Soil Conservation Service of N.S.W.

URBAN CAPABILITY STUDY :

CARTWRIGHT'S HILL SUBDIVISION

WAGGA WAGGA

This report, and the original maps associated with it, have been scanned and stored on the custodian's intranet.

Original maps drafted at 1:5,000 were catalogued SCS 10582/A -C.
The full size maps have been scanned and named
"UC_Cartwrights_Wagga_theme". S.J. Lucas April 2014

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INTRODUCTION

Cartwright's Hill Subdivision is situated on the northern side of the Murrumbidgee River in the City of Wagga Wagga. It is a triangular area of 210 hectares bounded by the Murrumbidgee flood plain to the south and south-west, a proposed road realignment of the Olympic Way to the north and a granitic ridge above the Municipal Abattoirs to the east.

This study involved an inventory of the physical features of the landscape - soils, slope, terrain and drainage pattern. This information has been interpreted to provide a landscape evaluation map which incorporates an assessment of urban development capability in terms of erosion hazard and landscape stability.

Recommendations place particular emphasis on physical constraints to development which will maintain a stable landscape.

Soils, landform and landscape evaluation maps have been prepared at a scale of 1:4000. Copies presented on pages 32, 33 and 34 of this report are reduced for convenience. Copies at the larger scale are available, on request, from the Soil Conservation Service.

Details of the soil survey and the laboratory analysis of soil samples are presented in the Appendix.

This report is a guide to development based on soil conservation principles. To ensure effective implementation of the recommendations, consultation with local officers of the Soil Conservation Service during the planning and construction is essential.

PHYSICAL FEATURES

Environmental features that influence erosion hazard and urban development capability of this land include:

1. Climate
2. Terrain and Slope
3. Drainage
4. Geology and Soils

1. Climate

Mean annual rainfall is 567 mm which tends towards winter dominance, but significant rainfall is also received in autumn and spring. Summers are relatively dry and warm to hot, while winters are cool.

Existing vegetation adapted to these conditions is dominated by winter annual grasses and clovers. Couch grass is the main perennial species.

High intensity storms in summer are a feature of the rainfall pattern (Table I). These storms may cause severe erosion on the highly erodible soils of the subdivision (figures 1 and 2).

Rainfall intensities shown in Table I have been derived using data from the Wagga Wagga Soil Conservation Research Centre. A rainfall intensity frequency duration curve is attached as Appendix II.

Table I Rainfall Intensities (mm/hr) for Various Durations and Return Periods - C~~artwright~~'s ~~Hill~~ NORTH WAGGA.

Duration (minutes)	Return Period (years)					
	2	5	10	20	50	100
10	80	120	141	168	200	230
15	60	87	104	123	147	170
20	48	72	85	103	122	141

During urban development, high levels of siltation will follow extensive stripping of vegetation if bare soil is exposed for any length of time to rainfall and runoff.

2. Terrain and Slope

The subdivision is situated predominantly on the western slope of a deeply weathered granitic dome.

Seven slope classes have been mapped. They are:

a. 0 - 1% slope
b'. 1 - 3% slope
b. 1 - 5% slope
c. 5 -10% slope
c'. approaching 10% slope
d. 10-20% slope
e. 20-30% slope

Predominant slope of the area is between 1 and 5 percent.

Terrain is largely short convex slopes. Some concave elements occur below the granitic dome and on the slopes dropping down to the flood plain of the Murrumbidgee River.

Five terrain or slope facets have been mapped. They are numbers 1, 2, 3, 4 and 5 of the following classes:

1. crests and ridges
2. sideslope
3. footslope
4. floodplain
5. drainage plain
6. incised drainage channel
7. disturbed terrain
8. general description - hillcrest/sideslope/ footslope - individual facets not distinguished
9. ox-bow lake

3. Drainage

A major watercourse - Dukes Creek - flows along the north-western boundary of the subdivision. This Creek has a large catchment originating in the Brucedale district and at present in a stable condition.

Natural drainage within the subdivision is poorly defined and has been altered by road construction. For example, on the yellow solodic and sandy soils gully erosion has occurred along the table drains at the southern end of East Street.

Two small watercourses in the south-eastern section of the subdivision are defined on the map. Winter seepage flows are associated with these.

4. Geology and Soils

Geologically the area consists of a granitic ridge surrounded by colluvium. The south-western face of the area has been buried by extensive sand deposits.

The granite is from the Wantabadgery Series of the Lower Ordovician Period (N.S.W. Department of Mines, 1966). The sand has been blown from the floodplain of the Murrumbidgee River during a prior dry period (Beattie, 1972). Soils within the subdivision reflect these differences in parent material.

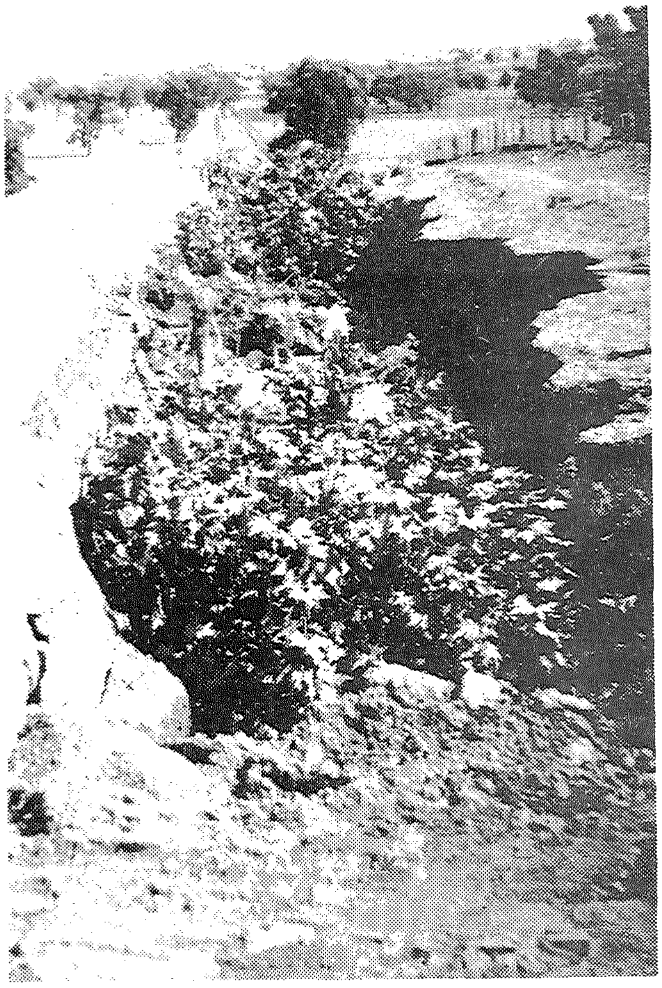

Figure 1 Severe gully erosion has undercut the road pavement on Cooramin Street - Cartwright's Hill, following a high intensity storm in March, 1966.

