Murrumbidgee Catchment Irrigation Profile

compiled by Meredith Hope and Marcus Wright, for the Water Use Efficiency Advisory Unit, Dubbo

The Water Use Efficiency Advisory Unit is a NSW Government joint initiative between NSW Agriculture and the Department of Sustainable Natural Resources.

This Irrigation Profile is one of a series for NSW catchments and regions. It was written and compiled by Meredith Hope and Marcus Wright (NSW Agriculture) for the Water Use Efficiency Advisory Unit, 37 Carrington Street, Dubbo, NSW, 2830.

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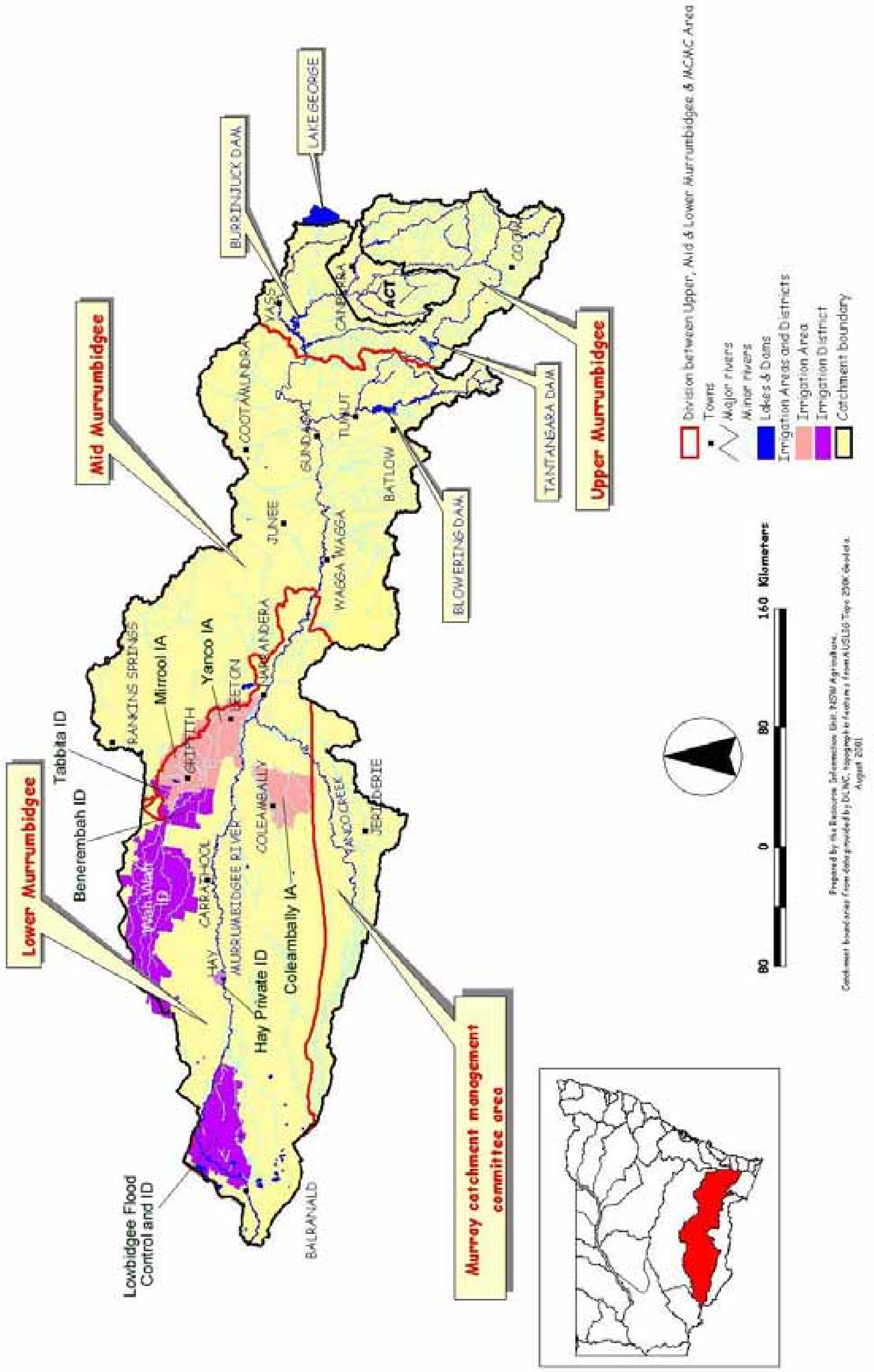
Figure 1. The Murrumbidgee catchment



1. EXECUTIVE SUMMARY

The *Murrumbidgee Catchment Irrigation Profile* was developed from a study to obtain catchment and industry based assessments of water use efficiency (WUE)[1] and irrigation efficiency (IE)[2].

Readily accessible irrigation data were collected from State and Commonwealth sources, published research and industry reports and unpublished reports. These data were assigned a reliability rating using a system developed by the National Land and Water Resources Audit (1999).

The report summarises, where possible by water source and catchment, what is known about:

- the number of irrigators
- the number of licences
- the entitled volume or area authorised for irrigation
- the area irrigated and water used in total and by crop type
- irrigation methods
- yields of irrigated crops
- the value of irrigation to agriculture

in the Murrumbidgee catchment.

This report does not attempt to analyse the reliability and accuracy of these data or calculate WUE from the data. This will be carried out in a subsequent report.

Users of this document are advised to proceed with caution. The data presented in this report should be treated carefully and with respect for the various collection, storage and retrieval processes that can impact on information reliability.

1.1 Overview of the Murrumbidgee catchment

The Murrumbidgee catchment is located in southern NSW (Figure 1) west of the Great Dividing Range and covers approximately 84 000 km^2 or about 8% of the Murray-Darling Basin. The landscape ranges from mountainous/undulating country in the east around Lake George and Burrinjuck Dam to broad semi-arid plains in the west

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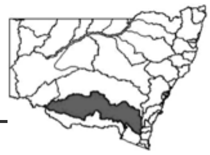
[1] WUE refers to the volume of crop produced (harvested dry matter) per unit of water delivered to the crop. This is usually expressed as tonnes per megalitre (t/ML) (Alexander & Foley 1998).

[2] IE is a measure, expressed as a percentage, of the volume of water used or delivered by a system relative to the total volume of water entering the system (Alexander & Foley 1998).



around Griffith and Balranald. The catchment has a semi-arid climate with an annual rainfall that declines in a westerly direction from approximately 990 mm in the east to 320 mm in the west. Rainfall is mostly winter dominant. Annual long-term evaporation increases from 1300 mm in the east to approximately 1800 mm in the west of the catchment.

Regulation of the Murrumbidgee River has allowed irrigation to thrive in the catchment. Water is stored in Burrinjuck and Blowering dams during winter and then used to supply irrigation farms downstream during summer. Burrinjuck Dam receives inflows from the upper catchment while Blowering Dam receives most of its inflow from the Snowy Mountains Hydro-Electric Scheme.

Irrigation farms are concentrated mostly on the riverine plains, especially in the region now managed by Murrumbidgee Irrigation (MI) and Coleambally Irrigation Co-operative Limited (CICL). This region, previously known as the Murrumbidgee Irrigation Area (MIA) and the Coleambally Irrigation Area (CIA), was initially developed by the government to foster regional development through irrigation in inland NSW. Massive diversion weirs and supply and drainage canals were constructed to support the numerous irrigation farms.

Technically, the lands of the MIA and CIA no longer exist. However, since the terms MIA and CIA are still in common usage this Profile will continue refer to them.

In addition to the MIA and CIA, there are many individual irrigation farms along the length of the Murrumbidgee River that pump river water directly to their farms. Groundwater is also extracted for irrigation purposes along the length of the Murrumbidgee catchment, especially around the Darlington Point region just south of the MIA. Irrigation farms dependent on unregulated supplies and farm dams are scattered in the upper catchment. Unlike farms extracting water from the regulated system, these enterprises are limited by access to a secure supply of water. During summer, when the demand for irrigation water is at a peak, river flows tend to be at their lowest. Farm dams are also used to support irrigation enterprises in the upper catchment. There are very few enterprises that irrigate from reticulated (town water) supplies and most of these are located around Wagga Wagga.

The Murrumbidgee catchment produces irrigated commodities ranging from annual crops such as rice, pasture, cereals, vegetables and oilseeds to perennial crops such as wine grapes, citrus and stone fruit. The bulk of these crops are grown in the MIA and CIA. There is also an important irrigation industry in the Batlow region where apples are grown.

In 1996–97, the total value of agriculture in the catchment was $1140 million and, of this, 42% or $476 million was attributable to irrigation. Roughly 80% of this total value can be attributed to irrigation in the MIA and CIA. The total value of irrigation has increased steadily since 1991, when it was $294 million. The most valuable crops were rice and fruit and nuts (excluding grapes) each worth $127 million (1996–97 figures).

Of the 1 150 000 ha of land irrigated in NSW, nearly thirty per cent (329 201 ha) is in the Murrumbidgee catchment. Cereals represent nearly 50% of the total area irrigated in the catchment while pasture represents 38%. Perennial horticulture comprises 4.5%.

In 1996–97, it was estimated that the total volume of water extracted from all sources was around 2 430 963 ML (Table 1). This volume cannot be accurately determined, as data on the extraction of water from some sources were either scant, or were never collected. The greatest amount of data relates to irrigation from the regulated system. Of the volume entitled to irrigation from the regulated system, roughly three-quarters is used by irrigators in the MIA and CIA.

Of the total water extracted by irrigated agriculture from the regulated system, a large proportion is used on rice and pasture. The remaining water was used on other broadarea crops such as wheat, maize and oats and horticultural crops such as citrus, vines and vegetables.

Depending on climate, irrigators have used between 62% and 95% of the volume entitled to irrigation from regulated rivers. By comparison, less than half the total area authorised for irrigation from unregulated streams was actually irrigated. Licences on unregulated streams were converted from area-basis to volume-basis in 2000. In future, levels of activity will be determined from volumes extracted rather than areas irrigated.

Of the estimated 24 000 licences in NSW, nearly 9% are in the Murrumbidgee catchment. Most of these licences are owned by single enterprises. However, there are also special corporate licences that supply water to many enterprises. For example, MI and CICL each own one licence and supply water to many enterprises.

Information on the number of enterprises irrigating is perhaps more telling than licence figures. Of the total number of enterprises irrigating in NSW in 1996–97 (7846), either 24% or 45% were in the Murrumbidgee catchment. In compiling this *Profile,* difficulty was experienced in obtaining a more reliable estimate of the number of enterprises irrigating in the catchment.

Most of the enterprises irrigating in the Murrumbidgee catchment rely on water from either the regulated or unregulated river supply (Table 1). There are far fewer enterprises using water from groundwater, farm dams and reticulated water supplies.

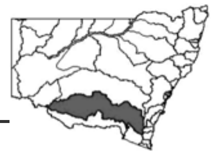


Table 1. Irrigation data for 1996–97 season in the Murrumbidgee catchment

Source of water	Total irrigated area (ha) [a]	Total water used by irrig. ag. (ML/y)	Number irrigation licences	Number enterprises irrigating [b]	Value of irrigation ($m/y)
Murrumbidgee catchment – all sources	329 201 or 348 692	nd *est. 2 430 963*	2 050	1896 or 3802	476 (rice and perennial hort. excl. grapes, 127 each)
MIA (all sources)	nd *157 516 (00–01)*	661 000[3]	1 bulk water licence	2733	325
CIA (all sources)	nd *71 000 (1997–98)*	nd *521 000[4] (1997–98)*	1 bulk water licence[5]	345 plus 35 on Coleambally Outfall drain	57
Regulated (all enterprises including corporations)	nd *315 007 (1993–94) (likely to be an overestimate)*	2 264 188[c]	801	nd *1851 (1993–94) Likely to be overestimated*	nd
Unregulated	8 335	nd *16 775 (avg. 1989–90 to 1994–95)*	502	nd *520 (1993–94)*	nd
Groundwater	nd *11 118 (1993–94)*	nd *est. 150 000*	747	nd *78 (1993–94)*	nd
Farm dams	nd *5881 (1993–94)*	nd	na	nd *100 (1993–94)*	nd
Town water supply	nd *27 (1993–94)*	nd	na	nd *5 (1993–94)*	nd
NSW Total	*1 150 000*	*7 700 000*	*24 000*	*7 846*	*2 496*

nd= no data; na = not applicable; **a.** The area irrigated from different sources does not add up to the area irrigated from all sources. Data for different water sources were collected using different collection methods; **b**. Numbers of enterprises for each water source do not add to the total number of enterprises irrigating. Some enterprises use more than one source of water to irrigate crops and consequently that enterprise may be counted more

[3] This figure is the estimated surface water component for 1996-97 (655 107 ML) plus around 5500 ML for groundwater extraction.

