APPENDIX 1. LAND CHARACTERISTICS

Land characteristics are soil and landform features that can be explicitly observed (a qualitative estimate) or measured (quantitative) during a land resource survey. Some land qualities are based on a single land characteristic, such as pH. Usually several soil or landform characteristics are combined to estimate a land quality. For example, wind erosion combines surface condition of the soil with an exposure factor based on the landform, such as a dune, or a flat.

The land characteristics below are used to derive many of the land qualities in Section 2. In addition, each land characteristic may be used by itself to create interpretive maps (e.g. a map of surface soil texture) or can be used directly in the land capability ratings tables to create land capability maps for specific crops.

Appendix A1 identifies 16 land qualities (see Table A1).

Table A1. Land characteristics used to determine land qualities

Section	Description	Acceptable codes (ratings)*
A1.1	Coarse fragments in profile	**VF** (very few), **F** (few), **C** (common), **M** (many), **A** (abundant)
A1.2	Depth of profile	**VS** (<15), **S** (<30), **MS** (30-50), **M** (50-80), **D** (>80), **VD** (>150) cm
A1.3	Permeability	**VS** (very slow), **S** (slow), **MS** (moderately slow), **M** (moderate), **MR** (moderately rapid), **R** (rapid), V**R** (very rapid)
A1.4	Rock outcrop	**N** (none), **S** (slight), **R** (rocky), V**R** (very rocky), **RL** (rockland))
A1.5	Slope	**F** (flat)**, VG** (very gentle), **G1** (gentle 1), **G2** (gentle 2), **M1** (moderate 1), **M2** (moderate 2), **S** (steep)
A1.6	Stones and boulders in profile	**VF** (very few), **F** (few), **C** (common), **M** (many), **A** (abundant)
A1.7	Surface condition	**C** (surface crust), **F** (firm), **HS** (hardsetting), **K** (cracking), **L** (loose), **SM** (self-mulching), **S** (soft), **X** (surface flake), **Z** (saline)
A1.8	Soil texture	**KS** (coarse sand), **SS** (light sand), **S** (sand), **FS** (fine sand), **LS** (loamy sand), **CS** (clayey sand), **SL** (sandy loam), **SCL** (sandy clay loam), **L** (loam), **CL** (clay loam), **C** (clay), **HC** (heavy clay)
A1.9	Soil arrangement	Loose **(G),** Earthy **(E),** Poor structure **(P),** Moderate structure **(M),** Strong structure **(S),** Shrink-swell **(SW),** Fractured pan **(PF),** Hard pan **(PH),** Weathered pan **(PW),** Fractured rock **(RF),** Hard rock **(RH),** Weathered rock **(RW)**
A1.10	Watertable depth	**0** (shallow)**, 50** (moderate)**, 100** (deep)**, 150** (very deep)**, 200** (extremely deep)**, 500** (none)
A1.11	Organic carbon	**VL** (very low), **L** (low), **M** (moderate), **H** (high)
A1.12	Phosphorus adsorption	**VL** (very low), **L** (low), **M** (moderate), **MH** (moderately high), **H** (high)
A1.13	Soil dispersion	**N** (Nil)**, P (**Partial)**, C** (Complete)
A1.14	Soil slaking	**N** (Nil)**, P (**Partial)**, C** (Complete)
A1.15	Available water capacity, lower storage limit and upper storage limit	Values in mm/m
A1.16	Bulk density	Dry weight in grams of 1cc

** **XX** or -**999** are the default **NOT APPLICABLE** values.

A1.1 Coarse fragments in profile

Coarse fragment includes all gravel, cobbles, stones and boulders over 2 mm in diameter present in the profile. The amount of fine earth (soil size particles) in the profile decreases in proportion to the amount of coarse fragments. It is from the fine earth that plants obtain most of their water and nutrients. The assessment of coarse fragments used here is on a percentage volume basis. It needs to be remembered that the weight percentage of coarse fragments may be significantly higher than the volume percentage. Table A1.1 presents the ratings for the land characteristic 'coarse fragments in the profile' which is used when determining the following land qualities:

- rooting depth; and
- soil water storage.

Table A1.1. Assessment of coarse fragments in profile (adapted from McDonald *et al*. 1990)

Stones and gravel (> 2 mm) in profile(by volume)	Coarse fragments in profile rating
0%	**Nil (N)**
<2%	**Very few (VF)**
2-10%	**Few (F)**
10-20%	**Common (C)**
20-50%	**Many (M)**
50-90%	**Abundant (A)**

A1.2 Depth of profile

Depth of profile is the depth to bedrock or an impenetrable hardpan. It differs from the rooting depth that can be affected by physical characteristics such as soil chemistry, or impermanent factors, such as the depth to a watertable. Table A1.2 presents the ratings for the land characteristic 'depth of profile' which is used when determining the following land qualities:

- Rooting depth
- Soil workability
- Microbial purification
- Ease of excavation
- Soil absorption ability.

Table A1.2. Assessment of depth of profile

Depth to bedrock or impenetrable pan	Depth of profile rating
<15 cm	**Very shallow (VS)**
15-30 cm	**Shallow (S)**
30-50 cm	**Moderately shallow (MS)**
50-80 cm	**Moderate (M)**
80-150 cm	**Deep (D)**
>150 cm	**Very deep (VD)**

A1.3 Permeability

Permeability is the capacity of a material to transmit a fluid such as water. A material that is highly permeable will have few restrictions to the passage of water. A material with low permeability (often referred to as poor permeability) will provide major restrictions to the movement of water. Permeability is an important characteristic as the movement of water through the soil has widespread impacts on erosion hazards, soil water storage and the movement of nutrients, salt and pollutants. Table A1.3a presents the ratings for the land characteristic 'permeability' which is used when determining the following land qualities:

- site drainage potential;
- microbial purification; and
- ease of excavation.

The assessment of permeability should be based on the hydraulic conductivity of the least permeable layer within the top 150 cm, regardless of whether or not it is a pedogenic soil horizon (including underlying substrate or bedrock occurring within the top 150 cm).

Table A1.3a. Assessment of permeability classes (from O'Neil 1952)

Hydraulic conductivity[1] (mm/h)	Examples (These are a general guide only)	Profile permeability rating
<1	Duplex, gradational or clay soils with impermeable mottled and/or gleyed poorly structured clay soils and/or an impermeable pan or bedrock.	**Very slow (VS)**
1-5	Duplex, gradational or clay soils with slowly permeable, poorly structured clays and/or a slightly permeable pan or bedrock.	**Slow (S)**
5-20	Duplex, gradational or moderately structured loams or clays, or soils where permeability is slightly increased by gravel or sand.	**Moderately slow (MS)**
20-65	Duplex, gradational or well structured loams or clays, or soils where permeability is increased by a large amount of gravel or sand.	**Moderate (M)**
65-130	Similar to above, but includes well structured loams, deep sandy gradational soils or deep sands over an impermeable layer at several metres.	**Moderately rapid (MR)**
130-250	Deep sands (e.g. sandplain, with fine or medium sand and some clay at depth).	**Rapid (R)**
>250	Deep coarse sands (e.g. sand dunes with minimal profile development).	**Very rapid (VR)**

[1] Use the most restrictive layer in the soil profile.

Table A1.3b. Estimated saturated hydraulic conductivity (mm/hr) for varying soil textures and arrangements

Soil texture	Ksat (mm/hr) for different soil arrangements						
	Loose (G)	Earthy or porous (E)	Poorly structured (P)	Moderately structured (M)	Strongly structured (S)	(Shrink-swell (SW)	Pan or rock
Coarse sand (KS)	400	300	-	-	-	-	-
Light sand (SS)	240	160	-	-	-	-	-
Sand (S)	230	150	-	-	-	-	-
Fine sand (FS)	220	140	-	-	-	-	-
Loamy sand (LS)	220	140	-	-	-	-	-
Clayey sand (CS)	210	135	-	-	-	-	-
Sandy loam (SL)	120	110	70	90	110	-	-
Loam (L)	110	100	70	90	100	-	-
Sandy clay loam (SCL)	-	60	40	50	70	-	-
Clay loam (CL)	-	50	30	40	60	-	-
Clay(C)	-	15	3	15	25	2	-
Heavy clay (HC)	-	6	0.5	3	6	2	-
Fractured rock or pan (PF, RF)	-	-	-	-	-	-	15
Weathered pan (PW)	-	-	-	-	-	-	10
Weathered rock (PW)							300
Solid rock or pan (PH, RH)							0.2

A1.4 Rock outcrop

The characteristic rock outcrop describes the proportion of the land surface within a land unit that is occupied by bare rock. The assessment of rock outcrop only applies where the rock is interspersed within a land unit, otherwise the land unit bare rock applies. Rock outcrop is considered to be a limitation where the spacing between the outcrops is less than 3 metres. Where outcrops are more than 3 m apart, the soil area is large enough to access with machinery. For example, a map unit with 15 per cent bare rock (as the landform) and 85 per cent yellow deep sand, may have 85 per cent high capability for horticulture. However this rating may be misleading if the rock outcrop is dispersed throughout the dominant land units within the map unit. Yellow deep sand with common rock outcrop as a soil group qualifier would have a lower overall rating. Tables A1.4a and A1.4b present the ratings for the land characteristic 'rock outcrop' which is used when determining the following land qualities:

- Soil workability
- Ease of excavation; and
- Soil absorption ability.

Table A1.4a Assessment of rock outcrop, where it is generally distributed throughout a land unit with spacing < 3 metres (adapted from McDonald *et al*. 1990)

% of rock outcrop	Rock outcrop rating
<2%	**None (N)**
2-10%	**Slight (S)**
10-20%	**Rocky (R)**
20-50%	**Very rocky (VR)**
>50%	**Rockland (RL)**

Table A1.4b. Values based on zone land unit properties (where better information from the map unit description is not available)

Zone land unit attribute	Rating
Bare rock (201), or where the landform is Rockland	Rockland
Where the landform is Breakaway/Cliff or Disturbed land	Very Rocky
Stony soils (202 or 203) or any soil with hard (RH) fractured (RF) or weathered rock (RW) in layer 1 or layer 2	Rocky
Any soil with hard (RH) fractured (RF) or weathered rock (RW) in layer 4	Slight
All other option	None

A1.5 Slope

The slope gradients of an area of land has a major impact on the movement of water in the landscape which will affect site drainage and erosion hazards. Steeper slope are unsuitable for operating machinery. Table A1.5 presents the ratings for the land characteristic 'slope' which is used when determining the following land qualities:

- Water erosion hazard
- Site drainage potential
- Ease of excavation
- Trafficability.

Table A1.5. Assessment of slope (adapted from McDonald *et al*. 1990)

Slope gradient	Slope rating
<2%	**Flat (F)**
1-3%	**Very gentle slope(VG)**
3-5%	**Gentle 1 (G1)**
5-10%	**Gentle 2 (G2)**
10-15%	**Moderate 1(M1)**
15-30%	**Moderate 2 M2)**
>30%	**Steep slope (S)**
Mixed gentle and steep???	**Mixed (MX)**

A1.6 Stones and boulders in profile

Stones and boulders include all coarse fragments over 20 cm (200 mm) in diameter. The assessment of coarse fragments used here is on a percentage volume basis. It needs to be remembered that the weight percentage of coarse fragments may be significantly higher than the volume percentage. Table A1.6 presents the ratings for the land characteristic 'stones and boulders in profile' which is used when determining the following land qualities:

- Soil workability.
- Ease of excavation; and
- Soil absorption ability.