Figure 2 Sandy soils in the Cartwright's Hill subdivision are highly erodible. This erosion of a table drain in Cooramin Street resulted from a high intensity storm in March, 1966. Tree loppings have been placed in the gully to reduce silt movement. Note the person standing in the gully. Provision of adequate storm water drainage should receive high priority in the early stages of development.

Despite the relative stability of the area, the soils have a moderate to high erosion hazard rating. This erodibility is exhibited by the exposed sandy roadside batters and the active gullies in the drainage lines.

The soil survey was carried out using a 1:4000 orthophotomap supplied by the Wagga Wagga City Council as a mapping base. Soil unit boundaries were determined by detailed field reconnaissance, classification after Northcote (1974) and sampling to 180 cm for laboratory analysis.

Results of laboratory analyses are presented in Appendix I.

Four major soil units have been defined. These are:

Red Podzolic soil
Yellow Solodic soil
Red Earth
Sand

The soil is relatively uniform throughout these units, with characteristics which are strongly dependent on parent material. All boundaries are gradual, occurring over about 50 metres. The edge of the sand deposits has been defined as where the depth of sand becomes less than the depth of the A horizon in the adjoining unit.

Map Units

Red Podzolic Soil

This unit is confined to the ridge in the east of the subdivision. The soils range from shallow, sandy, red podzolics lying directly on rock, to deep red, light to medium clay soils on a heavier yellow-grey clay base.

A typical profile consists of a sandy loam A horizon and a medium clay B horizon of moderate plasticity. The two are separated by a non-bleached, erodible A_2 horizon. The B horizon may directly overlie granite or it may be underlain by a heavy clay similar to that in other units.

The soil is slightly acid throughout the profile.

Major constraints to development of this area will be the high soil erodibility, seepage in the midslope area where rock comes close to the surface, and the shallow depth to bedrock in some areas.

Yellow Solodic Soil

This unit predominates on the more level areas and in drainage lines.

Soils are deep, extending to below 200 cm in a hard, grey clay which is moderately plastic when wet. As it has a very low permeability, this base clay is rarely wet and is essentially non-plastic.

The soil overlying this grey clay is a yellow solodic. It consists of a loam A horizon overlying a dispersible, sandy clay loam A_2 horizon of low bearing strength which may or may not be bleached. This changes abruptly at about 50 cm to a sandy clay B horizon of moderate plasticity and moderate shrink-swell potential.

The erosion potential of this soil is high. This is evident along the southern end of East Street, where table drains have eroded, and in holding paddocks east of East Street, where the drainage lines contain shallow, active gullies.

Red Earths

This unit of plastic red soils is confined to a ridge of granitic colluvium in the north-west quarter of the area. The soil is deep, with a red clay grading into a yellow clay. At 150 to 200 cm depth this overlies the same grey clay as the yellow solodic soil. Shrink-swell is minor in this soil unit.

The red earths have a moderate infiltration rate. However, when topsoil is removed, the top of the clayey B horizon may form an impermeable, scald-like surface.

Red podzolic and red earth soils occurring in this area are similar, both having a loamy A horizon and a B horizon consisting of a red, earthy clay that grades into a yellow clay at 100 to 150 cm depth. They are differentiated by the presence of a non-bleached A_2 horizon in the red podzolic unit. This development of the A_2 indicates impeded drainage and the possible existence of seepage areas.

In terms of erosion, these soils have a low to moderate erodibility rating, giving them the lowest erosion potential in the area.

Sand

Two broad sheets of unconsolidated sand, over 200 cm deep, have been deposited over the grey clay on the south-western slopes of the subdivision.

Due to the low clay content (8%) and lack of consolidation, the sand has a moderate to high infiltration rate. However, as this is accompanied by a lack of cohesion, it is also highly erodible. The main consequence is that the sand reverts to its natural angle of repose on cut batters and in trenches. Retaining walls and rapid revegetation are therefore necessary to prevent massive sand movement.

The sand can be recognised by its sandy textured surface soil which has a much lower mica content and is more evenly graded than soils of granitic origin. Its profile development is minimal. There is a darkening of the top 50 cm by accumulated organic matter.

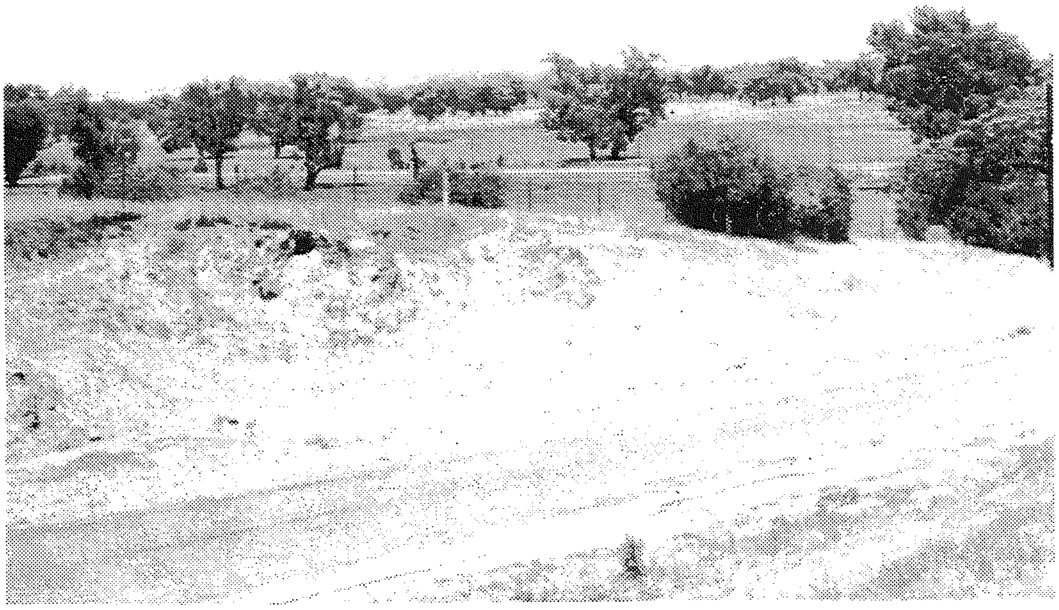

Figure 3 Road cutting through sandy soils adjacent to the Murrumbidgee flood plain. These steeper slopes and highly erodible soils are classed as C-1,3 lands suitable for low density residential development.

