NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Maximising returns from water in the Australian vegetable industry

Scroll down or skip this page.

3.5 – EVAPORATION AND RAINFALL IN NSW

The NSW vegetable production regions vary from the seasonally wet subtropical north coast to the hot, dry inland irrigation districts where evapotranspiration levels exceed rainfall by over 1500 mm per annum. This high variability in climate dictates that crop irrigation requirements need to be estimated on a district or regional basis. Weather-based scheduling advisory services are provided by NSW Department of Primary Industries, and are described in section 3.8. Vegetable farmers also make extensive use of private weather forecasting and irrigation scheduling services, and often complement this information with in-crop soil moisture monitoring on-farm.

Tables 21 to 24 and Figures 7 to 10 help to illustrate the temperature, rainfall and evapotranspiration patterns in the major vegetable production regions in NSW.

Table 21 – In-season rainfall and mean seasonal evapotranspiration (pan evap. mm)

Report regions and town		North Coast, Coffs Harbour	Sydney Basin, Richmond	Macquarie Valley, Bathurst	Lachlan Valley, Cowra	Murrumbidgee Valley, Griffith	Murray Valley, Deniliquin
Summer	rain	531	263	192	175	86	96
	ET	530	567	579	613	776	910
	deficit	-1	304	387	438	690	814
Autumn	rain	591	214	136	142	104	108
	ET	321	373	203	281	359	416
	deficit	-270	159	67	139	255	308
Winter	rain	264	150	142	150	110	101
	ET	188	330	161	120	163	190
	deficit	-76	180	19	-30	53	89
Spring	rain	277	170	165	168	101	110
	ET	461	503	388	351	491	543
	deficit	184	333	223	183	390	433
Total	rain	1663	797	635	635	401	415
	ET	1500	1773	1331	1365	1789	2059
	deficit	-163	976	696	730	1388	1644

Source: Bureau of Meteorology (BOM) long-term figures

Table 22 – Climate averages, major NSW vegetable production regions

Catchment		Climate average	Jan	Feb	Mar	Apr	May	Jun
Northern Rivers	Alstonville	Max temp °C	27.2	26.6	25.9	23.9	21.2	18.9
		Min temp °C	19.4	19.3	18.3	15.9	13.4	10.8
		Mean rainfall (mm)	177.6	234	283	196	198	151
		Pan evap. (mm/d)	5.8	5.0	4.3	3.5	2.7	2.5
	Coffs Harbour	Max temp °C	26.9	26.7	25.9	24.0	21.3	19.3
		Min temp °C	19.4	19.5	18.1	15.2	11.8	9.0
		Mean rainfall (mm)	180	215	245	179	167	112
		Pan evap. (mm/d)	6.5	5.9	5.2	4.1	2.9	2.5
Sydney Basin	Richmond	Max temp °C	29.4	28.9	27.1	23.8	20.3	17.4
		Min temp °C	16.8	16.8	15.0	11.3	7.3	4.7
		Mean rainfall (mm)	95	93	89	66	59	59
		Pan evap. (mm/d)	6.2	5.2	4.3	3.4	2.3	1.9
Macquarie Valley	Bathurst	Max temp °C	27.8	27.1	24.5	20.0	15.0	12.1
		Min temp °C	13.3	13.4	10.8	6.8	3.5	1.6
		Mean rainfall (mm)	68	56	50	43	43	44
		Pan evap. (mm/d)	6.8	5.9	4.5	2.9	1.6	1.1
Lachlan Valley	Cowra	Max temp °C	31.1	30.3	27.3	22.4	17.5	13.8
		Min temp °C	16.2	16.5	14.0	10.2	4.7	4.7
		Mean rainfall (mm)	66	53	47	44	51	44
		Pan evap. (mm/d)	7.2	6.2	4.7	2.9	1.6	1.0
	Hillston	Max temp °C	33.2	32.7	29.1	24.3	19.2	15.6
		Min temp °C	18.1	18.3	15.1	10.6	7.4	5.0
		Mean rainfall (mm)	30.7	26.5	31.8	27.2	33.0	34.0
		Pan evap. (mm/d)	8.8	8.2	6.0	3.8	2.2	1.3
M/bidgee Valley	Griffith	Max temp °C	31.5	31.3	28.1	22.9	18.4	14.8
		Min temp °C	16.2	16.4	13.6	9.4	6.4	2.9
		Mean rainfall (mm)	29.6	27.8	34.4	33.0	37.8	37.2
		Pan evap. (mm/d)	8.7	8.3	6.0	3.7	2.1	1.4
	Hay	Max temp °C	32.9	32.6	29.2	24.0	19.3	15.8
		Min temp °C	16.5	16.4	13.7	9.9	6.7	4.5
		Mean rainfall (mm)	27.7	27.9	29.7	28.4	35.8	36.0
		Pan evap. (mm/d)	8.7	7.8	6.0	3.9	2.4	1.6
Murray Valley	Deniliquin	Max temp °C	31.6	30.8	27.9	22.7	17.5	14.7
		Min temp °C	15.7	15.7	13.4	9.4	6.3	4.0
		Mean rainfall (mm)	36.5	27.9	37.5	27.9	43.7	34.1
		Pan evap. (mm/d)	10.7	9.4	7.0	4.2	2.3	1.7
	Wentworth	Max temp °C	31.8	31.6	28.4	23.4	18.9	15.6
		Min temp °C	16.4	16.4	14.0	10.5	7.8	5.8
		Mean rainfall (mm)	18.9	19.4	13.3	18.2	24.2	23.0
		Pan evap. (mm/d)	10.1	9.1	7.1	4.4	2.5	1.8

