SOIL CONSERVATION SERVICE
OF
NEW SOUTH WALES

LAND RESOURCES STUDY
OF THE
ALBURY-WODONGA GROWTH CENTRE
IN
NEW SOUTH WALES

Prepared for

THE ALBURY-WODONGA DEVELOPMENT CORPORATION

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FOREWORD

In recent years many Australians have experienced the adverse effects of inadequately planned urban developments. Homes have been flooded and buildings damaged to varying degrees because of unstable soils. Soil washed from urban blocks and deposited elsewhere has destroyed recreational areas, damaged wildlife breeding and feeding habitats and polluted water supplies.

In the Growth Centres of New South Wales, these problems can magnify, owing to the extent of development planned. American experience has shown that soil losses from developing urban areas can be as high as 500 tonnes/hectare. The deposition of the eroded soil on adjacent lands, and into streams, waterways and water storages can lead to significant economic and social costs.

In the newly establishing areas, it is imperative that these problems are not allowed to develop. Basic to this is the provision of accurate land resource information to the urban planner.

This Report of the Land Resources Study of the Albury-Wodonga Growth Centre, New South Wales, describes the approach used by the Soil Conservation Service of New South Wales in mapping and evaluating the land resources data for proposed urban and rural use. Individual land resource attributes are mapped - slope, terrain component, soils, soil erosion, drainage pattern and existing land use - and interpreted to derive a series of land capability classifications. These classifications enable the planner to allocate resources amongst the various uses proposed, such that deleterious effects upon these and adjacent environments are avoided.

Large-scale maps showing the distribution and extent of the resources and the land capability classifications, have been prepared in conjunction with the Report and made available to planners.

The response to this Study by planners of the Albury-Wodonga Growth Centre has been extremely encouraging. Preliminary drafts of some of the data are already being used in the planning of rural and urban subdivisions in the New South Wales sector of the Growth Centre. Close liaison is maintained between the Soil Conservation Service and the Albury-Wodonga Development Corporation to provide additional interpretation of the data as required and to carry out larger-scale studies prior to individual subdivision planning.

This Study is part of a State-wide programme by the Soil Conservation Service in providing assistance to planners of urban projects. I am sure that all those who study the Report will agree that the detail within is most impressive and provides valuable assistance to the planners of new urban developments. If such an approach is adopted then the planning mistakes of the past should no longer occur.

A.R.L. GORDON
MINISTER FOR CONSERVATION
AND WATER RESOURCES

LAND RESOURCES STUDY OF THE ALBURY-WODONGA GROWTH CENTRE IN NEW SOUTH WALES

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"SOIL WASHED FROM URBAN BLOCKS AND DEPOSITED ELSEWHERE HAS DESTROYED RECREATIONAL AREAS, DAMAGED WILDLIFE HABITATS AND POLLUTED WATER SUPPLIES".

Plate I

1. THE STUDY

The Land Resources Study establishes an index of land capabilities for rural, urban and recreational developments within the New South Wales sector of the Albury-Wodonga Growth Centre.

Planners are provided with land use alternatives based upon objective recognition and interpretation of resource values and their environmental effects. In addition, guidelines for development are given to reduce the impact of soil erosion, siltation and turbidity brought about by changing land use.

The rural capability is the potential land use a parcel of land can sustain without loss of the soil resource. Eight rural land classes are defined.

The urban capability is determined from an assessment of the erosion hazard. The five classes relate to the degree of surface disturbance involved in the establishment of various intensities of urban development and the long term effect that this development will have on the stability of the soil surface.

The recreational capability is determined by an objective assessment of the physical site conditions. Site suitabilities for eight recreational activities have been obtained together with a suggested intensity of use for each activity. Recommendations for site development are also given.

To determine these capabilities, physical attributes of the environment are examined and mapped onto base plans of a scale of 1:10 000. The attributes are - soils; landform comprising slope and terrain components; soil erosion; and drainage pattern. Other physical criteria considered in the evaluation of land capability are - climate, existing land use, geology, vegetation and flood zones of the Murray River and its tributaries.

2. RECOMMENDATIONS

This section contains a summary of conclusions and recommendations made in specific sections of this report.

Policies for the protection of the environment through care of the soil mantle and vegetative cover are considered essential at this early stage of planning of the Growth Centre.

Such policies should establish "Environmental Goals" that would be included for each of the land uses recommended in this Study.

Recommendations

1. Urban areas should be so designed that natural features are retained and efficiently utilized. This would include the retention of the main watercourses as the principle drainage system of the developing areas. Similarly the oxbow lakes on the Murray River floodplain should be retained for runoff detention purposes and conservation purposes in general.

2. Urban development on the floodplain is not recommended. Zoning of these lands for permanent agricultural use is desirable.

3. (a) Development of slopes in excess of 27% (15^{o}) should not be attempted.

   (b) Urban areas are best suited to slopes below 20% (11^{o}). Slopes above 20% are best retained as parklands or open space within the urban environment.

   (c) Buildings constructed on slopes between 18% (10^{o}) and 27% (15^{o}) require detailed attention to the design of their foundations.

   (d) Extensive reshaping of the land surface involving cut and fill operations is likely to cause problems with soil stability. This is due to the dispersive nature of the clay minerals on soils derived from micaceous metasediments.

4. (a) Specific soils investigations at the planning scale are required before any development is planned in areas of unstable soils. These investigations will identify the major physical constraints and the areas affected. The most unstable soil groups identified are : the Black Range Hill Soils, the Granite Hill Soils and the Kywana Soil Group.

   (b) Soils of the Howlong, Wirlinga and Mungabareena Soils Groups have physical constraints such as high shrink swell potential, low bearing strength and a high plasticity. Further soil investigations at a detailed planning scale are required for foundation design.

5. It is recommended that the sub catchment be adopted as the basic planning unit for urban development. An obvious though recurring example is the location of urban developments in the lower reaches of a sub catchment without adequate drainage facilities to carry the runoff should urbanisation take place in the upper reaches. Conversely, urban developments in the upper reaches of a sub catchment area can significantly alter the hydrological regime and cause severe erosion to the natural drainage system below.

6. *Lands generally in excess of 18° from the horizontal (33%) within Hume Catchment Area are 'Protected Lands'. The authority of the Catchment Areas Protection Board must be sought if any destruction of timber is proposed on these lands.*

7. *Destruction of timber in the bed and within 20 metres of the banks of the Eight Mile Creek and the Murray River is prohibited unless prior approval is obtained from the Catchment Areas Protection Board.*

8. *It is recommended that revegetation of disturbed areas should be undertaken during the period from April to July, as there is a 70% probability of obtaining a 5 month growing season in this period. Sowing of areas between November and March should not be attempted without the provision of irrigation.*

9. *The recommendations contained in the Rural Land Use Capability section are :*

   (a) *The rural land capability classes defines the potential use of land for sustained production. The use of land beyond its rural capability is not recommended.*

   (b) *Regular cultivation of lands with slopes in excess of 12% is not recommended.*

   (c) *Clearing of slopes above 30% is generally not recommended. Site investigations are needed if clearing is proposed on slopes steeper than 30%.*

   (d) *Soil conservation farm plans for individual property development or where property amalgamation has occurred can be prepared by the Soil Conservation Service of New South Wales. These plans will provide recommendations of land capability, property development including location of fences, access tracks, water supply and soil conservation treatments necessary. They will provide management guidelines to the operator of the property.*

   (e) *The following management practices are recommended for the steeper grazing lands. These include:- the regulation of stock numbers so that the vegetation cover of the slopes is not depleted, the control of rabbits on a regular basis, and the provision of fire protection of these areas. Management of these lands can be assisted by planning location of subdivision fencing, access tracks, and stock watering points on a soil conservation farm plan and systematically implementing these improvements.*

   (f) *It is recommended that filling of gullies on Class III and Class V lands receive high priority in a catchment management programme. Early treatment and stabilization of the gullies will ensure that this land is in a most suitable condition for later urban development.*

   (g) *It is recommended that the objectives of catchment management be fully adopted for Class VII lands. These objectives are primarily to reduce siltation, encourage infiltration of rainfall and to protect urban lands from flooding and siltation.*

10. *The management of the Murray floodplain lands is considered to be critical to the stability of the floodplain. It is recommended that the following management policies should be adopted.*

   (a) *Overgrazing of areas adjacent to the river bank should be avoided. Stock access to the river should be confined to gently sloping lands such as the depositional areas of*

(b) *Improvement in the present management of properties resumed on the floodplain may be achieved by property amalgamation or relocation of a property boundary on a stable landform feature on the floodplain.*

(c) *Subdivision fencing should be aligned wherever possible to the direction of flood water flow to avoid damage to fencing.*

11. *The Urban Capability Classification is based upon an erosion instability hazard. The intensive use of land beyond the capability will cause severe erosion and siltation problems in the short term and possible long term instability problems. It is strongly recommended that the use of urban land be planned according to its capability. The following recommendations on urban land use are made.*

(a) *Additional site investigations are recommended for Class C lands to identify the constraints that operate and the areas affected.*

(b) *Urban development is not recommended on the floodplain below the 1 in 100 year flood frequency.*

(c) *Class D lands are the most critical lands in terms of landscape stability. Construction of buildings is not recommended.*

(d) *Drainage lines are recommended for retention as a green belt area for reserves or playing fields. These can accept short term periodic flooding without being adversely affected.*

(e) *Grassed waterway reserves with an underground pipe to carry the 1 in 1 year flow are recommended as an efficient and practical method within an urban development.*

(f) *Major drainage features such as Eight Mile Creek should be retained and developed by stabilizing the banks and improving the stream channels and retaining an optimum flood capacity within the natural system.*

(g) *It is recommended that a catchment management programme be implemented for all lands above urban developments. This programme would include -*

(i) *The use of land consistent with its capability.*

(ii) *Improvement of catchment condition by control of existing soil erosion, maintenance and improvement of vegetation, the control of siltation from existing gravel pits, increasing rainfall infiltration and control of runoff water.*

(iii) *Control of fire and vermin.*

(iv) *Construction of runoff detention structures.*

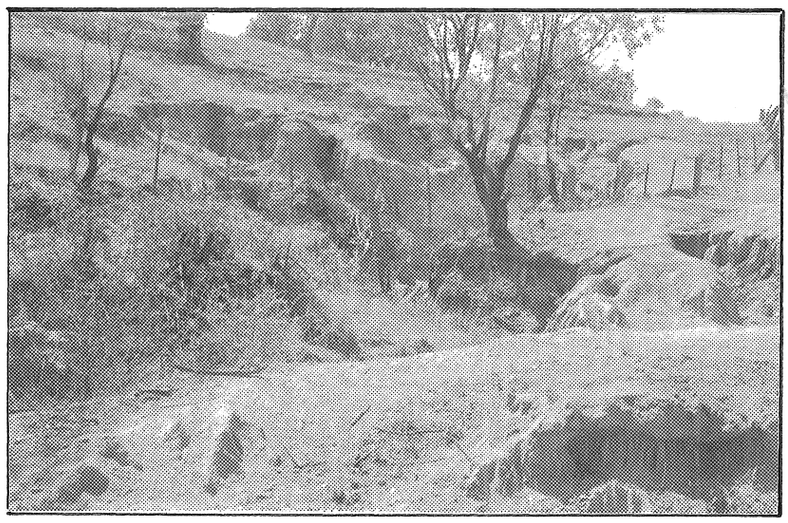
(v) *Control of siltation from construction sites and urban subdivisions.*

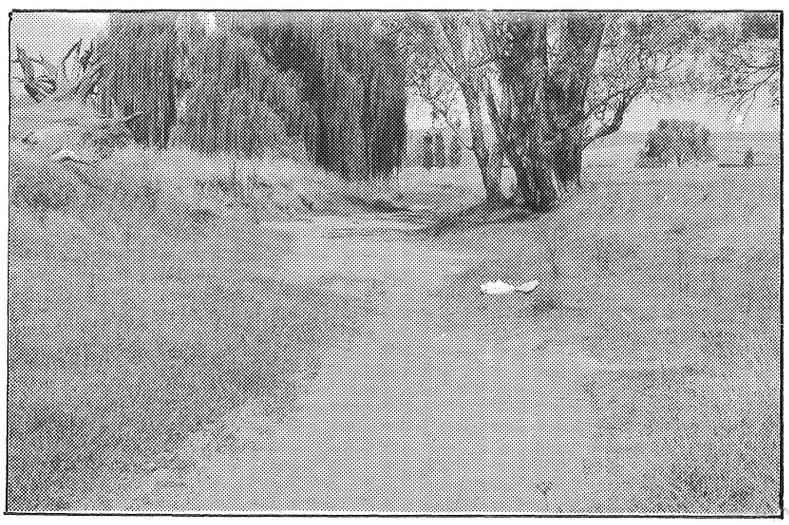
There is an urgent need for the adoption of this policy within the Bungambrawatha Creek Catchment which flows in a restricted channel through residential and commercial areas of Albury City.

12. (a) *It is recommended that where recreation amenities are proposed, specific site investigations should be made by the Soil Conservation Service prior to detailed planning.*

(b) *Development of a recreation amenity should adopt the site treatments recommended in Table 8 titled Recreational Development Categories and site recommendations prepared by the Soil Conservation Service.*

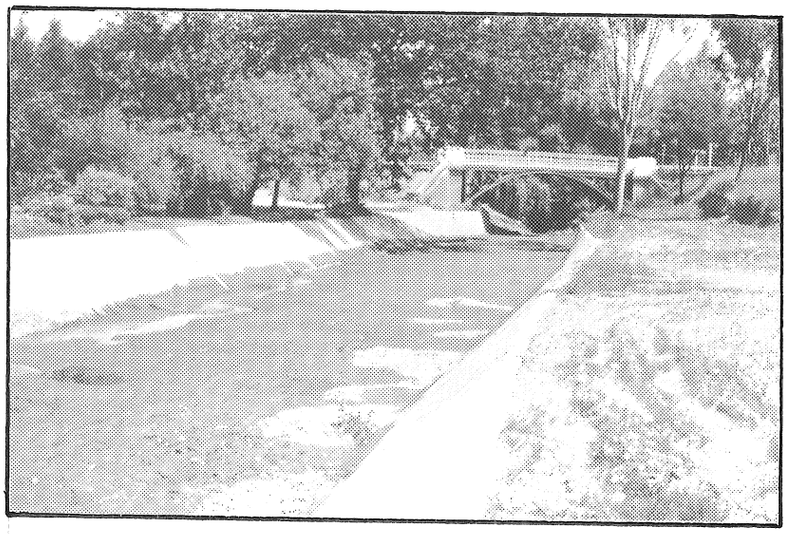
THE EROSION STORY





... *is filling the streams with silt and reduces their capacity to carry run off water.*

Flooding becomes more frequent and damage to property from the heavy silt loads is severe.



To keep this expensive concrete lined drain functional, frequent removal of silt will be a financial burden on the community.

3. INTRODUCTION

The Land Resources Study is an inventory and an evaluation of the physical resources of an area of 15 300 hectares in the immediate environs of the City of Albury. The area comprises the land designated for acquisition by the Albury-Wodonga Development Corporation to plan a new city..

The Study, prepared for the Albury-Wodonga Development Corporation, provides basic land resources data and a land capability assessment for inclusion in a Rural Development Plan of the land in New South Wales.

An essential feature in the development of any area is the mitigation of soil erosion and the conservation of the soil resources.

Identification of the soils, landform and drainage pattern is paramount to understanding the impact on the landscape of a developing city. Adverse effects upon these resources can be caused by changing patterns of land use in the designated area. These effects may be irreversible and extend throughout the Murray Valley.

Ecological and aesthetic qualities are an important consideration in the development of the Growth Centre. These qualities are basically confined to areas which are termed to have a high 'conservation value'. Such areas include the critical foreshore lands of Lake Hume, the floodplain of the Murray River and the timbered hills that surround the City of Albury which require special attention to their management and development to ensure stability.

A soundly based resource inventory is the foundation for assessing land capability of rural, urban and recreational land uses, and providing recommendations for the management of all major natural resources in the area. It allows planning to proceed with full recognition of landscape values and constraints of the environment. Integration of resource data into the planning of future urban and recreational areas can realise substantial savings in construction costs and future maintenance of resources.

The land capability assessment provides a sound, practical and readily interpreted land classification system that can be used by workers from all disciplines and understood by non-technical people.

Maps at a scale of 1:10 000 have been drafted from the base plans. They depict :

1. Landform
2. Soils
3. Soil erosion
4. Drainage pattern
5. Existing land use
6. Rural and Urban Land Capability

Segments of these maps are contained in this report as Appendix A.

All photographs contained in this report, with the exception of those in Plate XI, have been taken in the Albury-Wodonga Designated Area.

3.1 STUDY OBJECTIVES

* *To prepare an inventory of the physical resources of the Designated Area based upon an objective assessment of environmental features.*

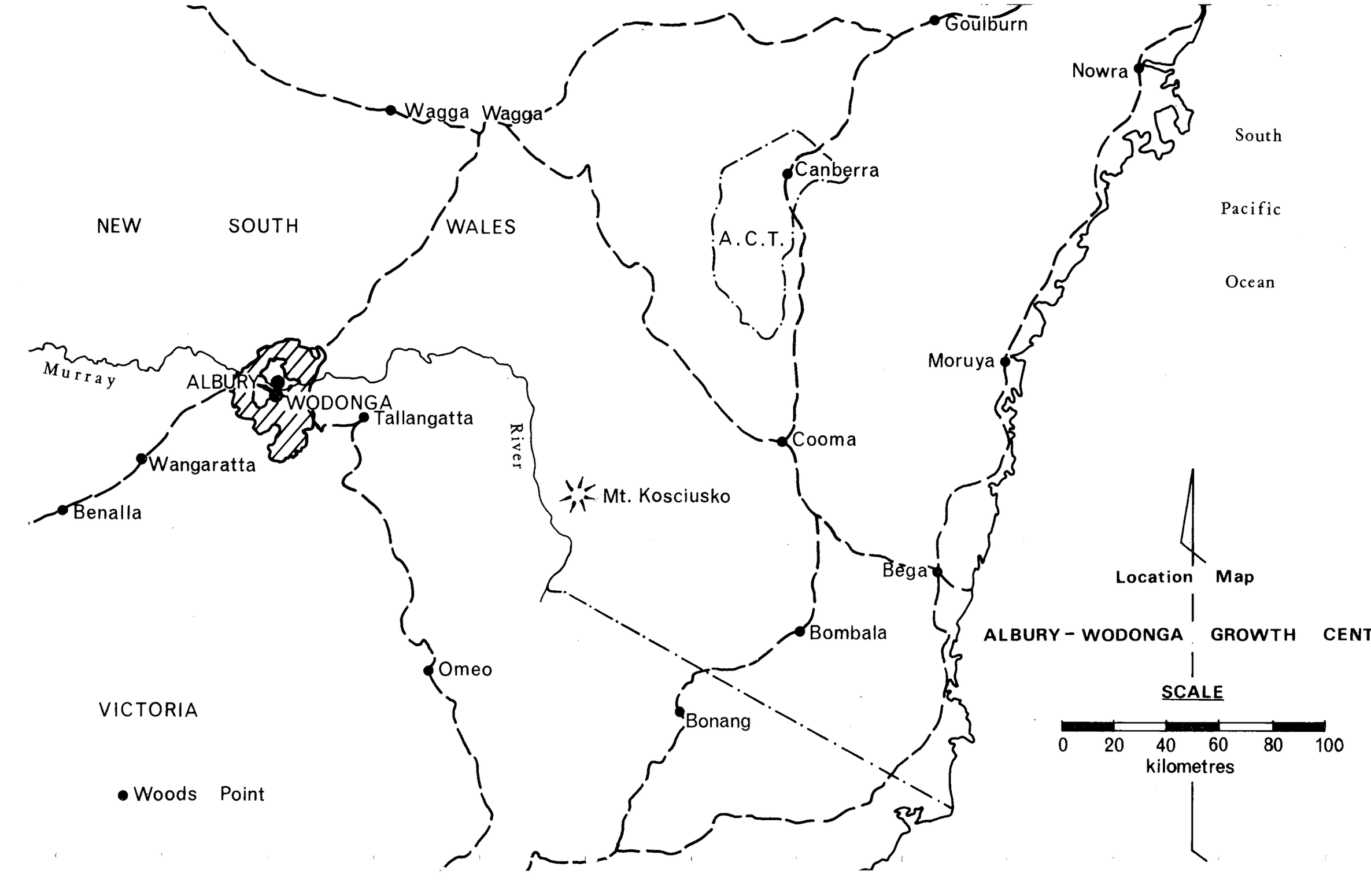
* *To arrange the basic data into key elements which combine to evaluate the capability of the landscape.*

* *To determine the land capability for urban, rural and recreational land use purposes in terms of long term stability of the soil surface.*

* *To present a system of land use alternatives to planners based upon an objective assessment of resource values.*

* *To provide an inventory of existing land use and property developments on agricultural land to assist land managers to determine suitable property and land management programmes.*

* *To create an awareness of the problems that increased soil erosion and sedimentation from developing urban areas has on the total environment and to prepare guidelines for development based upon soil conservation principles.*


Goulburn
Nowra
Wagga Wagga
South
Canberra
Pacific
NEW SOUTH WALES
A.C.T.
Ocean
Moruya
Murray
ALBURY
WODONGA
Tallangatta
River
Cooma
Wangaratta
Mt. Kosciusko
Benalla
Bega
Location Map
Bombala
ALBURY - WODONGA GROWTH CENT
Omeo
SCALE
VICTORIA
Bonang
0 20 40 60 80 100
kilometres
Woods Point

4. PHYSICAL RESOURCES OF THE NEW SOUTH WALES DESIGNATED AREA

The physical resources collected and mapped during the Land Resources Study are :

1. landform
2. geology
3. soils
4. drainage pattern and sub catchment areas
5. soil erosion
6. existing land use
7. climate

Except for the geological data, which have been collected by the Geological Survey of New South Wales, all resource information has been collected and mapped by the Soil Conservation Service of New South Wales.

The resource information is used to derive a series of capability classifications for specific land uses. In this report three types of land uses are considered :

1. rural
2. urban
3. recreational

The capability classifications identify the limitations of the use of the land as a result of the interaction between the physical resources and a specific land use. The principal limitation is the stability of the soil mantle. Subsidiary limitations include the susceptibility to flooding, the occurrence of rockiness and the depth of soils.

The relevance of the individual resources to an assessment of the rural, urban and recreational capabilities is discussed in the appropriate sections.

4.1 LANDFORM

Landform in the context of this report is a composite resource feature, comprising the two individual elements, slope and terrain component. In the preparation of capability classifications, landform is important for a number of reasons :

1. It defines slope and terrain components whose behaviour varies under different intensities of utilization within the one type of land use. Together with data about the soil type, and the underlying lithology, their reactions under certain land use enables a series of slope intervals to be selected.

   In the Albury sector of the Growth Centre, geological and soil characteristics limit urban development to slopes below 20 per cent. Lower limits apply to the more intensive forms of urban development.

   In the rural capability classifications, similar constraints apply. On suitable soil types, the recommended upper limit for regular cultivation is 12 per cent. Above this slope the erosion hazard is too great to permit safe cultivation. The recommended upper slope limit for grazing varies between 30 per cent and 50 per cent, depending upon the susceptibility of the terrain to soil erosion and mass movement.

In a similar manner, the description of terrain components permits the further identification of unstable or hazardous slopes. Floodplains of individual watercourses are not suitable for most forms of urban development, although they may be suited for recreation areas and are often highly desirable for horticultural production.

Footslopes assume significance in most descriptions of terrain as they indicate a geomorphic process - the colluvial deposition of soil and weathered rock. As such, they are important in the descriptions of soil types and their reactions to building loads. These soils are often highly eroded, owing to their topographic position and the depth of the weathered material.

2. *In urban and rural capability determinations, it is the first criterion for defining individual classes, i.e. slope and terrain component units must be suitable for the desired use before other criteria are assessed.*

3. *The physiographic units often correspond to soils boundaries in a "free" survey.*

4.1.1 Slope

The definition of slope classes is important to all forms of planning owing to the interrelationships between slope and soil erosion hazard for specific types of land use.

Slopes are measured at the direction of greatest declivity, which allows the most limiting slope to be identified.

All slope measurements in the Study are made from the aerial photographs. Although accurate slope measurements can be made from the detailed contour information available on the majority of the 1:10 000 series of orthophotomaps, covering the Albury-Wodonga Growth Centre, the aerial photographs have been used for several reasons :

(i) It is often difficult to identify the location of the breaks or changes in slopes from orthophotomaps, particularly on areas where slope gradients are less than 10 per cent.

(ii) Those slope classes where the relief is less than the height of the contour interval may not be shown in the contour overlays to the orthophotomaps. A particular example is the steep embankments of adjoining alluvial terraces where the heights of the embankments are less than the contour interval and may occur at an elevation between the two contour lines.

The greater the contour interval the more significant is this factor. For the Albury-Wodonga Study, the varying contour intervals in the overlays - 5 metres vs. 2 metres - means that different levels of interpretation occur if slope is to be determined solely from topographical maps.

(iii) Contour information is missing for sections of the Study area.

(iv) Terrain information can only reliably be determined from aerial photographs.

Where there is a lack of contour information, the validity of the slope measurements from the aerial photographs can be checked by two methods :

* *from field measurements taken prior to and after the interpretation of the aerial photograph.*

* *comparison to standard slopes in the stereodip comparator.*

Segments of the landform maps prepared for this Study are contained in Appendix A as Map 1, Map 7 and Map 13.

Slope Classes

Categories of slope defined for the survey and the criteria upon which they are based are described. As the purposes of the survey are to establish a series of capability classifications for rural, urban and recreational uses, some compromises have been made to achieve a workable system. The criteria used to select these slope ranges are further qualified in the descriptions of terrain components. Specific soil and geological types which may modify the general use of these slopes are not considered within the context of these descriptions.

Slope classes described in the study are :

A. *0-2 per cent slope: These slopes are considered suitable for all types of residential, recreational, industrial, commercial and institutional uses. For agricultural use, they require little or no structural treatment for erosion control except in those situations where runoff from adjacent land occurs.*

In Albury-Wodonga, these slopes are found on the floodplain and footslope terrain components. The use of these areas may be restricted because of specific hazards. Such hazards are related to the topographic location of the unit.

For example, the floodplains are periodically inundated. The incidence of flooding over the cross section of a floodplain will often vary, because of differences in the relative heights of the unit. Problems caused by poor profile and site drainage may also occur. On footslopes, spring discharges are occasionally observed.

B. *2-5 per cent slope: These lands are suited to all forms of urban use.*

Some restraints will apply to urban uses on slopes at the top of this range when major disturbance of the soil occurs. Such is the case in industrial and institutional uses where level sites are preferred.

Surface drainage conditions on these slopes are generally ideal. They have fewer problems of profile drainage, compared to the level areas, although spring activity does occur in the eastern sector of the Growth Centre on the Kywana and Granite Hill soils groups.

Gully erosion of these lands is caused mainly by runon from adjacent steeper lands. Extensive downcutting of the stream lines has taken place in these areas, depositing massive sediment loads into the principal watercourses.

Agriculturally, these slopes are suitable for intensive use and identify the areas where managerial and only simple structural techniques are required to prevent soil erosion.

C. *5-10 per cent slope:* *Agriculturally, this class defines the upper limit for cultivation of potentially arable lands. Above this limit, the erosion risks are too high to permit safe cultivation. Exceptions occur in specific localities on specific soils. For example, on red earth soils of the St.Johns soil group, the recommended upper limit for cultivation is 15 per cent.*

In urban areas, this range identifies slopes ideally suited to residential subdivision, with good surface drainage and little danger of mass movement.

D. *10-20 per cent slope:* *This unit defines the upper limit of slopes suitable for residential subdivisions in the Albury-Wodonga Growth Centre. Studies by the Geological Survey of New South Wales Department of Mines show that, lithologically, the area is potentially unstable for urban subdivision on slopes above 20 per cent.*

Surface drainage conditions are generally excellent, although a considerable amount of water seeps from springs in these slopes along the eastern catchment boundary of Eight Mile Creek and Hawdons Lagoon.

Agriculturally, this unit is used for grazing and identifies the upper slope limit for the use of structural methods to prevent and control soil erosion.

E. *20-30 per cent slope:* *Land not suited for residential use. In an agricultural classification, the upper slope limit corresponds closely to the boundary of 'Protected Lands' as defined in Section 21 of the Soil Conservation Act, 1938, and which applies only within notified catchment areas.*

F. *30-50 per cent slope:* *In the agricultural sector, this unit defines the upper limit to which slopes may be cleared provided the soils are of low to moderate erodibility. Slopes above 30 per cent approximately define the areas that could be classified as 'protected lands'.*

These slopes are also suitable for recreational areas, national parks and fauna reserves, forestry production and water supply catchments.

G. *Slopes greater than 50 per cent:* *Defines those areas which are best left undisturbed. Clearing of these slopes is not recommended, owing to the extreme erosion hazards. The most suitable uses of these areas are those compatible with the preservation of the natural vegetation, namely, water supply catchments, wildlife refuges, national and state parks and scenic areas.*

Where clearing has occurred the slopes have little grazing value and major managerial problems. Soil erosion is best controlled by encouraging the regeneration of native timber.

4.1.2 Terrain Component

The terrain component describes the physical appearance of the slope. It is a morphological description and does not always imply the geomorphological processes occurring on the slope.

Terrain components in the Growth Centre are :

1. Hillcrests and ridges: are the top of the interfluves between two drainage lines, delineating areas not susceptible to flooding.

   There significance in urban and agricultural use is that these components may have very shallow soils. Where these occur, the areas will be unsuitable for urban development if septic tank systems are required.

   Agriculturally, these shallow soils are also unsuitable and problems will be further compounded if rock occurs in the surface layers.

2. Sideslopes: comprise the middle and upper slopes where soil processes are usually erosional. On steep slopes, soil profiles will often be shallow, and in urban areas, not suitable for septic tanks. Where cut and fill conditions are necessary, slumping may occur. Agriculturally, these steeper areas are used for grazing.

   On gentle slopes, soil profiles are sufficiently deep for agricultural production and the areas are most suitable for urban development.

3. Footslopes: are defined as areas of colluvial deposition. Slopes are rarely greater than 20 per cent, and generally less than 10 per cent. Soils are usually deeper than similar soils on sideslopes. The low slopes and deeper soils are suited for urban and agricultural use. In parts of the Albury District, the footslopes are extremely long, with low gradients and soils suitable for intensive urban and arable use.

4. Floodplain: these are defined, geomorphologically, as those areas of alluvial deposition. They are characterised by level terraces adjacent to a watercourse. Soils are often deep and well-drained. Agriculturally they constitute the most productive soils in the district. These areas are not considered suitable for urban development because of the possible risk of flooding. However, because the floodplains are defined due to their genesis, rather than the current hazard, a knowledge of the hydrological regime of the adjacent stream is necessary before rejecting their use for urbanization.

   In some situations, a series of terrace levels occur within the floodplain, indicating different hydrological regimes in the catchment area of the watercourse. In the Albury-Wodonga Study, the different terrace levels have been identified from the aerial photographs. Three terrace levels occur along sections of Bungambrawatha Creek, and is evidence of periodic downcutting of the stream.

   In urban planning, the identification of the terrace levels is significant. The lowest levels should be left intact, or allocated to agricultural uses. Upper terrace levels can be used for a variety of urban purposes; the topmost for residential or commercial development if flooding hazards are negligible. The intermediate levels may be used for such urban purposes as recreational facilities, which are able to withstand flooding with negligible costs, yet do not divert, retard or impound flood waters.

In a situation of very restricted suitable agricultural lands, it may be desirable to zone these areas for permanent agricultural use, ensuring that rates and taxes do not make such production unprofitable.

5. *Drainage Plains: are defined as areas of footslopes which may be subject to seasonal waterlogging, owing to periodic overland flow of water. They may include areas of spring activity. In the Albury-Wodonga area drainage plains do not have an incised stream channel.*

   Soil types are usually deep, medium to heavy clays, unsuitable for urban and agricultural use. Their best use is to be retained for disposal of runoff.

6. *Incised Drainage Channel: the definition of this terrain feature is largely dependent upon the scale of the survey. In the Albury sector of the Growth Centre, this unit is important particularly in the headwater region of many of the streams, where extensive stream incision has occurred. By defining these streams, it is possible to design urban areas such that natural features are retained and efficiently utilized.*

7. *Disturbed terrain: identifies the terrain components permanently altered from their original state. The unit includes mining and quarrying pits, and construction sites.*

8. *Mixed Terrain Units: comprise those areas of land which cannot be separated into individual terrain units at a particular scale of mapping.*

9. *Water bodies: comprises those areas of natural and man-made water storages. It includes natural systems such as swamps, lakes and rivers, and such man-made features as dams, canals and viaducts.*

   The emphasis in planning is towards the retention of natural water systems. They can often be used as detention basins during periods of high runoff. In addition, they are valuable natural ecosystems which provide refuge to many forms of wildlife.

10. *Ox-bow lake: is a unit restricted to specific landforms. In the Albury-Wodonga Growth Centre, they identify the former channels of the Murray River and several of its major tributaries. In rural and urban environments their retention is recommended for runoff detention purposes, and for conservation purposes in general.*

4.2 GEOLOGY

A detailed geological survey of the area has been completed by the Geological Survey of the New South Wales Department of Mines. (Willis 1974)

The main rock types strongly determine the soil types and the natural stability of the area.

High grade metasediments of quartz-mica schists comprise the inner circle of hills that surround Albury from the west to the north and at Eastern Hill.

Granitic intrusions form the outer circle of hills adjacent to the Olympic Way in the north. Outcrops also occur at Hawkesview along sections of the interfluve between the Hume Reservoir and Eight Mile Creek.

Residual and colluvial deposits derived from the underlying volcanics and quartzites occupy the broad area of low hills which run in a north easterly direction from Albury. The steeper outer hills in the north east are comprised of residual and colluvial deposits from underlying gneiss. The main occurrence of biotite gneiss is found adjacent to the foreshore of Lake Hume.

Specific recommendations made by the Geological Survey of the New South Wales Department of Mines relating to natural land stability are :

* *Development of land with slopes in excess of 27% (15°) should not be attempted. Properly designed foundations for houses are required on slopes between 18% (10°) and 27% (15°).*

* *Slopes above 20% are not suited to urban use and should be retained as parklands. Considerable care will have to be given to maintain vegetation to allow their utilization for recreational purposes without concomitant introduction of severe problems of soil erosion.*

* *Problems can be introduced by attempts at reshaping of the topography due to the dispersive nature of the soils particularly on micaceous metasediments, where serious erosion effects would arise causing siltation of all drainage works. Compaction difficulties could be experienced on the deep soil profiles on the granitic or volcanic rock types.*

* *Hillslopes in excess of 18% (10°) are likely to undergo processes of soil creep, mud flow or perhaps major landslides where the thickness of soil or scree deposits is sufficient to allow such effects when the soil is saturated with water.*

* *The Murray River floodplain must be considered unsuitable for any residential development.*

These recommendations are endorsed by the investigations of slope, soils, drainage and erosion hazard features in this Land Resources Study. The constraints imposed by the development of these physical features are discussed fully in the appropriate sections of this report.

4.3 SOILS

Introduction

Soils have been surveyed as an input in the determination of the rural, urban and recreational capability classifications and to provide an evaluation of the physical behaviour of the 14 soil groups.

The soil types closely reflect variation in parent rock material. Two major rock types - granite and micaceous schist - dominate the high ridges and determine the soil type. On the lower, more gently undulating areas the origin of the colluvial and alluvial parent material significantly influence the soil type formed.

High water tables have contributed significantly to soil type modification on the various rock formations. The presence and degree of development of A_2 horizons and the degree of mottling in B horizons appears to reflect the influence of a periodic high water table, mainly caused by seepage.

This interaction between parent material and seepage substantially affects soil stability which has resulted in large variations in erodibility, trafficability, bearing capacity, and other factors influencing development.

Mapping units are defined as reoccurring combinations of related soils, i.e. soil groups.

Soils are divided into 14 groups which differ considerably in their stability under stress. This includes direct stress as applied by building or road foundations or stress due to poor urban or rural land management.

Survey Method

This survey prepared on 1:10 000 scale base maps identifies map units of major soil groups. Each group is defined in extent and in terms of -*

(i) Potential erosion hazard.
(ii) Suitability for soil conservation structures.
(iii) Constraints with respect to rural, recreational and urban developments.

The soil is classified to the principal profile form of Northcote (1971) and related to great soil groups to facilitate discussions.

Soil groups differ considerably in the degree of soil variation and may contain small areas of soil from other groups. During a reconnaissance survey of the area group names have been selected from localities in which a soil group predominates and variation in each group defined to enable boundary determination.