Figure 4 Erosion of a roadside table drain in East Street. The provision of storm water drainage at the early stages of development is essential if serious erosion problems are to be avoided.

URBAN CAPABILITY

A landscape evaluation map of the subdivision has been developed from an interpretation of the interaction of the physical features of the area. The area has been divided into a number of classes according to landscape stability and, within this context, the assessed potential for urban development.

Five major classes are defined on the landscape evaluation map:

Class A - Areas of low erosion/instability hazard
Class B - Areas of moderate erosion/instability hazard
Class C - Areas of high erosion/instability hazard
Class D - Areas of very high erosion/instability hazard
Class E - Areas of extreme erosion/instability hazard

Within these major categories a number of sub-classes are defined relating to the dominant physical features which restrict development potential. Numbers used to define these restricting features are:

1. Slope
2. Flooding/Drainage
3. Soil Type

The combination of two numerals indicates two physical features interact to restrict development potential. For example, the numerals "1,3" refer to slope and soil type as major constraints affecting development of a particular area.

The capability defined for each sub-class refers to the most intensive urban use which areas within that sub-class will tolerate 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 and the environment. Development planned to minimise erosion hazard is, however, generally consistent with an aesthetically pleasing landscape and savings in long term repair and maintenance costs.

Capabilities as defined relate 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 infers a level of construction which provides roads, drainage and services to cater for 600 square metre housing blocks. Low density residential development infers construction to cater for 4000 to 8000 square metre housing blocks. The development of reserves may require shaping and modification of the ground surface and vegetative improvement, but no building and minimal roadway construction is envisaged.

The definition of site capability for residential development or for extensive building complexes does not necessarily imply the capacity of that site to support multi-storey units or other major structures. Before such structural works are undertaken, a detailed analysis of the engineering characteristics of the soil, in particular bearing capacity and shear strength, is necessary.

In the following text, general recommendations are made regarding stabilisation and revegetation techniques. Specific advice relating to these techniques - such as seed and fertiliser mixtures and rates, cultivation measures, and batter slopes - should be sought from the local Soil Conservation Office prior to subdivision work commencing. This detail would be provided for inclusion in specifications if required.

Specifications for revegetation and general stabilisation measures should be included in the terms of development contracts.

1. General Recommendations

These general recommendations aimed at the control of erosion and siltation during development apply to the total site. They are an integral part of the capability plan and adherence to them is critical to its successful implementation.

(a) Development should be scheduled to minimise the area disturbed at any time and to limit the period of surface exposure.

(b) Disturbance of vegetation and topsoil should be kept to the minimum practicable. This is most critical on steep slopes.

(c) Where development necessitates removal of topsoil, this soil should be stockpiled for later re-spreading. The stockpile should not be deposited in drainage lines.

(d) Areas that remain bare for lengthy periods during subdivision development should be given temporary protection by sowing with a suitable fast growing plant species - cereal rye or barley in autumn-winter, Japenese millet in spring-summer - or by treatment with a surface mulch.

(e) Where appropriate, exposed areas such as construction sites should be protected by temporary banks and ditches upslope to contain and divert runoff. Simple drainage works will remove local water from construction sites.

(f) Where possible, development should be designed to minimise modification of the natural landscape. In this context, cut and fill and general grading operations should be restricted to the minimum essential for development.

(g) On steep slopes effective surface drainage will be greatly assisted by roadway alignment a little off the contour. The drawback of increased cut and fill which such an alignment requires is offset by the advantage of improved drainage.

(h) All permanent drainage works should be provided as early as possible during subdivision construction. <u>This provision should receive high priority.</u>

(i) Vehicular traffic should be controlled during subdivision development, confining access, where possible, to proposed or existing road alignments. Temporary culverts or causeways should be provided across major drainage lines.

(j) Temporary tracks used during development should be graded to a crown and provided with effective surface drainage, to prevent runoff eroding adjacent land.

(k) Permanent roads and parking bays should be paved as early as possible after formation.

(l) Borrow areas should not be located on steep slopes or on highly erodible soils. Topsoil from borrow areas should be stockpiled. Erosion control earthworks should be provided to protect these areas from upslope runoff.

(m) Areas of fill should be thoroughly compacted before any construction takes place.

(n) Cut and fill batters should be formed to a safe slope. On stable soils this will usually be no steeper than 1 in 2. On unstable soils it may be as low as 1 in 4.

Early stabilisation of exposed soil on cut and fill batters is essential:

(i) Suitable seed mixtures include cereal rye, Wimmera rye grass and Seaton Park subterranean clover. These should be sown at a heavy rate with a liberal dressing of fertiliser.

Specific recommendations on mixtures and application rates will be provided, on request, by the local Soil Conservation Office.

(ii) Vegetation establishment on batters is assisted by spreading topsoil over the surface.

(iii) Batters may be treated with a chemical or an organic mulch following sowing. This provides a measure of stability at an early stage.

(iv) Hydro-seeding is an alternative effective batter stabilisation technique. A mixture of seed, fertiliser, wood or paper pulp, and water is sprayed onto the batter through a specially designed applicator which may be hired from the Soil Conservation Service.

(v) Vegetation is best established in autumn. If seed is sown in spring, provision for watering may be required in summer.

(vi) Once vegetation is established on batters, regular topdressing with fertiliser is necessary.

(vii) Batters should be protected from upslope runoff by locating catch drains immediately above them. Batters more than six metres in height should have berm drains located at intervals down the batter face to prevent the accumulation of erosive concentrations of local runoff.

(o) Following roadway construction and installation of services, all disturbed ground which is not about to be paved or built upon should be revegetated:

(i) The surface should be scarified prior to return of topsoil.

(ii) Topsoil should not be respread while it is very wet or very dry.

(iii) Grasses and legumes should be sown into a prepared seed bed. The range of species which may be considered for general revegetation work includes phalaris, Perennial and Wimmera rye grasses, couch, creeping and browntop bent grasses, Kentucky blue grass, white clover, Seaton Park subterranean clover and, in moist situations, paspalum and kikuyu grasses. Clover seed should be inoculated with the appropriate rhizobium and lime pelleted before sowing.

Autumn sowings will generally be most successful for all species except kikuyu, which should be sown or planted in spring-summer. If spring sowing is necessary, irrigation may be required during summer to ensure establishment.

(iv) All revegetation sites should receive an adequate dressing of fertiliser at sowing to assist vigorous establishment and growth. Specific recommendations on seed and fertiliser mixtures and application rates will be provided, on request, by the local Soil Conservation Office.

