APPENDIX A. NOTES TO ACCOMPANY LAND CAPABILITY RATING TABLES

A.1 Total amount of water available to plants

Available Water Capacity (AWC) is a measure of the amount of usable water in the soil for plant growth. It is determined from the difference between the amount of water retained by the soil after drainage (field capacity) and the moisture content of a soil at wilting (permanent wilting point). There is a reasonable correlation between soil texture and AWC (Salter and Williams 1969) (Table A.1)

Table A.1 Available water capacity of soils.

Range (mm/m)	Average value for calculations (mm/m)	Sands	Sandy loams	Loams	Clay loams	Clays
76 - 100	90	KS				
101 - 125	110	LKS	KSL			
126 - 150	130	S				SC, C
151 - 175	160	CS, LS	SL	L	SCL	
176 - 200	190	FS	FSL	CL, ZL	ZCL	ZC
201 - 225	210	LFS				

The total amount of water available to plants can be calculated by adding the amount of available water in each horizon down to a maximum depth of 2 metres. Note that gravel content of the soil horizons should be taken into account.

Soil horizon	Texture	Depth of horizon (m)	AWC of horizon (mm/m)	Available water in horizon (mm)
A	SL	0.15	160	24
B2	SC	1.25	130	143

For example, the total amount of water in the worked example above = 167 (Class 2)

A.2 Bearing capacity

Measurements were not taken of bearing capacities.

A.3 Coarse fragment sizes

Gravel: 2 - 60 mm
Cobbles: 60 - 200 mm
Stones: 200 - 600 mm
Boulders: 600 - 2000 mm

A.4 Linear shrinkage

The Linear Shrinkage and depth of solum can replace the value for reactivity of a soil. Reactivity is used in the Australian Standard AS 2870.2 (SAA 1977), and is based on the depth of the clay layer and its shrink-swell capacity. Different areas of Victoria are identified, with 0.6 m depth being a common cut-off mark between two categories.

A.5 Condition of the topsoil

The texture, organic matter content and the size/strength of soil aggregates all influence the general behaviour of soils when subjected to different agricultural land uses and management practices. The lack of knowledge relating the performance of soils to specific attributes does not allow values for the above criteria to be divided into meaningful classes - certainly not the 5-class system used in these land capability rating tables. The concept of "Condition of topsoil" combines the score placed on each criteria to give a total score that is then compared to a 5-class rating, (Table A.2).

Table A.2 Rating for topsoil condition.

Criteria	Description	Score
Texture	Sands	1
	Sandy loams	2
	Loams	5
	Clay loams	4
	Clays	3
Structure (grade)	Apedal, massive	1
	Apedal, loose	2
	Weak	3
	Moderate	4
	Strong	5
Structure(size)	Very large (> 200 mm)	1
	Large (50 - 200 mm)	2
	Moderate (10 - 50 mm)	4
	Small (2 - 10 mm)	5
	Very small (< 2 mm)	3
Organic matter content (org. C x 1.72)	Very low (< 1%)	1
	Low (1 - 2%)	2
	Moderate (2 - 3%)	4
	High (> 3%)	5
Nutrient status of topsoil (sum of exch. Ca, Mg, K)	Very low (< 4 meq/100g)	1
	Low (4-8 meq/100g)	2
	Moderate (9-18 meq/100g)	3
	High (19-30 meq/100g)	4
	Very high (> 30 meq\100g)	5
Rating for topsoil condition:	**Class** 1	**Total score**
	2	21 – 25
	3	16 – 20
	4	11 - 15
	5	6 - 10 5

For profiles with more than one A horizon, i.e. A1 and A2, top soil conditions should be determined separately for each horizon and then averaged.

Nutrient status of topsoil: The topsoil is considered the major source of nutrients for plant growth whereas the subsoil is the more reliable source of moisture. Nutrient status of topsoil = sum of exchangeable base cations (Ca, Mg, K) (Lorimer and Schoknecht 1987).

A.6 Depth to hard rock or impermeable layer

This criterion provides a measure of the effectiveness of the soil profile in filtering the nutrient and bacterial content from the effluent. The Septic Tank Code of Practice (Environment Protection Authority *et al.* 1990) requires a depth of at least one metre.