Table A1.6. Assessment of stones and boulders in profile (adapted from McDonald *et al*. 1990)

% of stones and boulders (> 200 mm) in profile	Profile stone rating
0%	**Nil (N)**
< 2%	**Very few (VF)**
2-10%	**Few (F)**
10-20%	**Common (C)**
20-50%	**Many (M)**
50-90%	**Abundant (A)**

A1.7 Surface condition

Surface condition describes the physical state of the soil surface. The surface condition often changes as the soil moisture status alters. For example, a soil that is soft when moist, can become hardsetting when dry. Surface condition should be based on assessments of the soil in the dry state. Table A1.7 presents the ratings for the land characteristic 'surface condition' which is used when determining the following land qualities:

- Surface soil structure decline susceptibility;
- Wind erosion hazard; and
- Soil workability.

Table A1.7. Assessment of surface condition (from McDonald *et al*. 1990)

Nature of soil surface when dry	Surface condition rating
Incoherent mass of individual particles or aggregates. Surface easily disturbed by pressure of forefinger.	**Loose (L)**
Coherent mass of individual particles or aggregates. Surface easily disturbed by pressure of forefinger.	**Soft (S)**
Strongly pedal loose surface mulch forms on wetting and drying. Peds commonly less than 5 mm in least dimension.	**Self-mulching (SM)**
Coherent mass of individual particles or aggregates. Surface disturbed or indented by moderate pressure of forefinger.	**Firm (F)**
Compact, hard, apparently apedal condition forms on drying but softens on wetting. When dry, the material is hard below any surface crust or flake that may occur, and is not disturbed by pressure of forefinger.	**Hardsetting (HS)**
Distinct surface layer, often laminated, up to tens of mm thick which is hard and brittle when dry and is not easily separated from underlying soil.	**Surface crust(C)**
Cracks at least 5 mm wide extending from the surface to the base of any plough layer or thin surface horizon.	**Cracking (K)**
Surface has visible salt, or salinity is evident from the absence or nature of the vegetation or from soil consistence. These conditions are characterised by their notable difference from adjacent non-saline areas.	**Saline (Z)**

A1.8 Soil texture

The texture of the layers within a profile is a very important characteristic affecting many soil properties. Surface texture refers to the proportion of sand, silt and clay in the top 10 cm of the soil profile. Soil texture is used when determining the following land qualities:

- Surface texture
- Water repellence susceptibility
- Surface soil structure decline susceptibility
- Susceptibility to subsoil compaction
- Wind erosion hazard
- Water erosion hazard
- Soil water storage
- Soil workability
- Trafficability.

Table A1.8. Assessment of soil texture (adapted from McDonald *et al.* 1990)

Texture of surface horizon	Clay content	Surface texture rating
Coarse sand	< 5%	**Coarse sand (KS)**
Medium sands (-)	< 2%	**Sand (light) (SS)**
Medium sands	2-5%	**Sand (S)**
Very fine sand, Fine sand	< 5%	**Fine sand (FS)**
Very fine to medium loamy sands	5%	**Loamy sand (LS)**
Very fine to medium clayey sands	5-10%	**Clayey sand (CS)**
Sandy loam Light sandy clay loam	10-20%	**Sandy loam (SL)**
Loam, Silty loam, and	20-25%	**Loam (L)**
Sandy clay loam	20-30%	**Sandy clay loam (SCL)**
Sandy clay loam, Clay loam, and Silty clay loam	30-35%	**Clay loam (CL)**
Sandy clay, Light clay, Medium clay, and Silty clay	35-50%	**Clay (C)**
Heavy clay	> 50%	**Heavy Clay (HC)**
Rock or hardpan	Not applicable	**(XX)**

A1.9 Soil arrangement

Soil arrangement is an assessment of the manner in which the soil particles are arranged in the profile as this relates to water movement through the soil and root penetration. Table A1.9 presents the ratings for the land characteristic 'Soil arrangement'. It is generally considered along with soil texture to help determine the following land characteristics and land qualities:

- Ease of excavation
- Soil water storage, available water capacity, wilting point and field capacity
- Soil workability
- Subsurface compaction susceptibility
- Surface soil structure decline susceptibility
- Water erosion risk
- Bulk density
- Hydraulic conductivity and permeability.

Table A1.9. Assessment of soil arrangement

Nature of soil layer	Soil arrangement rating
Soil materials with which are apedal, **single grained**. These material are loose, typically with a sandy fabric	**Loose (G)**
Soil materials with which are apedal, massive with an earthy fabric or porous nature	**Earthy (E)**
Soil materials with **poor structure**. Includes materials that are apedal, massive and dense (not porous) as well as some soils with strong structure consisting of large dense columnar or blocky peds. Many, but not all, of the materials falling into this category will be sodic clays.	**Poor structure (P)**
Soil materials with a weak to moderate structure. Includes materials that are considered apedal and massive but are still slightly porous.	**Weak to Moderate structure (M)**
Soil materials that are strong (well) structured. Excludes large blocky or columnar peds	**Strong structure (S)**
Clays with shrink-swell properties	**Shrink-swell (SW)**
Fractured (solid but not continuous) pan	**Fractured pan (PF)**
Hard (solid-continuous) pan	**Hardpan (PH)**
Weathered pan	**Weathered pan (PW)**
Fractured or porous rock (e.g. limestone or fractured sandstone)	**Fractured rock (RF)**
Hard (solid) rock	**Hard rock (RH)**
Weathered rock	**Weathered rock (RW)**

A1.10 Watertable depth (to highest seasonal watertable)

The depth to the highest seasonal watertable describes the height to which the watertable rises and remains for a period of at least one week in the average season. Table A1.10 presents the ratings for the land characteristic 'depth to highest seasonal watertable' which is used when determining the following land qualities:

- Phosphorus export hazard
- Waterlogging/inundation risk
- Microbial purification.

Table A1.10. Assessment of depth to highest seasonal watertable

Depth to highest seasonal watertable, where water remains within the depth range for 1 week after rainfall	Watertable depth rating
0-30 cm	**Shallow (0)**
30-50 cm	**Moderately shallow (30)**
50-100 cm	**Moderate (50)**
100-150 cm	**Deep (100)**
150-200 cm	**Very deep (150)**
200-500 cm	**Extremely deep (200)**

A1.11 Organic carbon

Organic carbon content is assessed using the method described by Walkley-Black. The results obtained are typically 20-25 per cent lower than the wet combustion methods (Rayment and Higginson 1992). Table A1.11 presents the ratings for the land characteristic 'Organic carbon' which is used when determining the following land qualities:

- Subsurface acidification susceptibility
- Subsurface compaction susceptibility
- Surface soil structure decline susceptibility
- Water erosion susceptibility of soil, Water erosion risk
- Water repellence.

Table A1.11. Assessment of organic carbon (topsoil only)

Organic carbon % (Walkley-Black)	Organic carbon rating
<0.4%	**Very low (VL)**
0.4-1.2%	**Low (L)**
1.2-2.0%	**Moderate (M)**
>2.0%	**High (H)**

A1.12 Phosphorus retention index

Phosphorus retention index (PRI) is a measure that correlates reasonably well with phosphorus buffering capacity (PBC) of the soil (Allan and Jeffery 1990). PRI is used because it is more straightforward to measure than PBC. Table A1.12 presents the ratings for the land characteristic 'Phosphorus retention index' which is used when determining the phosphorus export hazard.

Table A1.12a. Assessment of Phosphorus adsorption

Phosphorus retention index value	Phosphorus adsorption rating
<2	**Very low (VL)**
2-5	**Low (L)**
5-20	**Moderate (M)**
20-100	**Moderately high (MH)**
>100	**High (H)**

A1.13 Soil dispersion

Soil dispersion refers to the scattering of primary soil particles in water. Table A1.13 presents the ratings for the land characteristic 'Soil dispersion' which is used when determining the following land qualities:

- Surface soil structure decline susceptibility
- Water erosion susceptibility of soil, Water erosion risk.

Table A1.13. Assessment of soil dispersion

Soil aggregate dispersion	Soil dispersion rating
Soil aggregate does not disperse	**Nil (N)**
Soil aggregate disperses partially	**Partial (P)**
Soil aggregate disperses completely	**Complete (C)**

A1.14 Soil slaking

Soil slaking refers to the collapsing or disintegration of dry soil aggregates or peds into micro-aggregates and primary particles when they are immersed in water. Note that some soils slake, but do not disperse (see Section A1.13). Table A1.14 presents the ratings for the land characteristic 'Soil slaking' which is used when determining the following land qualities:

- Surface soil structure decline susceptibility; and
- Water erosion susceptibility of soil, Water erosion risk.

Table A1.14. Assessment of Soil slaking

Soil aggregate slaking	Soil slaking rating
Soil aggregate does not slake	**Nil (N)**
Soil aggregate slakes partially	**Partial (P)**
Soil aggregate slakes completely	**Complete (C)**

A1.15 Available water capacity, lower and upper storage limits

Available water capacity (AWC) is the difference between the upper storage limit (USL) and lower storage limit (LSL) per unit depth (v/v) or mass (w/w). The upper storage limit is the water content following saturation, when free drainage has stopped (previously known as field capacity). The lower storage limit is the lowest water content to which plants can extract water (previously known as permanent wilting point). AWC is used in assessment of the land quality:

- Soil water storage.

Table A1.15a. Estimated available water capacity (mm/m) for varying soil textures and arrangements (e.g. see Table 2.12b)

Soil texture	Available water capacity (mm/m) for different soil arrangements						
	Loose (G)	Earthy or porous (E)	Poorly structured (P)	Moderately structured (M)	Strongly structured (S)	(Shrink-swell (SW)	Pans and rock
Coarse sand (KS)	20	25	22	-	-	-	-
Light sand (SS)	30	45	40	-	-	-	-
Sand (S)	40	50	45	-	-	-	-
Fine sand (FS)	50	70	60	-	-	-	-
Loamy sand (LS)	60	90	75	-	-	-	-
Clayey sand (CS)	80	100	90	-	-	-	-
Sandy loam (SL)	90	110	80	120	150	-	-
Loam (L)	100	130	130	170	220	-	-
Sandy clay loam (SCL)	-	130	100	140	180	-	-
Clay loam (CL)	-	120	100	140	190	-	-
Clay (C)	-	110	90	130	200	130	-
Heavy clay (HC)	-	130	90	110	120	110	-
Fractured rock or pan (PF, RF)	-	-	-	-	-	-	10*
Weathered pan (PW)	-	-	-	-	-	-	10*
Weathered rock (PW)							10*
Solid rock or pan (PH, RH)							0

* Estimates for use in theoretical calculations as there is limited information for root water use in rock. If possible derived values should be checked against real data.

