National Land and Water Resources Audit

Extent and impacts of Dryland Salinity in Tasmania

Project 1A

VOLUME 2 - APPENDICES

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Tasmania

DEPARTMENT *of*
PRIMARY INDUSTRIES,
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LIST OF APPENDICES

Appendix 1

LAND SYSTEMS IN TASMANIA CONTAINING AREAS OF SALINITY

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- The Soil Conservation section of the Tasmanian Department of Agriculture between 1980 and 1989 carried out a series of reconnaissance surveys of the State's land resources.

- It was intended that the data collected would allow a more rational approach to Tasmania's soil conservation problems and serve as a base for further studies, such as the detailed mapping of land resources in selected areas and the sampling of soils for physical and chemical analyses. It was therefore decided that this would be a logical framework on which to develop the Dryland Salinity Audit process.

- Land resources result from the interaction of geology, climate, topography, soils and vegetation

- Areas where these are considered to be relatively uniform for broad scale uses are classified as land components. **Land components are grouped into larger entities called land systems, which are the mapping units used for this Audit.**

- The land systems were differentiated initially by examining geomorphic patterns on aerial photographs in conjunction with geologic, topographic and climatic maps.

- All three parameters are relevant to understanding the salinity process. Geological data can indicate where salt stores are likely to occur whilst topography can indicate where overlying soils are likely to accumulate salt – while some saline areas in Tasmania pre-date white settlement, it is commonly associated with either the clearing of native vegetation in catchments or the effects of irrigation.

- Annual rainfall is the climatic parameter and thus enables the land systems to be linked to the definition of "Dryland".

- Comprehensive descriptions of the land systems are included in seven Departmental reports (Department of Agriculture, 1978 – 89) :

Region	**Author**	**Date**
1: King Island	Richley, L.R.	1984
2: Flinders Island	Pinkard, G.J	1982
3: North West	Richley, L.R.	1978
4: North East	Pinkard, G.J	1980
5: Central Plateau	Pemberton, M	1986
6: South, East and Midlands	Davies, J	1988
7: South West	Pemberton, M	1989

- The vast majority of salinity occurs in Regions 2, 4 and 6. These regions contain 258 land systems. Forty-one were identified by Grice (1995) as containing saline areas in 1992, and a further nine by Finnigan (2000), a total of 50.

- Each land system is described by a six digit code, based on rainfall, geology, surface rock or sediment, altitude, land form and a final unique land system number.

Table 1: The six digit land system code

- **First digit** — ***Annual Rainfall***

1	375 – 500
2	500 – 625
3	625 – 750
4	750 – 1000
5	1000 – 1250
6	1250 – 1500
7	1500 – 2000
8	2000 – 2500
9	2500 +

- **Second digit** — ***Surface Material geological age***

0	Precambrian (metamorphosed)
1	Precambrian (unmetamorphosed)
2	Cambrian
3	Ordovician
4	Silurian/Devonian
5	Lower Devonian/Cambrian
6	Carboniferous/Permian
7	Triassic/Jurassic
8	Tertiary
9	Quaternary

- **Third digit** — ***Surface rock or sediment***

1	Acid igneous (e.g. granite, granodiorite)
2	Basic igneous (e.g. dolerite, basalt)
3	Sedimentary siliceous (e.g. sands, sandstone)
4	Sedimentary argillaceous (e.g. mudstone)
5	Sedimentary calcareous (e.g. limestone, dolomite)
6	Sedimentary rudaceous (e.g. conglomerate)
7	Metamorphic (e.g. quartzite, schist)
8	Complexes of the above and / or peat deposits

- **Fourth digit** — ***Altitude***

1	0 – 300m
2	300 – 600m
3	600 – 900m
4	900 – 1200m
5	1200 – 1500m
6	1500 – 1800m

- **Fifth digit** — ***Land forms***

1	Flat plains
2	Undulating plains
3	Low hills
4	Hills

5 Mountains
6 Coastal dunes and beaches

- **Sixth digit** ***Unique land system number***
  First five digits the same, different soil or vegetation

Table 2: Land Systems containing areas of salinity – summary by 6 digit code

1st Digit	**Annual Rainfall (mm)**	**No.**	**2nd Digit**	**Geological Period**	**No.**
1	375 – 500	5	1	Precambrian	-
2	500 – 625	20	2	Cambrian	-
3	625 – 750	11	3	Ordovician	-
4	750 – 1 000	14	4	Silurian/Devonian	-
5	1 000 – 1 250	-	5	Lower	-
				Devonian/Cambrian	-
6	1 250 – 1 500	-	6	Carboniferous/Permian	2
7	1 500 – 2 000	-	7	Triassic/Jurassic	10
			8	Tertiary	13
			9	Quaternary	25
	Total	**50**		**Total**	**50**
3rd Digit	**Rock Type – e.g.**	**No.**	**4th Digit**	**Altitude (m)**	**No.**
1	granite, granodiorite,	-	1	0 – 300	47
2	dolerite, basalt	6	2	300 – 600	3
3	sands, sandstone	23	3	600 – 900	-
4	mudstone	8	4	900 – 1 000	-
5	limestone, dolomite	-	5	1200 – 1 500	-
6	conglomerates	-			
7	quartzite, schist	-			
8	complexes of the above and / or peat deposits	13			
	Total	**50**		**Total**	**50**
5th Digit	**Topography**	**No.**	**6th Digit**	**Unique descriptor**	**No.**
1	Flat plains	6	1	Based on soils and vegetation	
2	Undulating plains	28	2		
3	Low hills (less than 100m)	13	3		
4	Hills (100 – 300m)	3	4		
5	Mountains (over 300m)	-	5		
6	Coastal dunes and beaches	-	6		
			7		
			8		
			9		
	Total	**50**			

Table 3: Land system code – 2nd & 3rd digit (geological period and surface rock) total area containing saline soil, ha (%) as assessed by Grice (1995)

	3rd	**2**	**3**	**4**	**8**	
2nd		Dolerite	Sands, Sandstone	Mudstone	Complexes	**Total**
7	Triassic	3 088 (1.7)	8 858 (4.9)	-	279 (-)	**12 225 (6.7)**
8	Tertiary	5 418 (3.0)	-	44 496 (24.9)	8 705 (4.8)	**58 619 (32.6)**
9	Quaternary	-	97 925 (54.5)	4 319 (2.4)	6 685 (3.7)	**108 929 (60.6)**
	Total	**8 506 (4.7)**	**106 783 (59.5)**	**48 816 (27.2)**	**15 669 (8.6)**	**179 773 (100)**

Table 4: Additional area containing saline soil, ha (%) as assessed by Finnigan (2000)

	3rd	**2**	**3**	**4**	**8**	
2nd		Dolerite	Sands, Sandstone	Mudstone	Complexes	**Total**
6	Cambrian	-	-	261 (0.8)	6 525 (19.3)	**6 786 (20.1)**
7	Triassic	8 114 (24.0)	4 005 (11.8)	-	10 791 (31.9)	**22 910 (67.7)**
8	Tertiary	861 (2.5)	-	-	2 442 (7.2)	**3 303 (9.7)**
9	Quaternary	-	-	-	861 (2.5)	**861 (2.5)**
	Total	**8 975 (26.5)**	**4 005 (11.8)**	**261 (0.8)**	**20 619 (60.9)**	**33 860 (100)**

Table 5: Description of land systems and salinity rating (Grice, 1995, and Finnigan, 2000)

Grice rating 1 = Nil *2 = Moderate* ***3 = Severe***

Land System		Map 1:100 000	Land System Component		Grice Rating *
Number	**Area (ha)**		**Description**	**%**	
173121	10 500	Lake Sorell	Crests/slopes	20	1
			Well drained flats	65	1
			Saline drainage flat	*5*	*2*
			Saline lagoon flats	***5***	***3***
			Drainage lines/flats	*5*	*2*
		Little Swanport	Crests/slopes	20	
			Well drained flats	65	1
			Saline drainage flats	*5*	*2*
			Saline lagoon flats	*5*	*2*
			Drainage lines/flats	*5*	*2*
198121	8 298	Lake Sorell	Upper terraces	30	1
			Upper terraces	30	1
			Upper terraces	20	1
			Upper terraces	*10*	*2*
			Recent flood plains	*10*	*2*
		South Esk	Upper terraces	30	1
			Upper terraces	30	1
			Upper terraces	20	1
			Upper terraces	10	1
			Recent flood plains	*10*	*2*
		Little Swanport	Upper terraces	30	1
			Upper terraces	30	1
			Upper terraces	20	1
			Upper terraces	10	1
			Recent flood plains	10	1
272131	7 900	South Esk	Upper slopes	60	1
			Lower slopes	*40*	*2*
273121	1 300	South Esk	Upper plains	60	1
			Lower plains	*40*	*2*
273122	8 078	Lake Sorell	Stony crests/upper slopes	10	1
			Mid slopes	10	1
			Lower slopes/flats	30	1
			Drainage flats/lagoons	*30*	*2*
			Saline drainage flats	*10*	*2*
			Drainage lines	*10*	*2*
		South Esk	Stony crests/upper slopes	10	1
			Mid slopes	10	1
			Lower slopes/flats	30	1
			Drainage flats/lagoons	30	1
			Saline drainage flats	10	1
			Drainage lines	10	1

273133	5 511	Little Swanport	Stony crests/slopes Lower slopes *Sandy flats* *Sandy flats* *Sandy flats* *Drainage flats*	20 20 *20* *20* *10* *10*	1 1 *2* *2* *2* *2*
		Freycinet	Stony crests/slopes Lower slopes *Sandy flats* *Sandy flats* *Sandy flats* *Drainage flats*	20 20 *20* *20* *10* *10*	1 1 *2* *2* *2* *2*
278141	24 599	Derwent	Mudstone crests/slopes Sandstone crests/slopes Lower slopes Lower slopes Flats Drainage flats	20 20 20 20 10 10	1 1 1 1 1 1
		Lake Sorell	Mudstone crests/slopes Sandstone crests/slopes Lower slopes Lower slopes Flats *Drainage flats*	20 20 20 20 10 *10*	1 1 1 1 1 *2*
282131	2 620	South Esk	Crests and scarps Mid slopes *Lower slopes*	20 45 *55*	1 1 *2*
		St Pauls	Crests and scarps Mid slopes *Lower slopes*	20 45 *35*	1 1 *2*
282133	10 435	South Esk	Crests (shallow stony) Crests (deep soiled) Lower slopes/undulating plains *Drainage lines*	20 20 50 *10*	1 1 1 *2*
		St Pauls	Crests (shallow stony) Crests (deep soiled) *Lower slopes/undulating plains* *Drainage lines*	20 20 *50* *10*	1 1 *2* *2*
284131	4 442	Lake Sorell	Crests/upper slopes Mid slopes *Saline drainage flats*	40 40 *20*	1 1 *2*
288123	8 901	Derwent	*Upper terraces* *Sandy Terraces* *Lower terraces* *Drainage lines/flats*	*60* *10* *10* *10*	*2* *2* *2* *2*
293121	7 735	South Esk	Lower river terraces *Present floodplains*	65 *35*	1 *2*

293122	8 130	South Esk	Upper terrace *Lower terrace*	80 *20*	1 *2*
		St Pauls	Upper terrace Lower terrace	80 20	1 1
293123	7 620	South Esk	*Isolated dunes*	*100*	*2*
298114	7 142	Derwent	Upper terraces Lower terraces Recent flood plains	40 30 30	1 1 2
		Lake Sorell	Upper terraces Lower terraces *Recent flood plains*	40 30 *30*	1 1 *2*
298128	1 068	Freycinet	Low sandy crests Low stony dolerite crests Drainage flats *Drainage flats*	25 25 25 *25*	1 1 1 *2*
298133	6 637	South Esk	Rocky dolerite crests Well drained flats ***Sandy slopes*** ***Sandy flats*** *Drainage flats*	10 30 ***30*** ***20*** *10*	1 1 ***3*** ***3*** *2*
		St Pauls	Rocky dolerite crests Well drained flats ***Sandy slopes*** ***Sandy flats*** *Drainage flats*	10 30 ***30*** ***20*** *10*	1 1 ***3*** ***3*** *2*
298225	8 986	Shannon	Stony rises Sandy flats Flats Sandy flats *Drainage lines/flats* *Drainage flats*	20 20 20 20 *10* *10*	1 1 1 1 *2* *2*
		Lake Sorell	Stony rises Sandy flats Flats Sandy flats *Drainage lines/flats* *Drainage flats*	20 20 20 20 *10* *10*	1 1 1 1 *2* *2*
382131	7 825	South Esk	Crests and upper scarps Lower plateaux *Lower scarps and swales*	25 50 *25*	1 1 *2*
		St Patricks	Crests and upper scarps Lower plateaux Lower scarps and swales	25 50 25	1 1 1
		St Pauls	Crests and upper scarps Lower plateaux *Lower scarps and swales*	25 50 *25*	1 1 *2*

