SOIL FEATURES AND IRRIGATION

In this section some of the broad considerations concerned in the successful irrigation of the soil types found in the Mid-Loddon Valley are discussed. This necessarily involves reference to soil aspects dealt with in following sections and readers should refer to these sections, when necessary, for detailed information about the characteristics of the soil types.

Soil Permeability.

Used in a general sense, *permeability* describes the ability of a soil layer to transmit water. Thus soils are often described as being permeable or impermeable. However, no natural soil is completely impermeable and it is more correct to regard such soils as being very slowly permeable.

Amongst other things, the permeability of a soil layer depends on the size and number of natural pores present, and the amount and swelling properties of its clay component. Sandy soils usually have a relatively high proportion of large pores and little clay to swell when wet and so reduce pore size. Such soil layers have a high permeability and, moreover, their permeability remains high when saturated. On the other hand, many clay soils, although not all of them, have relatively few large pores to transmit water quickly, consequently the permeability of clay layers is usually low. If the clay swells, as it often does, such layers become very slowly permeable when saturated.

Swelling clays commonly crack when dry, so allowing rapid water entry from the surface to the subsoil when water is applied initially. In such circumstances, the rate of water entry falls off markedly as the surface layer becomes saturated and swells. This explains why soil types such as Macorna clay and Kerang clay which have low saturated permeabilities are sometimes described as permeable soils.

The behaviour of the soil types to water intake determines to a large degree the crops that can be grown successfully under irrigation. High intake rates lead to watertables and consequent danger of waterlogging and salinity, whilst low infiltration rates lead to shallow-rooting and moisture stress in plants and, under some circumstances, to waterlogging of the surface soil. Low soil permeability also increases the difficulty of reclaiming saline land.

The area of highly permeable soils, i.e., soils in which it is virtually impossible to prevent watertables from developing using gravity methods of watering, is very small. Pompapeil sandy loam is the principal soil type in this category. Yarrowalla fine sandy loam and Yarrowalla loam are slightly less permeable, nevertheless it is usual to find watertables within 6 ft. of the surface in these soil types when they are irrigated. The characteristics of the two Yarrowalla soil types are such that a permeable surface and permeable deep subsoil are interposed by a much less permeable clay subsoil. As a consequence of the slowly permeable subsoil, there are prospects of minimising entry of water into the deep subsoil by employing careful watering practices.

Watertables, once developed in the above soil types, fall slowly after irrigation ceases, since all are underlain by very slowly permeable clay layers. The depth to these deeper layers has not been investigated thoroughly in the present area - some occur within 6 ft. of the surface, but variable depths up to about 14 ft. are likely.

The relatively permeable soil types described comprise portion of an area totalling 25,800 acres which is identified as the Yarrowalla soil association on the folder map at the back of this bulletin.

The clay soil types are not necessarily free from watertable problems, and this is particularly the case with those soils which crack deeply when dry. The soil types Macorna clay, Kerang clay, and Tragowel clay in the *treeless plain*, and Boort clay and Wandella clay in the *low woodland landscape units* are in this category. When irrigated, water enters these soils initially through the cracks, building up a watertable in the subsoil. Such watertables disperse very slowly since subsequent swelling of the clay restricts water movement. Where the salt content of the soil is high, as is often the case in Macorna clay and Kerang clay, salinity then becomes a problem.

Apart from salinity, most of the soil problems of the Tragowel Plains and Boort Irrigation Areas relate to shallow penetration of irrigation water. In some of the clay soil types, although water penetrates to the subsoil through cracks when the soils are dry, swelling occurs as the soils become wetted. The tendency then is for either a shallow watertable to persist because of the low transmissibility of the saturated clay, or for the subsoil layers to remain moist. In either event, the entry of water at following irrigations is restricted, and it becomes difficult to maintain adequate moisture in the upper layer of the soil for the maintenance of summer grown pastures. The principal soil types concerned are Macorna clay, Kerang clay and, less comonly, Wandella clay and Janiember clay. An additional factor restrict water entry in some occurrences of Macorna clay is the presence within 12 in. of the surface of a dense clay layer which takes water only very slowly. In other clay soils, specifically Boort clay, Tragowel clay, Yando clay, Loga friable clay, Fernihurst friable clay and Kinypanial friable clay, the clay particles form more stable aggregates and shallow infiltration is less likely to occur. Experience has shown that perennial pastures can be grown more efficiently on the last grop than on the first group of soil types. Perennial pastures can be grown more efficiently on the last group than on the first group of soil types. Perennial pastures should not be attempted on soil types such as Macorna clay and Kerang clay unless an assured summer water-supply is available.