Table A1.15b. Estimated lower storage limit (mm/m) for varying soil textures and arrangements

Soil texture	Wilting point (mm/m) for different soil arrangements						
	Loose (G)	Earthy or porous (E)	Poorly structured (P)	Moderately structured (M)	Strongly structured (S)	(Shrink-swell (SW)	Pan or rock
Coarse sand (KS)	30	25	27	-	-	-	-
Light sand (SS)	40	45	43	-	-	-	-
Sand (S)	60	70	65	-	-	-	-
Fine sand (FS)	80	90	85	-	-	-	-
Loamy sand (LS)	85	95	90	-	-	-	-
Clayey sand (CS)	100	110	105	-	-	-	-
Sandy loam (SL)	110	115	150	125	115	-	-
Loam (L)	140	110	200	140	110	-	-
Sandy clay loam (SCL)	-	140	220	180	140	-	-
Clay loam (CL)	-	140	220	180	140	-	-
Clay (C)	-	150	260	200	140	200	-
Heavy clay (HC)	-	160	300	220	160	220	-
Fractured rock or pan (PF, RF)	-	-	-	-	-	-	150*
Weathered pan (PW)	-	-	-	-	-	-	150*
Weathered rock (PW)							150*
Solid rock or pan (PH, RH)							0

* Estimates for use in theoretical calculations as there is limited information for root water use in weathered or fractured rock. If possible derived values should be checked against real data.

Table A1.15c. Estimated upper storage limit (mm/m) for varying soil textures and arrangements

Soil texture	Wilting point (mm/m) for different soil arrangements						
	Loose (G)	Earthy or porous (E)	Poorly structured (P)	Moderately structured (M)	Strongly structured (S)	Shrink-swell (SW)	Pan or rock
Coarse sand (KS)	50	50	49	-	-	-	-
Light sand (SS)	70	90	83	-	-	-	-
Sand (S)	100	120	110	-	-	-	-
Fine sand (FS)	130	160	145	-	-	-	-
Loamy sand (LS)	145	185	165	-	-	-	-
Clayey sand (CS)	180	210	195	-	-	-	-
Sandy loam (SL)	200	225	230	245	265	-	-
Loam (L)	240	240	330	310	330	-	-
Sandy clay loam (SCL)	-	270	320	320	320	-	-
Clay loam (CL)	-	260	320	320	330	-	-
Clay (C)	-	260	350	330	340	330	-
Heavy clay (HC)	-	290	390	330	280	330	-
Fractured rock or pan (PF, RF)	-	-	-	-	-	-	160*
Weathered pan (PW)	-	-	-	-	-	-	160*
Weathered rock (PW)	-	-	-	-	-	-	160*
Solid rock or pan (PH, RH)	-	-	-	-	-	-	0

* Estimates for use in theoretical calculations as there is limited information for root water use in weathered or fractured rock. If possible derived values should be checked against real data.

A1.16 Bulk density

Bulk density is the weight of a unit volume of soil including its pore space. Bulk density and pore space affect water and aeration status, and root penetration and development. Bulk density is used when determining the following land quality:

- Subsurface acidification risk.

Table A1.16. Estimated Bulk Density for varying soil textures and arrangements (Based on values manually extrapolated from 171 WASG profiles in the soil profile database, plus a general consideration of values from the literature.)

Soil texture	Bulk Density (t/M3) for different soil arrangements						
	Loose (G)	Earthy or porous (E)	Poorly structured (P)	Moderately structured (M)	Strongly structured (S)	Shrink-swell (SW)	Pan or rock
Coarse sand (KS)	1.6	1.65	-	-	-	-	-
Light sand (SS)	1.4	1.5	-	-	-	-	-
Sand (S)	1.45	1.55	-	-	-	-	-
Fine sand (FS)	1.45	1.55	-	-	-	-	-
Loamy sand (LS)	1.3	1.4	-	-	-	-	-
Clayey sand (CS)	1.5	1.8	-	-	-	-	-
Sandy loam (SL)	1.25	1.45	1.45	1.45	1.25	-	-
Loam (L)	1	1.35	1.3	1.3	1.1	-	-
Sandy clay loam (SCL)	-	1.5	1.3	1.4	1.5	-	-
Clay loam (CL)	-	1.35	1.45	1.45	1.35	-	-
Clay (C)	-	1.65	1.7	1.7	1.3	1.65	-
Heavy clay (HC)	-	1.35	1.55	1.55	1.35	1.5	-
Fractured rock or pan (PF, RF)	-	-	-	-	-	-	2.4*
Weathered pan (PW)	-	-	-	-	-	-	2.4*
Weathered rock (PW)							2.4*
Solid rock or pan (PH, RH)							2.65*

* Indicative value for use in theoretical calculations

APPENDIX 2. SUITABLE SOILS FOR COMMERCIAL PINE PLANTATIONS *(PINUS PINASTER)*

This assessment is based on *Pinus pinaster* using information used by the Forest Products Commission when evaluating new plantation sites (Owen Donovan, pers. comm.)

This is a generic assessment for commercial pine plantations grown over extensive areas (i.e. hundreds of hectares). It is a regional assessment and neither the soil group qualifier or the landscape position is considered. Commercial pines are grown where annual average rainfall >400 mm. For commercial plantations, pines require deep sandy or gravelly soils (e.g. >3 m). **Other soils may be suitable but for economic reasons are normally used for other farming activities**.

A significant limitation to the assessment is information about soils deeper than 1.5 metres, which is generally sufficient for assessments of most other agricultural crops. To overcome this limitation, first a default set of 'ideal soils' was established. Regional differences of the suitability of different soils were then collated from Forest Products Commission field officers to identify zones where soil ratings vary from the default values. This information came from field knowledge of plantation growth and auger holes dug from to 3 to 5 m[1]. The resulting map is shown below Table A2.1 in Map A2.1.

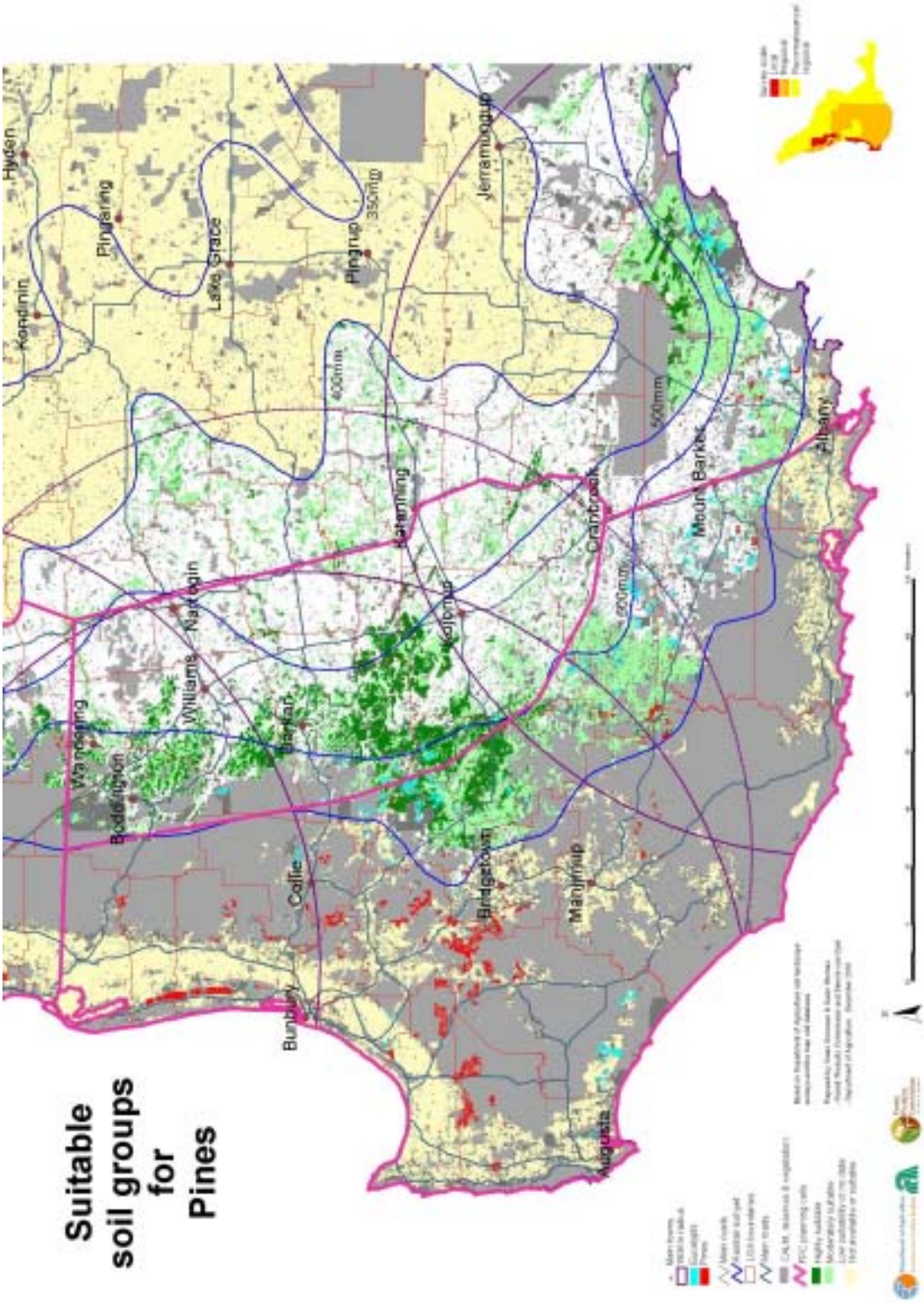
Table A2.1 Zone soil group ratings for *Pinus pinaster*

Soil group	Any zone	Zone specific adjustments						
	Default value	213	244	245	246	253	254	256
100	No chance							
101	No chance							
102	No chance							
103	No chance							
104	No chance							
105	No chance							
201	No chance							
202	No chance							
203	No chance							
300	No chance							
301	Excellent							
302	No chance	Good				Good		
303	No chance	Good				Good	Good	Good
304	No chance							
400	No chance							
401	No chance		Good	Good	Good			
402	No chance							
403	No chance		Good	Good	Good			
404	No chance							
405	No chance							
406	No chance							
407	No chance		Good					

[1] These auger holes are predominantly recorded on paper and have yet to be collated into a database. Many were collated before GPS, hence accurate locations may be problematic.

Soil group	Any zone	Zone specific adjustments						
	Default value	213	244	245	246	253	254	256
408	No chance							
409	No chance		Good					
420	No chance							
421	No chance							
422	No chance							
423	No chance							
424	Good		No chance					
440	Good							
441	Excellent							
442	No chance		Good	Good				
443	Excellent							
444	Excellent							
445	Good							
446	Excellent							
460	No chance							
461	No chance							
462	No chance							
463	No chance							
464	No chance							
465	No chance							
500	No chance							
501	No chance							
502	No chance							
503	No chance							
504	No chance							
505	No chance							
506	No chance							
507	No chance							
508	No chance							
520	No chance							
521	No chance							
522	No chance							
523	No chance							
540	No chance							
541	No chance							
542	No chance							
543	No chance							
544	No chance							
545	No chance							
600	No chance							
601	No chance							
602	No chance							
620	No chance							
621	No chance							

Soil group	Any zone	Zone specific adjustments						
	Default value	213	244	245	246	253	254	256
622	No chance							
701	No chance							
702	No chance							
703	No chance							



Map A2.1. Suitable soil groups for *Pinus pinaster*

APPENDIX 3. AVAILABILITY OF DIGITAL LAND RESOURCE SURVEYS (MAY 2005)

Current land resource and rangeland maps are prepared in digital form. Digital copies of most of the older maps have also been captured. The following tables list, by location, surveys for which digital maps have been (or are being) prepared. The locations of most of these surveys are shown in Maps A3.1 and A3.2. Bibliographic references for these surveys and related reports are provided at the end.