Identifying features of each soil group are selected as close to the soil surface as possible. Therefore, for map unit boundary location soil profiles are rarely examined deeper than 15 cm into the B.horizon. Boundaries are determined by profile examination and traced where possible by a change in surface characteristics, such as vegetation, surface texture, surface colour, or surface condition when wet, supplemented with periodic checking of profile characteristics. In the absence of a surface indicator soils are examined at intervals of 50 to 500 metres depending upon topography and the effect of the boundary on the land use constraints.

Stereo-aerial photographs are used where possible to identify areas with distinct surface differences and soils that occupied particular positions on a slope. These areas have been subsequently field checked.

Maps 3, 9, 15 in Appendix A are sections taken from the soil map prepared for the study.

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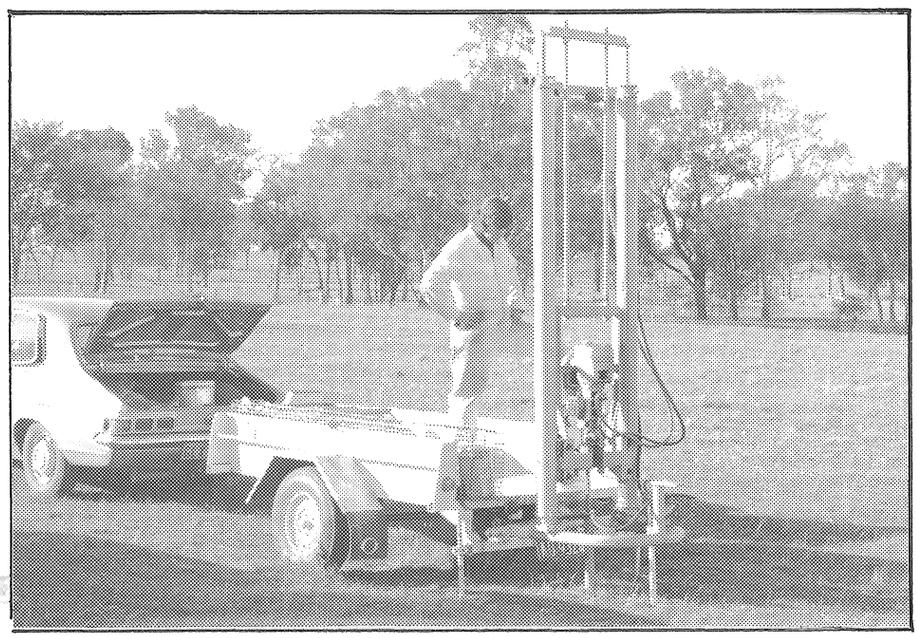
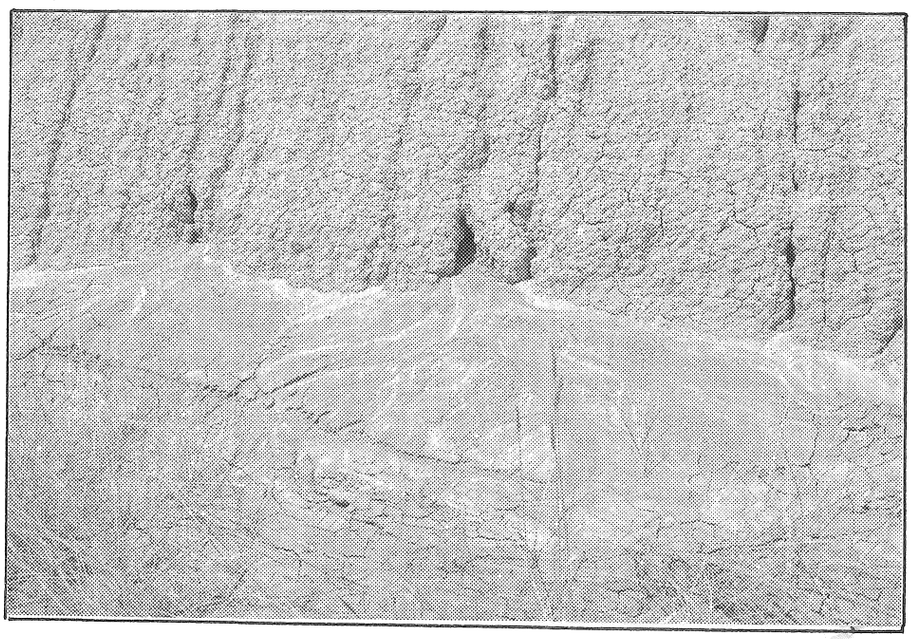
* *Soil groups as defined by Brewer & Butler (1953) - " a group of soils, morphologically and genetically related to each other showing a continuous but limited range of variation in one or more morphological and/or chemical characteristics."*

SOILS INVESTIGATIONS.



Soils are sampled with a mechanised coring machine.

The soil sample is evaluated and classified.



Highly dispersible soils may erode from beneath the surface. When further erosion takes place the surface collapses. Such erosion is a problem on the Kywana, Wirlinga and Black Range soil groups.

Soil Sampling: Soil is sampled to check the defined map units for variability and inconsistencies. Sampling is done to 180 cm using either a 10 cm Jarrett auger or an "Atlas-Copco" soil sampling rig which extracted a 5 cm diameter core. Sample sites have been selected to represent the range of soils present in a map unit and individual samples were taken from major changes in the profile.

Soil Analyses: Soil samples are subjected to basic engineering tests that are correlated with soil stability under stress. Tests include -

* Particle size analyses
* Dispersal index
* Volume expansion
* Liquid and Plastic limit

The results of these tests are presented in the Thurgoona Capability Study (Junor et al, 1975) and Bungambrawatha Creek Catchment Report (Crouch 1976).

A summary of the results of these tests are presented in Appendix B along with typical soil descriptions.

Soil Groups

Murray River Alluvium Group

Occurrence:

This unit confined to, and occupies all of the immediate floodplain of the Murray River. Generally it consists of swamps with some higher depositional areas. The floodplain is typical of a riverine depositional landform containing swales and oxbow lakes in old meander channels.

Characteristics:

Soils consist of either layered alluvium, deep uniform sand or silty clay overlying sand.

Variability:

This is an extremely variable group consisting of areas of heavy clay through to extensive sand and gravel deposits. In some areas there are extensive sand ridges, probably the result of wind action on alluvial deposits.

Identifying features:

1. Located on the floodplain of the Murray River.
2. Typically a layered alluvium.
3. Generally either a silty clay, sand or clay.

Soil types:

Very variable, alluvium, Ucl.21 or Ufl.23, or undifferentiated alluvium.

Land use:

Dairying, grazing, recreation, sand and gravel extraction.

Constraint to development:

1. Periodic inundation by the Murray River.
2. High shrink/swell potential of some areas of clay.

Bungambrawatha Creek Alluvium Group

Occurrence:

Floodplain of Bungambrawatha Creek and its tributaries.

Characteristics:

A layered alluvial soil of generally loam texture. It occupies a relatively flat well defined area surrounded by a higher terrace.

Variability:

Principally loam with some patches of silt loam and sandy loam.

Identifying features:

1. *Layered alluvium.*
2. *Loam to sandy loam.*
3. *Located on floodplain of Bungambrawatha Creek or its tributaries.*

Soil types:

Alluvial loam.

Land use:

Horticulture, orchards, grazing.

Constraints to development:

1. *Periodic inundation with fast flowing water.*
2. *Extensive silt deposition during flood events from soil erosion in the catchment.*

Eight Mile Creek Alluvium Group

Occurrence:

Floodplain of Eight Mile Creek and its tributaries. It is often not as entrenched as other alluvial soils. (Figure 1).

Characteristics:

This group is a typical layered alluvium soil generally more sandy and less fertile than along Bungambrawatha Creek. The Eight Mile Creek floodplain does not contain well developed alluvial terraces similar to the Bungambrawatha Creek. The soil boundary is not as sharply defined as the other alluvial groups and the soils are shallower.

Variability:

Generally a sandy loam with some patches of heavier and lighter soil.

Identifying features:

1. *Sandy loam layered alluvium.*
2. *Located on the floodplain of Eight Mile Creek.*

Soil types:

Alluvial sandy loam

Land use:

Grazing.

Constraints to development:

Periodic inundation with fast flowing water.

SECTIONS THROUGH THE ALBURY AREA SHOWING THE INFLUENCE OF TOPOGRAPHY AND GEOLOGY ON SOILS

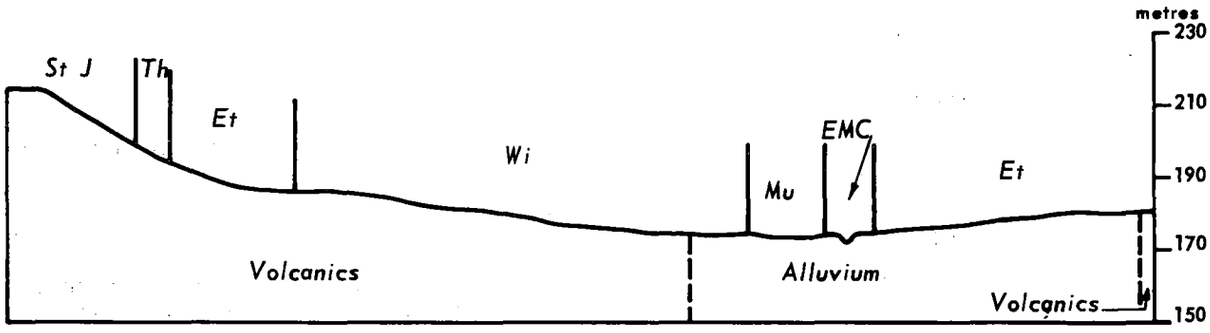


Figure 1 *Drainage conditions determine which soils predominate on the lower slopes.*

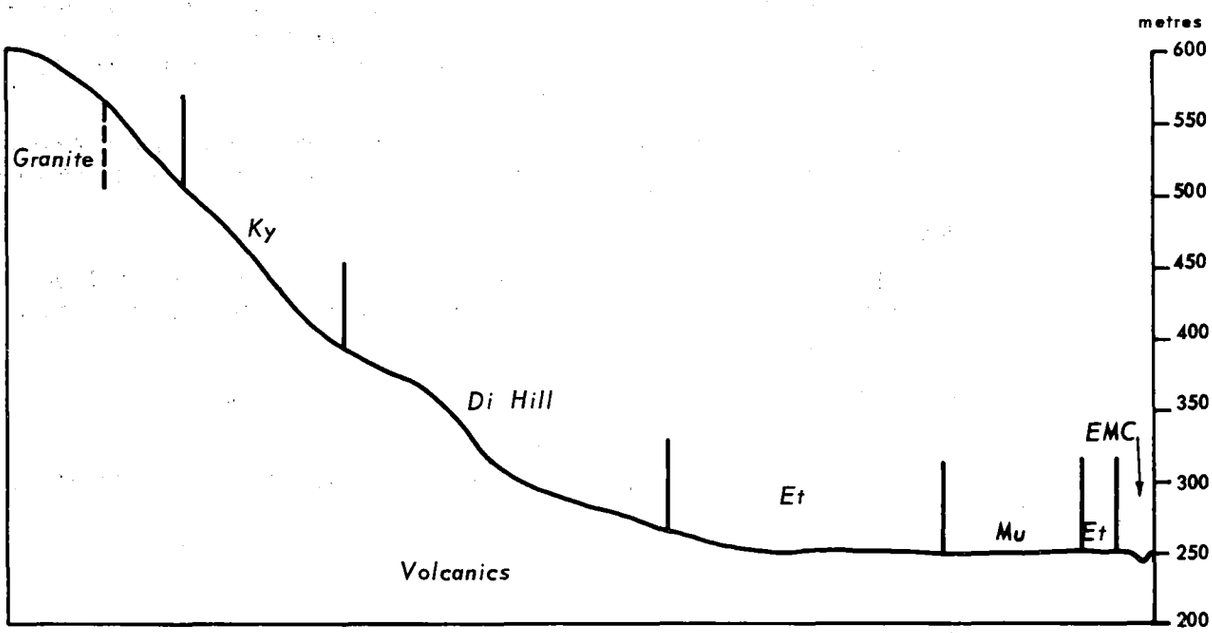


Figure 2 *The Kywana and Dights Hill Groups are formed on granite colluvium over the volcanics.*

KEY TO SOIL GROUPS

Et	*Ettamogah*
Th	*Thurgoona*
Ky	*Kywana*
Gr	*Granite Hill Soils*
St J	*St Johns*
Wi	*Wirlinga*
Mu	*Mungabareena*
EMC	*Eight Mile Creek Alluvium*
Sp Ck	*Splitters Creek*
Di Hill	*Dights Hill*
Ha V	*Hamilton Valley*
CHS	*Complex or Black Range Hill Soils*

Black Range Hill Soils Group

Occurrence:

The Black Range Hill soils are a complex of soils formed on micaceous schists.

Characteristics:

This group contains a mixture of soils similar to those of other groups. They have not been delineated due to the inaccessibility of the unit and its lack of suitability for rural or urban development.

The soils of this group form a topographic sequence consisting of highly micaceous lithosols on the ridge tops, red podzolic soils on the mid to high slope areas, yellow podzolic soils on the mid to low slope areas and sandy uniform or gradational soils in colluvial fans and yellow solodic soils in the drainage lines. (Figure 2) Rock outcrops often occur in the midslope situation. This topo sequence may vary slightly without apparent change in the lithology or physiography.

In general the yellow soils in this group are highly erodible while the red soils have moderate to low erodibility ratings.

Variability:

This group is highly variable and site inspection will be required to determine soil characteristics and suitability for specific uses.

Identifying features:

1. *Generally steep topography.*
2. *Micaceous schist rock generally accounted before 180 cm depth.*
3. *Highly micaceous soil, highly variable over short horizontal distances.*

Land use:

Limited grazing, forest, recreation.

Constraints to development:

1. *Steepness of slope.*
2. *Areas of highly unstable soil.*
3. *High soil erodibility.*

Granite Hill Soils Group

Occurrence:

The Granite Hill soils have formed on the granite hills in the east and north of the Designated Area.

Characteristics:

Soils in this group reflect strongly the grain size and mineralogical composition of their parent material. The predominate soils are sandy throughout consisting of either a bleached A_2 horizon and a white or yellow grey mottled B horizon (Uc2.21) or a deep light brown sand with minimal profile development (Uc1.21). Both soils being slightly acid throughout. They are highly erodible soils and in some situations subject to failure by mass movement. (Figure 3)

Variability:

Generally these soils are sandy with profile development varying considerably from uniform sands (Uc1.21) to strongly duplex (Dy3.41) bleached soils with sandy clay B horizons.

Identifying features:

1. *Rounded hills with granite outcrops.*
2. *Coarse sandy textured soil derived from granitic parent material.*

The boundary between the Granite Hill soils and the Kywana group is based on landform rather than soil features.

Land use:

Grazing, recreation.

Constraints to development:

1. *Steepness of slope.*
2. *Very high to extreme soil erodibility.*
3. *Susceptibility to mass soil movement.*
4. *Occurrence of seepage areas.*
5. *Seasonal high water table.*

Kywana Group (Uc2.21 - 1/0/35)

Occurrence:

In the east and north of the area on undulating areas adjacent to steep granite hills. (Figure 4)

Characteristics:

The main soil type is a podzol (Uc2.21-1/0/35). It is a sandy soil formed on highly weathered granite. It has a conspicuously bleached, sandy, deep A_2 horizon overlying a pale cemented clayey sand B horizon. The acidity of the soil decreases down the profile to a pH of approximately 5 in the B horizon.

Land form consists of rounded hills with a few rock outcrops.

Variability:

This group is made up of four soils, the type described above and three subdominant principal profile forms - Dy3.41, Dr2.21 and Uc1.21. With the exception of the red duplex soils occurring on a few ridge crests, the remainder of the soils are not related to topographic situation or slope. They are however, related to poor drainage conditions which have resulted in more intense weathering and clay formation to give gradational and duplex variants.

Identifying features:

Deep sandy soil generally white to yellow grey in the A_2, B and C horizons.

Land use:

Grazing.

Constraints to development:

1. *Very high soil erodibility.*
2. *Occurrence of seepage patches.*

Howlong Group (Ug5.23 - 6/3/25)

Occurrence:

The Howlong Group is limited to low lying internally drained areas subject to lengthy periods of inundation. These areas are strongly gilgaied and covered by hydrophilic vegetation.

Characteristics:

The area occupied by this group is flat with extensive interconnected circular gilgais. During most winters these gilgais are filled with water. Soils are clayey throughout consisting of grey clay A and B horizons which overly more grey or brown clay. A_2 horizons vary in development from not present to bleached. pH increases from 6.5 at the surface to 8.5 at 75 cm depth. Soils have a high shrink/swell potential and crack on drying.

Variability:

The only variations are in A_2 horizon development and clay colour below 120 cm.

Identifying features:

1. *Grey clay surface.*
2. *Hydrophilic vegetation.*

Land use:

Grazing.

Constraints to development:

1. *Prolonged seasonal inundation.*
2. *High shrink/swell.*

St.Johns Group (Gn2.12 - 3/1/20)

Occurrence:

This group dominates the crests of the low hills in the centre of the area from Table Top to Wirlinga. It is generally associated with small granitic rock outcrops near the ridge tops and overlies yellow clay further down slope. (Figure 2)

Characteristics:

Low ridges in a generally undulating landscape define the extent of this group. Soils are predominately red earths with variants ranging towards red podzolic soils due to A_2 horizon development and greater texture contrast.

The main soil type consists of a clay loam A horizon over a red silty or light clay becoming heavier with depth. This overlies a C horizon of weathered granite near the crests and a yellow, medium clay B_2 horizon further down the slope. The pH is neutral (6.5) throughout.

Variability:

The group as mapped is predominately a red earth (Gn2.12-3/1/20) bordered down slope by the Thurgoona group of yellow podzolic soils. Small patches of the Wirlinga group - yellow solodic soils with moderate to high shrink/swell - occur in depressions. These have not been delineated separately on the map, and impose additional developmental constraints.

Identifying features:

1. *Red clay B horizon.*
2. *Minimal A_2 horizon development.*
3. *Clay loam A_1 horizon.*

Land use:

Grazing, cropping in selected areas.

Constraints to development:

1. *Steepness of slope.*
2. *Hard rock in some situations near ridge crests.*
3. *Isolated areas of soil from the Wirlinga group.*

Dights Hill Group (Gn2.23 - 3/1/40)

Occurrence:

This group is limited to a relatively flat colluvial derived slope adjacent to granite hills in the west and north of the area. (Figure 3) It is a gently sloping colluvial area extending from the surrounding hills.

Characteristics:

The soil is gradational with a yellow B horizon and a high sand content throughout. The pH ranges from neutral at the surface to alkaline at 150 cm depth.

Variability:

Low-lying areas in the group contain duplex soil with medium clay B horizons.

Identifying features:

1. *Sandy loam surface soil.*
2. *Soil surface is hard setting.*
3. *Slight to moderate A_2 horizon development.*
4. *Pale yellow porous B horizon.*

Land use:

Grazing, cropping in selected areas.

Constraints to development:

Generally unconsolidated soil material.

Thurgoona Group (Dy2.22 - 3/1/30)

Occurrence:

This group occurs below the St.Johns group on low ridges at Thurgoona in the centre of the Study area. (Figure 2)

Characteristics:

Soils are mainly yellow podzolic soils occupying the midslope areas below the St.Johns group. The dominant soil consists of a clay loam to loam A horizon overlying a light clay, yellow, B horizon. An A_2 horizon may or may not be present.

Variability:

There is considerable soil variation depending on the development of the A_2 horizon and presence of mottles in the B horizon.

SECTIONS THROUGH THE ALBURY AREA SHOWING THE INFLUENCE OF TOPOGRAPHY AND GEOLOGY ON SOILS

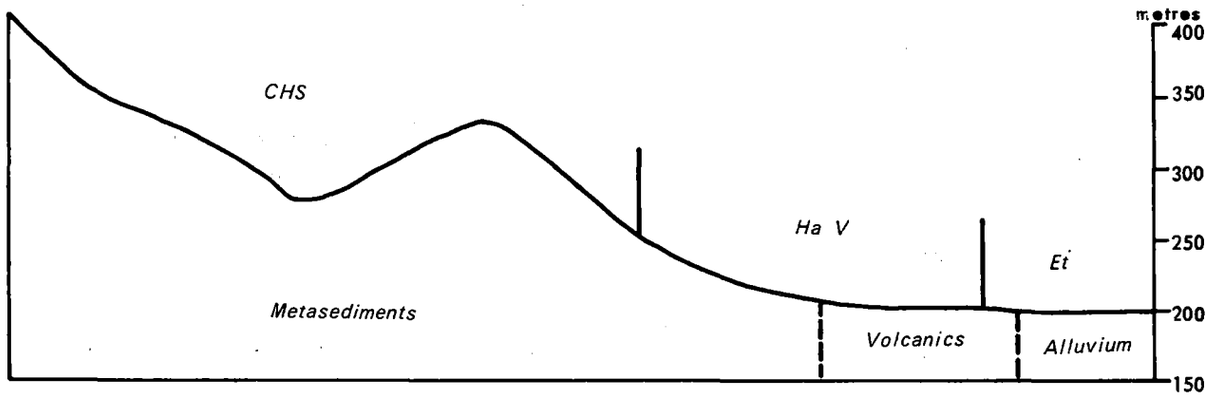


Figure 3 *The Hamilton Valley Group occurs on the undulating country between the metasediment hills and the flatter areas overlying volcanic rocks.*

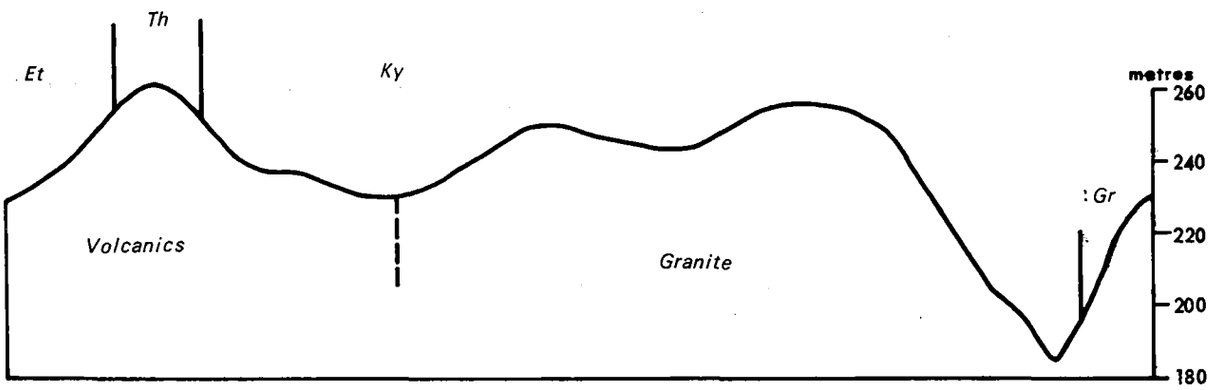


Figure 4 *The finer grained volcanic soils vary with topography more than the coarser granite soil.*

KEY TO SOIL GROUPS

Et	*Ettamogah*
Th	*Thurgoona*
Ky	*Kywana*
Gr	*Granite Hill Soils*
St J	*St. Johns*
Wi	*Wiringa*
Mu	*Mungabareena*
EMC	*Eight Mile Creek Alluvium*
Sp Ck	*Splitters Creek*
Di Hill	*Dights Hill*
Ha V	*Hamilton Valley*
CHS	*Complex or Black Range Hill Soils*

Identifying features:

1. *Clay loam to loam A horizon.*
2. *Bright yellow B horizon.*
3. *The A_2 horizon, if present, is relatively shallow - less than 20 cm.*

Land use:

Grazing, cropping in selected areas.

Constraints to development:

Nil.

Ettamogah Group (Dy3.22 - 3/0/30)

Occurrence:

This group occupies the extensive flat midslope zone on undulating country between Ettamogah and Thurgoona. (Figures 3 and 4)

Characteristics:

Soils are yellow podzolic soils lower down slope than the St.Johns and Thurgoona groups. The soil consists of a loam A horizon overlying a light to medium clay B horizon that usually contains red mottles in a yellow background. A non bleached shallow A_2 horizon is generally present.

Variability:

Major soil variation occurs towards the lower boundary of the unit. The A_2 horizon becomes deeper and bleached and the colour duller. At the upper boundary the mottles and A_2 horizon may be absent.

Identifying features:

1. *Loam textured soil surface.*
2. *A non bleached A_2 horizon.*
3. *Red mottles in the B horizon.*

Land use:

Grazing.

Constraints to development:

Nil.

Splitters Creek Group (Dy2.42 - 3/0/40)

Occurrence:

The Splitters Creek group of soils occur on the deep colluvial outwash from hills of micaceous schists in the south west of the area.

Characteristics:

Soils characterised by their bleached A_2 and yellow B horizons. They have a high mica content reflecting their parent material and are highly erodible.

A typical profile consists of a loam to sandy loam A horizon that may or may not be hard setting overlying a bleached A_2 horizon. This overlies a yellow whole coloured medium clay B horizon. The pH is neutral throughout.

Variability:

The main soil variation in this group is the degree of structural development in the B horizon and degree of A_2 horizon development.

Identifying features:

1. *High mica content*
2. *Bleached A_2 horizon*
3. *Yellow clay B horizon*

Land use:

Grazing.

Constraints to development:

1. *High soil erodibility.*
2. *Steepness of slope in some areas.*

Hamilton Valley Group (Dy3.41 - 3/0/30, Dr2.32 - 3/0/20)

Occurrence:

The Hamilton Valley group of soils are confined to valley slopes on the easterly aspect of the hills lying to the west of Lavington. (Figure 4)

Characteristics:

The group is a mixture of red and yellow podzolic soils occurring as a catena on low ridges. The red podzolic soils are on the ridge crests while the yellow podzolic soils occur on the lower slopes. Some yellow solodic soils occur in the drainage lines.

The red podzolic soils consist of a silty clay loam A horizon overlying a non bleached silty A_2 horizon which is separated abruptly from a red sandy clay or light clay B horizon.

The yellow podzolic soil differs in the colour of the B horizon and has a more intense bleach in the A_2 horizon.

Variability:

There is a regular soil variation across the area with topography.

Identifying features:

1. *Silty clay loam A horizon.*
2. *Red or yellow B horizon.*
3. *A_2 horizon not bleached.*
4. *Smooth faced peds.*

Constraints to development:

Steepness of slope.

Wirlinga Group (Dy3.42 - 3/0/50)

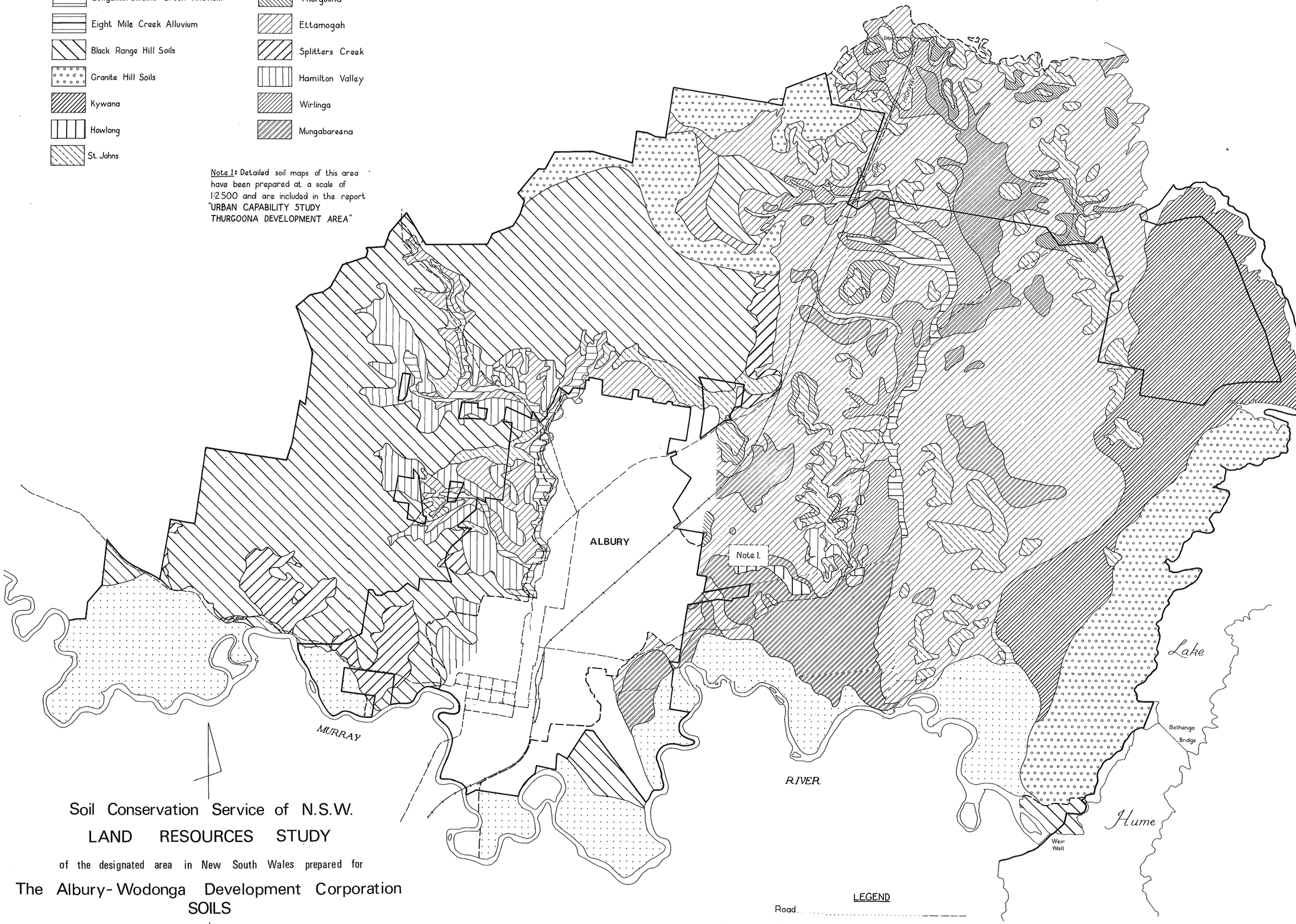
Occurrence:

The group occurs on gently sloping areas below the Ettamogah group. The area receives extensive seepage water from the slopes above after rain. (Figure 2)

Map Unit	Association Name
	Murray River Alluvium
	Bungambrawatha Creek Alluvium
	Eight Mile Creek Alluvium
	Black Range Hill Soils
	Granite Hill Soils
	Kywana
	Howlong
	St. Johns

Map Unit	Association Name
	Dights Hill
	Thurgoona
	Ettamogah
	Splitters Creek
	Hamilton Valley
	Wirlinga
	Mungabareena

Note 1: Detailed soil maps of this area have been prepared at a scale of 1:2500 and are included in the report "URBAN CAPABILITY STUDY THURGOONA DEVELOPMENT AREA"



Soil Conservation Service of N.S.W.

LAND RESOURCES STUDY

of the designated area in New South Wales prepared for

The Albury-Wodonga Development Corporation

SOILS

SCALE

kilometres 1 0 1 2 3 4 kilometres

LEGEND

Road .....

Railway .....

Boundary of Study Area .....

Boundary of Designated Area .....

Characteristics:

The soils are readily recognised by a deep bleached A_2 horizon overlying an olive-brown medium to heavy clay B horizon which generally contains grey mottles.

The A_2 horizon is always greater than 40 cm deep, strongly bleached and contain ironstone nodules.

Variability:

The group is relatively consistent throughout with some variation in mottle development and the concentration of ironstone nodules in the A_2 horizon.

Identifying features:

1. *Very deep A_2 horizon.*
2. *Olive brown mottled B horizon.*

Land use:

Grazing, cropping in selected areas.

Constraints to development:

1. *High soil erodibility.*
2. *Low bearing strength in the surface soil layers when wet.*
3. *Periodic deep overland runoff flow.*

Mungabareena Group (Dy3.43 - 3/0/50)

Occurrence:

The Mungabareena group occurs on the flat or poorly drained areas in the centre of the Designated Area. Major areas occur around the airport, and in the north between Bowna Road and the Hume Highway.

Characteristics:

Small gilgais 2-3 metres in diameter and isolated large gilgais characterise the surface features of this group. Soils are primarily yellow solodic soils with brown clay soil in the remainder of the area.

The solodic soils consist of a loam, structureless A_1 horizon overlying a clay loam strongly bleached A_2 horizon that often contains orange streaks. This is abruptly separated from a medium clay yellow grey mottled B horizon that merges with a heavy strongly structured clay at about 100 cm depth. The pH increases from 5.5 in the surface horizons to 8.5 at 150 cm depth.

The brown clay soil consists of a silty clay A horizon separated from a brown B_1 horizon by a narrow sporadically bleached A_2 horizon. The B_1 horizon is separated from a brown heavy clay layer by a band of quartz gravel.

Variability:

1. *A_2 horizon development.*
2. *Amount and location of iron and manganese concretions in the profile.*
3. *Absence of A_2 horizon in some of the brown clay soils.*

Identifying features:

1. *Moderately deep (20 to 50 cm) bleached A_2 horizon in the yellow solodic soil.*
2. *Moderately gilgaied landform.*
3. *Brown clay and yellow solodic soils.*

Land use:

Grazing.

Constraints to development:

1. *Moderate to high shrink/swell potential.*
2. *Periodic waterlogging.*
3. *Low bearing strength of the A horizon.*

4.4 DRAINAGE PATTERN AND SUB-CATCHMENT AREAS

The drainage pattern is an essential component of the land resources inventory to allow the planners to be consistent with requirements of resource maintenance and improvement.

Sedimentation effects from areas undergoing development can be devastating on lower areas in the catchment with high conservation values, such as the oxbow lakes on the flood plain of the Murray River. Similarly, urbanization of new areas in the headwaters of streams draining through established residential areas can contribute significantly to siltation of established drainage facilities and increase the incidence and intensity of flooding.

The Soil Conservation Service recommends the sub-catchment as the basic planning unit for urban development. Planning of an urban area should not be considered in isolation from its physiographic relationship in a drainage system.

Drainage and sub-catchment data can also be used as inputs in planning rural subdivision in the Designated Area. Opportunities for alternate water supply schemes using farm dams can be assessed, and site suitability can be determined by reference to the Landform and Soil maps prior to detailed site investigation.

Features which have been mapped on the Drainage Pattern and Sub-Catchment map are -

* *Drainage pattern*
* *Principal catchment areas*
* *Sub-catchment boundaries*
* *Areas of sub-catchments*
* *Lands generally in excess of 18°*
* *Prescribed streams*

Segments of maps of the drainage pattern prepared for this Study are presented as maps 3, 9 and 15 in Appendix A.

Drainage pattern

Drainage patterns have been described on the map using a hierarchical system of stream orders to classify individual drainage lines and their adjacent drainage plains.

Streams are classified in the following order -

1st Order Stream
2nd Order Stream
3rd Order Stream
4th Order Stream
5th Order Stream

The stream orders are assigned by subdivision of the drainage line into segments between stream junctions. A first order stream is given from its point of origin to its junction with another stream. Where two first order streams join, a second order stream segment commences and continues until a junction is formed with another second order stream to produce a third order stream and so on.

This classification of streams relates to their significance in carrying runoff. The higher the numerical order of the stream the more likely that overtopping of the drainage channel will occur.

The condition of the drainage pattern can be assessed by reference to the Landform Map which specifies if the drainage line is incised or if it comprises a drainage plain. The Soil Erosion Map specifies the degree and depth of gully erosion affecting the lower order streams and the extent and geomorphic process of stream bank erosion of the streams of high orders.

The present condition of streams have adjusted to the current rural land use. Further intensification of this use or increase in urban development will significantly alter the existing hydrological regime. Planners will need to take into account the changing hydrological patterns as the result of urban development. Drainage lines and their adjacent floodplains should be retained and soil conservation treatments incorporated to prevent the further downcutting and lateral widening of the streams.

Principal Catchment Areas

All runoff from the New South Wales Designated Area flows into the Murray River system. Tributary streams are ephemeral and flow only in direct response to rainfall or saturated soil conditions in the winter months. Some springs are located in these streams but they do not contribute to a permanent base flow.

Seven principal catchment area boundaries are mapped.

* *Hume Weir Catchment*
* *Hawdons Lagoon Catchment*
* *Eight Mile Creek*
* *Bungambrawatha Creek*
* *Horseshoe Lagoon*
* *Murray River*
* *Splitters Creek*

Two thousand one hundred and fifty hectares of the Hume Weir Catchment lie within the Designated Area. The catchment area is a Proclaimed Catchment constituted under the Soil Conservation Act of 1938.

Section 22 of this Act relates to the preservation of proclaimed works, whereby any action done or proposed to be done in relation to land within the Hume catchment area, is likely to cause damage or interfere with the utility of the proclaimed work, the Minister for Conservation and Water Resources may serve notice on the owner to abstain from carrying out such acts. Objections to such a notice from owners are referred to the Catchment Areas Protection Board.