Shallow penetration of irrigation water can also be expected to occur in soils having only a few inches of surface soil overlying much heavier and intractable clay subsoils. Soils types in this category which are presently being irrigated fairly extensively are Lyndger loam, Mologa loam, Fernihurst clay loam, Kinypanial clay loam and, to a slight extent, Towangurr clay loam.

With all of the above soil types which are subject to low permeability, it is difficult to achieve sufficient stored moisture in the soil to meet the water requirements of summer-grown crops. For this reason, these soil types are more suited to spring- and autumn-irrigated pastures than to perennial pastures.

All of the many recorded *named* soil types not yet mentioned in this section (except Minmindie clay and Towangurr clay) are duplex soils, that is they show a pronounced contrast in texture between a lighter surface soil and a heavier subsoil. Moreover, all of the subsoils are clays. Associated with the texture contrast is a permeability contrast from relatively high in the surface to low in the subsoil. There is little or no practical irrigation experience on these soil types as a guide to their infiltration characteristics – these can only be judged from general considerations of the physical nature of their profiles. The duplex features mentioned are conducive to underwetting of the subsoils should the soils be irrigated, although this may not lead to inadequate penetration of water in all of these soil types.

Measures, such as deep ripping and application of gypsum, aimed at increasing the depth of soil wetting of the slowly permeable soils have been only partly successfully and require further investigation. In experiments on Lyndger loam at Pyramid (Bartels 1968), deep ripping was not effective, gypsum gave slightly increased infiltration, but ripping plus gypsum gave a marked improvement. It is reasonable to expect the best effects of gupsum on infilgration in the clay soils and duplex soils in the area to be when it is worked into the subsoil. It is in this part of th profile that adverse sodic properties amenable to gypsum treatment occur. Surface applications of gypsum on pasture soils dissolve slowly and have difficulty in reaching the sodic zone.

Surface applications of gypsum, and gypsum in the irrigation water (Davidson and Quirk 1961), applied to clay soils prior to sowing down to pasture in the Riverina have improved the structure and moisture relationships of the immediate top soil, such that the emergence of subterranean clover seedling has been greatly increased. Clover seedling emergence appears to be adequate on the clay soils of the northern plains of Victoria. Trials with gypsum when sowing down, although sometimes increasing germination, have not shown the economic benefits obtained in the Riverina. This is probably because the Riverina clays are more sodic at the immediate surface, whereas the Victorian clay soils do not become appreciably sodic for several inches.

Soil Salinity

Salt has long been recognized as having a major influence on the irrigation of pastures on the plains of northern Victoria. Moreover, irrigation in the area has been shown to be a factor contributing to the salt load of the Murray River (Gutteridge at al. 1970).

There is ample visual evidence of the effects of salt on the surface in many places, but the hazard from soluble salts naturally present in the subsoils where surface salinity is not evident can only be assessed from a chemical analysis of the soil. There are several kinds of soluble salts found in soils, but the main one where salinity is significant in the soils of the present area is sodium chloride, and all references to salt in this section mean sodium chloride.

Salt Survey

The salt status of the subsoil has been investigated broadly by analysiing a large number of soil samples taken during the course of the soil survey. These samples were taken from approximately 16,000 sites scattered over the whole area. The soil samples analysed were taken mainly from 2 to 3 ft. below the surface. The salt content of this layer provides a suitable guide in unirrigated soils to the risk of salting should the soils be irrigated, since the concentration of salt tends to increase from the surface to reach a maximum concentration at about this depth. High concentrations, if found, usually persist below the 2 to 3 ft. layer. The danger to plants lies in redistribution of salt from these lower depths into the rootzone above, and the likelihood of salt rising is increased in situations which develop watertable.s

In this report, the salt status of the soil in terms of sodium chloride is described in four arbitrarily determined, salinity classs as follows: Low – 0-15% or less; moderate – 0.16 to 0.30%; high – 0.31 to 0.50%; very high – over 50%. The degree of risk at any one of these salt levels varies with the soil type and with the salt tolerance of the particular crop.

