SECTION 3 – WATER USE IN THE SOUTH AUSTRALIA VEGETABLE INDUSTRY

7. TOTAL WATER USED /CROP / CATCHMENT (AVAILABLE WHERE METERED)

Table 7a: Calculated Monthly and Total Irrigation Requirements for Selected Vegetables in South Australia

References 8, 9, 10, 11

The irrigation requirements in Table 7a have been calculated by PIRSA using software based on the FAO methodology, and assuming average rainfall, evaporation, and growing period for that crop applicable for that location. This methodology is being used in prescribed wells areas in the South-East and Mallee to convert their area-based licenses to volumetric allocations. Irrigation water required (mm) can be divided by 100 to obtain ML/ha.

Crop	Town	Region	Monthly Irrigation Requirement (Ir) (mm)												Total Irrigation Requirement (mm)
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Broccoli - summer	Lenswood	Adelaide Hills	189	63								28	116	184	579
Broccoli - summer	Murray Bridge	Riverland	203	73								60	131	204	672
Broccoli - summer	Virginia	Northern Adelaide Plains	170	66								48	121	164	569
Broccoli - winter	Lenswood	Adelaide Hills			89	18									107
Broccoli - winter	Virginia	Northern Adelaide Plains			113	50	34	12	9						217
Brussels Sprout	Lenswood	Adelaide Hills			89	25									113
Cabbage	Lenswood	Adelaide Hills			89	25									113
Cabbage	Virginia	Northern Adelaide Plains			113	56	30	9	10						219
Carrot - summer	Lenswood	Adelaide Hills	191									32	156	204	583
Carrot - summer	Murray Bridge	Riverland	206									66	172	226	670
Carrot - summer	Pinnaroo	Upper Mallee	207									52	159	249	666
Carrot - summer	Virginia	Northern Adelaide Plains	172									53	160	182	567
Carrot - winter	Murray Bridge	Riverland				53	28	21	18	44	69	98			331
Carrot - winter	Virginia	Northern Adelaide Plains				48	24	10	11	42	52	82			270
Cauliflower	Lenswood	Adelaide Hills			89	25									113
Cauliflower	Virginia	Northern Adelaide Plains			113	56	34	12							215
Cucumber	Virginia	Northern Adelaide Plains	161	139									86	128	514

Onion - summer	Keith	Upper South East	207	121							18	63	148	192	750
Onion - summer	Lenswood	Adelaide Hills	190	113								53	163	195	714
Onion - summer	Loxton	Riverland	270	167							56	112	219	270	1095
Onion - summer	Murray Bridge	Riverland	204	125							36	84	178	216	844
Onion - summer	Pinnaroo	Upper Mallee	205	143							40	68	165	238	858
Onion -summer	Virginia	Northern Adelaide Plains	170	114							23	70	166	174	718
Potato - summer	Keith	Upper South East	144								3	58	163	211	578
Potato - summer	Lenswood	Adelaide Hills	128									46	181	216	571
Potato - summer	Loxton	Riverland	189								35	104	240	295	863
Potato - summer	Murray Bridge	Riverland	142								18	78	196	237	671
Potato - summer	Penola	Lower South East	124									36	130	171	461
Potato - summer	Pinnaroo	Upper Mallee	142								21	63	181	261	668
Potato - summer	Virginia	Northern Adelaide Plains	117								8	64	183	191	563
Potato - winter	Loxton	Riverland		108	168	131	74	39	10						530
Potato - winter	Murray Bridge	Riverland		79	132	96	48	26	5						387
Potato - winter	Pinnaroo	Upper Mallee		89	142	98	51	27	8						416
Potato - winter	Virginia	Northern Adelaide Plains		71	140	92	48	16							368
Pumpkin	Loxton	Riverland	253	195								53	109	234	843
Sweet Melon	Loxton	Riverland	269	202								53	163	269	954
Tomato	Murray Bridge	Riverland	224	197	123							48	168	237	998
Tomato	Virginia	Northern Adelaide Plains	187	181	131							37	157	191	885

Notes:

Calculated using average seasonal conditions, by the method set out in Reference 10, p78-134.

Irrigation Requirement (Ir) takes into account crop evapotranspiration, effective rainfall, stored soil water, field application efficiency and leaching requirement.

Table 7b: Irrigation Water Requirements for Vegetables on the Northern Adelaide Plains

Reference 23, table 14, page 42

The irrigation water requirements in Table 7b were developed for users of reclaimed water on the Northern Adelaide Plains and are approximate. These figures were used to assist growers in relating their contracted allocations with crop demand. The recycled water contractor WRSV Pty Ltd , as part of their contract with growers, are required to supply daily at least 0.54% of a grower's annual allocation.

	Indicative Crop Requirement (KL/ha crop)
capsicums	3000-5000
carrots, parsnips, turnips	4000-5000
cauliflower, cabbage, broccoli	4000-5000
celery	3000-5000
cucumbers	120-170 per 150 metre square glasshouse
onions	5000-6000
potatoes	4000-7000
lettuce	4000-6000
tomatoes	200-280 per 150 metre square glasshouse

Table 7c: Agricultural Irrigation Water Use by Statistical Division South Australia 2002–03

Reference 3, table 2.9, p17

Irrigated agriculture in South Australia in 2002-03 covered approximately 183,000 ha with about 900,000 ML water applied. About 50% of the total irrigation water is applied in the Murray Lands and about 38% in the South East.

ABS Statistical Division	Volume Applied (ML)		Area Irrigated ('000ha)	
Adelaide	29,066		11	
Outer Adelaide	76,406	a	30	a
Yorke and Lower North	5,174	b	5	a
Murray Lands	443,984		61	
South East	341,295	a	75	
Eyre	1,949	c	-	c
Northern	1,657	c	-	b
TOTAL	899,530		183	

a = estimate has relative standard error of 10% to less than 25% and should be used with caution

b = estimate has relative standard error of 25% to 50% and should be used with caution

c = estimate has relative standard error greater than 50% and is considered too unreliable for general use

- = nil or rounded to zero including null cells

Table 7d: Vegetable & Other Horticultural Irrigation Water Use in South Australia 2002–03

Reference 3, 72 and 109

Water volumes applied to vegetables in South Australia increased from 74,536 ML in 2002–03, to 86,747 ML in 2003–04. This represented 17% and 19% respectively of the total volume applied to horticulture. Water volumes in 2005–06 were 83,075 ML.

Water volumes applied to all crops and pastures (agriculture) in South Australia were 899,530 ML in 2002–03 and 957,163 ML in 2003–04. Therefore the water volumes applied to vegetables in South Australia represented 8% and 9% respectively of the water volumes applied to all crops and pastures in South Australia.

Water volumes applied to vegetables in Australia were 439,229 ML in 2002–03 and 477,136 ML in 2003–04. Therefore the water volumes applied to vegetables in South Australia

South Australia 2002-03	Vegetables for human consumption	Fruit trees, nut trees, plantation or berry fruits (a)	Grapevines		Nurseries, cutflowers or cultivated turf		Vegetables for seed	
Total number of establishments	500	1557	2893		292	b	111	b
Number of establishments irrigating	501	1349	2773		213		51	b
Area under crop '000 ha	14	22	67		1	b	2	c
Area irrigated '000ha	13	18	66		1	b	1	c
Volume applied (ML)	74,536	145665	217496		6835	c	1720	b
Application rate (ML/ha) (e)	5.6	8.1	3.3		6.5		1.8	
South Australia 2003-04	Vegetables for human consumption	Fruit trees, nut trees, plantation or berry fruits (a)	Grapevines		Nurseries, cutflowers or cultivated turf		Vegetables for seed	
Total number of establishments	494	1415	3027		238		60	b
Number of establishments irrigating	448	1245	2586		200	b	43	b
Area under crop '000 ha	14	19	70		1	b	1	b
Area irrigated '000ha	13	17	64		2	d	1	b
Volume applied (ML)	86,748	123033	228156	b	20413	d	2996	b
Application rate (ML/ha)	6.5	7.1	3.6		9.4		3.8	
South Australia 2005-06	Vegetables for human consumption	Fruit trees, nut trees, plantation or berry fruits (a)	Grapevines		Nurseries, cutflowers or cultivated turf		Vegetables for seed	
Total number of establishments	664	1560	3295		284		86	
Number of establishments irrigating	623	1246	3052		264		64	
Area under crop '000 ha	16	23	89		1		1	
Area irrigated '000ha	14	19	83		1		1	
Volume applied (ML)	83,075	146,063	225,875		5859		3151	a
Application rate (ML/ha)	5.8	7.5	2.7		5.1		3.8	a

a = excludes grapevines

b = estimate has relative standard error of 10% to less than 25% and should be used with caution

c = estimate has relative standard error of 25% to 50% and should be used with caution

d = estimate has a relative standard error greater than 50% and is considered too unreliable for general use

e = averaged across all irrigated pastures or crops represented 17% and 18% respectively of the water volumes applied to vegetables in Australia.

Average application rates were 5.6 ML/ha for vegetables compared with 8.1 ML/ha for fruit trees and nuts, and 3.3 ML/ha for grapevines in 2002–03. Average application rates in 2003–04 increased to 6.5 ML/ha for vegetables compared with 7.1 ML/ha for fruit trees and nuts, and 3.6 ML/ha for grapevines.

Table 7e: Calculated Monthly and Total Irrigation Requirements for Selected Vegetables in South Australia

References 31, 33

The following irrigation requirements were published in commercial grower manuals for these crops in the late 1980's, and calculated using a similar method to the more recently produced Table 7a. Estimates assume average rainfall occurring in each district. Irrigation water required (mm) can be divided by 100 to obtain ML/ha.

Crop	Region	Planting/ Transplanting Time	Irrigation Water Required (mm)
Broccoli	Adelaide Hills	autumn	350
		spring	450
		summer	450
		winter	300
	Northern Adelaide Plains	autumn	400
		winter	350
	Riverland	autumn	425
		winter	375
Brussel Sprouts	Adelaide Hills	spring	600
		summer	500
Cabbage	Adelaide Hills	autumn	450
		spring	550
		summer	550
		winter	350
	Northern Adelaide Plains	autumn	500
		winter	450
	Riverland	autumn	525
		winter	475
Cauliflower	Adelaide Hills	autumn	400
		spring	500
		summer	500
		winter	300
	Northern Adelaide Plains	autumn	450
		winter	400
	Riverland	autumn	475
		winter	425

Crop	Region	Planting/ Transplanting Time	Irrigation Water Required (mm)
Chinese Cabbage	Adelaide Hills	autumn	350
	Northern Adelaide Plains	autumn	400
	Riverland	autumn	425
Lettuce	Adelaide Hills	spring	425
		summer	450
	Northern Adelaide Plains	autumn	425
		winter	400
	Riverland	autumn	450
		winter	475
	South East	spring	425
		summer	450

Table 7f: Reported Volume of Water Diverted Across 8 Supply Systems in South Australia during the 2003–04 and 2005–06 Irrigation Seasons

References 88, 110

Data in Table 7f is from irrigation water supply systems located across South Australia, and collated by ANCID. An "irrigation water provider" is broadly defined as an organisation that undertakes the retailing and distribution of irrigation water in rural areas of Australia (i.e. delivery of water from natural waterways or local storages (head works) to the farm gate). In 2003–04 the total area serviced by the 8 irrigation water provider businesses operating the supply systems in South Australia was reported to be 120,754 ha. Of this area, 33,341 ha is known to be irrigated using some 936,528 ML of water. The reported area irrigated in the following table however understates the total area irrigated, since the area irrigated was not reported by all of the data providers, and where reported, the figures do not include any area irrigated from private diversions from streams and private groundwater systems.