384121	29 800	Meander	*Residual surface* *Dissected plain* *Flat valley bottom*	*30* *45* *25*	*2* *2* *2*
		South Esk	Residual surface *Dissected plain* *Flat valley bottom*	30 *45* *25*	1 *2* *2*
384131	8 180	South Esk	Upper bench *Upper scarp* *Lower bench* *Lower scarp* *Drainage*	20 *20* *30* *20* *10*	1 *2* *2* *2* *2*
		St Patricks	*Upper bench* *Upper scarp* *Lower bench* *Lower scarp* *Drainage*	*20* *20* *30* *20* *10*	*2* *2* *2* *2* *2*
393111	1 880	Meander	***Lunettes*** ***Lagoon floors***	***15*** ***85***	***3*** ***3***
		South Esk	***Lunettes*** ***Lagoon floors***	***15*** ***85***	***3*** ***3***
393121	48 200	Meander	River terraces River terraces Present floodplains	50 10 40	1 1 1
		Tamar	River terraces River terraces Present floodplains	50 10 40	1 1 1
		South Esk	*River terraces* *River terraces* *Present floodplains*	*50* *10* *40*	*2* *2* *2*
		St Patricks	River terraces River terraces Present floodplains	50 10 40	1 1 1
		St Pauls	River terraces *River terraces* Present floodplains	50 *10* 40	1 *2* 1
		Break O’Day	River terraces River terraces Present floodplains	50 10 40	1 1 1

393123	5 100	Tamar	*Old dunes* *Swales* *Plains*	*50* *10* *40*	*2* *2* *2*
		St Patricks	*Old dunes* *Swales* *Plains*	*50* *10* *40*	*2* *2* *2*
		Ninth Island	*Old dunes* *Swales* *Plains*	*50* *10* *40*	*2* *2* *2*
		Break O'Day	*Old dunes* *Swales* *Plains*	*50* *10* *40*	*2* *2* *2*
		Georges Bay	Old dunes Swales Plains	50 10 40	1 1 1
393124	44 375	St Patricks	*Ridges* *Flats* *Gently sloping plains* *Drainage lines*	*35* *25* *25* *15*	*2* *2* *2* *2*
		Ninth Island	Ridges Flats Gently sloping plains Drainage lines	35 25 25 15	1 1 1 1
		Forester	*Ridges* *Flats* *Gently sloping plains* *Drainage lines*	*35* *25* *25* *15*	*2* *2* *2* *2*
		Cape Portland	*Ridges* *Flats* *Gently sloping plains* *Drainage lines*	*35* *25* *25* *15*	*2* *2* *2* *2*
		Goose Island	Ridges Flats Gently sloping plains Drainage lines	35 25 25 15	1 1 1 1
		Swan Is	Ridges Flats Gently sloping plains Drainage lines	35 25 25 15	1 1 1 1
		Lady Barron	Ridges Flats Gently sloping plains Drainage lines	35 25 25 15	1 1 1 1

394121	19 000	South Esk	River terrace *Small gentle scarps*	80 *20*	1 *2*
		St Patricks	River terrace *Small gentle scarps*	80 *20*	1 *2*
404111	6 406	King Island	*Flat plain*	*100*	*2*
484122	10 105	St Patricks	*Upper slopes* *Dissected mid slopes* *Upper marine bench* *Lower marine bench*	*15* *50* *20* *15*	*2* *2* *2* *2*
484123	6 145	Tamar	Residual surface Upper plain Mid plain Lower plain and swale	20 30 35 15	1 1 1 1
		St Patricks	*Residual surface* *Upper plain* *Mid plain* *Lower plain and swale*	*20* *30* *35* *15*	*2* *2* *2* *2*
493121	11 480	Meander	Plains Upper terrace Lower terrace Flood plain	30 35 20 15	1 1 1 1
		Tamar	*Plains* *Upper terrace* *Lower terrace* *Flood plain*	*30* *35* *20* *15*	*2* *2* *2* *2*
		St Patricks	*Plains* *Upper terrace* *Lower terrace* *Flood plain*	*30* *35* *20* *15*	*2* *2* *2* *2*
493122	11 885	Tamar	*River terraces and flood plains* *Mud flats*	*95* *5*	*2* *2*
		St Patricks	*River terraces and flood plains* *Mud flats*	*95* *5*	*2* *2*
		Ninth Island	River terraces and flood plains *Mud flats*	95 *5*	1 *2*
493124	14 580	Tamar	Old dunes *Plains*	55 *45*	1 *2*
		George's Bay	Old dunes Plains	55 45	1 1
		Swan Island	Old dunes Plains	55 45	1 1

493126	4 520	Lady Barron	Dunes Low rises *Swales* *Ridges*	15 35 *30* *20*	1 1 *2* *2*
493127	24 890	Killecrankie	Ridges *Flat plains* Low ridges *Broad flats* Small rises *Old coastal lagoons*	10 *20* 15 *25* 15 *15*	1 *2* 1 *2* 1 *2*
		Lady Barron	Ridges *Flat plains* Low ridges *Broad flats* Small rises *Old coastal lagoons*	10 *20* 15 *25* 15 *15*	1 *2* 1 *2* 1 *2*
		Babel Island	Ridges *Flat plains* Low ridges *Broad flats* Small rises *Old coastal lagoons*	10 *20* 15 *25* 15 *15*	1 *2* 1 *2* 1 *2*
493128	25 605	Killecrankie	Dunes *Swales* *Plains*	40 *15* *45*	1 *2* *2*
		Lady Barron	Dunes *Swales* *Plains*	40 *15* *45*	1 *2* *2*
		Babel Island	Dunes *Swales* *Plains*	40 *15* *45*	1 *2* *2*
493129	1 294	Welcome	Crest *Swales*	55 *45*	1 *2*
498111	185	Prosser	*Tidal flats* *Tidal flats* *Tidal flats* *Tidal flats*	*40* *40* *20* *5*	*2* *2* *2* *2*
593111	4 363	Forth	*Tidal flats* *Plain* *Upper terraces/sand ridges* *Drainage lines* *Very gentle slopes*	*5* *55* *15* *10* *15*	*2* *2* *2* *2* *2*

Finnigan rating 1 = Nil *2 = Moderate*

Land System		Map 1:100 000	Land System Component		Finnigan Rating
Number	**Area (ha)**		**Description**	**%**	
164131	1 303	Lake Sorell	Crests *Drainage lines/flats* *Well drained flats*	80 *20* *10*	1 *2* *2*
172131	40 572	Tyenna	Crests Exposed slopes Protected slopes *Drainage flats*	20 20 40 *20*	1 1 1 *2*
		Shannon	Crests Exposed slopes Protected slopes *Drainage flats*	20 20 40 *20*	1 1 1 *2*
		Lake Sorell	Crests Exposed slopes Protected slopes *Drainage flats*	20 20 40 *20*	1 1 1 *2*
		Little Swanport	Crests Exposed slopes Protected slopes *Drainage flats*	20 20 40 *20*	1 1 1 *2*
173131	2 539	Tyenna	Crests/upper slopes Upper slopes Lower slopes/flats *Sandy flats* *Flats*	30 30 20 *10* *10*	1 1 1 *2* *2*
		Shannon	Crests/upper slopes Upper slopes Lower slopes/flats *Sandy flats* *Flats*	30 30 20 *10* *10*	1 1 1 *2* *2*
		Lake Sorell	Crests/upper slopes Upper slopes Lower slopes/flats *Sandy flats* *Flats*	30 30 20 *10* *10*	1 1 1 *2* *2*
268242	21 750	Shannon	Mudstone crests Sandstone crests Upper slopes Lower slopes/flats *Drainage flats*	30 20 20 20 *10*	1 1 1 1 *2*
288122	4 131	Shannon	Slopes Slopes/flats *Flats* *Flats* *Drainage flats*	20 20 *20* *20* *20*	1 1 *2* *2* *2*

373144	22 708	Tyenna	Exposed crests	20	1
			Exposed upper slopes	20	1
			Protected slopes/creeks	20	1
			Lower slopes/flats	20	1
			Heathy flats	*10*	*2*
			Drainage flats	*10*	*2*
		Derwent	Exposed crests	20	1
			Exposed upper slopes	20	1
			Protected slopes/creeks	20	1
			Lower slopes/flats	20	1
			Heathy flats	*10*	*2*
			Drainage flats	*10*	*2*
		Prosser	Exposed crests	20	1
			Exposed upper slopes	20	1
			Protected slopes/creeks	20	1
			Lower slopes/flats	20	1
			Heathy flats	*10*	*2*
			Drainage flats	*10*	*2*
378232	36 110	Derwent	Crests	20	1
			Upper slopes	20	1
			Lower slopes	20	1
			Sandy flats	*20*	*2*
			Drainage flats	*20*	*2*
		Lake Sorell	Crests	20	1
			Upper slopes	20	1
			Lower slopes	20	1
			Sandy flats	*20*	*2*
			Drainage flats	*20*	*2*
		Prosser	Crests	20	1
			Upper slopes	20	1
			Lower slopes	20	1
			Sandy flats	*20*	*2*
			Drainage flats	*20*	*2*
		Little Swanport	Crests	20	1
			Upper slopes	20	1
			Lower slopes	20	1
			Sandy flats	*20*	*2*
			Drainage flats	*20*	*2*
398129	2 870	Prosser	Low stony crests	10	1
			Well drained flats	30	1
			Well drained flats	30	1
			Drainage flats	*30*	*2*
482134	1 575	Tamar	Crests and scarps	30	1
			Lower plateaux	45	1
			Lower slopes and swales	*25*	*2*
		St Patrick's	Crests and scarps	30	1
			Lower plateaux	45	1
			Lower slopes and swales	*25*	*2*

Appendix 2

EXTENT, TRENDS AND ECONOMIC IMPACT OF DRYLAND SALINITY IN TASMANIA

EXTENT, TRENDS AND ECONOMIC IMPACT OF DRYLAND SALINITY IN TASMANIA

EXTENT

- Grice (1995) reported on the extent of salinity on private and freehold land in Tasmania, and Finnigan (1995) reported on the extent in two districts known to contain some areas of salinity.

- Grice used data collected in 1992 by 20 Department of Primary Industry officers who were issued with 1:100 000 land systems maps of private and freehold land depicted on a topographic base and asked to shade out by pen those areas in which they had seen visual symptoms of salinity.

- Land systems are areas of land with the same annual rainfall, geology, altitude, and topography. Each land system is named and has a unique six digit code. In using land systems, Grice made two assumptions:
    1. Land within a system or its component is uniform.
    2. For a particular land system, the same severity of land degradation will occur within a land system regardless of where it occurs in the State.

- The land in Tasmania reported as containing areas of salinity is as follows:

Table 1: Private and freehold land containing areas of salinity

Salinity Class	Area (ha)
3: Severe	8 200
2: Moderate	169 200
1: Nil	1 884 600
Total	**2 062 000**

- For the Audit, land systems rated "severe" and "moderate" were checked.

- Four systems were detected. The total areas of these land systems and the percentages of the “lower slopes” and “drainage channels” components in each was then read from the Land System Survey reports. The affected areas were calculated from these two figures.