[4] This figure was estimated from the surface water component (460 877 ML) plus estimate groundwater use of 60 000 ML. The final figure has been rounded up. Note that the surface water component of 460 877 ML has a small amount of groundwater (around 4000 ML to 5000 ML) already included. The CICL bore pumps water directly into the main surface water supplies for the area. This groundwater component cannot be separated from the surface water component when it is metered at the farm gate.

[5] This has a surface and groundwater component.

than once. **c.** This volume was calculated by taking the diverted volume from the river for irrigation in 1996-97 (2 648 188 ML) and then subtracting the estimated volume that is 'lost' between the river off-take and the farm gate (384 GL). The lost volume includes seepage and evaporation. Meter inaccuracies also contribute to this volume.

1.2 Irrigation data issues

Irrigation data issues raised in the Murrumbidgee catchment relate to availability of information, the scales at which data were reported and the reliability of irrigation data.

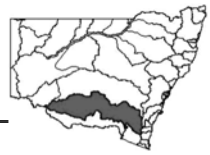
1.2.1 Data availability

Data have been collected for different purposes in the past to those currently needed. Since the implementation of water reforms and the development of water sharing plans, a much greater range of irrigation data are needed than are currently available (data on crop areas, crop water use, yield, value of production and irrigation methods). In the past, agency and community data needs were fewer and therefore fewer data were collected. For example, only details of the volume of water extracted from regulated rivers were collected by the DLWC for billing, operation or reporting purposes from each licence holder. There were no requirements to record other information such as crop areas and crop water use, yields, irrigation methods or values.

Data are needed to help target assistance for irrigators who may need to adjust practices as a result of water reform and to measure change because of extension activities aimed at improving WUE and IE. This Profile has shown that, for a range of irrigation data categories, information is scant: for example, crop area irrigated. In some instances, data had never been collected, for example, crop water use from unregulated rivers.

Information about irrigation is dispersed across the different organisations that administer water in the Murrumbidgee catchment. In order to build a comprehensive picture of irrigation in the catchment, one must approach each data-holding organisation (MI, CICL and DLWC) and make individual requests for information. This Profile identified information gaps in certain geographic regions in the catchment, such as irrigators along the regulated river system, and temporal gaps or periods where no data were collected, such as crop area data for the MIA during the 1990s.

Often useful information on irrigation, such as crop areas and water used, have been collected by one agency (for example, DLWC) but not used to full potential. Other organisations, such as NSW Agriculture, could use these data to help strategically focus extension efforts, such as those of WaterWise on the Farm, to areas where there are poor water use efficiencies.



1.2.2 Lack of data at useful scales

Point-scale data collected by the ABS and ABARE (for example, irrigation value and yield) are confidential and have been reported at SLA, catchment, groups of catchments or Agro-Ecological Region (AER) scales. AERs span many catchments and align with climatic characteristics (for example, arid interior or temperate slopes and plains). These scales limit the usefulness of data to natural resource managers, industry groups and researchers who are often working at much finer levels, for example, subcatchment or river-reach scale. These point-scale data are extremely useful in modelling the economic impact of changes to water sharing rules on irrigators or in generating profiles of irrigation for planning processes at subcatchment or river-reach scale. The ABS is considering geo-coding their data in the near future to help overcome this issue.

1.2.3 Reliability of data

Reliability of irrigation data varied according to water source. For example, data from regulated supplies were more reliable than data from unregulated supplies. The former dataset was collected from meters that measure water use whereas the latter was based on voluntary annual surveys filled out by irrigators and returned to the DLWC. The latter were often incomplete and inaccurate.

The reliability of irrigation data, for example, error bands or reliability ratings, is not consistently reported by State agencies. This makes it easier for users of the data to inappropriately manipulate or analyse irrigation data and draw spurious conclusions.

Reliability of irrigation data is affected by collection strategies. The ABS used definitions of regulated and unregulated water sources for the 1993–94 survey that were different to those used by the DLWC. Consequently, irrigated area and enterprise numbers may be overestimated for regulated water supplies and underestimated for unregulated water supplies.

1.3 Conclusion

In all Australian states, programs have been initiated to increase water use efficiency (WUE) and irrigation efficiency (IE) in irrigated agriculture. These programs require reliable and accurate irrigation data to underpin debates on efficiency.

A more comprehensive and consistent approach to the collection of irrigation statistics is needed. This would ensure that data are comparable across different water sources and industries and provide useful information to water managers and industry groups. The following measures are recommended to improve the situation:

- Recognition of the need to collect irrigation data on crop area, water used, irrigation methods and value of irrigation.
- Collection of data at scales coarse enough to protect point-scale confidentiality but fine enough to allow users to aggregate information to useful scales.

- Protocols for provision of data to users are needed. For example, information providers need to attach reliability ratings to data. This would help users make better decisions regarding how data should be treated.
- Two-way flow of information between agencies and irrigators needs to be fostered. Data need to flow back to irrigators in forms that might assist them make better water management decisions.
- Two-way flow of information about irrigation between different government agencies (for example, the DLWC and NSW Agriculture) needs to be fostered. This would aid in the strategic development and implementation of extension efforts to improve WUE and IE.

Finally, a more comprehensive and consistent approach to the collection of irrigation statistics is needed. Such an approach can only be developed with the full involvement of the many agencies and irrigators who require these data.

2. INTRODUCTION

During 1998, a desktop study was undertaken to develop a comprehensive database of irrigation in NSW in order to obtain catchment and industry based assessments of on-farm WUE and IE. From this study, irrigation profiles, or situation statements of irrigation, were developed for each of the major catchments in NSW. This is one such Profile. It focuses on the Murrumbidgee catchment (Figure 2) and attempts to detail what is known about the number of irrigators, the area irrigated and water used in total and by crop, irrigated production, irrigation methods and the value of irrigated agriculture.

This Profile does not attempt to calculate WUE or IE. This will be carried out in a subsequent report.

2.1 Background

Irrigation statistics have been collected in NSW over the last 50 years.

1980	The Water Resources Commission (WRC 1980) undertook an assessment of water resources across NSW. Water use statistics were compiled for the urban, industrial and irrigation sectors.
1986	The WRC (1986) undertook a study to assess WUE in NSW. Data on WUE were reported catchment by catchment. The study highlighted a lack of data on crop areas irrigated, water used, yields of irrigated crops and financial returns.
1980–1989	A report was compiled on crop areas irrigated, yields of irrigated crops and the values of individual irrigated commodities in NSW (DWC 1990).
1988–1992	Sloane (1993) provided an overview of the number of farms and area irrigated for four broad agricultural regions in NSW.
1986–current	The Australian Bureau of Statistics (ABS) has been collecting information on irrigation for various years since 1986 (ABS 1998).
1950s–current	The NSW Department of Land and Water Conservation (DLWC) and its predecessors have collected information over the last 50 years on the area irrigated and water used by sections of the irrigation industry across NSW.
1996–97	The Australian Bureau of Agricultural Resource Economics (ABARE 2000) completed a survey of broadarea[6] and dairy farms in each of the major catchments in NSW in 1996–97. There are also smaller surveys each year for various irrigation industry groups, for example, dairy and rice.

Despite the volume of statistics collected in NSW over the last two decades, a basic description of the irrigation industry remains elusive.

A review commissioned by the Murray-Darling Basin Commission (Crabb 1997a & 1997b) highlighted a lack of data describing:

[6] Broadarea refers to all crops excluding horticultural and vegetable crops.

1. the number of irrigators
2. the area of land irrigated
3. the location of irrigated land
4. the volume of water used

Four additional points could be added to the list: the crop type; the irrigated yields that are being obtained, the methods that are being used to irrigate crops, and, the value of irrigated agriculture.

Collation of water resource and irrigation statistics has already occurred at a national level, for example, the Australian Water Resources Assessment, a publication of the National Land and Water Resources Audit (2000). An electronic atlas and database of irrigation information describing the availability of irrigation statistics for catchments in NSW and Australia has been developed and covers categories such as area irrigated, water used, production, infrastructure and distribution and gross value (National Land and Water Resources Audit 2002).

More detailed information on irrigation over smaller areas and by water source (for example, regulated and groundwater supplies) is needed. Accurate and reliable irrigation data are needed in order to assess the impact of new water sharing rules on the irrigation industry and other users such as industry and the environment. Irrigation data are needed for planning, research and extension activities – the most obvious ones have been listed below.

- With the introduction of the new *Water Management Act 2000*, NSW community and agency groups have been developing water sharing plans. These plans require accurate and reliable irrigation data to underpin their development and implementation. Water sharing plans are operational for 10 years with a review in the fifth year. Plans are drafted for the Murrumbidgee regulated river, Adelong Creek, Tarcutta Creek and the Lower Murrumbidgee Groundwater Source (DLWC 2002).
- Catchment Blueprints are being developed and finalised by Catchment Management Boards (CMB) in each major catchment/region in NSW. These plans are designed to improve the management of natural resources across the State and are operational for 10 years. These plans require irrigation data both now and in the future to enable a proper assessment of their impact (Murrumbidgee Catchment Management Board 2001);
- A structural adjustment package aims to assist irrigators adjust to new water management sharing arrangements. The scheme is jointly managed by NSW Agriculture and the Rural Assistance Authority (RAA and NSW Agriculture 2002). In order to measure change as a result of this scheme, historical and current irrigation data are needed to describe the base-line situation and the situation post-implementation.

In summary, there is a pressing need to obtain these data in order to help strategically focus efforts to improve WUE and IE, provide communities with information on irrigation to aid decision making about sharing water in NSW, and help agencies and communities measure change as a result of water reform.

3. METHODS

3.1 Summary of data collection

During 1998, a desktop study was undertaken to review readily accessible data about irrigation from State sources, including the DLWC, and from Commonwealth sources including the ABARE and the ABS. Electronic data collected include:

1. the ABS Irrigation Statistics Catalogue, AgStats (ABS 1998). The ABS has collected information by Statistical Local Area (SLA) and, in most instances, these units can be aggregated into the Murrumbidgee catchment. For the grouping of SLAs used in this Profile, see Figure. For a definition of an SLA, see Appendix 14.1. Only the most recent years available (1993–94, 1995–96 and 1996–97) with the same Estimated Value of Agricultural Operations (EVAO)[7] and the same collection method have been compared (Table 2) for the following reasons:

- Before 1993–94, data were collected with different EVAOs (Table 2), making comparisons between years difficult.
- Between 1997–98 and 1999–2000, the ABS collected information by Agro-Ecological Regions (AER). These span across catchments and cannot be used to build catchment snapshots of irrigation. (Data for the 2000–01 year are yet to be released).

[7] The EVAO, or Estimated Value of Agricultural Operations, determines the population to be surveyed. The EVAO is estimated from a procedure that takes into account the value of the area of crops sown and the number of livestock on holdings at a point in time as well as the crops produced and the livestock turnoff during the year. The resultant aggregation of these commodity values is termed the EVAO.