Access to some mapping may be restricted, especially for surveys still in progress.

Key to table headings

Survey location: Abbreviated survey title/approximate location.

Survey code: The code is only given for surveys with zone land unit/land capability attribution. Note some surveys that used similar mapping methods have been amalgamated and share a survey code in the map unit database.

Map number: Publication reference number of the maps (may differ from the report number).

Publication status:

P:	Published
NP:	Not published
IP:	In preparation
NS:	Not started
NSP:	No survey planned

Publication scale: Scale at which the map is published or planned to be published. This reflects the detail or intensity of the survey.

Survey type: Indicates type or purpose of the survey.

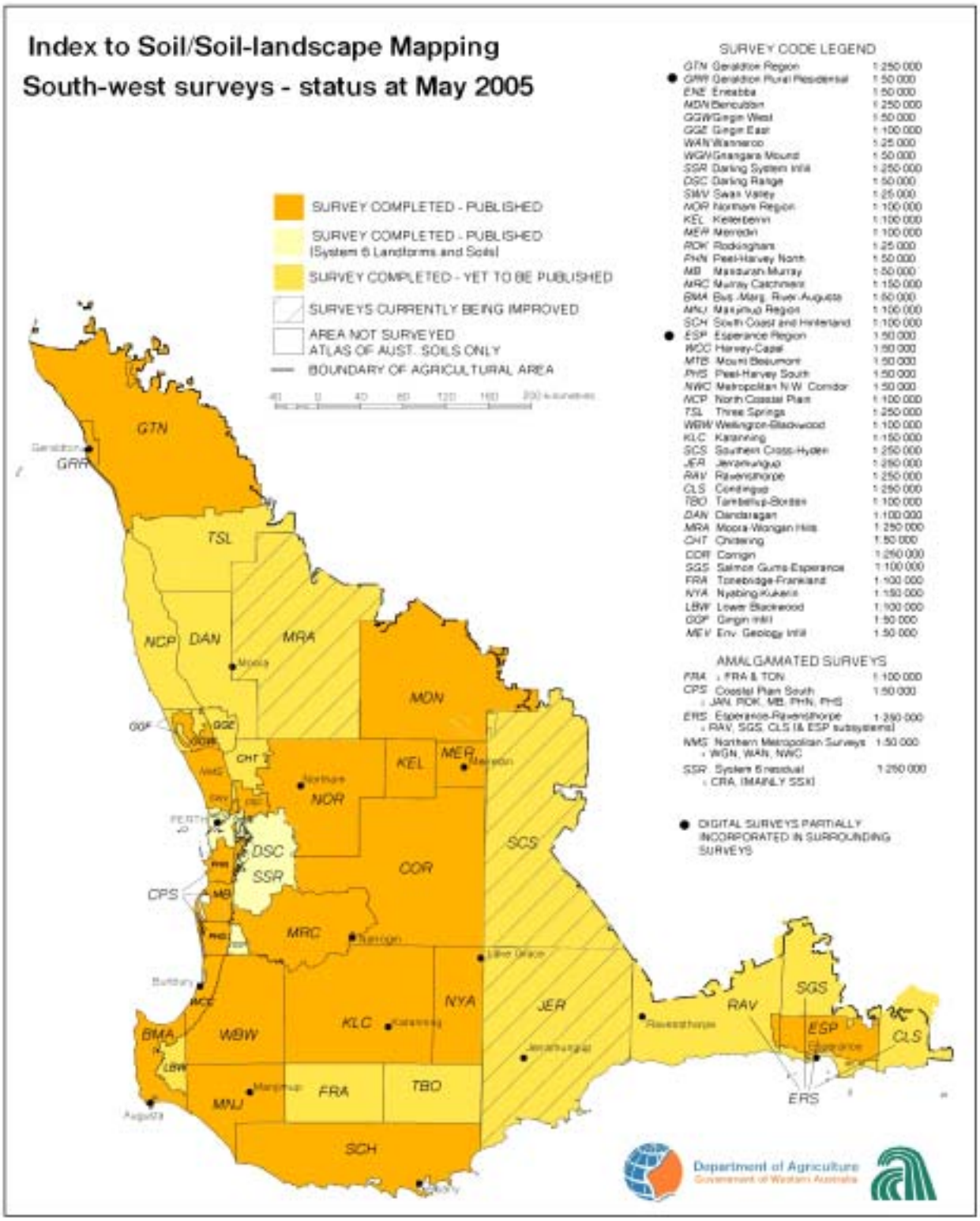
A question mark (?) attached to a date indicates that the exact date is uncertain.

South-west surveys (Map A3.1)

Survey location (map number)	Survey code	Report author/s (publication date)	Status	Scale	Survey type
Bencubbin	MDN	Grealish and Wagnon (1995)	P	1:250,000	Soil-landscape
Busselton-Margaret River-Augusta	BMA	Tille and Lantzke (1990)	P	1:50,000	Soil-landscape
Cascades	Not used	Scholz (1990 - unpublished)	IP	1:50,000	Soil-landscape
Chittering	CHT	Bessell-Browne (in prep.)	IP	1:50,000	Soil-landscape
Coastal dunes survey - Port Gregory to Cliff Head	Not used	Oma and Moore (1989)	NP	1:50,000	Soil-landscape
Condingup	Not used	Overheu (in prep.)	IP	1:100,000	Soil-landscape
Corrigin	COR	Verboom and Galloway (2005)	P	1:150,000	Soil-landscape
Coujinup Creek	Not used	Scholz (1987)	NP	1:20,000	Soil-landscape
Dandaragan	DAN	Griffin (in prep.)	IP	1:100,000	Soil-landscape
Darling Landforms	SSR (or CRA)	Mainly Churchward and McArthur (1978), plus Smolinski *et al*. (Unpublished)	P	1:250,000	Land system
Darling Range	DSC	King and Wells (1990)	P	1:50,000	Soil-landscape
Eneabba soil conditions	Not used	Scholz and Smolinski (1987?)	NP	1:50,000	Soil-landscape
Esperance	ESP	Overheu *et al.* (1993)	P	1:50,000	Soil-landscape
Geraldton region	GTN	Rogers (1996)	P	1:250.000	Soil-landscape
Geraldton rural residential	GRR	Dye *et al.* (1990)	P	1:50 000	Soil-landscape
Gingin east	GGE	van Gool (1998 - unpublished), based on work by Scholz (1995 - unpublished)	NP	1:100,000	Soil-landscape
Gingin west	GGW	Smolinski and Scholz (1997)	P	1:50,000	Soil-landscape
Gingin infill	GGF	Bessel-Browne (unpublished)	NP	1:50,000	Soil-landscape
Gnangara Mound	NMS	McArthur and Mattiske (1985)	P	1:50,000	Soil-landscape
Harvey-Capel	WCC	Barnesby *et al*. (in prep.)	IP	1:50,000	Soil-landscape
Jandakot	CPS	Wells *et al.* (1986 updated by van Gool 1990)	P	1:50,000	Soil-landscape
Jerdacuttup catchment	Not used	Moore *et al*. (1990)	P	1:50,000	Soil

Survey location (map number)	Survey code	Report author/s (publication date)	Status	Scale	Survey type
Jerramungup	JSI	Overheu (in prep.)	IP	1:250,000	Soil-landscape
Katanning	KLC	Percy (2000)	IP	1:150,000	Soil-landscape
Kellerberrin	KEL	McArthur (1992)	P	1:100,000	Soil-landscape
Lake Brown	Not used	Burvill (1932)	NP	1:25,000	Soil-landscape
Lower Blackwood	LBW	Smith and Smolinski (1997)	NP	1:100,000	Soil-landscape
Mandurah-Bunbury	Not used	McArthur and Bartle (1980a)	P	?	Soil-landscape
Mandurah-Murray	MB	Wells (1989)	P	1:50,000	Soil-landscape
Manjimup	MNJ	Churchward (1992)	P	1:100,000	Soil-landscape
Merredin	MER	Bettenay and Hingston (1961)	P	1:126,720	Soil-landscape
Metropolitan region (API infill mapping on rural land)	API	Barnesby (1991) Wells (1992) Bessell-Browne (1998)	NP	1:50,000	Soil-landscape
Metropolitan, north-west corridor	NMS	McArthur and Bartle (1980b)	P	1:25,000	Soil-landscape
Metropolitan environmental geology	MEV	Van-Gool (1998?)	NP	1:50,000	Geology with crude match to soil-landscape
Moora-Wongan Hills	MRA	Griffin *et al*. (in prep.)	IP	1:250,000	Soil-landscape
Mount Beaumont	Not used	Scholz and Smolinski (1996)	P	1:50,000	Soil
Murray Catchment	MRC	McArthur *et al* (1977)	P	1:150,000	Land system
North Coastal Plain	NCP	Schoknecht and Bessell-Browne (in prep.)	IP	1:100,000	Soil-landscape
Northam	NOR	Lantzke and Fulton (1993)	P	1:100,000	Soil-landscape
Nyabing-Kukerin	NYA	Percy (2003)	IP	1:150,000	Soil-landscape
Peel-Harvey North	CPS	van Gool (1990).	P	1:50,000	Soil-landscape
Peel-Harvey South	CPS	van Gool and Kipling (1992)	P	1:50,000	Soil-landscape
Ravensthorpe	RAV	Nicholas and Gee (in prep.)	IP	1:250,000	Soil-landscape
Rockingham	CPS	Wells *et al.* (1985)	P	1:50,000	Soil-landscape
Salmon Gums–Esperance	ERS	Nicholas and Gee (in prep.)	IP	1:100,000	Soil-landscape

Survey location (map number)	Survey code	Report author/s (publication date)	Status	Scale	Survey type
Salmon Gums detail	Not used	Burvill (1988)	IP	1:15,840	Soil
Salmon Gums District	Not used	Burvill (1935, 1988)	IP	?	Soil-landscape
South Coast and hinterland	SCH	Churchward *et al.* (1988)	P	1:100,000	Land system
Southern Cross-Hyden	SCS	Verboom *et al.* (in prep.)	IP	1:250,000	Soil-landscape
Swan Valley	SWV	Campbell Clause and Moore (1991), Pym (1955)	P	1:25,000	Soil-landscape
Tambellup-Borden	TBO	Stuart-Street, A. and Marold, R. (in prep.)	IP	1:100,000	Soil-landscape
Three Springs	TSL	Grose (in prep.)	IP	1:250,000	Soil-landscape
Tonebridge-Frankland	FRA	Stuart-Street. (2005)	IP	1:100,000	Soil-landscape
Wanneroo	NMS	Wells and Clarke (1986)	P	1:25,000	Soil-landscape
Wellington-Blackwood	WBW	Tille (1996)	P	1:100,000	Soil-landscape