(p) Correct maintenance of all areas which are to remain under a permanent vegetative cover will ensure a persistent and uniform sward. Regular topdressing with fertiliser is necessary in the early years of establishment, while mowing will control weeds and promote a vigorous turf.

Within the broad framework outlined above, development constraints specific to each of the individual sub-classes must also be applied. These are described below.

2. Sub-Class A-0: Low Hazard - No Major Constraints - Suitable for Extensive Building Complexes

The area delineated in this sub-class is a broad ridge crest and adjacent hillslope with gradients less than 3%. Soils are mainly red earths and yellow solodics of low to moderate erodibility.

This area can tolerate the maximum site disturbance of any land on the subdivision.

Common erosion problems which may arise from uncontrolled development on areas in this sub-class include sheet and rill erosion and resulting siltation.

(i) With careful management this area will tolerate the development of extensive shopping complexes and parking facilities, involving large scale ground disturbance and levelling, without serious erosion occurring. In the event of this form of development, particular attention should attach to provisions (h), (k), (m) and (o) in the general recommendations. Provision of adequate drainage onto the floodplain should precede any development.

(ii) If residential development takes place on this sub-class, the erosion hazard will not be significant provided the general recommendations are followed.

(iii) Few problems are associated with the use of this area as open space, although the development of such facilities as ovals will require care with cut and fill to ensure batters are stable and well vegetated.

3. Sub-Class B-3: Moderate Hazard - Soil Constraint - Suitable for Extensive Building Complexes

This sub-class comprises widely scattered hillslopes with gradients ranging from 2 to 5%.

Soils are mainly red podzolics and yellow solodics of moderate erodibility.

Uncontrolled development on areas of B-3 will lead to sheet and rill erosion, minor gullying and erosion of cut and fill batters.

(i) Commercial or industrial development can be located on these areas providing attention is paid to the following:

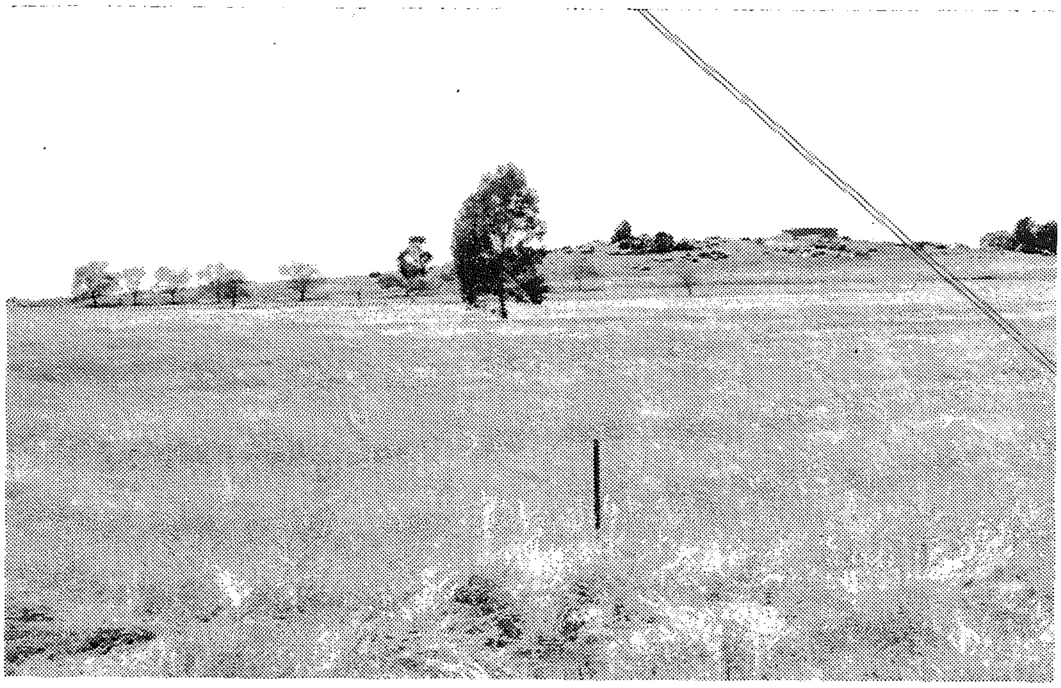

Figure 5 Land Class B-3 in the foreground suitable for Residential Development.
Land Class D-1,3 in the background containing steep hillslopes and extensive granite outcrops is not suited for development.

Figure 6 Land Class B-1,3 in the foreground is suited for residential development but not commercial or industrial development requiring large scale levelling, due to the erosion hazard.
The rocky hills in background are Land Class D-1,3.

- The provision of drainage works should precede large scale development.
- Where cut and fill batters are created, early stabilisation is required due to the erodibility of the soil. All fill should be well compacted. Embankments should be formed to a gradient no steeper than 1 in 3 on the yellow solodic soil and 1 in 2 on the red podzolic soil.
- Particular attention should be paid to provisions (b), (c), (d), (e), (h), (n) and (o) in the general recommendations.

(ii) These areas will tolerate residential development without generating severe erosion hazard.

In the event of such development, particular attention should be paid to provisions (b), (c), (d), (h), (n) and (o).

(iii) Few problems are associated with passive recreation on this sub-class, provided a healthy cover of vegetation is maintained. The development of such active recreation facilities as ovals, requiring large scale cut and fill, will be subject to similar restrictions to those set out in (i) above.

4. Sub-Class B-1,3: Moderate Hazard - Slope/Soil Constraint - Suitable for Residential Development

Slope gradients in this sub-class are largely between 5 and 10%, with pockets up to 20%. Soils are red podzolics and yellow solodics. The main difference between this sub-class and B-3 is the steeper slope. This, in association with soils of high erosion potential, poses a serious erosion hazard on exposed soils and a siltation hazard for drainage and roadworks below.

(i) Commercial or industrial development requiring large scale levelling is not recommended on areas in this sub-class.

(ii) These areas will tolerate residential development without generating a serious erosion hazard, provided particular attention is paid to the general recommendation items (a), (b), (c), (d), (e), (f), (g), (n) and (o).

(iii) Passive recreation on this sub-class presents no problems, provided attention is paid to development of a dense grass cover. Active recreation facilities are not recommended where they require substantial cut and fill to provide expanses of level ground.

5. Sub-Class C-1,3: High Hazard - Slope/Soil Constraint - Suitable for Low Density Residential Development

This sub-class contains the slopes leading down to the Murrumbidgee flood plain. Soils are mainly sand. Gradients range up to 20%.