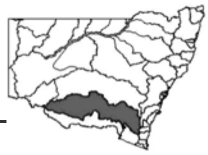


Figure 2. The Murrumbidgee catchment and ABS SLAs

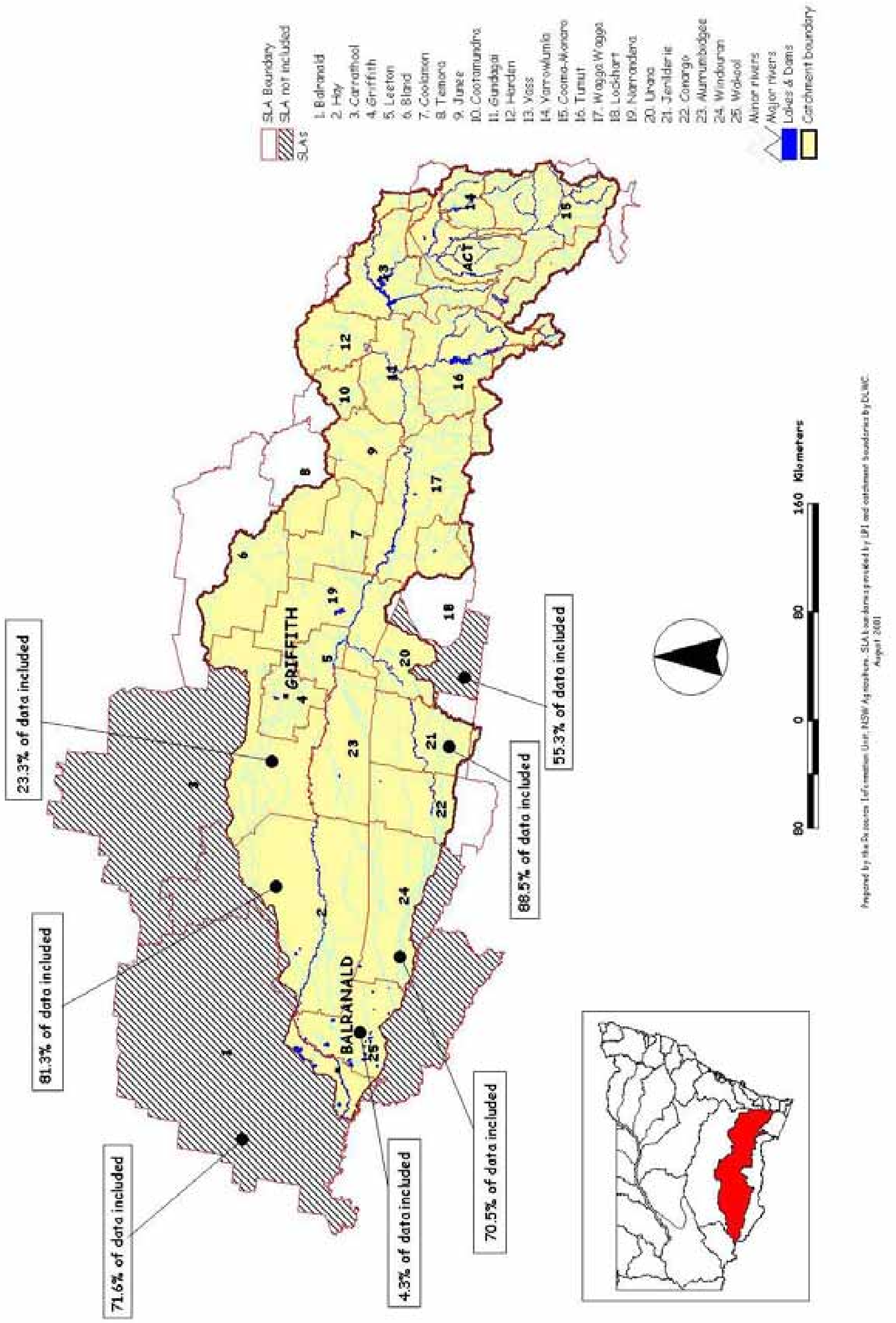


Table 2. EVAOs and collection units used by the ABS to collect data about irrigation in NSW

Year	EVAO ($)	Collection Unit
1986–87	20 000	SLA[a]
1989–90	20 000	SLA
1990–91	20 000	SLA
1991–92	22 500	SLA
1992–93	22 500	SLA
1993–94	5 000	SLA
1994–95	5 000	SLA
1995–96	5 000	SLA
1996–97	5 000	SLA
1997–98	22 500	AER[b]
1998–99	22 500	AER
1999–2000	22 500	AER
2000–01	5 000	SLA

[a] SLA = Statistical Local Area [b] AER = Agro-Ecological Region

Catchment totals may be over-estimated when SLAs cross into other catchments. In this Profile, the Balranald, Carrathool, Hay, Jerilderie, Urana, Wakool and Windouran SLAs spanned important areas of large-scale irrigation in the Murrumbidgee, Murray and Lachlan catchments. Including 100% of the data in each of these SLAs may lead to gross over-estimation of area irrigated and number of enterprises irrigating. For this reason, a licence-based concordance was used to apportion the SLA data in the Murrumbidgee catchment (Table 3).

Table 3. Proportion of surface licences within SLAs of the Murrumbidgee and surrounding catchments

	Percentage (%) of surface licences in each SLA and catchment						
SLA	Murrumbidgee	Lachlan	Murray	Snowy	Tuross	Unknown[b]	100% SLA data used in Profile
Balranald (S) [a]	71.6	16.6	10.7			1.1	✖
Bland (S)	25	75					✓
Carrathool (S)	23.3	76.7					✖
Conargo (S)	91.5		8.5				✓
Coolamon (S)	100						✓
Cooma-Monaro (S)	95.0			3.9	1.2		✓
Cootamundra (S)	60	40					✓
Griffith (C)	100						✓
Gundagai (S)	100						✓
Harden (S)	100						✓
Hay (S)	81.3	18.7					✖
Jerilderie (S)	88.5	11.5					✖

	Percentage (%) of surface licences in each SLA and catchment						
SLA	**Murrumbidgee**	**Lachlan**	**Murray**	**Snowy**	**Tuross**	**Unknown**[b]	**100% SLA data used in Profile**
Junee (S)	100						✓
Leeton (S)	100						✓
Lockhart (S)	36.8	63.2					✓
Murrumbidgee (S)	100						✓
Narrandera (S)	100						✓
Temora (S)	12.1	87.9					✓
Tumut (S)	100						✓
Urana (S)	55.3		44.7				✖
Wagga Wagga (C)	100						✓
Wakool	4.3		95.7				✖
Windouran (S)	70.5		29.5				✖
Yarralumla (S)	93.2	6.8					✓
Yass (S)	97.2	2.8					✓

[a] See Appendix 14.2 for SLA naming conventions. [b] cannot be categorised into catchment.

So, for example, Balranald SLA had 71.6% of its surface licences within the Murrumbidgee catchment. Only 71.6% of the data from this SLA was used in this Profile. Other SLAs where only a proportion of the data was used include Carrathool, Hay, Jerilderie, Urana, Wakool and Windouran. For other SLAs including Conargo, Cooma-Monaro, Cootamundra, Lockhart, Temora, Urana, Yarralumla and Yass, 100% of the data were included. The amount of irrigation that occurs in these SLAs is small and the impact on the total figures for the Murrumbidgee catchment minimal.

2. the 1996/97 ABARE Irrigated Farm Survey results obtained from the ABARE Survey of Primary Industry, Resources and Energy (ASPIRE) database (ABARE 2000). The Murrumbidgee catchment is the reporting unit for the 1996–97 survey of irrigators by ABARE (ABARE 2000). These data cannot be disaggregated into smaller units such as SLAs or subcatchments.

3. a DLWC database of crop area and water use, designed for use by NSW Agriculture (DLWC 1998a). The DLWC has collected information on water use and area by crop type and by licence for various years and these data can be aggregated to any fine scale (stream reach or subcatchment) or any coarse scale (catchment). These data do not include irrigation licences in the ACT.

4. various spreadsheets provided by the Water Analysis and Audit Branch, Sustainable Water Management, DLWC, Parramatta.

Data were also obtained from relevant research and industry reports. Finally, the profile was further developed in collaboration with NSW Agriculture staff in regional offices. As these staff uncovered regional data (for example, unpublished reports), this information was incorporated.

An irrigation profile, or situation statement of irrigated industries operating within the Murrumbidgee catchment, was developed from this information.

3.2 Rating data reliability

The reliability of irrigation data has been described using a rating system developed by the National Land and Water Resources Audit (1999). The system rates data against four classes:

1. **Class A:** data based on reliable recorded and surveyed information. Little or no extrapolation or interpolation required.
2. **Class B:** data based on approximate analysis and limited surveys. Some measured data and some interpolation/extrapolation required to derive the data set.
3. **Class C:** little measured data. Data based on reconnaissance survey.
4. **Class D:** data derived without investigation. Figures estimated from other data in nearby catchments or extrapolated/interpolated from any available data.

In this Profile, the reliability rating class has been indicated with the symbols:

- Class A: ①
- Class B: ②
- Class C: ③
- Class D: ④

So, for example, 'the number of irrigated enterprises in the Murrumbidgee catchment was 1896 (ABS 1998), ②)'.

3.3 Structure of *Murrumbidgee Catchment Irrigation Profile*

This report summarises the availability and reliability of irrigation data in the Murrumbidgee catchment for five water sources: regulated rivers; unregulated rivers; groundwater; farm dam supply and town water (reticulated) supplies. This Profile has been prepared before the full implementation of the *Water Management Act* 2000 but with knowledge of its provisions.

Regulated rivers[8] are those rivers that have been declared by the Minister, by order published in the *Gazette*, to be a regulated river (*Water Management Act 2000)*. Regulated rivers have their flows controlled by government-owned structures, such as dams or weirs. These capture water that is then released to users downstream when it is ordered (DLWC 1999c) or released for flood mitigation.

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[8] **Rivers:** A river includes:

(a) any water course, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved;

(b) any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows; and,

(c) anything declared by the regulations to be a river;

but does not include anything declared by the regulations not to be a river.

Unregulated rivers[8] are all other rivers that are not regulated rivers (*Water Management Act 2000 [NSW]*). Many of these rivers may still have dams or weirs built on them by urban water suppliers to control water flows (DLWC 1999c).

Groundwater is water that can be accessed from an aquifer. An aquifer is a geological structure or formation, or an artificial landfill, that is permeated with water or is capable of being permeated with water (*Water Management Act 2000*).

Farm dam water is water from dams containing water that is permitted to be captured under a Harvestable Right.

Reticulated water supplies are those that have been reticulated for a town or city's drinking water.

The presentation of information by water source was necessary, as data availability and reliability varied markedly according to water source.

This report summarises (where available), by water source and by SLA, subcatchment and catchment (Figure 2):

1. number of licences
2. number of enterprises using irrigation
3. entitled volume or area authorised for irrigation
4. area irrigated and water used in total and by crop type
5. method of irrigation
6. yield of irrigated crops
7. value of irrigated production.

4. CATCHMENT OVERVIEW

4.1 Physical description

The Murrumbidgee catchment is in southern NSW (Figure 1) and covers approximately 84 000 km^2 or 8% of the Murray-Darling Basin.

The catchment can be broken into four zones: the upper, mid and lower catchment and the Murray Catchment Management Board area (see Figure 1).

- **The upper catchment** includes the western slopes of the Great Dividing Range between Lake George and Burrinjuck Dam. The country is characterised by elevated (greater than 500 m), mountainous to undulating landscape. Water from the southern highlands is drained into Tantangara Dam via the unregulated portion of the Murrumbidgee River. The watercourse twists around the Australian Capital Territory (ACT) past the towns of Adaminaby, Cooma, Bredbo and the city of Canberra before draining into Burrinjuck Dam. Burrinjuck Dam also receives water from the Yass, Molonglo and Goodradigbee rivers. Information on irrigation from the ACT has not been included in this Profile since the DLWC does not collect these data. Regardless, very little irrigation occurs around the ACT.