- The results were as follows:

Table 2: Land system components containing areas of severe salinity

Land system	Total area (ha)	% lower slopes and drainage channels	Area affected (ha)
173121	10 500	15	1 575
298133	6 644	60	3 987
393111	1 845	100	1 845
393123	81	100	81
Total	**19 070**		**7 498**

- This is 9 % below Grice's original estimate of 8 200 ha but within the limits of the methods used.
- A similar procedure was used to calculate the area affected in the land systems rated **"2: moderate"**.
- Thirty-seven systems were detected. Some were rated **"2"** and **"1"** in different regions. In these cases the areas were added and the area rated **"2"** was expressed as a percentage of the total. The results were as follows:

Table 3: Land system components containing areas of moderate salinity (Grice 1995)

Land system	Total area (ha)	% lower slopes and drainage channels	Total area affected (ha)	%"2"	Area affected (ha)
198121	5 807.71	10	580.8	71	412.3
272131	7 720.53	40	3 088.2	100	3 088.2
273121	1 345.54	30	403.7	100	403.7
273122	7 987.10	50	3 993.5	97	3 873.7
273133	5 008.82	60	3 005.3	100	3 005.3
278141	13 101.42	5	651.1	56	279.0
282131	2 161.40	35	1 635.1	100	1 635.1
282133	10 413.76	30	3 124.1	100	3 124.1
284131	4 438.38	20	887.7	100	887.7
288111	383.59	30	96.8	100	96.8
288123	8 607.65	100	8 607.7	100	8 607.7
293121	7 862.45	20	1 572.5	94	1 478.2
293122	8 087.10	10	808.7	100	808.7
293123	8 771.20	100	8 771.2	100	8 771.2
298114	673.76	60	404.3	9	36.4
298128	1 068.05	25	267.0	100	267.0
298225	8 987.07	20	1 797.4	100	1 797.4
382131	7 237.54	10	723.7	91	658.6
384121	29 262.44	70	20 483.7	100	20 483.7
384131	8 193.38	95	7 783.7	100	7 783.7
393121	44 132.71	100	44 132.7	91	40 160.8

393123	3 437.81	50	1 718.9	79	1 357.9
393124	14 650.61	50	7 325.5	46	3 369.8
394121	21 592.79	20	4 318.6	100	4 318.6
484121	8 589.69	40	3 435.9	100	3 435.9
484122	8 876.79	100	8 876.8	100	8 876.8
484123	6 057.88	50	3 028.9	100	3 028.9
493112	4 963.10	100	4 963.1	100	4 963.1
493121	11 019.71	70	7 713.8	49	3 779.8
493122	10 031.03	100	10 031.0	100	10 031.0
493124	352.60	15	52.9	5	2.7
493126	3 994.38	40	1 597.8	100	1 597.8
493127	23 628 88	60	14 177.3	100	14 177.3
493128	8 623 25	60	5 174.0	100	5 174.0
493129	1 314.87	45	591.7	100	591.7
498111	184.65	100	184.7	100	184.7
593111	4 363.24	5	218.2	6	13.1
Total	**322 941**		**186 258**		**172 562**

The total corresponds very closely to the original estimate of 169 200 ha.

- Grice notes that “This is the total area of the land system components which contain salt affected areas……the actual size of the salt affected areas would be substantially less than this”.

- Finnigan analysed aerial photographs to locate saline areas in two districts known to contain salinity.

- One was the Cressy – Longford Irrigation Scheme. The total area of the Scheme is 10 200 ha.

- Field verification using EM31 technology and visual interpretation showed the following:

Table 4: Field verified area of salt affected land in the Cressy – Longford district

Salinity class	**Area (ha)**
Severe	77.0
High	367.0
Low to moderate	780.0
Suspect	5.0
Total saline	**1 229.0**

- The Grice estimate was checked as in the analysis above.

Table 5: Land system components containing areas of salinity in Cressy – Longford

Land System	Total area (ha)	% lower slopes and drainage channels	Area affected (ha)
384121	8 936	70	6 255
393111	785	100	785
394121	344	20	67
Total	10 065		**7 107**

- Finnigan's assessment of the salt affected area, based on field verification, is therefore one sixth of Grice's assessment, based on land systems.

- The other district was the Coal River Irrigation Scheme. The total area of the Scheme is 11 972 ha.

- Using the same approach as above, beginning with Finnigan's field verification:

Table 6: Field verified area of salt affected land in the Coal River district

Salinity class	Area (ha)
Severe	**148**
High	**362**
Low to moderate	**1 132**
Suspect	**463**
Total	**2 105**

- The Grice estimate is as follows:

Table 7: Land system components containing areas of salinity in the Coal River district

Land System	Total area (ha)	% lower slopes and drainage channels	Area affected (ha)
288123	5 660	100	**5 660**

- The area field verified by Finnigan is therefore one third the area visually assessed by Grice.

TRENDS

- Finnigan has subsequently collated reports of salinity symptoms in other land systems, assembled between 1996 and 2000. This was based on personal observation and also those reported by others, such as concerned landowners and Landcare coordinators with varying degrees of technical skills.

- The reports have been used to generate the only data available to estimate a trend. The data has been presented as a separate set for relating the extent of salinity to the second and third digit of the land system code (geological period and surface rock) in Appendix 1.

- Using a similar approach to that followed by Grice, the reports were used to plot locations on transparent sheets over 1:100 000 topographic maps. The sheets were then overlaid on 1:100 000 land system maps in order to identify the land system numbers. The results are as follows:

Table 8: Additional land system components containing areas of salinity (Finnigan 2000)

Land System	Total area (ha)	% lower slopes and drainage channels	Affected area (ha)
164131	1 303	20	261
172131	40 572	20	8 114
173131	2 539	20	508
268242	21 750	30	6 525
288122	4 070	60	2 442
373144	17 475	20	3 497
378232	26 977	40	10 791
398129	2 871	30	861
482134	3 443	25	861
Total	**121 010**		**33 860**

- Assuming one sixth of this area also has field verifiable salinity, the additional area is possibly 5 643 ha and assuming one third, the additional area is possibly 11 287 ha.

- Averaging these two estimates, **the best guess is a possible increase of 8 500 ha.**

- When added to the 1992 estimate, this gives the following:

Table 9: Area of saline land (ha)

Year	
1992	**45 000 ha** (30 000 – 60 000 ha)
2000	**53 500 ha** (36 200 – 71 200 ha).

- This may be an actual increase in the extent of land affected, an increase in detection of land already affected, or a combination of both.

- If it is an actual increase then, in eight years, salinity may have increased by 19%, or 2.4% / year.

- If it reflects increased detection of existing salinity, then there has been no actual increase**.**

- It is more likely to be a combination of both. Awareness of salinity has been raised by Finnigan's extension program which would have increased detection of existing salinity. However, Finnigan's recent field-work suggests that components other than lower slopes and drainage lines may now be affected but it is not possible to quantify or verify at this stage.

- **Assuming a 12% increase, in eight years salinity has possibly increased by 1.5% / year.**

LIMITATIONS

- Grice notes that:

  "By using land systems as mapping units, the extent of land degradation was exaggerated to some degree ….exaggeration occurs because most forms of land degradation are confined to certain components or just parts of components i.e. salting to lower slopes and drainage lines".

- The Grice map represents visually 322 900 ha of land systems containing areas of salinity in 1992.

- 180 000 ha of some components in those land systems contained areas of salinity or 55% of the total.

- Finnigan's field verifications suggest between 30 000 and 60 000 ha had possibly expressed salinity.

- This is between nine and 18 % of the total visual representation on the map (average 14%).

- The maps accompanying this Report were derived in the same way, which means that that only about 14% of the areas represented as containing areas of salinity are probably salt affected.

- The maps therefore represent visually the probability and risk of salinity occurring in an area, not the actual area of salt affected land.

- They should only be used as a tool on a broad scale for risk assessment.

TRENDS TO 2020 and 2050

- It is assumed that rising water levels will be the main driver of salinity in land systems known to contain areas of salinity.

- Water levels will rise if
  - land clearance increases
  - annual rainfall rises above the present average
  - irrigation increases.

- Kirkpatrick (pers.com.) has provided data from satellite image analyses which suggest that the annual rate of land clearance has dropped from 10 429 ha / year in the period 1988 – 1994 to 6 992 ha / year 1994 – 1999. Most of the latter clearance was in the higher rainfall areas and virtually none in the dryland areas, which are most at risk of salinity. The data is as follows:

Table 10: Annual rate of land clearance for agriculture and plantations, 1994 - 1999

Land	Agriculture	Plantations	Total (ha)
Private	2 879	1 869	4 748
Public	-	2 244	2 244
Total (ha)	2 879	4 113	6 992

- It therefore seems unlikely that land clearance will cause water levels to rise in dryland areas, unless this trend is reversed.

- The 120 month running average monthly rainfall at Swansea on the East Coast over the past 100 years has been analysed by Doyle, (pers com). The present 20 year downward trend from 58 mm per month in 1980 to the present 41 mm has exceeded the previous low of 43 mm (between 1914 and 1916) for four years. The longest downward trend previously was seven years. Similar overall trends have been recorded in other sites in the dryland areas. This may possibly be masking the visual expression of salinity.

- It is assumed rainfall will rise again in the future, with associated rising water levels.

- Dryland irrigation is increasing because of the prolonged dry period and because of market forces, resulting in an increase in annual cropping with a consequent reduction in pastures.

- The increased number of centre pivot units accounts for almost all the increase in irrigation.

- Thompson (pers.com) provided the following predictions:

Table 11: Centre pivot irrigator units (40 ha) - uptake to 2050

Year	Number	Area (ha)	Total (ha)
2000	120	4 800	**4 800**
2020	300	12 000	**16 800**
2050	300	12 000	**28 800**

- The farmer consultative group considered that most would be for "first time use". Assuming that this would account for 10 000 of the 12 000 ha increase predicted to 2020 and the same amount for the increase to 2050, this implies :

Table 12: Area of dryland under irrigation (ha)

Year	Centre pivots	Total
1995	-	100 000
2000	5 000	105 000
2020	15 000	115 000
2050	25 000	125 000

- Irrigation will therefore continue to increase, and water levels could rise if irrigation is not carefully managed.

- It is therefore possible that salinity will continue to increase at the estimated rate of 1.5%, giving:

Table 13: Possible area of saline land (ha) –1.5% annual increase

Year	"Best Guess"	Lower	Upper
2020	**69 550**	47 000	92 500
2050	**93 625**	63 350	106 800

- This is speculative, but is the "Best Guess" possible from existing information.

- If annual rainfall increases, irrigation in dryland areas increases more than predicted and the rate of land clearance rises again, then this would result in a greater rate of increase in the area of salt affected land.

- Assuming the annual rate doubled as a result:

Table 14: Possible area of saline land (ha) – 3.0% annual increase

Year	"Best Guess"	Lower	Upper
2020	85 600	57 000	114 000
2050	133 750	89 000	178 000

- **This estimate is extremely speculative, and is included simply as one possible "Worst Case".**

ECONOMIC IMPACTS

Current agricultural production

- Much of this land comprises extensive agricultural enterprises, mainly based on beef and sheep, with some cropping.

- Cropping has been traditionally cereals, with a significant increase in poppies in the past five years. There has also been an increase in vegetable production, particularly potatoes for processing.

Regional gross margins

The enterprise mix

- An average enterprise mix of 80% extensive grazing and 20% was derived by pooling the estimates of three Departmental officers with knowledge of the areas containing salinity and then checking the average with six farmers with land holdings in those areas.

- An overall approximation of $250 for this mix was used to calculate a gross State gross margin figure for use in estimating losses in 2020 and 2050.

- A more detailed analysis by Local Government Area was made using ABS data for 1995/1996.

- This data was used to calculate the total agricultural holding, the total area of pasture and grasses ("extensive"), the total area of cereal grain, poppies, vegetables and other crops ("cropping"), and the area of uncleared land.

- It was assumed that 15% of the agricultural land areas mapped as containing salinity in each LGA was actually salt affected, based on Finnigan's field verification.

- A "best guess" gross margin for the extensive agricultural and the cropping enterprises in each of those LGAs was made by two Departmental economists and the LGA gross margin calculated.

Estimated production loss: 1992 -2050

- Loss of production due to salinity was estimated from best guesses made by three Departmental Officers with knowledge of the extensive agriculture and cropping enterprises in the areas affected, the concensus being 40%.

- In 1992 it was estimated that 45 000 ha of dryland agricultural land were salt affected. The potential returns from such an area where 15% is cropped and 85% is extensive grazing, had it been unaffected by salinity would have been $11 340 000. A 40% reduction would equal a loss of **$4 536 000.**

- Details of the estimated production losses by Local Government Area are given in Table 15.

- Four LGAs account for 80% and seven for 90% of the estimated loss in agricultural production due to salinity.

- The total of this detailed analysis, which is sensitive to variation in the cropping mix component of the average gross margin estimates for each LGA, is within three percent of the 1992 estimate for the State overall.

- Assuming that the uptake of dryland irrigation is as predicted, then cropping in general can be expected to rise at around 500 ha / year with the associated risk of increased salinity.