The principal catchment nominated as the 'Murray River' includes all small sub-catchments adjacent to and draining directly into the Murray.

Sub-Catchment Boundaries

The seven principal catchments of the study area have been divided into 83 sub-catchments. The sub-catchment boundaries are determined on physiographic features such as the ridges of interfluves within the principal catchment, or when natural drainage has been intercepted and diverted by the construction of a road or railway line.

Sub-catchment units are included in the land resources inventory to emphasise the concept of using the sub-catchment unit as the basis for land use planning. This will ensure that development in one section of a sub-catchment will not proceed without consideration of the entire unit.

An obvious, though recurring example, is the location of urban developments in the lower reaches of a sub-catchment without adequate drainage facilities to carry the increased runoff, should urbanisation take place in the upper sectors.

The drainage units also provide the basis for planning soil erosion control programmes, including flood detention and sediment control schemes.

Area of Sub-Catchments

The area of each sub-catchment basin has been measured and given an individual number for reference purposes.

The legend of the maps give the location of each sub-catchment, its area, the total of any additional catchments that may lie upstream and the Principal Catchment Area to which the sub-catchment contributes.

Lands generally in excess of 18^{o} slope

'Protected lands' are those lands within notified catchment areas having a slope in excess of eighteen degrees from the horizontal (33%).

The Soil Conservation Act of 1938 (Amendment) provides that no person shall ringbark, cut down, fell or otherwise destroy any tree in these 'protected lands' without the authority of the Catchment Areas Protection Board. These restrictions are considered necessary on the steep areas to reduce the risk of erosion damage and siltation of Lake Hume.

The Soil Conservation Service assists the Catchment Areas Protection Board in the administration of this Act.

Prescribed Streams

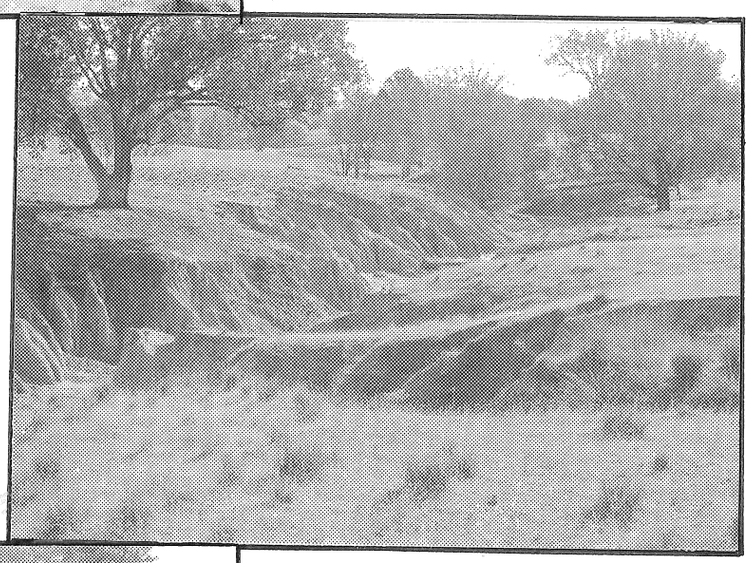
The Murray River and the Eight Mile Creek are 'prescribed streams' under Section 26D of the Water Act 1912. Destruction of timber within 20 metres of the banks of these 'prescribed streams' is prohibited unless prior approval is obtained from the Catchment Areas Protection Board.

4.5 SOIL EROSION

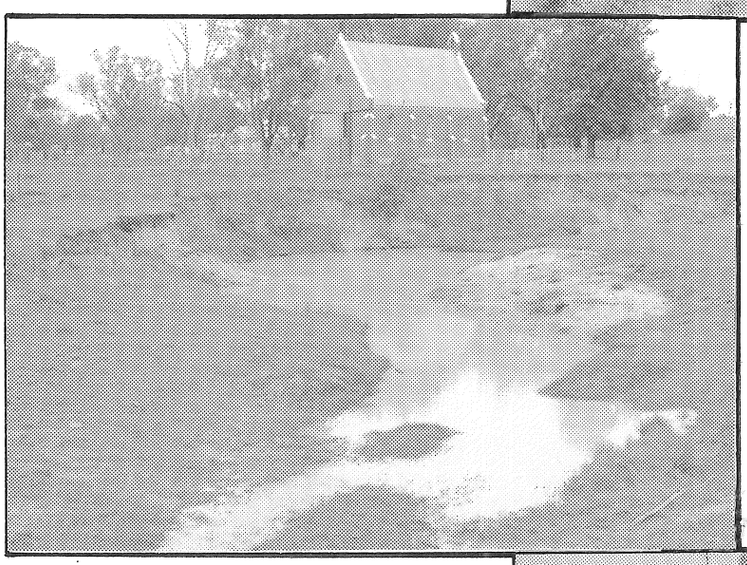
Soil erosion is mapped to show the extent of degradation of the soil resources within the Designated Area and to give some indication of the erodibility of the different soil types.

SOIL EROSION.

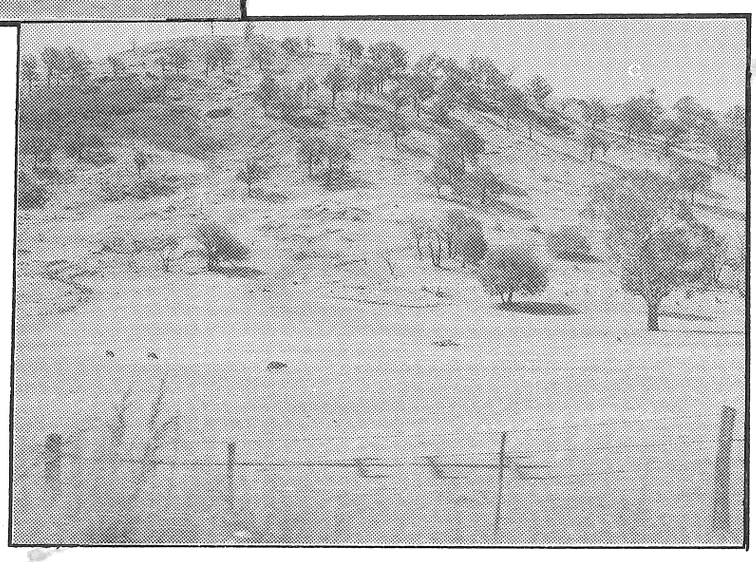
Moderate gully erosion can occur on unstable soils in small catchments. Sheet erosion in the foreground is limiting growth of grass.



Severe gully erosion produces vast quantities of silt. Control of this erosion in the drainage lines should precede urban development.



Stream bank erosion is likely to increase as increased urban development changes the condition of the catchment.



Mass movement of soils occurs in the form of earth flows and slumps. These are frequent on the granite soils.

Plate IV

From these erosion descriptions, an estimate of the cost of controlling the eroded areas is derived.

Mapping of soil erosion is carried out by stereoscopic interpretation of aerial photographs, supplemented by ground field survey to assess if any changes have occurred between the time at which the aerial photographs were taken and the present ground condition.

Soil erosion classes are -

No appreciable erosion

Sheet erosion	*- minor*
	- moderate to severe
Gully erosion	*- minor*
	- moderate
	- severe
	- very severe
Mass movement	
streambank erosion	*- caused by slumping of streambanks*
	- caused by undercutting of stream-banks
	- caused by gully or rill erosion of streambanks

Streambank erosion is mapped separately from gully erosion because in the Designated Area it is the principal form of soil erosion and the major contributor of bedload and suspended material. Of the three forms of streambank erosion mapped, the first two classifications are essentially complementary and are different stages of the one process. Undercutting of the streambank precedes the slumping of the streambank. However, the two stages have been identified separately as they are easily interpreted from the aerial photographs.

The third category of streambank erosion is characterised by rills and gullies, extending away from the banks, and caused by water flowing over the bank of the stream into the channel.

Mass movement in the area occurs in two basic forms - slumps and earthflows.

Slumps are characterised by a concave slip plane, with a short scarp at the head of the slump, backward tilt of the mass, and heaving at the toe. Increased slumping generally occurs when protracted dry weather is followed by heavy rain.

Earthflows are slow to relatively rapid movements of soil on steep slopes, associated with a high soil moisture content at the time of accelerated movement. On some soil types, erosion, having commenced as an earthflow, very quickly develops into gully erosion, removing all traces of the original displaced soil mass. This has occurred along the range of cleared hills on the western boundary of the Growth area.

The four classes of gully erosion are based upon the density and the form of the gullies over a unit area. Gully erosion is further qualified by assessing the depths of the individual gullies. Three depth classes are recognised -

Less than 1½ metres deep

1½ to 3 metres deep

Greater than 3 metres deep

Sheet erosion is mapped as one of two possible units. Minor sheet erosion generally occurs on those lands where the percentage bare ground is less than 10 per cent. Above 10 per cent bare ground cover, the sheet erosion is mapped as moderate to severe.

4.6 EXISTING LAND USE

Since 1850 the immediate area surrounding Albury has been traditionally used as small farm units supplying vegetables, dairy and horticultural products initially to the north-east Victorian goldfields and later to the town.

Many vineyards were established on the red soils in the Designated Area but succumbed to the disease phyloxera at the turn of this century.

Within the New South Wales Designated Area there is an abnormally large number of small holdings, of which approximately 78% are less than 30 hectares. This is attributed to the smaller horticulture and dairy farms, and the granting of many mining leases prior to 1940. Subsequent to this period further subdivision of farms into rural residential allotments has occurred on properties close to the city.

Remnants of the native forests are confined to the areas of poorer soils. Trees on the timbered hills surrounding Albury have been extensively exploited for fire wood since settlement of the area. Much erosion damage has occurred to these lands from numerous tracks, gold mining activities, overgrazing, and fire damage. This has resulted in a poor catchment condition, characterised by a low rainfall infiltration capacity and high rates of runoff. Where clearing of the steeper slopes has occurred, the resultant grazing value of both native and improved pastures is low. Overgrazing has been frequent and extensive sheet erosion is common.

Existing Land Use Maps

The features mapped are -

* Locations of buildings, sheds and yards.
* Subdivisional fencing including positions of gates and cattle grids.
* Farm dams.
* Alternate farm water supply such as windmills, reticulation tanks, troughs and pipelines.
* Springs - waterlogged or soakage areas that would affect agricultural production.
* Access tracks.
* Irrigation development.
* Areas of rabbit infestation.

Additional features shown on the land use maps include areas of uncleared native timber, cultivated areas, grasslands, roads, water features and cadastral information.

The inventory of existing land use will assist in making land management recommendations based on the land capability assessment.

Land management decisions may include -

* Properties suitable for amalgamation.

* Extent of existing developments such as sub-division fencing and farm dams, as the basis for planning rural subdivisions.

* Location of access tracks and water supply in remote areas for fire control purposes and strategic agistment of stock.

* Management of forested areas.

* Relocation of existing farm enterprises to alternate sites due to urban demands.

4.7 CLIMATE

Introduction

The climate of the Albury-Wodonga Designated Area was considered in relation to the response of plant growth, the hydrological responses of the various soil groups, and their stability to both high intensity storms and long duration rainfalls that can produce saturated soil conditions.

Rainfall

The annual rainfall for the Albury area is 700 mm. Rainfall increases from west to east due to the influence of topography. The median annual rainfall for Bungowannah, 15 km to the west of Albury, is 551 mm, at Albury, 695 mm, and at Bethanga, 15 km east of Albury, is 740 mm.

High intensity storms are a feature of the rainfall pattern during the summer months. Runoff and soil loss rates during this period are higher than during other times of the year because of these high intensity storms and poor ground cover conditions. The erosion hazard depends upon the soil erodibility and factors such as ground cover and slope which determine the potential soil loss.

Rainfall intensities for various durations and return periods are given in Table 1.

Table 1 Rainfall Intensities (mm/hr) for Various Durations and Return Periods

Duration Minutes	Return Period (Years)				
	5	10	20	50	100
10	77	92	110	132	154
20	56	67	82	98	111
30	44	52	64	77	87
40	37	43	52	63	71
60	28	32	39	46	52
100	19	23	27	32	35

Temperature

The following temperature ranges are experienced in the Albury area.

Mean monthly maximum for February	-	*32.4°C*
Mean monthly maximum for July	-	*13.6°C*
Mean monthly minimum for February	-	*15.7°C*
Mean monthly minimum for July	-	*3.4°C*

Extreme temperatures recorded at Albury are 46°C and -7°C.

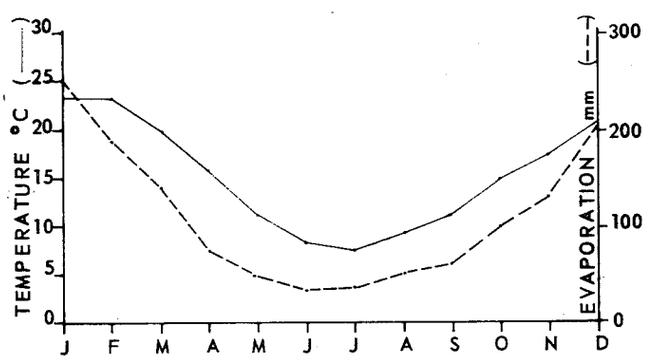
The average frost free period is 249 days.

The annual average evaporation for Albury is 1500 mm.

A plant growth model applicable to the Albury area has been derived. This is based on the interaction of available moisture and temperature, with available moisture to be calculated from rainfall, evaporation and the water holding capacity of the soil.

Figure 5

TEMPERATURE & EVAPORATION FOR ALBURY



Soil Moisture, Temperature and Plant Growth Relationships

To understand the response by plants to the seasonal variations in soil moisture availability and monthly temperatures the following figures have been prepared for the different soil groups that are mapped in this Study.

The soil associations are grouped in descending order based on their moisture holding capacity within the top 1 metre of the intact profile. (Table 2)

Table 2 Estimated Moisture Holding Capacity of Soils in the Study Area

Moisture Holding Capacity	Soil Association
High 150 mm	Mungambareena Howlong Murray River Alluvium
Medium 100 mm	Wirlinga Hamilton Valley Thurgoona Dights Hill Ettamogah Splitters Creek Bungambrawatha Creek Alluvium
Moderate 50 mm	St. Johns Eight Mile Creek Alluvium
Low 25 mm	Kywana Granite Hill Soils

Plant growth relationships for the Albury area are shown in figure 6. The growth potential is highest in spring when soil moisture is adequate and temperatures are increasing. In the autumn the commencement of growth depends on soil moisture recharge but will be retarded by low temperatures.

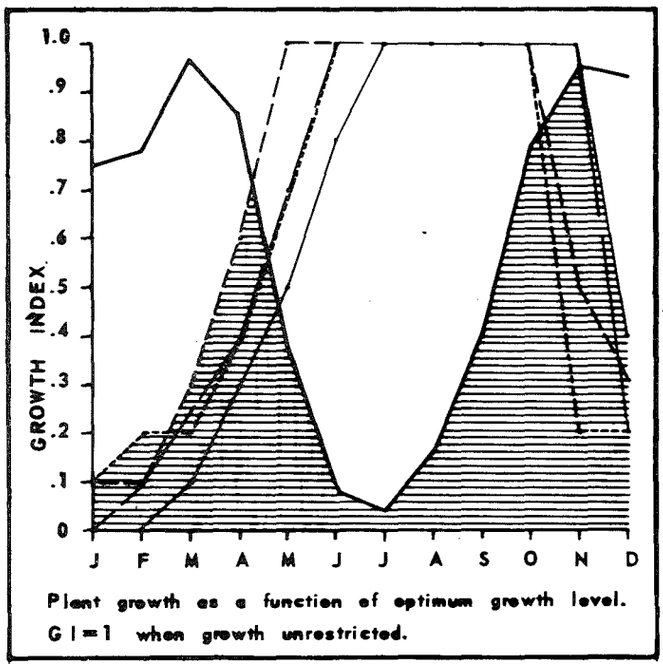
The effect of water holding capacity on growth is twofold. In the autumn soils which hold small amounts of water are recharged by rainfall more rapidly but are more affected by small evaporative losses. Because they are recharged rapidly much of the autumn rainfall is lost as runoff. Also evapotranspiration quickly depletes the available moisture. These soils consequently remain drier than those having an available moisture store of 100 mm, until the winter when evaporative loss rates decline.

A soil with a moisture holding capacity of 150 mm is not fully recharged by rainfall until July. Plant growth can be expected to be retarded up to this time.

Soil moisture holding capacity is an important factor determining the period that growth can be sustained in the spring.

Figure 6

PLANT GROWTH RELATIONSHIPS – ALBURY AREA



Temperature Response Only
Soil Moisture Index S_s = 150 *mm*
S_s = 100 *mm*
S_s = 50 *mm*
S_s = 25 *mm*
Plant Growth

* *Plant growth index - dry matter production at a given factor level relative to production at optimal or non limiting levels of factor.*

G.I. = 1 when growth unrestricted.

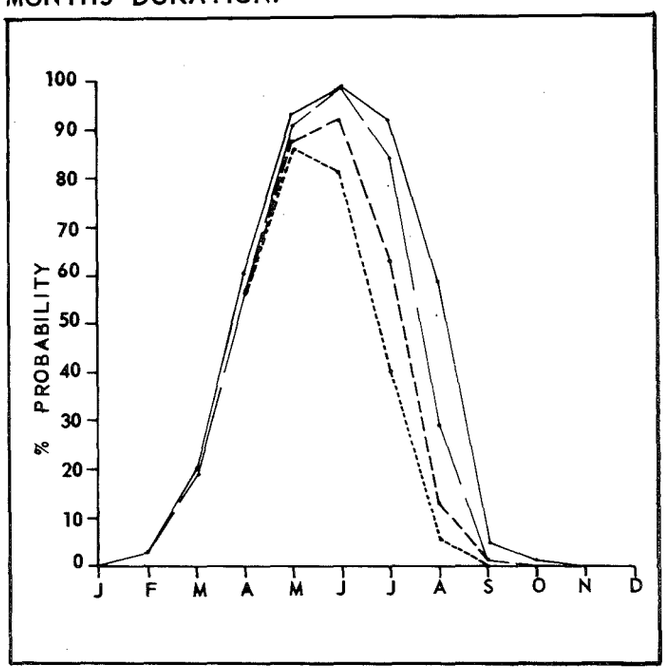
Probability of Growing Seasons

The availability of soil moisture is an important consideration for revegetation on areas denuded as a result of urban development. Figure 7 provides an indication of the probability of obtaining a growing season of 5 months duration for the various soils in the Development Area. This figure should be assessed together with figure 6 showing the growth index diagram.

Applying this information, revegetation of disturbed land should not be attempted between November and March without the provision of irrigation.

Figure 7

PROBABILITY OF GROWING SEASON OF 5 MONTHS DURATION.



Soil moisture holding capacity values

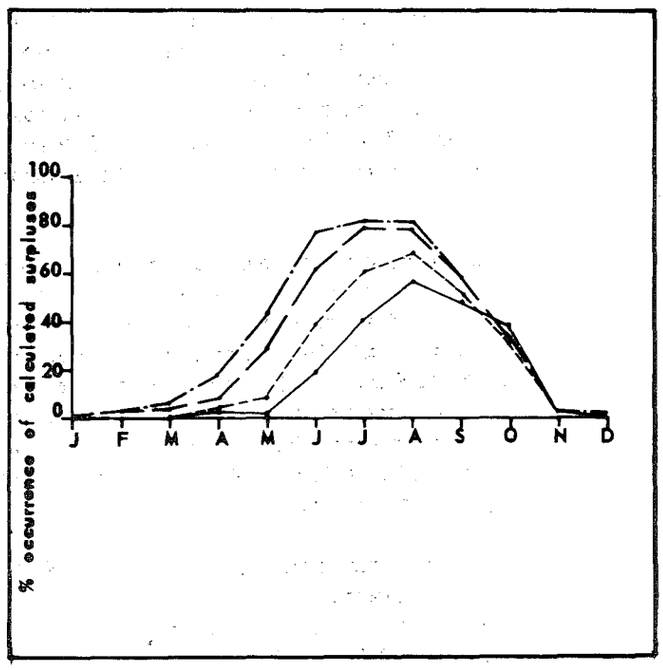
——— 150 mm
— — 100 mm
— — — 50 mm
------- 25 mm

Runoff Index

Reductions in soil moisture holding capacity results in higher rates of runoff during the autumn-spring period. The differences between the water holding capacities of the soil groups is most marked during June and July and are due to the greater amount of rainfall required to recharge soil capable of holding 100 mm or 150 mm of water. Runoff from soils having a low water holding capacity is more responsive to monthly rainfall values

Figure 8

RUNOFF INDEX FOR MAJOR SOIL GROUPS



Soil moisture holding capacity values

——— 150 mm
– – – – 100 mm
— — — 50 mm
—·— 25 mm

Selection of plant species

The seasonal summer drought experienced in this area makes it unsuitable for the use of tropical species or those requiring a mid to late summer growing period. Cool season species such as clovers, ryegrass, cocksfoot and phalaris are satisfactory for revegetation purposes but they must be sown sufficiently early to reach flowering and seed setting age by mid November. Sowing during the period April to late July could be carried out with a better than 70% chance of success. Late sowing leads to a progressively higher chance of failure.

5. METHOD OF LAND CAPABILITY ASSESSMENT

Land Capability Assessments have been determined for rural, urban and recreational land uses.

The capability classifications identify the limitations to the use of the land as a result of the interaction between the physical resources and a specific land use. The principal limitation recognised is the stability of the soil mantle. Subsidiary limitations include the susceptibility to flooding, the occurrence of rockiness and the depth of soils.

The relevance of the individual resources to an assessment of the rural, urban and recreational capabilities is discussed in the appropriate sections.

The development of the three alternate land uses provides planners with defined land use options in planning the structure of the Albury-Wodonga Growth Centre. They give recognition to the constraints and opportunities of available resources to permit a greater flexibility in planning. This will result in plans compatible with community needs and give full recognition to the environment.

Four major resources variables have been mapped. They are soils, landform, drainage pattern and soil erosion. Other constraints to development imposed by geology and flood zones of the Murray River have been obtained from studies prepared by the N.S.W. Department of Mines, (1974) and Gutteridge Haskins & Davey (1975). Factors of climate and vegetation have been assessed in a regional context and input has been on a subjective basis. Climate is considered from the point of suitability for growth of vegetation and erosion hazard.

The physical resources are arranged into key elements that combine to enable the evaluation of the capability of a site. The interaction between slope, terrain component and soils are considered as major factors. Where other physical constraints such as flooding occur on a particular terrain component, they are considered separately.

The physical resources have been assessed on an objective basis. The limitations of each resource on a land use are explained in the section describing the physical resources of the area.

The interpretation of the physical resources is made from engineering standards for soils, limitations to development recommended by the N.S.W. Department of Mines, and a knowledge of the cause-effect interactions of a land use upon a physical resource.

Soil interpretations are based upon a potential use that when applied to the soil will support a particular intensity of urban development or rural land use. Where soil limitations cannot be overcome with the application of feasible practices, e.g. drainage, application of soil ameliorants, or stabilization practices, the land use recommended is one that would be least damaging taking into account the soils limitations.

Table 3 has been prepared to assess the capability of the land for rural or urban uses. The impact of resource limitations on land use has been determined from this table. Class boundaries are defined on the mapping boundary of the most limiting resource value. Hence the land capability boundaries on the map correspond

Runoff Index

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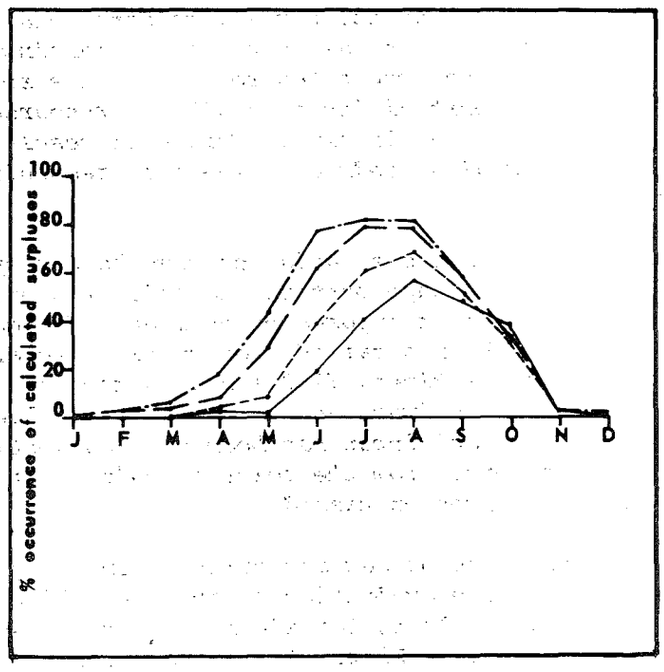

Soil moisture holding capacity values

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—·— 25 mm

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Table 3 has been prepared to assess the capability of the land for rural or urban uses. The impact of resource limitations on land use has been determined from this table. Class boundaries are defined on the mapping boundary of the most limiting resource value. Hence the land capability boundaries on the map correspond

principally to a landform or soil boundary. Where other constraints such as mass movement, severe gully erosion or flooding are identified, boundaries are mapped to the limit of the area susceptible to the constraint. Minor variations to the land capability boundaries have been made where local knowledge and experience of soil conservationists has shown that additional constraints may occur. This primarily has been in relation to seepage areas and the occurrence of localised high water tables.

Land classes contained in Table 3 show jointly a rural and urban land capability for the combination of each of the physical resources acting on a parcel of land. Roman numerals define the rural capability of the site while the capital letters define the urban capability.

Capability classes are presented in this manner for convenience as urban land use is mutually exclusive of rural use, and allows planners an immediate assessment of alternate land uses.

The Recreational Capability has not been mapped due to the large range of recreational activities having various impacts on the environment. The recreational capability of a site can be determined by reference to Tables 5 and 7 in the section on Recreation Capability. From these tables the capability of a site can be assessed for eight recreational activities.

Each land capability classification recommends the potential and most intensive use of a parcel of land. Alternate land uses can be readily assessed and positive objectives for maximising the resource potential and net productivity of the land can be achieved.

Management proposals for each land class assist planners and engineers to achieve their objectives consistent with maintaining or improving the resources of the area. These are discussed in the following sections.

Data presentation and interpretation techniques are illustrated in Appendix A, maps 1-18, which reproduce sections of the land resources and land capability maps from three map sheets - Bungil 1.2, Indigo 7.2 and Indigo 8.3. These figures illustrate the way in which the basic land resource data are mapped and presented to the planner. The relationships between the final capability assessments and the basic data can be observed by overlaying the individual maps.

A complete set of all maps for the study comprises 66 individual sheets. Because of their volume, they have a restricted distribution to planners and other authorities immediately involved in the Growth Centre.

Eleven 1:10 000 map sheets cover the Study area. They are -

Indigo	*7.2,*	*7.3,*	*7.4*	
Indigo	*8.1,*	*8.2,*	*8.3,*	*8.4*
Bungil	*1.1,*	*1.2,*	*1.3,*	*1.4*

EROSION/INSTABILITY HAZARD

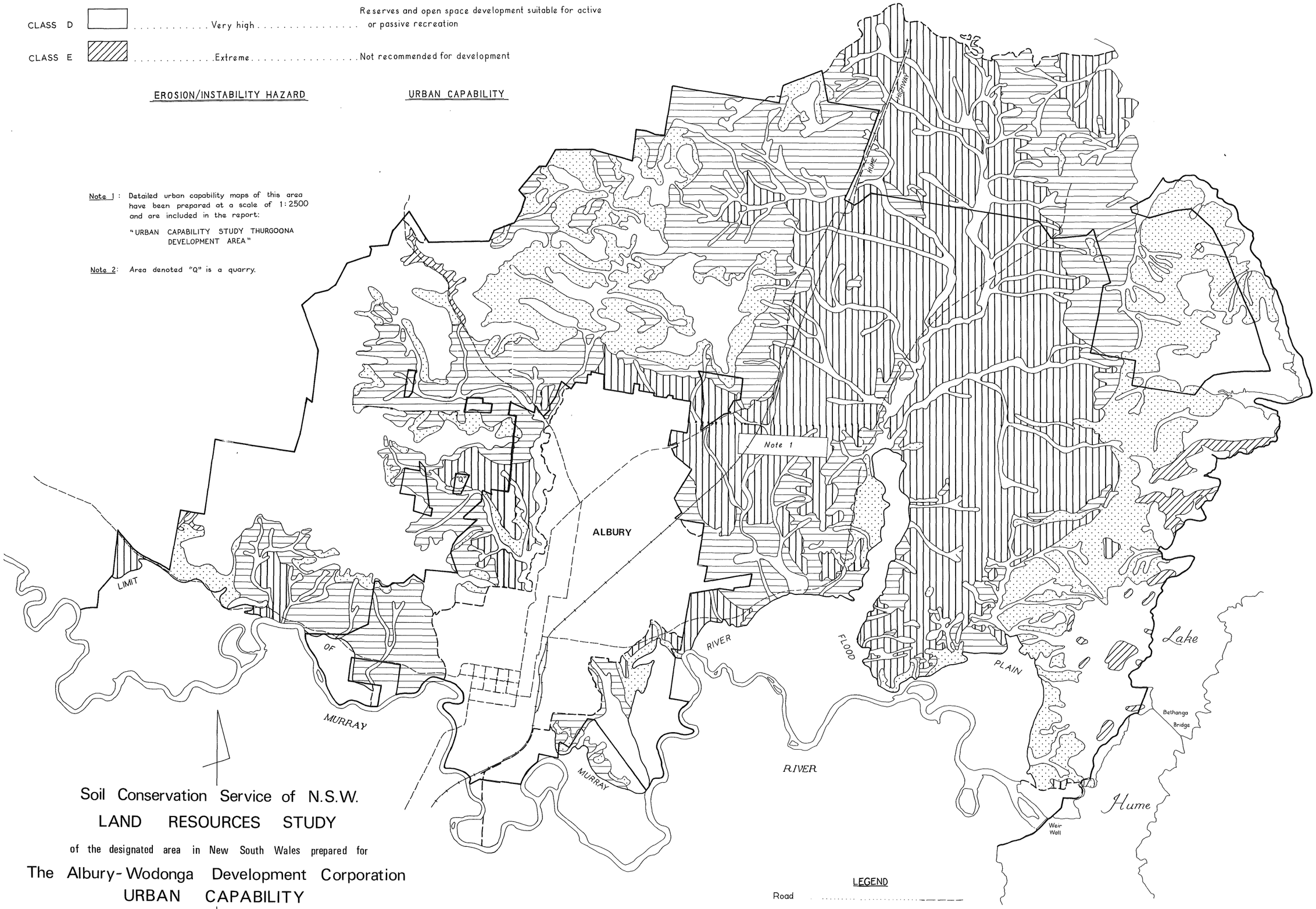
CLASS A	Low	Extensive Building complexes Industrial, Commercial, Residential
CLASS B	Moderate	Industrial, Commercial, Residential
CLASS C	High	Residential Use — Density will be determined by hazard
CLASS D	Very high	Reserves and open space development suitable for active or passive recreation
CLASS E	Extreme	Not recommended for development

URBAN CAPABILITY

Note 1 : Detailed urban capability maps of this area have been prepared at a scale of 1:2500 and are included in the report:

"URBAN CAPABILITY STUDY THURGOONA DEVELOPMENT AREA"

Note 2: Area denoted "Q" is a quarry.



Soil Conservation Service of N.S.W.

LAND RESOURCES STUDY

of the designated area in New South Wales prepared for

The Albury-Wodonga Development Corporation

URBAN CAPABILITY

SCALE

kilometres 1 0 1 2 3 4 kilometres

LEGEND

- Road
- Railway
- Boundary of Study Area
- Boundary of Designated Area

LAND SUITABLE FOR CULTIVATION

CLASS II ..... Land suited for regular cultivation associated with intensive horticulture, broad acre crops and improved pastures.

CLASS III ..... Land suited for regular cultivation for intensive horticulture and broad acre crops in rotation with improved pastures; intensive soil conservation treatment required.

LAND SUITABLE FOR GRAZING

CLASS IV ..... Improved pastures. Land can be cropped occasionally for renewal of pastures.

CLASS V ..... Improved or native pastures.

CLASS VI ..... Predominately native pastures or pastures improved by application of fertilizers mainly by air.

LAND BEST SUITED TO TIMBER

CLASS VII ..... Development as protective forest to improve catchment condition. Limited grazing.

OTHER LAND

CLASS VIII ..... Limited grazing use. May be suitable for wildlife or recreation.

Note 1: *Detailed rural capability maps of this area have been prepared at a scale of 1:2500 and are included in the report*
"URBAN CAPABILITY STUDY THURGOONA DEVELOPMENT STUDY."

Note 2: *Areas denoted "Q" are quarries*

HUME HIGHWAY

Note 1

ALBURY

MURRAY RIVER

Lake Hume

Bethanga Bridge

Weir Wall

LEGEND

Road

Railway

Boundary of Study Area

Boundary of Designated Area

Soil Conservation Service of N.S.W.

LAND RESOURCES STUDY

of the designated area in New South Wales prepared for

The Albury-Wodonga Development Corporation

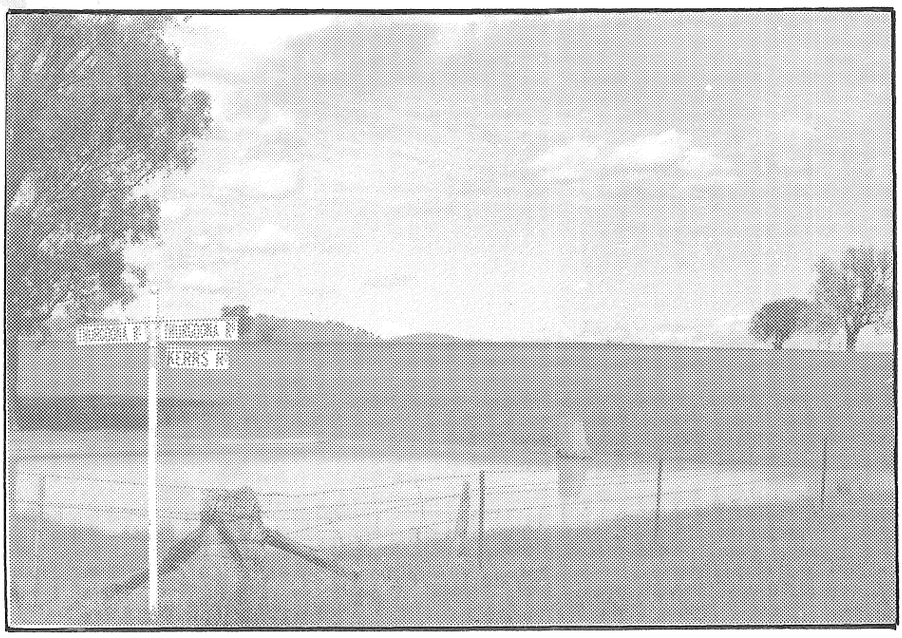
RURAL CAPABILITY

SCALE

URBAN AND RURAL LAND CAPABILITY CLASSES.

CLASS II D

Cultivation land on the flood plain. This land is not suitable for urban development because of the flooding hazard.



CLASS II A

Land suitable for cultivation and all urban uses.

CLASS III A

Gently sloping lands at Wirlinga are suitable for cultivation and urban uses.