Irrigation Water provider Supply System	2003-04			2005-06		
	Area in Irrigation System (ha)	Area Irrigated (ha)	Total Diversions into Supply System (ML)	Area in Irrigation System (ha)	Area Irrigated (ha)	Total Diversions into Supply System (ML)
Southeast Region (SA)	80,000	na	na	80,000	80,000	na
Central Irrigation	15,000	13,511	116,191	15,000	13,564	107,635
Golden Heights	828	778	6,785	na	na	na
Lower Murray	3,572	3,091	na	na	na	na
Renmark	4,800	na	na	na	na	na
Sunlands	898	796	6,583	898	796	7,279
Barossa Valley	7,656	7,656	7,478	46,000	na	na
Angas Bremer				8,200	7,800	15,646
TOTAL South Australia	120,754	33,341	936,528	150,098	102,160	127,647
TOTAL Australia (provided)	3,374,565	1,200,779	7,802,102	2,778,364	1,062,235	9,792,889

Fixed sprinkler irrigation systems are used for vegetable production in many regions of South Australia

Good irrigation practices are needed in the production of glasshouse tomatoes, especially under high-tech systems

Solid set irrigation is commonly used for vegetables

8. TONNES/ML/CROP

Table 8a: Tonnes/ML/crop for selected vegetables in regions in South Australia

References 4, 5, 23, 27–36, 52

The major irrigation methods for vegetables in South Australia are by overhead fixed sprinkler, centre pivot, and drip. Vegetable crops vary greatly in their estimated water requirement across the state. For example onions and garlic have a relatively high water requirement, since they are generally grown in areas with low natural rainfall, have a longer growing season than most vegetables, and require cover crop establishment prior to planting to prevent wind erosion. Tonnes/ML/crop is calculated from average yield. Field-grown carrots in the Riverland generally have a high yield relative to their water use.

Crop	Type	Region	Yield t/ha			Irrigation Method	Water Use KL/ha	Tonnes/ ML /crop
			average	low	high			
broccoli	field-grown	Riverland	8	6	10	oh sprinkler	500	16
brussel sprouts	field-grown	Adelaide Hills	35	25	45	oh sprinkler	5500	6
capsicum	field-grown	Riverland	50	40	60	oh sprinkler	8000	6
	glasshouse	N Adelaide Plains	16	12	25	drip	2000	8
cucumber	ghouse continental	N Adelaide Plains	12	10	14	drip	1600	8
carrot	field-grown	Riverland	40	35	45	centre pivot	500	80
cauliflower	field-grown	Riverland	17	14	20	oh sprinkler	500	34
garlic	field-grown	Riverland	7	3	10	oh sprinkler	11500	1
green beans	field-grown	Riverland	8	6	10	oh sprinkler	6750	1
lettuce	spring or summer	Adelaide Hills	45	27	63	oh sprinkler	4500	10
	autumn or winter	N Adelaide Plains	45	27	63	oh sprinkler	4250	11
onions	field-grown	Riverland	55	50	60	centre pivot	11500	5
	field-grown	N Adelaide Plains	50	30	70	oh sprinkler	5500	9
potatoes	fresh market	Murraylands	45	25	60	centre pivot	6875	7
	crisping	Upper Mallee	30	22	40	centre pivot	6875	4
	frozen french fry	South-East	51	35	67	centre pivot	5100	10
pumpkin	butternut	Riverland	25	20	30	oh sprinkler	4000	6
rockmelon	field-grown	Riverland	25	20	30	drip	3600	7
tomato	field-grown	Riverland	50	40	60	oh sprinkler	8000	6
	glasshouse	N Adelaide Plains	100	80	110	drip	2000	50
zucchini/squash	field-grown	Riverland	25	20	30	oh sprinkler	4000	6

Table 8b: Tonnes/ML/crop for potatoes in two regions of South Australia

Reference 4, 5

Potato irrigation benchmarking studies were conducted in two regions of South Australia. The aims of the projects were to develop modules that could be used by grower groups to assess irrigation management and make comparisons across a group of sites. A pilot group of irrigators was formed to test the process of benchmarking performance using a series of quantitative indicators. This also enabled a series of irrigation best management practices to be identified.

In the South-East benchmarking study, 'the indices are broken up into two distinct groups with a difference of about 5 t/ML between them. The four leading sites are made up of the three highest yielding sites and the site that had the second lowest yield. This was achieved with a low yield by having a low level of water use. The lower ranked sites generally had higher water consumption, with lower yields. They also included all the sites that listed environmental losses as a factor in the final yield'.

In the Murray Lands benchmarking study, 'water use efficiency shows more than a 4-fold variation in value, from 4.1 to 19.2 t/ML. This is indicative of the wide variation in both the yields achieved, and the volumes of water used to produce those yields. The case study sites show some variation, but all produced more than10 t/ML. In particular, (the top 2 sites with highest t/ML) scored very well because they used quite low volumes of irrigation over the season'.

	REGION					
	South East			Murraylands (Riverland / Upper Mallee)		
Site	Potato Yield (t/ha)	Volume of Irrigation Applied - Water Use (ML/ha)	Water Use Efficiency (t/ML)	Potato Yield (t/ha)	Volume of Irrigation Applied - Water Use (ML/ha)	Water Use Efficiency (t/ML)
1	34.76	5.09	6.83	25.0	3.95	6.33
2	50.74	6.1	8.32	28.3	4.302	6.58
3	49.24	5.879	8.38	37.0	9.1	4.07
4	46.89	5.52	8.49	42.5	5.69	7.47
5	66.62	5.155	12.92	46.9	2.97	15.79
6	55.00	4.17	13.19	48.0	3.75	12.80
7	59.30	4.211	14.08	54.3	5.06	10.73
8	-	-	-	55.3	5.19	10.66
9	-	-	-	61.8	3.21	19.25

Table 8c: Tonnes/ML/crop vegetables using state averages and calculated water use

References 6,7,8,9,10,11

Tonnes/ML/crop (or water use efficiency – WUE) was calculated from gross state regional production and area statistics against the calculated irrigation requirement for the vegetable crop grown at that location. Using this methodology, relatively high WUE is obtained for high-tonnage brassica crops grown in the high rainfall areas of the Adelaide Hills and Virginia, such as cabbage, brussel sprouts and cauliflower.

Crop	Town	Region	Irrigation Requirement for location (mm)	Irrigation Requirement for location (ML/ha)	Production per region	Production Unit	Production per region (tonnes)	Area per region (ha)	Average yield for region (t/ha)	WUE for region (t/ML)
Broccoli - summer	Lenswood	Adelaide Hills	579	5.79	477,018	kg	477	68.9	6.92	1.20
Broccoli - summer	Murray Bridge	Riverland	672	6.72	34,553	kg	35	5.8	5.96	0.89
Broccoli - summer	Virginia	Northern Adelaide Plains	569	5.69	1,266,519	kg	1267	168.9	7.50	1.32
Broccoli - winter	Lenswood	Adelaide Hills	107	1.07	477,018	kg	477	68.9	6.92	6.47
Broccoli - winter	Virginia	Northern Adelaide Plains	217	2.17	1,266,519	kg	1267	168.9	7.50	3.46
Brussels Sprout	Lenswood	Adelaide Hills	113	1.13	2,585,921	kg	2586	91.9	28.14	24.90
Cabbage	Lenswood	Adelaide Hills	113	1.13	1,074	tonnes	1074	26.2	41.00	36.28
Cabbage	Virginia	Northern Adelaide Plains	219	2.19	2,912	tonnes	2912	80.4	36.22	16.54
Carrot - summer	Lenswood	Adelaide Hills	583	5.83	3,199	tonnes	3199	72.4	44.18	7.58
Carrot - summer	Murray Bridge	Riverland	670	6.7	27,487	tonnes	27487	564.5	48.69	7.27
Carrot - summer	Pinnaroo	Upper Mallee	666	6.66	na	tonnes	na	na	na	na
Carrot - summer	Virginia	Northern Adelaide Plains	567	5.67	16,187	tonnes	16187	381	42.49	7.49
Carrot - winter	Murray Bridge	Riverland	331	3.31	27,487	tonnes	27487	564.5	48.69	14.71
Carrot - winter	Virginia	Northern Adelaide Plains	270	2.7	16,187	tonnes	16187	381	42.49	15.74
Cauliflower	Lenswood	Adelaide Hills	113	1.13	1,068	tonnes	1068	48.5	22.03	19.49
Cauliflower	Virginia	Northern Adelaide Plains	215	2.15	4,258	tonnes	4258	184.2	23.12	10.75
Cucumber	Virginia	Northern Adelaide Plains	514	5.14	1,364,836	kg	1365	75.8	18.01	3.50
Onion - summer	Keith	Upper South East	750	7.5	11,181	tonnes	11181	233.7	47.84	6.38

Crop	Town	Region	Irrigation Requirement for location (mm)	Irrigation Requirement for location (ML/ha)	Production per region	Production Unit	Production per region (tonnes)	Area per region (ha)	Average yield for region (t/ha)	WUE for region (t/ML)
Onion - summer	Lenswood	Adelaide Hills	714	7.14	2,251	tonnes	2251	56.4	39.92	5.59
Onion - summer	Loxton	Riverland	1095	10.95	34,116	tonnes	34116	679.3	50.22	4.59
Onion - summer	Murray Bridge	Riverland	844	8.44	34,116	tonnes	34116	679.3	50.22	5.95
Onion - summer	Pinnaroo	Upper Mallee	858	8.58	27,222	tonnes	27222	530	51.36	5.99
Onion -summer	Virginia	Northern Adelaide Plains	718	7.18	1,560	tonnes	1560	68.5	22.77	3.17
Potato - summer	Keith	Upper South East	578	5.78	30,480	tonnes	30480	826.1	36.90	6.38
Potato - summer	Lenswood	Adelaide Hills	571	5.71	25,843	tonnes	25843	976.8	26.46	4.63
Potato - summer	Loxton	Riverland	863	8.63	77,205	tonnes	77205	2312.6	33.38	3.87
Potato - summer	Murray Bridge	Riverland	671	6.71	77,205	tonnes	77205	2312.6	33.38	4.98
Potato - summer	Penola	Lower South East	461	4.61	90,455	tonnes	90455	2292.6	39.46	8.56
Potato - summer	Pinnaroo	Upper Mallee	668	6.68	67,073	tonnes	67073	1703	39.39	5.90
Potato - summer	Virginia	Northern Adelaide Plains	563	5.63	29,770	tonnes	29770	905.5	32.88	5.84
Potato - winter	Loxton	Riverland	530	5.3	77,205	tonnes	77205	2312.6	33.38	6.30
Potato - winter	Murray Bridge	Riverland	387	3.87	77,205	tonnes	77205	2312.6	33.38	8.63
Potato - winter	Pinnaroo	Upper Mallee	416	4.16	67,073	tonnes	67073	1703	39.39	9.47
Potato - winter	Virginia	Northern Adelaide Plains	368	3.68	29,770	tonnes	29770	905.5	32.88	8.93
Pumpkin	Loxton	Riverland	843	8.43	6,835	tonnes	6835	324.8	21.04	2.50
Sweet Melon (rock)	Loxton	Riverland	954	9.54	405	tonnes	405	220	1.84	0.19
Tomato	Murray Bridge	Riverland	998	9.98	21	tonnes	21	1.9	11.17	1.12
Tomato	Virginia	Northern Adelaide Plains	885	8.85	951	tonnes	951	91.4	10.40	1.18

9. WATER COSTS TO FARM BOUNDARY (WATER CHARGES OR PRIVATE PUMPING COSTS)

Table 9a: Water costs to farm boundary in vegetable growing districts of South Australia

References 24, 37–45

A range of governing bodies and catchment boards are responsible for collection of levies, access, supply or delivery charges and excess water use costs, applicable to vegetable growing districts. For private diverters accessing unpressurised water, costs depend on the head and distance over which the water is drawn (from pump or river). Additional pumping costs may need to be covered by vegetable growers for on-farm pumping (to increase the head pressure from low pressure irrigation schemes). These costs may include fuel or power (diesel or electric), pump overhead set up cost, depreciation, maintenance and labour costs. On-farm pumping (fuel only) costs for vegetable growers ranged from about $45–$55/ML at the time of this study in 2005. Pumping (electricity and diesel) costs are increasing for private diverters from the Murray River, and for groundwater users in other areas.