Salt Map

The pattern of salt distribution in the subsoils of the district, as disclosed by the salt survey and using the above four classes of salt status, is shown on a Salt Map at the back of this bulletin. The area of each salinity class is given in Table

2. This shows that approximately one-third of the surveyed area can be assessed in regard to irrigation as having a low salinity hazard, one-third a moderate hazard, and one-third a high or very high hazard.

Table 2 – Extent of Salinity Classes and Salinity Rating of Soil Associations

Salinity Class	Low	Moderate	High	Very High
Area (ac) %	196,100 32	207,800 33	144,100 23	72,500 12
SOIL ASSOCIATION	Boort Catumnal Marmal Mologa Mysia Terricks Tragowel Wandella Woolshed Wychitella Yarrowalla	Boort Catumnal Fernihurst Marmal Mologa Mysia Tragowel Wandella Woolshed Yarrowalla	 Fernihurst Mologa Tragowel	 Fernihurst

Comparison of the Salt Map with Fig. 2 in the section, "Landscape Units and Guide to Soil Types" shows that the areas with a high and very high salinity hazard are associated almost exclusively with the *treeless plain landscape unit*. Soil salinity in this unit increases from south to north, such that beyond a line joining Mologa and Durham Ox nearly all of highly saline subsoils. This area constitues the major part of the Tragowel Plains Irrigation Area. On the other hand, the soils of the granite highlands universally have a low salt status. Other relationships between the soils and salinity are evident from a comparison of the Salt Map with the Soil Association Map on its reverse side. This is the basis in Table 2 for the salinityratings given to each of the fourteen soil associations which are described in the section, "Soil Associations". The relationship of the soil associations with salinity is discussed below.

In addition to Terricks soil association, the soils of the Coombatook and Wychitella associations are either permeable or are situated above the natural drainage of the country. Much of the aCatumnal, Marmal and Woolshed soil associations which, with the Coombatook and Wychitella soil associations, comprise an aeolian land form on the western perimeter of the area in the same category. However, the first three soil associations also include drainage basins an low areas in which the soils are moderately saline. In general, the six soil associations mentioned here define areas where the risk of soil salinity developing under irrigation is slight. Very little is being irrigated at present.

The remainder of the area of dominantly clay soils is part of the vast Riverine Plain (Butler 1950). The better-drained parts of the plain and the relatively lighter soils ae represented by the Yarrowalla and Mysia soil associations in which subsoil salinity ranges from low to moderate. Much of the Yarrowalla soil association is being irrigated without salinity problems developing. The prospects of freedom from salinity troubles for the Mysia soil association are good also. However, prospects for the Mologa soil association, a somewhat similar soil association, are variable. In the south, salinity is either low or moderate, but north of Yarrowalla the subsoils become highly saline and irrigation risks are appreciable.

The most frequently inundated parts of the Riverine Plain are represented by the Tragowel and Wandella soil associations. As a consequence of flooding these soils are fairly well leached of salts and, except in the Parish of Tragowel where highly saline soils occur within the Tragowel soil association, salt contents are low or moderate. Low to moderate salinity is usual also in the low-lying Boort soil association. Salinity hazards for irrigation agriculture on these three soil associations are increased because of naturally poor surface drainage. However, experience has demonstrated that irrigated pastures can be grown satisfactorily if provision can be made for removal of surplus water.

The Macorna and the Fernihurst soil associations comprise very largely the highly and very highly saline parts of the treeless plain landscape unit north of the Mologa–Durham Ox line mentioned earlier in this section. The Macorna is the dominant soil association found here and salinity problems are widespread on the irrigated parts of this soil association. South of Mologa–Durham Ox the soils of the treeless plain landscape unit belong exclusively to the very widespread Fernihurst soil association and are moderately, or less frequently, highly saline. Irrigation is practised satisfactorily on these soils.

Value of Salt Map to Landholders and Advisory Officers.