A.7 Depth to seasonal watertable

The Septic Tank Code of Practice (Environment Protection Authority *et al.* 1990) requires a minimum of one m depth of unsaturated soil for the proper functioning of effluent disposal trenches. Ideally the groundwater table should be much lower than one m, thereby reducing the risk of a rising groundwater table influencing the effectiveness of the absorption trenches. The risk of surface salting problems also increases when a saline groundwater table rises to within 1 - 1.5 m of the soil surface.

A.8 Depth of topsoil

Topsoil depth is considered during dam construction and is used when measuring the susceptibility of topsoils to erosion (Table A.10). Depth of topsoil influences the quantity of overburden that needs to be scraped clear and kept for spreading back on a dam embankment to establish a grass cover, once the construction is completed.

A.9 Dispersibility

Sustainable land use requires that the soil be able to withstand the physical forces of cultivation and compaction without adverse structural change. Soil aggregate stability can be measured by the Emerson Aggregate Test (Emerson 1977). In the case of secondary roads, dispersion can significantly effect the condition of the road when slopes are greater than 4%. Because of the close correlation between dispersible soils and high exchangeable sodium percentages in those soils, it is unnecessary to include both criteria in the capability rating table.

A.10 Drainage

This parameter is the combination of several criteria that influence the moisture status of the soil profile, *viz* slope, subsurface and surface flow, water holding capacity, level of groundwater tables, perched or permanent, and permeability. Only because of its general usage, reasonable definition (McDonald *et al*. 1984) and direct relevance to effluent disposal fields, building foundations and secondary roads has this criterion been retained.

A.11 Electrical conductivity

The following correlation in Table A.3 between the electrical conductivity of soil samples taken from the 0 - 50 cm layer of the soil profile and soil salinity has been established.

Table A.3 The effects of soil salting on plant growth.

Class	Severity of salting	E.C. dS/m *	Site characteristics
1	Nil/very low	< 0.3	Plant growth unaffected
2	Low	0.30 - 0.53	Growth of salt-sensitive plants, eg cereals and clover is restricted
3	Moderate	0.53 - 1.26	Patchy pasture growth; salt-sensitive plants are replaced with species that are more salt-tolerant
4	High	1.26 - 2.5	Small areas of bare ground; surviving plant species have high salt tolerance
5	Very high/severe	> 2.5	Large areas of bare ground; highly salt-tolerant plants; trees may be dead or dying

* **NB: 1000 μS/cm = 1 dS/m**

A.12 Flooding risk

Building regulations prohibit building on flood-prone land, therefore land with some risk of flooding must be identified. Flooding is unlikely to cause a septic tank to fail, however the risk of polluting the floodwaters with phosphorus, nitrogen and bacterial organisms increases with the number of effluent disposal fields involved. The dilution factor will be dependent on the quantity of floodwater.

Dams are built to intercept and store run-off water. It is not possible in these tables to distinguish between seasonal run-off and seasonal flooding; the latter poses a threat to the stability of the dam, and the risk of flooding will depend on the intensity and duration of rainfall, the run-off characteristics of the catchment and the land use within the catchment. Flooding risk is rated in Table A.4

Table A.4 Flooding risk.

Risk	Class	Limitation	Condition of flood
Nil	1	No limitation	No flooding
Low	2	Minor	Minor inundation No debris Flood return period: annual
Moderate	3	Significant	Broad, slow moving No debris Flood return period: 1 in 20 to 1 in 50 years
High	4	Major	Broad, slow moving Little debris Flood return period: 1 in 100 years
Severe	5	Prohibitive	Deep channel, fast flowing Debris carrying Flood return period: 1 in 100 years

A.13 Length of the growing season

Agricultural production is governed by moisture, temperature and photoperiod (photoperiod is taken to be consistent throughout Victoria).

Length of Growing Season (months) = 12 - (P + T)
P = Number of months where monthly evapotranspiration > average monthly rainfall
T = Number of months where mean monthly temperature < 6^{o} C

A.14 Number of months per year when average daily rainfall > K_{sat}

This parameter is included (although it is closely aligned to drainage) to provide an indication from climatic, rather than soil and topographic data, of the period of time each year when effluent absorption trenches might cease to function.