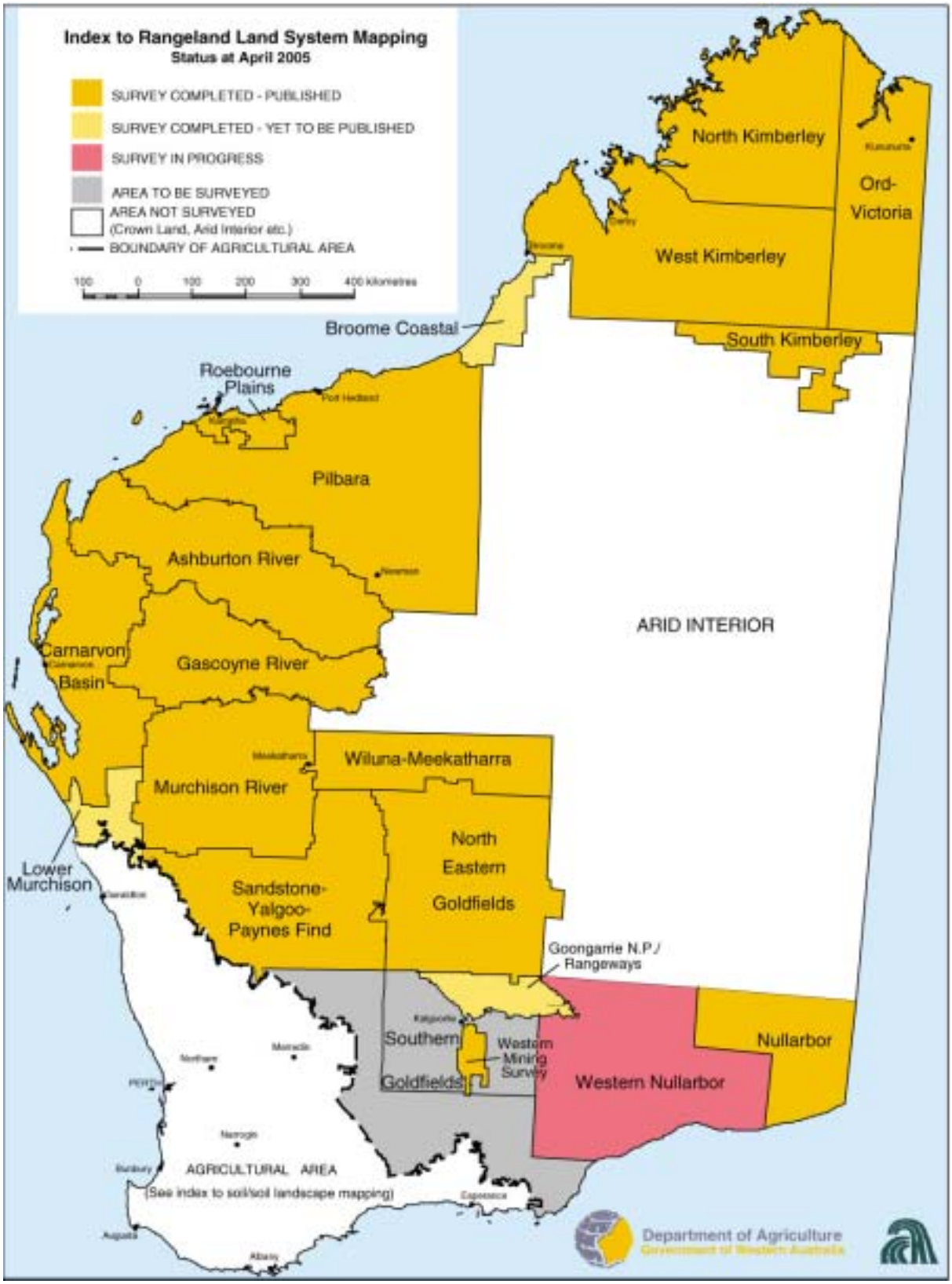


Map A3.1. Survey areas in the south-west agricultural area of Western Australia

Rangeland surveys (Map A3.2)

Survey location	Report author/s (publication date)	Status	Scale	Survey type
Ajana		NS		
Arid Interior		NSP		
Ashburton River	Payne *et al.* (1982)	P	1:250,000	Land system
Broome Coastal	Cotching (2006)	NP	1:100,000	Land system
Carnarvon Basin	Payne *et al.* (1987)	P	1:250,000	Land system
Gascoyne River	Wilcox and McKinnon (1972)	P	1:250,000	Land system
Gascoyne River near Carnarvon	Bettenay (1971)	P	1:150,000	Soil
Kambalda (part of Southern Goldfields)	Payne *et al.* (1998)	IP	1:150,000	Land system
Lake Johnston		NS		
Murchison River	Curry *et al.* (1994)	P	1:250,000	Land system
North Kimberley	Speck *et al.* (1960)	P	1:250,000	Land system
North-Eastern Goldfields	Pringle *et al.* (1994)	P	1:250,000	Land system
Nullarbor	Mitchell *et al.* (1979)	P	1:250,000	Land system
Ord-Victoria	Stewart *et al.* (1970)	P	1:250,000	Land system
Pilbara	Van Vreeswyk *et al*. (2004)	IP	1:250,000	Land system
Roebourne Plains	Payne and Tille (1992)	P		Land system
Roy Hill-Ethel Creek (part of Pilbara)	Payne and Mitchell (1992)	NP	1:250,000	Land system
Sandstone-Yalgoo-Paynes Find	Payne *et al.* (1998)	P	1:500,000*	Land system
Southern Goldfields		NS	1:250,000	Land system
West Kimberley	Speck *et al.* (1964)	P	1:250,000	Land system
Western Nullarbor		NS	1:250,000	Land system
Wiluna-Meekatharra	Mabbutt *et al.* (1963)	P	1:250,000	Land system

* Mapping conducted for 1:250,000 publication scale.



Map A3.2. Rangeland survey areas in Western Australia

Carnarvon and East Kimberley areas (medium to high intensity surveys)

Survey location (map number)	Report author/s (publication date)	Status	Scale	Survey type
Carlton plain (58)	Stoneman (1988)	P	1:75,000 (approx.)	Soil
Carnarvon Irrigation District (63)	Wells and Bessell-Browne (1990)	P	1:50,000	Soil-landscape
Carnarvon regional (30)	Wells *et al.* (1992)	P	1:100,000	Soil-landscape
Carnarvon, North Common (64)	Wells *et al.* (1987)	NP	1:25,000	Soil-landscape
Groundnut survey (62)	Dixon and Petheram (1979)	P	1:20,000	Soil
Ivanhoe north west (65)	Dixon and Holman (?)	NP	1:25,000	Soil
Ivanhoe Plain (37)	Aldrick *et al* (1990)	P	1:25,000	Soil
Ivanhoe West Bank (59)	Schoknecht and Grose (1996a)	P	1:25,000	Soil
King Location 369	Sherrard (1993)	NP	1:15,000	Soil
Knox Creek Plain (61)	Schoknecht and Grose (1996b)	P	1:25,000	Soil
Lower Weaber and Keep Plains, N.T. (39)	Aldrick and Moody (1977)	P	1:20,000	Soil
Mantinea Flats/Goose Hill (35)	Burvill (1991)	P	1:125,000 (approx.)	Soil
Mantinea Loop (57)	Schoknecht and Grose (1996c)	P	1:50,000	Soil
Maxwell-Biyoogoong Plain (60)	Schoknecht (1993)	NP	1:50,000	Soil-landscape
North-west Packsaddle (66)	Schoknecht (1996a)	P	1:20,000	Soil
Packsaddle infill (67)	Schoknecht (1996b)	P	1:20,000	Soil
Packsaddle Plain (36)	Stoneman (1972)	P	1:80,000 (approx.)	Soil
Weaber Plain (38)	Dixon (1996)	P	1:50,000	Soil

Broad overview surveys

Survey location	Report author/s (publication date)	Status	Scale	Survey type
Atlas of Australian soils	Northcote *et al.* (1967)	P	1:2,000,000	Soil
Soil groups of WA	Schoknecht (1998)	NP	1:2,000,000	Soil

Survey references

Aldrick, J.M. and Moody, J.M. (1977). Report on the soils of the lower Weaber and Keep Plains, NT. Department of NT, Animal Industry and Agriculture Branch. Technical Bulletin 19.

Aldrick, J.M., Clarke, A.J., Moody, P.W., van Cuylenburg, M.H.R. and Wren, B.A. (1990). Soils of the Ivanhoe Plain, East Kimberley, Western Australia. Technical Bulletin No. 82. Department of Agriculture, Western Australia.

Barnesby, B.A. (1991). API infill mapping prepared for the metropolitan rural policy (unpublished).

Barnesby, B.A. and Proulx-Nixon, M.E. (2000). Land resources from Harvey to Capel on the Swan Coastal Plain, Western Australia - Sheet 2. Land Resources Map 23/2. Agriculture Western Australia.

Bessell-Browne, J.A. (in prep.). Chittering area land resources survey.

Bettenay, E. (1971). Soils adjoining the Gascoyne River near Carnarvon, Western Australia. CSIRO Division of Soils. Soils and land use series No. 51.

Bettenay, E. and Hingston, F.J. (1961). The soils and land use of the Merredin area, Western Australia. CSIRO Division of Soils. Soils and Land Use Series No. 41.

Burvill, G.H. (1932). Lake Brown soil survey (unpublished).

Burvill, G.H. (1935). Salmon Gums soil and alkali survey. Maps (scale 1:15,840, 42 map sheets). Unpublished internal report. Department of Agriculture, Western Australia.

Burvill, G.H. (1988). The soils of the Salmon Gums District, Western Australia. Western Australian Department of Agriculture, Technical Bulletin No. 77.

Burvill, G.H. (1991). Soil surveys and related investigations in the Ord River area, East Kimberley, 1944. Technical Bulletin No. 80. Western Australian Department of Agriculture.

Campbell Clause, J. and Moore, G.A. (1991). Land capability study for horticulture in the Swan Valley. Department of Agriculture Western Australia. Land Resources Series No. 6. (See also Pym 1955.)

Churchward, H.M. (1992). Soils and landforms of the Manjimup area. Western Australian Department of Agriculture, Land Resources Series No. 10.

Churchward, H.M. and McArthur, W.M. (1978). Landforms and soils of the Darling System, Western Australia. *In*: 'Atlas of Natural Resources, Darling System, Western Australia'. Department of Conservation and Environment, Western Australia.

Churchward, H.M., McArthur, W.M., Sewell, P.L. and Bartle, G.A. (1988). Landforms and soils of the south coast and hinterland, Western Australia. Northcliffe to Manypeaks. CSIRO Australia. Division of Water Resources Divisional Report 88/1.

Cotching, W.E. (2006). An inventory of rangelands in part of the Broome Shire, Western Australia. Technical Bulletin No. 93. Department of Agriculture.

Curry, P.J., Payne, A.L., Leighton, K.L., Hennig, P. and Blood, D.A. (1994). An inventory and condition survey of the Murchison River catchment, Western Australia. Western Australian Department of Agriculture, Technical Bulletin No. 84.

Dixon, J. and Holman, W.F. (1980). Land capability study of sandy soils north-west of the Ivanhoe Plains, Kununurra, WA. Department of Agriculture, Western Australia report (unpublished).

Dixon, J.C. (1996). Soils of the Weaber Plain, East Kimberley, Western Australia. Resource Management Technical Report 152. Agriculture Western Australia.

Dixon, J.C. and Petheram, R.J. (1979). Soil Survey Report 65 (3 map sheets). Department of Agriculture, Western Australia.