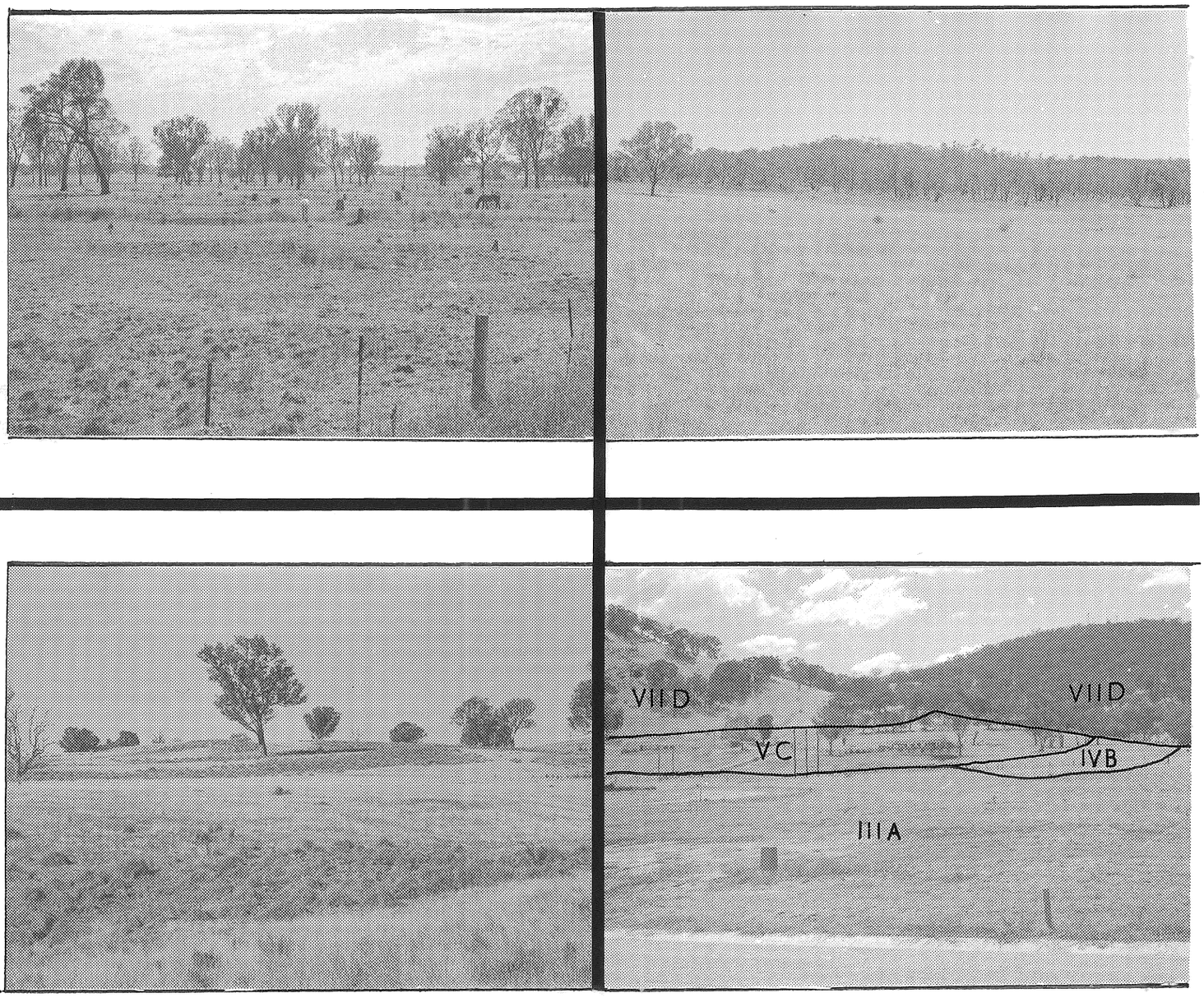
URBAN AND RURAL LAND CAPABILITY CLASSES.

CLASS IV B

Grazing land. Poor drainage and soils of high plasticity are constraints to be over come for urban development.

CLASS V B

Shallow, low fertility soils restrict the use of this land to grazing. This area is suited to residential development.



CLASS V C

Land suitable for grazing. High water tables, extensive seepage patches and unstable soils are major constraints limiting urban development.

The Capability Classification Illustrated:

III A	*Low hazard - cultivation land, maximum urban development.*
IV B	*Moderate hazard - grazing or residential land use.*
V C	*High hazard - grazing and low density residential land use.*
VII D	*Very high hazard not suited for grazing or urban use forest lands.*

Table 3 — *Land Capability Assessment for Rural and Urban Land Use*

TERRAIN COMPONENTS	SLOPE a 0-2%	b 2-5%	c 5-10%	d 10-20%	e 20-30%	f 30-50%	g 50%		
1 Ridge Hill-crests	IA IIA IIA IVB IVC	IA IIA IIIA IVB IVC	IIA IIIA IIIB IVC VC	IVB IVB VB VC VD	VIC VIC VIC VID VID	VID VIC VIID VIID VIIE	VID VIID VIID VIIE VIIIE	L M H VH E	SOIL ERODIBILITY
2 Side Slope	IA IIA IIB IVB IVC	IIA IIA IIIB IVB IVC	IIA IIIA IVB VC VC	IVB IVB VB VC VD	VIC VIC VIC VID VID	VID VID VIID VIID VIIE	VID VID VIID VIIE VIIIE	L M H VH E	
3 Foot Slope	IIA IIA IIB IIC IVC	IIA IIIA IIIB IVC IVC	IIIA IIIB VB VC VC	IVB VB VC VD VD				L M H VH E	
4 Flood Plain	IIA IID IID IVD IVE	IIA IID IID IVD IVE	Old River Terrace above 100 year 20 year to 100 year 5 to 20 year Below 5 year flood level Flood channels, old meander scrolls					Flood Frequency	OTHER PHYSICAL CONSTRAINTS
5 Drainage Plain	IVC IVD IVD	IVC IVD VD	VC VD VD	VC VD VIID	Seasonally high water table. High water table liable to overland flow. Localised flood liable land.			Wetness	
6 Incised Drainage Channel	VD	VD	VD	VIID	VIID	VIIE		High Instability Hazard	
7 Disturbed Terrain	VC	VC	VC	VIC	VID	VIID	VIIIE		
8 Mixed Terrain Unit	Classification determined by stability of the soils, degree of slope and site drainage.								
9 Water Bodies	IVD VD	Swamps (not located on the floodplain) Man made features. e.g. Farm dams.						Wetlands - Prime Conservation Areas	
10 Oxbow Lake	IVE	Former channels of the Murray River having a permanent high water table.							

5.1 RURAL LAND USE CAPABILITY CLASSIFICATION

In the rural capability classification, the land is classified according to the potential of an area to achieve a sustained production basis over time. In order to achieve this potential, specific soil conservation and land management measures are required to maintain the soil resource. Land which is used beyond its capability can be expected to deteriorate rapidly, resulting in loss of production and the permanent loss of the soil resources. Soil erosion can be rapid adversely affecting not only the immediate area but adjoining lands by the deposition of sediment. Erosion of drainage lines by lateral or vertical incision may also result from the increased runoff.

The classification system used in this study is one which is used State-wide by the Soil Conservation Service of N.S.W. (1975). The eight standard classes for rural lands are :

Land suitable for cultivation

Class I — *No special soil conservation practices necessary.*

Class II — *Simple soil conservation practices necessary to prevent soil erosion such as contour cultivation, adequate crop rotations and good soil management.*

Class III — *Intensive soil conservation measures such as graded banks, waterways and diversion banks necessary in addition to the practices for Class II.*

Land suitable for grazing

Class IV — *Simple soil conservation practices such as pasture improvement, livestock control, application of fertilizer and contour chisel ploughing necessary on lands which have a low erosion hazard.*

Class V — *Intensive soil conservation measures such as pasture furrows, absorption banks, diversion banks, and deep contour ripping are necessary in addition to the practices for Class IV on lands which have slopes generally less than 20 per cent.*

Class VI — *Good management practices are necessary. These may include limitations of livestock, broadcasting of seed and fertilizer, prevention of fire and destruction of vermin, together with retention of green timber on slopes above 33 per cent.*

Structural soil conservation measures are usually impracticable on this steep or broken or rocky land.

Timbered land - not suitable for grazing

Class VII — *Land best suited for green timber for any of the following reasons - erosion hazard, steepness, shallowness, or infertility. Generally livestock should be excluded.*

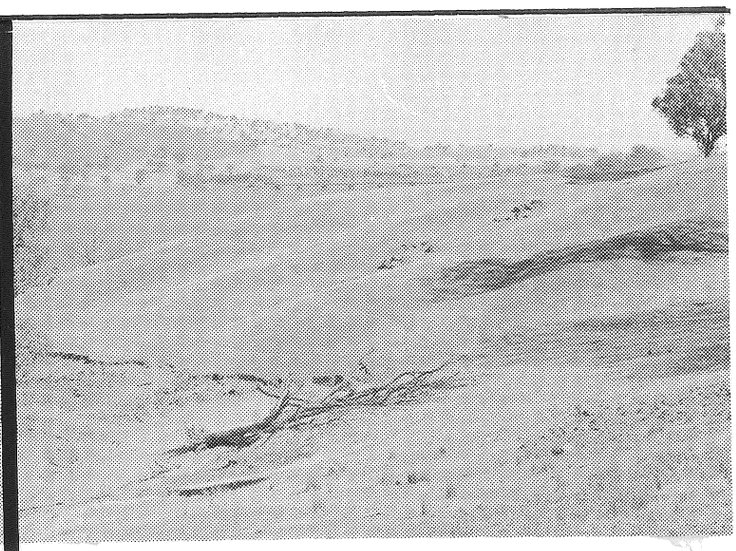
URBAN AND RURAL LAND CAPABILITY CLASSES.

CLASS V D

Suitable for grazing. Erodible soils, high water tables and mass movement makes this land unsuitable for urban use.

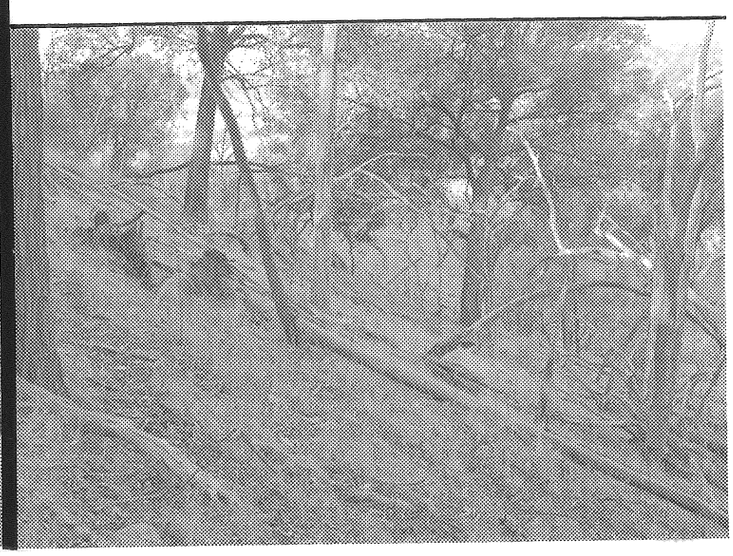
CLASS VI D

Suitable for grazing. Steep slopes above 20% and highly erodible soils are major constraint to urban development.



CLASS VII D

Severly eroded drainage line that should be stabilized and fenced to exclude stock, and planted with trees.



CLASS VII D

Steep slopes on the Black Range are unsuitable for urban development. They have limited grazing value and are best retained under forest.

Other land

Class VIII *Cliffs, lakes, swamps, and other land unusable for agricultural or grazing purposes.*

Description of the Rural Land Classes and Land Management Requirements

Class I

Description

Land in this class is not found within the boundary of the Study area.

Class II

Description

Comprises land on the elevated sections of the floodplain above a 1 in 5 year flood frequency level, and the gentle slopes (less than 2 per cent) of the hills at Ettamogah and Thurgoona. The main soil types on the floodplain are a medium to heavy textured loam and at Thurgoona and Ettamogah a yellow podsolic soil of moderate fertility.

Management

This land is suitable for regular cultivation on a sustained production basis providing that attention is given to simple soil conservation practices which include -

- *Adequate crop rotation to maintain soil structure.*
- *Contour cultivation and stubble mulching.*
- *Simple water diversion or drainage systems.*
- *Grassed waterways may be necessary to protect these lands from runoff originating from higher lands, to reduce flooding and to reduce soil saturation of these areas.*

This land class is the most suitable class for intensive horticultural production with irrigation.

Class III

Description

Class III lands occupy the large area forming an arc from Wirlinga through Thurgoona to Ettamogah. Slopes range from 2 to 10% having yellow solodic and yellow podsolic soils of moderate fertility. These lands are gently sloping to undulating and are the most suited to cereal growing, particularly oats.

Past cultivation practices have led to moderate sheet and gully erosion. Where cultivation has occurred on slopes above 10%, soil erosion has been more intense reducing the productive capability of the area.

As all the rainfall cannot be absorbed on these lands, structures such as graded banks are necessary to carry the runoff safely across the slope into dams, stable natural watercourses or to constructed grassed waterways. Once runoff is controlled, regular cultivation for cereal crops, orchards or vineyards can be carried out on a sustained production basis.

Management

Management of Class III land initially requires the control of runoff water from these lands onto adjacent areas without increasing the erosion risks. Grassed water disposal areas should be established and never cultivated or used for farm access.

Establishment of stable drainage and water disposal areas is important to the overall catchment management policy of the designated area.

Planning of subdivision fencing for efficient land management is most desirable.

Attention should be given to the following :

* *Land suitable for cultivation should be fenced off from lands best suited for grazing, i.e. Class III land should be fenced off at the land class boundary to Class IV or Class V.*

* *Subdivision fencing in Class III should be located to allow the longest direction of cultivation across the slope. Fences can be located below graded banks to provide least interference with cultivation practices.*

* *A subdivision fencing plan relating to the land capability assessment, includes the location of suitable dams and watering places and the movement of vehicles, farm machinery and stock throughout the farm, to overcome potential soil erosion problems.*

Preparation of land management plans for individual properties is undertaken by the Soil Conservation Service.

Class IV

Description

Class IV land is best suited to grazing because of its stony nature, poor soil fertility, high water table or being subject to regular or seasonal inundation.

Two major land types are included in this land class. They are -

1. *The lower slopes of steep rocky hills.*
2. *Land on the Murray River floodplain which is situated below a 1 in 5 year flood frequency level, including the former river channels.*

Land on the lower slopes of steep rocky lands

These are located in the western half of the Designated Area on the lower slopes of the hills surrounding Albury. Slopes range from 0 to 20%. The soils comprise the Black Range or Complex Hill soils and yellow solodic soils of low fertility and high erodibility.

These lands become very wet during the winter months with seepage from the hills above. Other areas have a seasonal high water table or are liable to overland flow.

Management

Management of this land is aimed at improving the grazing potential by using improved pasture species, phosphate fertilizers and chisel seeding. Occasional cultivation for the purpose of restoring pastures may be practicable and even desirable on this land type.

Control of stocking rates and rabbit infestations are desirable to avoid the depletion of ground cover.

The Flood Plain

The frequency of flooding of the Class IV land and its erosion hazard can be assessed with reference to the combined rural and urban capability symbol on the Land Capability Maps.

Land classed IV D is below a 1 in 5 year flood frequency determined by Gutteridge, Haskins and Davey (1975). These include the broad level areas between the old river channels containing oxbow lakes. They are highly productive grazing areas.

Land classed IV E is below the 1 in 5 year flood frequency and contains the old river channels and oxbow lakes which are identified on the Landform map. These are areas subject to the most frequent flooding of any land on the floodplain and will carry flood flows at very high velocities in flood events. They are the most susceptible areas to erosion damage and should not be cultivated.

Management

The management of these lands is critical to the stability of the entire flood plain to avoid any major shift in the present river channel of the Murray.

Grazing of lands classed IV E should aim at maintaining a dense sward of native vegetation that is adapted to wet conditions and a fluctuating water table. Cultivation of these lands for cropping or horticultural production is not recommended due to the high probability of flooding and resultant severe erosion damage of the alluvial soils.

Occasional cultivation for the establishment of improved pastures should be confined to areas away from the flood channels. Pasture species must be able to withstand prolonged periods of inundation.

The positioning of fences to run parallel with the direction of water in flood channels and allow easy stock movement in times of flood is an important management factor in the subdivision of these Class IV lands. Roads should be located to avoid the flood channels and other areas of high water velocities. Opportunities exist for farm access roads to be established to serve two or more properties.

Access by stock to the river for water should be controlled, preferably to the inside bank of meander bends where slope gradients are shallow and deposition has formed a broad fan. Overgrazing of areas adjacent to the river bank should be avoided.

Improvements in present management of resumed lands of the floodplain may be achieved by property amalgamation or relocation of the property boundary to a more suitable position. The Soil Conservation Service could assist the Land Management Division of the Corporation in planning land use in this area.

Class V

Description

These are the hilly grazing lands with slopes below 20%. The main soil types are the Granite Hill soils and the Black Range or Complex Hill soils which are of low fertility and highly erodible. Gully erosion exists on most water-courses due to overgrazing, stock tracks and excessive clearing of native timber.

Management

To achieve a stable landscape and to improve the productivity of these lands, soil conservation measures such as graded and absorption banks, gully control structures and the filling of existing gullies are required. These measures aim at reducing runoff by increasing infiltration into the soil for pasture growth, and collection and storage of runoff water in farm dams.

Class IV and Class V lands require similar stock and pasture management practices. These lands should be fenced off from the Class VI land as they are generally more productive and easier to manage; farm machinery and earthmoving machinery can be operated over them.

Treatment of the gullied drainage lines should receive a high priority in the catchment management of these lands. Such treatment would include gully filling and stabilization of the drainage line. This would assist farm management by allowing ready access, removing rabbit harbour and preventing the deposition of silt into farm dams and against fences. The catchment hydrological condition would also be improved as the amount of channelised flow would be reduced, time of concentration would be increased, and infiltration increased. Siltation within the stream channels would be reduced.

Class VI

Description

Class VI land contains the steeper grazing lands of the hills surrounding Albury and those adjacent to Lake Hume. Slopes range from 20% to 50%. Soil types are Granite Hill soils and Black Range or Complex Hill soils which are low in fertility and have a high to extreme erosion hazard. They are subject to mass movement.

These lands are suitable for grazing, preferably by cattle.

Management

Farm machinery or earthmoving machinery generally cannot be operated over this land, and management is confined to control of stock numbers, aerial application of fertilizers and control of rabbits.

A grazing management programme should aim at maintaining complete ground cover. This can be achieved as follows :

* *A continuous rabbit eradication programme.*

* *Control of stocking in the late spring on steep hill lands to allow native grasses to reseed. Stock should be held on better undulating country to utilise the normally abundant spring pasture growth.*

* *Application of superphosphate to maintain pasture density and subterranean clover component.*

* *Avoid heavy application of superphosphate on hill tops and ridges in steep areas. This practice has led to annual species dominating the sward and results in extensive bare ridge tops in the summer and early autumn. These generate excessive runoff and cause erosion of drainage lines.*

* *Location of subdivision fencing on ridgetops that form natural subcatchment boundaries in steep country reduces erosion damage by stock tracks. It is also valuable for general farm management. Location of fencing on land capability class boundaries is desirable, particularly between Class V and VI lands. This assists in the implementation of the different management practices which are required for the control of erosion on these two land classes.*

* *Locate access tracks on ridge lines or well drained areas of red earth or podsolic soils. Solodic soils should be avoided as they have a low wet strength and will erode readily once the surface is disturbed. Soil slumps may occur where an access track is formed by a side cut across a hillslope. Where a permanent road formation is required adequate pipe drains should be provided, particularly where springs or soakages occur, together with surface drainage of the road to avoid runoff accumulation.*

* *Special precautions must be taken to protect this land from fire. These include the location of adequate fire breaks on lower land, the provision of good access, and the provision of suitable fire fighting equipment that can negotiate the steep terrain.*

* *Even grazing pressures over this land class can be achieved with the provision of several dispersed watering points. Concentrations of stock around a watering point can cause severe sheet erosion of a localised area and puddling of saturated areas such as springs and bogs. Damage to these areas can initiate gully erosion.*

Class VII

Description

Because of its steepness, shallow stony soils and high erosion hazard, these lands are best suited to green timber. Approximately 3000 hectares has been classified as Class VII.

The following areas have been included in this Land Class.

* *Large areas surrounding Albury on the Black Range or Complex Hill soils with slopes above 30%.*

* *Slopes above 30% on the steep hills adjacent to the Lake Hume. The Granite Hill soils in this area have an extreme erosion hazard and mass movement is extensive.*

* *Other areas of extreme erosion hazard that are affected by mass movement or extensive gully erosion, where tree planting is the most economic method of restoring stability.*

* *Areas adjacent to and including the incised drainage channels of the major watercourses. Clearing of these areas must not be undertaken. Natural regeneration or improvement to the existing vegetation can be achieved by the exclusion of stock and control of rabbits.*

The land use recommended for Class VII is primarily one of catchment management for streamflow regulation and to reduce siltation of drainage or retarding basin facilities downstream. This area also has an amenity value which would not conflict with the prime use. These values are timber supply, recreation, wild life, and limited grazing.

Recreation is acknowledged as a present use and a potentially very important use of Class VII land. Whatever recreational activity is being planned it is essential that the prime function of soil stability and water regulation must be considered. A use that causes erosion directly or indirectly must be recognised and an alternate use or plan developed.

Management

Class VII land occupies the headwaters of the major creeks which drain through Albury and other areas proposed for urban development. Management of this land unit is therefore of strategic importance to protect these urban areas from flooding and prevent the siltation of drainage facilities.

Mismanagement arising from clearing of timber, overgrazing or an intensification of land use would generate increased runoff, contributing to the flooding and siltation in urban areas.

Maintenance of a productive pasture cover is not feasible. In most cases the encouragement of natural forest development and regeneration would represent the most economic form of land management, and enhance the recreational value of the area.

A policy of strategic grazing with cattle by agistment on a week to week basis would be an acceptable management practice to utilize excessive growth and to reduce the fire danger. Stock numbers would need to be assessed annually, dependent upon current seasonal conditions. In addition, these lands may be used to hold cattle during flood events from other Corporation lands on the floodplain.

Continuous grazing of Class VII land is not recommended.

The recommendations contained in the report "Woodland Management in the Albury-Wodonga Development Corporation Designated Area in N.S.W." prepared by Mr. D.I. Hamilton of the N.S.W. Forestry Commission are fully supported. This report should form the basis of the Management Plan for Class VII land.

The objectives of this Management Plan are :

(a) The protection of the soil surface by retention, regeneration, or the establishment of timber.

(b) The maintenance of a woodland amenity by protection and improvement of growing stock.

(c) Organisation of a fire protection programme which includes a basic fire plan and an action fire plan.

(d) Implementation of soil erosion control measures to control existing erosion and reduce siltation damage to lower lands.

(e) The establishment and maintenance of a trails system for fire control and management access.

(f) Location of watering points with easy access for fire control or strategic stock grazing.

(g) Fencing off from other leased land or Class VI land and fencing of new planting areas.

(h) Continual maintenance of fences, gates and cattle grids.

(i) Continual rabbit eradication programme.

(j) Control of noxious weeds.

Class VIII

Description

This land class includes cliffs, lakes or other unusable agricultural or grazing land. Only two small areas are defined, one at Hawkesview, the other in Albury. Both of these sites have resulted from quarrying operations. These areas have limited recreational use such as abseiling.

Management

The management of these areas would be included in the 'Management Plan' proposed for Class VII land.

5.2 URBAN CAPABILITY CLASSIFICATION - NEW SOUTH WALES DESIGNATED AREA

The urban capability of the Designated Area has been developed from an assessment of the interaction of the key physical elements of the environment.

Five major classes of erosion/instability hazard are defined on the Land Use Capability Map :

Class A - low
Class B - moderate
Class C - high
Class D - very high
Class E - extreme

The "capability" defined for each class refers to the most intensive urban use which that class will sustain without the occurrence of serious erosion and siltation in the short term, and possible instability and drainage problems in the long term. In assessing this "capability" no account is taken of development costs, social implications, aesthetics or other factors relating to ecology other than those effects caused by sedimentation or increased turbidity. Development which is planned to minimise erosion hazard is, however, generally consistent with an aesthetically pleasing landscape and savings in long term repair and maintenance costs.

Table 4 *Summary of the Urban Capability Classification Based on the Landscape Stability Hazard*

Class	Hazard	Major Physical Constraint	Urban Capability
A	Low	Nil	Extensive building complexes. Industrial Commercial Residential Institutional
B	Moderate	Soil type, drainage, slope	Industrial Commercial Residential Institutional
C	High	Soil type, flooding, poor drainage, slope	Residential use - Density will be determined by severity of the hazard.
D	Very high	Slope, flooding, soil type, poor drainage	Reserves and open space development. Suitable for active or passive recreation.
E	Extreme	Frequent flooding, mass movement, extreme erosion hazard areas due to soil type, slope or topographic location.	Not recommended for development.

The above urban capability classifications relate to the degree of surface disturbance involved in the establishment of the various intensities of urban development and the long term effects that this development will have on the total environment.

These classes rank the limitation of urban use in broad categories to assist planners in preparing land use structure plans. Once planning concepts are determined, detailed site investigations at the planning scale of 1 : 2500 can then be initiated to define the specific physical constraints that affect urban development. Further recommendations can be made to either overcome these constraints or suggest alternate land uses within the urban area that would tolerate the constraint without adversely affecting the environment.

The urban capability defined relates to the degree of surface disturbance involved in the various categories of urban development. "Extensive Building Complexes" refers to the development of shopping malls, industrial centres, or other structures which require large scale clearing and levelling for broad areas of floor space and for parking bays. Residential development refers to a level of construction that provides roads, drainage and services to cater for 600 square metre housing blocks. The development of reserves may require shaping and modification of the ground surface and vegetative improvement. No building and minimal roadway construction are envisaged.

Class A

Description

This land class occupies a large area forming an arc from Wirlinga through Thurgoona to Ettamogah. The terrain comprises crests and gentle hillsides with gradients up to 5%, on stable soils with a low erosion hazard.

Development

Land in this class will tolerate extensive site disturbance and landscape modification for the establishment of commercial or industrial centres, residential subdivision, or active recreation facilities such as sporting ovals, without a serious erosion hazard being generated. However, a responsible approach to development is required in order to minimise the erosion damage at the site during construction and more importantly prevent sediment originating from the site polluting streams and damaging adjoining land. Attention is drawn to the items listed in the Erosion Control Techniques section contained in this report. In addition, site recommendations, including specifications for erosion control and site stabilization on a particular development concept should be sought from the Albury Soil Conservation Service office.

Maximum site development implies that a large proportion of this land will be covered by impervious structures such as buildings, roads and parking areas. In addition, an artificial drainage system of these structures will be established. These factors would change the characteristic of the watershed and its response to precipitation. Higher volumes and peak rates of runoff can be expected and these may frequently exceed the capacities of existing streams. Extensive erosion to the creek banks can result as the stream adjusts to the change in catchment condition.

To offset this change consideration should be given in the planning stage to applying a principle of stormwater management whereby the peak rate of discharge of runoff water after development should not exceed the peak rate of discharge prior to development for a particular frequency storm. This principle could be achieved by providing temporary storage within the development. Car parks often provide large areas whereby up to 15 cms depth of runoff could be held from a storm event with little additional cost to development. Similarly, landscape mounding or creation of sunken lawn areas to a water feature in a landscape treatment around major industrial or commercial developments could be utilized to provide temporary runoff pondage. A conscious effort to look for and exploit opportunities to provide runoff detention structures should be made, as considerable community benefits both economic and aesthetic, would be obtained in maintaining the natural major drainage systems.

Class B

Description

Class B land consists of the steeper slopes up to 20% above Class A and flatter areas with poor soil characteristics. Limitations to intensive use of these areas are imposed by increasing slope and the physical characteristics of the soils, including high shrink/swell potential, deep poorly structured A_2 horizon, high dispersibility, high erodibility and poor profile drainage. These factors adversely affect site stability necessitating considerable additional capital expenditure if these areas are to be intensively developed.

Development

This class is best suited to residential development with a minimum of site disturbance. However, it also has the capability to support industrial and commercial development at a smaller scale than that envisaged for Class A land. Extensive cut and fill of these steeper slopes to provide suitable sites for intensive development will cause high levels of siltation and runoff with high turbidity.

No major problems are associated with the use of this land for recreation although the development of facilities such as ovals, requiring large scale cut and fill are not recommended and are best located on Class A land.

Planned urban use of this land class should observe the recommendations set out in the Erosion Control Techniques section of this report.

Class C

Description

This class has a high erosion/instability hazard where urban development will be affected by the major constraints of unstable soils, poor site drainage, high seasonal water table, localised flooding or steep slopes. Class C lands are mainly located within a 20 to 30% slope range below steeper slopes, or on footslopes or local drainage plains, that are subject to periodic inundation from runoff from local catchments.

Development

Commercial or industrial development of this land is not recommended due to the difficult site conditions and the high instability hazard of the area.

Intensive development of this class on slopes above 20% will cause a high erosion hazard and possibly mass movement. Such use is beyond the natural capability of the land without the support of major engineering structures. The high rates of runoff, siltation and turbidity concentrations associated with dispersible soils in this class will severely affect the adjoining lands and the total environment if extensive development is permitted.

These lands are suited for residential use,the intensity of which would be determined by the severity of the major physical constraint that affects the particular site.

Additional site investigations made at a larger scale of 1 : 2500 are recommended to identify the constraints that operate, and the areas affected. Subdivisions can then be planned to avoid or to minimise the impact of these constraints on development. The Soil Conservation Service can assist the Development Corporation in evaluating the suitability of Class C land at the larger scale.

It is envisaged that residential developments on this land class will be at a lower density than land Class B. Individual block sizes would vary between 0.5 and 5 hectares in area.

This land class is not suited to the establishment of active recreation facilities due to the high erosion hazard.

Construction works planned for this area should observe the recommendations set out in the Erosion Control Techniques for urban development contained in this report. These recommendations should be included in site works specifications.

Class D

Description

Class D land is unsuited for industrial, commercial or residential use due to a very high erosion instability hazard. The major constraints to development are imposed by steep slopes, highly erodible soils predisposed to mass movement, and land on the Murray River Floodplain below a 1 in 100 year flood frequency.

Three main land components are included in this class. They are :

Hill Lands

The largest area of Class D land forms the crests and sideslopes of the major hill features in the Designated Area. These have slopes ranging from 20% to above 50%. The soils are variable with poor structure and high dispersibility and are very erodible. Mass movement in the form of landslips, slumps and earth flows occur particularly on the hills to the east of the area.

Flood Plain

Class D land on the floodplain is located between the 1 in 5 year frequency flood and the 1 in 100 year frequency flood level determined by Gutteridge Haskins and Davey (1975). Within the N.S.W. Designated Area the limit of the 1 in 100 year flood frequency is well defined where it adjoins an ancient high level river terrace or residual hills. However, at the confluence of Eight Mile Creek with the Murray floodplain the extent of the 1 in 100 year flood level merges with land that is inundated by flooding of Eight Mile Creek. The floodplain of the Eight Mile Creek is determined by the terrain component of the Landform map.

Slope gradients of the floodplain generally do not exceed 2%. The soils are variable in texture from heavy clays to sandy soils.

Drainage Lines

All drainage lines, drainage plains liable to overland flow, and incised drainage channels, defined on the Landform map, are included in Class D. The slopes range from level to 20%, and occur on all soil groups identified in this Study.

Development

Hill Lands

Urban development is not recommended in this unit. These lands are considered to be too steep for safe development of subdivisions or roadways. Construction activity will create a severe soil slip hazard which will affect not only this area but will threaten areas of Classes C and B downslope due to soil and rock movement.

The maximum use of these lands in an urban environment is restricted to reserves for passive recreation. Their development should entail the encouragement or regeneration of natural forests. Management of this land class as reserves for public recreation is discussed in the section of Rural Capability and Management of Class VII land.

If, however, construction works are undertaken on this steeper land, e.g. the construction of a road, or water reservoir site, careful engineering design such as structural retaining walls, sub surface and surface drainage installations and batter stabilization will be required to reduce the hazard of slip failure.

Flood Plain

An industrial or residential land use is not recommended. If any development extends onto the floodplain there is a major risk of future structural damage, and problems of flooding and waterlogging. To retain land stability the most suitable urban use is for parks, playing fields, and passive recreation activities.

Measures used to control flooding such as the construction of levee banks, substantial filling, or the straightening and widening of channels will reduce the natural storage capacity of the floodplain resulting in increased water elevation upstream of the area and higher water channel velocities immediately downstream of the construction. Accelerated erosion of the bed and banks of the stream is likely to occur as a result.

Roads that are required on the floodplain for access and recreation should be located on elevated areas to allow adequate site drainage. As the stability of the road pavement will be affected by the physical characteristics of the various soil textures, water table fluctuation, and flood waters, specific soils investigations are needed. Suitable crossings of flood channels should be designed to allow unrestricted passage of flood waters.

The floodplain has high value as an open space area for recreation. The suitability of specific sites on the floodplain for various forms of recreation can be determined from the Guidelines for Recreation Capability contained in this report.

Drainage Lines

These areas are the most critical in terms of landscape stability in the Designated Area. Changes in the catchment condition brought about by urban development will increase flood peak discharge, volume of runoff and flood frequency. Drainage facilities established in urban areas will decrease the time of concentration of runoff from that of the rural catchment. Short duration high intensity rainfall will produce critical flood peaks which will cause extensive erosion of natural drainage lines. This will add considerably to the sediment load produced by land development and roading. All sediment from these areas will be deposited on the Murray River floodplain or into the Murray River where it will cause many adverse effects upon the environment and ecology of the area.

Building construction is not recommended in these areas.

It is recommended that the drainage line be retained as a green belt area for reserves or playing fields that could accept periodic short term flooding. This approach can reduce costly trunk drainage facilities that have been accepted in the past as part of the urban development.

Two forms of drainage reserves are required in the Designated Area.

1. *The drainage lines from the upper catchment areas with catchments of less than 1000 hectares.*
2. *Main drainage features such as creeks and their associated floodplains in the lower section of the catchment, e.g. Eight Mile Creek.*

A grassed waterway reserve in combination with a small underground pipe is recommended for development of the drainage lines in the upper catchments. This has proved an efficient method of storm runoff disposal through urban areas. By separation of the low flows in a pipe, the grassed waterway can be easily maintained to carry heavy storm flows with minimum erosion damage. In addition, they provide a recreational space and allow free pedestrain access within an urban area.

Development of main drainage features is seen to be one of stabilizing, revegetating and improving existing stream channels. As it is important to retain an optimum flood capacity within the natural system and to reduce stream velocities, straightening of creek meanders is not recommended. Accelerated erosion of the stream banks will result if such extensive modifications are made.

Runoff detention structures in the upper catchments and valley floor areas are most desirable to ensure the stability of the natural system.

A strategy plan of catchment management is essential if planning objectives are to utilise natural systems, and maintain environmental quality with least detriment to the Murray River system.

The catchment management programme envisaged entails :

1. *The use of land consistent with its capability.*

2. *Improvement of catchment conditions aimed at increasing rainfall infiltration and control of runoff water. This involves maintenance or improvement of existing vegetative cover, control of existing soil erosion, soil conservation treatment of disturbed terrain and location of silt detention structures.*

3. *Fire and vermin control.*

4. *Location of runoff detention structures in valley floor areas to pond runoff water within drainage reserves or public open space such as golf courses and playing fields. This will reduce the peak flow in the lower part of the system with minimum damage or nuisance.*

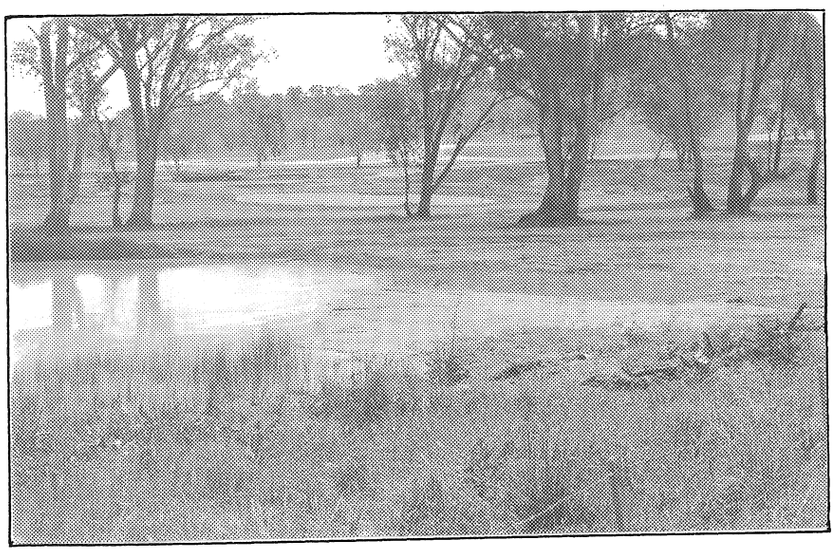
5. *Within urban areas.*

   (a) *Control of siltation from construction and subdivision sites. Sediment produced from these sites can be 400 times the rate in rural areas and can seriously reduce stream channel capacity.*

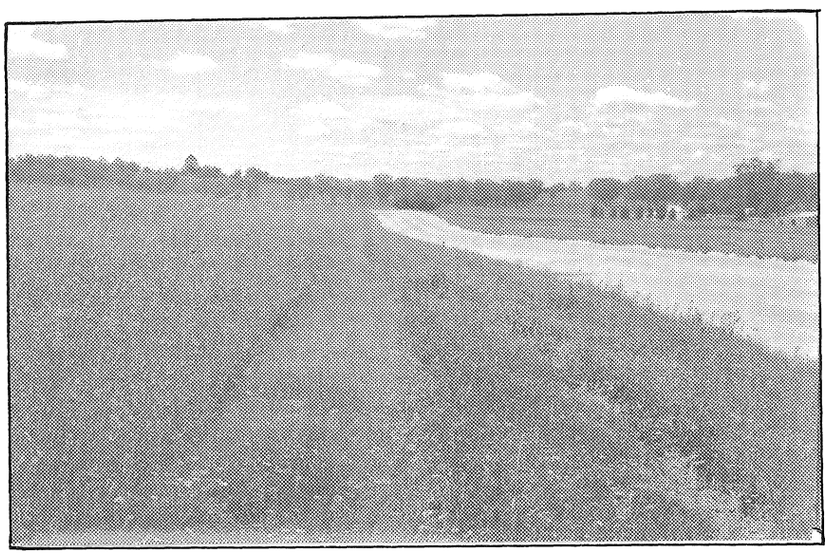
   (b) *Provision of ponding areas within the urban development using carparks or landscaping effects. Raised kerbs with restricted raised outlets can be used to pond 15 cm of water over large areas with minimum inconvenience.*

There exists an obvious need for the adoption of a catchment management policy within Bungambrawatha Creek which flows through the urban and commercial areas of Albury. Recent events have shown that poor catchment condition together with extensive erosion damage associated with urban development is causing a significant siltation problem to the creek and drainage system. The removal of the silt will involve the community in a continuous maintenance cost until a systematic approach to management and development of the whole catchment is made.