Grants to Offset Water Costs: A $10M Federal government 'Building Better Cities' grant was accessed to set up the recycling of Bolivar effluent water at Virginia, with state and private enterprise contributions. Federal and state grants and private funds have facilitated the Central Irrigation Trust of the River Murray cover overhead administration and infrastructure rehabilitation costs.

Region	Sub-Region	Town(s)	Governing Body / Catchment Board	Water Source	Irrigation Access Charge ($/ML) based on allocation	Catchment Levy (cents in $ of capital value of property pa)	Supply Fee ($ pa)	Charge $/ha equiv. pa	Supply Charge (% property value)	Useage or Delivery Charge $/ML	Excess Cost ($/ML)	River Murray Catchment Annual Levy ($/ML)	Save the River Murray Levy ($ /property /qtr)
Murraylands	Riverland	Lyrup	Lyrup Village Association-private diversion	Murray River	-	-	-	-	-	$53 (+approx $10 re-pump on-farm cost)	$1000/ML 20% greater than 7.6ML/ha	3.63	-
Murraylands	Riverland	Berri, Cobdogla	Central Irrigation Trust - low pressure	Murray River	6	-	-	-	-	39.70	-	3.63	-
Murraylands	Riverland	Cadell, Mypolonga	Central Irrigation Trust - medium pressure	Murray River	6	-	-	-	-	48.40	-	3.63	-
Murraylands	Riverland	Cooltong, Loxton	Central Irrigation Trust - high pressure	Murray River	6	-	-	-	-	58.00	-	3.63	-

Region	Sub-Region	Town(s)	Governing Body / Catchment Board	Water Source	Irrigation Access Charge ($/ML) based on allocation	Catchment Levy (cents in $ of capital value of property pa)	Supply Fee ($ pa)	Charge $/ha equiv. pa	Supply Charge (% property value)	Useage or Delivery Charge $/ML	Excess Cost ($/ML)	River Murray Catchment Annual Levy ($/ML)	Save the River Murray Levy ($ /property /qtr)
Murraylands	Riverland	Murray Bridge	Private diversion	Murray River	-	-	-	-	-	-	-	3.63	-
			Private Trusts e.g. Greenways Irrigation Trust	Murray River	-	-	-	330	-	117	-	-	-
			SA Water - mains water commercial rate (e.g. to glasshouses)	Murray River (filtered town water)	-	-	-	-	0.134 with minimum of $155	$264/ML (1st 125KL), $618/ML (>125KL)	-	-	34.35
Murraylands	Upper Mallee	Pinnaroo, Peebinga	Mallee Prescribed Wells Area (South)	groundwater (bore)	-	-	-	26.94	-	-	-	-	-
Adelaide Hills	-	Lenswood, Piccadilly Valley, Onkaparinga Valley	Onkaparinga Catchment Water Management Board / Adelaide Hills Council Area - West Mount Lofty Ranges	groundwater (bore), surface (dam, river)	-	0.12034	-	-	-	-	-	-	-
Northern Adelaide Plains	-	Virginia	Water Reticulating Services Virginia (WRSV)	Bolivar Effluent - recycled water	$115.70 (summer), $95 (spring & autumn) $68 (winter)	-	$900 for up to 3 connect-ions	-	-	-	$115.70 (summer), $95 (spring & autumn) $68 (winter)	-	-
			Northern Adelaide & Barossa Water Catchment Board	groundwater (bore)	5	-	-	-	-	-	5	-	-
South East	Lower South East	Penola	South East Water Catchment Board - Lacepede Kongorong & Naracoorte Ranges Prescribed Wells Areas	groundwater (bore)	1.97	-	-	-	-	-	-	-	-

10. & 11. GROSS RETURNS AND GROSS MARGINS $/ML/CROP

Table 10a: Gross returns and margins $/ML for main vegetables grown in South Australia

References (see below table)

The on-farm and state net returns for water used, were calculated for the main vegetable crops by area for South Australia. Average gross margins (with limited verification) were used with calculated water requirements. On-farm net return for water used (column 5) ranged from $271 to $9,264/ML. State net return for water used (column 11) ranged from -$11,071 to $3,896/ML. Negative figures are largely attributed to large standard errors when calculating on a state basis, particularly for glasshouse crops (cucumber and tomato).

Vegetable Crop	1. On-Farm Gross Income ($/ha)	2. On-Farm Variable Costs ($/ha)	3. On-Farm Gross Margin ($/ha)	4. On-Farm Water Use (ML/ha)	5. On-Farm Net Return for Water Used ($/ML)	6. State Area (ha)	7. State Gross Income ($M)	8. State Variable Costs ($M)	9. State Gross Margin ($M)	10. State Water Use (ML)	11. State Net Return for Water Used ($/ML)
Potatoes	$13,625	$12,188	$1,438	5.30	$271	9,092.6	123.5	110.8	12.7	48,191	$264
Onions	$17,875	$15,289	$2,586	8.44	$306	1,724.6	50.4	26.4	24.0	14,556	$1,650
Carrots	$15,000	$9,989	$5,011	6.66	$752	1,020.2	36.7	10.2	26.5	6,795	$3,896
Lettuce	$63,756	$38,898	$24,858	5.00	$4,972	279.0	8.0	10.9	-2.8	1,395	-$2,017
Brussel sprouts	$7,059	$43,691	$7,059	5.50	$1,283	92.0	5.2	4.0	1.1	506	$2,240
Cauliflower	$11,700	$9,281	$2,419	5.50	$440	241.3	3.9	2.2	1.6	1,327	$1,224
Melons	$19,375	$17,438	$1,937	3.60	$538	220.0	3.8	3.8	0.0	792	$10
Pumpkins	$15,000	$10,649	$4,351	4.00	$1,088	377.6	3.4	4.0	-0.6	1,510	-$388
Broccoli	na	na	na	5.79	na	271.1	3.4	na	na	1,569	na
Cucumbers	$200,000	$125,886	$74,114	8.00	$9,264	82.1	3.1	10.3	-7.3	657	-$11,071
Leeks	na	na	na	na	na	50.9	2.6	na	na	na	na
Cabbages	na	na	na	2.19	na	112.7	2.5	na	na	247	na
Tomatoes	$150,000	$130,833	$46,149	16.00	$2,884	113.3	2.2	14.8	-12.7	1,813	-$6,989

Data in Columns:

1. 2. & 3. from references 15, 24, 25, 28-35, 46-48 and 52-53 (with updated prices)
4. from tables 7a, 7b & 8a, from regions as specified in notes below
5. = column 3 divided by column 4
6. from Table 2a.
7. from Table 4
8. = column 2 x column 6 then divided by 1million
9. = column 7 - column 8
10. = column 4 x column 6
11. = column 9 x 1million then divided by column 10

na Not available

Vegetable Crop	Relevant information for data in Table 5 (column 5) - under Water requirement
Potatoes	Riverland, Loxton, winter
Onions	Murray Lands, Murray Bridge, summer, white and brown
Carrots	Pinnaroo, Upper Mallee - summer
Lettuce	Virginia, Northern Adelaide Plains, field-grown
Brussel sprouts	Lenswood, Adelaide Hills, summer
Cauliflower	Adelaide Hills, spring & summer, (1.13ML irrigation requirement)
Melons	Riverland, drip (9.54ML for sprinkler)
Pumpkins	Riverland, sprinkler (8.43ML irrigation requirement)
Broccoli	Lenswood, Adelaide Hills, summer
Cucumbers	Virginia, Northern Adelaide Plains, continental, traditional glasshouse
Leeks	Adelaide Hills
Cabbages	Virginia, Northern Adelaide Plains
Tomatoes	Virginia, Northern Adelaide Plains, fresh market, traditional glasshouse

High water tables and compaction can cause yield losses in some areas

Managing soil structure, reducing sodicity, compaction and fertiliser excess can improve growth of vegetables

12. IRRIGATION MANAGEMENT AND END PRODUCT QUALITY

Table 12a: Effect of irrigation on vegetable end-product quality in regions of South Australia

References 58, 62, 63, 64

Irrigation management strategies are used by South Australian vegetable growers to improve both end-product quality and yields.

Irrigation Management Strategy	Description	Effect on End Product Quality
Optimise pump efficiencies, system maintenance, operating pressures & flushing	Accurate operating pressures ensure water is applied at expected rate, and that crop receives correct amount.	Crop may receive inadequate water, at critical times, if pump pressures are not accurate. This can affect end product quality causing small and miss-shapen product. This may occur at critical flowering and setting in field-grown cucurbit crops (in Murray Lands), and at tuber set in potatoes (in South-East and MurrayLands). Lower rainfall vegetable growing areas of the state, relying largely on irrigation, are affected more.
Ensure timely system flushing	Flush supply lines regularly to avoid buildup of sediment which can affect flow rates.	Flushing is important in drip-irrigated vegetable crops on sandy soils (e.g. rockmelons and pumpkins in the Murraylands), as whole plants can die due to a blockage, in hot weather where irrigated daily. Since drippers are hidden under plastic and the crop canopy, the lack of water is not immediately apparent.
Timely Irrigation to prevent wind erosion	Improve wind protection through timely irrigation to establish nurse crops or prevent wind erosion during high winds	Using timely irrigation for wind protection is particularly important on sandy soils during November when winds cause sand-drift and cut off young onion seedlings in Murray Lands region. High winds can also cause soft-fruit and leaf damage which may cause scarring or lead to disease.
Optimise irrigation method for situation	Use of drip instead of sprinkler in some vegetable crops	Vegetable crops such as rockmelon and pumpkin benefit from drip vs sprinkler irrigation, to improve quality, as fruit develops on dry soil surface, with less disease at contact point. Also the use of drip reduces the interrow weed growth which may occur under sprinkler. Weeds may host insect and disease pests which if spread to the crop, may affect end product quality.
	Use of centre pivot instead of fixed overhead sprinkler in some broadacre vegetable crops	Vegetable crops such as potatoes, onions and carrots grown in broadacre areas, benefit from moveable centre pivot irrigation instead of fixed overhead sprinkler. The pivot is moved onto fresh ground after 1-2 seasons, enabling reduced disease buildup and effects on end-product quality. e.g. carrots are affected by buildup of root-knot nematode which cause distortion of roots.
Improve irrigation of non-wetting sands	Spread clay to improve water absorbency properties of non-wetting sands in South-East region.	Particularly for processing potatoes in the South East, where non-wetting sandy soil characteristics affect moisture holding and runoff, and potato yields & quality.

Irrigation Management Strategy	Description	Effect on End Product Quality
Manage soil water tables	Manage Irrigation preventing high water tables and applying water appropriate to depth of impermeable layers	Impermeable Blanchetown clay layers in flat, low areas between sand dunes in the Murray Lands, particularly if within one metre of the surface, affect water application, and lead to perched water tables when water drains from higher areas. Most vegetables are yield-affected if waterlogged for more than 2 hours. Severe flooding from higher residential areas has recently affected vegetable crops on the Northern Adelaide Plains in November 2005. Limestone and impermeable clay layers also occur at shallow depths in the Murraylands, on river flats, in swales and depressions, where light frequent irrigations are necessary to ensure roots are never waterlogged, or droughted, with drainage installed if irrigation is not meticulously scheduled over the whole area.
Reduce salinity effects	Irrigate at night to avoid salt crystallisation and leaf burn during hot periods.	Night irrigation is particularly important in leafy vegetables grown with irigation water of higher salinity such as lettuce on the Northern Adelaide Plains, and potatoes in the Upper Mallee grown with higher salinity bore water.
	Shandy water sources to improve overall salinity	Mixing water sources during the vegetable growing period to reduce the overall salinity is conducted on the Northern Adelaide Plains with recycled and bore water, and in Langhorne Creek with Lakes and bore water.
Use irrigation to fertigate more efficiently	Constant regular applications of water and fertiliser	Constant regular applications of water and fertiliser ensure growth, flowering and setting uniformity - particularly in drip irrigated rockmelons, with subsequent improved fruit quality. Schedule may include daily irrigations in peak periods and weekly fertiliser (especially nitrogen and potassium).
Scheduling irrigations to match vegetable water requirements	Good understanding of soil moisture holding capacity, plant rooting depth and water requirements in conjunction with soil moisture monitoring devices.	Capacitance probes have been used in potatoes in the South East, Adelaide Plains and Riverland, and in leeks and onions in the Lower Murray. Monitoring devices help prevent overwatering, underwatering and improve timing of irrigations during critical growth periods. Improved production and product appearance, reduced disease, root rot and scarring, have been observed.