Estimated production losses: 2000 – 2050

The following estimates have been made, assuming that the enterprise mix remains the same:

Table 15: Production losses to 2050, assuming 1.5% annual increase in salinity ($)

Year	"Best guess"	Lower	Upper
1992	4 500 000	3 000 000	6 000 000
2000	5 350 000	3 620 000	7 120 000
2020	6 955 000	4 700 000	9 250 000
2050	9 362 500	6 335 000	10 680 000

Table 16: Production losses to 2050, assuming 3.0% annual increase in salinity ($)

Year	"Best guess"	Lower	Upper
2020	8 560 000	5 792 000	11 392 000
2050	13 375 000	9 050 000	17 800 000

- **This estimation is highly speculative and is included simply to illustrate the dimensions of a "Worst Case Scenario"for the purposes of the Audit.**

Table 17: Losses due to salinity by LGA, assuming 40% yield reduction, based on ABS statistics for 1995/6

Area	Area Agric Land (Crops & Pasture/Grasses) (ha)	Area Pastures & Grasses (ha)	Area Crop (ha)	Area of Land Containing Salt (ha)	"Extensive" Gross Margin Affected ($)	"Cropping" Gross Margin Affected ($)	Total Gross Margin Affected ($)	Loss Due to Salinity ($)
Northern Midlands	280 492	260 143	20 349	22 299	2 675 897	1 783 931	4 459 828	1 783 931
Southern Midlands	181 208	174 689	6 520	8 426	1 011 142	1 179 665	2 190 807	876 323
Central Highlands	175 403	171 722	3 682	6 578	789 314	657 762	1 447 076	578 831
Dorset	100 651	96 307	4 344	3 171	380 462	253 642	634 104	253 642
Flinders	39 534	39 272	262	2 669	320 226	160 113	480 339	192 136
Meander Valley	95 770	88 097	7 673	1 437	172 387	258 580	430 967	172 387
Glamorgan/Spring Bay	70 616	69 331	1 285	1 589	190 664	95 332	285 996	114 399
West Tamar	17 298	16 404	894	986	118 319	78 879	197 198	78 879
Break O'Day	53 019	50 915	2 104	795	95 434	63 623	159 057	63 623
Launceston	40 325	39 247	1 078	665	79 844	53 229	133 073	53 229
King Island	61 081	60 824	258	733	87 957	43 979	131 936	52 774
Clarence	8 974	7 983	991	404	48 457	40 381	88 839	35 535
George Town	14 475	13 874	601	347	41 688	34 740	76 429	30 571
Latrobe	14 949	8 900	6 049	202	24 218	36 327	60 545	24 218
Central Coast	28 802	24 384	4 417	173	20 737	31 106	51 843	20 737
Sorell	28 213	27 241	972	254	30 470	15 235	45 705	18 282
Kingborough	7 522	7 191	331	248	29 785	14 893	44 678	17 871
Derwent Valley	11 597	10 600	997	122	14 612	17 047	31 660	12 664
Devonport	5 172	3 510	1 663	39	4 655	6 982	11 637	4 655
Waratah/Wynyard	25 030	22 284	252	0	4 505	5 256	9 762	3 905
Burnie	14 096	13 317	779	0	2 537	3 806	6 343	2 537
Tasman	3 950	3 845	105	0	3 555	1 778	5 333	2 133
Brighton	4 857	4 605	252	7	874	437	1 311	525
Glenorchy	114	85	29	0	20	10	31	12
Hobart	1	0	1	0	0	0	0	0
Huon Valley	17 403	15 057	2 346	0	0	0	0	0
Circular Head	90 211	88 019	2 192	0	0	0	0	0
Kentish	4 893	18 118	2 291	0	0	0	0	0
West Coast	1 760	1 610	105	0	0	0	0	0
Total	**1 412 931**	**1 337 571**	**75 360**	**51 149**	**6 147 761**	**4 836 733**	**10 984 494**	**4 393 798**

Appendix 3

GROUND WATER

Depth to Water Struck and EC levels

Ground water

- Records have been compiled by Mineral Resources Tasmania on 4 340 ground water bores with GPS coordinates drilled between 1922 and 1999.
- Most of these were prospectivity bores and do not represent a structured sampling of the hydrogeology of Tasmania. Consequently, some areas known to contain salinity are under - represented e.g. the Central Highlands LGA.
- Further, little account was taken of the topography and elevation at which the bores were drilled. It has not been possible to conduct digital elevation modelling to compensate for this.
- The results should therefore be treated with caution.
- 2 903 of these have records of Depth to Water Struck (DWS). Where water was struck at more than one level, the first level only was analysed.

Table 1: Depth to Water Struck – Statewide

DWS (m)	Number	%
0 - 2	49	1.7
2 - 5	255	8.8
5 – 10	839	28.9
Over 10	1760	60.6
Total	2903	100.0

- **Only l.7 % of the water tables located by these bores are within the Audit benchmark of "2 metres or less" for water tables at risk of rising salinity.**
- If water tables were to rise by three metres due to some disturbance in the hydrogeological balance, then a further 8.8 % would be at risk.
- The only trend data available is from a series of 54 piezometers and bores monitored by the Department of Primary Industries, Water and the Environment in the Cressy Longford (CL) area and the Coal River Valley (CRV) irrigation scheme.
- Data collected over five years or more were used to generate trend lines for comparison with the Audit benchmark of annual changes of 30mm or more in the Standing Water Level (SWL) for the two schemes.
- The results are as follows:

Table 2: Trend and Salinity Risk classification for Standing Water Levels in Cressy - Longford and the Coal River Valley – DPIWE monitored

Standing Water Level(m)	Trend	C - L Number	CRV Number	Total	Risk
0 - 2	Rising	4	2	6	High
	Flat	14	5	19	High
	Falling	16	-	16	Moderate
2 - 5	Rising	2	2	4	High
	Flat	3	1	4	Moderate
	Falling	3	-	3	Moderate
5 - 10	Rising	-	1	1	Moderate
	Flat	1	-	1	Low
	Total	**43**	**11**	**54**	
			Risk	**29**	**High**
				24	**Moderate**
				1	**Low**

Ground water quality

- Salt levels were measured in 444 of the 4 340 MRT bores.

The Murray Darling Commission uses the following benchmarks for salinity based on electroconductivity, measured in microsiemens/cm (EC):

- 800 EC is the upper limit recommended by the WHO for drinking water and for optimum irrigation;
- 800 – 1 500 EC, at which level it is increasingly difficult to manage for irrigation;
- 1500 –5 000 EC at which level adverse biological effects are likely to occur in aquatic ecosystems, and irrigation becomes increasingly risky;
- 5 000 EC which is the accepted value for aquatic biology which divides fresh from saline water and which imposes very severe restrictions on irrigation.

- The results are as follows

Table 3: Groundwater conductivity – Statewide

EC	Number	%
< 800	203	45
800 – 1 500	51	12
1 500 – 5 000	142	32
> 5 000	48	11
Total	**444**	**100**

- These results were extracted from a total data set assembled by MRT for a variety of purposes, are samples rather than averages and should be treated with caution.

- 70 bores were drilled by MRT in 1999 to estimate the prospectivity of ground water for irrigation in five districts known to contain salinity.

Table 4: Groundwater conductivity – areas known to contain salinity

EC	Number	%
0 – 800	4	5.7
800 – 1 500	4	5.7
1 500 – 5 000	20	28.6
Over 5 000	42	60.0
Total	70	100.0

- The results show that 88.6% of the bores contained water which is risky to use for irrigation if EC levels are maintained. These are being monitored and will be reported by Dell (2000).

Appendix 4 (a)

SURFACE WATER MONITORING

Catchments with land systems containing areas of salinity and their monitoring status

Table 1: Tasmanian Planning and Management Catchments

Catchment No	Catchment Name
1	Furneaux Islands
2	Musselroe – Ansons
3	George
4	Scamander – Douglas
5	Swan –Apsley
6	Little Swanport
7	Prosser
8	Tasman
9	Pitt Water – Coal
10	Jordan
11	Clyde
12	Ouse
13	Upper Derwent
14	Lower Derwent
15	Derwent Estuary - Bruny
16	Huon
17	Port Davey
18	Wanderer - Giblin
19	Gordon - Franklin
20	King - Henty
21	Pieman
22	Nelson
23	Arthur
24	Welcome
25	King Island
26	Montagu
27	Duck
28	Black - Detention
29	Inglis
30	Cam
31	Emu
32	Blythe
33	Leven
34	Forth - Wilmot
35	Mersey
36	Rubicon
37	Meander
38	Great Lake
39	Brumby's - Lake
40	Lake - Macquarie
41	South Esk
42	North Esk
43	Tamar Estuary
44	Pipers
45	Little Forester
46	Great Forester - Brid
47	Boobyalla - Tomahawk
48	Ringarooma

Table 2: Surface water monitoring and salinity status in Tasmania's 48 Planning and Management Catchments

Catchment	Monitoring	Conductivity (EC)	Catchment number	Total
With Land Systems containing salinity	No	-	5 6 8 11 12 13 26 33	8
	Yes	>800	1 9 10 25 35 36 39 41 42 43 44 45 46 47	14
		<800	34 37 40 48	4
With no Land Systems containing salinity	No	-	3 4 17 18 19 21 22 23 24 27 28 29 30 31 32 38	16
	Yes	>800	2 14 15 16 20	5
		<800	7	1

Table 3: DPIWE Permanent Monitoring Sites: Time Lapse Recordings (Bobbi, 2000)

Catch-ment Number	Catchment Name	Site	Easting	Northing	Recording Dates	No days Recorded	% Time in Range (µs/cm)				Maximum Reading During Period (µs/cm)
							0-280	280-800	800-2300	>2300	
9	Pittwater - Coal	Coal at Richmond	536000	5268800	Jan 95 - Dec 99	1361	1	59	40	0	1455
11	Clyde	Clyde at Hamilton	486100	5289400	Mar 96 - Dec 99	1298	60	40	0	0	524
16	Huon	Huon at Judbury	494050	5239050	June 96 - Apr 00	705	100	0	0	0	216
27	Duck	Duck at Scotchtown	341400	5473600	Mar 96 - Nov 99	1303	25	75	0	0	643
29	Inglis	Flowerdale at Moorleah	387100	5462800	Mar 94 - Nov 96	978	100	0	0	0	165
35	Mersey	Mersey u/s Latrobe	451500	5430600	Apr 96 - Feb 00	1319	100	0	0	0	288
36	Rubicon	Rubicon u/s Tidal Limit	463700	5432600	May 94 - Feb 00	1936	62	38	0	0	653
37	Meander	Meander at Strath Bridge	492625	5406875	June 94 - Mar 00	1687	100	0	0	0	189
41	South Esk	South Esk at Perth	517100	5394500	May 94 - Dec 99	1502	100	0	0	0	168
42	North Esk	North Esk at Ballroom	532500	5406100	May 96 - Dec 99	1338	100	0	0	0	151
44	Pipers	Pipers d/s Yarrow Creek	509300	5453900	Mar 96 - Feb 00	1354	95	5	0	0	591
46	Great Forester - Brid	Brid u/s Tidal Limit	531300	5458800	Mar 94 - Feb 00	2005	99	2	0	0	653

Appendix 4(b)

SURFACE WATER IN TASMANIA

An Overview *

Janice Miller

*** Full report available from DPIWE**

SURFACE WATER IN TASMANIA – AN OVERVIEW

Janice Miller, Longford

Introduction

A major problem in compiling a profile of threats from salinity to surface water in Tasmania is the lack of historical data. Despite extensive Hydro-electric schemes and dams for irrigation purposes, surface water monitoring in the past has been sparse and where recordings have been undertaken rarely have they included conductivity. However, this is now changing as the spread of salinity within agricultural lands is being recognised and the potential threats from surface runoff into streams and rivers is being understood.

Patterns are already emerging in some in-stream monitoring sites where conductivity levels rise and fall in response to changes in flow rates and volumes. These data when matched to surrounding land systems which indicate salinity problems can provide reasonable "best guess' estimates of threats to the surface water. Certainly they indicate where extensive and prolonged monitoring should be undertaken to determine whether conductivity levels are changing. Waterwatch groups throughout Tasmania are monitoring many sites. Usually catchment-based these groups supply local landholders and interested parties with kits to regularly monitor their rivers and streams. This monitoring is providing some very good data for surface water monitors.

This Appendix (4 b) deals only with publicly owned surface water bodies which run through private land areas, no private dams have been included. In addition, it should be noted that there are significant wetland areas in the State potentially under threat from increased salinity problems. However this Appendix of the Report does not take particular note of these as they are covered in Appendix 5 'Biodiversity'.

Method

Using the 1:500 000 series, the salinity (field assessed) map of Tasmania was overlaid on the Catchment Map for the State. Each catchment was looked at to determine the areas identified as having saline problems. The salinity map denotes each land system for the entire state (except King Island). Each region was then cross-referenced with the maps in the *Land Systems of Tasmania* series, seven volumes in total, to ensure that the correct land system was identified from the overlaid map.

The number of times each land system was highlighted as having salinity problems within individual catchments was counted; where areas of the same land system number bordered one another they were counted as one continuous area; to be counted as a distinct area the area had to fall within a different land system and thereby be distinct from other similarly affected land systems in the catchment with the same number.