	Climate average	July	Aug	Sept	Oct	Nov	Dec	Annual total
Alstonville	Max temp °C	18.5	19.9	22.3	24.0	25.3	26.2	
	Min temp °C	9.8	10.5	12.7	14.7	16.5	18.4	
	Mean rainfall (mm)	91	73	52	108	132	160.6	1855
	Pan evap. (mm/d)	2.7	3.5	4.6	5.1	5.5	6.1	1551
Coffs Harbour	Max temp °C	18.7	19.7	21.8	23.5	24.9	26.7	
	Min temp °C	7.5	8.2	10.8	13.7	16.0	17.6	
	Mean rainfall (mm)	74	78	60	80	129	136	1663
	Pan evap. (mm/d)	3.6	4.8	4.8	5.6	6.2	6.5	1500
Richmond	Max temp °C	17.3	18.9	22.1	25.0	27.1	29.1	
	Min temp °C	3.2	4.4	7.1	10.5	13.1	15.5	
	Mean rainfall (mm)	47	44	42	56	72	75.3	797
	Pan evap. (mm/d)	2.2	2.8	4.1	4.9	5.3	6.4	1773
Bathurst	Max temp °C	11.2	12.8	16.2	19.7	23.1	26.3	
	Min temp °C	0.5	1.3	3.4	6.2	8.8	11.6	
	Mean rainfall (mm)	48	50	46	61	58	62	635
	Pan evap. (mm/d)	1.1	1.8	2.7	4.0	5.2	6.6	1331
Cowra	Max temp °C	12.9	14.6	17.8	21.6	25.4	29.4	
	Min temp °C	3.6	4.5	6.5	9.1	11.6	14.6	
	Mean rainfall (mm)	52	54	51	63	54	56	635
	Pan evap. (mm/d)	1.1	1.6	2.5	3.8	5.3	7.0	1365
Hillston	Max temp °C	14.8	17.0	20.6	24.4	28.3	31.4	
	Min temp °C	3.8	5.0	7.2	10.3	13.6	16.4	
	Mean rainfall (mm)	31.0	31.3	27.9	36.1	27.4	29	370
	Pan evap. (mm/d)	1.5	2.1	3.5	5.2	7.1	8.7	1759
Griffith	Max temp °C	14.3	16.2	19.6	23.2	27.0	30.1	
	Min temp °C	2.9	4.0	6.0	9.1	11.9	14.7	
	Mean rainfall (mm)	33.2	40.4	32.5	41.3	28.5	30.7	401
	Pan evap. (mm/d)	1.6	2.4	3.6	5.3	7.3	8.9	1789
Hay	Max temp °C	15.1	17.2	20.7	24.4	28.4	31.2	
	Min temp °C	3.5	4.5	6.6	9.4	12.4	14.9	
	Mean rainfall (mm)	30.5	32.2	32.2	36.0	24.2	26.5	
	Pan evap. (mm/d)	1.8	2.5	3.6	4.9	7.0	8.7	
Deniliquin	Max temp °C	14.0	15.6	18.7	22.0	25.9	29.3	
	Min temp °C	3.3	4.2	5.7	8.6	10.7	13.6	
	Mean rainfall (mm)	31.6	35.8	36.5	46.8	28.4	33.6	415
	Pan evap. (mm/d)	1.7	2.8	3.9	5.9	8.0	10.2	2059
Wentworth	Max temp °C	15.2	17.0	20.3	23.6	27.3	30.2	
	Min temp °C	5.3	6.1	8.2	10.6	13.2	15.3	
	Mean rainfall (mm)	25.0	24.6	24.7	27.9	22.4	19.2	261
	Pan evap. (mm/d)	1.9	2.7	4.2	6.0	8.0	9.5	2037