  The Snowy Mountains Hydro-electric Scheme uses the headwaters of the Snowy, Murrumbidgee, Eucumbene, Tooma and Tumut rivers and some tributaries of the Murray River for electricity generation. Flows are diverted from Lake Eucumbene (which sits at the centre of the scheme) via a complex series of tunnels to power stations for the generation of hydro-electricity. After passing through the turbines, water flows into the Murray and the Murrumbidgee rivers where it is used to support irrigated agriculture (Scoccimarro et al. 1997) and other purposes.

- **The mid catchment** includes the section of river from Burrinjuck Dam to just downstream of Wagga Wagga. Water from the Tumut River is captured in Talbingo Dam and then Blowering Dam for release to downstream industrial, irrigation, stock and domestic and town water users. The mid catchment is characterised by undulating landscape and fertile alluvial floodplains adjacent to the watercourse. Towns in this area include Cootamundra, Tumut and Wagga Wagga.

- **The lower catchment** includes the section of river downstream of Wagga Wagga to Balranald and is characterised by flat landscapes (slope < 1%) with broad, fertile alluvial floodplains. Towns in this area include Narrandera, Leeton, Griffith, Hay and Balranald. The former Murrumbidgee Irrigation Area (MIA) and Coleambally Irrigation Area (CIA) are also in this section. These regions are now run by the private companies, Murrumbidgee Irrigation (MI) and Coleambally Irrigation Cooperative Limited (CICL).

- **The Murray Catchment Management Committee area** lies south of the mid and lower Murrumbidgee catchment areas. This region could be in either the Murrumbidgee or Murray catchment. For licensing purposes, the area is considered part of the Murrumbidgee catchment, but, for water management purposes, the area is considered part of the Murray catchment. Yanco Creek is an effluent of the Murrumbidgee River. The creek also receives water from Billabong Creek that drains water from the ranges south of Wagga Wagga. Yanco Creek joins Edward River, which then drains to the Murray River.

For an indication of how much water flows through the Murrumbidgee catchment, see Appendix 0. Of the total volume entering the river system in 1999–2000 (2 429 000 ML), around 80% is from the dams and 20% from gauged tributaries downstream of the dams. Of the 2 429 000 ML, around 26% of the water leaves the Murrumbidgee catchment, and 70% is used by irrigation, mining, stock and domestic and town water supply. The remaining 4% is unaccounted for (Appendix 0).

4.2 Climate

Annual rainfall increases in an easterly direction with increasing elevation while mean daily temperature decreases (Table 4).

Table 4. Climate in the Murrumbidgee catchment

	Tumbarumba	Wagga Wagga	Griffith	Balranald
Location within catchment	Upper	Mid	Lower	Lower
Elevation (m)	645	240	126	61
Mean daily max (C°)	18.6	21.9	23.2	24
Highest max (C°)	39.4	44.8	43.9	47.7
Mean daily min (C°)	4.9	9	9.6	9.8
Lowest min (C°)	-10.4	-6.3	-5.4	-4.8
Long-term annual evaporation (mm)	1301[a]	1639	1797	1786
Evapotranspiration[b] (mm)	1003	1282	1287	1315
Mean rainfall (mm)	986	560	406	322
Evaporative deficit[c] (mm)	16	722	880	993

Source: Bureau of Meteorology (2000) ①.

[a] based on Canberra forestry station.

[b] Reference evapotranspiration is the amount of evaporation and transpiration of a grass reference crop (Allen et al. 1998).

[c] Evaporative deficit = reference evapotranspiration minus rainfall. Reference evapotranspiration was determined using the FAO 56 methodology (Allen et al. 1998).

In the **upper catchment**, the long-term mean annual rainfall is 986 mm (Table 4), although the hilly topography can result in considerable geographic variation. For example, Monaro experiences a strong rain-shadow effect such that evaporation exceeds rainfall all year round. Even so, this rainfall variability tends to be less than across the rest of the catchment (DLWC 1996). This section of the catchment is dominated by winter rainfall (Appendix 14.3). The temperature in the upper-catchment is slightly cooler, resulting in a shorter growing season for crops.

The **mid catchment** experiences cool to cold winters with hot summers and a long-term mean rainfall of 560 mm (Wagga Wagga). The rainfall pattern is slightly spring-dominant with 60% of the annual mean rain falling between May and October. Rainfall is slightly more variable than the upper Murrumbidgee catchment and prolonged dry periods are expected on average one in ten years (DLWC 1996). The mean daily maximum temperature is around 22 C° and temperatures range from extreme lows of –6 C° to extreme highs of 45 C°.

In the **lower Murrumbidgee catchment**, rainfall ranges from 406 mm at Griffith to 322 mm at Balranald in the far west (Table 4). Rainfall can vary considerably from year to year. At Narrandera, the mean annual rainfall is 441 mm but falls have ranged from a low of 174 mm (1967) to a high of 917 mm (1956) (DLWC 1996). Irrigated agriculture is located around Griffith, Leeton and Narrandera. Here the rainfall pattern is winter/spring dominant with 55% of the annual mean rain falling between May and October.

The evaporative deficit is greatest in the lower catchment (Table 4). The evaporative deficit is the difference between reference evapotranspiration and rainfall and gives some indication of when irrigation water is needed by crops. The period during which rainfall exceeds evapotranspiration becomes smaller from east to west: in the upper part of the catchment, rainfall exceeds evapotranspiration between April and October; in the mid-catchment, between May and August; and, in the eastern part of lower-catchment, between June and July. At Balranald, evapotranspiration generally exceeds rainfall all year (Figure 3).

The whole of the Murrumbidgee catchment experiences about 10 severe frosts per year with wide variation depending on location. These frosts usually occur from June to August (DLWC 1996). The number of frosts is greatest in the upper-catchment. For example, Tumbarumba experiences up to 60 severe frosts between March and November. Griffith and Balranald experience 19 and 8 severe frosts respectively (Bureau of Meteorology 2000).

4.3 Population

The largest population centre (excluding Canberra) in the Murrumbidgee catchment is Wagga Wagga (55 500 people) on the Murrumbidgee River. Other major population centres include Griffith, Leeton and Tumut, with more than 10 000 people each (Figure 4) (ABS 1997)①.

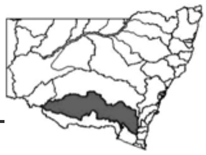


Figure 3. Evaporative deficit at Tumbarumba, Wagga Wagga, Griffith and Balranald

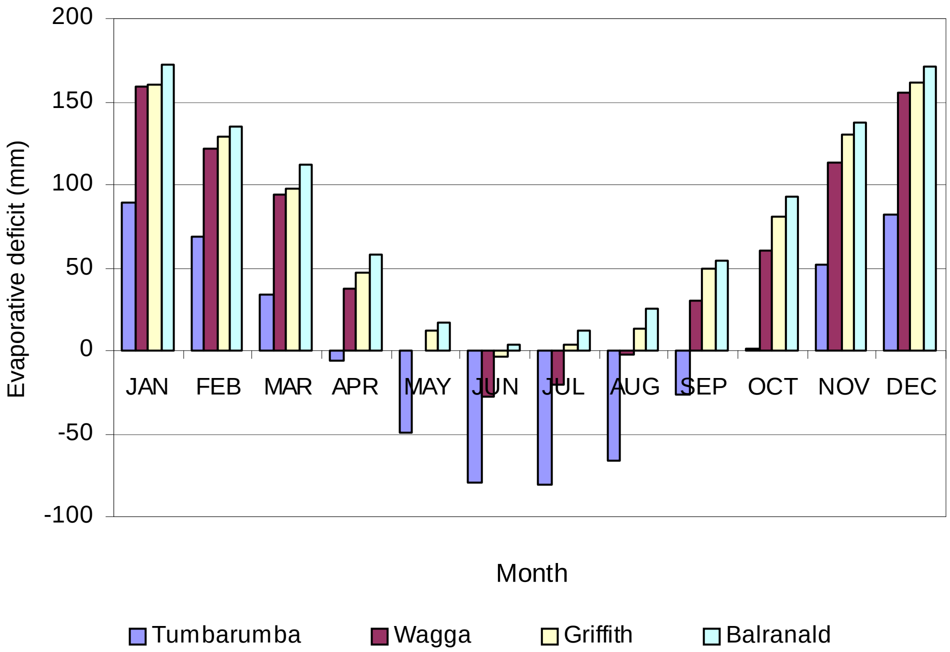
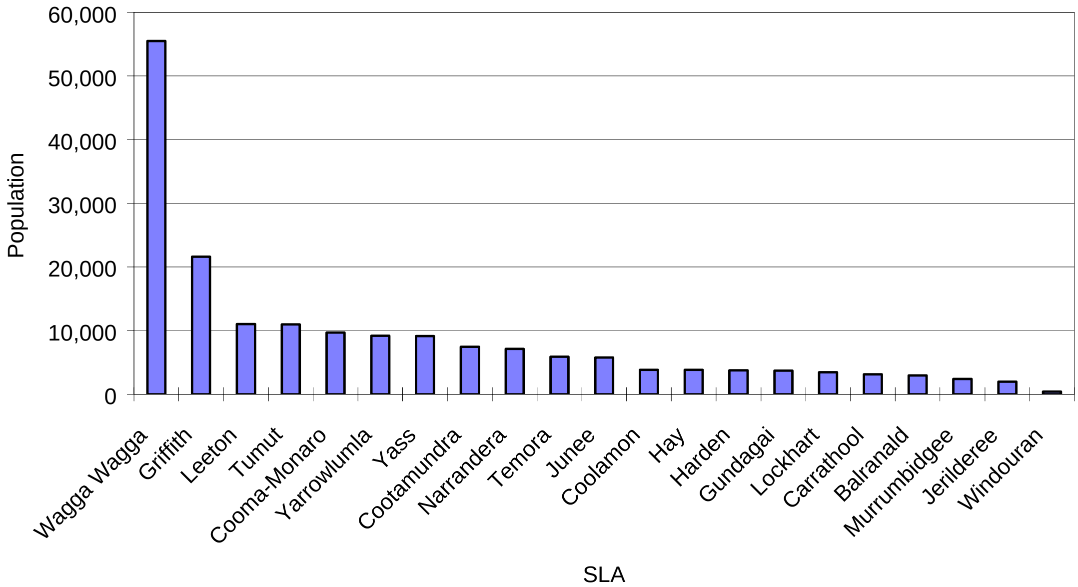


Figure 4. Population in SLAs of the Murrumbidgee catchment in 1996 (excluding Canberra)



Source: ABS (1997) ①

5. IRRIGATION FROM ALL SOURCES

5.1 Description of irrigation

5.1.1 History of irrigation in the Murrumbidgee catchment

Before the construction of Burrinjuck Dam, pastoralists irrigated fodder crops in order to produce reliable sources of feed. However, unreliable river flows restricted further irrigation expansion in the catchment.

Following devastating drought at the turn of the century, interest in irrigation increased. In 1906, State Government legislation made it possible to acquire land for irrigation farms, establish associated towns and infrastructure and construct dams, weirs and water supply systems (Crabb 1997b). In 1910, the Murrumbidgee Act was passed to establish a trust to control irrigation in the region (Hallows and Thompson 1995).

Work began in 1907 on Burrinjuck Dam at the headwaters of the Murrumbidgee River about 60 km northwest of Canberra (Hallows and Thompson 1995). In 1911 the diversion weir on the Murrumbidgee River at Berembed, the Main Canal head gate, and 130 km of the Main Canal were completed. The Main Canal was subsequently enlarged and lengthened such that it is now 160 km long and has a maximum capacity of 6500 ML/d.

