APPENDIX 1 - NOTES TO ACCOMPANY LAND CAPABILITY RATING TABLES

1. Total amount of water available to plants

This parameter 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) viz:

Table A1 – Available Water Capacity

Range	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, e.g.

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

TOTAL AMOUNT OF WATER: 167 (Class 2)

2. Bearing capacity

For the Marong land capability study, this measurements were not taken. A simple, repeatable field measurement is being sought.

3. Coarse fragment sizes

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

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 (1990) p. 16, 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 table comparing the two values with Classes 1 to 5 is required.

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 which is then compared to a 5-class rating, viz.

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 me%)	1
	Low (4-8 me%)	2
	Moderate (9-18 me%)	3
	High (19-30 me%)	4
	Very high (>30 me%)	5

Rating for topsoil condition:

Class	Total Score
1	21-25
2	16-20
3	11 - 15
4	6-10
5	1-5

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) and should be calculated on the Al and A2 horizons separately because of major differences in these horizons of some profiles.

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 EPA Septic Tank Code of Practice (1991) requires a depth of at least one metre.

7. Depth to seasonal watertable

The EPA Septic Tank Code of Practice (1991) requires a minimum of 1 m depth of unsaturated soil for the proper functioning of effluent disposal trenches. Ideally the groundwater table should be much lower than 1 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.

8. Depth of topsoil

This measurement has been excluded since major differences in the topsoil depth do not influence the performance or stability of an earthen dam. Topsoil depth only influences the quantity of overburden that needs to be scraped clear and kept for spreading back on the embankment to establish a grass cover, once the construction is completed.

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% only.

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.

10. Drainage

This parameter is the culmination of several criteria that influence the moisture status of the soil profile, viz slope, sub-surface 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.

11. Electrical conductivity (µS cm^{-1})

The electrical conductivity of a 1:5 soil-water suspension is a good indicator of the total dissolved salts - soil salinity - in a soil (USDA 1954, Matters and Bozon 1989). The following correlation in table A2 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 A2 - The effects of electrical conductivity on plant growth

Class	Severity of salting	E.C. µS cm^{-1}*	Site characteristics
1	Nil Very low	< 300	Plant growth unaffected
2	Low	300 - 530	Growth of salt-sensitive plants is restricted, e.g. cereals, clover
3	Moderate	530 - 1260	Patchy pasture growth; salt-sensitive plants are replaced with species that are more salt-tolerant
4	High	1260 - 2500	Small areas of bare ground; surviving plant species have high salt tolerance
5	Very high/severe	> 2500	Large areas of bare ground; highly salt-tolerant plants; trees may be dead or dying

* NB: 1000 µs cm^{-1} = 1 ds m^{-1}

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 P, N and bacterial organisms increases with the number of effluent disposal fields involved. The dilution factor will be dependant on the quantity of floodwater.

Dams are built to intercept and store runoff water. It is not possible in these tables to distinguish between seasonal runoff 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. The location of the dam and the design of the overflow structure will greatly reduce the adverse effect of floods.

13. Length of growing season

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

Length of growing season = 12

Minus No. of months were P (monthly Et > Av monthly R) >50%

Minus No. of months were av. Mean monthly temp < 6°C

Where

P: Probability
Et: Evapotranspiration
R: Rainfall

14. No. of months/yr 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.
- Ksat values.

Assumptions made:

- Evapotranspiration = 0 for winter months.
- The winter-early spring months are usually when problems arise.
- The soil profile is at field capacity.
- Where slope is significant, run-off = run-on.

Table A3 - 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 slow	< 10	Months	Absence of visible pores
Slow	10 - 100	Weeks	Some pores visible
Moderate	100 - 500	Moderate blocky structure	Clearly visible pores
Rapid	500 - 1500	Hours	Large, continuous clearly - visible pores
Very rapid	1500 - 3000	Rarely saturated	Abundant large pores
Excessive	> 3000	Never saturated	No restriction to water movement through the soil profile

15. Permeability of a soil profile (It)

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 also an indicator of the tendency of a soil to saturate - an important feature if plant growth is to be maintained in areas where rainfall is spasmodic or unreliable. High permeability in high rainfall areas and low permeability in low rainfall areas could be an advantage for plant growth.

Permeability provides a measure of the rate at which a saturated soil profile will conduct water to depth. Ksat measurements may give an over-estimated 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 Kit 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 Ksat values are not available, however it should be clearly indicated where estimates have been made, refer Table A3.

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 because 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 A4.

Table A4 - Index for permeability/rainfall

Index for permeability/rainfall						
Permeability		Average annual rainfall (mm/yr)				
Estimated	Ksat (mm/d)	< 400	400 - 600	600 - 800	800 -1000	> 1000
Very slow	< 10	High	High	Moderate	Low	Very low
Slow	10 - 100	High	Very high	High	Moderate	Low
Moderate	100 - 500	Moderate	High	Very high	High	Moderate
Rapid	500 - 1500	Low	Moderate	High	Very high	High
Very rapid	> 1500	Very low	Low	Moderate	High	Very high

17. Rock outcrop

This estimate has not been included as a parameter which 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.

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 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.