Table 23 – Mean potential evapotranspiration (mm/day), Griffith and Dareton

	Griffith (1968–81)	Dareton, Sunraysia (1984–2001)
	ETo (mm/day)	ETo (mm/day)
Early October	4.8	5.0
Mid October	4.9	5.8
Late October	5.4	6.3
Early November	5.7	6.7
Mid November	6.6	7.2
Late November	7.5	8.4
Early December	7.6	8.5
Mid December	7.9	8.6
Late December	7.9	8.6
Early January	8.1	8.5
Mid January	8.1	9.2
Late January	8.1	8.6
Early February	7.6	8.5
Mid February	7.3	7.9
Late February	6.7	7.5
Early March	6.3	7.1
Mid March	5.7	6.0
Late March	5.0	5.0
Early April	4.4	4.3
Mid April	4.0	3.6
Late April	3.3	3.3

Source: Erskine and Smith 1983

Table 24 – In-season mean seasonal evapotranspiration (mm ETo)

Report regions	Representative town	Summer	Autumn	Winter	Spring	Total annual ETo
North Coast	Coffs Harbour	530	321	188	461	1500
Sydney Basin	Richmond	567	373	330	503	1773
Macquarie Valley	Bathurst	579	203	161	388	1331
Lachlan Valley	Cowra	613	281	120	351	1365
Murrumbidgee Valley	Griffith	776	359	163	491	1789
Murray Valley	Deniliquin	910	416	190	543	2059