Data required:
- Average monthly rainfall figures.
- Average number of wet days for each month.
- K_{sat} values.

Assumptions made:
- Evapotranspiration <1 for winter months.
- Winter-early spring months are when problems arise.
- The soil profile is at field capacity.
- Where slope is significant, run-off = run-on.

A.15 Permeability of a soil profile (K_{sat})

Permeability is controlled by the least permeable layer of a soil profile and its ability to transmit water. Permeability is independent of climate and surface drainage. The rate at which water moves down through the soil profile is an indicator of the tendency of a soil to saturate, it is an important feature if plant growth is to be maintained in areas where rainfall is spasmodic or unreliable.

Permeability provides a measure of the rate at which a saturated soil profile will conduct water to depth. K_{sat} measurements may over-estimate the value for the disposal of effluent because the soil macropores are transmitting water, whereas the real situation must take into account the clogging effect of effluent on the bottom of effluent disposal trenches, thereby reducing the rate of water movement into the soil.

The measurement of K_{sat} often produces quite variable results even between replicates on the same site, so the setting of class limits is difficult and by necessity must be very broad. Estimates of permeability can be made using the features of the least permeable soil horizon if K_{sat} values are not available, however it should be clearly indicated where estimates have been made (Table A.5).

Table A.5 Permeability characteristics of a soil profile.

Estimated permeability	Ksat range (mm/day)	Time taken for saturated soil to drain to field capacity	Soil features
Very low	< 10	Months	Absence of visible pores
Low	10 - 100	Weeks	Some pores visible
Moderate	100 - 500	Days	Clearly visible pores
High	500 - 1500	Hours	Large, continuous clearly visible pores
Very high	1500 - 3000	Rarely saturated	Abundant large pores
Excessive	> 3000	Never saturated	No restriction to water movement through the soil profile

A.16 Index for permeability/rainfall

This relationship has been included to take into account the situation where a strongly structured soil with very high permeability would be assessed as having a major limitation. In a dry climate, this would be correct as the soil would be drought-prone most of the year, however in a high rainfall area such a soil may be highly productive. Conversely a soil with low permeability may experience waterlogging for extended periods in a high rainfall area, but store sufficient moisture to extend the average growing season of a low rainfall area. A method of combining permeability and rainfall is shown in Table A.6.

Table A.6 Index for permeability/rainfall.

Permeability		Average annual rainfall (mm/year)				
Estimated	**Ksat (mm/day)**	**< 400**	**400 - 600**	**600 - 800**	**800 - 1000**	**> 1000**
Very low	< 10	High	High	Moderate	Low	Very low
Low	10 - 100	High	Very high	High	Moderate	Low
Moderate	100 - 500	Moderate	High	Very high	High	Moderate
High	500 - 1500	Low	Moderate	High	Very high	High
Very high	> 1500	Very low	Low	Moderate	High	Very high

A.17 Rock outcrop

This estimate has not been included as a parameter that influences the performance of earthen dams because the parameter, depth to hard rock, is inversely correlated to the proportion of rock outcropping at the soil surface, and is a good surrogate.

A.18 Slope

As the slope increases, so too does the chance of run-on water entering effluent disposal trenches and saturating the system. In addition, run-off of unfiltered effluent is more likely to enter minor drainage depressions and water courses. The increasing incidence of algal blooms in water storages emphasises the need to eliminate the entry of unfiltered effluent into watercourses.

The best ratio of earth moved to water stored in dams occurs on land with slopes between 3-7%. Gentler slopes involve greater expense as the above ratio approaches unity, whereas steeper slopes require higher embankments for proportionally less water stored.

A.19 Susceptibility to gully erosion

No single factor can adequately represent the susceptibility of an area to the gully erosion process. A number of factors are involved and each should be scored independently and then the sum of the scores can be related back to a 5 - class rating (Table A.7).

Table A.7 Susceptibility to gully erosion.