Dye, R.A., van Vreeswyk, A.M.E. and Moore, G.A. (1990). Geraldton rural-residential land capability study. Land Resources Series No. 4. Department of Agriculture, Western Australia.

Grealish, G. and Wagnon, J. (1995). Land resources of the Bencubbin area. Agriculture Western Australia, Land Resources Series No. 12.

Griffin, E.J. and Frahmand, M.A. (in prep.) Moora-Wongan Hills land resources survey.

Griffin, E.A. (in prep.). Dandaragan land resources survey.

Grose, C. (in prep.). Three Springs area land resources survey.

King, P.D. and Wells, M.R. (1990). Darling Range land capability study. Western Australian Department of Agriculture, Land Resources Series No. 3.

Lantzke, N. and Fulton, I. (1993). Land Resources of the Northam region, Land Resources Series No. 11, Department of Agriculture Western Australia.

Mabbutt, J.A., Litchfield, W.H., Speck, N.H., Sofoulis, J., Wilcox, D.G., Arnold J.A., Brookfield, M. and Wright, R.L. (1963). General report on the lands of the Wiluna-Meekatharra area, Western Australia, 1958. CSIRO Land Research Series No. 7.

Marold, R. and Roberts, M. (in prep.). Tambellup-Borden land resources survey

McArthur, W.M. (1992). Land resources of the Kellerberrin region. Western Australian Department of Agriculture, Division of Resource Management Technical Report 134.

McArthur, W.M. and Bartle, G.A. (1980a). Soils and land use planning in the Mandurah-Bunbury coastal zone, Western Australia. CSIRO Land Resources Management Series No. 6.

McArthur, W.M. and Bartle, G.A. (1980b). Landforms and soils as an aid to urban planning in the Perth metropolitan northwest corridor, Western Australia. Maps (scale 1:25,000, 4 map sheets). CSIRO Australia, Land Resources Management Series No. 5.

McArthur, W.M. and Mattiske, E.M. (1985). The Gnangara mound groundwater area landforms, soils and vegetation. Soil-landscape map (scale 1:50,000). Appendix C *In* 'Gnangara mound groundwater resources, environmental review and management programme'. Report by Dames and Moore, November 1986.

McArthur, W.M. and Stoneman, T.C. (1991). Landforms and soils of the south coast and hinterland, Western Australia. Northcliffe to Manypeaks. Supplementary data. Department of Agriculture, Western Australia, Land Assessment Group.

McArthur, W.M., Churchward, H.M. and Hick, P.T. (1977). Landforms and soils of the Murray River catchment area of Western Australia. CSIRO Australia. Division of Land Resources Management Series No. 3.

Mitchell, A.A., McCarthy, R. and Hacker, R.B. (1979). A range inventory and condition survey of part of the Western Australian Nullarbor Plain, 1974. Western Australian Department of Agriculture, Technical Bulletin No. 47.

Nicholas, B.D. and Gee, S.T. (in prep.). Ravensthorpe land resources survey.

Nicholas, B.D. and Gee, S.T. (in prep.). Salmon Gums-Esperance land resources survey.

Northcote, K.H., Bettenay, E., Churchward, H.M. and McArthur, W.M. (1967). Atlas of Australian soils, Sheet 5, Perth-Albany-Esperance area with explanatory data. CSIRO Australia, Melbourne University Press, Melbourne.

Oma, V.M. and Moore, G.A. (1989). Mapping for assessing erosion in the coastal Dune system, Shire of Greenough (unpublished).

Payne, A.L., Curry, P.J. and Spencer, G.F. (1987). An inventory and condition survey of the Carnarvon Basin, Western Australia. Western Australian Department of Agriculture, Technical Bulletin No. 73.

Payne, A.L. and Tille, P. (1992). An inventory and condition survey of the Roebourne Plains and surrounds, Western Australia. Department of Agriculture, Western Australia, Technical Bulletin No. 83.

Payne, A.L., Mitchell, A.A. and Hennig, P. (1998). Land systems of the Kambalda area and surrounds (report prepared for WMC Resources Ltd).

Payne, A.L., Mitchell, A.A. and Holman, W.F. (1982). An inventory and condition survey of the Ashburton River catchment, Western Australia. Western Australian Department of Agriculture, Technical Bulletin No. 62.

Payne, A.L., Van Vreeswyk, A.M.E., Pringle, H.J.R., Leighton, K.A. and Hennig, P. (1998). An inventory and condition survey of the Sandstone-Yalgoo-Paynes Find area, Western Australia. Agriculture Western Australia, Technical Bulletin No. 90.

Percy, H. (in prep). Katanning area land resources survey.

Percy, H. (2003). Nyabing-Kukerin area land resources survey. Land Resources Series No. 18. Department of Agriculture, Western Australia.

Pringle, H.J.R., Van Vreeswyk, A.M.E. and Gilligan, S.A. (1994). An inventory and condition survey of rangelands in the north-eastern Goldfields, Western Australia. Department of Agriculture, Western Australia, Technical Bulletin No. 87.

Pym, L.W. (1955). Soils of the Swan Valley vineyard area, Western Australia. CSIRO Division of Soils, Soils and Land Use Series No. 15.

Rogers, L.G. (1996). Geraldton region land resources survey. Agriculture Western Australia, Land Resources Series No. 13.

Schoknecht, N. (1996a). Assessment of the suitability for Agriculture of the North-west Packsaddle area Kununurra. Agriculture Western Australia. Resource Management Technical Report 156.

Schoknecht, N. (1996b). Assessment of the suitability for agriculture of the Packsaddle infill area, Kununurra. Agriculture Western Australia. Resource Management Technical Report 157.

Schoknecht, N. (1997). Soil groups of Western Australia. A simple guide to the main soils of Western Australia. Agriculture Western Australia, Resource Management Technical Report No. 171.

Schoknecht, N. and Grose, C. (1996a). Soils of the Ivanhoe West Bank, East Kimberley, Western Australia. Agriculture Western Australia, Resource Management Technical Report 155.

Schoknecht, N. and Grose, C. (1996b). Soils of the Knox Creek Plain, East Kimberley Western Australia and Northern Territory. Agriculture Western Australia. Resource Management Technical Report 153.

Schoknecht, N. and Grose, C. (1996c). Soils of the Mantinea Loop, Ord River Valley, East Kimberley Western Australia. Agriculture Western Australia. Resource Management Technical Report 154.

Schoknecht, N.R. (1993). Maxwell-Biyoogoong Plains survey, East Kimberley (unpublished).

Schoknecht, N. (in prep.). North Coastal Plain land resources survey.

Scholz, G.G.H. and Smolinski, H.J. (1987). Eneabba sand textural map (unpublished).

Scholz, G. (unpublished). Soil morphology and chemistry of the cascades area, Western Australia.

Scholz, G.G.H. (unpublished). Coujinup Creek Land Resource Survey. Map (scale 1:20,000). Department of Agriculture, Western Australia. Unpublished internal report.

Scholz, G.G.H. and Smolinski, H.J. (1996). Soils of the Mount Beaumont area, Western Australia. Agriculture Western Australia, Land Resources Series No. 7.

Sherrard, J.H. (1993). Land capability study of King Location 369, adjoining reserve 36951 and freehold location 599. Agriculture Western Australia (unpublished).

Smith, R. and Smolinski, H.J. (1997). Soils and landforms of the Lower Blackwood. (unpublished).

Smolinski, H. and Scholz, G. (1997). Soil assessment of the West Gingin area. Agriculture Western Australia, Land Resources Series No. 15.

Smolinski, H. (unpublished). Soils of the south west forest region, Western Australia. Unpublished AGWEST Land Management report. Agriculture Western Australia. (Rapid assessment of State forest areas using existing mapping and aerial photography.)

Speck, N.H., Bradley, J., Lazarides, M., Paterson, R.A., Slatyer, R.O., Stewart, G.A. and Twidale, C.R. (1960). Lands and pastoral resources of the North Kimberley area, Western Australia. CSIRO Land Research Series No. 4.

Speck, N.H., Wright, R.L., Rutherford, G.K., Fitzgerald, K., Thomas, F., Arnold, J.M., Basinski, J.J., Fitzpatrick, E.A., Lazarides, M. and Perry, R.A. (1964). General report on lands of the West Kimberley area, Western Australia. CSIRO Land Research Series No. 9.

Stewart, G.A., Perry, R.A., Paterson, S.J., Traves, D.M., Slatyer, R.O., Dunn, P.R, Jones, P.J. and Sleeman, J.R. (1970). Lands of the Ord-Victoria area, Western Australia and Northern Territory. CSIRO Land Research Series No. 28.

Stoneman, T.C. (1972). Packsaddle Plains soil survey. Western Australian Department of Agriculture. Technical Bulletin No. 55.

Stoneman, T.C. (1988). Carlton Plains soil survey in the Shire of Wyndham, East Kimberley. Western Australian Department of Agriculture, Division of Resource Management Technical Report 76.

Stuart-Street, A. and Marold, R. (in prep.) Tambellup-Borden land resources survey. Land Resources Series. Department of Agriculture, Western Australia.

Stuart-Street, A. (2005). Tonebridge-Frankland land resources survey. Land Resources Series No. 19. Department of Agriculture, Western Australia

Tille, P.J. (1996). Land capability assessment for the Wellington-Blackwood survey. Resource Management Technical Report 162. Agriculture Western Australia.

Tille, P.J. (1996). Wellington-Blackwood land resources survey. Agriculture Western Australia, Land Resources Series No. 14.

Tille, P.J. and Lantzke, N.J. (1990). Busselton-Margaret River-Augusta land capability study. Western Australian Department of Agriculture, Land Resources Series No. 5.

Tille, P. and Lantzke, N. (1990). Busselton-Margaret River-Augusta Land Capability Study; Methodology and Results, Vol. 1, Technical Report 109, Division of Resource Management, Department of Agriculture, Western Australia.

van Gool, D. (1990). Land resources in the northern portion of the Peel-Harvey Coastal Catchment, Swan Coastal Plain. Department of Agriculture. Miscellaneous Publication.

van Gool, D. (1992). Land resources in the southern portion of the Peel-Harvey Coastal Catchment, Swan Coastal Plain. Department of Agriculture. Miscellaneous Publication.

van Gool, D. (unpublished). Remapping of Gingin East soil survey using aerial photograph and existing linework from other sources. Based on work by Scholz, G. (1995). Land resource map of East Gingin.

van Gool (unpublished). Soil-landscape map unit correlation of published environmental geology mapping.

van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004). An inventory and condition survey of the Pilbara Region, Western Australia. Department of Agriculture Technical Bulletin No. 92.

Verboom, W. and Frahmand, M.A. (in prep.). Southern Cross-Hyden land resources survey.

Verboom, W. and Galloway, P. (2005). Corrigin area land resources survey. Land Resources Series No. 19. Department of Agriculture, Western Australia.

Wells, M.R., Keating, C.D.M. and Bessell-Browne, J.A. (1992). Land resources of the Carnarvon Land Conservation District and part of Boolathana station, Western Australia. Department of Agriculture. Land Resources Series No. 9.

Wells, M.R. (1989). Land capability study of the shires of Mandurah and Murray. Western Australian Department of Agriculture, Land Resources Series No. 2.