Source: BOM long-term figures

Figure 7 – Average annual rainfall, NSW

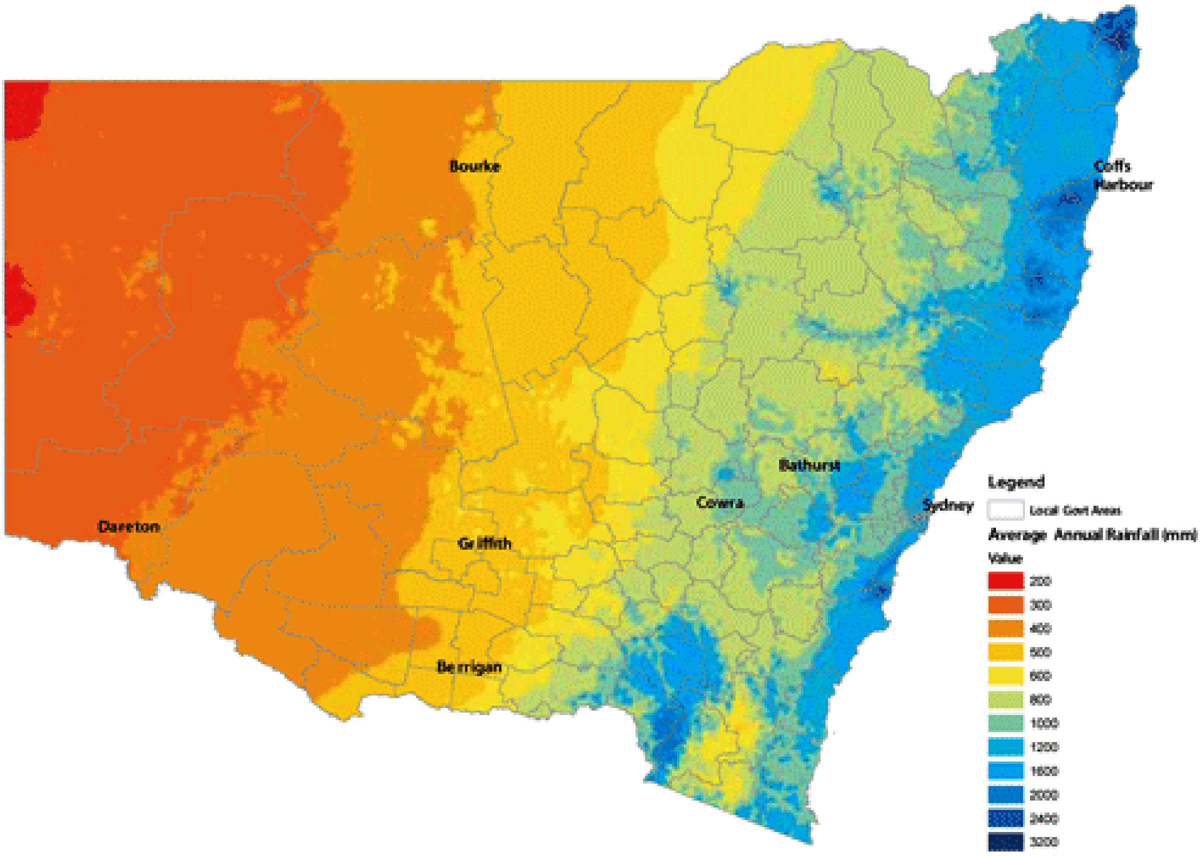


Figure 8 – Average maximum temperatures, NSW