Criteria	Description	Score
Slope	< 1%	1
	1 - 3%	2
	4 - 10%	3
	11 - 32%	4
	> 32%	5
Sub-soil dispersibility	E1	5
	E2, E3(3), E3(4)	4
	E3(1), E3(2)	3
	E4, E5	2
	E6, E7, E8	1
Depth to rock/hardpan	0 - 0.5m	1
	0.6 - 1.0m	2
	1.1 - 1.5m	3
	1.6 - 2.0m	4
	> 2.0m	5
Subsoil structure	Apedal, massive Weak	1
	fine < 2 mm	3
	mod. 2 - 10 mm	2
	coarse > 10 mm Moderate	1
	fine < 2 mm	4
	mod. 2 - 10 mm	3
	coarse > 10 mm Strong	2
	fine < 2 mm	5
	mod. 2 - 10 mm	3
	coarse > 10 mm	1
	Apedal, single grained	5
Lithology of substrate	Basalt	1
	Volcanic	2
	Rhyodacite	2
	Granite	4
	Alluvium	3
	Colluvium	5
	Tillite	4
	Ordovician sandstone/mudstone	5
	Silurian sandstone/mudstone	4
Rating for susceptibility to gully erosion:	**Class**	**Total score**
	1. Very low	6 - 10
	2. Low	11 - 13
	3. Moderate	14 – 17
	4. High	18 – 20
	5. Very high	21 - 25

A.20 Susceptibility to slope failure

The instability of slopes in a catchment area of a dam poses a threat to the storage capacity of that dam. Additional costs are also involved if the dam requires regular desludging. This assessment considers that land slips are the result of factors such as soil depth, slope, soil texture, volume of water held in the soil, permeability of the solum and the underlying parent material. Since the quantity of water in a profile is itself a function of soil texture, depth and permeability, the table below is presented as a first attempt to assess the susceptibility of land to slope failure by relating the total amount of water in the soil profile to the slope (Table A.8).

Table A.8 Susceptibility to slope failure.

Slope %	Total amount of water in the soil profile		
	Low (< 70 mm H_20)	Moderate (70-170 mm H_20)	High (> 170 mm H_20)
Gentle < 10	Very low	Very low	Low
Moderate 10-32	Low	Moderate	High
Steep > 33	Moderate	High	Very high

A.21 Suitability of subsoil for earthen dams

Table A.9 In the building of earthen dams, suitability of subsoil is dependent on the nature of the material, which is represented by the Unified Soil Group classification, and depth of the material. Refer to

Table A.9 Suitability of subsoil for earthen dams.

Unified soil group of subsoil					
DEPTH OF SUBSOIL (m)	SP, SW, GP, GW, Pt, OH, OL	ML, MH	GM, CH, SM	CL	GC, SC
< 0.5	Very low	Very low	Very low	Very low	Very low
1.0 - 0.5	Very low	Low	Moderate	Moderate	Moderate
1.5 - 1.0	Very low	Moderate	High	High	High
> 1.5	Very low	Moderate	High	High	Very high

A.22 Susceptibility of soil to sheet and rill erosion by water

The table following (Table A.10) has been adapted from Elliott and Leys (1991). The erodibility index for a range of soil properties closely relates to the susceptibility of soils to erosion by water, and in the tables below, the same soil properties have been used (texture, structure grade, topsoil depth and dispersibility (Emerson aggregate test)) and then related to slope to determine a rating for susceptibility. The final rating for susceptibility to sheet/rill erosion is read from Table A.11 once the erodibility of the topsoil and the slope of the area have been assessed.

Table A.10 Erodibility of topsoils.