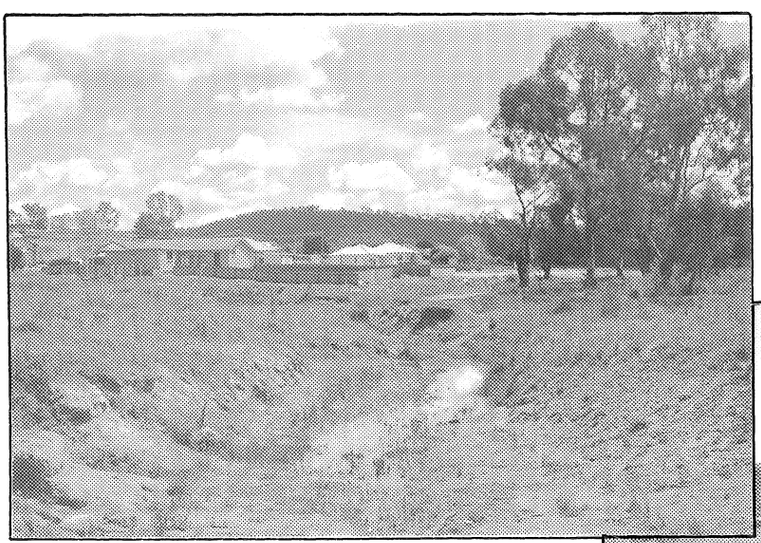
CONTROL OF SEDIMENT FROM URBAN AREAS.

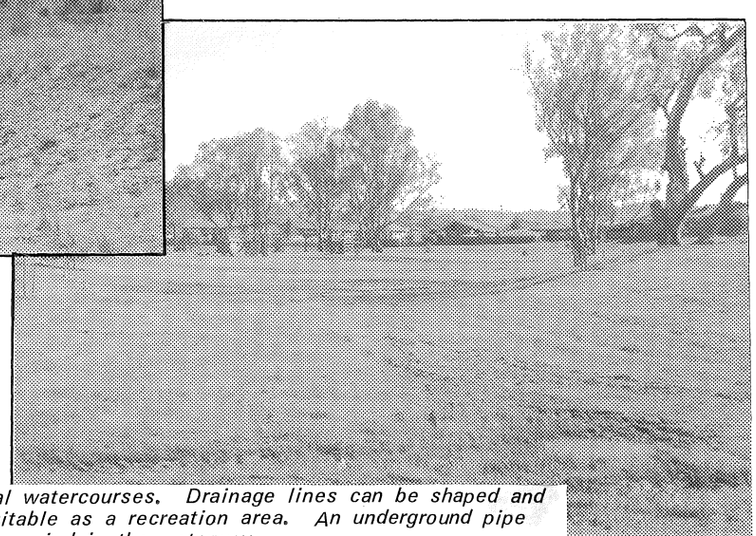


During the urban development phase farm dams should be retained or improved as sediment basins.



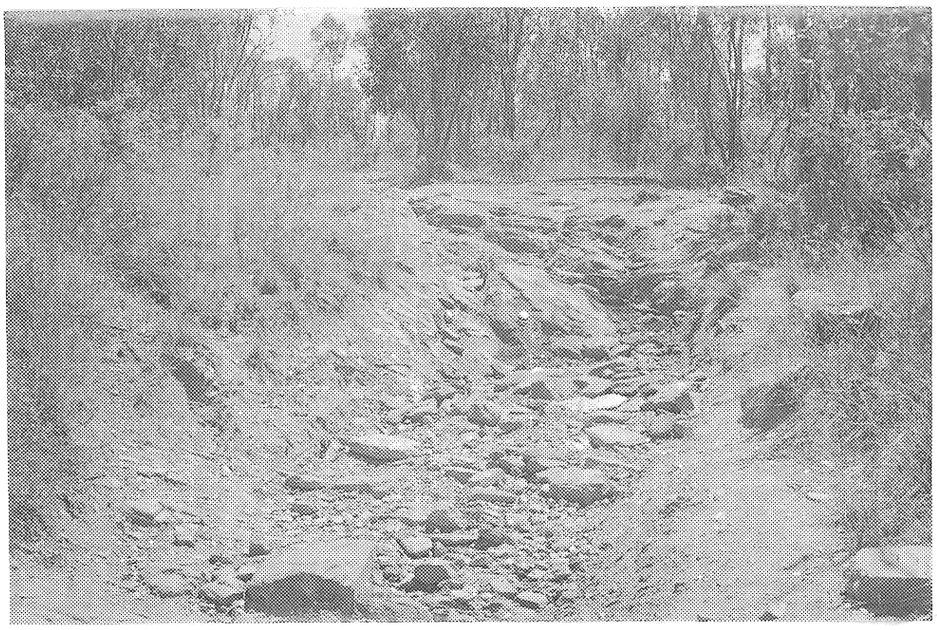
Sowing grasses on newly completed subdivisions holds the soil in place while buildings are constructed.





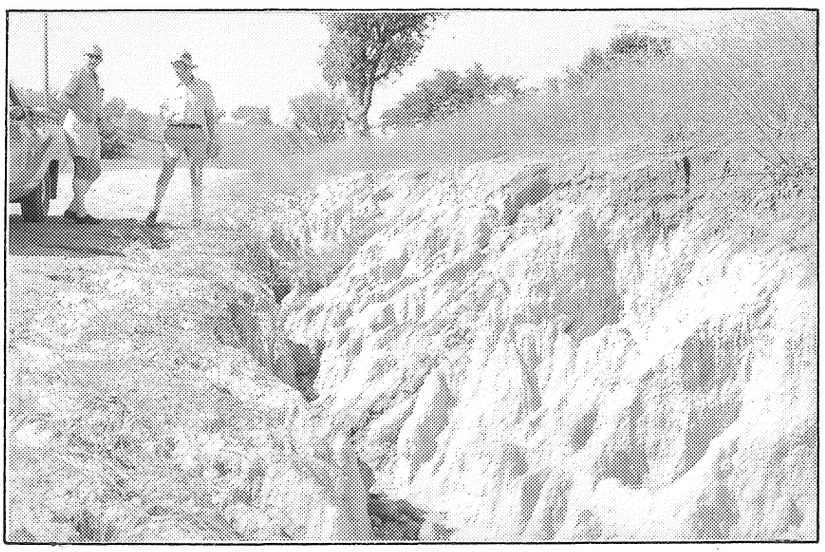
Large quantities of sediment is eroded from natural watercourses. Drainage lines can be shaped and sown to form a broad grassed waterway that is suitable as a recreation area. An underground pipe carries the low water flows while large flows are carried in the waterway.

A SOIL CONSERVATION LAND MANAGEMENT PROGRAMME IS REQUIRED TO REDUCE SILTATION FROM PUBLIC LANDS.



This eroded fire trail on Nail Can Hill becomes a silt laden, raging torrent in times of heavy rain.

Roadside drains are readily destroyed on highly erodible soils.



Many gravel pits are left in an eroding and unstable condition. They are contributing to the siltation of streams in the Designated Area.

Class E

Description

Due to the extreme erosion instability hazard Class E land is not suitable for urban development. There are two land components that are contained in this class.

(a) The Murray River floodplain which has a flood frequency greater than the 1 in 5 year level. This comprises the former channels of the Murray River including oxbow lakes, and the bed and banks of the present river.

(b) Steep slopes above 30% that are affected by land slips and earth flows. These are mainly confined to the Granite Hill soils at Hawkesview and the Kywana soil group to the north. Localised areas affected by extensive gully erosion on highly dispersible soils are included in this class.

Development

Due to their topographic location and extreme erosion and instability hazard, urban development of this land is not recommended. Land included in this class should be assigned as open space.

Replanting with trees is required to achieve stability of the area and protect land downslope. Control of rabbits and restriction on stocking rates are necessary.

5.3 RECREATIONAL CAPABILITY

Introduction

The demand for recreational areas is expected to accelerate rapidly. This is due not only to the hastened residential development but to changes in life styles brought about by flexible working hours, greater mobility, and increasing leisure time and affluence.

Recreation opportunities are available on four major land components in the Designated Area of New South Wales. These are :

- *The floodplain of the Murray River.*
- *The foreshore lands of Lake Hume.*
- *The timbered hills.*
- *Recreational developments within the urban areas.*

The recreational capability of these sites can be determined on an objective basis by reference to the inventory of the physical resources that has been prepared for this Study.

Assessment of the limitations environmental factors exert on a particular site will determine the intensity of visitor use. Over use of an area can cause rapid site deterioration which may require extensive site modification or development. In extreme cases a complete loss of a recreational opportunity may occur, e.g. a beach area on the Murray River.

Recreational Capability Assessment

A recreational potential of a site must consider :

1. *The stability of the site for the activity.*

2. *The intensity to which the recreational amenity can be utilized.*

3. *The extent of site development to cater for a predetermined demand.*

The Recreational Capability Assessment is designed to guide planners on the suitability of a site and allow alternate sites to be evaluated at the structure planning stage. Once the choice of a site has been determined, specific site investigations including soils, slope and drainage, should then be made at a planning scale. Specific site development recommendations by the Soil Conservation Service would follow.

The Assessment is based on an instability hazard rating that a particular activity would have on the land. By adopting this basis, incompatibility between an activity and a land capability is overcome. An example of such incompatibility would be the establishment of golf courses or playing fields on the timbered hills, Class VII, where the Strategy Plan for Catchment Management recommended in a previous section of this report is for catchment protection and runoff control.

Table 5 provides an assessment of the impact to the environment of nine specific recreational activities, and the suitability of the site for service buildings and septic absorption fields that may be essential to the activity.

Eight environmental criteria are considered, and these are readily obtained from the Landform and Soils maps prepared for this Study. A summary of the soil criteria for each soil group is contained in Table 6.

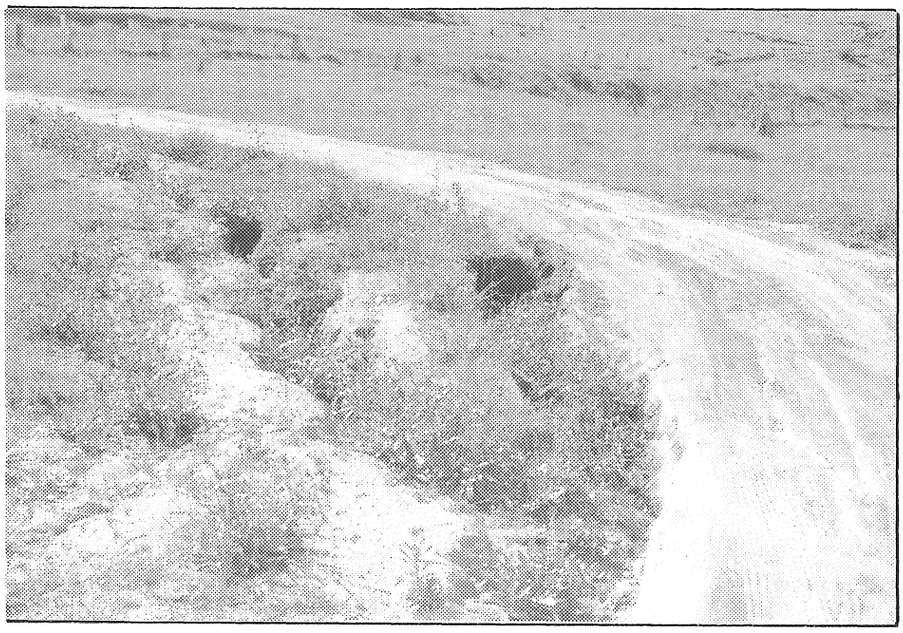
The Recreational Capability Assessment is determined from Table 7.

Having determined the recreational capability of an area the extent of site development must be considered to withstand a level of intensity of recreational use. Visits to recreational amenities fluctuate widely between seasons and during the days of the week. Intensive use of an area at weekends or over a summer season can cause the gradual deterioration of the grass cover, loss of topsoil, and the eventual death of established trees. (Plate X)

To plan the development of a site the intensity of recreation visits in high demand periods should be assessed.

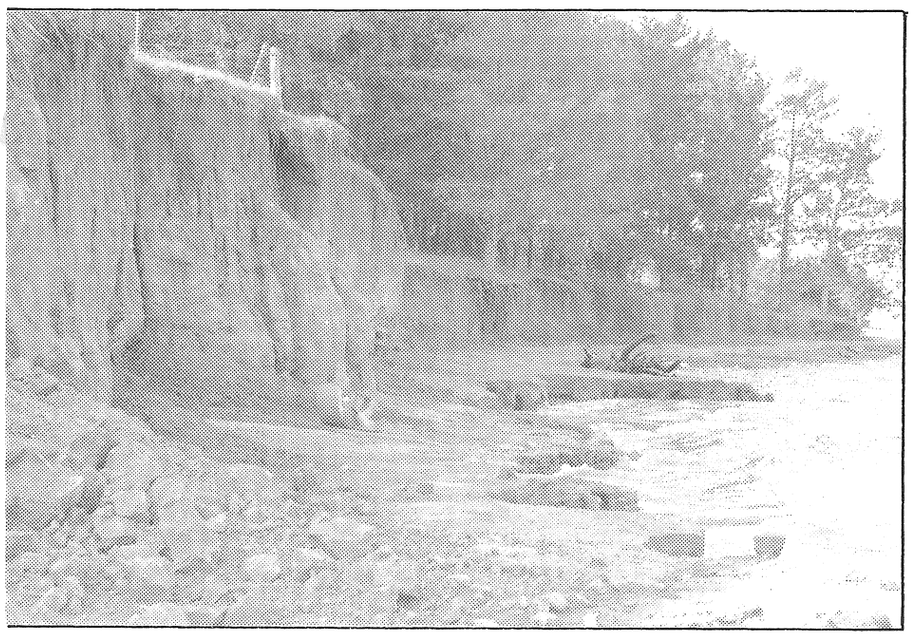
Three broad categories of recreational visitation rates have been considered in this capability assessment, to give planners and engineers a guideline for site development to maintain a stable condition and to assist future management under that visitation pressure. (Table 8)

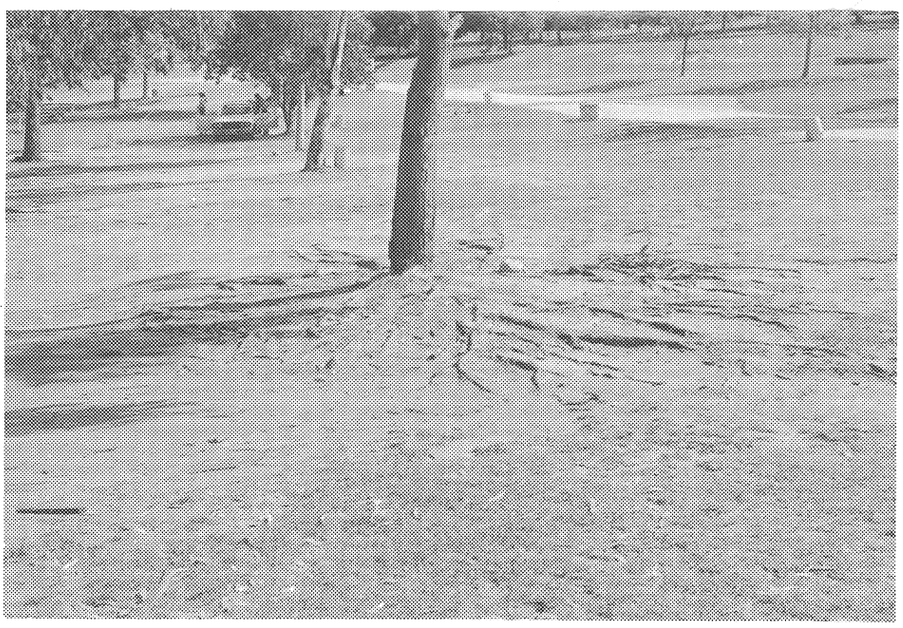
SOIL EROSION CAN DESTROY RECREATIONAL AREAS.



As erosion makes access tracks impassable new tracks are made. Access to recreational areas should be confined to formed and well drained roads.

Severe erosion to the foreshore lands of Lake Hume can occur on the unstable soils.





Heavy public use of a recreational area causes the topsoil to be eroded and the eventual death of established shade trees. The Soil Conservation Service can assist in planning of areas to prevent this damage.

The categories are :

1. *<u>High demand areas</u> having visitation rates in excess of 50 visitors per hectare per day in peak demand periods. Recreational activities considered are: beach areas, football grounds, camping grounds, etc.*

2. *<u>Moderate demand areas</u> having visitation rates below 50 visitors per hectare per day. Recreational activities in this category are: picnic areas, archery and gun club sites, etc.*

3. *<u>Low demand areas</u> having visitation rates below one visitor per hectare per day. Recreational activities would include bushwalking, orienteering, fishing, etc.*

<u>Recreational Capability Assessment Method</u>

The recreational capability of a site is determined in the following manner:

1. *A site is identified for a particular recreational activity.*

2. *The degree slope and the terrain component of the site is obtained from the Landform map.*

3. *The soil group at the site is identified from the Soils map.*

4. *From Table 5 a score is taken from each of the eight criteria for the particular recreational activity being considered. Each of the eight criteria has been subdivided into a series of classes which allows a limitation rating to be made. The specific limitation rating for the criterion being evaluated is the score.*

   The eight scores are totalled, and the total used to assess the Recreational Capability in Table 7.

5. *From Table 7, scores less than 16 suggest that the site is suited to the recreational activity being considered, and can tolerate a high intensity recreation use following the guidelines relating to Category I of Table 8. Scores greater than 16 and below 22 indicate a high instability hazard rating for theparticular recreational activity. A high intensity recreational use is not recommended.*

   Scores greater than 22 indicate that the environmental limitations are too severe and the site does not have the capability to withstand intensive recreational demands of Categories 1 and 2 due to a severe land instability hazard. These lands can be used as 'wilderness' areas for bush walking, orienteering and related low intensity recreational activities.

6. *The intensity of recreation use and site development recommendations required to withstand these pressures can be obtained from Table 8.*

<u>Site Selection</u>

The Recreational Capability Assessment will allow sites to be identified for inclusion in the Structure Plan of the Albury-Wodonga Growth Centre. Comparative advantages between sites

can be determined at this stage. Once the locations of suitable areas for recreational development have been selected specific site investigations are recommended prior to detailed planning.

Intensive Recreation Areas

Specific site investigations are necessary for the design of the facility, to locate roads and parking areas, control runoff from adjacent lands and within the area, and to plan optimum conditions for grass establishment and vegetation management. Problems of site instability caused by a high intensity land use must be anticipated at this stage, and close liaison with the Soil Conservation Service in planning the facility, and determining a management policy is recommended.

Development of recreational sites on the foreshore lands of Lake Hume is an example where careful design of the facility and planning of a recreation land management programme is essential.

Within the New South Wales part of the Designated Area, slope gradients fronting Lake Hume range between 5% to 30%. The granitic soil types are highly erodible, become saturated in the winter months and prone to mass movement. Control of run-off from the steep slopes above a recreational area will require special attention to prevent erosion of the site, damage to roads and removal of sand from "beach" areas.

Low Intensity Recreation Areas

Areas suitable for low intensity recreational use are those lands having a high landscape instability hazard such as the steeper hills, or flood channels of the Murray River. In these locations the decision as to the type of recreational use must not conflict with the prime management objective for the area.

Provision of access to these areas becomes the focal point for control of the intensity of recreational use and the implementation of a land management policy. If vehicular entry is allowed consultation with the Soil Conservation Service in road locations and disposal of road drainage is most desirable as these lands have a high instability rating.

Table 5 LIMITATIONS FOR RECREATION DEVELOPMENT BASED ON A LAND INSTABILITY HAZARD RATING

Criteria	Class Limit	ACTIVITY										
		Camp Sites	Walking Paths & Trails	Roads & Parking Developed Picnic Areas	Golf Courses	Intensive Recreation Areas Playing Fields	Water Based Recreation		Equestrian Activities Dressage	Motor Bike Trails	Service Buildings	Septic Absorption Fields
							Boating Ramps*	Swimming Areas*				
Slope	0- 2	Mod. 2	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Mod. 2	Slt. 1
	2- 5	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1
	5-10	Mod. 2	Slt. 1	Mod. 2	Slt. 1	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Slt. 1	Slt. 1
	10-20	High 3	Mod. 2	High 3	Mod. 2	Sev. 4	Sev. 4	High 3	High 3	Mod. 2	Mod. 2	Mod. 2
	20-30	Limiting	High 3	Sev. 4	Sev. 4	Limiting	Sev. 4	High 3	Limiting	Sev. 4	Sev. 4	Limiting
	>30%	Limiting	Sev. 4	Limiting	Limiting	Limiting	Limiting	Sev. 4	Limiting	Sev. 4	Limiting	Limiting
Terrain Component	1.Ridge	Slt. 1	Slt. 1	Mod. 2	Slt. 1	Mod. 2	Nil 0	Nil 0	Slt. 1	Slt. 1	Slt. 1	Mod. 2
	2.Side Slope	Mod. 2	Slt. 1	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Slt. 1	Mod. 2	Mod. 2	Mod. 2	Mod. 2
	3.Foot Slope	Mod. 2	Slt. 1	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Slt. 1	Mod. 2	Mod. 2	Mod. 2	High 3
	4.Flood Plain											
	>100yr Flood	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1
	20yr-100yr	Slt. 1	Slt. 1	Mod. 2	Slt. 1	Mod. 2	Slt. 1	Slt. 1	Slt. 1	Slt. 1	High 3	Slt. 1
	5yr- 20yr	Mod. 2	Slt. 1	Mod. 2	High 3	Mod. 2	Slt. 1	Slt. 1	Mod. 2	Mod. 2	Sev. 4	Mod. 2
	<5yr	Sev. 4	Mod. 2	Sev. 4	Sev. 4	Sev. 4	High 3	Slt. 1	Sev. 4	Sev. 4	Sev. 4	Sev. 4
	5.Drainage Plain	High 3	Mod. 2	High 3	High 3	Sev. 4	High 3	High 3	Sev. 4	Sev. 4	Sev. 4	Sev. 4
	6.Incised Drainage Channel	Limiting	Sev. 4	Limiting	Sev. 4	Limiting	Limiting	High 3	Limiting	Limiting	Limiting	Limiting
	7.Disturbed Terrain	High 3	Mod. 2	High 3	High 3	High 3	High 3	Mod. 2	High 3	Mod. 2	High 3	Sev. 4
	9.Water Bodies											
	a)Flowing	N.A.	N.A.	N.A.	N.A.	N.A.	High 3	Slt. 1	N.A.	N.A.	N.A.	N.A.
	b)Storage	N.A.	N.A.	N.A.	N.A.	N.A.	Slt. 1	Slt. 1	N.A.	N.A.	N.A.	N.A.
	10.Oxbow lakes	Limiting	Mod. 2	Limiting	Sev. 4	Limiting	Sev. 4	Mod. 2	Limiting	Sev. 4	Limiting	Limiting
Soil Erodibility	Low	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1
	Moderate	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Mod. 2	Mod. 2	Slt. 1	Mod. 2	Mod. 2	Slt. 1	Slt. 1
	High	Mod. 2	Mod. 2	Mod. 2	Mod. 2	High 3	High 3	Mod. 2	High 3	High 3	Mod. 2	Slt. 1
	Very High	Sev. 4	High 3	High 3	High 3	Sev. 4	Sev. 4	Mod. 2	High 3	Sev. 4	High 3	Mod. 2
	Extreme	Sev. 4	Sev. 4	Sev. 4	Sev. 4	Sev. 4	Sev. 4	High 3	Sev. 4	Sev. 4	Sev. 4	High 3

Table 5 (Continued)

Criteria	Class Limit	ACTIVITY										
		Camp Sites	Walking Paths & Trails	Roads & Parking Developed Picnic Areas	Golf Courses	Intensive Recreation Areas Playing Fields	Water Based Recreation: Boating Ramps *	Water Based Recreation: Swimming Areas *	Equestrian Activities Dressage	Motor Bike Trails	Service Buildings	Septic Absorption Fields
B Horizon Unified Soil Classification System (U.S.C.S.)	CH	Slt. 1	Mod. 2	Sev. 4	Mod. 2	High 3	High 3	Mod. 2	High 3	Mod. 2	Sev. 4	Sev. 4
	CL - CH	Slt. 1	Slt. 1	High 3	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Slt. 1	High 3	High 3
	CL	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1
	ML	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Slt. 1	High 3
Soil Structure 'A$_2$' Horizon	Absent	Nil 0	Nil 0	Nil 0	Nil 0	Nil 0	Nil 0	Nil 0	Nil 0	Nil 0	Nil 0	Nil 0
	3	Nil 0	Nil 0	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Nil 0	Slt. 1	Slt. 1	Nil 0	Slt. 1
	2	Nil 0	Slt. 1	Slt. 1	Nil 0	Nil 0	Nil 0	Nil 0	Nil 0	Slt. 1	Nil 0	Nil 0
	1	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Mod. 2	Nil 0	Mod. 2	High 3	Slt. 1	Slt. 1
	0	Sev. 4	High 3	Sev. 4	High 3	High 3	Sev. 4	Mod. 2	High 3	Sev. 4	Mod. 2	High 3
Profile Drainage	Good	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1
	Moderate	Mod. 2	Slt. 1	Mod. 2	Mod. 2	High 3	Mod. 2	Slt. 1	High 3	Mod. 2	High 3	High 3
	Poor	Sev. 4	Mod. 2	High 3	Sev. 4	Sev. 4	Mod. 2	Mod. 2	Sev. 4	High 3	High 3	Sev. 4
Soil Depth	0.5 m	Sev. 4	High 3	High 3	High 3	Sev. 4	Mod. 2	Mod. 2	Sev. 4	High 3	High 3	Sev. 4
	0.5 to 0.8 m	Mod. 2	Mod. 2	Mod. 2	Mod. 2	High 3	Mod. 2	Slt. 1	High 3	High 3	Mod. 2	Sev. 4
	0.8 to 1.5 m	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Mod. 2	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Mod. 2
	1.5 m	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1
Rock Outcrops	None	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Mod. 2	Slt. 1	Slt. 1	Slt. 1	Slt. 1	Slt. 1
	<10%	Slt. 1	Slt. 1	Mod. 2	Slt. 1	Mod. 2	Mod. 2	Slt. 1	Mod. 2	Slt. 1	Mod. 2	Slt. 1
	10-40%	High 3	Mod. 2	High 3	Mod. 2	High 3	Mod. 2	Slt. 1	High 3	Mod. 2	Sev. 4	Mod. 2
	>40%	Sev. 4	Mod. 2	Sev. 4	High 3	Sev. 4	Slt. 1	Slt. 1	Sev. 4	Mod. 2	Sev. 4	Sev. 4

* Refers to effect on adjacent areas

Limiting - Development of Site not Recommended.

Abbreviations - N.A. Not Applicable
Slt. Slight
Mod. Moderate
Sev. Severe

Adapted from Jeffery & Howe 1976

Table 6 Soils Criteria for Recreational Capability Assessment

Soil Group	1 Soil Erodibility	2 B_1 Horizon U.S.C.S.	3 Soil Structure A_2 Horizon	4 Profile Drainage	5 Soil Depth	6 Rock Outcrop
Murray River Alluvium	Moderate	CL	Absent	Poor	>1.5 m	None
Bungambrawatha Creek Alluvium	Moderate	ML	Absent	Moderate	>1.5 m	<10%
Eight Mile Creek Alluvium	Moderate	ML	Absent	Good	>1.5 m	None
Black Range or Complex Hill Soils	High	ML	0	Poor	<0.5 m	10-40%
Granite Hill Soils	Extreme	ML	0	Poor	0.5 m to 0.8 m	10-40%
Kywana	Very High	ML	0	Poor	>1.5 m	<10%
Howlong	Low	CH	Absent	Poor	>1.5 m	None
St.Johns	Low	CL	Absent	Good	0.5 m to 0.8 m	<10%
Dights' Hill	Moderate	CL	1	Good	>1.5 m	None
Thurgoona	Low	CL	Absent	Moderate	>1.5 m	None
Ettamogah	Moderate	CL	0	Moderate	>1.5 m	None
Splitters Creek	High	CL	0	Moderate	>1.5 m	<10%
Wirlinga	High	CL	0	Poor	>1.5 m	None
Hamilton Valley	Moderate	CL	1	Moderate	>1.5 m	<10%
Mungambareena	Moderate	CL-CH	0	Poor	>1.5 m	None

Table 7 *Recreational Capability Assessment*

Score	
<10	*Low instability hazard: Area most suited to the recreational activity. The site is capable of intensive recreational use and the maximum site development specified in Category 1 of Table 8.*
10-16	*Moderate instability hazard: Area most suited to a particular activity. Specific attention to be paid to the highest scoring site limitation factors. The site is capable of intensive recreational use. Site developments will require the soil conservation treatments recommended in Category 1 of Table 8.*
16-22	*High instability hazard: Area suited to the particular activity. Due to the higher instability hazard a lower intensity of use specified in Category 2 of Table 8 is required.*
>22	*Severe instability hazard: The area is unsuitable for the recreational activity, due to the severe site limitations. The intensity of recreational use is specified in Category 3 of Table 8. These areas would have a recreational value as open space or wilderness areas for bushwalking, orienteering and wild life observation.*

Table 8 *Recreational Development Categories*

Category 1 *High Recreational Demand* greater than 50 visitors/ha/day.

Requiring major landscape modification, soil conservation treatment, and full site development of public amenities.

The following treatments are required to maintain stability of the site.

1. *Terracing.*
2. *Runoff control, site drainage.*
3. *Control of vehicular access.*
4. *Well drained formed roading.*
5. *Vehicular parking on hard areas with drainage.*
6. *Control of pedestrian access to formed or paved paths.*
7. *Management of vegetative cover.*
8. *Provision of full service buildings including water reticulation.*

Category 2 *Moderate Recreational Demand* less than 50 visitors/ha/day.

Requiring minor landscape modification, soil conservation treatment, and provision of public amenities.

Following treatments required to maintain stability of the site.

1. *Well graded formed vehicular access.*
2. *Hard standing parking areas.*
3. *Controlled vehicular access.*
4. *Runoff control and drainage measures both above and within recreation area.*
5. *Location of permanent walking tracks and trails with erosion control and drainage measures.*
6. *Management policy for vegetation areas.*
7. *Provision of basic amenities toilet blocks.*

Category 3 *Low Recreational Demand* less than 1 visitor/ha/day.

Requiring minor soil conservation treatments - no public amenities provided.

Following treatments may be required.

1. *Control vehicular access to formed roads.*
2. *Erosion control measures on walking tracks or trails.*
3. *Limitation to entry in periods of extreme fire danger, snow or prolonged rain periods.*
4. *Areas managed primarily for forest, water production or catchment condition.*

6. EROSION CONTROL TECHNIQUES

The degree and intensity of erosion and sediment control structures will be related to the proposed land use and the value of the development requiring protection. The need for an erosion and sediment control programme is seen to operate at 3 levels.

(i) A total catchment management programme.

(ii) Soil erosion control measures for rural lands.

(iii) Erosion control measures for developing urban areas.

A Total Catchment Management Programme

Control of soil erosion and sedimentation can be achieved by planning land use in accordance with a rural or urban land capability that is based on sound resource data.

The development of any project should not be considered, in isolation from its physiographic position within the entire catchment.

Management of the timbered hill lands of the upper catchments is just as important in maintaining the stability of the natural drainage lines as is the emphasis placed on flood detention basins at lower levels in the catchments.

Control of erosion and sedimentation in the catchments is essential if the capacities of these flood detention basins and natural drainage channels are to be retained.

A catchment management programme in the Designated Area should have the following objectives.

* Protection of the surface soil by achieving a good cover of vegetation.

* Improve the condition of the catchment so that rainfall infiltration is increased.

* Control of existing soil erosion.

* Construction of sediment retarding structures.

* Fire and vermin control programmes.

* Control of stock and vehicular access.

Erosion control techniques for catchment protection are discussed in the Rural Land Use Capability section relating to Class VI and Class VII lands, and in the Urban Capability section for Class D lands.

Soil Erosion Control Measures for Rural Lands

It is recommended that any intensification of cultivation or other rural land use proposed by tenants of land held by the Albury-Wodonga Development Corporation should be referred to the Soil Conservation Service for comment. Following an inspection, advice would be given as to the suitability of the land use and any erosion control measures that may be required.

Control of existing erosion of rural land at an early stage would have many benefits to the Corporation. Apart from the immediate effect of reducing the volume of sediment reaching the streams, gully filling, shaping and revegetation of these lands would provide stable watercourses and have the land in a more suitable condition for urban development.

Soil conservation measures required for rural lands are discussed for each land capability class in the Rural Land Capability section of this report.

Erosion Control Measures for Urban Areas

For the effective control of soil erosion and sedimentation in urban areas it is recommended that all proposed plans for land development be reviewed by the Soil Conservation Service. This review would assure that adequate temporary and permanent erosion control measures are included in the plan. In addition, field inspections during construction and development operations can be given to assist the developer to implement recommendations.

The important aspects of sediment control from these areas are :

(a) Disturb only those areas needed for immediate construction purposes. While natural vegetation covers adjacent areas there is little erosion.

(b) Stockpile topsoil in convenient locations for respreading. Sowing of grasses on these stockpiles will prevent erosion, and subsequently silt being washed into the construction site.

(c) Install diversion banks and prepare sediment basins before stripping large areas for construction purposes.

(d) Areas that are to remain bare for lengthy periods should be sown with a temporary grass mixture.

(e) All cut and fill embankments should be topsoiled and stabilized. Techniques for establishing vegetation may include treatment with a chemical or organic mulch at sowing or by hydroseeding.

(f) All permanent drainage works should be installed as early as possible during subdivision construction.

(g) Control of vehicular traffic to existing or proposed alignments during subdivision, is required particularly in the winter months. Temporary culverts or causeways should be provided across major drainage lines.

(h) Permanent roads and parking areas should be paved as early as possible after their formation.

7. AUTHORS

The authors of the sections of this report were :

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The Study, Introduction, Study Objectives, Geology, Drainage Pattern and Sub Catchment Areas, Climate, Erosion Control Techniques.
Method of Land Capability Assessment.
Rural Land Capability
Urban Land Capability
Recreational Capability

Preparation of the
- Land Capability Maps
- Existing Land Use Maps
- Drainage Pattern Maps

Mr. K.A. Emery, Research Officer, Soil Conservation Service, Sydney.

Physical Resources of the New South Wales Designated Area.
Landform - Slope and Terrain Component.
Soil Erosion.

Preparation of the
- Landform Maps
- Soil Erosion Maps

Mr. R.J. Crouch, Soil Conservationist, Wagga Wagga Research Centre.

Soils of the New South Wales Designated Area.
Preparation of the Soils Maps.

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Mr. B. Danson, Laboratory Attendant, carried out the soil analyses.

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Mr. W.S. Johnston, Soil Conservationist, Albury, assisted with the Soil Survey and Mapping of the Existing Land Use.

To the staff of the Soil Conservation Service Drawing Office for the drafting of the maps and figures for this Study.

Mrs. M.M. Thompson, Office Assistant at Albury, for typing the drafts and Mrs. D. Horn for typing the final copy of this report

AND

To those officers of the Soil Conservation Service who provided useful discussion and comments.