Wells, M.R. (1992?). Land resource infill mapping for the Armadale local rural strategy. (unpublished).

Wells, M.R. and Bessell-Browne, J.A. (1990). Horticultural capability study of soils adjacent to plantations at Carnarvon, Western Australia. Western Australian Department of Agriculture. Division of Resource Management Technical Report 115.

Wells, M.R. and Clarke, A.J. (1986). Shire of Wanneroo, a study of land resources and planning considerations. Soil-landscape map (scale 1:25 000, 4 map sheets, included in the report as microfiche copies: maps. 408, 409, 410, 411). Division of Resource Management, Technical Report 47. Department of Agriculture, Western Australia.

Wells, M.R., Oma, V.P.M. and Richards, N.L.B. (1985). Shire of Rockingham, a study of land resources and planning considerations. Maps (scale 1:25,000: soil-landscape map plus two interpretive maps). Division of Resource Management, Technical Report 44. Department of Agriculture, Western Australia.

Wells, M.R., Richards, N.L.B. and Clarke, A.J. (1986). Jandakot groundwater scheme - a study of land resources and planning considerations. Soil-landscape map (scale 1:25,000: one map sheet, included as a microfiche copy: map 458). Resource Management Technical Report 48. Department of Agriculture, Western Australia.

Wells, M.R. (unpublished). Metropolitan infill mapping, prepared for the Armadale Local Rural Strategy. City of Armadale.

General references

Bettenay, E. and Hingston, F.J. (1964). Development and distribution of the soils in the Merredin area, Western Australia. *Australian Journal of Soil Science* **2:** 173-186.

Bettenay, E., McArthur, W.M. and Hingston, F.J. (1960). The soil associations of part of the Swan Coastal Plain, Western Australia. CSIRO Australia, Soils and Land Use Series 35.

Blood, D.A. (1995). Rangeland reference areas. Department of Agriculture, Western Australia, Resource Management Technical Report 141.

Burnside, D., Holm, A., Payne, A. and Wilson, G. (1995). Reading the rangeland: a guide to the arid shrublands of Western Australia. Department of Agriculture, Western Australia.

Hingston, F.J. and Bettenay, E. (1960). A laboratory examination of soils of the Merredin area, Western Australia. CSIRO Australia. Division of Soils, Divisional Report 7/60.

Hosking, J.S. and Greaves, G.A. (1936). A soil survey of an area at Gingin, Western Australia. *Journal of the Royal Society of Western Australia* **22:** 71-112.

Lantzke, N.C. (1992). Soils of the Northam Advisory District, Vol. 1, The Zone of Ancient Drainage. Western Australian Department of Agriculture, Bulletin No. 4244.

Lantzke, N.C. (1993). Soils of the Northam Advisory District, Vol. 2, The Zone of Rejuvenated Drainage. Western Australian Department of Agriculture, Bulletin. 4245.

Lantzke, N.C. (1993). Soils of the Northam Advisory District, Vol. 2, Darling Range and Kokeby Zones. Western Australian Department of Agriculture, Bulletin 4245.

McArthur, W.M. (1958). Further Investigation of the Soils of the Harvey and Waroona areas, Western Australia. CSIRO Division of Soils. Division report 4/58.

McArthur, W.M. (1991). 'Reference soils of South-Western Australia'. Australian Soil Science Society of Australia Inc. (WA Branch), Perth, Western Australia.

McArthur, W.M. and Bettenay, E. (1956). The soils and irrigation potential of the Capel-Boyanup area, Western Australia. CSIRO Division of Soils. Soils and Land Use Series No. 16.

McArthur, W.M. and Bettenay, E. (1957). Soils of the proposed extension of the Collie Irrigation District, Western Australia. CSIRO Division of Soils. Divisional report 7/57.

McArthur, W.M. and Bettenay, E. (1974). Development and distribution of soils of the Swan Coastal Plain, Western Australia, 2nd edition. CSIRO Australia. Soil Publication 16.

McArthur, W.M., Bettenay, E. and Hingston, F.J. (1959). The soils and irrigation potential of the Pinjarra-Waroona area, Western Australia. CSIRO Division of Soils. Soils and Land Use Series No. 31.

Nicholas, B.D., Overheu, T.D. and Needham, P.J. (1996). Soil information sheets for the Mount Beaumont, Mallee and Esperance agricultural areas. Miscellaneous Publication 21/96. Agriculture Western Australia.

Overheu, T.D. (1996). Soil information sheets for part of the Jerramungup agricultural area. Miscellaneous Publication 20/96. Agriculture Western Australia.

Overheu, T.D., Muller, P.G., Gee, S.T. and Moore, G.A. (1993). Esperance land resources survey. Western Australian Department of Agriculture, Land Resources Series No. 8.

Overheu, T.D. (1995). Soil information sheets for Ravensthorpe and part of the Jerramungup agricultural area. Miscellaneous Publication 16/95. Agriculture Western Australia.

Patabendige, D.M. and Rogers, L.G. (1997). Soil information sheets for the Northern agricultural areas. Miscellaneous Publication 13/97. Agriculture Western Australia.

Payne, A.L. (1985). Maps showing pastoral potential in the Kimberley region of Western Australia. Western Australian Department of Agriculture.

Payne, A.L. and Mitchell, A.A. (1992). An assessment of the impact of Ophthalmia dam on the floodplains of the Fortescue River on Ethel Creek and Roy Hill stations. Department of Agriculture, Western Australia. Technical Report 124.

Payne, A.L., Kubicki, A. and Wilcox, D.G. (1974). Range condition guides for the West Kimberley area in Western Australia. Western Australia Department of Agriculture.

Payne, A.L., Wilcox, D.G. and Short, L.C. (1972). A report on the erosion and rangeland condition in the West Kimberley area of Western Australia. Western Australian Department of Agriculture, Technical Bulletin No. 42.

Pringle, H.J.R. (1991). Rangeland survey in Western Australia - history, methodology and applications. Department of Agriculture, Western Australia. Miscellaneous Publication 22/91.

Pringle, H.J.R. (1994). Pastoral resources and their management in the north-eastern Goldfields, Western Australia. Department of Agriculture, Western Australia Miscellaneous Publication 22/94.

Pym, L.W. (1951). Soil survey of Wokalup State Research Farm, Western Australia. CSIRO Division of Soils. Divisional Report 6/51.

Stoneman, T.C. (1990). Soils of the Albany Advisory District. Bulletin 4203. Department of Agriculture, Western Australia.

Stoneman, T.C. (1990). Soils of the Geraldton Advisory District. Bulletin 4181. Department of Agriculture, Western Australia.

Stoneman, T.C. (1990). Soils of the Jerramungup Advisory District. Bulletin 4201. Department of Agriculture, Western Australia.

Stoneman, T.C. (1990). Soils of the Moora Advisory District. Bulletin 4182. Department of Agriculture, Western Australia.

Stoneman, T.C. (1990). Soils of the Three Springs Advisory District. Bulletin 4180. Department of Agriculture, Western Australia.

Stoneman, T.C. (1991). Soils of the Katanning Advisory District. Bulletin 4202. Department of Agriculture, Western Australia.

Stoneman, T.C. (1992). Soils of the Merredin Advisory District. Bulletin 4235. Department of Agriculture, Western Australia.

Teakle, L.J.H. (1953). Soil survey of the Many Peaks District, Albany Road Board, Western Australia. Western Australian Department of Agriculture, Leaflet No. 2070.

Van Vreeswyk, A.M.E. and Godden, P.T. (1998). Pastoral resources and their management in the Sandstone-Yalgoo-Paynes Find area, Western Australia, Agriculture Western Australia, Miscellaneous Publication 1/98.

APPENDIX 4. LAND EVALUATION TERMINOLOGY

This lists the main terms used in land evaluation and their definitions as used by the Department of Agriculture in Western Australia. The Department uses terminology similar to the New South Wales glossary of terms used in soil conservation (Houghton and Charman 1986) for land evaluation purposes.

The terminology has varied over time, and differences occur between the Australian States. For example there is no consensus on the use of common terms such land capability and land suitability which are often used interchangeably.

> Readers should be aware that multiple definitions are in common usage.

A reading list of some publications relevant to land evaluation terminology is also provided.

Land attribute: A specific property of the land that has been identified and described and which can be associated with a soil or land mapping unit. Land attributes used in WA include land qualities, land characteristics, soil series and soil group attributes.

Land capability: Land resource suitability: In Australia land capability is often used interchangeably with land suitability.

Land capability, as used in Western Australia is: 'The ability of land to support a type of land use without causing damage' (Austin and Cocks 1978). Dixon (1986) expanded this definition slightly to emphasise that damage referred to both on-site and off-site effects. The term land capability was adopted in Western Australia from the Land Capability Methodology described by Wells and King (1989). Although this work refers to the 'Land-Capability Classification' (Klingebiel and Montgomery 1961, Olson 1973), the methods described are closer to a stage I land suitability assessment described in 'A framework for land evaluation' FAO 1976).

Although land capability will probably continue to be used in WA for some time, the term **Land resource suitability** is suggested to accord with the nationally adopted standard. Physical has been added to the definition of 'land suitability' to distinguish it from the all encompassing FAO definition of land suitability (below) which also includes social and economic considerations.

Land capability in WA has five classes for a defined land use and the final capability rating is simply determined by the most limiting land quality or qualities. Class 1 is essentially non-limiting and the ratings decrease gradually to class 5 which is severely limiting.

Land degradation: Describes the decline in quality of natural land resources, commonly caused through poor land management practices.

Land degradation encompasses soil degradation and the deterioration of natural landscapes and vegetation. It includes the adverse effects of overgrazing, excessive tillage, over-clearing, erosion and sediment deposition.

The definition also encompasses off-site effects. These also include nutrient pollution which may result from erosion or drainage from a given land unit.

Land evaluation: The determination of the extent of one or more land attributes, the assessment of potential land uses, and the effect upon the environment and the resource resulting from these uses.

The process of interpreting the technical information associated with land resource maps summarises those resources. Examples include land capability maps (general and specific),

land degradation susceptibility maps and maps showing the distribution of land qualities such as average soil depth or average soil pH.

Landform: The shape and form of the land surface.

Land qualities: Those attributes of land that influence its capability for a specified use (Wells and King 1989). Land qualities can be applied to map units or defined components of map units, and are used directly in the preparation of degradation hazard maps. They may be combined to prepare land capability maps. Land qualities may be single characteristics such as soil permeability, or they may be derived from some combination of soil and landscape characteristics. For example the inherent erodibility of a soil is combined with the landscape position to derive susceptibility to wind erosion.

Land qualities are classified (e.g. low, moderate or high), and may be applied directly to map units, to components of map units, or assessed as a proportion of a map unit.

Land resource (survey): A survey of land resources, sometimes called natural resources and covering one or more of soil, landform, vegetation and regolith/geology.

Recent surveys in the south-west of Western Australia map soil-landscapes and utilise taxonomic soil series in the map unit descriptions. Rangeland mapping is based on land systems that give more emphasis to vegetation and less to soils.

Land suitability: The potential uses of the land based upon consideration of prevailing physical, technical and socio-economic conditions (FAO 1976). Land suitability evaluation involves a multi-disciplinary approach to land evaluation and includes a basic inventory of land resource data; an understanding of the ecological requirements of the land use contemplated; basic data on the economics of land use, land improvement, new technologies, marketing and transport, and a knowledge of the attitudes and goals of people affected by the proposed changes.

