11	11-27	27-37	37-60	0-10	10-18	18-24	24-34	34-41	41-54	0-7	22-36	66-84
Texture	S-SL	SL	S	SC	ClS	SL	S	SC	LC	LC	SC	S	S	S
Gravel														
Coarse sand	34.1	32.5	28.8	23.4	33.4	30.7	31.3	25.9	23.7	29.2	28.5	42.0	45.4	32.4
Fine sand	40.4	41.4	50.3	44.3	44.7	44.7	51.1	34.3	26.2	29.7	34.9	46.8	48.6	60.5
Silt	9.6	9.8	7.3	5.9	3.8	12.7	9.7	9.6	8.9	6.9	7.4	3.0	2.9	1.8
Clay	12.2	13.6	11.3	22.8	15.2	9.5	7.7	26.0	36.5	30.9	25.4	5.1	3.4	3.9
Moisture	1.2	0.9	0.6	1.4	0.9	0.7	0.3	1.4	2.4	2.0	1.9	0.6	0.2	0.2
Loss on acid treatment	0.6	0.7	1.1	0.6	1.0	0.9	0.5	1.2	1.2	1.2	0.5	0.6	0.1	0.1
Loss on ignition	3.9	2.9	1.6	2.7	1.8	2.4	1.4	3.4	4.6	3.9	3.2	2.9	0.8	0.7
Specific conductivity	4	4	5	7	4	5	5	4	5	5	5	4	2	3
Chlorides (Cl)	.003	.005	.006	.008	.004	.003	.005	.003	.005	.004	.005	.003	.001	.001
Nitrogen	.146					.084						.098		
Organic carbon	1.57					0.89						1.40		
C-N ratio	10.8					10.6						14.3		
Reaction (pH)	5.5	5.7	6.9	6.8	7.2	5.8	6.1	6.4	6.5	7.1	7.1	6.2	7.0	7.0

SOIL TYPE	CLYDEBANK SANDY LOAM						CLYDEBANK LOAM						
Soil No.	6167	6168	6169	6170	6171	6172	6149	6150	6151	6152	6153	6154	6155
Depth (in.)	0-7	7-16	16-19	19-25	25-32	32-36	0-8	8-14	14-18	18-21	21-27	27-42	44-60
Texture	SL	S	SCL	SC	SC-LC	SCL	L	FSL-L	FSL	SC	SC	LC	FSC
Gravel													
Coarse sand	11.2	12.2	5.8	3.5	2.0	1.7	12.4	13.4	13.5	14.6	19.8	7.7	7.0
Fine sand	57.4	59.8	59.8	54.2	59.4	57.4	50.9	54.1	53.6	49.5	39.7	26.5	36.0
Silt	16.5	15.7	14.2	12.6	10.5	14.4	13.8	13.1	12.6	11.1	10.6	24.1	27.0
Clay	10.4	9.2	17.7	25.9	24.3	22.9	16.8	15.7	16.8	21.0	26.1	36.2	25.8
Moisture	1.1	0.4	0.9	1.7	1.6	1.7	1.2	0.6	1.0	0.8	1.2	2.5	1.3
Loss on acid treatment	0.5	1.5	0.7	0.7	1.0	0.8	0.9	0.8	1.1	1.3	1.8	1.6	1.7
Loss on ignition	3.7	1.5	2.0	3.1	3.2	2.9	4.3	3.1	2.4	3.5	4.1	4.2	3.5
Specific conductivity	8	5	7	11	9	10	7	6	6	10	15	25	24
Chlorides (Cl)	.007	.005	.006	.016	.010	.011	.006	.006	.008	.012	.020	.037	.037
Nitrogen	.140						.140						
Organic carbon	1.61						1.54						
C-N ratio	11.5						11.0						
Reaction (pH)	5.6	6.1	6.1	5.5	5.6	5.8	5.3	6.1	7.1	6.8	6.6	6.2	8.0