Using the individual *Land Systems of Tasmania* series maps all surface water, including rivers, streams, lakes and lagoons, were recorded for each land system which was highlighted on the large map as containing salinity areas. In some instances it was necessary to refer to tourist and 1:250 000 regional maps to plot the course of a particular river or stream. Where creeks were unnamed on all of the maps referred to then they were simply denoted as such.

This information was then tabulated to provide a quick reference for surface water bodies lying within recognised saline areas (Appendix A ‘Surface Water Potentially Under Threat from Surrounding Potentially Saline Land’ – full Surface Water report). However, it should be noted that whilst the entire land system is shaded as having saline areas for mapping purposes, and has therefore been recorded, the specific areas of salinity within that land system are not mapped and whilst the land system denoted might be large in area, the known salinity might be small in area but the potential for that affected area to increase is certainly recognised. It is this potential which is considered to be threatening to surface water just as much as the actually known areas.

Appendix A does not indicate which part of the river or stream is affected, ie headwaters, middle reaches or lower catchment. In some cases it was the entire river or stream and in others only a part of the system. Time did not permit for a further break-down but for many rivers this is covered in the 'Results and Discussion' section.

To enable a more detailed understanding of the current conductivity of various rivers and streams in Tasmania, various sources were used including: the *State of the Rivers* series; catchment management plans and strategies; recordings from the Department of Primary Industries, Water and Environment permanent probes; Waterwatch data; personal communication with DPIWE officers; Waterwatch co-ordinators; NRM and Catchment Management co-ordinators.

It has been decided to combine the sections ‘Results’ and ‘Discussion’ for ease of reference to the reader and to keep the information for each river, stream and catchment together.

Results and Discussion

Appendix A ‘Surface Water Potentially Under Threat from Surrounding Potentially Saline Land’ is the result of the mapping work undertaken and simply lists all surface water bodies which lie within those areas denoted as having salinity problems.

Table 1 gives the data from the DPIWE permanent monitoring program in various rivers across the State. From this table it can be seen that only one river, The Coal, has recorded a conductivity level of more than 800 µs/cm with a maximum reading of 1455 µs/cm. However none of the rivers monitored fell outside the Australian and New Zealand Environment and Conservation Council (ANZECC) prescribed limit for agricultural purposes of 2,300 µs/cm (Bobbi *et al*, 1995, ix).

Each of the most severely salinity-affected catchments is discussed below.

Table 1: DPIWE Permanent Monitoring Sites: Time Lapse Recordings (Bobbi, 2000)

Catch-ment No.	Catchment Name	Site	Easting	Northing	Recording Dates	No days Recorded	% Time in Range (µs/cm)				Maximum Reading During Period (µs/cm)
							0-280	280-800	800-2300	>2300	
9	Pittwater - Coal	Coal at Richmond	536000	5268800	Jan 95 - Dec 99	1361	1	59	40	0	1455
11	Clyde	Clyde at Hamilton	486100	5289400	Mar 96 - Dec 99	1298	60	40	0	0	524
16	Huon	Huon at Judbury	494050	5239050	June 96 - Apr 00	705	100	0	0	0	216
27	Duck	Duck at Scotchtown	341400	5473600	Mar 96 - Nov 99	1303	25	75	0	0	643
29	Inglis	Flowerdale at Moorleah	387100	5462800	Mar 94 - Nov 96	978	100	0	0	0	165
35	Mersey	Mersey u/s Latrobe	451500	5430600	Apr 96 - Feb 00	1319	100	0	0	0	288
36	Rubicon	Rubicon u/s Tidal Limit	463700	5432600	May 94 - Feb 00	1936	62	38	0	0	653
37	Meander	Meander at Strath Bridge	492625	5406875	June 94 - Mar 00	1687	100	0	0	0	189
41	South Esk	South Esk at Perth	517100	5394500	May 94 - Dec 99	1502	100	0	0	0	168
42	North Esk	North Esk at Ballroom	532500	5406100	May 96 - Dec 99	1338	100	0	0	0	151
44	Pipers	Pipers d/s Yarrow Creek	509300	5453900	Mar 96 - Feb 00	1354	95	5	0	0	591
46	Great Forester - Brid	Brid u/s Tidal Limit	531300	5458800	Mar 94 - Feb 00	2005	99	2	0	0	653

South Esk Basin

From Appendix A it can be seen that three of the most severely affected catchments are the Macquarie, the Meander and the South Esk. These three catchments form the South Esk Basin and in 1995 the DPIWE published a major report as part of their *State of Rivers* series on this Basin. The recording period for data included in the report was 1992 to 1995.

The Basin covers approximately 8,900 km^2, it is a region of extensive agriculture, forestry and mining. Throughout the Basin a major concern is the loss of mature native riparian vegetation. Often this has been totally removed or has been overtaken by exotic species (Bobbi *et al.,* 1995, 6). Generally higher conductivity readings were recorded in reaches where there is a greater water:soil interface, ie where riparian vegetation has been removed. This results in a greater deposition of contaminants from surface run-off and thus elevated conductivity readings.

Throughout the Basin it was found that conductivity levels often peaked just prior to the river flow peaks. This is considered to be due to the large amount of contaminants being added to the river during a heavy rainfall event. Once the river peaked there was usually a significant drop in conductivity readings until the river level once again dropped (Bobbi *et al.,* 1995, 34).

Lake Trevallyn which is at the bottom of the Basin and is the reservoir for the city of Launceston, had conductivity readings around 81 µs/cm (Bobbi *et al.,* 1995, 120).

South Esk

Conductivity in the South Esk is generally low with 45 µs/cm being recorded in the upper catchment and 128 µs/cm in the lower reaches. Some tributaries of the South Esk register slightly higher conductivity levels but none go above 200 µs/cm (Bobbi *et al.*, 1995, ii).

The highest readings in the South Esk River have been recorded at Perth which is located in the lower catchment but upstream of the river's confluence with the Macquarie. Downstream of this junction the conductivity readings drop markedly, especially in the summer months. This drop is considered to be due to the freshwater inputs from the Poatina Power Station Tailrace (Bobbi *et al.,* 1995, 120; 125).

Two tributaries to the South Esk, the Break O'Day and St Pauls rivers, recorded higher means than any other river in the Catchment - 180 µs/cm and 128 µs/cm respectively. These slightly elevated readings were found to be caused by an increase in ionic concentration. The main ions being Chloride, Calcium and Sodium (Bobbi *et al.,* 1995, 120). It was noted that these tributaries are subject to prolonged periods of low flows with evaporation compounding the concentration of ions in the summer months. However, the effect of the higher ionic concentration of these tributaries on the main river was marked. Readings taken in winter below the confluences of Break O'Day and St Pauls showed an increase from 51 to 103 µs/cm and 80 to 95 µs/cm respectively (Bobbi *et al.,* 1995, 120; 124). Interestingly, the summer readings were not so affected, instead showing a steady increase from the tributaries' and main river's headwaters of about 50 µs/cm to 125 µs/cm upstream of the Meander River junction (Bobbi *et al.,* 1995, 120; 124).

Meander

Conductivity readings in the Meander River range between 29-86 µs/cm. Some tributaries have recorded higher levels but these were less than 200 µs/cm, the median conductivity for the river is less than 100 µs/cm (Bobbi *et al.*, 1995, iii; 31). There is one exception in this catchment and that is Quamby Brook which during the study period generally recorded higher conductivity levels than the rest of the catchment. A maximum 332 µs/cm was recorded at the site located downstream of the Westbury sewage treatment plant, which would have had a significant effect. The median for this site was 162 µs/cm (Bobbi *et al.* 1995, 31).

Intensive cropping and dairying in the Meander catchment puts pressure on irrigation requirements. At the time of the *State of Rivers Report* (1995) no significant salinity problems had been recognised in the region. However, salinity is now being recognised as a major problem in the catchment and work is being undertaken by natural resource managers and landholders to monitor surface water for conductivity as well as soil and ground water testing (Elliott, pers. comm. May 2000).

In the Liffey River conductivity readings tended to record higher levels in the upper reaches in summer than the lower catchment. In winter this trend was reversed and it is likely that the readings were showing the effects of water being released from Poatina Power Station during its operation in the summer months (Bobbi *et al.,* 1995, 34).

At one site on the Meander River the diluting effects of rainfall were clearly shown through a series of readings over the study period. In January 1995 a sudden downpour saw a drop from 155 µs/cm to 25 µs/cm, an 84% drop in conductivity. As the water levels dropped then there was a rise in conductivity readings again (Bobbi *et al.,* 1995, 34).

Macquarie

The Macquarie catchment is prone to prolonged periods of drought and there is a heavy reliance on irrigation from various schemes in the catchment, eg. Tooms Lake, Lake Leake and Woods Lake. The Cressy-Longford Irrigation Scheme was established in the early 1970s with water diverted from the Poatina Tailrace. This scheme has allowed the region to embark on intensive vegetable and seed cropping. However, due to poor drainage and extensive clearing, areas of severe and moderate salinity are appearing in this region (refer Table 1). (Bobbi *et al.,* 1995, 5).

The Macquarie River recorded the highest conductivity readings in the South Esk Basin, with a range between 56 µs/cm at Lake Leake to 216 µs/cm at Coburg (between Epping Forest and Cressy). Maximum conductivity along the river was recorded at Ross (300 µs/cm) during an extreme low flow period (Bobbi *et al.*, 1995, iv; 181). Many reaches along the Macquarie River have areas of long pools, or 'broadwaters', which are vulnerable to evaporation, especially when flows are greatly reduced. This will also lead to elevated conductivity readings (Bobbi *et al.,* 1995, 189).

Conductivity in the Lake River and Brumby's Creek is generally low with a median of 75-80 µs/cm. Recordings on Brumby's Creek were a series of peaks and troughs, particularly in summer, due to the effect of outflows from the Poatina Power Station Tailrace, however none went over 100 µs/cm (Bobbi *et al.,* 1995, 18).

There is a permanent DPIWE water quality monitoring probe in the Macquarie at Longford. This site is downstream of Brumby's Creek and is therefore subject to large peaks and troughs in conductivity readings, ranging from 20-200 µs/cm. The dissolved ions were found to be mainly chloride, calcium and potassium (Bobbi *et al.,* 1995, 189).

The worst affected river in the Macquarie catchment and in the South Esk Basin is Back Creek which drains the Cressy-Longford Irrigation Scheme. The hydrology of this creek has been significantly altered and the impact on it from activities in its region are marked (Bobbi *et al.,* 1995, 136).

Conductivity in Back Creek is severely affected by the irrigation scheme. When the irrigation scheme is not in operation (winter) conductivity levels are high, usually >700 µs/cm with recordings reaching 1090 µs/cm . When the Scheme is in operation (summer) and flows correspondingly increase, conductivity drops to about 150 µs/cm (Bobbi *et al.,* 1995, 136).

It is considered that saline run-off from the surrounding affected land contributes significantly to this creek's high conductivity readings. Water analysis has shown that ionic concentration is extremely high for many salts, particularly chloride which varies from 13 mg/L in the summer months to 145 mg/L in the winter (Bobbi *et al.,* 1995, 141).

<u>King Island</u>

A snapshot study of surface water quality on King Island was undertaken in July 1999 as part of the DPIWE's *State of Rivers* series for the North West of Tasmania. Despite its being a 'snapshot' with no historical data with which to compare readings, it was considered to be indicative of the conditions under 'normal' winter flows (Bobbi *et al.,* 1999, 2).

On the Island streams flowing west had much higher conductivity readings than those flowing east. An exception was the east-flowing Egg Lagoon Creek in the north-east of the island which recorded the highest conductivity reading of 4400 µs/cm (Bobbi *et al.,* 1999, 14). Egg Lagoon Creek does not flow through any designated saline region (on the map), however it does flow across land systems with the same code as those denoted as containing salinity, so it might be considered that there are salinity spots in this region.

Yellow Rock River recorded some very high conductivity readings of >2300 µs/cm and this river flows through a region recorded as having potentially moderate salinity. The two most severely affected streams, Yellow Rock River and Egg Lagoon Creek are both surrounded by highly modified land systems and drainage channels. There is also concern that the water quality issues of Egg Lagoon Creek may affect the wetland regions on the East Coast (Bobbi *et al.,* 1999 25).

In the south and east of the Island conductivity readings were generally much lower, between 300-700 µs/cm, which is considered reasonably 'normal' for coastal rivers and streams in North West Tasmania (Bobbi *et al*, 1999, 7). There were two exceptions to this. Two tributaries to the Seal River had readings of >800 µs/cm, these tributaries flow through land systems not yet denoted as having salinity problems.

Water analysis was undertaken for elevated recordings to determine the ionic composition. Results for the site on Egg Lagoon Creek are given in Table 2 and it can be seen that the levels for each salt are severely elevated. Sulphate at this site was much higher than for any other site on the Island and the sodium concentration is significant, typically concentrations of sodium in free-flowing freshwater is <10 mg/L (Bobbi *et al.,* 1995, 50).