Uncontrolled development on this sub-class will cause severe gully erosion. Any proposed surface disturbance should take account of the severe erosion hazard.

(i) The area is not suitable for industrial or commercial development because of the erosion hazard.

(ii) It is suitable for low density housing blocks of 4000 to 8000 square metres area. In the event of such development, houses should be located on the more gentle upper slopes. The attention of developers should be drawn to the poor coherence of this soil type.

Particular attention should be paid to the general recommendation items (a), (b), (c), (d), (e), (f), (g), (h), (i), (n) and (o).

If possible, roadways should be located above the steep slopes that run onto the flood plain.

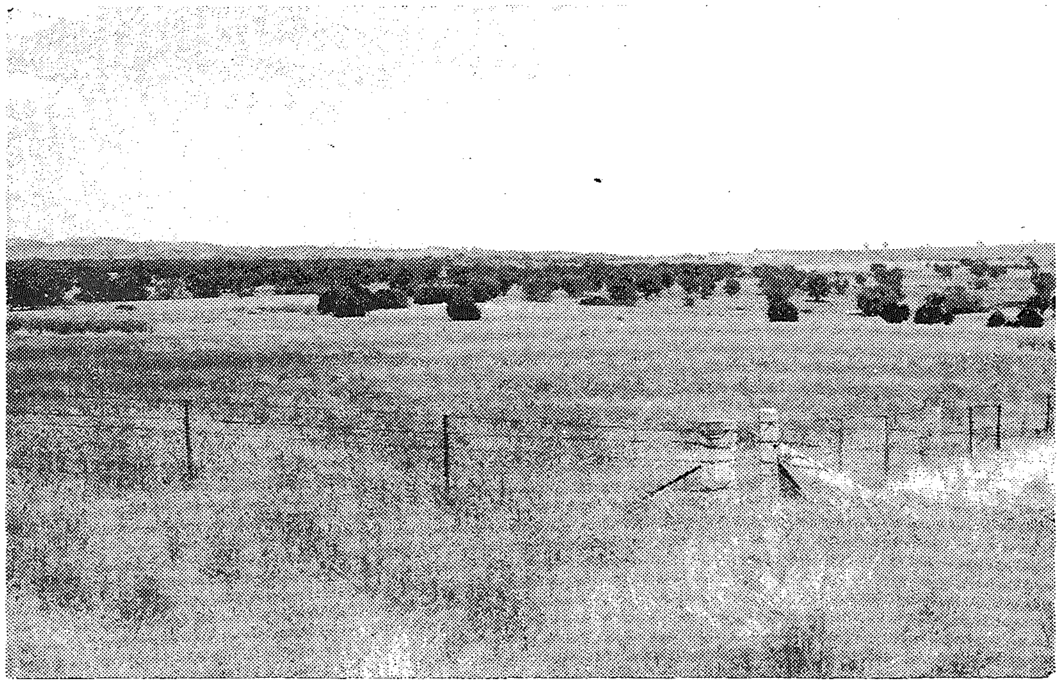

Figure 7 Land Class A-0 in foreground is most suited for intensive urban development.

Figure 8 Gully Erosion of a drainage line in the south-eastern quarter of the subdivision, Land Class D-1,2,3. These lands should be developed as Drainage reserves within residential areas.

(iii) Passive recreation on this sub-class presents no problems, although a good vegetative cover should be maintained.

Active recreation areas which require excavation works are not recommended.

6. Sub-Class D-1,3: Very High Hazard - Slope/Soil Constraint - Suitable for Reserve

This sub-class covers an area where granite out outcrops and boulders occur on a highly erodible red podzolic soil.

Because of slope gradient, erosion hazard, and the prolific boulder and rock outcrops, this sub-class is not recommended for commercial or residential development. As far as possible the area should remain undisturbed and be retained for passive recreation.

7. Sub-Class D-2: Very High Hazard - Drainage/Flooding Constraint - Suitable for Reserve

This sub-class contains the floodplain of the Murrumbidgee River, an area subject to regular waterlogging. Slope gradient is less than 1% and the soil is alluvium.

The area is not recommended for industrial, commercial or residential development and would be best retained for passive recreation.

8. Sub-Class D-1,2,3: Very High Hazard - Slope/ Drainage/Soil Constraint - Suitable for Reserve

This sub-class comprises two drainage lines and their associated floodplains in the south-eastern quarter of the subdivision.

Soils are a mixture of red podzolics, yellow solodics and sands. Slopes range up to 10 percent.

These areas are subject to soil saturation and should be developed as drainage reserves. If it is intended to divert road drainage from the subdivision into these reserves, they should be shaped to form a grassed waterway of adequate cross section to carry the maximum anticipated runoff from the subdivision.

A pipe should be installed beneath the waterway with sufficient capacity to carry the once in one year flow. This will carry winter seepage and minor storm flows. Without this provision, continuous small flows will erode the floor of the waterway, while rushes, sedge and other water loving species will proliferate along the trickle path. The general appeal of the reserve for passive recreation would suffer as a result.

9. <u>Sub-Class E-2,3:</u> <u>Extreme Hazard - Flooding/Soil Constraint - Nil Development Recommended</u>

This sub-class contains Dukes Creek and the associated floodplain. It is unsuited to any development. The area should be retained as a drainage reserve, preferably as a natural grassed waterway. Where it is proposed to construct roads or service facilities across this creek, specific recommendations should be sought from the Soil Conservation Office.

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TABLE II: SUMMARY OF SOIL PROPERTIES

Mapping Unit	a		b		c		d
Northcote Coding	Dr2.22 - 2/1/30		Dy3.42 - 3/1/60		Gn2.12 - 3/2/20		Uc1.22 - 1/1/60
Great Soil Group	Red podzolic soil		Yellow solodic soil		Red earth		
Underlying Material	Granite		Grey clay		Grey clay		Grey clay
Depth to Bedrock	100 cm - very variable		-		-		-
Profile Drainage	Moderate		Poor		Moderate		Good
Texture of B Horizon	Light clay		Medium clay		Medium clay		Sand
Sample Depth (cm)	30-55	55-100	20-60	60-100	20-45	45-180	30-180
Liquid Limit (%)	NL	34	12	30	18	42	NL
Plastic Limit (%)	NP	16	NP	14	12	16	NP
Plasticity Index (%)	NP	18	NP	16	6	26	NP
U.S.C. Code	ML	CL	ML	CL	ML-CL	CL	SM
Optimum Moisture Content (%)	19.2	17.3	19.2	17.3	16.8	17.3	14.5
Volume Expansion (%)	14	17	sh	20	8	25	sh
Dispersal Index	8.3	4.6	2.0	20.6	4.0	14.5	1.3
Erodibility	High	High	High	Moderate	Moderate	Moderate	High
pH	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$7\frac{1}{2}$	6	8	7
Suitability for Ponds	Poor		Good		Good		Poor
Topsoil Quality	Poor		Poor		Moderate		Poor
Ease of Revegetation	Moderate		Difficult		Moderate		Difficult
Special Features	Seepage patches		Few seepage patches		-		-