Texture group (A1)	Structure grade (A1)	Horizon depth (A1 + A2)	Dispersibility		
			VL-L E3(1), E3(2), E4 E5, E6, E7, E8	**M-H E3(3), E3(4) E2**	**VH E1**
Sand	apedal	< 0.2 m	M		
		0.2 - 0.4 m	L		
		> 0.4 m	L		
Sandy loam	Apedal	< 0.2 m	M	H	
		0.2 - 0.4 m	L	M	
		> 0.4 m	L		
	Weakly pedal	< 0.2 m	H	E	
		0.2 - 0.4 m	M	V	
		> 0.4 m	M		
Loam	Apedal	< 0.2 m	M	H	
		0.2 - 0.4 m	L	M	
		> 0.4 m	L		
	Weakly pedal	< 0.2 m	H	E	
		0.2 - 0.4 m	M	V	
		> 0.4 m	M		
	peds evident	< 0.2 m	H	E	
		0.2 - 0.4 m	H		
		> 0.4 m	H		
Clay loam	Apedal	< 0.2 m	M	H	
		0.2 - 0.4 m	L	M	
		> 0.4 m	L		
	Weakly pedal	< 0.2 m	H	E	
		0.2 - 0.4 m	M	V	
		> 0.4 m	M		
	peds evident	< 0.2 m	H	E	
		0.2 - 0.4 m	H	E	
		> 0.4 m	M		
Light clay	Weakly pedal	< 0.2 m	H	E	E
		0.2 - 0.4 m	M	V	E
		> 0.4 m	M	V	E
	peds evident	< 0.2 m	M	V	E
		0.2 - 0.4 m	M	H	E
		> 0.4 m	M	H	E
	highly pedal	< 0.2 m	H	E	
		0.2 - 0.4 m	M	V	
		> 0.4 m	M	V	
Medium to heavy clay	Weakly pedal	< 0.2 m	M	H	E
		0.2 - 0.4 m	M	H	V
		> 0.4 m	M	H	V
	peds evident	< 0.2 m	H	E	E
		0.2 - 0.4 m	M	V	E
		> 0.4 m	M	V	E
	highly pedal	< 0.2 m	H	E	E
		0.2 - 0.4 m	M	V	E
		> 0.4 m	M	V	E

L - Low M - Moderate H - High V - Very high E - Extreme

Table A.11 Susceptibility of soil to sheet and rill erosion.*

Slope %	Topsoil erodibility (from Table A.10)				
	Low	**Moderate**	**High**	**Very high**	**Extreme**
< 1 %	Very low	Very low	Low	Low	Moderate
1 - 3 %	Very low	Low	Moderate	Moderate	High
4 - 10%	Low	Moderate	Moderate	High	Very high
11 - 32%	Moderate	Moderate	High	Very high	Very high
> 32%	Moderate	High	Very high	Very high	Very high

***Note:** Topsoil erodibility is determined from the texture, structure, depth and dispersibility of the topsoil (Table A.10). The susceptibility of the topsoil to sheet and rill erosion relates to the combined effect of slope and topsoil erodibility (Table A.11).

A.23 Susceptibility of soil to erosion by wind

The susceptibility of land to wind erosion is a function of soil erodibility, the probability of erosive winds when the soil is dry and the exposure of the land component to wind (Lorimer 1985). Soil erodibility is a very important factor to consider in land capability rating tables (Table A.12).

Table A.12 Soil erodibility.

Soil type		Rating
1.	Surface soil has a strong blocky structure (aggregates > 0.8 mm), or is apedal and cohesive or has a dense layer of stones, rock or gravel	Very low
	Surface soil has strong fine structure (aggregates < 0.8 mm)	Moderate
	Surface soil has a weak-moderate structure or is apedal and loose	Go to 2
2.	Surface soils with organic matter > 20%	High
	Surface soils with organic matter 7 - 20%	Moderate
	Surface soils with organic matter < 7%	Go to 3
3.	Surface soils with the following textures:	
	Fine-medium sands	Very high
	Loamy sands	High
	Sandy loams, silty loams	High
	Loams, coarse sands	Moderate
	Clay loams	Low
	Clays	Very low

A.24 Susceptibility to acidification

Soil acidification is usually observed over time as a decrease in soil pH. It may take place in the topsoil or subsoil. Soil acidification will cause contrasting effects depending upon the initial pH of the soil. In general, soil pH below 4.5 ($CaCl_2$) will cause toxic aluminium and manganese to be released. This causes retarded root growth in plants and may increase leaching of soluble salts and nutrients into groundwater, rivers and streams.

Measurement of susceptibility to acidification for this report is based upon the following table (Table A.13) and analysis of topsoils from each map unit.

Table A.13 Susceptibility of soil to acidification.

Susceptibility	Texture	pH ($CaCl_2$)	Annual rainfall
Low	Medium Heavy	< 4.5 All	> 450mm > 450 mm
Moderate	Medium Light	> 4.5 < 4.5	> 450 mm > 450 mm
High	Light	> 4.5	> 450 mm

Note: Land management, such as pasture species and stocking rates can contribute to acidification. Organic matter is not used as an indicator for susceptibility as its effects are complex.