13. SALINITY IMPACTS ON PRODUCTION

References 8, 65–69, 71

Increasing salinity of the groundwater at Virginia (market garden area near Adelaide) has led to the drive towards recycled water. Recycled water at Virginia has an electrical conductivity (EC) reading of about 1200 µS/cm (1000 µS/cm can be too high for some sensitive vegetable crops, others can utilise up to 1700 µS/cm). In the South East (e.g. at Padthaway), salinity of the groundwater is driving out salt-sensitive crops. In the Lower Mallee, irrigation is restricted to cells of better water (e.g. at Peebinga and Parilla - potatoes, onions and carrots) with an estimated irrigable life of 30–50 years. Murray River water salinity has only been about 200–300 µS/cm in recent years, and the river-irrigated zones have an estimated life about 50+ years. High salinity impact zones along the Murray River also impact on new developments and their location.

Salt interception schemes have been implemented along the Murray River in areas where there are definite salt inputs (e.g. Woolpunda, Waikerie, Lock 4, and in development in 2006 at Loxton). Salt interception schemes prevent groundwater flowing back into the river, sourcing water at strategic points under irrigation areas, from regional groundwater tables along the edge of the river valley, and pumping the water out to evaporation ponds.

Table 13a: Irrigation salinity effect on vegetable production in regions of South Australia

Region	Main Irrigation Methods for Vegetables	Source & Salinity of Irrigation Water (EC µS/cm)	Effect of Salinity on Vegetable Production	Salinity Ranking 1=low 7=high
Murray Lands - Riverland	centre pivot, sprinkler, drip	river: 200-700, average 450	Higher quality water, hence potential for higher yield and quality vegetables	1
Adelaide Hills	sprinkler	bore: 1600 - 2000 dam: <800	Generally good quality water, and corresponding good quality vegetables produced. Vegetables using bore at Charleston (1700 - potato), Mt Barker (via effluent ponds, 1100-1300-2100, brussel sprouts export quality), Forreston (broccoli, mix of dam 800 and bore 2000), Picadilly Valley (higher rainfall, 500), Nairne (leeks & onions, bore 2000 & some dam 800).	2
South East - Lower South East	centre pivot, sprinkler	bore 500 - 1500 (variable)	Lower salinity than Upper South East, better quality expected, fewer water quality problems. Potatoes at Penola around 700.	3
Murray Lands - Murray Bridge	sprinkler, drip	river: 300 - 750, average 500	Further down river hence salinity higher than Riverland	4
Murray Lands - Upper Mallee	centre pivot, sprinkler	bore: 800 - 1000	Lameroo and Pinnaroo areas. Minor quality problems, although quality will vary depending on variable groundwater salinity, and impermeable layer close to surface. Irrigation management critical to prevent waterlogging.	5
Northern Adelaide Plains	sprinkler, drip	Recycled: 1500-2000 Bore: 1300-1700	Irrigation water is mainly sourced from the T2 layer (105+ metre deep). Other layers (T1 - 55-95m) and groundwater Q1 (4 metre underground) have salinity up to and greater than 3000 EC. Gypsum is applied in horticultural areas if soil test indicates sodicity, at the beginning of winter and flushed through soil by winter rains.	6
South East - Upper South East	centre pivot, sprinkler	bore: 1500 - 2000 (variable)	Higher salinity than Lower South East, therefore poorer quality expected. Potatoes Kalangadoo through to Frances	7

The optimum size of centre pivots and their sprinkler properties is now better understood for application in vegetables in South Australia

14. OTHER WATER QUALITY IMPACTS ON PRODUCTION

Reference 8, 91

In the Adelaide Hills, private diverters using water from creeks or groundwater, face catchment issues related to domestic water use due to fertiliser contamination of groundwater.

Occasional Murray River toxic algal blooms occur depending on the year and weather, however they do not normally impact on agricultural production, only recreational use of the river.

Chlorination of river water and ground water is required for packing shed washing operations to manage water-borne pathogens related to QA and food safety issues.

Recycling of effluent and management of sediment from packing shed washing operations is required through Environmental Management Plans.

Water treatment plants across South Australia are required for for domestic consumption of water (e.g. Murray River water in the Riverland), removing sediment (cloudiness) and treating with chlorine and ammonia to control pathogens.

The South Australian Environment Protection Authority's (EPA) Environment Protection Policy (Water Quality Policy) protects South Australia's rivers, marine and ground waters from pollutants, and brings South Australia in line with the National Water Quality Management Strategy. Water quality values within the rural catchments relate to drinking water, aquatic ecosystems, agricultural use, and recreational and aesthetic uses. Of these, drinking water and aquatic ecosystems are paramount because by protecting these, other values are protected. SA Water conducts a risk assessment of Adelaide's water supply annually. Environmental Management Plans (EMP) have been developed to document initiatives, targets and to identify actions to address environmental challenges and manage environmental risks.

The EPA have identified water quality issues within the rural catchments in South Australia of which some (marked with *) are directly related to horticultural production:

Blooms of toxic algae in dams and reservoirs, major reservoirs closed because of contamination of water by algae, stock deaths from animals, drinking water contaminated by toxic algae.

* Pesticides causing contamination in some rivers and streams.

Water-borne parasites, Cryptosporidium and Giardia, detected in rivers and streams.

*Sediment from erosion of degraded river banks, overgrazing and intensive horticultural practices deposited in reservoirs.

Animal and human faecal contamination of rivers and streams making them unsuitable for drinking without disinfection.

*Localised heavy metal contamination

15. ACCESS TO WATER IMPACTS ON PRODUCTION

Reference 8

Access to Murray River water in some areas along its route from the NSW/Vic border to the river mouth, impacts on potential vegetable and other agricultural production. For example, high river cliffs and distances of more than 5km from the river can cause high pumping costs, reducing profitability (also section 9, Water costs to farm boundary (water charges or private pumping costs)).

Drought impacts on Murray River flows into South Australia, and has resulted in reduced % allocations for irrigators (refer also section 26, Average allocation over last 3 years (drought affected)). Under severe drought restrictions, vegetable production may shift to other locations unlike tree or vine crops (e.g. to areas under bore irrigation).

Lowering aquifer levels due to bore drawdown in the Mallee, Upper South East and Northern Adelaide Plains have impacted on available production areas. Access to allocations of bore water on the Northern Adelaide Plains impacted on production particularly prior to the recycled effluent scheme in this region, which has increased the availability of water of adequate quality for the expansion of vegetable and horticultural cropping (also section 34, Drainage/recycling capacity/farm)).

16. NUMBER OF FULL TIME EQUIVALENT JOBS

Table 16a: Persons employed in vegetable, horticulture and related value adding industries in South Australia and Australia - 2001

Reference 16, 111

There were 1642 persons employed in the vegetable growing industry in South Australia in 2006, representing about 12% of the total number of persons employed in horticulture growing. An additional 3595 persons were employed in processing, retailing and wholesaling of fruit and vegetables.

Industry of Employment	Unit	2001			2006		
		South Australia	Australia	SA % Australia	South Australia	Australia	SA % Australia
Vegetable Growing	male	1,064	10,266	10	1,133	9,421	12
	female	539	5,355	10	509	5,130	10
	persons	1,603	15,621	10	1,642	14,551	11
Horticulture & fruit growing (including vegetable growing)	male	7,882	70,244	11	5,761	21,707	27
	female	3,701	24,279	15	2,660	12,724	21
	persons	11,583	69,667	17	8,421	34,431	24
Fruit & vegetable processing	persons	1,004	9,762	10	836	13,045	6
Fruit & vegetable retailing	persons	1,493	13,926	11	1,328	13,828	10
Fruit & vegetable wholesaling	persons	2,133	16,139	13	1,431	13,193	11

17. WATER TRADING FLEXIBILITY (PRICE)

Reference 112, 113

In SA in 2004–05, there were 364 (33,421ML) permanent water trades, and 446 (49,525ML) temporary water trades. The majority was water traded within or into SA, in the River Murray Prescribed Water Course (PWC) Water Management Area. SA sources permanent and temporary water from Victoria and NSW. The average price ($/ML) of water traded was unavailable.

Table 17a: Irrigation water value for permanent and lease water in regions of South Australia

References 50, 51, 55

Region	Sub-Region	Towns	Permanent $/ML (a)	Lease ($/KL) (a)	Comment
South East	Upper South East	Frances, Keith	$50	na	low values for water salty and low demand, mainly olives and pasture
		Naracoorte, Wrattonbully	$2500	na	potatoes, grapes and vegetables, higher demand, better quality water, higher values
		Lucindale, Padthaway	$100 - $1500	na	low to medium values, some good pockets of water, some areas with very salty water are gwing back ownership
	Lower South East	Mt Gambier	na	na	water is valuable south of Mt Gambier, but of limited availability
Northern Adelaide Plains		Gawler River	$1200	na	lower values in region around Gawler River and outer areas, higher values around Virginia and other pockets, average of $4000 – $5000/ML
		Virginia	$7000	na	
Murray Lands	Riverland	Loxton, Waikerie, Mannum, Murray Bridge	$1400 - $1500	$40 - $80	water sourced from River Murray
	Barossa		$1500 - $2500	na	piped water, value is less than Riverland
Adelaide Hills		Lenswood, Picadilly Valley	na	na	No transfer permitted at present, and as there is no allocation, there is no $value to water However, this catchment is coming up for prescription soon.
		Kangarilla, Strathalbyn, Ashbourne	$1000 - $1500	na	pockets, with less value, since water rights leased long term, not much spare water
		Strathalbyn	$300 - $700	na	pockets of good quality bore water are shandied with River water, gives good result with lower price
		Mclaren Flat	$16,000 - $18,000	na	
		Willunga	$14,000	na	
Other	Upper Fleurieu	Mclaren Vale	$1200 - $1600	na	less water available hence (formerly) more valuable than Riverland water
		Langhorne Creek	$300 - $700	na	pockets of good quality bore water are shandied with River water, gives good result with lower price
	Mid-North	Clare	$1500 - $2500	na	piped water has value less than Riverland; higher values may be expected from good bore water from fractured rock

(a) Values of permanent and lease water are approximate. Values and comments are as at October 2005.

Water Trading, or the buying and selling of water access entitlements, was first introduced in SA in 1983. Water trading may entail the purchase of a permanent allocation of water, or the leasing of water temporarily (e.g. for a season, or a few years). Water trading along the Murray River is very flexible, with water transferred between states within the Murray Darling Basin, but not above the Barmah 'Choke' on the NSW-Victorian Border above Shepparton (refer Table 17a).

Figure 17b: Prescribed Area Map of Water Resources in South Australia

Reference 55

Apart from the River Murray, water in general can be sold within, but not transferred between other prescribed areas of South Australia (Figure 17b), due to identified physical, social and environmental constraints. Water transfer within these areas is dependent upon individual prescribed area regulations. The water "Transfer Criteria" are in the relevant Water Allocation Plans for all the prescribed areas detailing the general principles applying to the transfer of surface and/or groundwater within that area. These Water Allocation Plans can be viewed at http://www.nrm.sa.gov.au and selecting the relevant Natural Resources Management Board website.

Table 17c: Water Trading Websites

References 56, 57

Apart from conventional water traders and brokers the following websites assist with water trading.