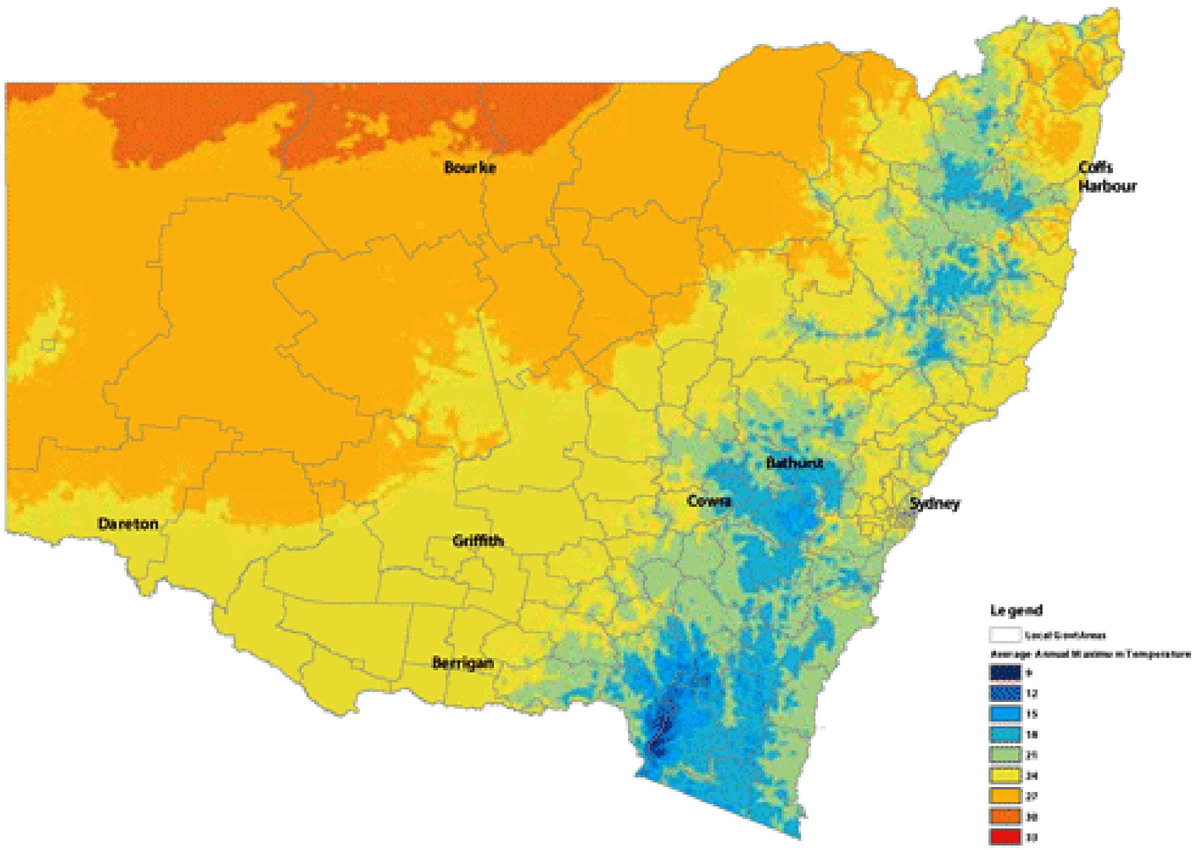
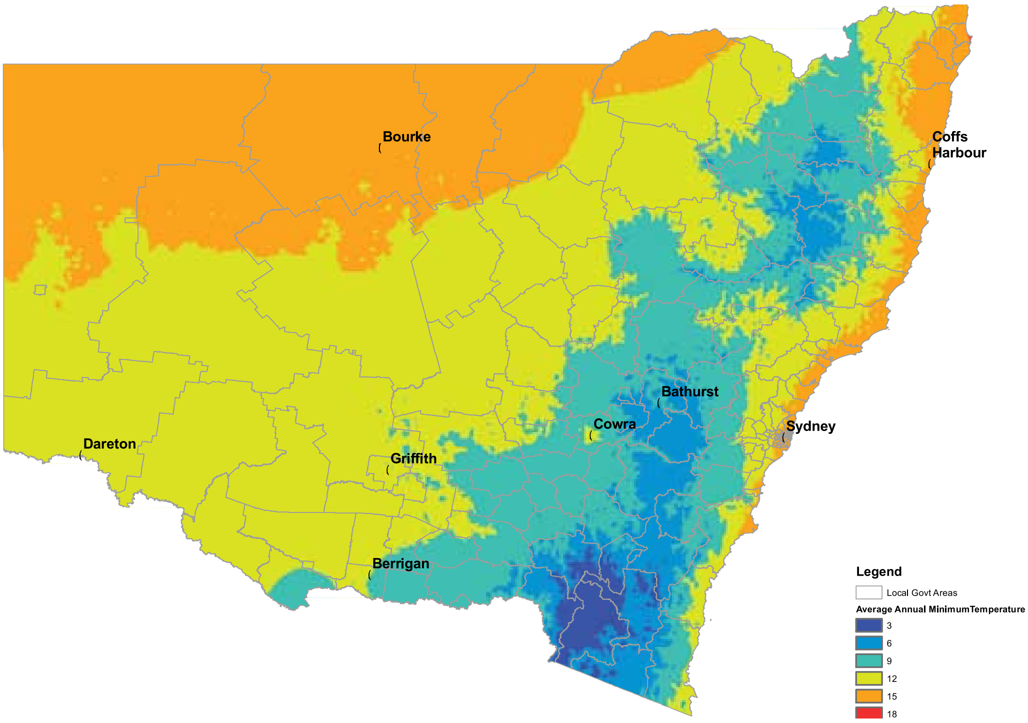
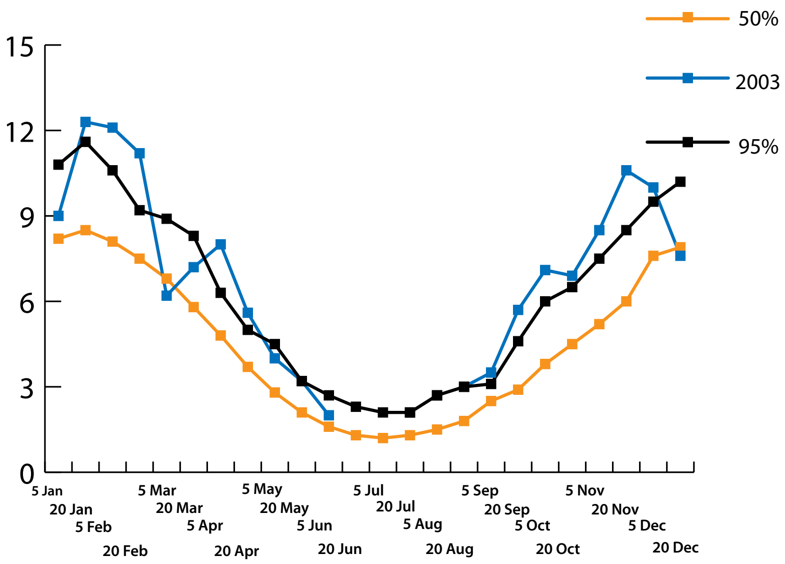