TABLE III LABORATORY ANALYSES OF SOIL SAMPLES

No.	Depth (cm)	Particle Size Analysis (g/100 g soil)						L.L.	P.I.	D.I.	Emerson Class	V.E. (%)	pH
		Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones						
6	30-180	8	4	32	56	0	0	NL	NP	1.3	3	sh	7
7	0-60	33	29	17	20	0	0	30	14	3.1	3	10	5½
	60-90	24	16	22	39	0	0	23	13	2.3	3	14	7
	90-150	18	6	28	49	0	0	18	3	2.5	3	11	7
8	25-55	8	10	39	44	0	0	NL	NP	1.6	3	sh	5½
	55-95	16	8	39	38	0	0	15	2	4.5	1	8	6
9	15-65	10	4	50	37	0	0	11	NP	2.5	2	8	7
	65-100	33	4	32	30	0	0	12	0	8.5	2	16	7
10	20-40	12	10	37	41	0	0	12	NP	2.0	3	sh	6
	40-100	37	8	29	26	0	0	30	16	20.0	>3	20	7½
11	15-40	13	27	16	38	1	4	NL	NP	2.3	3	5	6
	40-100	39	4	27	30	0	0	32	15	6.6	2	16	7
12	30-55	49	4	22	25	0	0	NL	NP	8.3	3	14	6½
	55-100	25	8	22	45	0	0	34	18	4.6	3	17	6½
13	20-60	14	10	36	41	0	0	IS	IS	2.3	3	5	6½
	60-100	39	6	26	29	0	0	IS	IS	10.0	3	14	7
14	0-100	45	8	30	17	0	0	32	19	7.6	>3	16	7
15	0-45	18	14	44	25	0	0	18	6	4.0	3	8	6
	45-180	57	6	24	13	0	0	42	26	14.5	>3	25	8

Definition of Terms used in Tables

Northcote Coding

From Northcote, K.A. - "A Factual Key for the Recognition of Australian Soils." Rellim Technical Publications, Edition 4 (1974).

Soil Conservation Service addendum to this coding (last three numbers) refers to surface texture, surface structure, and depth of the A horizon in centimetres. Texture classes range from 1 to 6 (from sand to heavy clay). Structure classes range from 0 to 3 (from structureless to strongly developed structure).

Great Soil Group

The equivalent Great Soil Group correlating with the Northcote code. From Stace et al (1968) - "A Handbook of Australian Soils". Rellim Technical Publications.

Underlying Material

Defined as the country rock where it is encountered above 180 centimetres depth, otherwise the defined soil type.

Depth of Bedrock

Depth in centimetres to bedrock where it is encountered above 180 centimetres depth. Also indicates minimum depth of soil profile.

Texture B Horizon

Field assessment of a moist bolus as described by Northcote (1974).

Liquid Limit (L.L.)

The moisture content at which the soil passes from the liquid to the plastic state. 'NL' indicates liquid limit could not be determined. 'IS' indicates insufficient sample to determine liquid limit.

Plastic Limit

Minimum moisture content at which the soil is plastic - i.e. can be rolled into a thread 3.5 millimetres thick and 25 millimetres long without crumbling.

Plasticity Index (P.I.)

Difference between the liquid and the plastic limits. Toughness and dry strength are proportional to the plasticity index. 'NP' indicates non-plastic soil.

U.S.C. Code

Unified Soil Classification System: Foundation and Construction Materials - "Design of Small Earth Dams". U.S.D.I. (1961). Engineering properties can be estimated from this coding.

'SM' refers to silty sands and poorly graded sand-silt mixtures.

'ML' refers to inorganic silts and very fine sand, and silty or clayed fine sands of low plasticity.

'CL' refers to inorganic clays of low to medium plasticity, gravelly clays, sandy clays and lean clays.

Optimum Moisture Content

The moisture content for Proctor maximum density. Derived from U.S.C. Code.

Dispersal Index (D.I.)

Method used by the Soil Conservation Service as described by Ritchie, J.A. (1963) - "Earthwork Tunnelling and the application of Soil Testing Procedure." Journal of the Soil Conservation Service of New South Wales, Volume 19.

1-2 Highly dispersible
2-3 Moderately dispersible
>3 Slightly dispersible

Erodibility

Assessed in the field. Possible classes - low, moderate, high.

pH

Measurement of soil reaction trend.

>7 alkaline
7 neutral
<7 acid

Suitability for Ponds

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

Possible classes - poor, moderate, good.

Topsoil Quality

Relates to fertility as assessed in the field. Possible classes - poor, moderate, good.

Ease of Revegetation

Based on fertility and texture. Possible classes - difficult (special site treatment required), moderate (special fertiliser treatment required), good (achieve revegetation with normal sowing techniques).

Emerson Class

Classes derived from Emerson Crumb Test on undisturbed soil crumb, as described by Emerson, W.W. (1967) - "A Classification of Soil Aggregates Based on their Coherence in Water". Australian Journal of Soil Research, Volume 5.

1 Highly dispersible
2 Moderately dispersible
3 Slightly dispersible
>3 Not dispersible

Volume Expansion (V.E.)

Free swell determination using Keen Rackzowski test.