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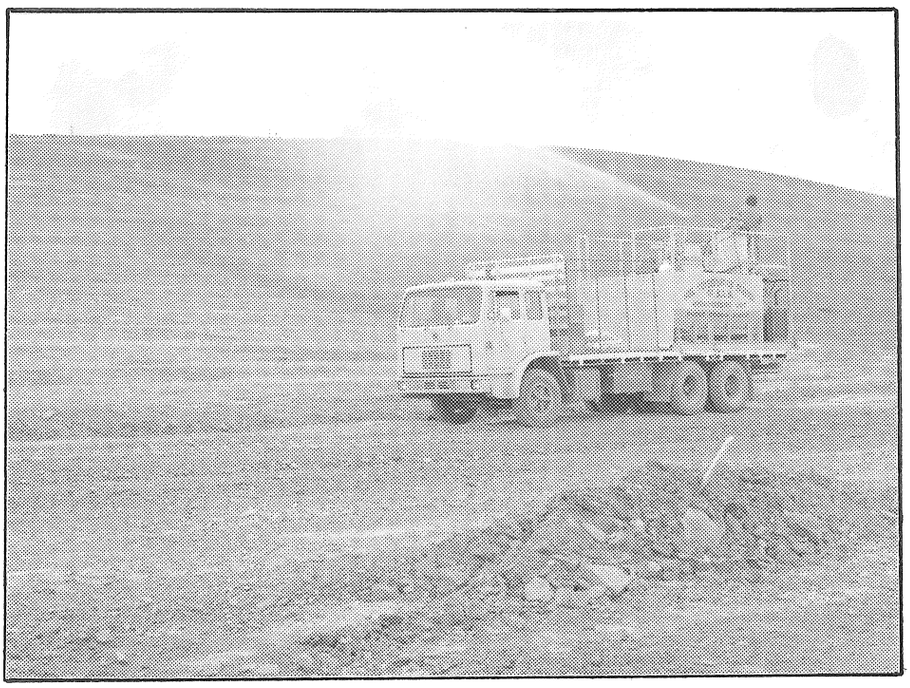
SOIL EROSION CONTROL TECHNIQUES.



Hydroseeding of steep embankments is required immediately following construction.

Revegetation of critical areas with hay mulch and bitumen is required on highly erodible soils.

Stabilization of drainage channels will require special techniques.

APPENDIX A

Maps 1 to 18 contained in this Appendix reproduce sections of the land resources and land capability maps from three sheets - Bungil 1.2, Indigo 7.2, Indigo 8.3.

They illustrate the way in which the basic land resource data are mapped and presented to the planner. The relationships between the final capability assessments and the basic data can be observed by overlaying the individual maps.

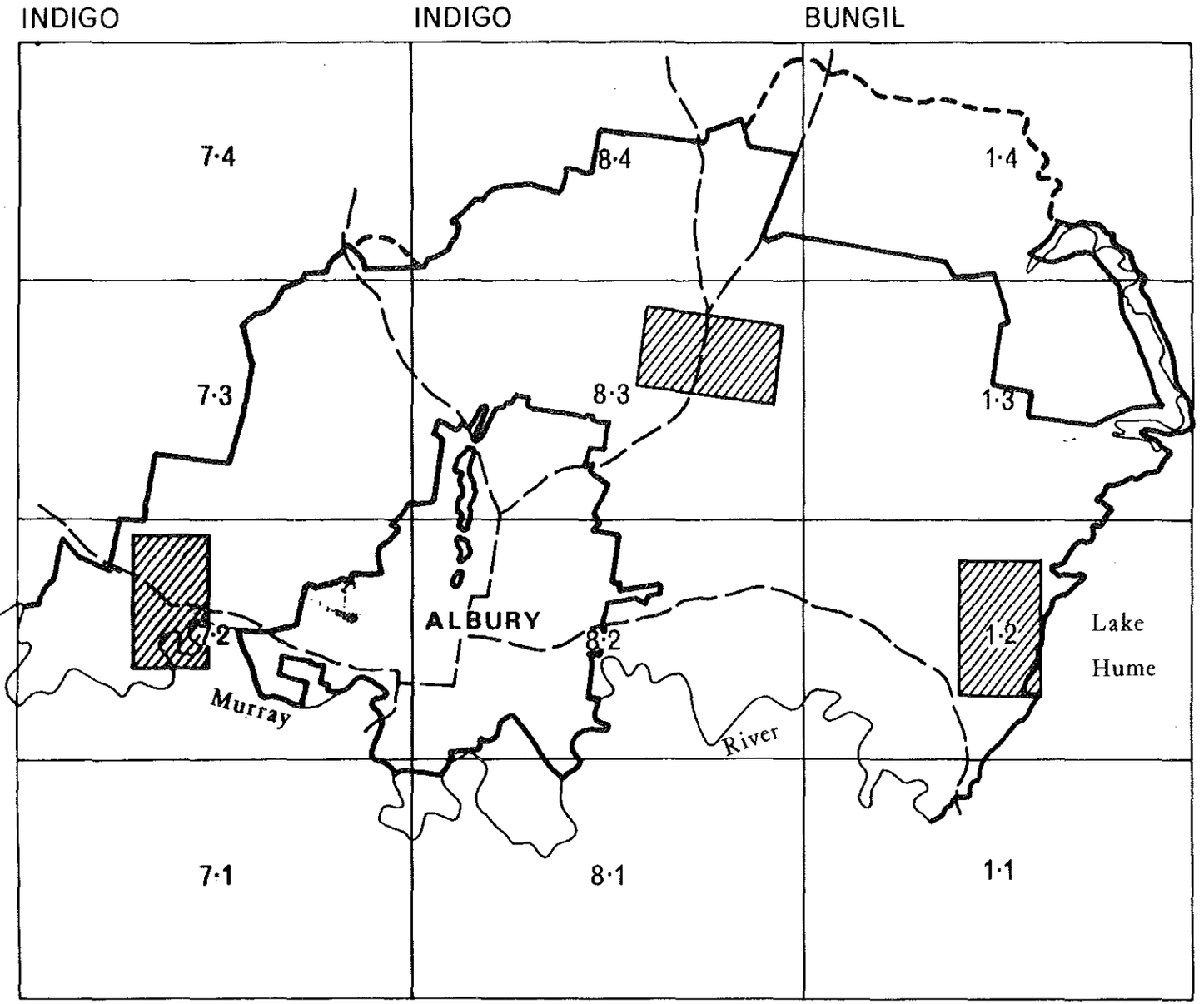
A complete set of all maps for the study comprises 66 individual sheets. Because of their volume they have restricted distribution to planners and other authorities immediately involved in the Growth Centre.

Eleven 1:10 000 map sheet cover the Study area. They are -

Indigo 7.2, 7.3, 7.4

Indigo 8.1, 8.2, 8.3, 8.4

Bungil 1.1, 1.2, 1.3, 1.4



LEGEND

Boundary of Study Area .....

Boundary of Designated Area ....

Location of Report Maps .....

1:10 000 Orthophotomap sheets. . . .INDIGO 8·3

ALBURY – WODONGA GROWTH CENTRE

N.S.W. SECTOR

SCALE

0 1 2 3 4 5

kilometres

LAND RESOURCES STUDY

OF THE

ALBURY – WODONGA GROWTH CENTRE, N. S. W.

LANDFORM

LEGEND

Slope Classes

0 – 1% slopes . . . . . A

1 – 5% slopes. . . . . B

5 – 10% slopes. C

10 – 20% slopes. . . . . D

20 – 30% slopes. . . . . E

30 – 50% slopes. . . . . F

Greater than 50% slopes . . . . . G

10% slope is the recommended upper limit of cultivation in this district.

20% slope is the recommended upper limit of urban development.

Terrain Component

Hillcrest and ridge 1

Sideslope. 2

Footslope 3

Floodplain 4

Drainage plain – liable to overland flow. 5

Incised drainage channel. 6

Disturbed terrain 7

General description – hillcrest / sideslope / footslope

Slope facets not distinguished 8

Ox – bow lake. 9

Swamp 10

LAND RESOURCES STUDY

OF THE

ALBURY – WODONGA GROWTH CENTRE, N. S. W.

DRAINAGE PATTERN AND SUB – CATCHMENT AREAS

LEGEND

Drainage Pattern

1st Order Stream. . . . . .

2nd Order Stream . . . . . .

3rd Order Stream. . . . . .

4th Order Stream. . . . . .

5th Order Stream. . . . . .

Sub – Catchment Boundary. . . . . .

Sub – Catchment Number. . . . . (7)

Protected Land . . . . . .

LAND RESOURCES STUDY

OF THE

ALBURY – WODONGA GROWTH CENTRE, N. S. W.

SOIL EROSION

LEGEND

No appreciable erosion	a
Minor sheet erosion	b
Moderate to severe sheet erosion	c
Minor gully erosion	d
Moderate gully erosion	e
Severe gully erosion	f
Very severe localised gully erosion	g
Erosion by mass movement	h
Streambank erosion caused by slumping of streambanks	j
Streambank erosion caused by undercutting of streambanks	k
Streambank erosion caused by gully or rift erosion of streambanks	m

Depth of Gullies

Less than 1.5 metres	1
1.5 metres to 3 metres	2
Greater than 3 metres	3

LAND RESOURCES STUDY

OF THE

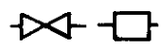
ALBURY – WODONGA GROWTH CENTRE, N. S. W.

EXISTING LAND USE

LEGEND

Boundary of designated area . . . . .

Subdivisional fencing . . . . . 

Gate – Cattle grid . . . . . 

Existing dam, shape as indicated . . . . . 

Existing trough . . . . . 

Existing tank . . . . . 

Existing bore – windmill . . . . . 

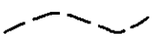
Existing pipeline . . . . .

Spring . . . . . 

Waterlogged or soakage areas . . . . . 

House . . . . . 

Shed . . . . . 

Access track . . . . . 

Yards – cattle or sheep . . . . . 

Vermin – rabbit infestation . . . . . 

LAND RESOURCES STUDY
OF THE
ALBURY-WODONGA GROWTH CENTRE, N.S.W.

LAND CAPABILITY

LAND CLASSIFICATION FOR RURAL USE

LAND CLASSIFICATION		SOIL CONSERVATION LAND MANAGEMENT MEASURES REQUIRED	RURAL CAPABILITY
LAND SUITABLE FOR CULTIVATION	I	No special soil conservation practices necessary	Regular cultivation implied: Orchards, vineyards, market gardens, broad acre crops.
	II	Simple soil conservation practices such as, contour cultivation, adequate crop rotation and good soil management.	Land suited for regular cultivation associated with intensive horticulture, broad acre crops and improved pastures.
	III	Intensive soil conservation measures such as graded banks, diversion banks and waterways in addition to practices for Class II.	Land suited for regular cultivation for intensive horticulture and broad acre crops in rotation with improved pastures.
LAND SUITABLE FOR GRAZING	IV	Simple soil conservation practices such as pasture improvement stock control, application of fertilizer, contour chisel seeding may be necessary on lands generally less than 15% slope.	Improved pastures. Land can be cropped occasionally for renewal of pastures.
	V	Intensive soil conservation measures such as, absorption banks, diversion banks and deep contour ripping are necessary on land generally less than 20% slope in addition to the practices for Class IV.	Improved or native pastures.
	VI	Good land management practices are necessary these include limitation of stock, broadcasting seed and fertilizer, prevention of fire destruction of vermin with retention of green timber on slopes above 30%.	Predominately native postures or pastures improved by application of fertilizers mainly by air
LAND BEST SUITED TO TIMBER	VII	Land best suited for green timber for any of the following reasons: erosion hazard, steepness, shallowness or infertility, catchment protection. Generally stock should be excluded. Control of vermin.	Development as protective forest to improve catchment condition. Limited grazing.
OTHER LAND	VIII	Cliffs, lakes, swamps and other land unusable for agricultural or grazing purposes.	Limited grazing use. May be suitable for wildlife or recreation.

LANDSCAPE STABILITY HAZARD FOR URBAN DEVELOPMENT

CLASS	EROSION/INSTABILITY HAZARD	MAJOR PHYSICAL CONSTRAINTS	URBAN CAPABILITY
A	Low	Nil	Extensive building complexes. Industrial, Commercial, Residential.
B	Moderate	Soil type, drainage, slope.	Industrial, Commercial, Residential
C	High	Soil type, flooding, drainage, slope(limitation dependent on site.)	Residential Use- Density will be determined by hazard.
D	Very high	Slope, drainage, flooding, soil type.	Reserves and open space development suitable for active or passive recreation.
E	Extreme	Land slip, severe erosion hazard due to soil type, slope, topographic location	Not recommended for development.

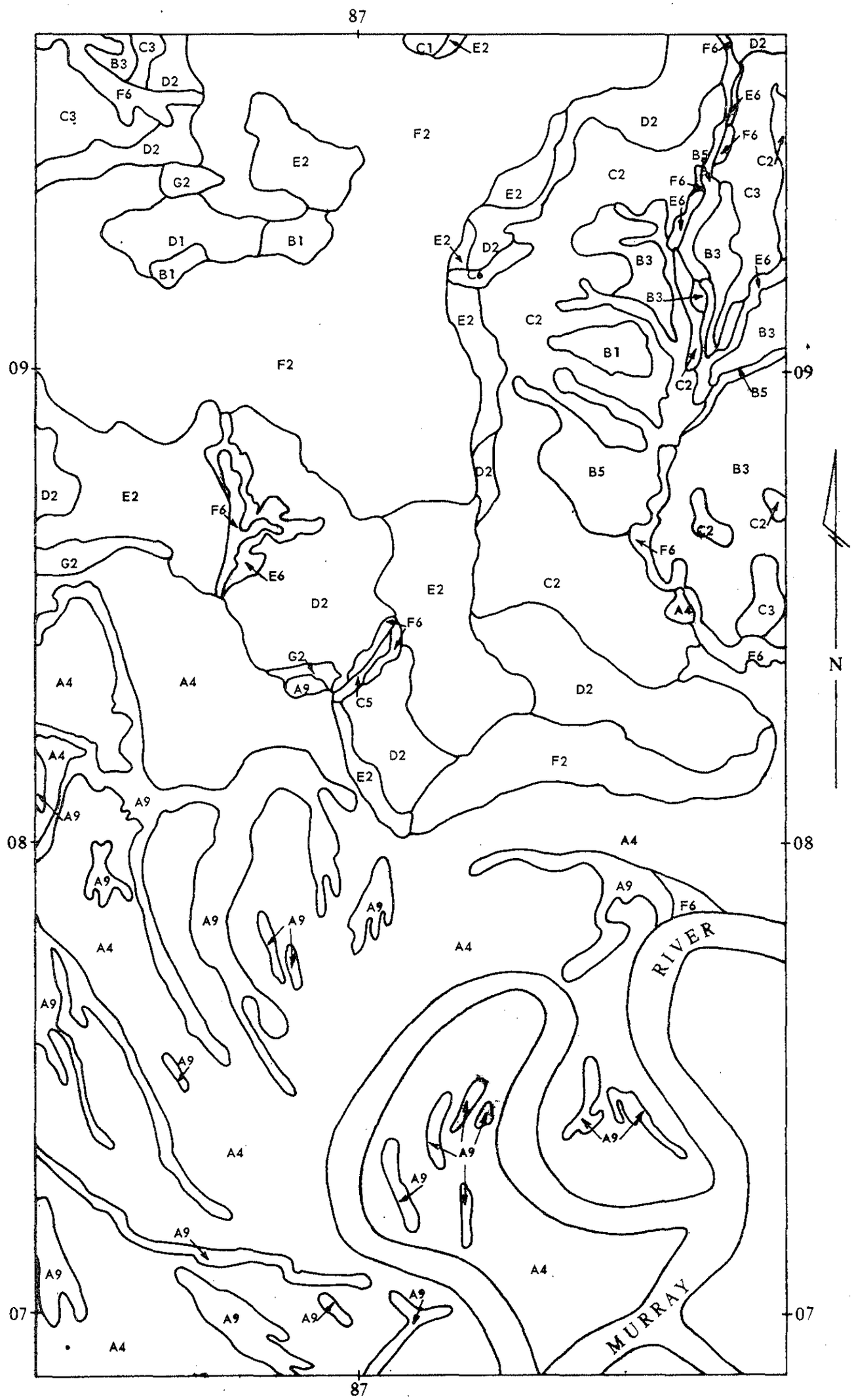
LAND RESOURCES STUDY
OF THE
ALBURY-WODONGA GROWTH CENTRE, N.S.W.

SOILS

LEGEND

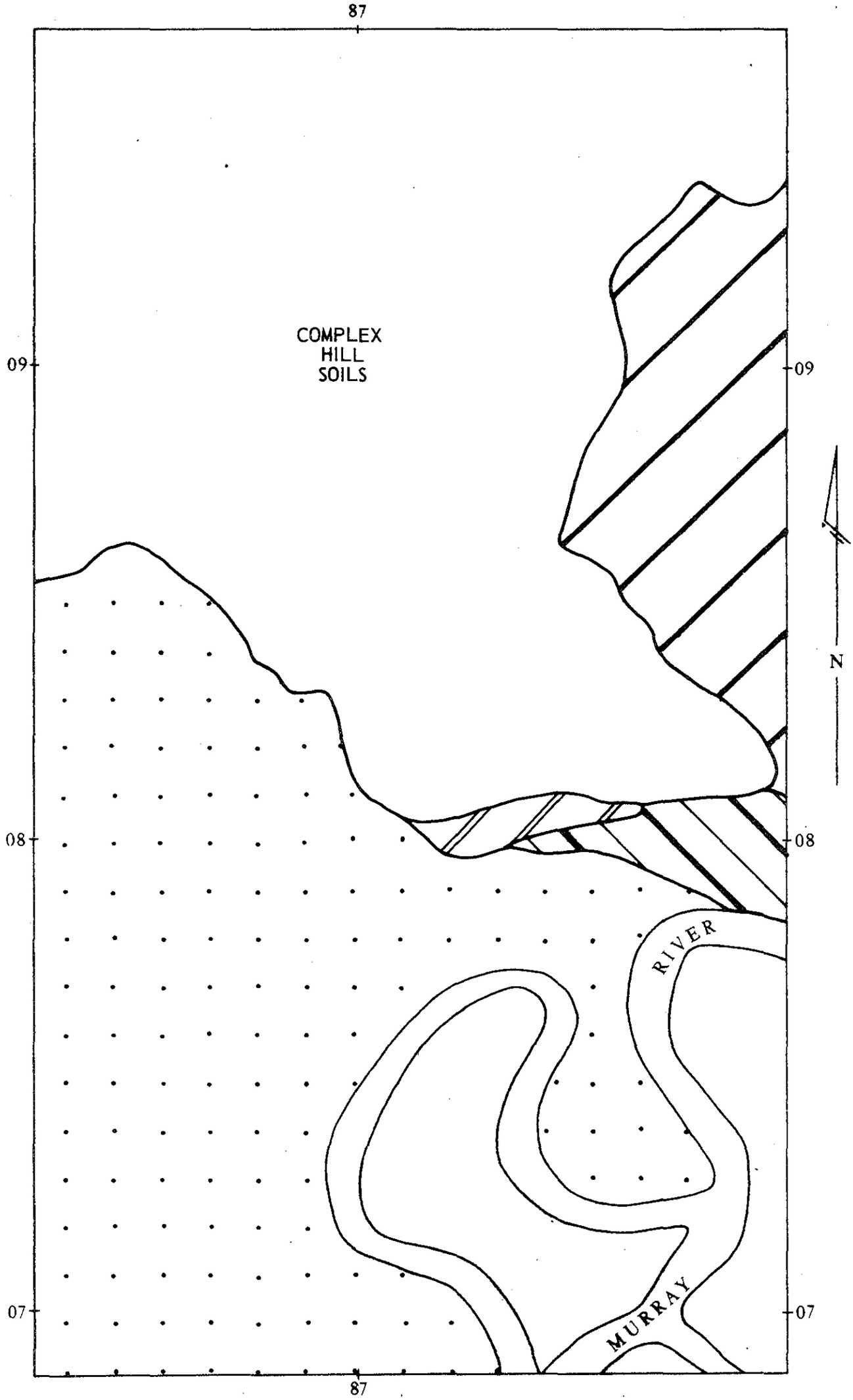
MAP UNIT	ASSOCIATION NAME	GREAT SOIL GROUP	DOMINANT NORTHCOTE CODING(S)	TEXTURE OF 'B' HORIZON	PROFILE DRAINAGE	VOLUME EXPANSION	PLASTICITY INDEX	DISPERSAL INDEX	SUITABILITY FOR PONDS	QUALITY OF TOPSOIL	ERODIBILITY	SPECIAL SITE FEATURES
	Murray River Alluvium								Poor	Good	Moderate	Subject to flooding
	Bungambrawatha Ck. Alluvium		DUE TO THE HIGH DEGREE OF VARIATION IN THESE UNITS NO TYPICAL VALUES HAVE						Poor	Good	Moderate	Subject to flooding
	Eight Mile Ck. Alluvium			BEEN PRESENTED					Poor	Good	Moderate	Subject to flooding
	Black Range Hill Soils								Variable	Poor	High	
O	Granite Hill Soils								Poor	Poor	Extreme	Seepage patches Mass movement
	Kywana	Podzol	Uc 2.21	Clayey sand	Poor	<5%	Non-plastic	2.0	Poor	Poor	Very high	Prolonged seepage patches subject to mass movement
	Howlong	Grey clay	Ug 5.23	Heavy clay	Poor	33%	30	3.0	Good	Moderate	Low	Gilgaied, high watertable
	St. Johns	Red earth	Gn 2.12	Medium clay	Good	16%	19	30.0	Poor	Good	Low	
	Dight's Hill	Yellow earth	Gn 2.23	Sandy clay	Good	10%	20	5.0	Good	Moderate	Moderate	
	Thurgoona	Yellow podzolic	Dy 2.22	Medium clay	Moderate	12%	22	13.0	Good	Moderate	Low	
	Ettamogah	Yellow podzolic	Dy 3.22	Light medium clay	Moderate	15%	18	4.0	Good	Moderate	Moderate	
	Splitters Ck.	Yellow solodic	Dy 2.42	Medium clay	Moderate	16%	25	2.5	Good	Moderate	High	
	Hamilton Valley	Red and yellow podzolic	Dy 3.41;Dy 2.32	Light medium clay	Moderate	9-15%	18	4.5	Good	Moderate	Moderate	
	Wirlinga	Yellow solodic	Dy 3.42	Heavy clay	Poor	25%	39	2.0	Moderate	Moderate	High	Subject to overland flow and seepage after rain
	Mungabareena	Yellow solodic	Dy 3.43	Medium clay	Poor	7%	26	2.8	Good	Moderate	Moderate	Periodic high water table, gilgaied