Table 2: Ionic Composition for Water Sample from Egg Lagoon Creek, King Island (Bobbi *et al.,* 1999, 14)

Salt	Concentration (mg/L)
Chloride	840
Sulphate	710
Calcium	320
Sodium	480
Potassium	22

In coastal streams and rivers it would be expected that these salts would be present in higher concentrations than inland streams. Oceanic aeolian deposition would contribute to this, however land clearing and poor drainage may also increase levels. The concentration of potassium may be increased through fertiliser runoff into the river or be from industrial pollution. In other regions of Tasmania data collected from rivers has generally shown readings for sulphate and potassium in the region of 5 mg/L, seldom are they higher (Bobbi *et al.,* 1999, 14).

Two monitoring sites on Porky Creek on the West Coast recorded very different conductivity readings. One site (PC 1) was in the upper reaches whilst the other (PC 2) was in the lower catchment, upstream of the cheese factory but downstream of the abattoir. It would therefore be expected that readings would be very different. Table 3 gives the conductivity readings for each site whilst Table 4 shows the ionic breakdown for each site (no information given for sodium).

Table 3: Conductivity Readings for Porky Creek, King Island

Site	Period Recorded	Conductivity (µs/cm)
PC 1	July 1999 - 2 days	1500
PC 2	July 1999 - 2 days	3000

Table 4: Ionic Composition of Water Samples Taken from Porky Creek, King Island (Bobbi *et al.*, 1999, 16-19)

Salt	PC 1 Concentration (mg/L)	PC 2 Concentration (mg/L)
Sulphate	< 25	25-125
Potassium	<11	11-22
Chloride	340	830
Calcium	32	32-150

Although this creek does not flow across as yet designated land systems prone to salinity, there are two sites of potentially moderate salinity within the catchment which may be affecting conductivity levels. However, the elevated readings at PC 2 are most likely due to the effluent out-fall from the abattoir rather than the surrounding land systems.

The report concludes by suggesting that the salt loads in the western and northern rivers are more likely due to the maritime influence and aeolian salt deposits in the soil than to agricultural practices (Bobbi *et al.*, 1999, 25). It does however suggest that land clearance will certainly have led to a mobilisation of the salt deposits in the soil which in turn may be affecting conductivity readings in the rivers and streams.

Conclusion

Rainfall events and the resultant runoff result in elevated conductivity readings usually followed by a rapid decrease in levels. It is important that regular monitoring is undertaken not only to read the conductivity levels but to also analyse the sample so that the constituent ions can be determined. Only through analysis can it be known whether sodium and/or chloride ions are responsible and then these can be linked back to the land systems to determine problem areas.

References

Bobbi, C., Fuller, D. and Oldmeadow, D. (1995). *South Esk Basin State of Rivers Report*. Department of Primary Industry and Fisheries, Tasmania.

Bobbi, C. (1997). *Water Quality of Rivers in The Mersey Catchment*, Department of Primary Industry and Fisheries, Tasmania.

Bobbi, C., Nelson, M., Krasnicki, T. and Graham, B. (1999). *State of Rivers Report for Rivers in the Great Forester Catchment*, Department of Primary Industries Water and Environment, Tasmania.

Bobbi, C., Graham, B., Krasnicki, T. and Nelson, M (1999). *State of Rivers Report for the Brid River Catchment*. Department of Primary Industries Water and Environment, Tasmania.

Bobbi, C., Graham, B., Read, M. and Nelson, M (1999). *State of Rivers Report for the Pipers River Catchment*. Department of Primary Industries Water and Environment, Tasmania.

Department of Agriculture Tasmania. 1980-1989. *Land Systems of Tasmania.* Volumes 1-7.

Appendix 5

POTENTIAL IMPACTS OF SALINITY ON BIODIVERSITY VALUES IN TASMANIA

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Potential Impacts of Salinity on Biodiversity Values in Tasmania

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Summary

The potential impact on biodiversity values of increasing dryland salinity was assessed. A number of vegetation communities and threatened plant and animal species are considered to be potentially at risk. The impact was assessed at a land systems level, and the four land systems most at risk were in low rainfall areas (< 700 mm per annum), low-lying topographically and were on sedimentary substrates or Holocene sands. The bioregions potentially most affected by salinity are the Flinders and Northern Midlands bioregions. Vegetation associated with wetlands and lowland plains and river flats is considered to be most at risk. Vegetation types at high risk of being impacted by salinity include herbaceous wetland communities, silver tussock *Poa labillardierei* and kangaroo grass *Themeda triandra* grasslands, and swamp gum *Eucalyptus ovata*, cabbage gum *Eucalyptus pauciflora* and swamp peppermint *Eucalyptus rodwayi* woodlands, which are already some of Tasmania's most endangered vegetation types. Fourteen forest types and fifteen non-forest vegetation types are at medium risk from salinity.

Introduction

It is estimated that 2.5 million hectares of Australia is currently saline, with 15 million hectares predicted to be at risk (Barrett-Lennard 2000). In Tasmania soil salinity was recognised as an issue as early as the 1950s (Working Party on Dryland Salting in Australia 1982) and there is increasing concern about its potential impact.

A preliminary assessment of the extent and impacts of dryland salinity in Tasmania on agriculture, water resources, biodiversity and infrastructure has recently been undertaken in Tasmania as part of the National Land and Water Resources Audit. This paper presents an assessment of the potential impact of dryland salinity on biodiversity values, in particular on environmental values of national significance, protected areas, remnant native vegetation and threatened species.

Recent work by the Department of Primary Industries, Water and Environment and Mineral Resources Tasmania has estimated the extent of salinity in Tasmania and has also identified areas potentially at risk. Grice (1995) mapped salinity at 1:250,000 using a land systems approach. Land system surveys describe areas of land with similar geology, topography, soils, vegetation and rainfall, and these have been completed for the whole of the state (Richley 1978, 1984; Pinkard and Richley 1982; Pinkard 1980; Pemberton 1986, 1989). This information was supplemented by ground water data from Mineral Resources Tasmania and Department of Primary Industries, Water and Environment. Soil and water salinity assessment has been conducted using various techniques including aerial photograph analysis, electromagnetic induction techniques, field survey, ground and surface water quality assessments (Finnigan

1995). The Audit has shown that the area of salinity is about 50 000 hectare or about 3% of cleared agricultural land.

Methods

Fifty land systems in Tasmania have been mapped as part of the current audit as containing areas of salinity or have identified as potentially saline, with four land systems identified as potentially severe. These land systems formed the basis of the assessment of the potential impact of dryland salinity on biodiversity values. This was undertaken by intersecting those values with land systems already identified as having medium to high potential risk of salinity. The impact of saline surface water upstream of biodiversity values or from biodiversity values in land systems adjacent to saline land systems has not been assessed as part of this current study. The potential impact was also assessed at the bioregional, catchment and local government levels. Tasmania is divided into 9 interim biogeographic regions (Peters and Thackway 1998), 48 major river catchments and 29 local government areas. An assessment of the impact on protected areas was also undertaken, using the IUCN Reserve categories as the basis for the assessment (IUCN Commission on National Parks and Protected Areas and World Conservation Monitoring Centre 1994).

The assessment of native vegetation at risk from salinity was determined by intersecting the coverage of extant native vegetation with land systems at medium to high risk of future salinity. The vegetation of Tasmania is currently being mapped under TASVEG2000, a project funded through the Natural Heritage Trust. Vegetation is mapped at 1:25,000 using aerial photograph interpretation assisted by field verification and the use of a range of other data sources. The Geo Temporal Species Point Observations Tasmania (GTSpot) database held on the Tasmanian Parks and Wildlife GIS Web server is used extensively to validate vegetation communities identified from aerial photograph interpretation.

Similar predictive techniques were utilised to determine the potential impact of dryland salinity on threatened flora. Point data for threatened plant species were intersected with land systems at medium to high risk of future salinity. Whilst many common plant species may be potentially at risk, at the present stage only plant species listed under the Commonwealth *Endangered Species Protection Act 1992* and the Tasmanian *Threatened Species Protection Act* (1995) were assessed. An assessment was also made of the potential risk of each species based on expert opinion, using factors such as life history, ecology, habitat requirements, plant physiology etc. Species nomenclature for plant species follows Curtis & Morris (1975, 1994), Curtis (1963, 1967, 1979) and Jones *et al.* (1999) for orchids.

A list of threatened fauna was compiled for each land system by intersecting the known and potential threatened fauna and faunal species of conservation significance listed for the relevant 1:25,000 map sheets by Bryant & Jackson (1999), and by assessment of the relevant areas and habitat types encompassed by each land system within those map sheets. Expert knowledge, including habitat types and distribution information, was used to sort these lists further, by removing species that were not in the areas under threat (e.g. the Flinders Island Burrowing Crayfish, *Engaeus martigener*, would be adversely affected by salinity, but is only known to occur at much higher altitudes than the areas affected). Marine and salt tolerant species were also removed, although it should be noted that some of the latter may be inadvertently affected by remedial actions. Finally, threatened species at low or indirect threat from salinity (e.g. bandicoots, eagles) were also removed from the lists. Further comment is made on these species in the discussion.

Wetlands on the Tasmanian wetlands database held in the Nature Conservation Branch of Department of Primary Industries, Water and Environment were overlain with the land systems salinity data. This database contains information about approximately 800 wetlands and consists largely of the wetlands surveyed by Kirkpatrick and Harwood in the late 1970s (Kirkpatrick and Harwood 1981). Many wetlands on the salinity maps were therefore readily identifiable from the maps included in that report. Not all wetlands in a land system were included in the database so the figures in this report are an underestimate of the total potential effects of salinity. The conservation significance of potentially affected wetlands at a national and international level was assessed. Wetlands are determined to be of national significance if they meet one or more of a set of criteria developed by Environment Australia to identify wetlands of special value (Australian Nature Conservation Agency 1996). Wetlands were identified as internationally significant if they met criteria established under the Convention on Wetlands of International Significance (Ramsar Convention Bureau 1997) and are listed under that convention. Tasmania has 10 wetlands listed as Ramsar sites. Wetlands were assigned a risk code (low, medium or high) based on expert opinion of their potential susceptibility, condition and importance.

It should be noted that the assessment of the impact of salinity has only been assessed at the land system level and no impact has currently been made of the potential impact downstream of that land system, although in some cases this effect will be significant.

Results

The fifty land systems identified as being at moderate to severe risk of salinity are generally in the lower rainfall (<750 mm per annum) areas of the state, with the exception of the Tamar Valley, King Island and Flinders Island. They are mostly less than 300 metres in elevation, and the majority are Quaternary deposits such as aeolian sand sheets or alluvial deposits of sand, silt, clay and gravel, generally derived from sandstone.

These land systems are concentrated in the Flinders and Northern Midlands bioregions, which both contain significant wetland systems and threatened vegetation types, plant and animal species.

At the Municipal level the local government areas containing the greatest proportion of the area potentially affected by salinity are Northern Midlands, Southern Midlands, Central Highlands, Clarence, Latrobe, West Tamar, Dorset, Break O'Day and Flinders Island, all of which contain important biodiversity values.

Thirty-seven conservation reserves including four national parks, eight nature reserves and seven forest reserves occur in areas with a moderate to high risk of salinity (Table 1). This includes twelve IUCN Category I reserves managed to conserve biodiversity and natural resource values (8 nature reserves and 4 forest reserves), five Category II reserves managed for ecosystem conservation and recreation (4 national parks and 1 state reserve), six Category IV reserves (6 wildlife sanctuaries) and thirteen Category VI reserves (game reserves, conservation areas, state recreation areas, coastal reserves etc).

Wetlands

The greatest risk to biodiversity from salinity is to freshwater ecosystems, particularly wetlands. A number of threatened fauna species associated with wetlands are considered to have a high risk (Table 2). These include the green and gold frog, freshwater snails and caddis flies. Over one hundred and thirty wetlands occur in land systems of severe and moderate salinity risk, including 44 wetlands listed on the Register of Wetlands of National Significance (Table 3). Six of Tasmania's ten Ramsar sites, which are wetlands of international significance, occur in medium and high risk areas (Table 4). These are Jocks Lagoon, Lower Ringarooma River floodplain, Logan Lagoon Wildlife Sanctuary, Lavinia Nature Reserve, East Coast, Cape Barren and Pitt Water/Orielton Lagoon Nature Reserve. The Cape Portland (393124) and Central Flinders (493127) land systems, both in the Flinders bioregion, between them contain 4 Ramsar wetlands and 27 wetlands of national significance.