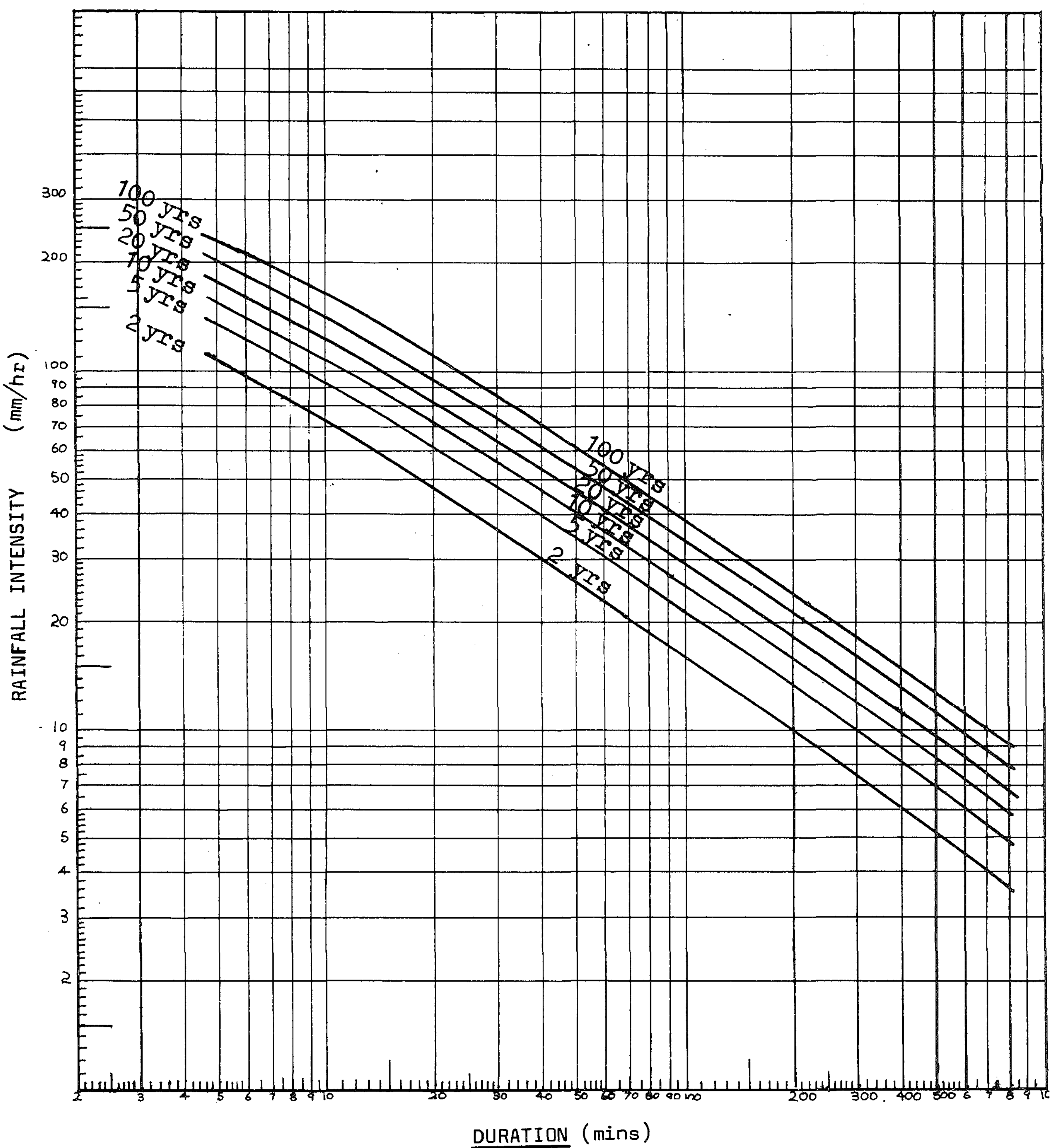
<5%	Very low
5-10%	Low
10-20%	Moderate
20-40%	High
>40%	Very high

Special Features

Additional features considered to be of importance.