INDIGO 7·2 (1:10 000) – LANDFORM



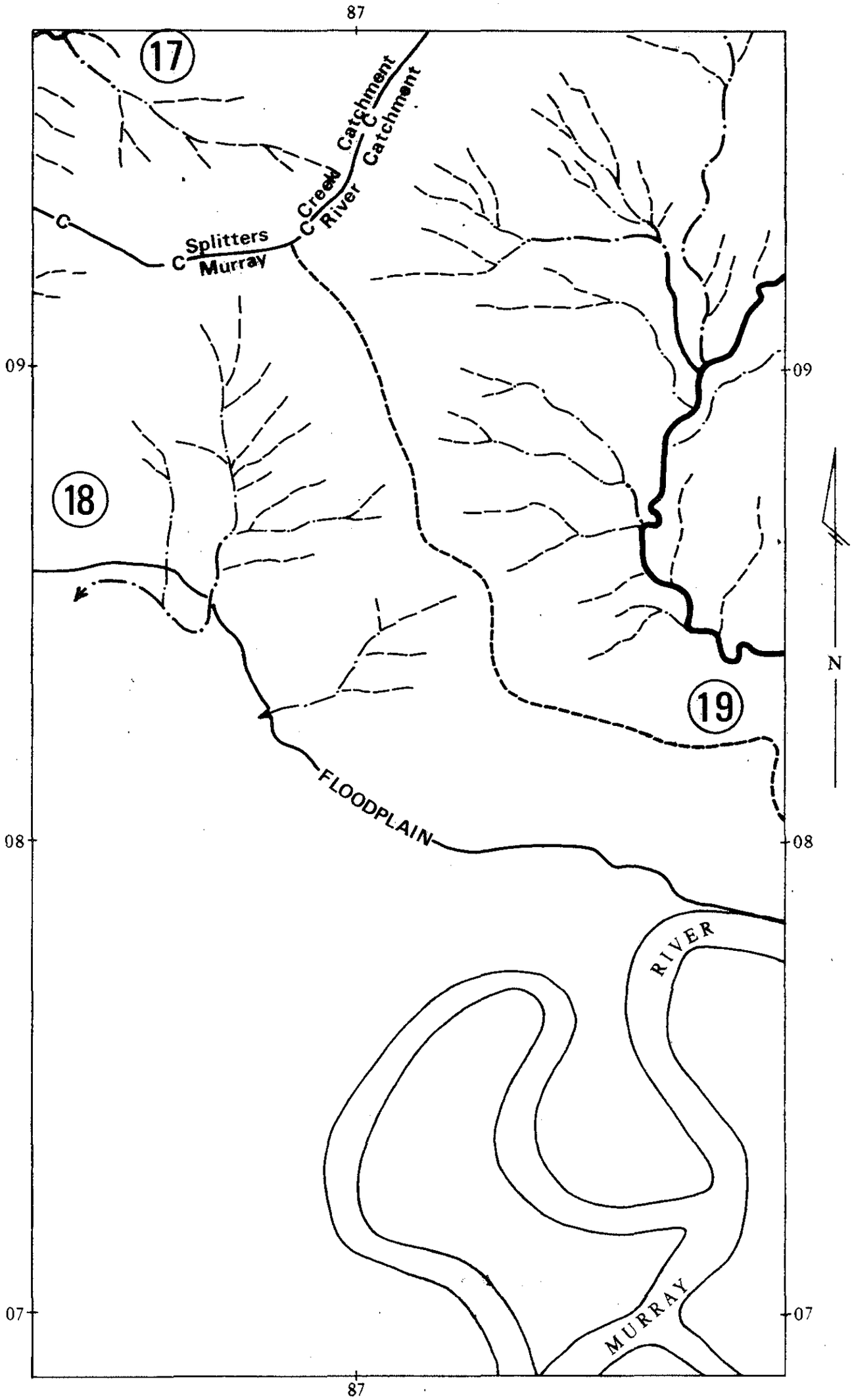
MAP 1

INDIGO 7·2 (1:10 000) – SOILS



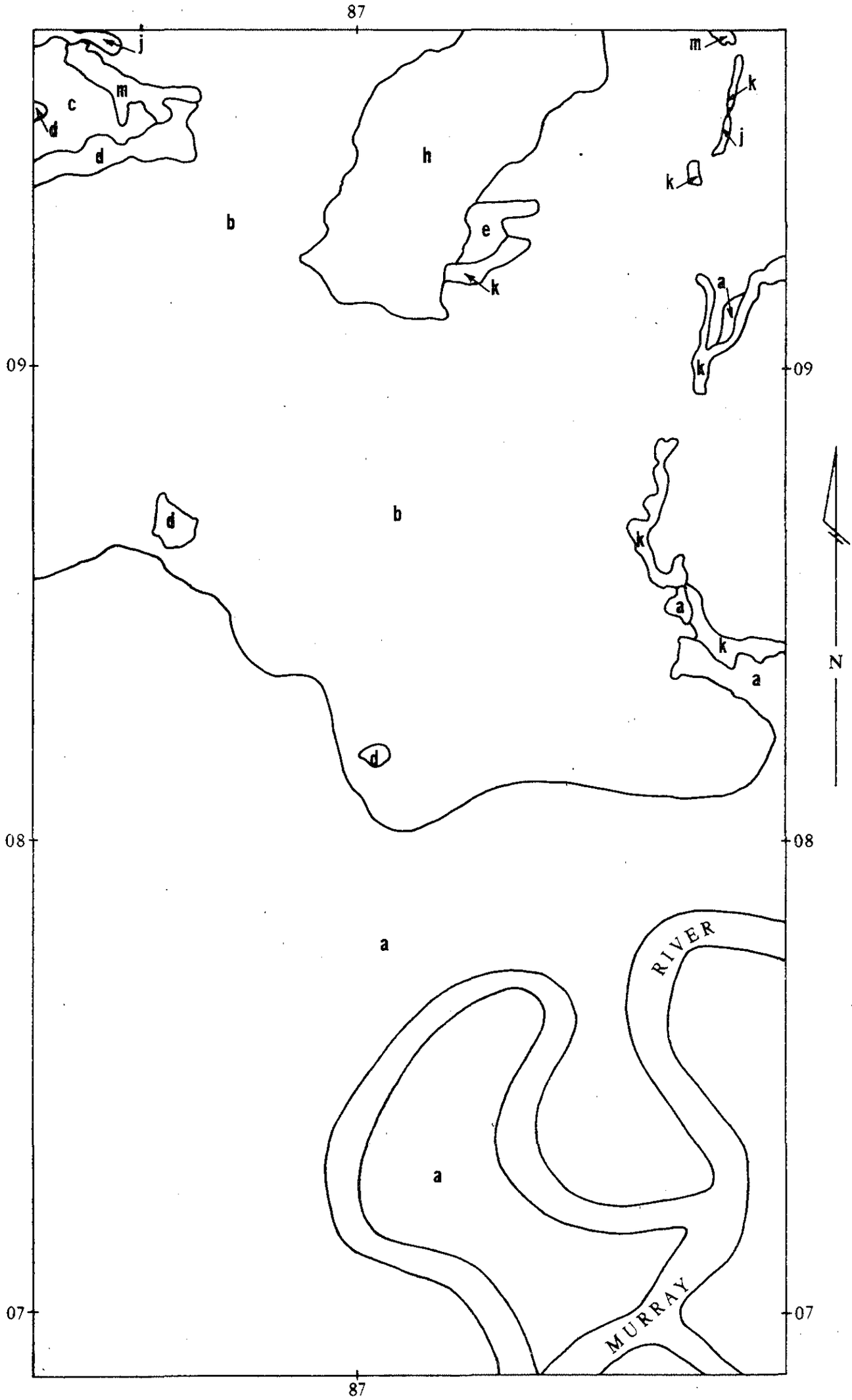
MAP 2

INDIGO 7·2 (1:10 000) – DRAINAGE PATTERN



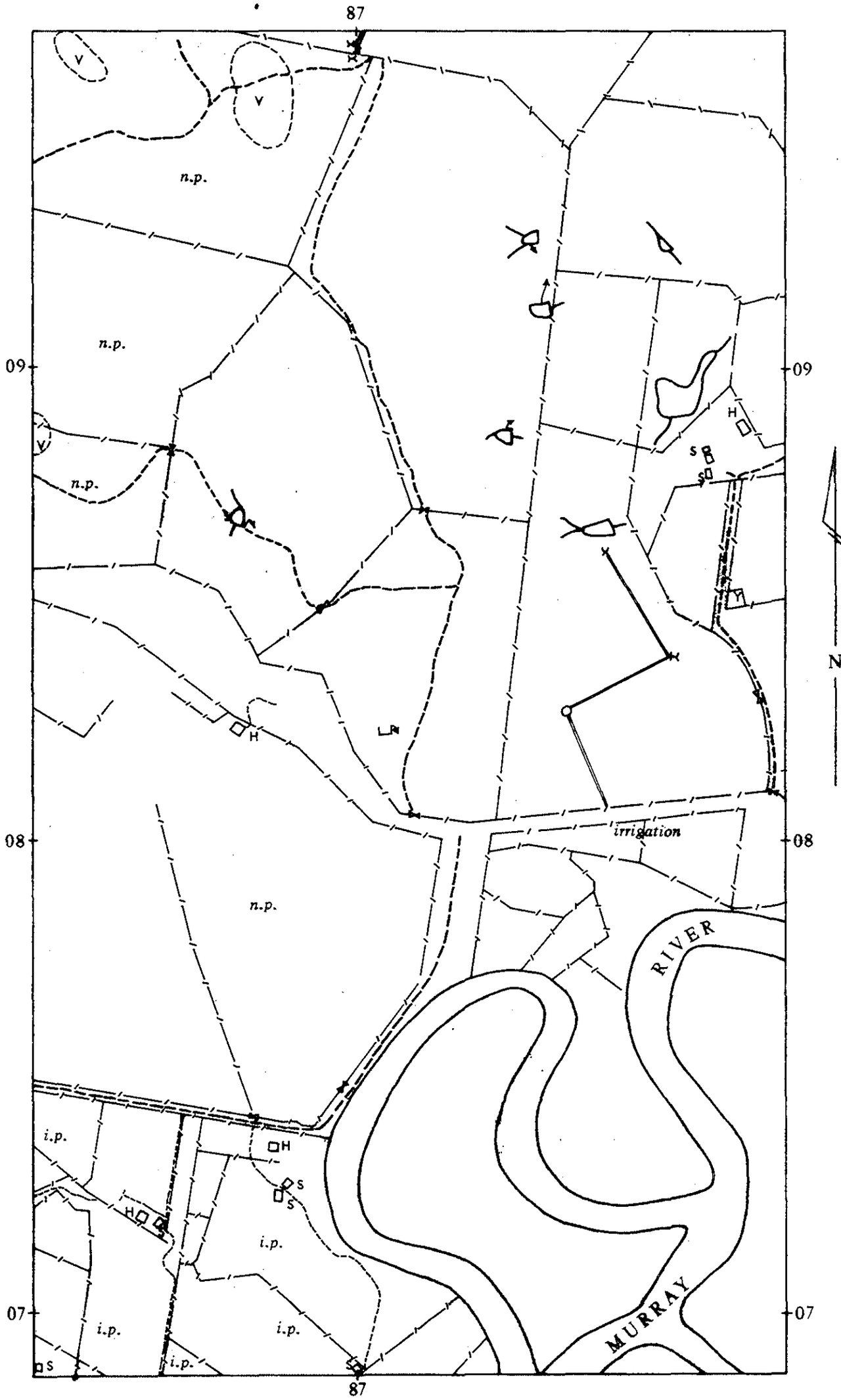
MAP 3

INDIGO 7·2 (1:10 000) – SOIL EROSION



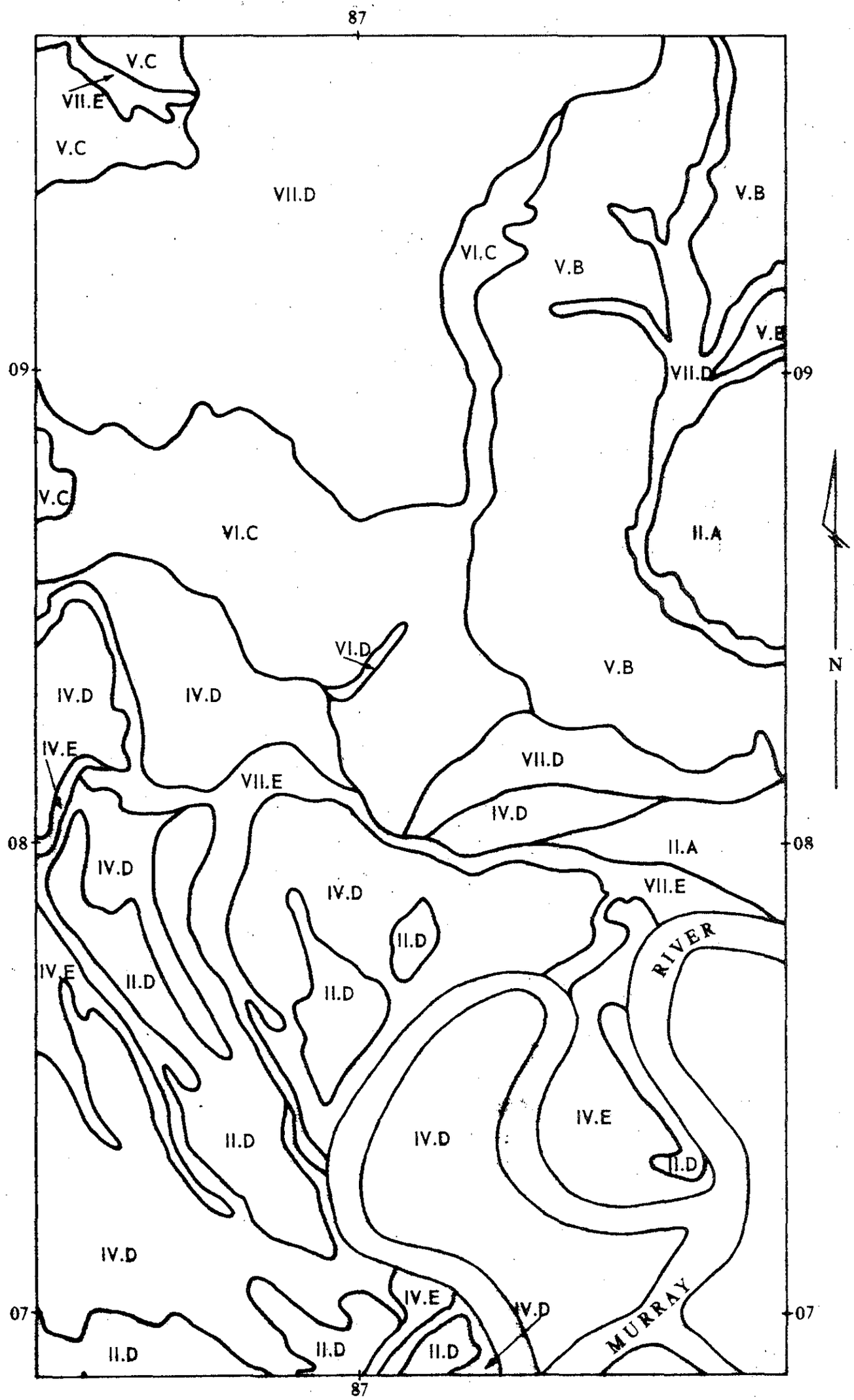
MAP 4

INDIGO 7·2 (1:10 000) – EXISTING LAND USE

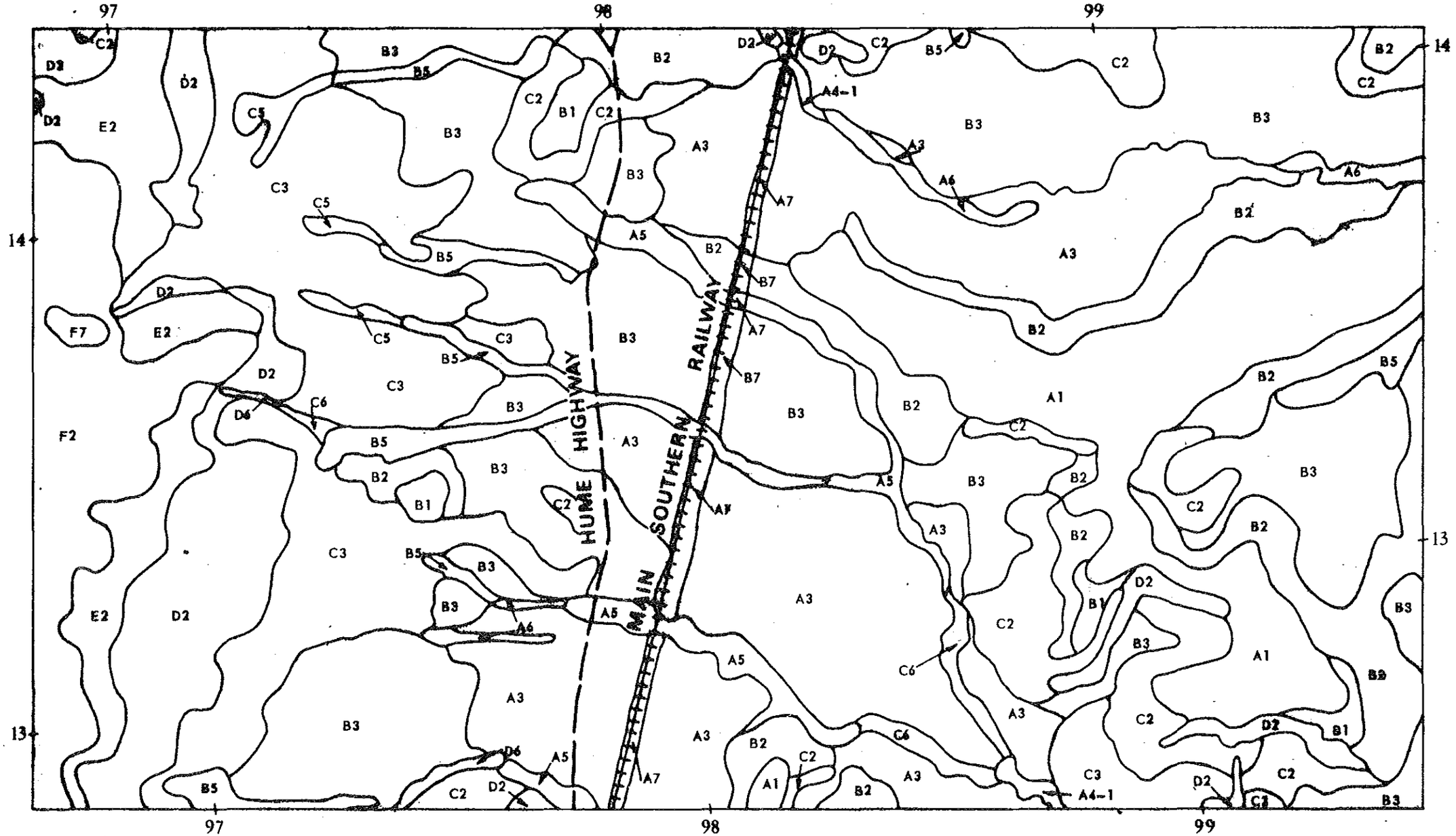


MAP 5

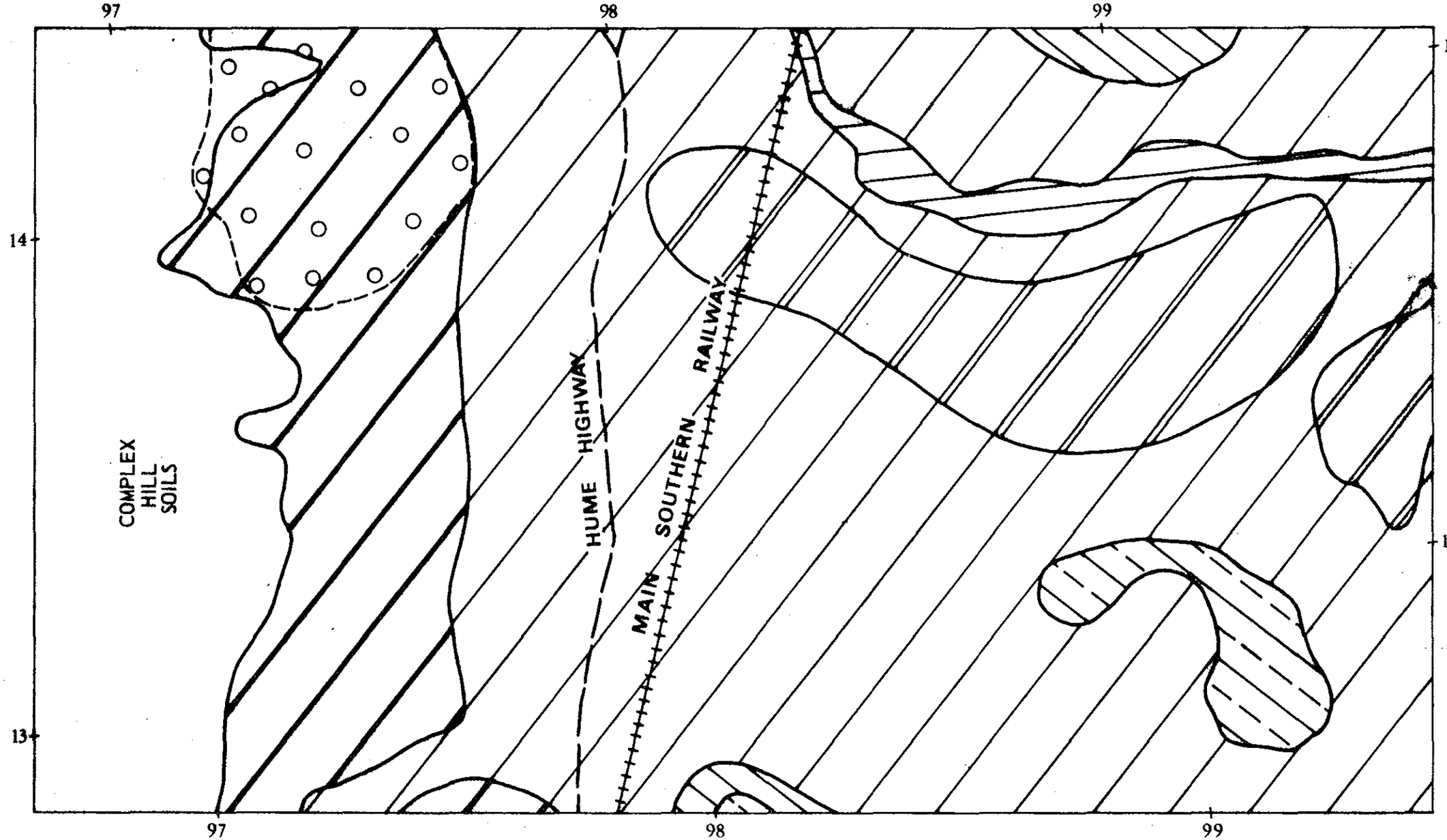
INDIGO 7·2 (1:10 000) – LAND CAPABILITY



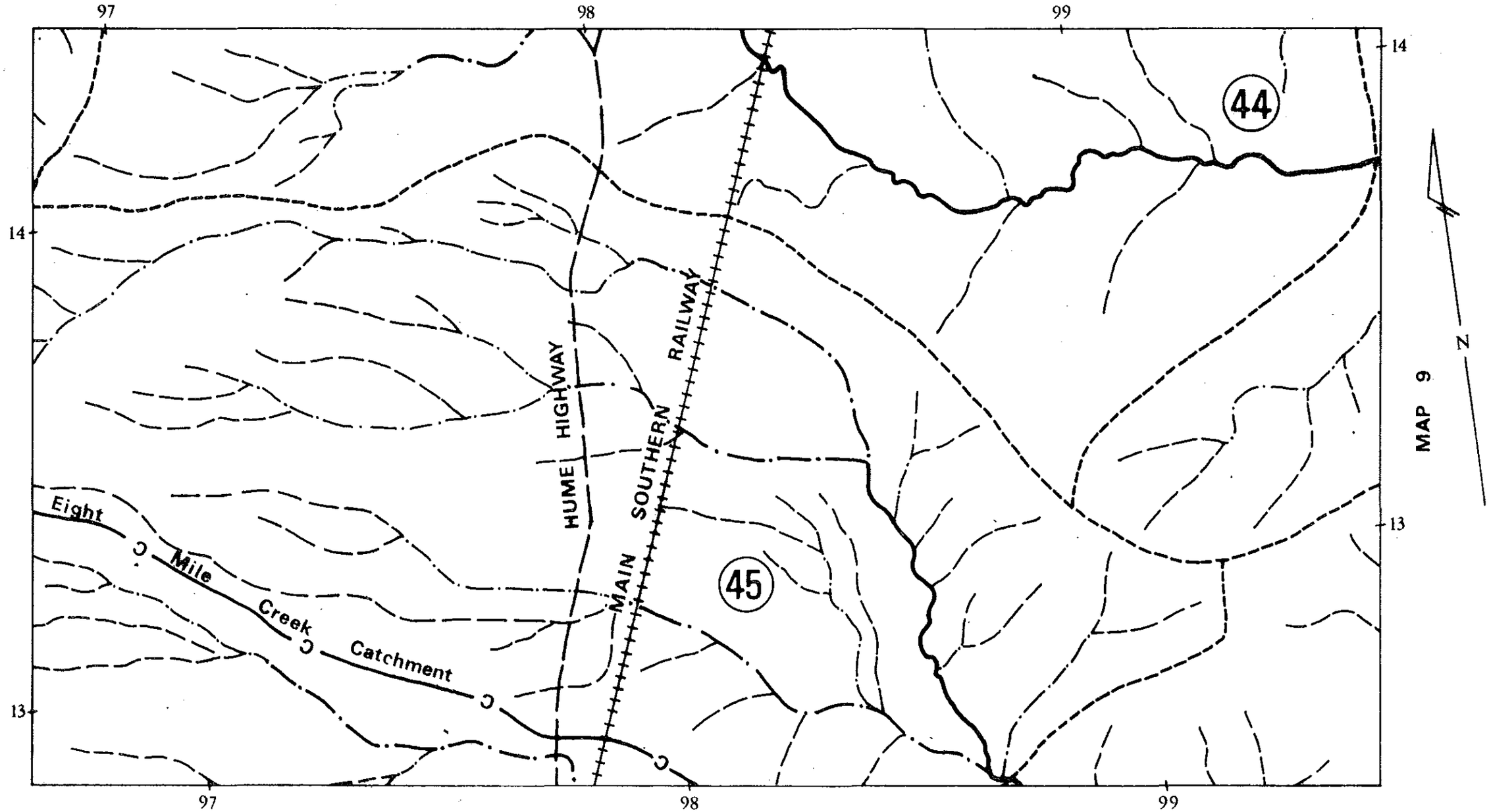
MAP 6



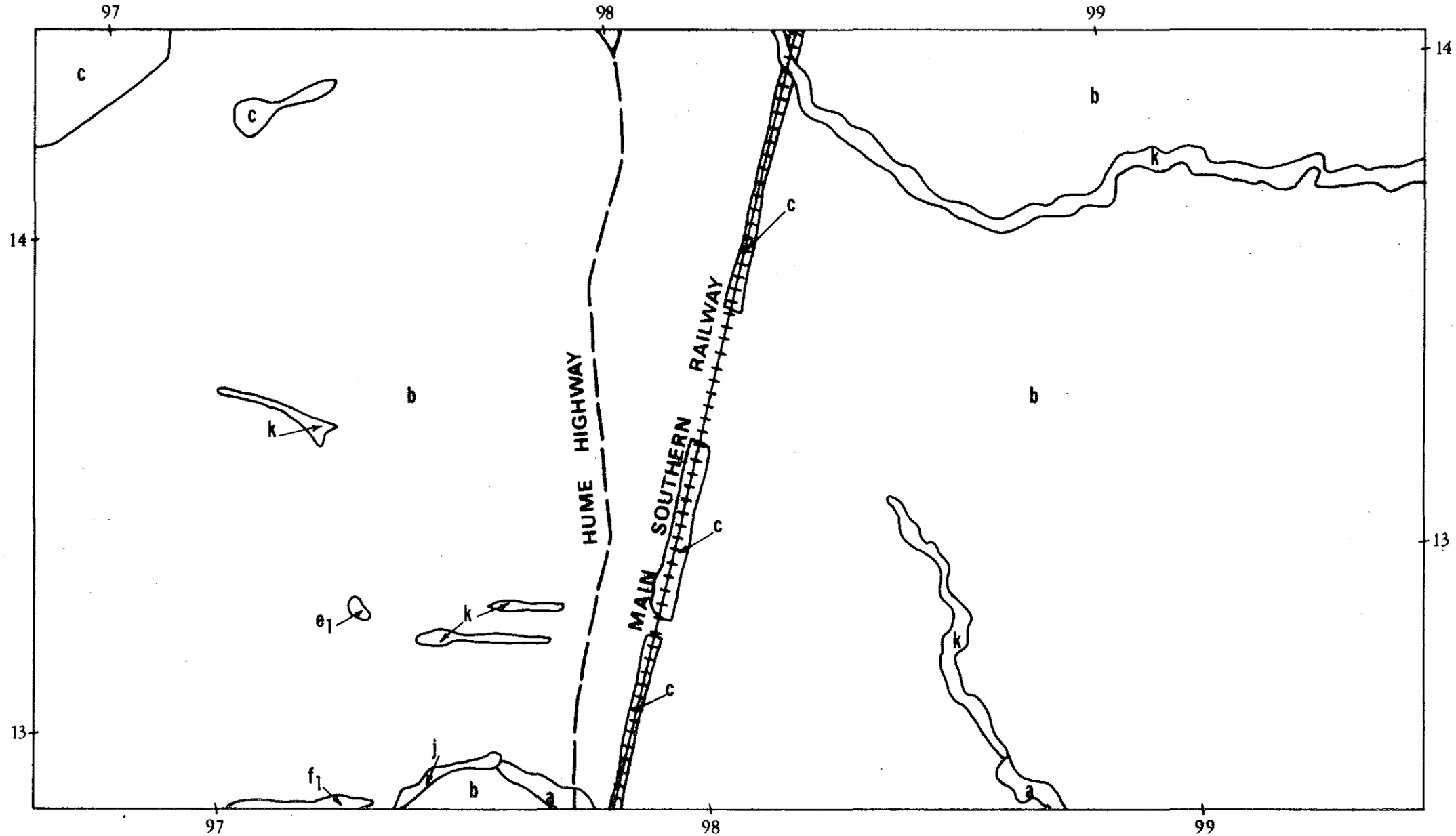
INDIGO 8·3 (1:10 000) – **LANDFORM**



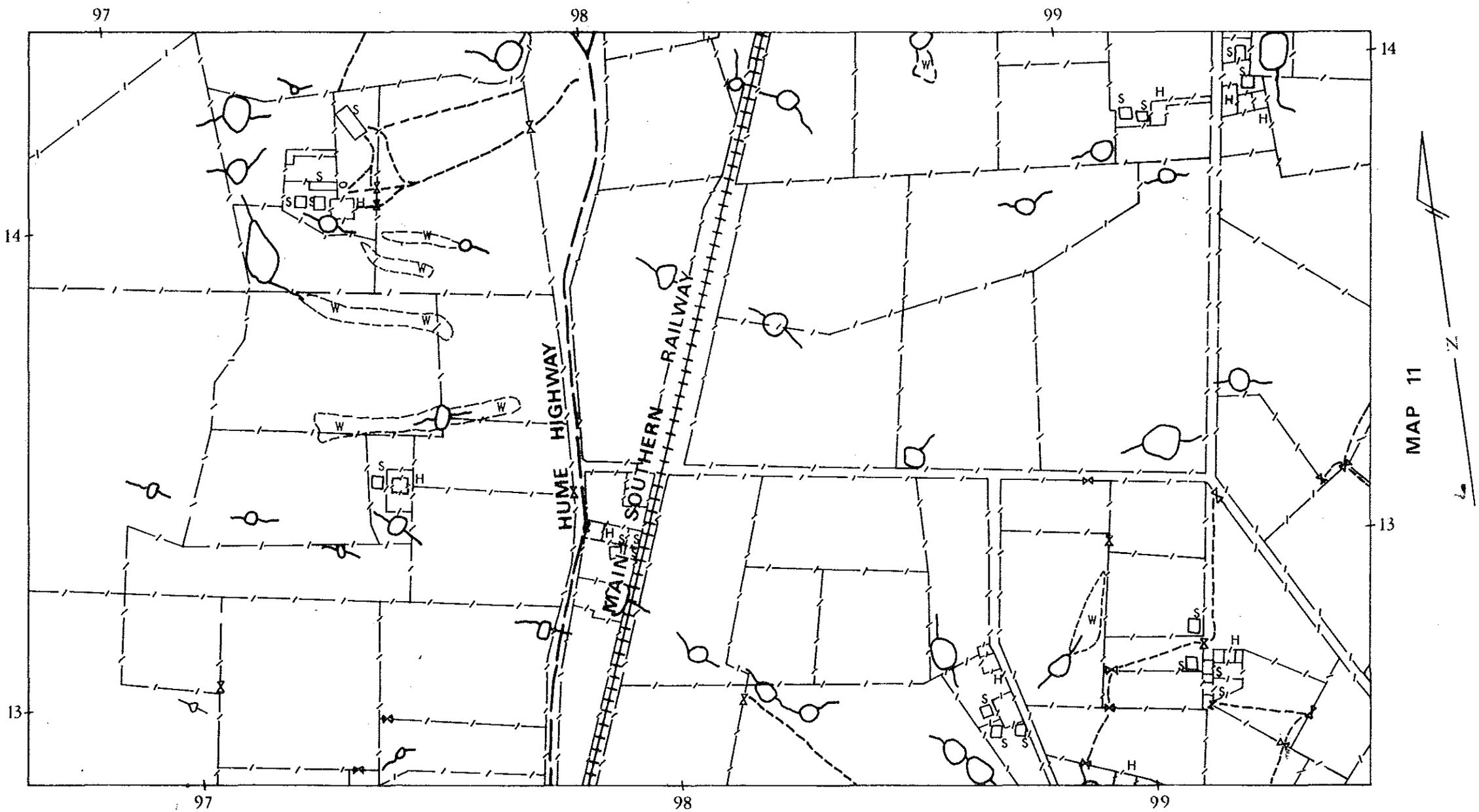
INDIGO 8·3 (1:10 000) – **SOILS**



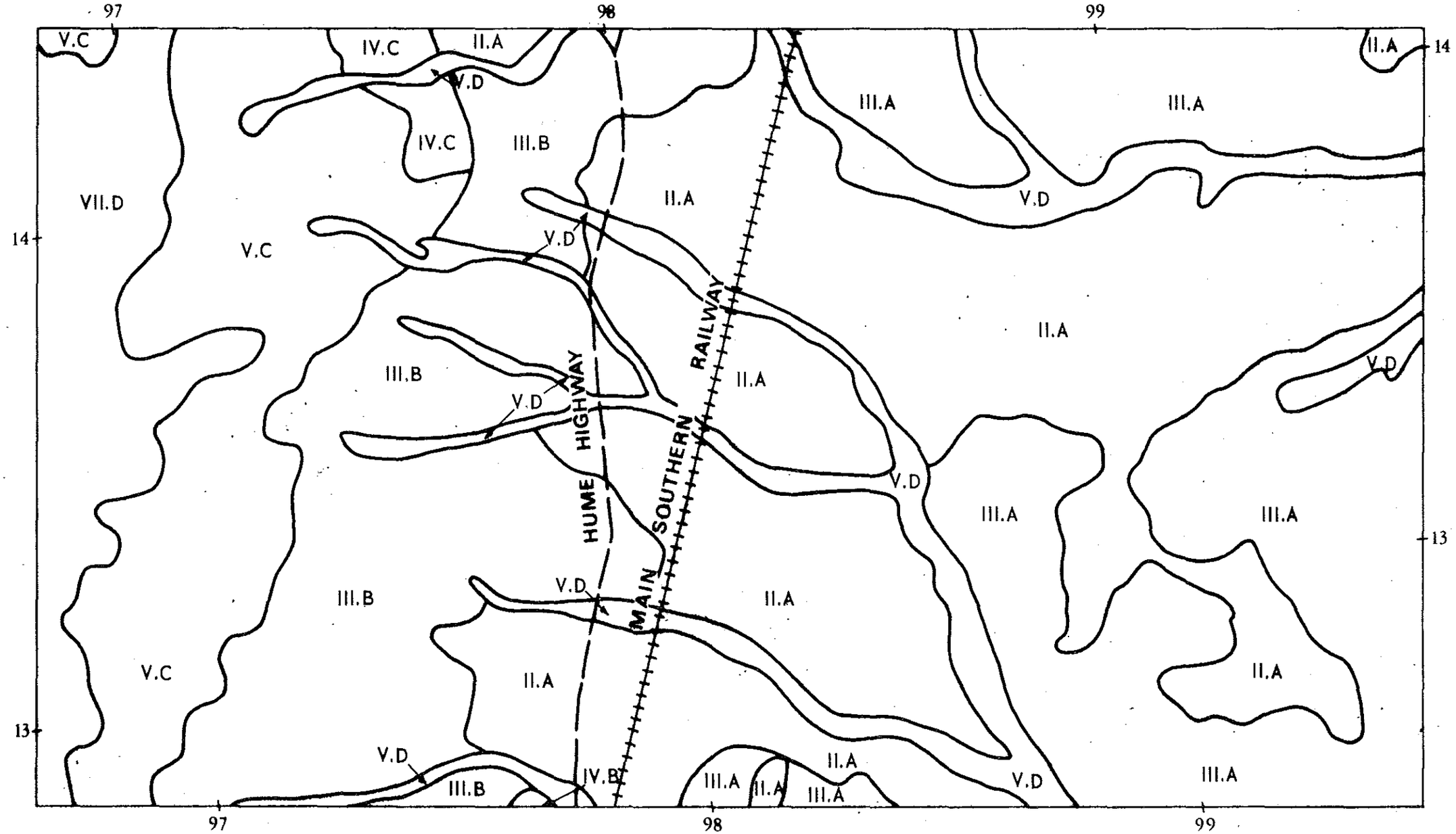
INDIGO 8·3 (1:10 000) – **DRAINAGE PATTERN**



INDIGO 8·3 (1:10 000) – **SOIL EROSION**

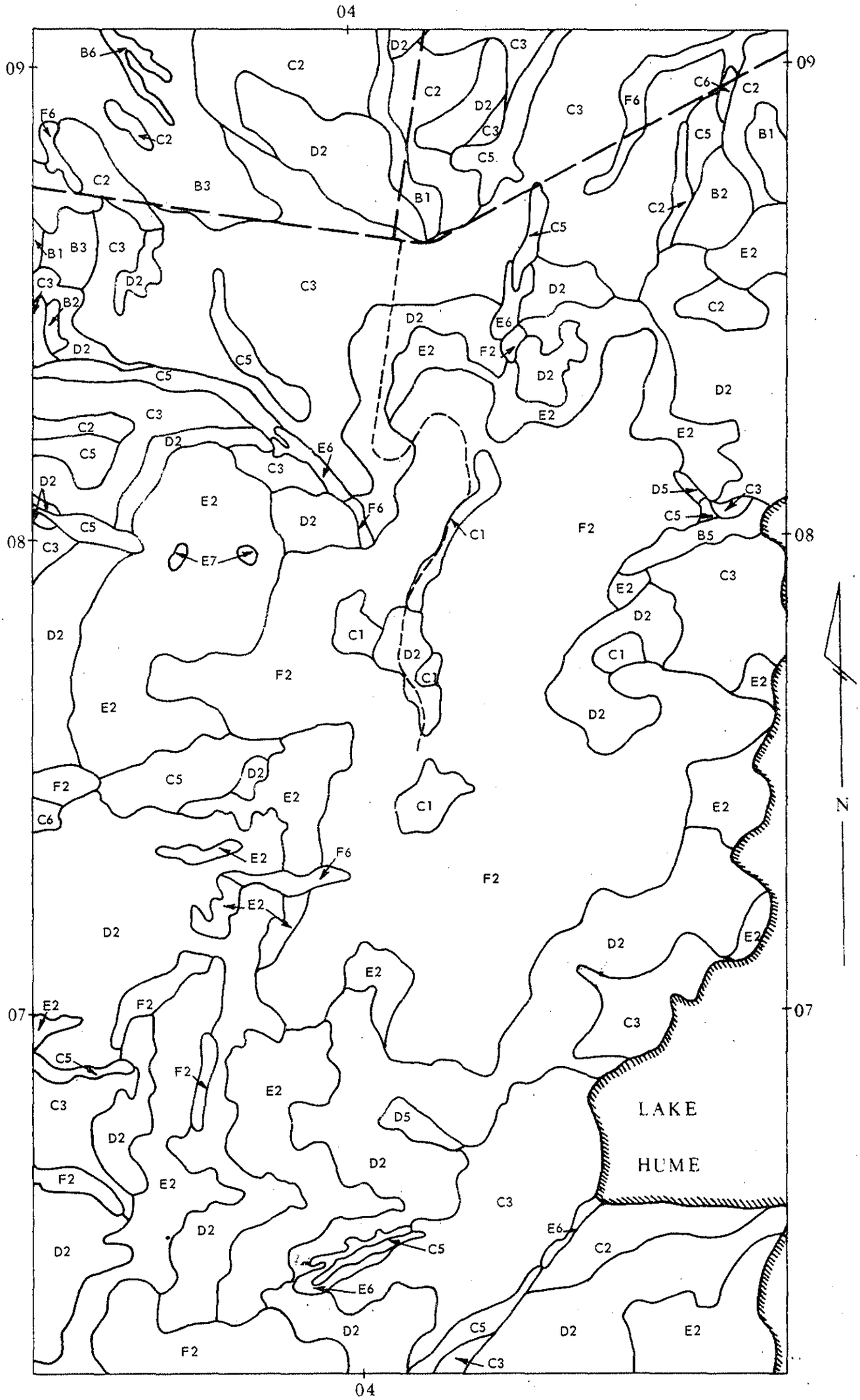


INDIGO 8·3 (1:10 000) – **EXISTING LAND USE**



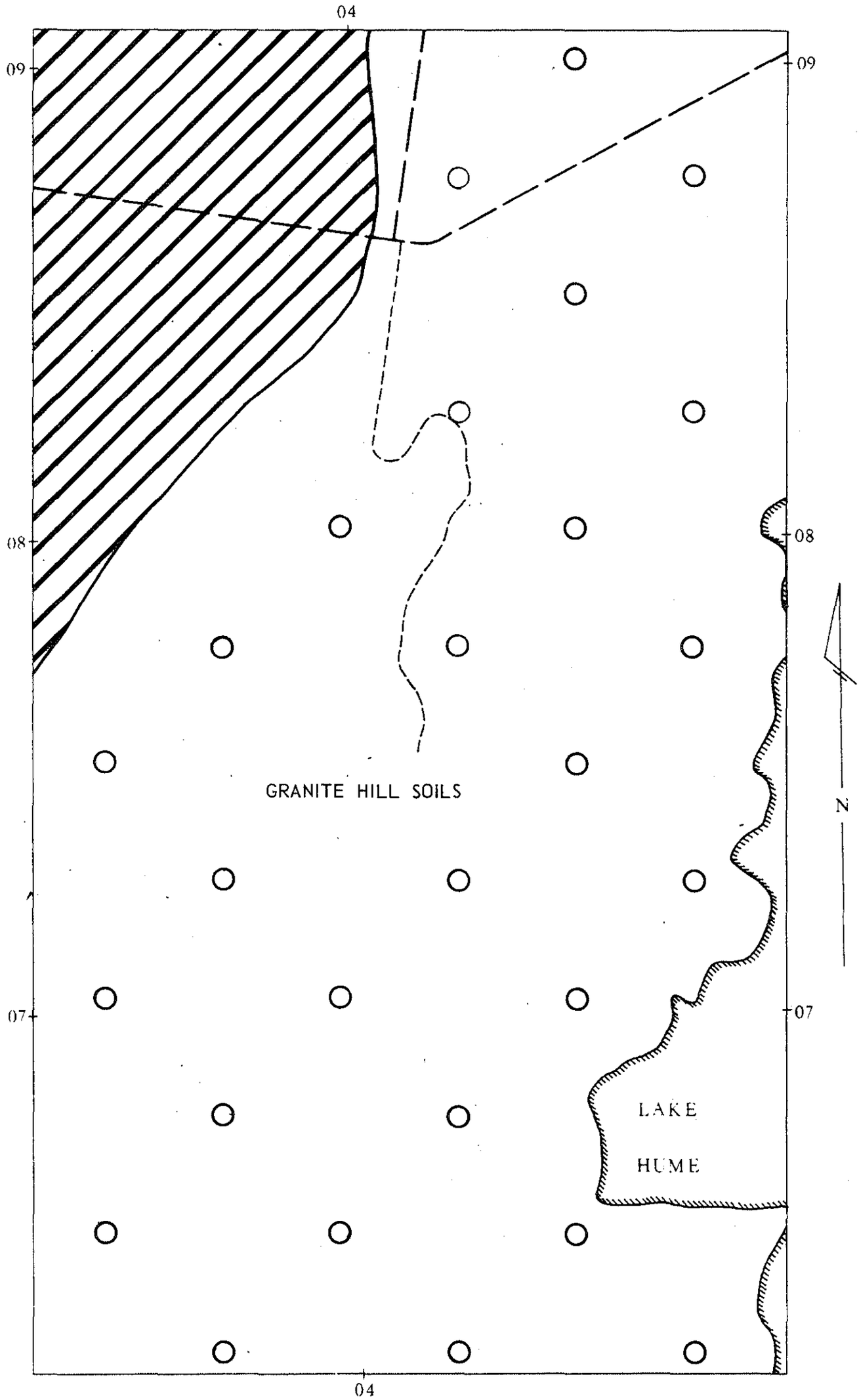
INDIGO 8·3 (1:10 000) – **LAND CAPABILITY**