SOIL TYPE	CLYDEBANK CLAY LOAM						BUNDALAGUAH CLAY LOAM					
Soil No.	6141	6142	6143	6144	6145	6146	6204	6205	6206	6207	6208	6209
Depth (in.)	0-9	9-14	14-18	18-21	21-30	30-50	0-8	8-15	16-26	26-34	34-46	46-57
Texture	CL	CL	CL	CL	LC	FSC	CL	CL	LC-MC	VFSC	FSC	FSCL
Gravel											3.8[X]	
Coarse sand	9.1	10.5	11.2	11.1	1.5	3.0	11.9	10.9	2.6	0.5	0.6	0.4
Fine sand	38.0	38.8	36.8	31.3	30.7	43.0	28.5	31.9	22.3	32.2	46.2	64.1
Silt	28.4	27.9	27.5	23.1	28.0	24.5	29.1	30.7	30.7	31.2	25.4	18.8
Clay	19.3	20.1	21.4	28.9	35.0	25.4	21.1	21.5	37.6	31.5	25.5	16.2
Moisture	2.0	1.4	1.1	2.1	2.3	1.8	2.1	1.5	2.7	2.1	1.7	1.1
Loss on acid treatment	0.9	0.9	1.2	0.9	0.9	0.9	1.3	1.0	1.1	1.1	1.0	0.6
Loss on ignition	6.3	4.4	4.7	4.8	3.8	3.3	7.0	4.5	3.1	3.9	3.5	2.3
Calcium carbonate										0.05	0.14	
Specific conductivity	6	5	4	7	7	8	7	6	17	32	45	34
Chlorides (Cl)	.004	.004	.005	.006	.008	.012	.006	.013	.024	.045	.056	.054
Nitrogen	.204						.235					
Organic carbon	2.55						3.20					
C-N ratio	12.5						13.6					
Reaction (pH)	5.7	6.4	6.9	6.6	6.5	6.7	5.8	6.0	7.3	8.8	9.4	9.0

[X] Limestone rubble.

SOIL TYPE	DENISON CLAY LOAM LIGHT PHASE							DENISON CLAY LOAM LIGHT PHASE							
Soil No.	6158	6159	6160	6161	6162	6163	6164	6195	6196	6197	6198	6199	6200	6201	6202
Depth (in.)	0-8	8-14	14-17	17-28	28-35	35-45	45-62	0-5	5-10	10-14	14-18	18-28	28-34	34-50	50-69
Texture	CL	CL	CL	MC	LC	LC	MC	FSCL	CL	CL	MC	MC	LC	LC-FSC	LC
Gravel							20[x]					2.2[φ]			
Coarse sand	3.4	1.0	0.5	0.3	0.3	0.8	1.3	12.0	9.6	8.4	4.0	1.8	0.8	1.0	0.4
Fine sand	41.1	44.5	41.8	34.2	41.6	22.8	20.7	34.7	37.3	36.0	24.5	19.7	26.9	28.6	10.7
Silt	29.9	29.4	27.7	17.4	19.3	38.0	26.3	33.0	33.4	32.8	27.5	27.8	29.2	36.0	48.1
Clay	20.6	21.8	24.9	42.5	32.6	32.8	47.3	15.3	17.0	18.9	38.6	44.2	37.6	30.4	37.1
Moisture	1.3	1.1	0.9	2.5	2.0	2.4	2.9	1.3	1.2	1.3	2.5	3.4	2.7	2.3	2.4
Loss on acid treatment	1.5	1.3	0.9	2.3	1.1	0.8	3.1	0.8	0.7	0.6	1.6	1.4	1.7	0.8	1.4
Loss on ignition	6.1	4.2	3.4	5.3	4.1	3.8	4.6	4.8	3.4	2.9	4.6	5.5	4.4	3.6	3.8
Calcium carbonate					0.02	0.06	0.90						0.01	0.02	0.14
Specific conductivity	13	16	16	34	39	44	51	23	27	33	70	92	85	77	.120
Chlorides (Cl)	.018	.020	.024	.053	.053	.060	.059	.022	.046	.058	.121	.155	.137	.125	
Nitrogen	.202							.160							
Organic carbon	2.44							2.13							
C-N ratio	12.1							13.3							
Reaction (pH)	5.7	5.7	5.8	6.5	7.4	8.7	9.4	5.6	5.4	5.6	5.9	7.1	8.1	8.3	9.0

x limestone rubble

φ ferruginous concretions

SOIL TYPE	WANDOCKA CLAY LOAM						WINNINDOO CLAY LOAM				
Soil No.	6120	6121	6122	6123	6124	6125	6115	6116	6117	6118	6119
Depth (in.)	0-6	6-10	10-15	15-22	22-28	30-48	0-3	3-7	8-24	24-32	32-48
Texture	CL	LC	HC	HC	HC	SiMC	CL	LC	HC	HC	HC
Gravel											
Coarse sand	2.8	4.8	2.1	1.0	1.3	0.3	7.5	4.3	1.7	0.4	0.2
Fine sand	14.9	15.4	7.8	4.6	5.7	3.8	21.5	20.3	10.8	7.6	4.6
Silt	36.8	35.7	26.6	24.5	30.4	28.6	42.2	39.3	29.2	29.1	31.4
Clay	35.5	40.4	57.3	63.8	59.2	64.3	23.0	31.2	53.0	57.4	57.3
Moisture	2.5	2.8	3.4	4.7	3.7	3.5	1.8	2.0	3.7	4.2	3.9
Loss on acid treatment	1.5	1.1	1.5	1.3	1.4	1.6	1.0	1.0	1.6	1.6	1.3
Loss on ignition	8.0	6.1	6.8	7.4	6.0	5.5	5.9	3.9	5.2	5.3	5.1
Calcium carbonate						0.03				121	
Specific conductivity	12	10	14	24	32	55	15	17	89	.332	92
Chlorides (Cl)	.025	.033	.027	.050	.072	.129	.030	.041	.271		.262
Nitrogen	.241						.190				
Organic carbon	2.98						2.61				
C-N ratio	12.4						13.7				
Reaction (pH)	5.9	5.7	6.4	7.0	8.0	8.7	5.9	5.6	5.5	5.4	6.6