In 1912, as settlers began arriving in the region, the trust was replaced by the Water Conservation and Irrigation Commission. In the same year, the NSW Government established the Murrumbidgee Irrigation Area (MIA). Channels were built and pastoral properties subdivided into small irrigable farms (Crabb 1997b).

The MIA refers to a group of Irrigation Areas and Districts, each of which comprise irrigation farms supplied by an arterial network of channels. See Table 5 for the Areas and Districts that form the MIA group. Historically, where ‘Area’ farms were supported by both a supply and a drainage system, ‘District’ farms were supported by a supply system only.

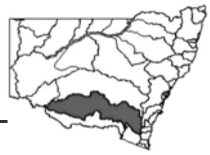


Table 5. Characteristics of Irrigation Areas and Districts and individual irrigators in the Murrumbidgee catchment

Admin. body	Historical name	Irrigation Area or District	Year estab. [a]	Total area of scheme (ha) [a]	Number of farms [a]	% of total area usually irrigated	Crop mix[b]
MI	MIA	Yanco Irrigation Area	1912	88 760	1 173	70	Rice, pasture, vines, citrus
MI	MIA	Mirrool Irrigation Area	1924	74 791	1 249	70	Rice, pasture, citrus, vines
MI	MIA	Benerembah Irrigation District	1933	44 235	138	80	Rice pasture, cereals
MI	MIA	Tabbita Irrigation District	1933	10 473	22	<50	Pasture, rice, cereals
MI	MIA	Wah Wah Irrigation District	1930	261 955	151	7	Pasture, rice cereals
CI	CIA	Coleambally Irrigation Area	1960	79 161	345	95	Rice, wheat, pasture
CI	CIA	Coleambally Outfall Drain		NA	35		Cereals, rice pasture
HPID[c]	HIA	Hay Irrigation Area	1913*	2 460	64	<50	Pasture, cereals
DLWC		Licensed irrigators		NA	NA		Winter pasture, summer pasture, rice

Source: [a] Crabb 1997b, [b] L Parker, pers. comm. [c] Private Irrigation District * Information from Hallows and Thompson (1995).

In 1912, Burrinjuck Dam was ready to store water, the diversion tunnel was sealed and the first water delivered from the supply channels. Burrinjuck Dam is a mass concrete structure with a maximum wall height of 75m and a storage capacity on completion in 1929 of 800 000 ML (Hallows and Thompson 1995).

In 1912, Yanco Irrigation Area was established to utilise water from the Burrinjuck Dam. Rice was grown experimentally in 1924 and is now one of the major commodities cultivated (MIA & D LWMP WG 1997). Yanco Irrigation Area is 88 760 ha and around 70% of this is irrigated annually. Horticulture and pasture are also grown.

In 1913, Hay Irrigation Area was developed by the Water Conservation and Irrigation Commission. At that stage, 380 ha had been taken up and used for fodder and dairy production (Hallows and Thompson 1995). In 1976, a weir was proposed at Hay to provide some river regulation and a pool from which to pump. Hay Weir work commenced in 1982 and was completed by 1983 (Hallows and Thompson 1995). Hay Irrigation Area was converted to a Private Irrigation District under the *Private Irrigation District Act 1973* in 1999. Currently, there are approximately 64 farms. The scheme has an area of 2460 ha and under half of this is irrigated.

The pace of irrigation expansion in the Riverina was rapid over the period between 1910 and 1935. By 1914, there were 677 farms (Crabb 1997b). Farms were originally occupied on a perpetual lease basis and a person could hold only one irrigation farm. By 1917, the number of farms had grown to 900 and in 1926 an Act was passed that allowed farmers to purchase farms outright (Hallows and Thompson 1995). In 1924, Mirrool Irrigation Area was established. There are 1173 farms in this Area growing rice, pasture, citrus and vines. Around 70% of its total area is irrigated.

In 1929, Burrinjuck Dam was completed. The irrigation industry further developed around Leeton and Griffith (which was proclaimed a town in 1916).

Benerembah Irrigation District (part of the MIA) was developed in 1933 to use the drainage water from Yanco and Mirrool irrigation areas. The District, to the south-west of Griffith, was initially established to supply water to stock and domestic licence holders. Following World War II, rice growing began in the District and expanded rapidly (MIA & D LWMP WG 1997). Benerembah has 138 farms and a total scheme area of 44 235 ha. Around 80% of this land is irrigated.

Tabbita Irrigation District (part of the MIA) was also developed in 1933 and is small compared to the other Areas and Districts, with only 22 farms. The District has a total area of 10 473 ha and just under half of this is irrigated.

Wah Wah Irrigation District (part of the MIA) was developed in 1930 and, like Benerembah Irrigation District, was created to use the drainage water from Yanco and Mirrool Irrigation Areas. The District was initially established to supply stock and domestic licence holders. Following World War II, rice growing was introduced to the District and expanded rapidly and like Benerembah Irrigation District, it is now cultivated on a vast majority of farms (MIA & D LWMP WG 1997). Wah Wah Irrigation District has a total scheme area of 261 955 ha but only 7% of this is irrigated.

After World War II, Blowering Dam was constructed on the Tumut River to regulate the additional water available from the Snowy Mountains Scheme. Preliminary work started at the dam site in 1963 and in 1969, a year after it was completed, the Coleambally Irrigation Area (CIA) was established as a government-owned enterprise to utilise this new water resource. Unlike the MIA, the CIA refers to one Area only; it has its own arterial supply and drainage canal network.

The CIA is located 60 km south of the city of Griffith. The total scheme area is 79 161 ha and around 95% of this is irrigated. The CIA is a predominantly rice-based and supplements income with soybeans, winter cereals, sheep, wool and limited horticultural products such as grapes, prunes and vegetables. There are 345 farms and, of these, 12 were designated for horticulture purposes. There are now 39 horticultural designated farms (CICL Unpublished). There are 26 bores for groundwater located in Coleambally and a further 17 along Kerabury Channel.

The Coleambally Outfall Drain is located west of the CIA and is used by 35 licensed irrigators. However, the volume is not guaranteed and extractions are opportunistic. The main crops grown are winter cereals, rice and pasture. Six groundwater bores are used to supplement wool and beef enterprises.

Gogeldrie Weir, some 50km downstream of Berembed, was completed in 1959 to enable the diversion of extra water to the MIA and associated District s and later to the CIA. Sturt Canal leading north from the Gogeldrie Weir was constructed to supply parts of Mirrool Irrigation Area, Benerembah Irrigation District and the Coleambally Canal leading south.

The Areas and Districts have undergone considerable administrative change over the last century. The MIA and CIA were initially owned and operated by the Water Conservation and Irrigation Commission (WCIC). They were subsequently administered by the Water Resources Commission (WRC), the Department of Water Resources (DWR) and the Department of Land and Water Conservation (DLWC).

The MIA and CIA were corporatised, and later privatised, under the *Irrigation Corporations Act* 1994 and the *Irrigation Corporations Amendment Act* 1998.

- The MIA became a state-owned corporation in July controlled by Murrumbidgee Irrigation (MI). MI had full responsibility for irrigation supply and drainage. In 1999, the company became locally owned with the shares transferred to its irrigation entitlement holders.
- In 1997, Coleambally Irrigation Corporation (also a state-owned corporation) was formed to control what was previously called the CIA. The company was incorporated in 1999 and privatised in 2000 and shares were transferred to its irrigator shareholders. On June 30, 2000, shareholders resolved to adopt a co-operative structure and the business is now known as Coleambally Irrigation Co-operative Limited (CICL).

Because of these processes, the MIA and CIA technically no longer exist and the land formerly under their control is now operated by MI and CICL. However, given that the terms MIA and CIA are still in common usage, they have continued to be used in this Profile.

In addition to all the irrigation farms in the Areas and Districts, irrigation farms are also distributed along the entire length of the Murrumbidgee River.

- In the upper Murrumbidgee catchment, irrigation above the dams draws water from unregulated streams. There is a well-established apple industry at Batlow with a cannery and packing facility. Water supply is variable due to the lack of structures to store and regulate flows. Stream flows are consequently greatest during winter and early spring when the requirement for irrigation water is the lowest. As a result, a large number of enterprises rely on farm dams for irrigation water.

- In the mid Murrumbidgee catchment, irrigation is dependent mostly on regulated supplies. Wheat, canola, pasture, barley and legumes are grown on the red earth soils around Wagga Wagga. The area supports lucerne production and pasture for dairying on the alluvial soils close to the river. Around Cootamundra, lupins are irrigated.

- In the lower Murrumbidgee catchment, a wide variety of crops is grown along the river. Rice is cultivated around Darlington Point, Carrathool and Hay where there are heavy clay soils. Substantial volumes of groundwater are extracted for irrigation especially around Darlington Point. Irrigated agriculture generally and rice growing specifically has expanded dramatically around the Hay region over the last decade largely as a response to low returns from the livestock industry. Because of this increased production, a 30 000 tonne rice receival depot has been constructed (HWUA 1998). Maize, soybeans, canola, lucerne, sunflowers, safflower, cereals and pasture are also grown on farms close to the river. Vegetables, citrus and other permanent plantings and are grown on the lighter soils or on the old sand hill formations in this part of the catchment (DWR 1987).

5.1.2 Environmental issues for Irrigation Areas and Districts

Salinisation and waterlogging are major issues in the Irrigation Areas and Districts. Watertables have risen because of the following physical processes and cultural practices:

- The high water content of irrigated soils. This limits the soil's capacity to absorb rainfall and results in water moving past the root zone to greater depth.

- The practice of applying a leaching fraction (a volume in excess of that required by the plant). The net downward flow helps prevent the accumulation of salt in the root zone.

- The application of water in excess of that required by the crop. Excess water moves past the crop's root zone to the watertable.

- Leakage of on-farm and District supply channels.

- Increased ponding of water and hence greater deep percolation (GH&D and ACIL Australia 1985).

Shallow watertables can reduce yields when the crop's root zone becomes salinised and/or oxygen deprived. Yields may also be depressed by cultivation and harvesting problems such as poor timing in sowing and harvesting (GH&D and ACIL Australia 1985).

The sustainability of irrigated production in the Irrigation Areas and Districts of the Riverina is being addressed in a number of ways.

- The Rural Industries Research and Development Corporation (RIRDC) has a significant program in rice research.

- Research into rice is also funded through Land and Water Resources Australia, (previously Land and Water Resources Research and Development Corporation or LWRRDC), the Murray Darling Basin Commission and the National Heritage Trust.

- The CSIRO, NSW Agriculture, the Department of Land and Water Conservation, the Environment Protection Authority and the Murrumbidgee and Coleambally irrigation supply authorities all have programs that address the future sustainability of the industry.

- The Cooperative Research Centre for Sustainable Rice Production has been established. Rice growing and poor government policy in the MIA and CIA is recognised as a significant contributor to high watertables, salinity and waterlogging. The CRC is an unincorporated joint venture of seven major partners: Charles Sturt University; the University of Sydney; the Rice Growers' Cooperative Limited; CSIRO - Land and Water; CSIRO - Plant Industry; NSW Agriculture and the Rural Industries Research and Development Corporation. It brings together a team of researchers, technologists, extension officers and educators to improve sustainability of the Australian rice industry.

- Murrumbidgee Irrigation (MI) and the Coleambally Irrigation Cooperative Limited (CICL) are implementing Land Water Management Plans (LWMP) that were developed by communities and agencies in the region. These plans are regarded as a preferred means for planning productivity and ecological goals for distinct geographical (catchments) or industry-based (e.g. irrigation) areas (Soil and Water Conservation Association of Australia 1995).

  These plans are required by the State and Federal governments for the provision of properly targeted assistance for improved land management (Soil and Water Conservation Association of Australia 1995). These plans include assistance to help growers manage on-farm accessions to the watertable, such as the Net Recharge Management model (Prathapar and Madden 1995, CIA LWMP Committee 1997). Examples of other extension activities include the promotion of Best Management Practices, Whole Farm Planning and Landcare (DWR nd).