BUNGIL 1·2 (1:10 000) – LANDFORM



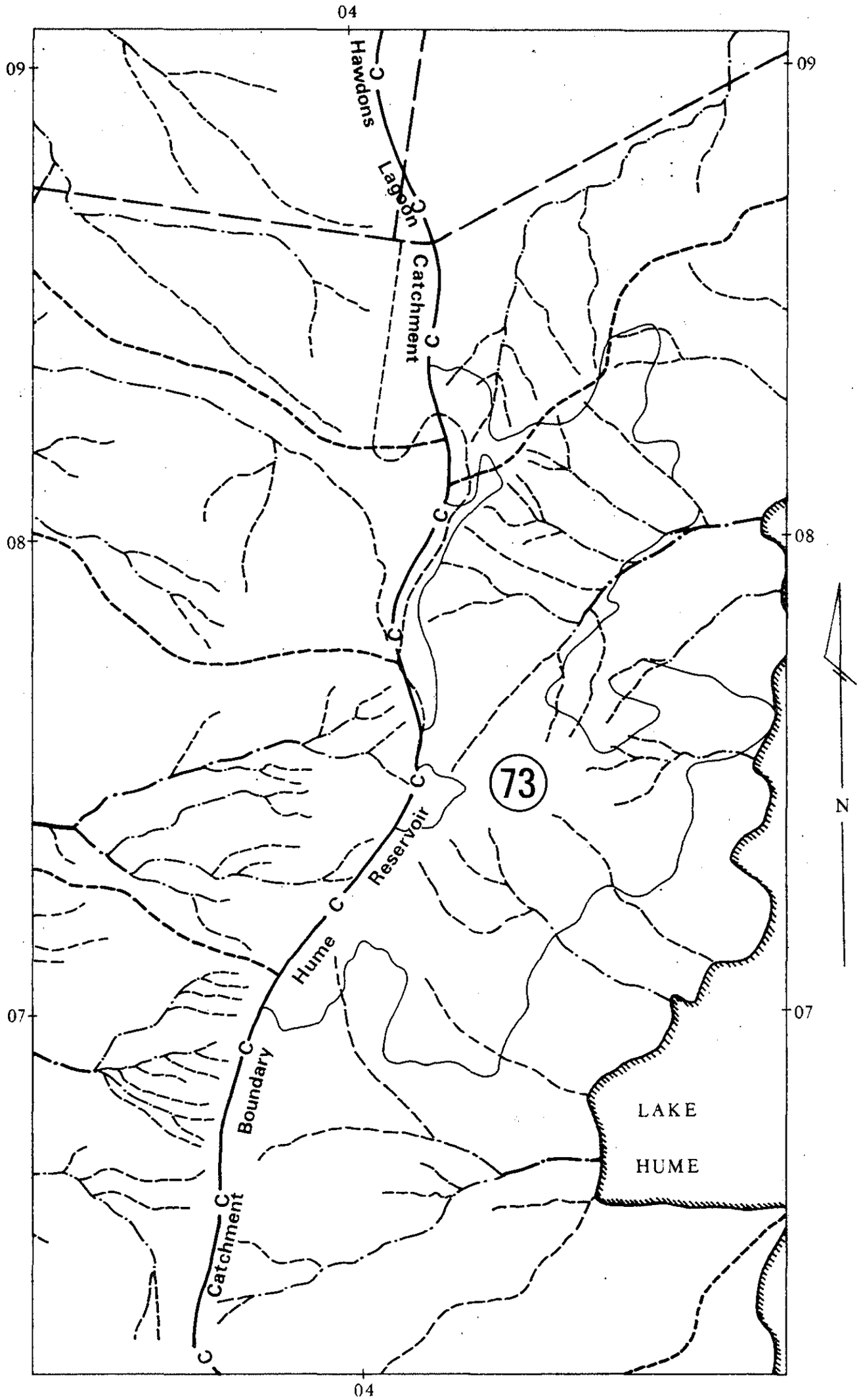
MAP 13

BUNGIL 1·2 (1:10 000) – SOILS



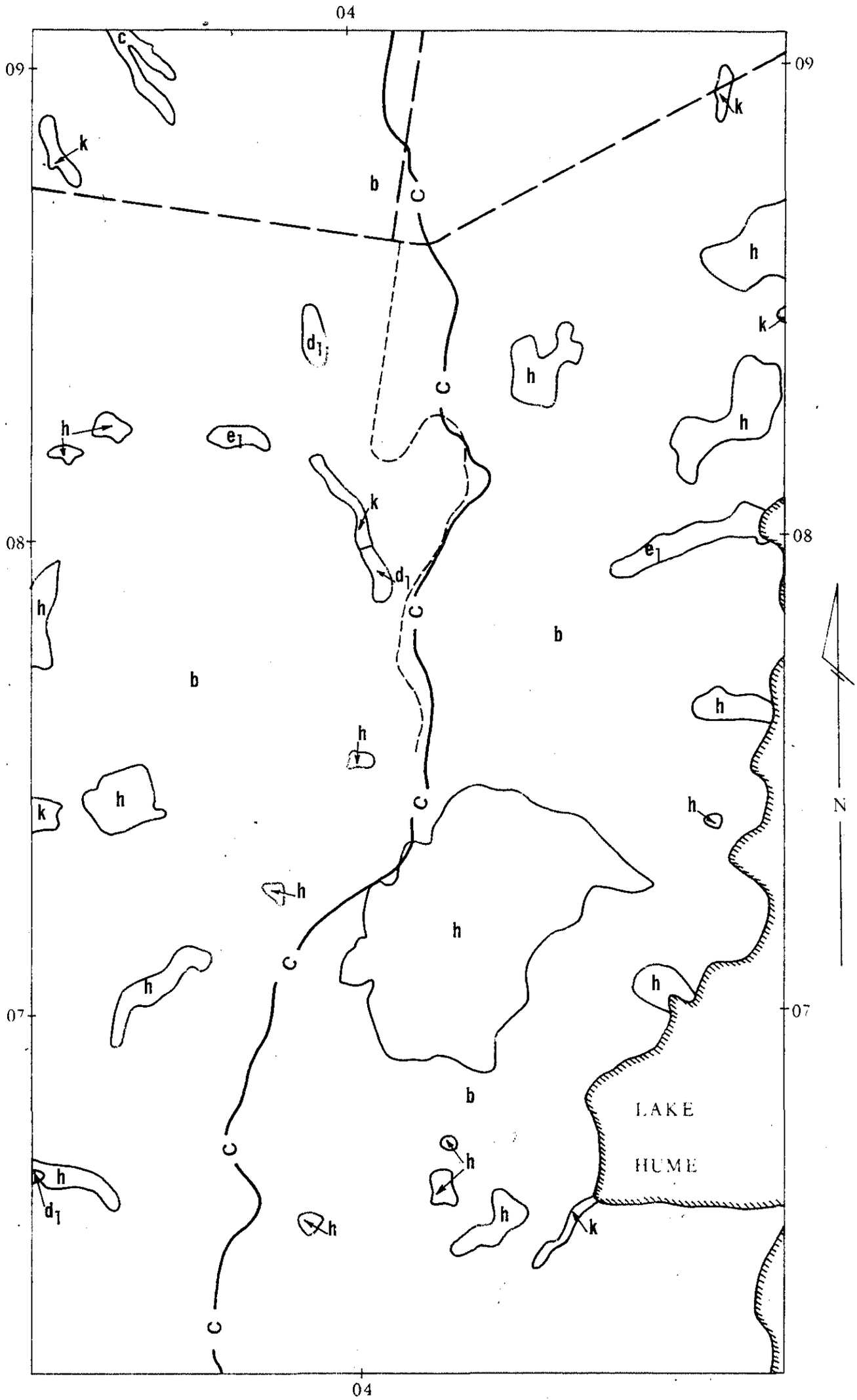
MAP 14

BUNGIL 1·2 (1:10 000) – DRAINAGE PATTERN



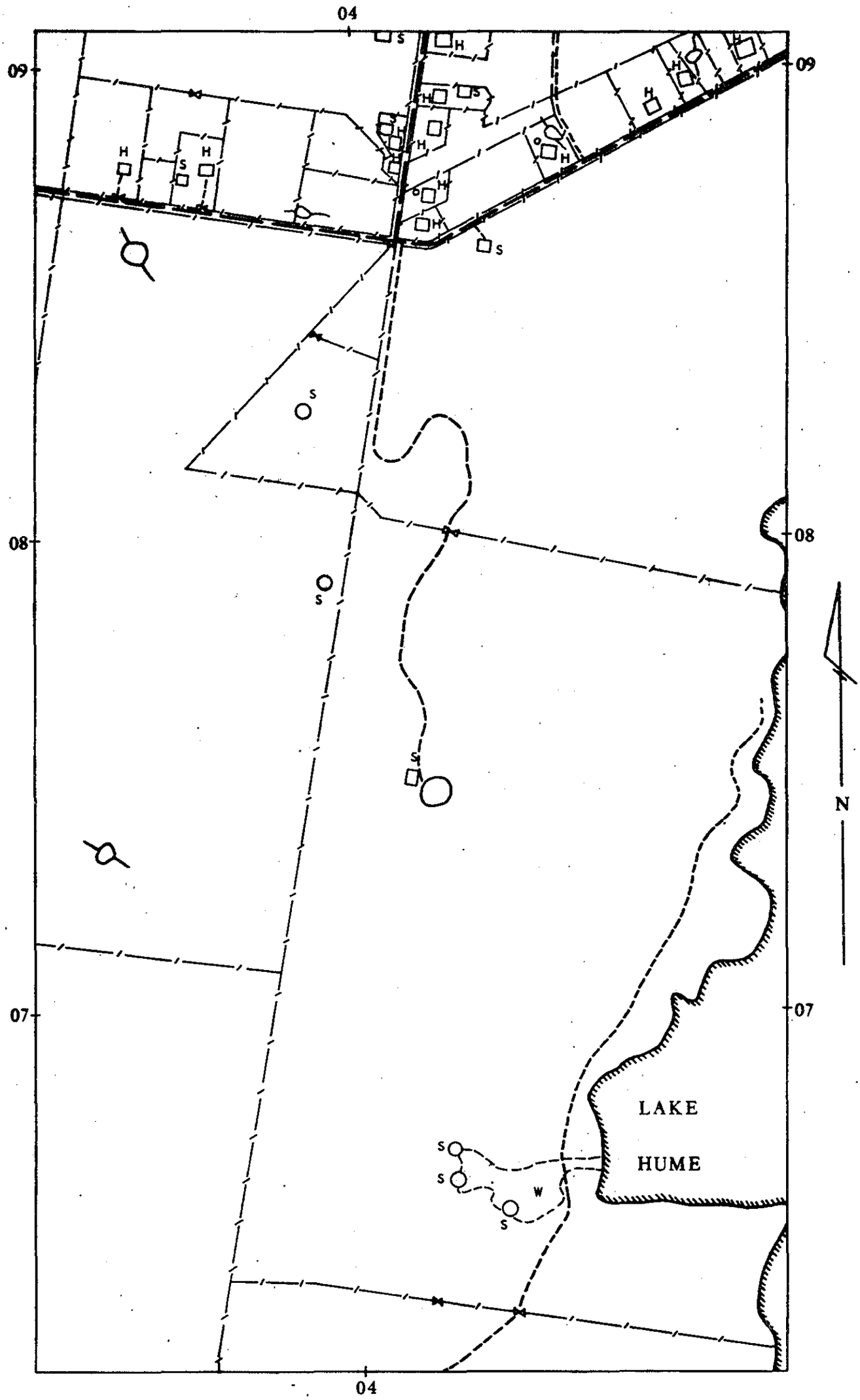
MAP 15

BUNGIL 1·2 (1:10 000) – SOIL EROSION



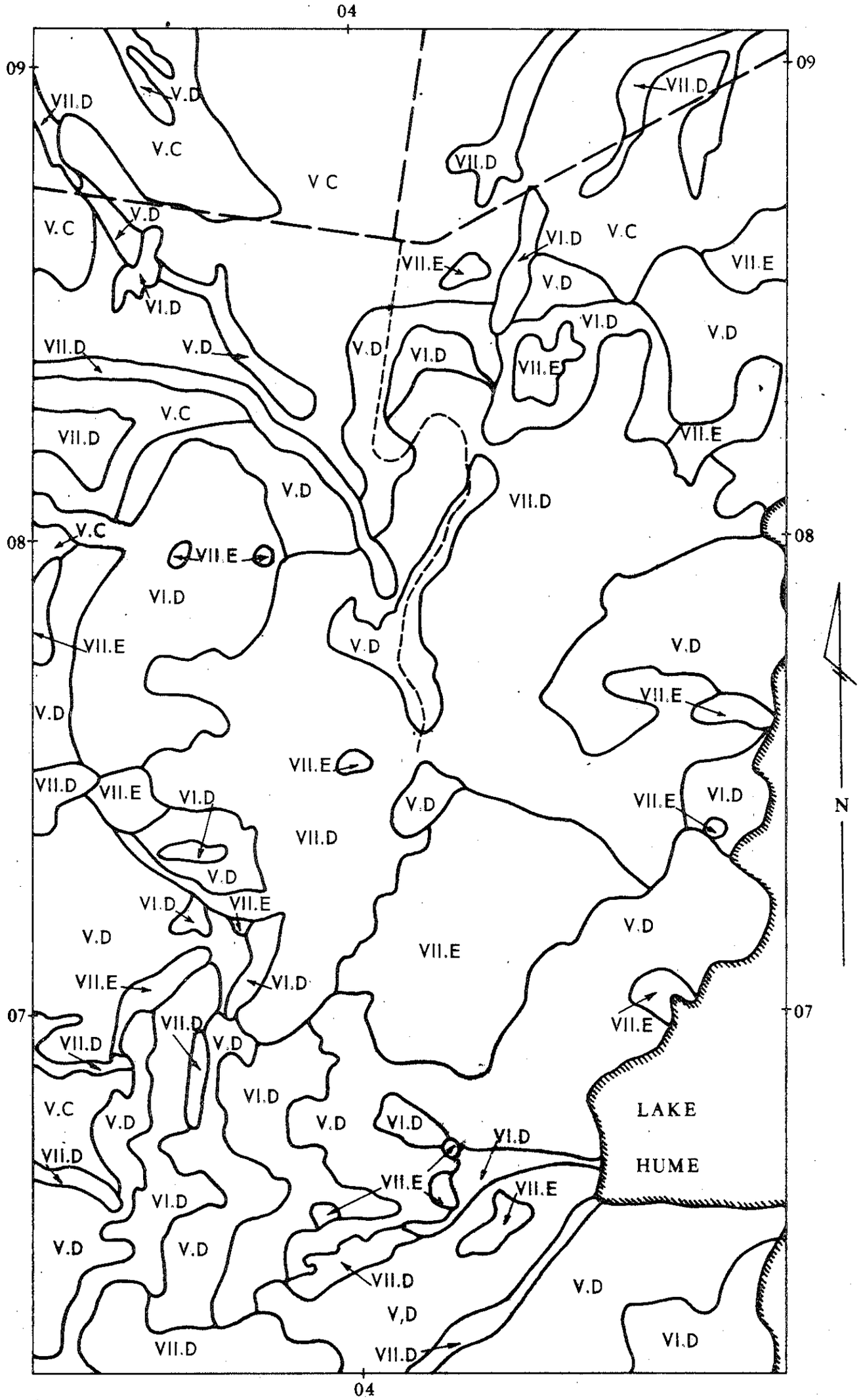
MAP 16

BUNGIL 1·2 (1:10 000) - EXISTING LAND USE



MAP 17

BUNGIL 1·2 (1:10 000) – LAND CAPABILITY



MAP 18

APPENDIX B

EXPLANATION OF PROPERTIES ASSESSED FOR SUMMARY OF SOIL PROPERTIES

Northcote Coding

From Northcote, K.H. (1971)
"A Factual Key for the Recognition of Australian Soils."
Rellim Publications. S.A.

Great Soil Group

From Charman, P.E.V. (1975)
A chart for the Identification of Great Soil Groups in New South Wales.

Underlying Material

Country rock if encountered before 180 cm or soil type extending below 180 cm.

Depth of Bedrock

If encountered before 180 cm. Also indicates minimum depth of soil.

Profile Drainage

Estimated from site characteristics and soil appearance.
Possible values: Poor, Moderate, Good.

Texture A_1, A_2 and B Horizon

Field Assessment.

Liquid Limit

The moisture content at which the soil passes from the liquid to the plastic state.

Plastic Limit

The lowest moisture content at which the soil is plastic.

Plasticity Index

The difference between the Liquid and Plastic Limits.

U.S.C.S.

The Unified Soil Classification System from which engineering data can be estimated.

ML - Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.

CL - Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.

CH - Inorganic clays or high plasticity and expanding clays.

SC - Clayey sands, poorly graded sand - clay mixtures.

GC - Clayey gravels, poorly graded gravel - sand - clay mixtures

Optimum Moisture

For compaction.

Volume Expansion

Keen Rackowski method as used by the Soil Conservation Service.

5	-	very low
5-10	-	low
10-20	-	moderate
20-40	-	high
40	-	very high

Dispersal Index (D.I.)

Dispersal Index test as used by the Soil Conservation Service.

1-2	highly dispersible
2-3	moderately dispersible
3	slightly dispersible

Dispersibility is a measure of soil structural stability to wetting, and so is important in the determination of erodibility and permeability. It is assessed on both Ritchie's Dispersal Index outlined above and by the Emerson Crumb Test (1967).

Erodibility

As assessed in the field. Possible values: Low, Moderate, High, Very High, Extreme.

Suitability for Ponds

Determination based on grading analysis, dispersibility, Unified Soil Coding, and an assessment or the water-holding characteristic of the soil. Intended as a guide to suitability for runoff detention basins.

Possible values: Good, Moderate, Poor.

Topsoil Quality

Relates to fertility as assessed in the field.
Possible values: Good, Moderate, Poor.

Ease of Revegetation of Disturbed Subsoil

Low	-	Special site treatment required.
Moderate	-	Special fertilizer treatment required.
Good	-	Achieved with normal sowing techniques.

SOIL SURVEY - ALBURY DESIGNATED AREA

SUMMARY OF SOIL PROPERTIES

Mapping Unit	Murray River Alluvium Group	Bungambrawatha Creek Alluvium Group	Eight Mile Creek Alluvium Group	Black Range or Complex Hill Soils	Granite Hill Soils Group
Northcote Coding	-	-	-	-	-
Great Soil Group	Alluvial	Alluvial	Alluvial	-	-
Underlying Material	-	-	-	Micaceous Schists	Granite
Depth to bedrock (cm)	-	-	-	-	-
Profile drainage	Poor	Moderate	Good	-	-
A_1 Horizon - Texture	-	Loam	Sandy loam	-	-
- Structure	-	Good	Moderate	-	-
A_2 Horizon - Texture - Structure B Horizon - Texture - Structure - E.C.T. - V.E. - D.I. - P.I. - U.S.C.S.	DUE TO THE HIGH DEGREE OF VARIATION IN THESE UNITS NO TYPICAL VALUES HAVE BEEN PRESENTED.				
Erodibility	Moderate	Moderate	Moderate	High	Extreme
Suitability for ponds	Poor	Poor	Poor	Variable	Poor
Topsoil quality	Good	Good	Good	Poor	Poor
Ease of revegetation	High	High	High	-	Low
Special features	Periodic inundation	Periodic inundation	Periodic inundation	Highly erodible	Some mass movement

SOIL SURVEY - ALBURY DESIGNATED AREA

SUMMARY OF SOIL PROPERTIES

Mapping Unit	Kywana Group	Howlong Group	St.Johns Group	Dight's Hill Group	Thurgoona Group
Northcote Coding	Uc 2.21	Ug 5.23	Gn 2.12	Gn 2.23	Dy 2.22
Great Soil Group	Podzol	Grey clay	Red earth	-	Yellow Podzolic
Underlying Material	Granite	Clay	-	-	-
Depth to bedrock (cm)	-	-	50	-	-
Profile drainage	Poor	Poor	Good	Good	Moderate
A_1 Horizon - Texture	Sand	Silty clay	Loam	Sandy loam	Loam
- Structure	0	0	2	1	2
A_2 Horizon - Texture	Clayey-Sand	-	-	Sandy loam	-
- Structure	Poor 0	Absent	Absent	Poor 1	Absent
B Horizon - Texture	Clayey-Sand	Heavy clay	Medium clay	Sandy clay	Medium clay
- Structure	0	3	2	1	2
- E.C.T.	1	3	> 3	2	>3
- V.E.	>5	30	16	10	12
- D.I.	2	3	30	5	13
- P.I.	Non-plastic	30	19	20	22
- U.S.C.S.	ML	CH	CL	CL	CL
Erodibility	Very high	Low	Low	Moderate	Low
Suitability for ponds	Poor	Good	Poor	Good	Good
Topsoil quality	Poor	Moderate	Good	Moderate	Moderate
Ease of revegetation	Low	Low	High	Moderate	High
Special features	Prolonged seepage mass movement	Prolonged waterlogging			

SOIL SURVEY - ALBURY DESIGNATED AREA

SUMMARY OF SOIL PROPERTIES

Mapping Unit	Ettamogah Group	Splitters Creek Group	Hamilton Valley Group	Wirlinga Group	Mungambareena Group
Northcote Coding	Dy 3.22	Dy 2.42	Dy 3.41	Dy 3.42	Dy 3.43
Great Soil Group	Yellow Podzolic	Yellow Solodic	Yellow Podzolic	Yellow Solodic	Yellow Solodic
Underlying Material	-	-	-	-	-
Depth to bedrock (cm)	-	-	-	-	-
Profile drainage	Moderate	Moderate	Moderate	Poor	Poor
A_1 Horizon - Texture	Loam	Loam	Sandy loam	Silty loam	Silty loam
- Structure	1	1	1	0	0
A_2 Horizon - Texture	Silty loam	Silty loam	Sandy clay	Silty loam	Silty clay
- Structure	0	0	1	0	0
B Horizon - Texture	Medium clay	Medium clay	Medium clay	Heavy clay	Medium clay
- Structure	2	1	1	2	3
- E.C.T.	2	2	2	1	2
- V.E.	15	16	9-15	25	7
- D.I.	4.0	2.5	4.5	2.0	2.8
- P.I.	18	25	18	39	26
- U.S.C.S.	CL	CL	CL	CL	CL- CH
Erodibility	Moderate	High	Moderate	High	Moderate
Suitability for ponds	Good	Good	Good	Moderate	Good
Topsoil quality	Moderate	Moderate	Moderate	Moderate	Moderate
Ease of revegetation	Moderate	Moderate	Moderate	Low	Moderate
Special features				Periodic Waterlogging	Periodic Waterlogging

APPENDIX B

DESCRIPTION OF SOIL PROFILES

A typical soil profile description from each of the major soil groups described in this Study follows. For soil groups having a wide variability additional soil profile descriptions are made.

Bungambrawatha Creek Alluvium

Location: Near Lavington Public School
Landform: Floodplain of Bungambrawatha Creek
Parent Material: Alluvium
Drainage: Good
Land use: Grazing

Morphology

Depth (cm)	Description
0-15	Dark brown (7.5YR 4/2) silt loam. Moderate crumb structure, numerous grass roots pH 6.5 sharp to -
15-25	Brown (10YR 5/3) sandy loam, structureless pH 6.5 sharp to -
25-40	Greyish brown (10YR 4/2) silt loam, slight platy structure pH 6.5 sharp to -
40-70	Greyish brown (10YR 4/2) loam, slight structure pH 6.5 sharp to -
70-105	Yellowish brown (10YR 5/6) clay loam, slight structure pH 6.5

Eight Mile Creek Alluvium

Location: Adjacent to the Olympic Way
Landform: Floodplain of Eight Mile Creek
Parent Material: Alluvium
Drainage: Good
Land use: Grazing, improved pasture

Morphology

Depth (cm)	Description
0-90	7 bands of silt, sand and gravel 5 to 20 cm thick pH 7 throughout.
90-125	Yellowish brown (10YR 5/4) coarse sand, structureless, pH 6.5 sharp to -
125-200	Dark olive grey (5Y 3/2) with 40% brownish yellow (10YR 6/6) mottles. Light clay, strong blocky structure, pH 7.

Black Range or Complex Hill Soils Group

Location: Hillslope Upper Bungambrawatha Creek
Landform: Sideslope
Parent Material: Micaceous schist
Drainage: Good
Land use: Grazing, improved pasture
Principal profile form: Dy 2.21 - 3/1/20

Morphology

Depth (cm)	*Horizon*	*Description*
0-15	*A*	*Brown (10YR 4/3) moist, loam, weak crumb structure, pH 6, gradual to -*
15-20	*A_2*	*Light yellowish brown (10YR 6/4) moist, clay loam. Structureless pH 5½ clear to -*
20-120	*B*	*Brownish yellow (10YR 6/8) moist medium clay moderate blocky structure, pH 5.*

Location: *Hillslope Upper Bungambrawatha Creek*
Landform: *Footslope*
Parent Material: *Micaceous schist*
Drainage: *Good*
Land use: *Grazing, native pasture*
Principal Profile Form: *Uf 1.43 - 5/2/20*

Morphology

Depth (cm)	*Horizon*	*Description*
0-20	*A*	*Loose stone and gravel, probably recently deposited.*
20-40	*A*	*Yellow red (5YR 4/6) sandy clay. Many rock fragments pH 5 gradual to -*
40-200	*B*	*Yellow red (5YR 4/6) light clay. Many rock fragments. Strong sub angular blocky structure up to 2 cm diameter. Hard consistency pH 5½.*

Location: *On ridge behind Albury Golf Club*
Landform: *Ridge*
Parent Material: *Micaceous schist*
Drainage: *Good*
Land use: *Native timber*
Principal Profile Form: *Dr 2.32 - 3/1/5*

Morphology

Depth (cm)	*Horizon*	*Description*
0-15	*A*	*Dark brown (7.5YR 4/4) loam, slight platy structure, medium consistency. pH 5½ clear to -*
15-20	*A_2*	*Yellow red (5YR 5/6 moist) light reddish grey (2.5YR 7/2 dry) clay loam. Slight structure, hard consistency, dispersible pH 6 clear to -*
20-130	*B*	*Red (2.5YR 4/6) medium clay, strong blocky structure, very hard consistency, rock fragments increasing with depth.*

Murray Valley Alluvium

Location: *Floodplain west of Albury*
Landform: *Floodplain*
Parent Material: *Alluvium*
Drainage: *Moderate*
Land use: *Grazing, improved pasture*

Morphology

Depth (cm)	*Horizon*	*Description*
0-1		*Grass litter mixed with silt.*
1-15		*Dark brown (7.5YR 3/2) silt loam medium platy to fine crumb structure. pH 6, clear to -*
15-20		*Dark reddish brown (5YR 3/3) silt, massive. Hard when dry. pH 6 clear to -*
20-120		*Dark brown (7.5YR 4/4) silty clay, soft and plastic when wet, hard when dry. pH 6 clear to -*
120-180		*Dark yellowish brown (10YR 4/4) clayey sand, single grain, water bearing when examined. pH 7.5*

Location: *Floodplain west of Albury*
Landform: *Floodplain*
Parent Material: *Alluvium*
Drainage: *Good*
Land use: *Grazing*
Principal Profile Form: *Uc 1.21 - 1/0/25*

Morphology

Depth (cm)	*Horizon*	*Description*
0-2	*Ao*	*Grass litter*
2-25	*A*	*Dark brown (7.5YR 3/3) sand, single grain, some organic matter, pH 6 gradual to -*
25-180	*B*	*Yellowish brown (10YR 5/4) sand, single grain, pH 6.*

Granite Hill Soils Group

Location 1: *Near crest of ridge above Hume Weir wall.*
Landform: *Ridge*
Parent Material *Granite*
Drainage: *Good*
Land use: *Grazing*
Principal Profile Form: *Uc 2.21 - 2/2/25*

Morphology

Depth (cm)	*Horizon*	*Description*
0-8	A_1	*Dark greyish brown (10YR 4/2 moist) sandy loam, much organic matter, medium platy structure. Hard consistency. pH 7 clear to -*
8-25	A_2	*Light grey (10YR 7/2) loamy sand, single grain. Apedal, soft consistency, pH 7 clear to -*
25-130	*B*	*Mottled, about 50% each of strong brown (7.5YR 5/6) and pale olive (5 Y 6/4) coarse sand. Cemented into aggregate 10 to 15 cm in diameter. pH 7 Very hard.*

Location 2: Mid slope on ridge above Hume Weir wall.
Landform: Sideslope
Parent Material: Granite
Drainage: Good
Land use: Grazing
Principal Profile Form: Uc 1.22 - 1/0/20

Morphology

Depth (cm)	Horizon	Description
0-20	A	Dark brown (10YR 3/3) loamy sand. Single grain except for organic material gradual to -
20-200	B	Yellowish brown (10YR 5/4) sand, single grain. pH 7.

Kywana Soils Group

Location 1: Near Knobles Road, Wirlinga.
Landform: Sideslope
Parent Material: Granite
Drainage: Moderate to poor
Land use: Grazing
Principal Profile Form: Uc 2.21 - 1/0/35

Morphology

Depth (cm)	Horizon	Description
0-15	A_1	Dark greyish brown (10YR 4/2 moist) sandy loam. Much organic matter, medium platy structure. Hard consistency, pH 7 clear to -
15-35	A_2	Light grey (10YR 7/2) loamy sand, single grain, apedal, soft consistency pH 6.5 clear to -
35-70	B_1	Mottled, about 30% each of strong brown (7.5YR 5/6), pale olive (5Y 6/4) and yellow red (5YR 5/8) clayey sand. Cemented into aggregate about 15 cm in diameter. pH 5 Very hard.
70-120	B_2	Yellowish brown (10YR 5/6) sandy clay strong blocky structure. pH 6.

Location 2: In road cutting on the Riverina Highway, Hawkesview.
Landform: Sideslope
Parent Material: Granite
Drainage: Good
Land use: Grazing
Principal Profile Form: Dr 2.21

Morphology

Depth (cm)	Horizon	Description
0-20	A_1	Dark greyish brown (10YR 4/2) loamy sand. Slight platy structure, hard consistence, contains some gravel pH 7 gradual to -
20-40	A_2	Light brown (7.5YR 6/4) loamy sand. Apedal, very hard consistence. pH 6.5 sharp to -
40-80	B	Red (2.5YR 5/6) sandy clay. Massive

Location 3: Across road from Wirlinga Army Depot
Landform: Footslope
Parent Material: Granite
Drainage: Good
Land use: Grazing
Principal Profile Form: Dy 3.41

Morphology

Depth (cm)	Horizon	Description
0-20	A	Dark greyish brown (10YR 4/2) loamy sand. Slight platy structure. pH 6 gradual to -
20-40	A_2	Very pale brown (10YR 8/3) loam fine sandy. Apedal, very hard consistence pH 6 sharp to -
40-120	B	Light brownish grey (10YR 6/2) with 30% brownish yellow (10YR 6/8) sandy clay. Strong blocky structure. pH 5.

Howlong Soils Group

Location: North of Albury Airport
Landform: Drainage plain
Parent Material: Unknown
Drainage: Poor
Land use: Grazing
Principal Profile Form: Ug 5.23

Morphology

Depth (cm)	Horizon	Description
0-10	A	Dark grey (5YR 4/1) silty clay numerous cracks. Moderate crumb structure. pH 5 clear to -
10-110	B_1	Dark grey (10YR 4/1) heavy clay, strong blocky structure. pH 6.
110-150	B_2	Greyish brown (2.5Y 5/2) heavy clay strong blocky structure. pH 8.5.

St.Johns Soils Group

Location 1: Near Hume Highway to Ettamogah
Landform: Ridge
Parent Material: Igneous instrusions
Drainage: Good
Land use: Grazing
Principal Profile Form: Gn 2.22

Morphology

Depth (cm)	Horizon	Description
0-20	A	Reddish brown (5YR 4/3) loam, fine sandy, fine crumb structure. pH 6 clear to -
20-50	B_1	Yellow red (5YR 5/6) light clay earthy fabric. pH 6.5 diffuse to -
50-75	B_2	Yellow red (5YR 4/6) medium clay earthy fabric pH 6.5 diffuse to -
75-120		Strong brown (7.5YR 5/6) medium clay earthy fabric. pH 6.5.

Location 2: 5 metres down slope from Location 1.
Principal Profile
Form: Dr 2.12

Morphology

Depth (cm)	Horizon	Description
0-30	A_1	Strong brown (7.5YR 5/6) fine sandy loam. Fine angular blocky structure. pH 6.5 sharp to -
30-150	B	Red (10R 4/4) medium clay. Sub-plastic. Fine angular blocky. pH 6.5.

Dights Hill Soils Group

Location: Near Riverina Highway west of Albury
Landform: Floodplain - high terrace
Parent Material: Colluvium
Drainage: Moderate
Land use: Grazing
Principal Profile
Form: Gn 2.23

Morphology

Depth (cm)	Horizon	Description
0-25	A_1	Very dark greyish brown (10YR 3/2) silt loam with slight structure, soft, pH 7 clear to -
25-40	A_2	Brown (10YR 5/3) loam fine sandy apedal. Soft. pH 7 clear to -
40-200	B	Strong brown (7.5YR 5/6) fine sandy clay loam. Earthy fabric, porous. Some gravel to 5 mm diameter. pH 7 increasing to 8.5 at about 150 cm.

Thurgoona Soils Group

Location 1: 300 metres east of the main southern railway line.
Landform: Sideslope
Parent Material: Volcanics
Drainage: Good
Land use: Grazing
Principal Profile
Form: Gn 2.22

Morphology

Depth (cm)	Horizon	Description
0-10	A_1	Reddish brown (5YR 4/4) loam. Medium structure, relatively soft and friable. pH 6 gradual to -
10-90	B_1	Yellowish brown (10YR 5/8) silty clay moderate crumb structure. pH 5.5 gradual to -
90-150	B_2	Yellow red (5YR 4/8) medium clay strong blocky structure. pH 6.

Location 2: East of the northern end of St.Johns Road.
Landform: Sideslope
Parent Material: Volcanics
Drainage: Good
Land use: Grazing
Principal Profile Form: Dy 2.22

Morphology

Depth (cm)	Horizon	Description
0-15	A_1	Dark brown (7.5YR 4/4) loam. Moderate platy structure, friable. pH 6 clear to -
15-35	A_2	Reddish yellow (7.5YR 6/6) clayey silt. Apedal hard. pH 5.5 clear to -
35-110	B_1	Yellowish brown (10YR 5/8) light clay. Moderate crumb structure, pH 5.5 diffuse to -
110-150	B_2	Yellow red (5YR 5/6) with 20% olive (5Y 5/3) Medium clay, strong blocky structure. pH 7.

Ettamogah Soils Group

Location 1: 300 metres east of the junction of Hume Highway and Olympic Way.
Landform: Footslope
Parent Material: Colluvium
Drainage: Moderate to poor
Land use: Grazing
Principal Profile Form: Dy 3.22

Morphology

Depth (cm)	Horizon	Description
0-15	A_1	Brown (7.5YR 5/4) clay loam. Poor structure. Hard setting. pH 6 clear to -
15-30	A_2	Pinkish grey (7.5YR 6/2) silty clay Apedal hard consistence. pH 5.5 sharp to -
30-110	B_1	Pale yellow (2.5 Y 7/4) with 15% brownish yellow (10YR 6/6) medium clay moderate blocky structure. pH 7 diffuse to -
110-150	B_2	Yellow (10YR 7/8) heavy clay strong blocky structure. pH 7.5.

Location 2: Corry's Road near Radio Mast.
Landform: Sideslope
Parent Material: Colluvium
Drainage: Moderate to poor
Land use: Grazing
Principal Profile Form: Dy 3.12

Morphology

Depth (cm)	*Horizon*	*Description*
0-15	A_1	*Brown (7.5YR 5/4) loam, poor structure hard setting. pH 6, sharp to -*
15-80	B_1	*Brownish yellow (10YR 6/8) with 30% yellow red (5YR 5/8) medium clay. Moderate blocky structure. pH 6, clear to -*
80-150	B_2	*Brownish yellow (10YR 6/8) with 40% light grey (10YR 7/1) heavy clay strong blocky structure. pH 6.*

Location 3: *300 metres west of St.Johns School*
Landform: *Sideslope*
Parent Material: *Colluvium*
Drainage: *Poor to moderate*
Land use: *Grazing*
Principal Profile Form: *Dy 5.43*

Morphology

Depth (cm)	*Horizon*	*Description*
0-10	A_1	*Very dark greyish brown (10YR 3/2) silt loam, light structure, soft consistence, pH 6 clear to -*
10-30	A_2	*Very pale brown (10YR 7/4) silt. Apedal, pH 6.5 sharp to -*
30-150	*B*	*Brownish yellow (10YR 6/8) with 20% red (2.5YR 5/6) medium clay strong blocky structure.*

Splitters Creek Soils Group

Location: *On terrace west of Splitters Creek*
Landform: *Sideslope*
Parent Material: *Micaceous schists*
Drainage: *Poor*
Land use: *Grazing or native timber*
Principal Profile Form: *Dy 2.42*

Morphology

Depth (cm)	*Horizon*	*Description*
0-25	A_1	*Dark greyish brown (10YR 4/2) silt loam. Moderate structure, very hard consistence, pH 5.5 clear to -*
25-60	A_2	*Pale brown (10YR 6/3) sandy clay loam. Slight structure, very hard, pH 6, sharp to -*
60-200	*B*	*Yellowish brown (10YR 5/6) medium clay, strong sub angular blocky aggregates to 3 cm diameter, pH 7.*

Hamilton Valley Soils Group

Location 1: Hamilton Valley
Landform: Ridge
Parent Material: Unknown
Drainage: Good
Land use: Grazing
Principal Profile Form: Dr 2.32

Morphology

Depth (cm)	Horizon	Description
0-10	A_1	Dark brown (7.5YR 4/2) loam, moderate platy structure, pH 6.5 clear to -
10-30	A_2	Pink (7.5YR 7/4) sporadically bleached fine sandy loam, apedal pH 6 clear to -
30-120	B	Red (2.5YR 4/6) sandy clay, strong blocky structure, pH 6.5.

Location 2: Hamilton Valley
Landform: Sideslope
Parent Material: Unknown
Drainage: Moderate
Land use: Grazing, cultivation
Principal Profile Form: Dy 2.32

Morphology

Depth (cm)	Horizon	Description
0-15	A_1	Dark brown (7.5YR 4/2) loam, moderate structure, pH 6.5 clear to -
15-30	A_2	Pinkish grey (7.5YR 6/2) loam fine sandy, apedal, hard. pH6 clear to -
30-100	B	Yellowish brown (10YR 5/8) medium clay, strong blocky structure, pH 6.

Location 3: Hamilton Valley
Landform: Drainage Plain
Parent Material: Unknown
Drainage: Poor
Land use: Grazing
Principal Profile Form: Dy 3.41

Morphology

Depth (cm)	Horizon	Description
0-15	A_1	Greyish brown (10YR 5/2) loam or silt loam structureless, hard, pH 6.5 clear to -
15-35	A_2	Light grey (2.5Y 7/2) silty clay. Apedal very hard contains numerous ironstone concretions to 1.5 cm diameter in lower half. pH 6 sharp to -
35-150	B	Yellowish brown (10YR 5/8) with 40% reddish brown (2.5Y 6/4) medium clay, very strong blocky structure.

Wirlinga Soils Group

Location: Beside Hume Highway near Table Top
Landform: Sideslope
Parent Material: Unknown
Drainage: Poor
Land use: Grazing
Principal Profile Form: Dy 3.42

Morphology

Depth (cm)	Horizon	Description
0-10	A_1	Pale brown (10YR 6/3) silt loam. Massive, hard. pH 6.5 clear to -
10-55	A_2	White (10YR 8/2) silty clay. Apedal, hard, some ironstone nodules to 1 cm. pH 5.5 sharp to -
55-150	B	Olive (2.5Y 5/4) with 20% light grey (5Y 7/2) medium to heavy clay, very strong structure. pH 6.

Mungambareena Soils Group

Location 1: Thurgoona 400 m south of 2AY Radio Mast
Landform: Drainage plain
Parent Material: Colluvium
Drainage: Poor
Land use: Grazing
Principal Profile Form: Dy 3.43

Morphology

Depth (cm)	Horizon	Description
0-6	A_1	Light brown (7.5YR 6/4) loam, slight structure, hard. pH 5.5 clear to -
6-15	A_2	Pinkish white (7.5YR 8/2) silt loam, apedal, very hard when dry, pH 6 sharp to -
15-75	B_1	Light grey (10YR 7/2) medium clay, strong blocky structure, pH 6.
75-150	B_2	Light brownish grey (2.5Y 6/2) heavy clay, very strong structure, pH 7.5 increasing to 8.5 in base of profile. Some carbonate earth.

Location 2: 1 km east of road bridge over railway.
Landform: Footslope/drainage plain
Parent Material: Colluvium
Drainage: Poor
Land use: Grazing
Principal Profile Form: Ug 5.34

Morphology

Depth (cm)	*Horizon*	*Description*
0-20	A_1	*Strong brown (7.5YR 5/6) clay loam, very hard. pH 5.5 clear to -*
20-70		*Reddish yellow (7.5YR 6/8) 40% yellow red (5YR 5/8) medium clay, strong structure. pH 6 clear to -*
70-105		*Reddish yellow (7.5YR 7/6) with 30% pinkish grey (7.5YR 7/2) medium clay, blocky structure, pH 7.*
105-150	B_2	*Light yellowish brown (10YR 6/4) heavy clay very strong blocky structure. pH 8.5 some carbonate earth.*

Location 3: *200 metres from the Riverina Highway along St.Johns road.*
Landform: *Drainage plain/footslope*
Parent Material: *Colluvium*
Drainage: *Poor*
Land use: *Grazing*
Principal Profile Form: *Db 1.33*

Morphology

Depth (cm)	*Horizon*	*Description*
0-15	A_1	*Dark brown (7.5YR 4/2) silty clay, moderate structure. pH 5.5 clear to -*
15-20	A_2	*Silty, apedal, massive. pH 5.5 clear to -*
20-90	B_1	*Dark brown (10YR 4/3) heavy clay, very strong blocky structure. pH 8 gradual to -*
90-150	B_2	*Yellow red (5YR 4/6) heavy clay, strong blocky structure. pH 8.5.*