The salt map does not necessarily indicate areas where actual salt injury to crops has occurred. Nevertheless, injurious salt contents are likely to be present in the surface soils in the areas where subsoil salinity is high.

The main purpose of the salt map is to show areas of different degrees of potential salt *hazard* to irrigated crops. It is useful, therefore, to indicate the localities where the crops re-commended in the section, "Suitability of the Soils for Various Irrigated Crops" might be grown with a minimum risk of salt injury. It also indicates areas where special precautionary drainage measures might be necessary, or where the situation should be investigated by further soil analyses for salt content before irrigation development takes place. The map is not detailed enough to show the salt status of individual holdings, consequently land-holders should seek advice from an advisory officer of the Department of Agriculture[‡]
when planning the irrigation of suspected salty land.

Salinity Investigations

Experiments on reclamation of salty land were commenced in the adjoining Kerang Irrigation Area in 1939. Morgan (1947) achieved establishment of satisfactory perennial pastures on highly saline Kerang clay at Tragowel after four or five years of intermittent irrigation averaging 30 in. an acre annually. Soil analyses showed appreciable removal of salt from all parts of the soil profile to at least 5 ft. depth.

Averaged over this depth the salt content fell from 0.86 per cent to 0.19 per cent during the period of reclamation. Salt tolerant annual crops were sown first followed by perennial species. Prerequisites were careful grading and provision for removal of surface drainage. Other requirements for success were adequate topdressing with superphosphate, and maintenance of the surface cover when established by giving attention to grazing management.

Other pasture establishment experiments on Macorna clay and Kerang clay with moderately saline subsoils have been reported by Morgan (1950). Based on these early experiments and subsequent district experience, Jones (1962) has stated the principles and methods of reclamation of saline clay soils in the Kerang district. These have general application to the heavy-textured saline soils of the present area.

Following sowing down to perennial pasture, salinity changes over periods of about ten years have been measured in soil profiles of Lyndger loam at Pyramid (Garland 1958) , Boort clay at Boort (Garland and Jones 1958) and Mologa loam at Durham Ox (Garland and Jones 1962) . These experiments show that, provided established principles of preparing and irrigating the land are followed, salt naturally present in the subsoil at about 2 ft. depth does not rise into the rootzone, but is leached slowly to greater depth. Problems with the maintenance of perennial pastures on soil types such as Lyndger loam and Mologa loam are more likely to be due to the poor infiltration characteristics of the subsoils.

Chemical Aspects

The soils are deficient in phosphorus and nitrogen, and superphosphate is a necessary fertilizer on pastures and crops. The nitrogen requirement is usually provided by the clover component of irrigated pastures, but there are some circumstances where fertilizer nitrogen can be used profitably.

The analytical data show that potassium, calcium and magnesium are at good levels, and that the pH is satisfactory. Under these circumstances no benefit can be expected from using potash, lime, dolomite or magnesium-containing materials. However, should sulphate of ammonia be used consistently, some soils may become sufficiently acid to warrant the use of lime to counter the soil acidity produced. Soil tests are useful to indicate whether liming is warranted in such cases.

There is no evidence that the trace elements, copper, zinc, manganese, iron, boron and molybdenum are deficient in any of the soils. Field trials in the region have shown that the application of these elements does not improve the establishment or growth of pasture species. In southern Victoria, copper, above the amount needed to maintain satisfactory clover growth in pastures, is sometimes required for the maintenance of stock health. Cobalt is also a trace element sometimes needed by stock. There is no evidence that either copper or cobalt need to be applied to pastures for this purpose in the present area.

High amounts of exchangeable sodium occur in most of the subsoils, particularly in the soil types found on the treeless plains. Frequently salt is present also, and, in these circumstances, the clay particles are floxxulated into aggregates and the permeability of the soil may be satisfactory. However, as salt is leached out of the subsoil, the exchangeable sodium exerts an influence and causes the clay aggregates to disperse, so causing a marked reduction in the permeability of the soil. Some of the deeper subsoils contain gypsum, and this counters the deflocculating effect of exchangeable sodium in the gypseous layer following leaching out of salt.

[‡] District Agricultural Centre, Kerang