Water Trading Noticeboard of Department of Water Resources (SA)
Water vendors can post advertisements for inclusion in the Water Trading Noticeboard of Department of Water Resources website for the sale, lease or purchase of water. The aim of the Noticeboard is to facilitate water trading activities and to provide a Noticeboard which is accessible to the public 24 hours a day 7 days a week. The actual trade of the water allocation does not take place on this web site. The information is made available for potential buyers and sellers to contact each other. Negotiation of the terms of the trade is a private arrangement between the trading parties and once finalised, 'Application for Transfer' forms need to be submitted in the normal way.
Waterfind
Waterfind.com.au is a national water trading website that matches buyers and sellers of water allocations, locally and interstate. Irrigators can use this website to buy, sell and lease their water. The water trading platform can facilitate price negotiation, trade of ownership and leasing arrangements. Local and interstate regions that can legally trade with each other are identified.

18. ON FARM METERING AND WATER LICENSING

Reference 8, 69, 79, 92

The Department of Water, Land and Biodiversity Conservation (DWLBC) in South Australia manages a number of business functions associated with the management of the State's natural resources including the issuing of water licenses and well permits, and managing the allocation of the State's water resources. Licenses and permits apply to each of the prescribed water resource areas of the state, which include: Angas Bremer, Eastern Mount Lofty Ranges, Western Mount Lofty Ranges, Clare Valley, Barossa, Eyre Region, Far North, Mallee Prescribed Wells Area, McLaren Vale, Northern Adelaide Plains, River Murray and South East.

The South East Catchment Water Management Board installed meters in a phased program over 3 years to 2006, with the development of volumetric water licensing. Farm metering, licensing and introduction of water allocations is also in development in the Mallee and Adelaide Hills.

In the Riverland and Northern Adelaide Plains, farm metering and licensing is already established.

Benefits of metering water use, installation recommendations and newsletters have been detailed in a range of extension information from the South East Catchment Water Management Board and DWLBC. Benefits of metering water use in that region are described and include:

improved resource management

more equitable distribution of the resource

provide opportunities for trading

monitor pump performance

monitoring irrigation system performance

reduce fertiliser leaching

basis for automated irrigation systems

improved crop yields

improved profitability of irrigation enterprise

reduce degradation of water quality

reduce degradation of soil structure

assist with the assessment of the effectiveness of Water Allocation Plans

contribute to overall sustainable use of the resource

19. BENCHMARKING DATA – GENERAL

References 4, 5, 8

The winegrape, potato, lucerne seed, dairy, prime lamb and prime beef industries have had benchmarking studies conducted in the South East region. Potato (refer table 8b), winegrape and citrus benchmarking studies have been conducted in the Riverland Region.

20. BENCHMARK ET REQUIREMENTS

Reference 8

Refer information contained in Tables 7a, 7b, 7e and 8b, for calculated vegetable irrigation requirements for main regions of South Australia. ETo figures (evapotranspiration of reference crop by location by month) were used in the calculation of each vegetable crop's irrigation requirements in these tables.

21. USE OF SOIL MOISTURE MONITORING

References 8, 58, 59, 70

There has been an increased use in South Australia of soil water monitoring, particularly in response to setting of crop and region-dependent water allocations and on-farm water meter installation. The increased use of soil water monitoring tools have included mainly logging capacitance sensors (e.g. Sentek), tensiometers, some neutron probes, and portable capacitance probes.

Capacitance probes are mainly used in low rainfall areas of the Riverland, and on the Adelaide Plains in potatoes. Capacitance probes are useful for use in potatoes in the South East, where irrigations may be up to every second day, to avoid under- and over-irrigation, and control fertiliser leaching into swamps and groundwater. Capacitance probes are also used in leeks and onions in the Lower Murray, and at Blanchetown and Langhorne Creek. Use of probes in these high input crops enable managed salt leaching past the rootzone, but avoiding nitrogen leaching into creeks and rivers. Reports of improved packouts and production have occurred, as well as reduced disease and potato scarring. In the Mid-Murray area, TDR probes (e.g. Aquaflex - modified TDR probe) are also used in potatoes. Capacitance probes however require minimal soil and profile disturbance during installation. In sandy areas of the Mallee Prescribed Wells Area (Upper Mallee) gypsum blocks and tensiometers are used in preference to capacitance probes, which are reported to not work as effectively in the sandy soils in that area, however in other areas, do work effectively.

Table 21a : Number of Establishments using soil moisture monitoring tools in South Australia in 2002–03

Reference 72

Tools Used (b)	Number of Establishments
Evaporation figures or graphs ^	606
Tensiometers ^	579
Soil probes	1,644
Government or commercial scheduling service ^	125
Calendar or rotational scheduling	795
Knowledge or observation	4,630
Other ^	366

^ estimate has a relative standard error of 10% to less than 25% and should be used with caution

* estimate has a relative standard error of 25% to 50% and should be used with caution

(b) Agricultural establishments reporting more than one tool are shown against each tool reported.

22. USE OF WEATHER BASED SYSTEMS FOR SCHEDULING

References 70, 72, 94, 97

Table 22a : Number of Establishments using weather based systems for scheduling in South Australia in 2002–03

There were over 1400 irrigators in South Australia in 2002–03, reported using weather-based systems for irrigation scheduling. Weather-based systems are largely used in conjunction with irrigation scheduling tools in broadacre vegetables, such as under centre pivots.

Tools Used (b)	Number of Establishments
Evaporation figures or graphs (a)	606
Calendar or rotational scheduling	795

(a) estimate has a relative standard error of 10% to less than 25% and should be used with caution

(b) Agricultural establishments reporting more than one tool are shown against each tool reported.

New developments in weather monitoring are also occurring in South Australia. A weather station grid is being installed across Riverland, Mallee and Lower Murray with data accessible online. The Bureau of Meteorology to forecast evapotranspiration (e.g. 2 days ahead), enabling improved irrigation application planning. Rain forecasting by the Bureau of Meteorology and SILO also facilitates irrigation management in relation to more effective disease and pest spraying and control.

23. TOTAL CATCHMENT WATER USED FOR VEGETABLE CROPS

References 67, 68, 87, 95

Water Resource Management Areas of South Australia now operate under eight Natural Resource Management Boundaries (refer Map 4). The NRM Boundaries of relevance to vegetable growing in South Australia include SA Murray Darling Basin, Adelaide & Mount Lofty Ranges and South East.

The amounts that irrigators apply are typically very different from the calculated targeted irrigation needs figures (based on ABS census data and crop water requirements). The DWLBC collects meter readings from water licensees across the state where meters have been installed, but does not collect data about what crop received the metered volume. In 2003–04, the South East Catchment Water Management Board reported vegetable irrigators used 3,273 ML from the unconfined aquifer.

In those few districts where it has been successfully introduced, Irrigation Annual Reporting collects accurate data from each irrigator about how much water was applied to each crop type (e.g. by Central Irrigation Trust (CIT) in the Riverland and the South East Water Management Board in the South East).

Table 23a : Water Use for Vegetables and Agriculture in South Australia and Australia 2000–01 and 2004–05

References 93, 112

Vegetables consumed 64,724 ML water in South Australia in 2000–01, this represented 5% of water consumption by agriculture in South Australia, and 12% of the water consumption by vegetables in Australia.

2000–01		Self-extracted (b) ML	Mains water (c) ML	Reuse water (d) ML	Water In-stream (e) ML	Consumption (a) ML
Vegetables	South Australia	45,123	9,229	10,372	-	64,724
	Australia	422,008	117,033	16,670	-	555,711
Agriculture	South Australia	1,017,147	273,234	12,073	-	1,302,454
	Australia	9,132,095	7,105,022	423,264	-	16,660,381
2004–05						
Vegetables	South Australia	72,353	7,553	14,969		94,874
	Australia	307,003	132,544	15,796		455,373
Agriculture	South Australia	806,882	194,820	18,139		1,019,841
	Australia	6,582,435	5,329,012	279,925		12,191,372

(a) Water consumption = Self-extracted use + Distributed water use + Reuse water use - Distributed supply - In-stream use..

(b) Includes water extracted directly from the environment for use.

(c) Includes water supplied to a user usually through a non-natural network (piped/open channel or other carrier) where an economic transaction has occurred for the exchange of water regardless of method of delivery. Mains water is a subset of the self-extracted total.

(d) Refers to wastewater that may have been treated to some extent before being used. It excludes water reused on-site.

(e) This is a subset of Self-extracted water use.

Water volumes applied to vegetables in South Australia have increased annually to 94,874ML in 2004-05, but fell to 83,075ML in 2005-06 (refer Table 7d).

24. AVERAGE WATER ALLOCATION/FARM (TYPE, HIGH/LOW SECURITY)

References 8, 69

Water allocations may be described as 'high security' from the Murray River, interpreted as receiving a full allocation approximately 99 years in 100, however the % authorised use of allocation growers are allowed may change due to drought circumstances in any one year (refer Table 26a). Water allocations on the Northern Adelaide Plains recycled effluent scheme have guaranteed delivery quantity, pressure and salinity range. Availability and quality of bore water in the Adelaide Hills, Northern Adelaide Plains, Mallee and South East, have no security attached, since it is dependent on drawdown due to use and salinity, and re-assessment of the resource volumes which can be safely drawn. Estimated Irrigation requirements by vegetable crop by location in South Australia (in mm/ha/crop) are given in Table 7a, and may be used in water allocation estimations.

Table 24a : Average Water Applied per Horticultural Irrigation Establishment in South Australia

References 3, 109

The average water applied per horticultural irrigation establishment in South Australia was calculated from figures given in Table 7d (total volume applied divided by number of establishments). The average water applied per vegetable irrigation establishment was 149 ML in 2002–03, and 133 ML in 2005–06, and generally higher than other horticultural enterprises such as fruits, nuts and grapevines. This may be due to more than one vegetable crop being grown in an irrigation year compared with permanent plantings.

2002-03	Vegetables for human consumption	Fruit trees, nut trees, plantation or berry fruits (a)	Grapevines	Nurseries, cutflowers or cultivated turf		Vegetables for seed	
Number of establishments irrigating	501	1349	2773	213		51	b
Volume applied (ML)	74,536	145665	217496	6835	c	1720	b
Volume applied (ML) per establishment irrigating	149	108	78	32		34	
2005-06							
Number of establishments irrigating	623	1,246	3,052	264		64	
Volume applied (ML)	83,075	146,063	225,875	5,859		3,151	b
Volume applied (ML) per establishment irrigating	133	117	74	22		49	

a = excludes grapevines

b = estimate has relative standard error of 10% to less than 25% and should be used with caution'

c = estimate has relative standard error of 25% to 50% and should be used with caution

25. AVERAGE ALLOCATION % / FARM OVER LAST 10 YEARS

Reference 8

In prescribed water areas of South Australia, where allocations have been instituted (refer Table 30a), there has generally been 100% of allocation over the last 10 years. Other non-prescribed areas were dependant on the seasonal or other availability of suitable water from the water source (e.g. dam, bore), which may have been affected by drought or excessive drawdown, or re-assessment of the resource (refer section 24).

26. AVERAGE ALLOCATION OVER LAST 3 YEARS (DROUGHT AFFECTED)

Table 26a : River Murray Water Restriction **in Water Use Years July 2003 – June 2005**

References 8, 114

Date Restriction Gazettal Approved	% of Licensed Allocation (Restriction to Authorised Use)
June 2003	65%
September 2003	75%
November 2003	95%
July 2004	70%
August 2004	70%
September 2004	90%
February 2005	95%
July 2005	70%
August 2005	70%
September 2005	82.50%
October 2005	100%
July 2006	80%
November 2006	60%
July 2007	4%
August 2007	13%
October 2007	16%
December 2007	22%
December 2007	32%

Drought restrictions have affected the % authorised use of allocations in certain prescribed water areas across South Australia, where allocations have been instituted. Table 26a lists the dates and % restriction to authorised use of allocations from the Murray River, which have ranged from 4% to 100% between July 2003 and December 2007, particularly affecting Riverland growers. This has been due to impacts of drought conditions throughout the Murray Darling Basin, and the prospect of SA receiving less than its Entitlement Flow (1850GL in 2003-04).

27. CROP TYPES /FARM

Refer Tables 2a, 2b and 2c for irrigated areas of vegetable crops in South Australia. Statistics of vegetable crop types per farm are not available, apart from general local knowledge.