Threatened fauna

Seventeen faunal species listed on the *Threatened Species Protection Act* (1995) occur in land systems at moderate or severe risk of salinity (Table 2). Thirteen of these species occur in freshwater systems or associated aquatic or riparian vegetation, and the remainder are species of native grasslands. Three of these species are listed nationally as vulnerable on the *Endangered Species Protection Act* (1992).

Threatened vegetation types

The vegetation types considered most threatened by salinity are those which are found on valley floors and low slopes, including native grassland remnants, wetlands and woodlands (Table 5). Vegetation types at high risk of being impacted by salinity include herbaceous wetland communities, silver tussock *Poa labillardierei* and kangaroo grass *Themeda triandra* grasslands, and swamp gum *Eucalyptus ovata*, cabbage gum *Eucalyptus pauciflora* and swamp peppermint *Eucalyptus rodwayi* woodlands, which are already some of Tasmania's most endangered vegetation types.

Threatened flora

A range of flora species are at risk from salinity. Thirty-five flora species are considered to be at high risk (Table 6), including 14 species which are listed as endangered in Tasmania and 6 species which are listed as vulnerable. Of the 44 plant species listed as medium risk (Table 6), 14 are endangered and 13 are vulnerable. Twenty-two of the species considered at risk are species endemic to Tasmania and 20 are listed on the national Endangered Species Protection Act as endangered or vulnerable at the national level. Plant species at greatest risk are orchids which have mycorrhizal fungi associated with their root systems and are very sensitive to changes in soil chemistry. Annual plants such as grass daisy, dwarf sunray, tiny daisy, and many aquatic species are also potentially at high risk.

Discussion

The potential impact of salinity on biodiversity is predicted to be greatest on wetlands and freshwater systems. This review has identified over 130 wetlands from land systems at risk, including a significant proportion of Tasmania's internationally and nationally significant wetlands. The majority of faunal species at risk are freshwater species. The impact on wetlands is potentially greater than indicated as there are many more wetlands in Tasmania than are included on the database used for this assessment. In addition, this assessment has not included an assessment of the potential impact of salinity on freshwater aquatic systems which is predicted to be considerable.

The potential impacts on biodiversity are greatest in the low rainfall areas of Tasmania where there has already been considerable impact on biodiversity following European settlement. These areas have little remaining native vegetation, and have the highest numbers of plant and animal species which have become locally extinct, and threatened taxa. Four land systems have been identified as having severe salinity risk. These are Tunbridge Flats 173121, Morningside 298133 and Lagoon 393111, all in the Northern Midlands, and Bothwell Flats 298225 in the Central Highlands. These four land systems all have important native vegetation, and have 19 threatened flora species and 8 threatened fauna species considered to be at high or medium risk. Four orchid species are at high risk and are listed as endangered at a national level and are endemic to Tasmania.

Tunbridge Flats land system has less than 20% of the original native vegetation. This land system contains ten wetlands, six of which are of national significance (Blackman River 1 TM002TA, Glen Morey Saltpan TM007TA, Mona Vale Saltpan TM014TA, Tin Dish Rivulet 1 TM019TA, Township Lagoon TM020TA, White Lagoon TM021TA), and an important nature reserve. Township Lagoon Nature

Reserve contains the only lowland temperate grassland remnant on public land in Tasmania, and has important populations of threatened plant and animal species. This is a land system with naturally high salinity levels and there are a number of saltlakes in the district which is known as the Saltpan Plains. Many species of flora and fauna are adapted to the salt levels. This may mean that some species could be threatened by works undertaken to ameliorate salinity. For example, the endangered endemic Midlands buttercup *Ranunculus prasinus* is a salt-tolerant species that grows on the margins of wetlands that may be threatened if salt levels were reduced. Similarly, the rare isopod *Haloniscus searlei* is found in two salt lakes in the Tunbridge area, and though tolerant of high salinity, may be sensitive to changes in water chemistry if amelioration works in the region reduce naturally saline levels.
The remaining three land systems with a severe salinity risk (Morningside 298133, Lagoon 393111, Bothwell Flats 298225) have 16 wetlands at risk.

Some shallow wetlands in eastern and central Tasmania are already naturally saline (Buckney & Tyler 1976). However, increased salinity in these areas may still have adverse impacts on biodiversity by changing or reducing the species present. For example, many of the wetlands listed in this report frequently support large numbers of waterbirds. Increased salinity may exceed the tolerance of these birds and lead to a decline in use and even an avoidance of the wetlands. The adults of several bird species that use these areas are capable of extracting and excreting through nasal glands, some of the salt from water that is ingested (Baudinette *et al.* 1982). However, young birds are less able to process saline water and suffer weight loss and even mortality if restricted to drinking water with high salt concentrations (> 12 000µS/cm) at an early age (Stolley *et al* 1999). Ducks have been observed leading their ducklings to drink at freshwater soaks near saline wetlands for at least six days after hatching until the young birds develop glands to extract and secrete the excess salt. If these soaks become saline there will be a likely adverse impact on young ducklings.

There is some evidence of adverse effects on other aquatic biota if salinity is increased beyond 1000 mg/l (approx. 18 000µS/cm). This is reviewed in Jackson (1997) and includes direct effects on macroinvertebrates, macrophytes, algae and riparian vegetation as well as indirect effects such as deoxygenation and disruption of detrital pathways.

It should be noted that the impact on flora and fauna is potentially greater than indicated in this summary as this is only considering the impact on flora and species listed on the *Threatened Species Protection Act* (1995). Many common and widespread species may potentially be at risk because of salinity, and this risk may need to be determined in the future. In particular, presently common orchids, annual plants, and aquatic flora and fauna may be highly susceptible to the effects of salinity and may become threatened in the future in land systems where salinity is severe. Salinity within the root zone affects the ability of the plant to utilise water. As the salt concentration of soil water increases water movement onto the root becomes more difficult with plants eventually suffering water stress. Plants on saline soils have retarded germination and seedling survival is reduced. Hence, plant communities are significantly affected as common species disappear from an area.

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References

Australian Nature Conservation Agency (1996) A Directory of Important Wetlands in Australia Second Edition. Australian Nature Conservation Agency, Canberra

Barrett-Lennard E. (2000) Plants in Saline Environments. Natural Resource Management: Special Issue. Australian Association of Natural Resource Management, Canberra.

Baudinette R.V., Norman F.J. and Roberts J. (1982) Salt gland secretion in saline-acclimated chestnut teal, and its relevance to release programs. *Australian Journal of Zoology* 30, 407-15.

Bryant, S.L. & Jackson, J. (1999). Tasmania's Threatened Fauna Handbook: what, where and how to protect Tasmania's threatened animals. Threatened Species Unit, Parks and Wildlife Service, Hobart.

Buckney R.T. and Tyler P.A. (1976) Chemistry of salt lakes and other waters of the sub-humid regions of Tasmania. *Aust. .J Mar. Freshwater. Res.* **27,** 359-66.

Curtis W.M.C. & Morris D.I. (1975) The students flora of Tasmania. Part 1. Government Printer, Hobart.

Curtis W.M.C. & Morris D.I.(1994) The students flora of Tasmania. Part 4B. *Angiospermae: Alismataceae to Burmanniaceae.* St. David's Park Publishing, Hobart.

Curtis W.M.C.(1963) The students flora of Tasmania. Part 2. Government Printer, Hobart.

Curtis W.M.C.(1967) The students flora of Tasmania. Part 3. Government Printer, Hobart.

Curtis W.M.C.(1979) The students flora of Tasmania. Part 4a. Government Printer, Hobart.

Davies J. (1988) Land systems of Tasmania : Region 6 - South, East and Midlands Dept. of Agriculture, Tasmania.

Finnigan J. (1995) Salinity Assessment in Tasmanian Irrigation Schemes and regional areas, Department of Primary Industry and Fisheries, Tasmania

Grice M. S. (1995) Assessment of Soil and Land Degradation. Department of Primary Industry and Fisheries, Tasmania.

IUCN Commission on National Parks and Protected Areas and World Conservation Monitoring Centre (1994) *Guidelines for Protected Area Management Categories*. IUCN, Gland, Switzerland.

Jackson J. (1997) State of habitat availability and quality in inland waters, Australia: State of the Environment Technical Paper Series (Inland Waters), Department of the Environment, Canberra.

Jones D., Wapstra H. Tonelli P. and Harris S. (1999) The Orchids of Tasmania. Miegunyah Press, Melbourne.

Kirkpatrick J.B. and Harwood C.E. (1981) The conservation of Tasmanian wetland macrophytic species and communities. Report to the Australian Heritage Commission from the Tasmanian Conservation Trust Inc., Hobart.

Pemberton M. (1986) Land systems of Tasmania: Region 5 – Central Plateau. Dept. of Agriculture, Tasmania.

Pemberton M. (1989) Land systems of Tasmania: Region 7 - South West.. Dept. of Primary Industry, Tasmania.

Peters, D. and Thackway, R (1998) A New Biogeographic Regionalisation for Tasmania. Report prepared by the Tasmanian Parks and Wildlife Service for the National Reserve System Program Component of the Natural Heritage Trust.

Pinkard G. J. and Richley L. R. (1982) Land systems of Tasmania: Region 2 – Flinders Island. Dept. of Agriculture, Tasmania.

Pinkard G.J. (1980) Land systems of Tasmania: Region 4 – North East. Dept. of Agriculture, Tasmania.

Ramsar Convention Bureau (1997) "The Ramsar Convention Manual: a Guide to the Convention on Wetlands", 2nd edn, Ramsar Convention Bureau, Gland, Switzerland.

Richley L. R. (1978) Land systems of Tasmania: Region 3 – North West. Dept. of Agriculture, Hobart.

Richley L. R. (1984) Land systems of Tasmania: Region 1 – King Island. Dept. of Agriculture, Hobart, Tasmania.

Stolley D.S., Bissonette J.A., Kadlec J.A. and Coster D. (1999) Effects of saline drinking water on early gosling development. *J. Wildlife. Management.* 63(3), 990-96.

Working Party on Dryland Salting in Australia (1982) Salinity of Non-irrigated land in Tasmania. Soil Conservation Authority of Victoria for Standing Committee on Soil Conservation.

Table 1: Reserves located in land systems that are potentially affected by the risk of salinity

Reserve	IUCN Category
Asbestos National Park	II
Boltons Beach Conservation Area	VI
Bradys Lookout State Reserve	II
Bruny Neck Game Reserve	VI
Cape Portland Wildlife Sanctuary	IV
Chauncy Vale Wildlife Sanctuary	IV
Coal River Nature Reserve	Ia
Dans Hill Forest Reserve	Ia
Dennes Hill Nature Reserve	Ia
Diprose Lagoon Nature Reserve	Ia
Foochow Conservation Area	VI
Harry Walker Tier Forest Reserve	Ia
Heathy Hills Forest Reserve	Ia
Humbug Point SRA	VI
Lackrana Conservation Area	VI
Lake Tiberias Game Reserve	VI
Lavinia Nature Reserve	Ia
Logan Lagoon Wildlife Sanctuary	IV
Mt Douglas Conservation Area	VI
Mt William National Park	II
Mussleroe Bay Coastal Reserve	VI
Native Point Wildlife Sanctuary	IV
North East River Game Reserve	VI
Paper Beach Conservation Area	VI
Patriarchs Conservation Area	VI
Pepper Creek Forest Reserve	Ia
Pitt Water/Orielton Nature Reserve	Ia
Ringarooma Coastal Reserve	VI
Sea Elephant River Wildlife Sanctuary	IV
South Bruny National Park	II
St Helens Point SRA	VI
Strzelecki National Park	II
Tamar River Wildlife Sanctuary	IV
Tanina Bluff Forest Reserve	Ia
Tom Gibson Nature Reserve	Ia
Township Lagoon Nature Reserve	Ia
Wingaroo Nature Reserve	Ia

Table 2: Threatened fauna species considered to be at medium to high risk from salinity. (Codes: e = endangered in Tasmania, E = endangered nationally, v = vulnerable in Tasmania, V = vulnerable nationally, r = rare in Tasmania).