Figure 9 – Average minimum temperatures, NSW



Potato crop growing under centre pivot irrigation

Figure 10 – Historical evapotranspiration, Griffith



In the drought years between 2002 and 2005, unusually high evapotranspiration (ETo) figures were recorded. In Figure 10, the 2003 average ETo shown in blue remained at or above the 95 percentile ETo line, which indicates extreme weather conditions during that period. The 95 percentile ETo line generally occurs only one year in 20, and is often used by irrigation designers who are designing irrigations systems to have the highest level of reliability, that is, that the system can deliver crop water requirements in the hottest and driest years. These extreme ETo levels combined with low water allocations during the drought years resulted in periods during the summer crop growing season when crop demand for water exceeded the ability of irrigation systems to deliver.

3.6 – WATER QUALITY AND IRRIGATION

Water salinity

Water quality monitoring programs are carried out on most of the regulated river systems in NSW. The purpose is to gather information on the relative health of the river systems and help determine actions required to decrease salt loads entering or returning to river systems in drainage water from irrigation schemes.

The benchmark for salinity used in NSW is the Protection of Aquatic Ecosystems (POAE) for moderately disturbed ecosystems in south-east Australia (ANZECC 2000). The guideline used is 125–2200 µS/cm. For example, in the years 2000/01 to 2002/03 (Table 25), water entering the Murrumbidgee supply system was below the POAE trigger value. In the previous two years (1998/99 to 1999/2000), the levels were above the POAE trigger value. The drought years in the Murrumbidgee between 2000 and 2005 resulted in more water being drawn from the Snowy scheme instead of the Burrinjuck supply, resulting in lower salinity levels. The lower volumes of water in the system during the drought years also resulted in reduced salt loads entering and leaving the Murrumbidgee system.