Land system: A mapping unit that identifies a recurring pattern of topography, soils and vegetation. May be subdivided into land facets or land units that are described but not mapped.

Land units and zone land units: Land units described in this report are an area of common landform and similar soils that occur repeatedly at similar points in the landscape. They usually have similar vegetation and geology. Land units are components of map units. At relatively detailed scales (e.g. 1:25,000) the land unit may be synonymous with the map unit, though this can vary according to the complexity of the soils and landforms. More commonly, land units are described as a proportion or percentage of a map unit.

The land units that are attributed in the map unit database in WA are called zone land units, as they are differentiated according to the soil-landscape zone in which they occur.

Map unit: A set of map polygons having common land attributes. The homogeneity of the map unit will depend on the scale and purpose of mapping.

For some more detailed mapping (1:25,000 scale), land qualities are applied directly to mapping units. However for most surveys component land units (unmapped) are described as a proportion of a mapping unit.

Minimum dataset: A user-defined minimum set of information required to achieve a specific set of outcomes. (e.g. 22 land qualities)

The term is often discussed by users of geographic information systems without being defined.

It is possible to create many land qualities, however 20 have been selected as a minimum dataset used for a wide range of rural and agricultural land capability interpretations. These 20 land qualities are a base reference for land use interpretation. They can be determined

from the data available for most surveys and are described in detail in Section 2. Land qualities include the major land degradation and land management considerations and are used for a wide range of land capability assessments, including those listed in Section 3.

Land resource suitability: (See land capability).

Proportional mapping: Refers to map units that are defined and described as unmapped components of mapping units so that interpretations can be presented as percentages of a given mapping unit.

Soil association: A soil mapping unit in which two or more soil taxonomic units occur together in a characteristic pattern. The units are combined because the scale of the map, or the purpose for which it is being made, does not require delineation of individual soils. The soil association may be named according to the units present, the dominant unit, or given a geographic name based on a locality where the soil association is well developed.

Soil classification: The systematic arrangement of soils into groups or categories on the basis of similarities and differences in their characteristics. Soils can be grouped according to their genesis (taxonomic classification), their morphology (morphological classification), their suitability for different uses (interpretative classification) or according to specific properties.

The purposes of soil classification are:

- As a means of grouping soils into useful categories so that statements about one particular soil are likely to apply to other soils in the same group
- With experience, the identification and categorising may lead to the inference of other soil properties (apart from those used in the classification)
- A formal system of classification encourages the scientific and logical study of soils
- The standardisation and objectivity involved are desirable for communication purposes.

Soil-landscape: A mapping unit that is defined in terms of landform and soils. In WA a hierarchy of soil-landscape mapping units has been defined (regions, provinces, zones, systems, subsystems and subsystem phases).

Soil profile class: A survey-specific grouping of soil profiles based on the frequency distribution of attributes.

Soil series: A unit of soil classification (or a soil taxonomic unit) for describing soils which are alike in all major profile characteristics. Each soil series is developed from a particular *parent material*, or group of parent materials, under similar environmental conditions. The name is geographic in nature and indicates a locality where the series is well developed (adapted from Houghton and Charman 1986).

Soil taxonomic unit: A conceptual soil unit with defined class limits. Usually identified within a national soil classification system.

Soil type: An obsolete term used to describe subdivisions of a soil series based on variants in soil texture.

Soil variant: A soil taxonomic unit with properties that exclude it from the named unit which it is associated, but which are not extensive enough to warrant a taxa identification in its own right.

Terminology references

McKenzie, N.J., Ringrose-Voase, A.J. and Grundy, M.J. (in press). Australian Soil and Land Survey Handbook. Guidelines for Conducting Surveys. CSIRO Australia.

Austin, M.P. and Cocks, K.D. (1978). Land use on the south coast of New South Wales. A study in methods acquiring and using information to analyse regional land use options. CSIRO Melbourne.

Dixon, J. (1986). Classification of land capability. Department of Agriculture Technote 2/86.

FAO (1976). A framework for land evaluation. Food and Agriculture Organisation of the United Nations, Rome. Soils Bulletin 32.

Houghton, P.D. and Charman, P.E.V. (1986). A glossary of terms used in soil conservation. Soil Conservation Service of New South Wales, Sydney.

Klingebiel, A.A. and Montgomery, P.H. (1961). 'Land capability classification.' Soil Conservation Service, United States Department of Agriculture. Agricultural Handbook p. 210.

Olson, G.W. (1973). Soil survey interpretation for engineering purposes. FAO Soils Bulletin 19.

Wells, M.R. and King, P.D. (1989). Land capability assessment methodology. Land Resource Series No. 1, Western Australian Department of Agriculture.

APPENDIX 5. LAND CAPABILITY TABLES FOR LUPINS, OATS, BARLEY, CANOLA AND WHEAT

Table A5.1 Lupin capability (from van Gool and Vernon 2006a)

Land Quality	LC1	LC2	LC3	LC4	LC5
Permeability	R VR	M MR	MS	S	VS XX
pH at 0-10 cm (zf)	Mac Slac N	Sac	Vsac		Malk Salk XX
pH at 50-80 cm (zg)	Slac N	Sac Mac	Vsac	Malk	Salk XX
Salinity hazard (y)	NR PR MR	HR			PS XX
Surface salinity (ze)	N			S	M H E XX
Salt spray exposure (zi)	N				S XX
Surface condition	L S F LG SG SM FG SL	X K	C		HS XX
Trafficability (zk)	G F		P		VP XX
Rooting depth (r)	VD D		M	MS	S VS XX
Waterlogging / inundation risk (i)	N	VL	L		M H VH XX
Water repellence susceptibility (za)	N L M		H XX		
Soil water storage (m)	H M	ML L	VL XX		
Soil workability (k)	G F P VP XX				

Table A5.2. Oats capability (from Vernon and van Gool 2006b)

Land Quality	LC1	LC2	LC3	LC4	LC5
Flood hazard (f)	N L		M	H XX	
pH at 0-10 cm (zf)	Slac N	Mac	Sac	Vsac Malk XX	Salk
pH at 50-80 cm (zg)	Slac N	Sac Mac	Vsac Malk XX		Salk
Phosphorus export risk (n)	L	M H	VH	E XX	
Salinity hazard (y)	NR		PR	MR HR	PS XX
Surface salinity (ze)	N		S	M	H E XX
Salt spray exposure (zi)	N			S XX	
Surface soil structure decline susceptibility (zb)	L	M	H XX		
Subsurface acidification susceptibility (zd)	L	M	H P	XX	
Subsurface compaction susceptibility (zc)	L	M H XX			
Trafficability (zk)	G	F		P	VP XX
Rooting depth (r)	VD D	M	MS		S VS XX
Water erosion hazard (e)	VL L	M	H	VH	E XX
Waterlogging / inundation risk (i)	N VL L	M	H	VH XX	

Land Quality	LC1	LC2	LC3	LC4	LC5
Water repellence susceptibility (za)	N L	M H XX			
Soil water storage (m)	H	M ML	L	VL XX	
Wind erosion risk (w)	L	M	H VH		E XX

Table A5.3 Barley capability (from van Gool and Vernon 2006b)

Land quality	LC1	LC2	LC3	LC4	LC5
Flood hazard (f)	N L		M	H XX	
pH at 0-10 cm (zf)	Slac N	Mac Malk	Sac	Vsac Salk XX	
pH at 50-80 cm (zg)	Slac N	Mac Malk	Salk	Sac XX	Vsac
Phosphorus export risk (n)	L	M H	VH	E XX	
Salinity hazard (y)	NR		PR	MR HR	PS XX
Surface salinity (ze)	N	S	M		H E XX
Salt spray exposure (zi)	N			S XX	
Surface soil structure decline susceptibility (zb)	L	M	H XX		
Subsurface acidification susceptibility (zd)	L	M	H		P XX
Subsurface compaction susceptibility (zc)	L	M XX	H		
Trafficability (zk)	G	F		P	VP XX
Rooting depth (r)	VD D	M	MS		S VS XX
Water erosion hazard (e)	VL L	M	H	VH	E XX
Waterlogging / inundation risk (i)	N	VL	H	M H	VH XX
Water repellence susceptibility (za)	N L	M H XX			
Soil water storage (m)	H M	ML L		VL XX	
Wind erosion risk (w)	L	M	H	VH	E XX

Table A5.4 Canola capability. (from Vernon and van Gool 2006a)

Land quality	LC1	LC2	LC3	LC4	LC5
Flood hazard (f)	N L		M	H XX	
pH at 0-10 cm (zf)	Slac N	Mac	Sac Malk	Vsac Salk XX	
pH at 50-80 cm (zg)	Slac N	Sac Mac Malk	Vsac XX	Salk	
Phosphorus export risk (n)	L	M H	VH	E XX	
Salinity hazard (y)	NR		PR	MR HR	PS XX
Surface salinity (ze)	N		S	M	H E XX
Salt spray exposure (zi)	N			S XX	
Surface soil structure decline susceptibility (zb)	L	M	H XX		

Land quality	LC1	LC2	LC3	LC4	LC5
Subsurface acidification susceptibility (zd)	L	M	H P	XX	
Subsurface compaction susceptibility (zc)	L	M XX	H		
Trafficability (zk)	G	F		P	VP XX
Rooting depth (r)	VD D		M	MS	S VS XX
Water erosion hazard (e)	VL L	M	H	VH	E XX
Waterlogging/inundation risk (i)	N	VL	L M	H	VH XX
Water repellence susceptibility (za)	N L	M H XX			
Soil water storage (m)	H	M ML	L	VL XX	
Wind erosion risk (w)		M	H VH		E XX

Table A5.5 Wheat capability (from van Gool and Vernon 2005)

Land quality	LC1	LC2	LC3	LC4	LC5
Flood hazard (f)	N L		M	H XX	
pH at 0-10 cm (zf)	Slac N	Mac Malk	Sac	Vsac Salk XX	
pH at 50-80 cm (zg)	Slac N	Sac Mac Malk	Vsac Salk XX		
Phosphorus export risk (n)	L	M H	VH	E XX	
Salinity hazard (y)	NR		PR	MR HR	PS XX
Surface salinity (ze)	N	S		M	H E XX
Salt spray exposure (zi)	N			S XX	
Surface soil structure decline susceptibility (zb)	L	M	H XX		
Subsurface acidification susceptibility (zd)	L	M	H P	XX	
Subsurface compaction susceptibility (zc)	L	M H XX			
Trafficability (zk)	G	F		P	VP XX
Rooting depth (r)	VD D	M	MS		S VS XX
Water erosion hazard (e)	VL L	M	H	VH	E XX
Waterlogging/inundation risk (i)	N	VL L	M	H	VH XX
Water repellence susceptibility (za)	N L	M H XX			
Soil water storage (m)	H	M ML	L	VL XX	
Wind erosion risk (w)	L	M	H VH		E XX

The five publications by van Gool and Vernon listed above can be accessed through the website:

www.agric.wa.gov.au/pls/portal30/docs/FOLDER/IKMP/LWE/RPM/LANDCAP/WHEAT_AND_CLIMATE.PDF. (Accessed, 19 October 2005)