Common name	Scientific name	habitat	risk	T	N
Green and Gold Frog	*Litoria raniformis*	freshwater systems	high	v	
Dwarf galaxiid	*Galaxiella pusilla*	freshwater systems	high	r	V
Giant Freshwater Lobster	*Astacopsis gouldi*	freshwater systems	high	v	V
Mt Arthur Burrowing Crayfish	*Engaeus orramakunna*	freshwater systems	high	v	V
Caddis flies	*Ecnomina vega*	freshwater systems	high	r	
	Leptocerus souta	freshwater systems	high	r	
	Oecetisgilva	freshwater systems	high	r	
	Orthotrichia maculata	freshwater systems	high	r	
Freshwater snails	*Beddomeia ronaldi*	freshwater systems	high	r	
	Beddomeia tasmanica	freshwater systems	high	r	
	Beddomeia kershawi	freshwater systems	high	r	
	Beddomeia krybetes	freshwater systems	high	v	
	Beddomeia launcestonensis	freshwater systems	high	r	
Jungermans land snail	*Pasmadaditta jungermanniae*	riparian	medium	r	
Catadromus carabid beetle	*Catadromus lacordairei*	native grasslands	medium	r	
Ptunnara Brown Butterfly	*Oreixenica ptunarra*	native grasslands	medium	v	
Tunbridge Looper Moth	*Chrysolarentia decisaria*	native grassland	medium	e	

Table 3: Wetlands of national significance occurring in land systems with medium to high potential risk of salinity

Wetland name	Code	Bioregion	Locality	Risk
Bells Lagoon	TM011TA	NM	Tunbridge	high
Blackman River 1	TM002TA	NM	Tunbridge	high
Blackmans Lagoon	BEN001TA	NS	Cape Portland	high
Calverts Lagoon	TM003TA	DE	Lauderdale	high
D'Arcys Lagoon	DE 001TA	SE	The Neck, Bruny Is.	high
Fergusons Lagoon	FUR001TA	FL	Flinders Island	high
Flyover Lagoon	FUR002TA	FL	Flinders Island	high
Folly Lagoon	TM006TA	NM	Tunbridge	moderate
Glen Morey Saltpan	TM007TA	NM	Ross	low
Glen Morriston Rivulet 1	TM008TA	NM	Ross	high
Hogans Lagoon	FUR004TA	FL	Flinders Island	high
Lake Tiberias	TM011TA	NM	Oatlands	high
Lavinia Nature Reserve	WOO003TA	KI	King Island	high
Little Thirsty	FUR005TA	FL	Flinders Island	high
Little Waterhouse Lake	BEN003TA	NS	Cape Portland	high
Logan Lagoon	FUR006TA	FL	Flinders Island	high
Macquarie River 2	TM012TA	NM	Ross	high
Macquarie River 4	TM013TA	NM	Ross	high
Mona Vale Saltpan	TM014TA	NM	Ross	low
Near Lagoon	TM015TA	NM	Tunbridge	moderate
Oyster Cove	DE002TA	SE	Oyster Cove	moderate
Sellars Lagoon	FUR007TA	FL	Flinders Island	high
South Esk River 1	TM018TA	NM	Avoca	low
Stans Lagoon	FUR008TA	FL	Flinders Island	high
Syndicate	FUR009TA	FL	Flinders Island	high
The Chimneys	BEN003TA	NS	Cape Portland	high

Thompsons Lagoon	FUR010TA	FL	Flinders Island	high
Tin Dish Rivulet 1	TM019TA	NM	Tunbridge	high
Township Lagoon	TM020TA	NM	Tunbridge	low
Tregaron Lagoon 1	BEN007TA	NS	Cape Portland	high
Unnamed wetland	BEN002TA	NS	Cape Portland	high
Unnamed wetland	BEN008TA	NS	Cape Portland	high
Unnamed wetland	BEN009TA	NS	Cape Portland	high
Unnamed wetland	BEN010TA	NS	Cape Portland	high
Unnamed wetland	BEN011TA	NS	Cape Portland	high
Unnamed wetland	BEN012TA	NS	Cape Portland	high
Unnamed wetland	BEN013TA	NS	Cape Portland	high
Unnamed wetland	BEN014TA	NS	Cape Portland	high
Unnamed wetland	BEN015TA	NS	Cape Portland	high
Unnamed wetland	FUR011TA	FL	Flinders Island	high
Unnamed wetland	FUR012TA	FL	Flinders Island	high
Unnamed wetland	FUR013TA	FL	Flinders Island	high
Unnamed wetland	FUR014TA	FL	Flinders Island	high
White Lagoon	TM021TA	NM	Tunbridge	low

Table 4: Ramsar sites in Tasmania occurring in medium and high risk land systems

Pitt Water/Orielton Lagoon
Jocks Lagoon
Lower Ringarooma River floodplain
Logans Lagoon
East Coast Cape Barren Island
Lavinia Nature Reserve

Table 5: Native vegetation communities considered to be at medium to high risk from salinity. The topographic position of the vegetation type is described. Forest (F) and non-forest (NF) communities are indicated.

Eucalyptus ovata – E. viminalis shrubby forest	valley flats, swampy areas high	F
E. ovata - *E. viminalis*- *E. pauciflora* grassy woodland	valley flats, swampy areas high	F
E. rodwayi forest and woodlands	valley flats, swampy areas high	F
Herbaceous wetlands	low lying areas, marshes high	NF
Rush/sedge wetlands	low lying areas, marshes high	NF
Marginal herbfields associated with wetlands	low lying areas, marshes high	NF
Lowland *Poa* tussock grassland	lower slopes, valley bottoms high	NF
Lowland kangaroo grass native grassland	lower slopes, valley bottoms high	NF
Wet heath	coastal areas, swampy areas high	NF
Allocasuarina verticillata woodlands and forest	coastal areas, slopes <400 m medium	F
Callitris rhomboidea forest	riparian areas <300 m medium	F
E. amygdalina forest and woodland on sandstone	flats and slopes<500 m medium	F
E. globulus grassy forest and woodlands	coastal flats and lower slopes medium	F
E. pauciflora forests and woodlands on sediments	slopes and flats <500 m medium	F
E. perriniana forest	swampy areas <300 m medium	F
E. viminalis grassy woodlands	lower slopes <500 m medium	F
Inland *E. amygdalin*a forest and woodland	gravel flats medium	F
Inland *E. tenuiramis* forest and woodland	slopes on mudstone <500 m medium	F
Furneaux *E. nitida* forest	low lying country medium	F
Melaleuca ericifolia forest	low lying country medium	F
Danthonia/Austrostipa grassland	flats and lower slopes < 500 m medium	NF
Lowland and coastal sedgey heath (*Lepidosperma* spp.)	slopes and flats < 300 m medium	NF
Lowland and intermediate heath	slopes and flats medium	NF
Short paperbark swamp	swampy areas and flats medium	NF
Flinders Island scrub	swampy areas and flats medium	NF
King Island sedge-heath-scrub	swampy areas and flats medium	NF
Tall dry scrub	swampy areas and flats medium	NF
Tall wet scrub	swampy areas and flats medium	NF

Kunzea scrub	slopes medium	NF

Table 6: Threatened plant species listed on the *Threatened Species Protection Act (1995)* indicated by T, or the Commonwealth *Endangered Species Protection Act (1992)* indicated by N, identified as potentially at risk from salinity. Endemic species are indicated with an asterisk*. (Codes: e = endangered in Tasmania, E = endangered nationally, v = vulnerable in Tasmania, V = vulnerable nationally, r = rare in Tasmania).

Plant name	common name	lifeform	T	N	Risk
*Acacia axillaris**	Midlands wattle	tree	v	V	medium
*Acacia mucronata var. dependens**	sallow wattle	tree	r		medium
Acacia ulicifolia	Juniper wattle	tree	r		medium
Alternanthera denticulata	lesser joyweed	perennial herb	e		medium
Amphibromus macrorhinus	swamp wallaby-grass	perennial grass	e		medium
Amphibromus neesii	swamp wallaby grass	perennial grass	r		medium
Angianthus preissianus	salt angianthus	annual herb	r		high
Aphelia gracilis	slender aphelia	annual sedge	r		medium
Aristida benthamii	three-awned spear grass	perennial grass	e		medium
Asperula scoparia var. *scoparia*	prickly woodruff	perennial herb	r		medium
*Austrodanthonia popinensis**	hairy wallaby-grass	perennial grass	e	E	medium
Barbarea australis	native wintercress	annual herb	e		medium
Bertya rosmarinifolia	native rosemary	shrub	v		medium
Brachyscome perpusilla	tiny daisy	annual herb	r		high
Brachyscome rigidula	cut-leaf daisy	perennial herb	v		medium
Bracteantha bicolor	straw daisy	perennial herb	r		medium
Brunonia australis	blue pincushion	perennial herb	r		medium
*Caladenia anthracina**	black-tipped spider orchid	orchid	r	E	high
Caladenia brachyscapa	short spider orchid	orchid	r		high
*Caladenia lindleyana**	Lindley's spider orchid	orchid	e	E	high
*Caladenia pallida**	rosy spider orchid	orchid	e	E	high
*Caladenia saggicola**	sagg spider orchid	orchid	e	E	high
Calandrinia granulifera	purslane	annual herb	r		high
Callitris oblonga ssp. *oblonga**	South Esk or St. Paul pine	tree	v	E	medium
Calocephalus citreus	lemon beauty heads	perennial herb	e		medium
Cryptandra amara	bitter cryptandra	shrub	e		medium
Discaria pubescens	Austral thorn-bush	shrub	e		medium
*Epacris acuminata**	coral heath	shrub	v	E	high
*Epacris exserta**	south esk heath	shrub	v	E	high
*Epacris virgata**	heath	shrub	v	E	high
Eryngium ovinum	blue devil	perennial herb	e		high
Eutaxia microphylla	common eutaxia	shrub	r		medium

Glycine latrobeana	native soybean	perennial herb	v	V	high
Gompholobium ecostatum	dwarf wedge-pea	shrub	e		high
Haloragis heterophylla	variable raspwort	perennial herb	r		high
Hyalosperma demissum	dwarf sunray	annual herb	e		high
Isoetopsis graminifolia	grass daisy	annual herb	e		high
Isopogon ceratophyllus	horned cone-bush	shrub	v		medium
Lasiopetalum baueri	slender velvet-bush	shrub	r		medium
*Lasiopetalum micranthum**	Tasmanian velvet-bush	shrub	v		medium
Lawrencia spicata		perennial herb	r		high
Lepidium hyssopifolium	peppercress	perennial herb	e	E	medium
Lepilaena preissii	slender water-mat	aquatic herb	r		high
Leptorhynchos elongatus	lanky buttons	perennial herb	e		medium
Leucochrysum albicans var. *tricolor*	hoary sunray	perennial herb	e	E	medium
Lythrum salicaria	purple loosestrife	perennial herb	r		high
*Melaleuca pustulata**	Swan River paperbark	shrub	r		medium
Muehlenbeckia axillaris	matted lignum	perennial herb	r		medium
Myriophyllum muelleri	water milfoil	aquatic herb	r		high
*Olearia hookeri**	blue daisy-bush	shrub	r		medium
Parietaria debilis	pellitory	herb	r		medium
Persicaria decipiens	slender knotweed	aquatic herb	v		high
Potamogeton pectinatus	fennel pondweed	aquatic herb	r		high
*Prasophyllum milfordense**	Milford leek orchid	orchid	e	E	high
Prasophyllum olidum	pungent leek orchid	orchid	e	E	high
*Prasophyllum pulchellum**	pretty leek orchid	orchid	e	E	high
*Prasophyllum secutum**	northern leek orchid	orchid	e	E	high
*Prasophyllum tunbridgense**	Tunbridge leek orchid	orchid	e	E	high
Prostanthera cuneata	Alpine mint bush	shrub	e		medium
Prostanthera rotundifolia	round-leafed mint bush	shrub	v		medium
*Pterostylis commutata**	Midland greenhood	orchid	e	E	high
Pterostylis sanguinea	banded greenhood	orchid	r		high
Pultenaea humilis	dwarf bush-pea	shrub	v		medium
Pultenaea paleacea	silky bush-pea	shrub	v		medium
Pultenaea prostrata	bush-pea	shrub	v		medium
Ruppia megacarpa		aquatic herb	r		medium
Rutidosis multiflora	small wrinke-wort	herb	r		high
Schoenus latelaminatus	medusa bog-rush	perennial sedge	e		medium
Scleranthus diander	knawel	perennial herb	v		medium
*Spyridium parvifolium var. molle**	velvet dusty miller	shrub	r		medium
Spyridium parvifolium var. parviflorum	dusty miller	shrub	r		medium

Spyridium vexilliferum	helicopter bush	shrub	r		medium
*Stackhousia gunnii**	Midlands mignonette	perennial herb	e		medium
*Stenanthemum pimeleoides**		shrub	v	E	medium
Stenopetalum lineare	threadcress	annual herb	e		high
Stylidium despectum	small trigger-plant	herb	r		high
Triptilodiscus pygmaeus	common sunray	annual herb	v		high
Velleia paradoxa	spur velleia	perennial herb	v		medium
Villarsia exaltata	yellow marsh-flower	aquatic herb	r		high