Table 25 – Irrigation water, median salinity levels, 2002/03

		Median salinity (EC)
Murray System* (2003)	Mulwala canal at Mulwala	350
	Mulwala Escape into Edwards River	560
	Edward River at Stevens Weir	420
Murrumbidgee System (2003)	Narrandera Regulator	104
	Sturt Canal	76
Lachlan System (2001)	Wyangala Dam	275
	Cowra	360
	Forbes	390
	Condobolin	418
	Hillston	520
	Belubula River	584

* Source: DIPNR

With relatively low water salinity levels in the major NSW rivers such as the Murrumbidgee and Murray there are not the constraints on water use as in districts such as Sunraysia or Werribee. However, high watertables and the soil salinity increase in low-lying areas, particularly within the Murrumbidgee Irrigation Area, pose a threat to ongoing vegetable production. The 2000–05 drought resulted in some of the lowest percentage of watertable levels within the 0 to 2 metre zone in the MIA, but a return to a series of wet years could see the problem re-emerge.

Over the last twenty years a dramatic improvement of salinity management in the Murray and Murrumbidgee has been seen due to the adoption of laser levelling in surface-irrigated cropping systems as well as drainage water recycling and on-farm soil and water monitoring. The extensive system of tile drains and efficient disposal of saline drainage water installed in sensitive permanent horticultural crops such as citrus and grapes has contributed to the improved general health of the irrigation systems.

Salt tolerances for vegetable crops

Vegetable crops vary in their ability to tolerate soil and water salinity. Water salinity threshold levels are lower, as salt levels accumulate with extended use of saline water, and use of overhead irrigation systems can result in damage to foliage. The threshold value is the average salinity at which salts begin to affect crop growth. Beyond this, yield decline can be expected. These values are a guide only, and can vary with soil type, leaching potential, irrigation system efficiency and age of plant.

Table 26 – Crop tolerances for soil and water salinity (dS/m)

Crop	Soil salinity EC_e		Water salinity EC_w	
	Threshold	25% yield loss	Threshold	25% yield loss
Beans	1.0	2.3	0.7	1.5
Broccoli	2.8	5.5	1.9	3.7
Rockmelon	2.2	5.7	1.5	3.8
Capsicum	1.5	3.3	1.0	2.2
Carrot	1.0	2.8	0.7	1.9
Cucumber	2.5	4.4	1.7	2.9
Lettuce	1.3	3.2	0.9	2.1
Onion	1.2	2.8	0.8	1.8
Potato	1.7	3.8	1.1	2.5
Sweet corn	1.7	3.8	1.1	2.5
Tomato	2.5	5.0	1.7	3.4

Source: NSW Salt Action Program 1999

Table 27 – Drainage, groundwater and surface water quality, by region

	M/bidgee (MIA, Districts, Hay and Lower Bidgee)	Coleambally	NSW Murray	Sunraysia (NSW & Victoria)
Area irrigated – all crops (ha)	263 000	75 000	321 000	37 000
Area serviced by surface drainage	208 696	95 000	245 000	0
Area serviced by subsurface drains	10 000	40	48 000	24 422
Number of groundwater monitoring bores	854	887	1 452	0
Irrigated area with watertable < 2 m (%)	33	24	2	0
Salinity of irrigation water (EC)	104	132	44	128
Salinity of surface drainage water (EC)	412	754	290	2 500
Salinity of shallow groundwater(EC)	2400–6500	200–2000	100–125 000	na
Salt retained (tonnes per annum)	92 099	34 842	25 427	9 538

Source: ANCID 2004b Benchmarking Report 2002/03

EC is µS/cm which is 1000 × dS/m

Groundwater quality

The level of dissolved salt determines the usefulness of water for irrigation purposes. A level above 1500 milligrams/litre (mg/L) is generally unsuitable for irrigation. Most vegetable crops are sensitive to levels above 1000 mg/L. The proportion of high quality groundwater extracted in NSW is shown in Table 28.