- Benchmarking programs (for example, Ricecheck) involve the collection, collation and comparison of figures from numerous farms (Lacy 1997). Data on WUE and IE can be examined across a group of irrigators. Murrumbidgee Irrigation has developed a benchmarking program where large-area farms are surveyed for crop type, sowing and harvest dates, yield and water use (S Tijis, pers. comm.). This program helps extend concepts about WUE and IE.

Table 6 is a summary of irrigation data related to all source of water.

Table 6. All sources: summary of irrigation data, Murrumbidgee catchment

Year July to June	Number enterp's irrigating	Total area irrig. (ha)	Total area of rice irrig. (ha)	Total area of rice irrig. in MIA and CIA	Total water used by irrig. ag. in catchment (ML) *	Total water used on rice in catchment (ML) ¥	Total water used on rice in MIA and CIA (ML) §	Yield of rice (t/ha)	Value of irrigation ($ m)[e]	Value of rice ($ m)[e]
1988–89	-	-	-	-	-	-	-	8.2 [c]	-	-
1989–90	-	-	-	-	-	-	-	8.6[c]	-	-
1990–91	-	-	-	-	-	-	-	9.3 [c]	-	-
1991–92	-	-	-	-	-	-	-	9.4 [c]	294	72
1992–93	-	340 769[h]	58 492 [b] 60 856[g]	58 491[g]	-	-	-	8.3 [c] 8.1[g]	285	68
1993–94	2 207 [a]	373 978 [a]	65 797 [b] 64 964[g]	58 758 [g]	-	-	-	8.4 [c] 8.3 [g]	368	112
1994–95	-	-	72 670 [b] 67 982[g]	61 264 [g]	-	-	-	9.2 [c] 9.0 [g]	355	98
1995–96	1 588 [a]	235 256 [a]	82 800 [b] 77 553 [g]	65 787 [g]	-	-	-	7.1 [c] 6.6 [g]	422	99
1996–97	1 896 [a] 3 802 [f]	329 201 [a] 348 692[h]	85 564 [b] 81 107 [g]	66 503 [g]	*Est.* *2 430 963*	-	-	10.2 [c] 8.9[d] 8.4[g]	476	127
1997–98	-	-	78 703 [b] 79 082 [g]	64 780 [g]	-	-	-	12.0 [c] 9.7[g]	-	-
1998–99	-	-	81 984 [g]	64 955 [g]	-	-	-	9.4[g]	-	-
1999–00	-	-	-	-	-	-	-	-	-	-
2000–01	-	-	-		-	-	-	-	-	-
Refer to Section	0	5.4	5.4	5.4	5.4	5.4	5.4	5.6	0	0

a. ABS (1998) ② (EVAO - $5000)

b. DLWC (1998b) ②

c. M Hedditch, pers. comm. from the RGA① - Numbers for MIA only

d. ABARE (2000) ③

e. Donovan (2000) ③

f . Crabb (1997b) ① plus ABS (1998) ②

g. Caldwell (2000) unknown reliability rating. For rice areas in the Areas and Districts, CIA bore pumpers have been included. For yield figures, data for the whole catchment are provided.

h. National Land and Water Resources Audit (2002) reliability rating unknown

* It is difficult to calculate the total volume used by irrigation on an annual basis because there were limited data for some sources of water. The estimate for the 1996–97 season does not include the volume lost in transmission between the river off-take and the farm gate. See Table 1 for the figures used to calculate this total. The bulk proportion of the total water use in the catchment is from regulated supplies and figures range from 1 700 000 ML to 2 650 000 ML. Information for unregulated supplies is also available over a short period (1989–90 and 1994–95) and between 13 500 and 27 000 ML were used. Information on the volume of groundwater supplies used for irrigation each year across the whole catchment is not readily available. It is estimated that around 150 000 ML are used from groundwater supplies each year. Details on the availability of data from these sources of water can be found in Table 11 and Table 12.

¥ It is difficult to calculate the total volume of water used on rice in the catchment. While information on extraction from the regulated system is available, information on extraction from groundwater is not.

§ Data on water used on rice in the MIA and CIA are available and are based on data from the regulated river system (Table 8). Figures range from 590 000 ML to 870 000 ML. However, information on volumes of groundwater used on rice in the MIA and CIA were not available

The matrix shows a lack of information across most categories, but especially relating to water used in total and by crop type. These irrigation data are also presented in the text.

5.2 Number of licences (all sources)

There were 2050 licences with the purpose of irrigation in 1999. This figure was determined by summing the following data:

- 801 volumetric licences with the purpose of irrigation from regulated surface supplies (DLWC 1999a)①

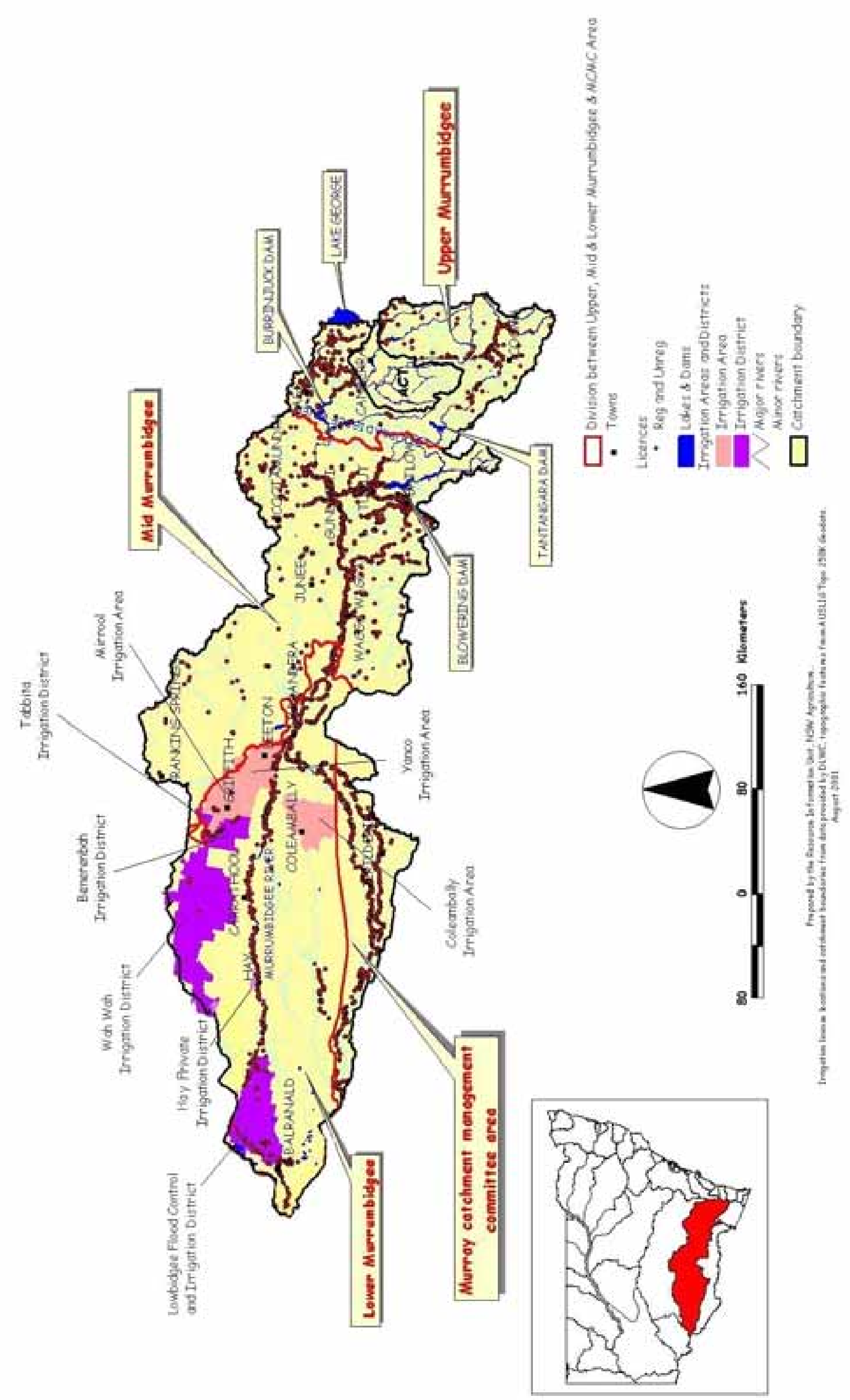
- 502 area-based licences with the purpose of irrigation from unregulated rivers (P Gustafson, pers. comm.) ①[9]. These have been converted to volume-based licences (DLWC 2000d).
- 747 volumetric licences with the purposes of irrigation using water from groundwater aquifers (P Gustafson, pers. comm.) ①[9].

It should be noted that MI and CICL have one licence each for the supply of many irrigation enterprises.

Figure 5 shows the location of regulated and unregulated surface irrigation licences.

[9] These figures were derived from the Licence Administration System (LAS).

Figure 5. Location of all licences with the purpose of irrigation in the Murrumbidgee catchment ①



5.3 Number of enterprises irrigating (all sources)

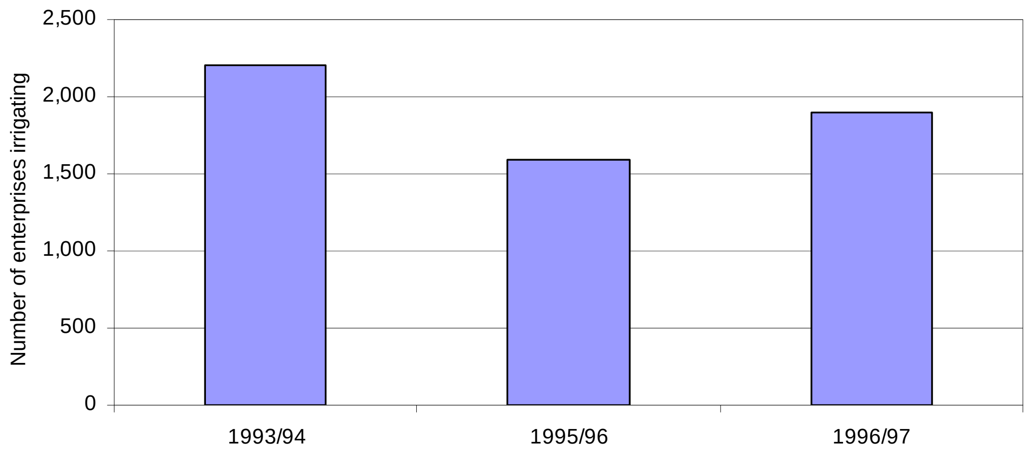
In 1996–97, the number of enterprises irrigating was either:

- 1896 (ABS 1998)②, a figure determined by summing the data in the SLAs of the Murrumbidgee catchment, or
- 3802 (Crabb 1997b)① plus (ABS 1998) ②. This figure was determined by adding the number of enterprises irrigating in the MIA and CIA and HIA, as reported by Crabb (1997b), to the data in the remaining ABS SLAs (Balranald, Bland, Carrathool, Coolamon, Conargo, Cooma-Monaro, Cootamundra, Gundagai, Harden, Junee, Lockhart, Narrandera, Temora, Urana, Tumut, Wagga Wagga, Wakool, Windouran, Yarralumla, Yass). The SLAs that covered the MIA, CIA and HIA (Griffith, Murrumbidgee, Jerilderie, Leeton and Hay) were excluded. So, for example, in 1996–97, there were 3177 enterprises irrigating in the MIA, CIA and HIA and there were 625 enterprises irrigating in the rest of the catchment, giving 3802.

The reason for the difference between the two figures is not known.

According to ABS figures, the total number of enterprises irrigating fell between 1993–94 and 1995–96 and then rose again in 1996–97 (Figure 6).