APPENDIX II

Rainfall Intensity Frequency Duration Curve
Wagga Research Centre



CARTWRIGHT'S HILL SUBDIVISION

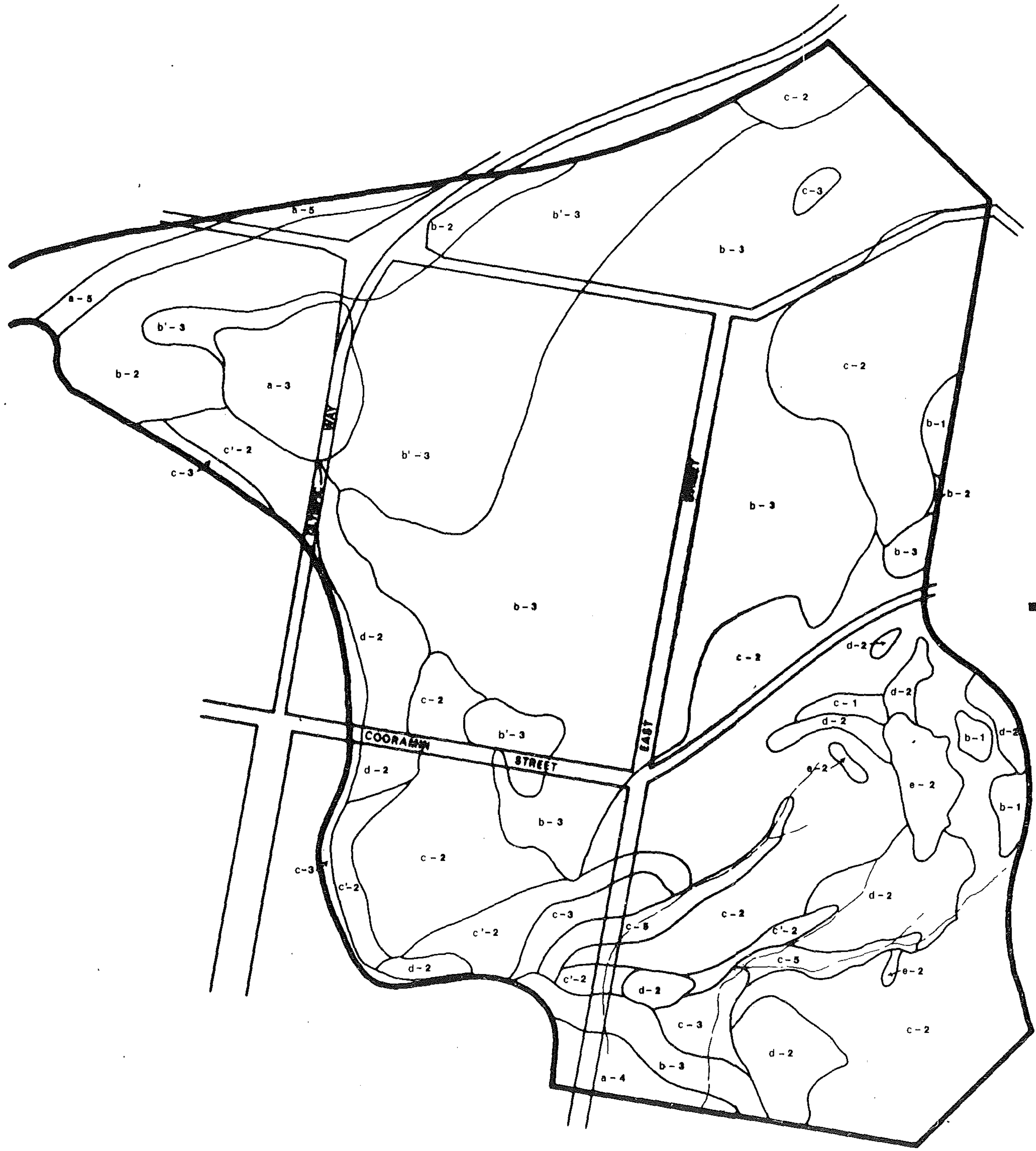
CITY OF WAGGA WAGGA

SOILS

100 50 0 100 200 300 400 500 metres

Soil Conservation Service
of
New South Wales

KEY	NORTHCOTE CODING	GREAT SOIL GROUP	U.S.C.S.
a	Dr 2 22-2111 30	Red podsolic	CL
b	Dy 3·42-31 1160	Yellow solodic	CL
c	Gn2 12 312120	Red earth	CL
d	Uc 22 11 1160	Sand	SM
e		Colluvium from Brucedale	



CARTWRIGHT'S HILL SUBDIVISION

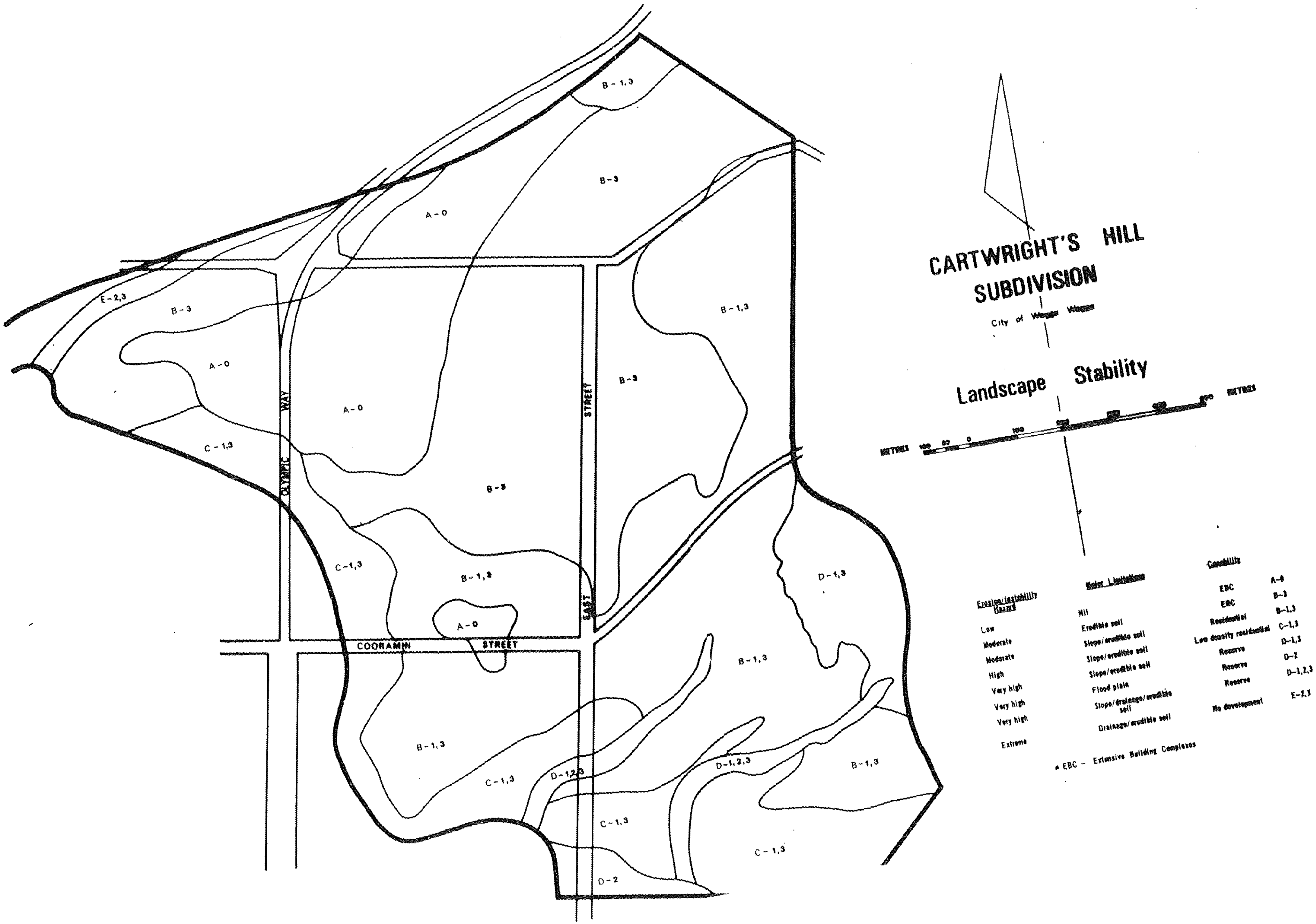
'City of Wagga Wagga

LANDFORM

SLOPE (%)	
0 – 1	a
1 – 3	b'
1 – 5	b
5 – 10	c
approaching 10	c'
10 – 20	d
20 – 30	e

TERRAIN	
hillcrest/ridge	1
sideslope	2
footslope	3
floodplain	4
drainage plain	5
incised drainage channel	6
disturbed terrain	7
general description – hillcrest/sideslope/footslope	8
ox-bow lake	9

Drainage line


CARTWRIGHT'S HILL
SUBDIVISION
City of Wagga Wagga
Landscape Stability
METRES
OLYMPIC WAY
EAST STREET
COORAMIN STREET
B - 1,3
B - 3
A - 0
E - 2,3
B - 3
A - 0
A - 0
C - 1,3
B - 3
B - 1,3
B - 3
C - 1,3
B - 1,3
A - 0
D - 1,3
B - 1,3
B - 1,3
C - 1,3
D - 1,2,3
D - 1,2,3
B - 1,3
C - 1,3
C - 1,3
D - 2
Erosion/instability Hazard
Major Limitations
Capability
Low — Nil — EBC — A-0
Moderate — Erodible soil — EBC — B-3
Moderate — Slope/erodible soil — Residential — B-1,3
High — Slope/erodible soil — Low density residential — C-1,3
Very high — Slope/erodible soil — Reserve — D-1,3
Very high — Flood plain — Reserve — D-2
Very high — Slope/drainage/erodible soil — Reserve — D-1,2,3
Extreme — Drainage/erodible soil — No development — E-2,3
* EBC – Extensive Building Complexes