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 A5 - 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, E3.1, E3.2	4
	E3.3, E3.4	3
	E4, E5	2
	E6	1
Depth to rock/hardpan	0 - 0.5	1
	0.6 - 1.0	2
	1.1 - 1.5	3
	1.6 - 2.0	4
	> 2.0	5
Subsoil structure	Apedal, massive	1
	Weak fine, < 2 mm	3
	mod. 2 - 10 mm	2
	coarse, > 10 mm	1
	Moderate fine, < 2 mm	4
	mod. 2 - 10 mm	3
	coarse, > 10 mm	2
	Strong fine, < 2 mm	5
	mod. 2 - 10 mm	3
	coarse, > 10 mm	1
	Apedal, loose	5
Lithology of substrate	Basalt	1
	Volcanic	2
	Rhyodacite	2
	Granite	4
	Alluvium	3
	Colluvium	5
	Tillite	4
	Sediments	5
	Ordovician sandstone/mudstone	
	Silurian sandstone/mudstone	4
Rating for susceptibility to gully erosion:	Class	Total score
	1	1-10
	2	11-13
	3	14 - 17
	4	18-20
	5	21 - 25

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, and the permeability of the solum and the underlying parent material. Since the quantity of water in a profile is itself a product 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 A6 - Susceptibility to slope failure

Susceptibility to slope failure			
Total amount of water in the soil profile			
Slope	Low < 70 mm H_2O	Moderate 70-170 mm H_2O	High > 170 mm H_2O
Gentle, < 10%	Very low	Very low	Low
Moderate, 10-32%	Low	Moderate	High
Steep, > 32%	Moderate	High	Very high

21. Susceptibility to sheet/rill erosion by water

The table below (Table A8) 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 A9 once the credibility of the topsoil and the slope of the area have been assessed.

22. Suitability of subsoil

In the building of earthen dams, suitability of subsoil is dependent on the nature of the material, which is represented by the Universal Soil Group classification, and depth of the material.

Table A7 - Suitability of subsoil for earthen dams

	Universal Soil Group				
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	Very Low	Low	Low	Moderate
1.5 - 1.0	Very Low	Low	Moderate	Moderate	High
1.5 - 2.0	Very Low	Low	Moderate	Moderate	High
> 2.0	Very Low	Moderate	High	Very High	Very High

Table A8 - Erodibility of topsoils

Texture Group (A_1)	Structure Grade (A_1)	Horizon Depth ($A_1 + A_2$)	VL-LE_3,E_4,E_5	Dispersibility M-H	Dispersibility VH
				E_2	E_1
Sand	apedal	< 0.2 m	M		
		0.2-0.4 m	L		
		> 0.4m	L		
Sandy Loam	apedal	< 0.2 m	M	H	
		0.2-0.4 m	L	M	
		> 0.4m	L		
	weakly pedal	< 0.2 m	H	E	
		0.2-0.4 m	M	V	
		> 0.4m	M		
Loam	apedal	< 0.2 m	M	H	
		0.2-0.4 m	L	M	
		> 0.4m	L		
	weakly pedal	< 0.2 m	H	E	
		0.2-0.4 m	M	V	
		> 0.4m	M		
	peds evident	< 0.2 m	H	E	
		0.2-0.4 m	H		
		> 0.4m	H		
Clay Loam	apedal	< 0.2 m	M	H	
		0.2-0.4 m	L	M	
		> 0.4m	L		
	weakly pedal	< 0.2 m	H	E	
		0.2-0.4 m	M	V	
		> 0.4m	M		
	peds evident	< 0.2 m	H	E	
		0.2-0.4 m	H	E	
		> 0.4m	M		
Light Clay	weakly pedal	< 0.2 m	H	E	E
		0.2-0.4 m	M	V	E
		> 0.4m	M	V	E
	peds evident	< 0.2 m	M	V	E
		0.2-0.4 m	M	H	E
		> 0.4m	M	H	E
	highly pedal	< 0.2 m	H	E	
		0.2-0.4 m	M	V	
		> 0.4m	M	V	
Medium to Heavy Clay	weakly pedal	< 0.2 m	M	H	E
		0.2-0.4 m	M	H	V
		> 0.4m	M	H	V
	peds evident	< 0.2 m	H	E	E
		0.2-0.4 m	M	V	E
		>0.4m	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 A9 - Susceptibility to Sheet/Rill Erosion*

	Topsoil erodibility (from Table A8)				
Slope	**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	High	High	Very high
11-32%	Moderate	High	Very high	Very high	Very high
> 32%	High	Very high	Very high	Very high	Very high

* Topsoil erodibility is determined from the texture, structure, depth and dispersibility of the topsoil (Table A8). The susceptibility of the topsoil to sheet/rill erosion relates to the combined effect of slope and topsoil erodibility (Table A9).

23. Susceptibility to erosion by wind (Lorimer 1985)

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. Soil erodibility is the initial, most important factor to assess for the land capability rating tables.

Table A10 - Soil erodibility

	Rating	
1	Surface soil has a strong blocky structure (aggregates >0.8 mm), or is a pedal 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 weak-moderate structure or is apedal and loose	2
2	Surface soils with organic matter >20%	High
	Surface soils with organic matter 7-20%	Moderate
	Surface soils with organic mater <7%	3
3	Surface soils with the following texture:	
	- Fine-medium sands	Very high
	- Loamy sands	High
	- Sandy loams, silty loams	High
	- Clay loams	Moderate
	- clays Very low	Low

24. Transpiration beds

Transpiration beds are more suitable than absorption trenches when:

i) soil depths are shallow, e.g. < 75 cm deep
ii) and/or when Ksat values are low, e.g. < 10 mm/day
iii) and/or when rainfall is > 900 mm/yr.