The Murraylands and South East regions may rotate broadacre vegetables under centre pivot (or overhead fixed sprinkler), such as machine harvested potatoes (processing or fresh), onions and carrots. Cereal crops in these regions are often used in the rotation. Within the Murraylands region, Riverland farm businesses may also include cereals or permanent plantings of citrus, olives, winegrapes or almonds, whilst in the Mallee and South East mainly cereals. Cereals are used in rotations with vegetables in these regions mainly because of lower land prices than other areas, the income from the grain (or hay), and to boost organic matter and soil retention during fallow periods.

Glasshouse vegetable crops on the Northern Adelaide Plains may rotate tomatoes, zucchini, cucumber and capsicum, adding organic matter soil amendments instead, to improve nutrient holding capacity and improve soil structure and drainage.

Adelaide Plains field grown vegetable crops include small allotments of lettuce, bunching vegetables, herbs, potatoes, onions and/or other brassicas or root vegetables in varied rotations, although the farm business may also have permanent plantings such as winegrapes, olives or almonds.

The Adelaide Hills specialises in small allotments of cool-climate vegetable crops such as brussel sprouts or leeks, perhaps with permanent plantings of apples, cherries, olives or winegrapes in the farm business.

Glasshouse cucumber production on the Northern Adelaide Plains

28. % TOTAL ALLOCATION DEVOTED TO VEGETABLES VS OTHER CROPS

Table 28a : Water Volume Applied to Irrigated Pastures and Crops in South Australia

References 3, 72, 109

Crop types per farm, in association with vegetables, have been loosely described (refer section 27, Crop types per farm). Vegetables (for human consumption) in 2005–06 accounted for 83,075 ML, or 9% of the total water applied to pastures and crops in SA. The largest water volumes were applied to pastures for grazing and grapevines.

South Australia	Volume Applied (ML)					
Crop	2002-03		2003-04		2005-06	
Pasture for grazing	226,199	h	283,999	h	265,079	
Pasture for seed production	75,231	h	87,133	h	94,077	
Pasture for hay and silage	117,116	h	103,524	h	77,863	
Cereal crops cut for hay	10,218	k	9,266	k	6,709	
Cereal crops for grain or seed(b)	7,928	h	5,039	h	8,385	h
Cereal crops not for grain or seed	7,910	j	1,359	k	1,637	h
Rice	-	c	-	c	-	c
Sugarcane	-	c	-	c	-	c
Cotton	-	c	-	c	-	c
Other broadacre crops(d)	8,648	k	5,575	k	6,816	
Fruit trees, nut trees, plantation or berry fruits(e)	145,665		123,033		146,063	
Vegetables for human consumption	74,536		86,478		83,075	
Vegetables for seed	1,720	h	2,996	h	3,151	h
Nurseries, cutflowers or cultivated turf	6,835	k	20,413	j	5,859	
Grapevines	217,496		228,156	h	225,875	
Total(g)	899,530		957,613		927,264	

(b) excludes rice
(c) data not collected
(d) excludes sugar cane and cotton
(e) excludes grapevines
(h) estimate has relative standard error of 10% to less than 25% and should be used with caution
(j) estimate has relative standard error greater than 50% and is considered too unreliable for general use
(k) estimate has relative standard error of 25% to 50% and should be used with caution
(g) totals include other pastures or crops not elsewhere classified

29. TREND (% CHANGE) IN HIGH TECH ADOPTION, PAST 5 YEARS

References 8, 70, 115

The major changes in high tech adoption by vegetable growers in South Australia occurred more than 5 years (10–20 years) ago, with the introduction of drip irrigation in greenhouses and field production, improved distribution uniformity of sprinklers and better centre pivot irrigation units for broadacre vegetable production.

More recent changes on larger vegetable properties have been the use of integrated irrigation development and management services. These services may include, soil survey and interpretation, irrigation and fertigation design, advanced water management systems with more expensive irrigation-related computer technology-data capture, advanced nutritional systems with continual injection for pH and nutrition requirements, soil nematode testing, compaction amelioration, variety recommendations, conversion to drip etc, and customised training for staff.

Other more recent technology advances in irrigation with some application to vegetables include: buried drip irrigation systems deep in crop roots, no-drain irrigation systems which do not drain after an irrigation ends nor let air or sand get back into irrigation outlets, pulsing irrigation particularly of use in difficult shallower soils, combination hi-tech systems such as pulsed, buried, no-drain drip systems, plant monitoring systems for horticulture such as stem diameter and leaf potential vs soil water monitoring.

Smaller vegetable properties use largely non-integrated irrigation services by irrigation shops and other providers, where the services and products are bought individually. Government regulation has been a driver for larger horticultural developments to seek integrated irrigation services. Irrigation upgrade incentives have not generally been provided by the South Australian government (unlike in other states), although irrigation training programs in South Australia have been funded through various incentives. More recently (2007), drought assistance grants have become available (e.g. Planning For Recovery grants), which have encouraged irrigation upgrades, such as installation of more efficient irrigation systems, implementation of practices that increase water use efficiency and introduction of scheduling.

Uptake of high-tech irrigation practices have in part been due to the trend for larger company-based vegetable developments in South Australia with need to reassure investors and guarantee faster $ returns. Hence larger vegetable properties are run by professional property managers, and require integrated irrigation services. Increased Water Use Efficiencies (WUE) are also more technically demanding of irrigation systems.

Domestic supermarkets and export markets are demanding increased vegetable quality and environmental management, which requires better irrigation management and technology. The demand for irrigation services, changes with vegetable crop price fluctuations, for example good vegetable prices may lead to an investment in irrigation, whereas in bad times, there is less demand for change and irrigation improvements.

Generally, irrigation services are always in demand in the drier regions of South Australia (e.g. Riverland and Mallee) because it is an arid area, compared with other areas of South Australia where irrigation is only supplementary to rainfall, hence irrigation equipment is easier to sell in the Riverland than other areas.

Table 29a : Irrigation Methods by Agricultural Establishments in South Australia 2002–2004

Reference 2, 68, 95, 118

Irrigation methods used by vegetable establishments is not available for all growing regions of South Australia, but is selectively available through Irrigation Annual Reporting in a few districts. The annual surveys collect accurate data from each irrigator about how much water was applied to each crop type (e.g. by Central Irrigation Trust (CIT) in the Riverland and the South East Water Management Board in the South East).

The most common irrigation methods used by crop and pasture establishments in South Australia in 2002–05 were the more advanced, above ground drip or trickle, followed by microspray sprinkler. This contrasts nationally where surface irrigation was the most common method.

South Australia		Number of Agricultural Establishments					
Irrigation Method		2002-03		2003-04		2004-05	
Surface (c)		699	a	754	a	602	a
Drip or Trickle	above ground	2,235		2,010		1,939	
	subsurface	27	b	70	b	101	b
Sprinkler	microspray	1,278		1,347		1,211	
	portable irrigators	510	a	378	a	383	a
	hose irrigators	355	a	306	a	356	a
	large mobile machines	589		635		522	
	solid set	1046		851		796	
Other		96	b	120	a	97	b

(a) estimate has relative standard error of 10% to less than 25% and should be used with caution

(b) estimate has relative standard error of 25% to 50% and should be used with caution

(c) Surface irrigation refers to flood, furrow, basin or border check

Understanding soil characteristics and water holding capacity are important for vegetable irrigation

Improved irrigation practices ensure uniformity of yield and quality in vegetable production

Logging of soil moisture monitoring tools in carrots

Table 29b : Changes to Irrigation Practices in South Australia – 5 years to end June 2003

Reference 72

In South Australia, 3,945, or 72% of irrigating establishments, made one or more changes to irrigation practices in the five years to end June 2003. Of the establishments making one or more changes, 71% reported changing to more efficient irrigation application techniques as one of their changes, and 66% reported that more efficient irrigation scheduling was one of the changes made. These figures are comparable with the changes reported nationally.

South Australia - 5 years to June 2003	Number of establishments	
Total irrigating	5,471	
Made no changes	1,526	
Made one or more changes	3,945	
Type of Change (c)		
More efficient irrigation application techniques	2,785	
More efficient irrigation scheduling	2,584	
Piping or covered open channels to reduce water loss	413	b
Levee banks and/or drains	136	b
Laser-levelled	379	b
Irrigation water re-use or recycling	133	a
On-farm soil moisture monitoring	1,631	a
Documented farm water plan	406	a
Other	389	a

(a) estimate has relative standard error of 10% to less than 25% and should be used with caution

(b) estimate has relative standard error of 25% to 50% and should be used with caution

(c) Agricultural establishments reporting more than one intended change are shown against each change reported

30. DELIVERY CAPACITY OF IRRIGATION SCHEMES

Reference 8, 85, 87

Irrigated agriculture is the largest user of water in South Australia. Approximately 80% of all water use in South Australia is applied to various irrigated crops on 5 500 farms. Nearly 40% of the water taken for irrigation comes from the River Murray, 50% from South East groundwater and the majority of the remaining 10% is extracted from smaller groundwater basins around Adelaide.

In the South East and Mallee, groundwater is piped to pivots or sprinklers. Some channels are still present in the South East in isolated areas for flood irrigation of pastures or lucerne seed, but not for vegetables. Recycled water on the Northern Adelaide Plains is delivered by sealed pressurised pipe. Prior to infrastructure rehabilitation and pressurised delivery systems (compared with channels), Murray River water was not available on demand in Government irrigation areas of the Riverland, and vegetables required irrigation from privately pumped diversions from the river for successful production.

Table 7f refers to the reported volume of water diverted across 8 supply systems in South Australia, which was 936,528 ML during the 2003–04 irrigation season. The reported area irrigated however understates the total area irrigated, since figures do not include any area irrigated from private diversions from streams and private groundwater systems (refer also Table 30a).

In some areas of the state, and in some years, the actual water used for irrigation purposes may either exceed or be less than the allocation. In some areas, therefore there is capacity for expansion. For example, the total permissable annual volume (PAV) of groundwater from the Murray Group limestone aquifer in the Mallee Prescribed Wells Area is approximately 52,800 ML pa. A doubling of the current irrigation use (17,032 ML) could be accommodated within the PAV. In the Adelaide Hills however, allocations have fallen short of crop requirements in some years, attributed to over-planting.

Table 30a : Delivery Capacities of Prescribed Water Resource Areas in South Australia

Reference 87, 96

Prescribed Region 2004	Sustainable Available Water (b) GL	Allocated Water (c) GL	Water Used (d) GL
Angas Bremer	34.5	34.5	17.2
Barossa	15.8	15.8	12.5
Clare	4.8	4.8	3.0
Comaum-Caroline	100.2	85.5	73.0
Lacepede-Kongorong	570.3	346.8	187.0
*Mallee	52.8	51.9	27.3
McLaren Vale	10.8	10.7	8.6
Musgrave	6.3	0.2	0.2
Naracoorte Ranges	82.6	80.1	80.0
*Northern Adelaide Plains	21.5	41.5	29.5
Padthaway	32.3	35.2	49.0
Southern Basins	13.5	0.3	0.3
Tatiara	126.1	92.4	105.0
Tintinara-Coonalpyn	114.8	78.6	74.4
*Murray River (a)	500.0	569.1	416.0
East Mt Lofty Ranges (e)	na	na	34.5
*West Mt Lofty Ranges (e)	na	na	17.5
TOTAL	1,686.2	1,447.4	1,135.0

(a) excluding Angas Bremer, Barossa and Clare Prescribed Regions

(b) includes all available water which can be sustainably used for all purposes in prescribed area, including piped, wastewater, groundwater, surface water, reclaimed water and SA water (domestic)

(c) includes allocated water for all purposes in prescribed area including groundwater, surface water, River Murray (incl. piped water), reclaimed and SA water

(d) includes water used for all purposes from groundwater, surface water, Murray River,reclaimed water and SA Water (domestic)

(e) areas not yet prescribed, estimates used

* region with significant vegetable growing areas

In Table 30a, delivery capacities of water resource areas across South Australia are defined (for all purposes, including irrigation) as: 1. sustainable available water, 2. allocated water and 3. used water volumes. The total sustainable available water for the state in 2004 was estimated at 1,686 GL, of which 1,447 GL is allocated and 1,135 GL used.