Table 28 – Sustainable yield of groundwater by salinity level, NSW and Australia, 2000

	NSW GL	Australia GL
Less than 1 500 mg/L		
< 500 mg/L	698	10 217
500–1 000 mg/L	3 928	8 093
1 000–1 500 mg/L	34	2 670
Total	4 660	20 980
1 500 mg/L and over		
1 500–3 000 mg/L	812	3 208
3 000–5 000 mg/L	2	1 510
5 000–14 000 mg/L	440	2 307
> 14 000 mg/L	–	1 168
Total	1 254	8 193

Total sustainable yield	
NSW	5 914 GL
Australia	29 173 GL
Proportion less than 1500 mg/L	
NSW	79%
Australia	72%
Proportion: 1500 mg/L and over	
NSW	21%
Australia	21%

Source: ABS Yearbook 2005

The accumulation of salts in the root zone is also a variable issue that depends on the soil's drainage capacity and the underlying groundwater conditions. This can be an issue where drainage water is reused for vegetable crops. Table 29 shows the upper limits for conductivity of irrigation water and how it relates to soil texture and tolerance of crops to salt. For vegetable crops that are sensitive to salt (that is, beans, onion, lettuce), drainage water would require a dilution to salinity of 0.4 dS m^{-1} before being used for irrigation.

Table 29 – Crop and soil interactions using saline water

	Crop tolerance to salinity (dS/m)		
Soil texture	Sensitive	Moderately tolerant	Tolerant
Loamy sand	1.6	4.0	6.0
Loam	1.0	3.0	4.5
Loamy clay	0.8	2.0	3.0
Clay	0.4	1.0	1.6

Sensitive: e.g. lettuce Moderately tolerant: e.g. broccoli Tolerant: non-vegetable crops

Source: Shainberg and Shalhever 1984

The groundwater used in NSW is quite variable in salts and salt balances and should be tested before use. High chloride levels have an impact on the EC of water, as do all ions, adding to the total salts, and the effect on crops depends on environmental conditions, crop species and irrigation management practice. While irrigation water with moderate chloride concentrations can be managed effectively with surface and drip irrigation, it becomes a bigger concern when spray irrigation is used. Overhead irrigation which wets the foliage is not recommended when chloride content of water exceeds 700 mg/L, as it can result in foliage damage in most vegetable crops (Table 30).

Table 30 – Chloride concentration in irrigation water causing foliar damage in vegetable crops

Sensitivity	Chloride concentration (mg/L Cl)	Affected crops
Sensitive	< 178	Lettuce, rockmelon, carrot, beans
Moderately sensitive	178–355	Potato, tomato
Moderately tolerant	355–710	Cucumber, maize
Tolerant	> 710	Cauliflower

Source: Westcot and Ayers 1984

Sodicity

Sodic waters are those that have a high proportion of sodium related to calcium and magnesium. Application of sodic water to the soil may cause soil structure and permeability problems.

Sodic water is commonly found in NSW groundwater sources but does not show up as being high total salts. A comprehensive water test measuring Sodium Absorption Ratio (SAR) and the Residual Sodium Carbonate (RSC) will indicate whether extended use of groundwater is likely to cause soil problems. Table 31 shows how these two factors can interact.

Table 31 – Sodicity classes of water

SAR	RSC (meq/L)	Sodicity class	Management options
< 3	< 1.25	S0	No sodicity problem
3–6	< 1.25	S1	Low SAR. Few problems except for sodium sensitive crops
6–8	< 2.5	S2	Medium SAR. Increasing problems. Use gypsum. Avoid sodium-sensitive crops.
8–14	< 2.5	S3	High SAR. Generally not recommended
> 14	disregard	S4	Very high SAR. Unsuitable.
< 6	1.25 – 2.5	S5	Medium RSC. Increasing problems. Use gypsum. Avoid sodium sensitive crops.
< 14	2.5–5.0	S6	High RSC. Not recommended.
< 14	> 5.0	S7	Very high RSC. Unsuitable