Figure 6. Number of enterprises irrigating in the Murrumbidgee catchment



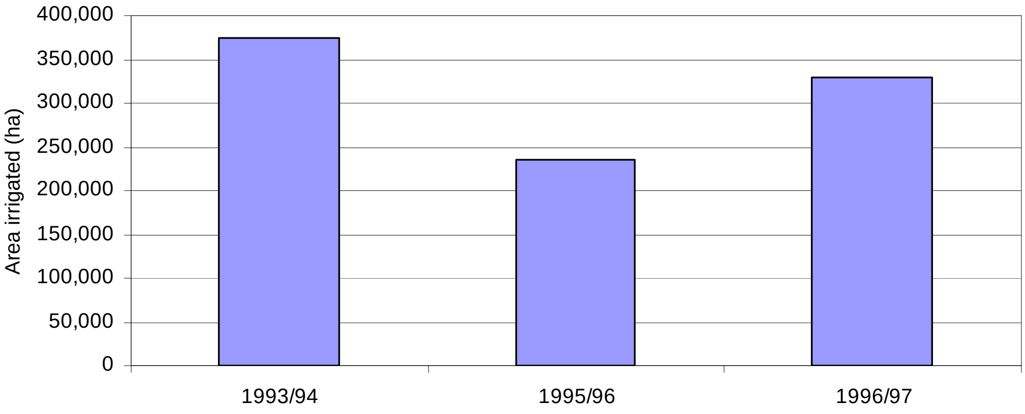
Source: ABS (1998) ②

By 1996–97, large drops (greater than 50% of the 1993–94 figures) had occurred in the SLAs of Bland, Coolamon, Lockhart and Temora (ABS 1998)② (Appendix 14.4)②. Reasons for this apparent overall decrease are not clear and these trends should be treated with caution. Firstly, the stability of irrigation, particularly in the MIA and CIA, would preclude such dramatic changes. Secondly, the allocation from the dams in the Murrumbidgee catchment was 100% or greater for 1993–94, 1995–96 and 1996–97 (Appendix 14.5). In other words, the same volume of water was available to irrigation for each of these seasons. In summary, this trend (decreasing numbers between 1993-94 and 1996-97) exists in most SLAs across the State despite a huge diversity in climate, rainfall and water supply systems.

5.4 Area irrigated and water used (all sources)

Area irrigated – The area irrigated from all sources of water decreased from 373 978 ha in 1993–94 to 235 256 ha in 1995–96 and then increased again to 329 201 ha in 1996–97 (ABS 1998)② (Figure 7)[10]. These estimates from the ABS should be treated with caution for the same reasons provided in Section 5.3.

Figure 7. Area irrigated (ha) from all sources in the Murrumbidgee catchment



Source: ABS (1998) ②

Where comparisons could be made, figures on total area irrigated were reasonably close (Table 6). The difference between the National Land and Water Resources Audit (2002) figure and that used in this Profile is probably the result of differing SLA collation methods. The Audit aggregated SLAs lying in catchments and then proportioned SLA irrigation data using an area-based concordance and local knowledge. This Profile aggregated SLAs lying in the catchment and then applied a licence-based concordance (see Section 3.1).

Of the area irrigated in the whole catchment, the MIA irrigated 157 516 ha (L Parker, pers. comm.) and the CIA irrigated 71 000 ha (W Bolsch, pers. comm.). Both these figures include land that is irrigated from groundwater supplies.

Cereals (which includes rice, wheat, oats and barley) was the dominant irrigated crop group in the Murrumbidgee catchment and represented around half (158 742 ha) of the total area irrigating in 1996–97. This crop group was concentrated in the Griffith

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[10] ABS conducted surveys in other years (1986–87, 1989–90, 1990–91, 1991–92 and 1992–93). However these years have a different EVAO and cannot be compared with 1993–94 and 1996–97 data.

(32%), Murrumbidgee (17%) and Jerilderie (14%) SLAs, which cover the major Irrigation Areas and Districts. The concentration of irrigation can be seen in Figure 8 (ABS 1998) ②. See also Appendix 14.6. Rice is the dominant cereal crop and is one of the most important industries in the catchment. Rice areas have been increasing over the last decade (Figure 9 and Table 6).

Pasture is the next largest irrigated crop in the catchment and occurred mostly in the SLAs of Griffith and Conargo (Figure 10) (Appendix 14.6). Pasture was also irrigated in the Wakool SLA, which is located on the Murray and Murray catchment border. When the licence-based concordance was used to proportion data within this SLA, the actual area irrigated in the Murrumbidgee catchment was reduced to around 2000 ha in 1996–97. Total pasture irrigated areas decreased between 1993–94 and 1996–97 from 200 290 ha to 126 145 ha (ABS 1998) ②.

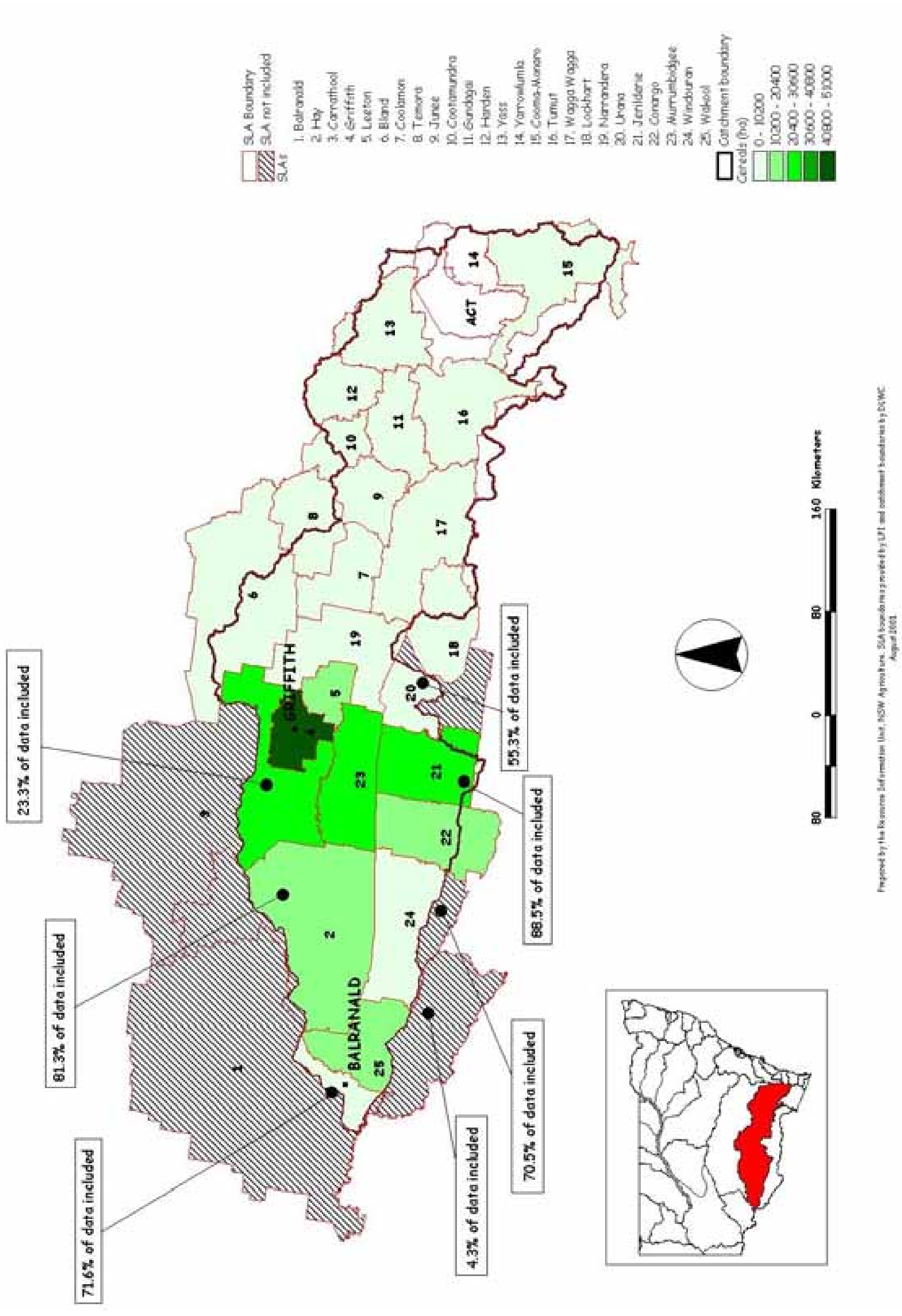
Other crops not categorised elsewhere by the ABS (field peas, chickpeas, lupins, nursery production, canola, soybean and sunflowers) were the next largest irrigated crop group in the catchment. Between 1993–94 and 1996–97, the area of 'other crops' irrigated increased from 18 632 ha to 22 515 ha (Appendix 14.6) (ABS 1998) ②. Increases were particularly evident in the SLAs of Hay, Jerilderie and Murrumbidgee (Appendix 14.6) ②.

Water used. In 1996–97, it was estimated that 2 430 963 ML ③ were used from all sources by irrigated agriculture (Table 1). It was not possible to give a figure with greater reliability than this. The volume was determined by summing the data shown in Table 1. It should be noted that:

- the volume extracted from the regulated system by irrigators was known for this season and is based on metered information
- the water use data for this same season for unregulated rivers, groundwater, farm dams and town water supplies were either incomplete or had never been collected. For these water sources, data from seasons other than 1996–97 were used in the calculation and this decreased the reliability rating of the overall figure accordingly.

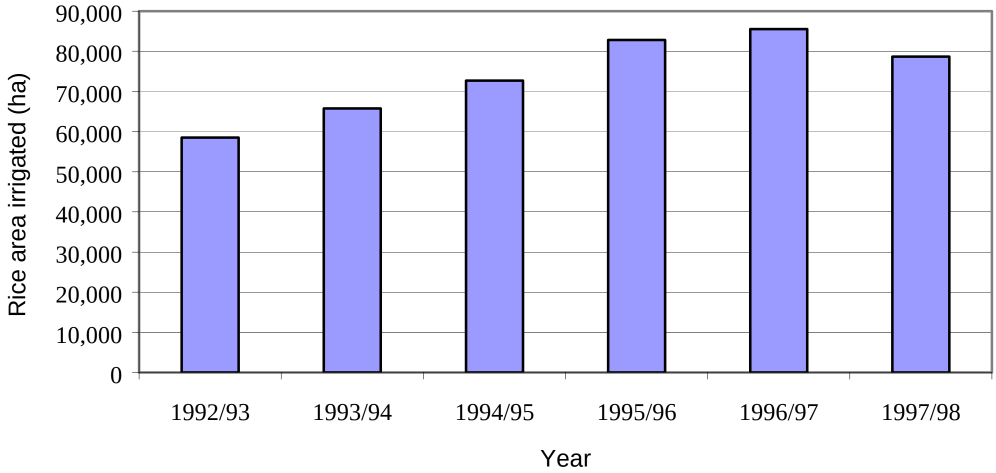
Similar difficulties were encountered in determining the total amount of water used on different crop types. Again, the difficulty was finding a year where data were collected across all sources.