31. DELIVERY RELIABILITY OF SCHEMES

Water schemes delivering pressurised water to vegetable growers on the Northern Adelaide Plains (reclaimed water) and from Murray River, generally have guaranteed delivery reliability, unless % authorised use of allocation has been affected by drought. However, water pumped from individually licensed bores in the Adelaide Hills, Northern Adelaide Plains, Mallee and South East, is dependent on drawdown, increased salinity and re-assessment of the resource (refer sections 24, 25 and 26).

32. INFORMATION ACCESSIBILITY

Table 32a : Irrigation Information Providers in South Australia

Vegetable growers in South Australia can obtain irrigation information from a wide network of government and private providers across South Australia. Regional presence of most information providers and their websites, with fact sheets and e-newsletters has increased the accessibility of information and knowledge transfer. Primary Industries and Resources SA (PIRSA) provides phone and office technical inquiry servicing and publication sales to vegetable growers through Rural Solutions SA consultants in regional centres, and online at www.pir.sa.gov.au/resources.

Irrigation Infomation Provider	Irrigation Information Accessed
DWLBC (Department of Water, Land and Biodiversity Conservation), NRM (Natural Resource Management) Areas	Manage water licensing, water allocations, water use monitoring, water levies, strategic sustainable use of resource, research and extension project funding. Information can be accessed by phone at regional offices across the state, or online at www.dwlbc.gov.au or www.nrm.sa.gov.au
Irrigation Schemes	Supply pressurised water to users within their area e.g. CIT (Central Irrigation Trust), RIT (Renmark Irrigation Trust), WRSV(Water Reticulating Services Virginia). Information can be accessed by phone at their regional offices across the state, or online (e.g. www.cit.org.au)
SA Water	Manages water supply and delivery infrastructure across SA e.g. design and construct salt interception schemes, Murray River pipeline to Barossa for the Murray Darling Basin Commission, in addition to services to irrigator pumps to maintain performance. Information available by phone from their regional offices or web: www.sawater.com.au
Water Brokers, Water Trading Websites	Provide assistance with regional and interstate water trading and transfers, and govemment transfer documentation, refer Table 17c, Water trading websites.
Irrigation Equipment Resellers and Consultants	Design, supply and install irrigation parts and integrated irrigated systems, including scheduling equipment, fertigation, pumps, sprinklers, filters etc for small and large irrigators, offering one-to-one advice and training e.g. Yandilla Park Ltd
Irrigation Project Consultants	Project manage and deliver larger, often strategic consultancy research and extension irrigation-related projects for regional horticultural irrigator groups on behalf of govemment (e.g. for PIRSA or DWLBC). Consultants include e.g. Rural Solutions SA (training, software development with information accessed from regional offices by phone or web: www.ruralsolutions.sa.gov.au), SARDI (water resources and irrigation research at www.sardi.sa.gov.au)

33. SERVICE (COMMERCIAL AND GOVERNMENT) PROVISION, SURROUNDING INFRASTRUCTURE

References 39, 69, 102–106

To regulate the flow of the river, the River Murray Commission coordinated the construction of storages, locks and weirs; six of them in South Australia, in the 1920's and 1930's. Pressurised water schemes now pump water through pipelines to properties within their area in South Australia, and have ongoing asset replacement and servicing and maintenance plans in place, funded by the charge to users of the scheme. These private (non-Government run) water schemes pumping from the River Murray include the Central Irrigation Trust, Renmark Irrigation Trust, Sunlands Qualco and Langhorne Creek.

Central Irrigation Trust (CIT) pumps 120,000 ML (05/06) from the River Murray through large diameter pipeline systems to 1,600 growers who irrigate 13,000 hectares of horticultural crops in nine Private Irrigation Districts in the Riverland Region of South Australia, including Berri, Cadell, Chaffey, Cobdogla, Kingston, Loxton, Moorook, Mypolonga and Waikerie irrigation areas. Asset replacement costs are based on performance monitoring (vibration, wear, electrical hotspots, flow testing and balance), and repair and maintenance of major plant pumps and valves, mains pipes and outlets and tanks. About $700,000 was recently spent on replacing mechanical meters with electrical meters.

Renmark Irrigation Trust (RIT) delivers 35,000 ML (05/06) water through underground pipelines from a main pumping station on the River Murray, and three re-lift pumping stations, to 906 water (all purpose) users (of which 615 are >0.5ha). The Trust has some Private Diverters under its licence and these irrigators pump their own water from the River Murray or from creeks or billabongs. Asset replacement costs are around $314,000 per annum, with maintenance involving pipe and pump repairs, pump station upgrades and meter replacement.

Water Reticulation Services Virginia (WRSV) supply recycled water to 250 users (300 outlets). About 17,000 ML is contracted (March 2006), with 14,000 ML actually used, although this may extend to 20,0000 ML with the Angle Vale pipeline extension. Asset replacement and repairs are estimated at about $150,000 pa, and include meter replacement, repair of corrosion on flow controls, pump maintenance, weed management on ponds, electrical, air valve and pipe repairs.

Irrigators operating their own private diversion pumps along the Murray River conduct their own asset replacement and repairs and maintenance using their own labour and/or commercial businesses, and the cost is proportional to the scale of the water pumping requirements.

SA Water is a water utility wholly owned by the Government of South Australia for the people of South Australia, who deliver water and wastewater services to almost 1.4 million people across the State. They have an annual turnover of about $750M pa, assets of more than $6 billion and more than 1300 staff. SA Water has set up various delivery infrastructures across SA. For example the design and construction of salt interception schemes, rehabilitation of the Government irrigation areas, and Murray River pipeline to the Barossa for the Murray Darling Basin Commission. These major infrastructure developments have been funded through combined user, state and Commonwealth Government funding. The asset replacement and maintenance of these infrastructures then is the responsibility of the groups who manage the water on behalf of the users in those areas.

Natural Resource Management Boards (NRM) Boards across SA, where groundwater is sourced (e.g. South East, Mallee, Adelaide Hills), facilitate various projects to manage their resource including bore integrity and water monitoring. For example the South East Natural Resource Management Board in partnership, conduct an Integrated Water Monitoring Review of the current monitoring of groundwater, surface water and water dependent ecosystems in the South East, to identify any gaps and overlaps and then make recommendations for an integrated monitoring program. The Tintinara Coonalpyn Cost Sharing Scheme was developed to share the costs to landholders of lowering pumps and replacing, deepening or equipping wells affected by irrigation induced aquifer draw downs.

34. DRAINAGE/RECYCLING CAPACITY/FARM

References 80, 81, 90, 100, 101

Recycling of irrigation water in South Australia is less than in other states, because there is less surface irrigation (e.g. flood, furrow) used in South Australia, hence there is minimal loss in runoff (refer Table 29a).

Use of recycled effluent water is however undertaken on the Northern Adelaide Plains, and users include vegetable and horticultural production. It is Australia's largest reclaimed water scheme. The Virginia pipeline scheme in South Australia delivers 10GL per annum from the Bolivar sewerage treatment plant to horticulturists on the Northern Adelaide Plains. The reclaimed water is used by some 230 vegetable growers, and could increase as the system is designed to deliver up to 23 GL per annum. The scheme provides an alternative source of water to the local underground water supplies, which were overused and progressively deteriorating in quality. It also supports one of South Australia's most valuable produce markets.

The scheme was a co-operative undertaking of the Virginia Irrigation Association (representing market gardeners and other irrigators), SA Water and Water Reticulation Services Virginia (WRSV, a private sector subsidiary of Tyco International). As part of its Environment Improvement Program, SA Water constructed a $30 million filtration/disinfection plant (DAFF), to treat lagoon effluent from the Bolivar wastewater treatment plant, producing Class A reclaimed water which can be used for irrigation of Virginia's crops. The quality of the water is closely monitored in accordance with procedures set down by the Department of Human Services to ensure public health standards are maintained.

Water storage dams are used in areas of higher rainfall

Water Reticulation Services Virginia (WRSV), with financial assistance from SA Water and the Federal Government, constructed an extensive distribution system involving more than 100 kilometres of pipes at a cost of about $22 million. The system was commissioned in 1999 and has a capacity of 110 ML/day. It commences at the Bolivar plant and fans out to provide water to irrigators as far north as the Gawler River. The scheme now has more than 240 contracts using more than 15,000 ML of reclaimed water for irrigation each year. Use of reclaimed water is expected to increase as the horticultural industry continues to expand production, as groundwater substitution takes place, and as growers establish on-site infrastructure and refine their irrigation methods. The diversion of wastewater from the Port Adelaide Treatment Plant will make more recycled water available through the scheme. It is expected that ultimately between 50% and 70% of the treated wastewater flow from the Bolivar plant could be used for irrigation on the Northern Adelaide Plains. The Virginia Pipeline Scheme was the first and largest reclaimed water scheme of its type in Australia.

The Bolivar Aquifer Storage and Recovery Project is investigating methods of storing surplus water from the Bolivar scheme in underground aquifers so that in future it can be recovered and used during periods of high demand in summer. Initial results indicate that recharge rates were maintained or enhanced, quality of recovered water was suitable for irrigation, there were no adverse environmental effects, and the injection and recovery operation is economic (at 8 to 18 c/KL). Prospects for scaling-up to an operational scheme (5–10GL/yr) appear promising and are currently under investigation.

From previous Table 23a, vegetables in South Australia used 10,372 ML re-use water in 2000-01 and 14,969 ML in 2004-05, or 16% of the total water used by vegetables in SA. Vegetable water re-use in South Australia was higher than the Australian estimate, where re-use water by vegetables was only 3% of total water used.

Table 34a : Sources of Agricultural/Irrigation Water in South Australia 2002–2004

Reference 3

The number of irrigation establishments in South Australia sourcing irrigation water as recycled or re-use water from off farm sources in 2002–03 and 2003–04 were 114 and 157 respectively. The remaining sources of irrigation water mainly included: surface water, groundwater and mains supply, totalling 5924 establishments in 2003–04.

South Australia	Number of Establishments			
Source of Agricultural/Irrigation Water	2002-03		2003-04	
Surface water	2,444		2,296	
Groundwater	2,662		2,514	
Town or country reticulated mains supply	1,073	a	747	a
Recycled or re-used water from off farm sources	114	a	157	a
Other	22	b	367	a

(a) estimate has relative standard error of 10% to less than 25% and should be used with caution

(b) estimate has relative standard error greater than 50% is considered too unreliable for general use

35. PRODUCTION TREND/CATCHMENT

High-tech large greenhouses are gradually replacing the smaller traditional glasshouses on the Northern Adelaide Plains, attributed to targeted tomato market contracts with large retailers interstate.

Processing potatoes in the South East are remaining static as production contracts are not increasing.

Fresh market potato and onion production in the Riverland and Mallee are increasing slightly, however cucurbit, carrot and some other vegetable field crops in the Riverland have declined due to market competition, and reduction in processing, in preference for winegrape, and other permanent fruit and nut crop plantings.

Vegetable production in the Adelaide Hills has reduced due to high land values and city developments, as well as preference for winegrape plantings.

Reclaimed water has enabled expansion of vegetable production on the Northern Adelaide Plains

Access to water and labour are important criteria for the expansion of some vegetable crops

36. LAND VALUE

Table 36a: Value of land suitable for vegetables in regions of South Australia

Reference 49

Land values in South Australia range from an estimated $7000 to $62,000 per hectare as at October 2005. Highest land values ($/ha) occur closer to urban Adelaide on the Northern Adelaide Plains and the Adelaide Hills. Values of agricultural land are influenced by access to adequate quantities of water of suitable quality (e.g. salinity), as well as soil and topographic characteristics (e.g. soil depth and land slope). Proximity to markets, packing or processing, also influence land values.