SOIL TYPE	THOMSON SILTY CLAY LOAM						TYPE M					
Soil No.	3049	3050	3051	3052	3053	3054	6224	6225	6226	6227	6228	6229
Depth (in.)	0-4	4-10	10-33	33-60	72-84	84-96	0-10	10-16	17-27	27-34	24-40	40-60
Texture	SiCL	SiLC	SiMC	SiMC	LC	FSC	CL-SiCl	CL-SiCl	LC-SiLC	LC	LC-FSC	FSC
Gravel												
Coarse sand	2.5	2.4	1.3	2.9	5.4	5.8	2.9	3.5	4.3	4.4	5.6	6.6
Fine sand	8.5	9.5	10.0	10.7	26.3	41.3	21.2	19.9	19.4	25.7	33.3	42.3
Silt	33.1	35.5	36.5	39.0	36.7	29.8	37.4	36.2	35.8	33.0	30.9	25.8
Clay	37.4	41.3	44.4	43.5	28.2	22.4	31.9	33.3	35.5	33.4	28.2	24.6
Moisture	4.4	3.8	33.0	2.8	1.8	1.6	3.4	3.4	2.7	2.3	1.9	1.5
Loss on acid treatment	1.9	1.2	1.1	1.0	0.9	0.4	1.1	0.7	1.7	0.6	1.1	0.4
Loss on ignition	16.6	9.8	6.4	5.0	3.7	3.1	8.6	7.3	5.4	4.6	4.0	3.3
Specific conductivity	16	9	48	54	19	11	10	9	7	8	9	11
Chlorides (Cl)	.012	.009	.087	.096	.027	.014	.010	.006	.004	.006	.010	.013
Nitrogen	.583						.263					
Organic carbon	7.72						3.27					
C-N ratio	13.2						12.4					
Reaction (pH)	5.7	5.7	6.4	8.4	8.4	8.1	5.7	5.6	5.8	5.9	6.1	6.0

SOIL TYPE	AVON SUITE TYPE 1					AVON SUITE TYPE 2					AVON SUITE TYPE 3				
Soil No.	6185	6186	6189	6191	6193	6175	6178	6181	6182	6184	6108	6109	6110	6111	6112
Depth (in.)	0-5	5-18	39-46	56-78	88-102	0-7	15-21	33-48	52-63	68-84	0-5	5-12	12-16	16-28	32-42
Texture	FSL	ClFS	S	FS	SiCL	FSL	FSL	FSCL	SiCL	SiMC	SiL	SiL	SiCL	SiLC	S
Gravel															2.3
Coarse sand	7.2	1.4	7.2	0.6	0.8	4.0	0.4	0.5	3.8	3.5	0.4	2.0	5.0	2.3	66.1
Fine sand	67.1	74.4	76.4	79.4	19.7	68.2	75.8	54.2	16.7	16.5	22.9	14.6	13.9	8.6	22.6
Silt	11.8	11.8	7.3	9.0	43.4	13.6	13.3	27.0	43.9	34.6	48.2	41.2	37.0	35.8	5.5
Clay	7.5	8.1	5.5	8.0	29.4	9.3	7.1	12.4	29.5	41.0	20.2	30.8	36.4	49.4	4.7
Moisture	0.9	0.7	0.6	0.8	2.2	0.9	0.7	1.3	2.5	2.5	2.4	3.9	3.7	3.0	0.2
Loss on acid treatment	0.4	0.4	0.4	0.7	1.2	0.5	0.5	0.7	1.0	0.7	1.3	2.4	2.6	1.4	0.4
				2.4	5.6										
Loss on ignition	4.7	2.9	2.3	13	21	4.1	2.6	4.2	6.2	5.0	7.7	10.2	8.3	7.1	1.0
Specific conductivity	5	5	16	.008	.019	5	6	30	57	44	63	209	230	147	24
Chlorides (Cl)	.004	.005	.013			.004	.006	.041	.081	.059	.070	.264	.336	.236	.024
Nitrogen	.140					.132					.199				
Organic carbon	1.72					1.50					2.76				
C-N ratio	12.3					11.4					13.9				
Reaction (pH)	5.8	6.1	5.6	5.7	5.4	5.8	6.4	5.5	5.8	8.1	5.7	4.8	4.3	4.3	4.1