Region	Sub-Region	Towns	Characteristics	Value $'000/ha (a)
Murray Lands	- Riverland	Loxton, Waikerie	dependent on size of area, existing plantings, proximity to river	12 - 25
		Murray Bridge	good water, land and soil, ready for cash crops	10 - 12
	- Murray Mallee	Pinnaroo, Parilla		na
South East	- Upper South East	Keith, Naracoorte		na
	- Lower South East	Penola	potatoes (processing), smaller parcels 16-20ha are more valuable	7 - 20
Northern Adelaide Plains		Gawler, Angle Vale, Virginia	larger areas 40ha+	15
			smaller parcels 4-10 ha	50 - 62
Adelaide Hills		Lenswood, Picadilly Valley	not many sales, tightly held, parcels 28 to 36 ha	20 -30
Other	Fleurieu Peninsula	Langhorne Creek, Ashbourne	potatoes, lettuce	8.5 - 11
		Milang	onions	10 - 15

(a) Approximate range in saleable value as at October 2005.

37. NUMBER OF GROWERS, COMPLETED IRRIGATION TRAINING

Reference 59, 60, 61

There are several groups statewide, coordinating and/or delivering irrigation courses to irrigators, including horticultural and vegetable growers.

Rural Solutions SA (PIRSA, Loxton) have delivered courses to about 800 horticultural producers statewide over the 5 years to 2005, of which about 10% were vegetable growers. The varied courses have included original Rivercare course components of soils, systems and scheduling, which have been supplemented with drip irrigation, pump efficiency and maintenance, soil water interpretation, pivot irrigation and surface irrigation. Specific courses have also been developed for the South-East (Irrigation for Profit), and translated irrigation courses for NESP Vietnamese growers on the Northern Adelaide Plains. The courses have been delivered for the state's various water catchment boards, and include all areas along the Murray River, the South-East, McLaren Vale, Mallee and Barossa, and Northern Adelaide Plains.

Yandilla Park Services (Renmark) have delivered courses to about 500 horticultural producers (which included a small vegetable grower %), over the last five years. These courses were delivered statewide including Goolwa, Murray Bridge and the Adelaide Hills, under the former Rivercare course, then under the Irrigation Management Course which included soils, soil moisture monitoring and irrigation scheduling and maintenance, but ceased in 2005.

The South Australian Murray Darling Basin Natural Resources Management Board (SAMDBNRM) now delivers some of the courses for irrigators along the River Murray corridor. Under the Improving Irrigation Efficiency Project, the SAMDBNRM project has either delivered or coordinated delivery through Rural Solutions & Yandilla Park Ltd. Between 2001 and end June 2005, 2040 irrigators attended 137 workshops. Approximately 80% of attendees were from the Upper Murray of which about 2% were vegetable growers. The remaining 20% were from the Lower Murray of which approximately 15–20% were vegetable growers.

Rural Solutions SA also delivers irrigation management courses in the Mallee Prescribed Wells Area, which includes Pinnaroo and Lameroo groundwater areas in the Upper Mallee, on behalf of the SAMDBNRM. Approximately. Approximately 120 irrigators have attended these courses over the last 3–4 years (to 2005). Courses have included soils, systems and scheduling components, as well as specialised modules for centre pivot irrigation. Approximately 90% of attendees have been vegetable growers of potatoes onions and carrots.

Hi-tech glasshouse vegetable production being demonstrated on the Northern Adelaide Plains

Training of vegetable growers on the Northern Adelaide Plains

38. OTHER INITIATIVES

Table 38a: Project Initiatives Directly Related to Vegetable Irrigation in South Australia

References 74–76, 99

Catchment/ Region	Program / Project	Description
Northern Adelaide Plains	Greenhouse Demonstration Site	The Greenhouse Modernisation Project at Virginia Horticultural centre was established to demonstrate and promote technologies and best practices which can benefit growers in the region (mainly greenhouse tomatoes, capsicum and cucumber). It is an experimental centre which demonstrates success or failure in systems, techniques or production methods, including irrigation, under hi-tech greenhouse conditions
South Australia	Saline Horticulture and Drainage Projects	Includes two CNRM- funded SARDI-PIRSA research projects: the first is entitled 'Developing reliable model of drainage production from irrigated horticulture at the farm and district level'. A second project 'Managing horticultural production under a more saline environment' develops a fresh-water flush irrigation strategy; to examine the causes of continuing yield decline after a drought year and boron tolerance of wine-grape rootstocks, aimed at developing survival strategies for Riverland horticulture at times of saline slugs in Murray River (included research on techniques for reducing the effects of saline water sprinkler irrigated vegetables e.g. onions and potatoes).
Northern Adelaide Plains	Sustainable Horticultural Development	As part of a continuing Northern Adelaide Plains (NAP) Landcare Project, PIRSA, the Virginia Horticultural Centre (VHC) and Rural Solutions SA in 2005-06 is assisting with a sustainable horticulture development component to optimise use of water resources on the Northern Adelaide Plains and minimise drainage problems. The project involves working with industry to identity key issues and ensure that activities and goals are consistent with industry needs. Demonstration sites will be used to develop specifications for best irrigation practices that maximise productivity and minimise drainage and salinity issues. The sites will also be used on the NAP and in other areas to encourage adoption of improved irrigation practices. Extension material will be developed and the project will provide input into the Strategic Planning and drainage components of the wider VHC Landcare program.
Northern Adelaide Plains	Virginia Flood Response	In November 2005, in the Virginia and Two Wells areas, close to where the Gawler River empties into the Gulf St Vincent, major flooding with water up to a metre deep occurred on the Adelaide Plains in the Gawler basin, with estimated damage to crops (mainly vegetables), machinery and buildings of at least $40M. Moisture that brought heavy rain across SA during the period, caused widespread flooding to Adelaide and the Adelaide Hills. Flash flooding accounted for the widespread nature of the flooding. Adelaide's three main river basins, the Torrens, Gawler to the north and Onkaparinga to the south, all experienced moderate to major flooding as all three had their headwaters close to where the heaviest rain fell around Mt Lofty. More than $4 million in assistance was promised to combat the Virginia floods: $3.5 million to fund $10,000 grants for up to 350 affected growers, $500,000 to help councils tackle the massive clean up operation and $250,000 towards emptying septic tanks and pumping pooled surface water from properties. A Recovery Centre was also set up at the Virginia Horticulture Centre (VHC).
South East	Irrigation Management in Processing Potatoes	The processing potato industry in the South East is supporting the adoption of soil moisture monitoring devices to meet targets of yield and quality, in addition to the development and use of Irrigation Management Tools and Checklist (with other crop management tools e.g. nutrition and pest and disease).

Table 38b: Project Initiatives Indirectly Related to Vegetable Irrigation in South Australia

References 73,75, 77, 78, 83–86

Catchment/ Region	Program/ Project	Description
South East	Tintinara Coonalpyn Sharing Scheme	Currently in its third round, the scheme was developed to share the costs to landholders of lowering pumps and replacing, deepening or equipping wells affected by irrigation induced aquifer draw downs.
South East	South East Metering Implementation	All volumetric licenses in the region to be metered by June 2006. This has been facilitated by various newsletters and fact sheets relating to meter benefits, suppliers, installation etc.
All Prescribed Water Resources	Water Allocation Planning	Water Allocation Plans are developed for prescribed water resources throughout the regions in line with state legislation.
Mount Lofty Ranges	Regional Groundwater Monitoring Program	The prescription of surface and groundwater resources of the Eastern and Western Mount Lofty Ranges requires the development of a water allocation plan, and an effective monitoring program is needed to evaluate impacts on groundwater resources. The regional groundwater monitoring program collects a range of water quality and water level data.
Mallee Prescribed Wells Area	Volumetric Conversion of Irrigation licences	Currently all irrigation licences in the area are allocated in Hectares Irrigation Equivalent (HaIE). Since the adoption of the Water Allocation Plan, new licences have been allocated by volume, but existing irrigation licences still remain in HaIE, and require assessment for volumetric conversion.
River Murray, South East	South Australian Murray and South East Resource Information Centres (SAMRIC, SERIC)	The Resource Information Centres (RIC's) are regionally located Geographic Information System and Operation Units that facilitate the acquisition, storage, management and dissemination of spatial reference information. The development of the RIC's is a cooperative approach to sharing of data, resources and ideas and is a joint venture between public and private sectors. The RIC's supply technical skills, access, manipulation and analysis of spatial (and temporal) data within and between the partner organisations (e.g. District Councils, PIRSA, DWLBC).
River Murray	Irrigation Areas Rehabilitation	The rehabilitation of the River Murray Irrigation Districts (e.g. Loxton) has involved upgrade of the existing pumping station and replacement of open channels and low-pressure pipelines to provide a high pressure system delivering water at a minimum pressure of 35 m at the property boundary. The pressurised supply provides direct pressure to growers, removing the need to pump onfarm through to the irrigation system and enabling irrigation on demand.
Northern Adelaide Plains	Sustainable Salinity and Water Management Project	Final works on this project are completed. Crops such as grapes, potatoes and almonds were being severely affected as a result of rising water table problems north of Virginia. This project has helped to alleviate these problems. Funding was provided by the Commonwealth and State Governments under the National Action Plan for Salinity and Water Quality.

Catchment/ Region	Program/ Project	Description
River Murray	Improving Irrigation Efficiency Project	The On-Ground Water Use Efficiency Project provides irrigators with education and awareness programs to encourage the adoption of irrigation best management practices and improve irrigation water use efficiency. While irrigation technology is well adopted throughout the region, a full understanding and high level of education is often not provided with this technology. This project endeavours to fill the education void left, which complements the technology in use today. It does this through the use of irrigation courses, awareness tools, scheduling trials, subsidised programs and Irrigation Field officers, which offer one on one on-farm support to irrigators. The project is a partnership between the River Murray Local Action Planning Groups, Central Irrigation Trust, Renmark Irrigation Trust, and the River Murray Catchment Water Management Board. The project area extends from the South Australian Border to the Lower Lakes, and has been available to all irrigators within this area.
River Murray	River Murray Improvement Program	The River Murray Act 2003 was assented to on 31 July 2003, and came into operation in October 2003. The Act effected an amendment to the Environment Protection Act 1993 that requires State of the Environment Reports for South Australia to provide a specific assessment of the health of the River Murray. The River Murray Improvement Program, to be funded by the River Murray Levy over the next four years, is a significant commitment and represents an important step towards improving the health of the River Murray. This will be complemented by action under the South Australian River Murray Salinity Strategy. These initiatives were built upon to see a long term improvement in the health of the river.
South Australia	IRES Irrigation Recording and Evaluation System Software	IRES (Irrigation Recording and Evaluation System) computer program has been developed by the Irrigated Crop Management Service of Rural Solutions SA (PIRSA Loxton SA), to record irrigation events, simulate soil water content of crop root zones and evaluate irrigation efficiency. The software is part of the Farm Level Water Management Module. The system enables planning, mapping, labelling planting patches and irrigation valve units, recording irrigation events (dates, hours, valves and water meter readings in the record booklet or computer using IRES software). It also enables checking of water use efficiency (WUE) and assists with identifying opportunities to improve irrigation management and water use efficiency.
South Australia	Centre for Natural Resource Management	The Centre for Natural Resource Management (CNRM) has been established to underpin regional and state natural resources management (NRM) plans with high quality scientific information and research. The Centre for Natural Resource Management (CNRM) was established through funding from the National Action Plan for Salinity and Water Quality (NAP) to address priority research needs identified in State and regional natural resources management (NRM) plans. It has sought to invest in the creation of innovative, regionally based solutions to problems such as salinity and water quality. Its role has been to coordinate research programs and ensure that productive partnerships in NRM are created in South Australia between regional communities, research and government agencies, and private industry. The CNRM is managed by a board and seeks to encourage co-investment in NRM projects with other investment bodies such as Land and Water Australia, Rural Industries R&D Corporation and other R&D agencies, Research providers (e.g. CSIRO's Water for a Healthy Country), NRM boards, local government, and rural industry. The initial aim is to use the$11m from the NAP to attract co-investment and generate up to $22m in NRM investment tor South Australia.

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