Figure 8. Area of cereals irrigated in the Murrumbidgee catchment in 1996–97



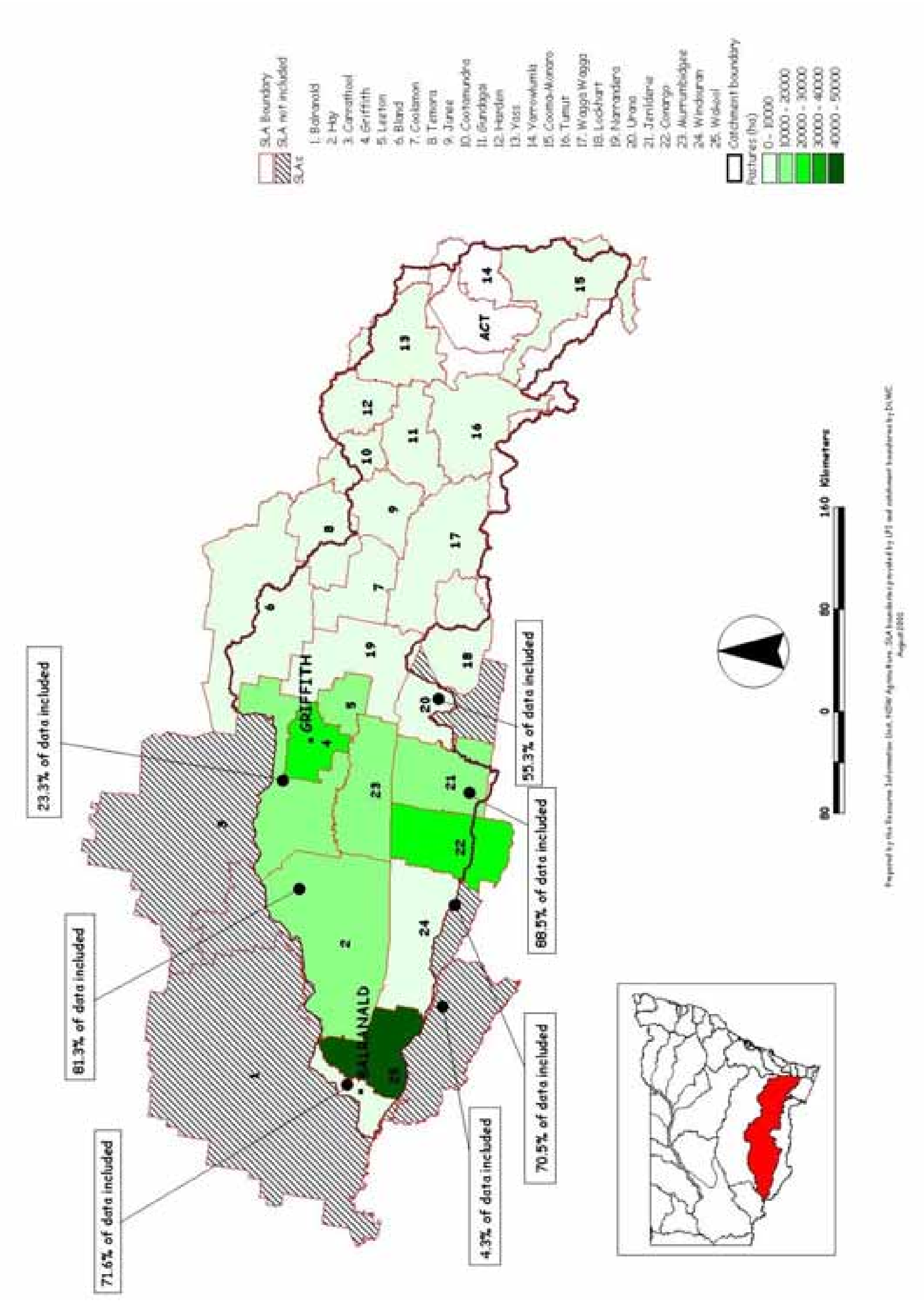
Source: ABS 1998 ②

Figure 9. Rice area, 1992–1998, Murrumbidgee catchment



Source: DLWC (1998b)② For alternative figures see Table 6 and Caldwell (2000) (unknown reliability rating).

Figure 10. Area of irrigated pasture in the Murrumbidgee catchment, 1996–97



Source: (ABS 1998) ②

Estimates of water used by crops were further complicated by the following problems:

- Crop water use data from the regulated system are not based on metered information but on estimates made by meter inspectors. This reduces the reliability rating of these data.
- Crop water use data from the unregulated, farm dam and reticulated water supply system have never been collected.
- Crop water use data from the regulated system (outside the Irrigation Areas and Districts) were collected only between 1989–90 and 1994–95.

Application rates. Due to a lack of complete crop water use and area irrigated information for many sites across the catchment, calculation of reliable crop application rates[11] were generally not possible. Theoretical[12] (Appendix 14.7) or estimated (Appendix 14.8)④ crop irrigation requirements must suffice.

Caution needs to be exercised when growers use more than one source of water to irrigate crops. In the CIA for example, some rice growers have access to both bore and regulated supplies. Bores are managed and monitored by the DLWC, while regulated supplies are managed and monitored by CICL. Groundwater and regulated records for these properties have not yet been integrated. Consequently, when CICL reports on water use for these farms, only the surface water component can be reported. Yet crop area records will include the area irrigated by groundwater and regulated supplies. The result of this would be an underestimated application rate. CICL are attempting to resolve this problem.

In the MIA, the volume of groundwater used on rice is thought to be small and therefore application rates will be more reliable.

5.5 Irrigation methods (all sources)

Approximately 91% of the total area irrigated in the catchment was irrigated using surface methods (Figure 11) (ABARE 1998). This figure is the same as the NSW estimate (Appendix 14.9) ③.

[11] Irrigation rates are defined as the volume of irrigation water applied to crop over a hectare (ML/ha). In this context, the amount of water applied is either measured or estimated and may includes losses between the measuring device (*eg*. Dethridge wheel) and the field.

[12] Irrigation requirements refer to the amount of water required by a crop after effective rainfall has been taken into account. In this context, the rate is theoretical and is for a well watered, disease-free crop.

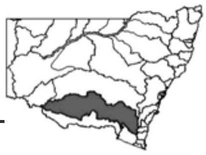
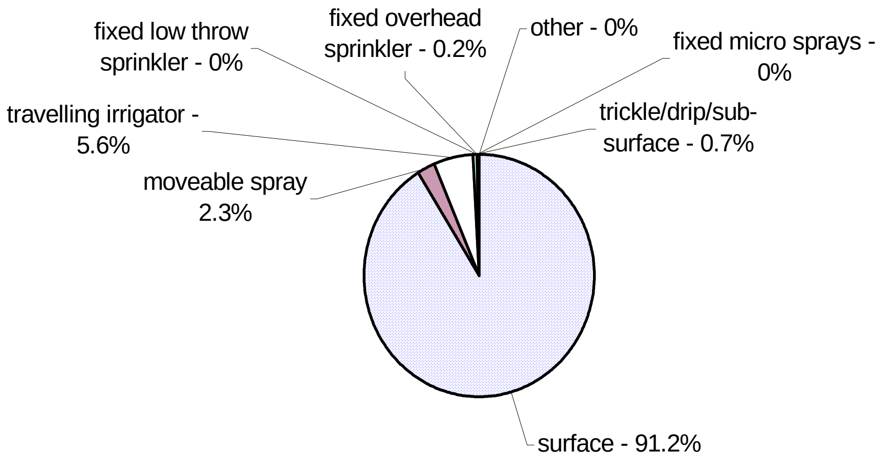


Figure 11. Irrigation methods used in the Murrumbidgee catchment



Source: ABARE (1998)③

Rice is flood-irrigated, whereas cereal are either planted on raised beds and irrigated down the furrows or planted on contour or border check bays and flood-irrigated. Oilseeds (with the exception of tea tree) are irrigated in a similar way. Tea tree was irrigated using drip, while chickpeas, field peas and lupins were irrigated using border check. Vegetables were either grown on beds and irrigated down furrows or irrigated using centre pivots (Appendix 14.8).

5.6 Irrigation yields (all sources of water)

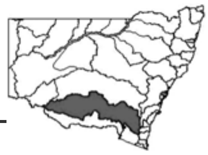
Data on the yields of irrigated crops are summarised in Table 7 (see also Appendix 14.8, ④). As shown here, the yields for irrigated lucerne vary widely between references (Table 7).

It should be noted that comprehensive data exist for some industries. For example, rice yields are available for the last 20 years (M Hedditch, pers. comm.) ① [13] and show a steady increase from 5.1 t/ha in 1979–80 to 12 t/ha in 1997–98 (see Figure 12 and Appendix 14.10).

[13]These data receive a reliability rating of ① because these data were based on measured tonnage and areas estimated from aerial survey

Table 7. Irrigated yields in the Murrumbidgee catchment

Crop	Avg (t/ha)	Min. (t/ha)	Max. (t/ha)	References and reliability rating
Cereals				
Rice	8.9			ABARE (2000) [a]③
	9	6	12	M Parker, pers. comm. ④
	7.9	5.1	12	M Hedditch, pers. comm. See also Appendix 14.10.
	9.5	6	12	D Williams et al., pers. comm. ④
	11.1	10.2	12.4	Beecher et al., 1995③
Barley	2.4			ABARE (2000) [a]③
	2	1	3	D Williams et al., pers. comm. ④
	4.7	2.5	5.9	Inland Agriculture (1997) ③
Grain sorghum	3.0			ABARE (2000) [a]③
Oats	1.7			ABARE (2000) [a]③
	2	1	3	M Parker, pers. comm. ④
	2	1	3	D Williams et al., pers. comm. ④
Wheat	3.3			ABARE (2000) [a]③
	2	1	3	M Parker, pers. comm. ④
	5.3	4.9	6.2	Beecher et al., (1995) ③
	2	1	3	D Williams et al., pers. comm. ④
Maize	8	6	12	M Parker, pers. comm. ④
	8.5	6	12	D Williams et al., pers. comm. ④
	10.2	8.6	13.6	Beecher et al., (1995)③
Oilseeds	2.1			ABARE (2000) [a]③
Canola	2.3	1.5	3.5	M Parker, pers. comm. ④
	2.5	1.8	3	D Williams et al., pers. comm. ④
	3.2	1.9	4	Inland Agriculture (1997)③
Soybeans	2.4	1.5	3.8	M Parker, pers. comm. ④
	2.6	1.5	3.8	D Williams et al., pers. comm. ④
	3	2.3	4.5	Beecher et al., 1995③
Sunflowers	2.7	2	3.7	Inland Agricultural (1997) ③
Grain legume	1.5			ABARE (2000) [a]③
Faba beans	4	2.5	5	Beecher et al., 1995③
Lucerne [b]	1.8			ABARE (2000) [a]③

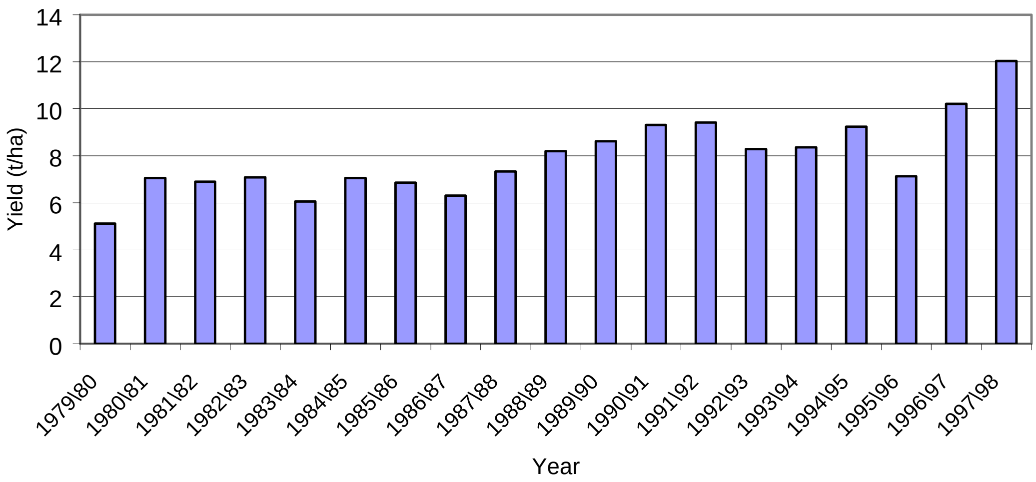


Crop	Avg (t/ha)	Min. (t/ha)	Max. (t/ha)	References and reliability rating
	7.3	5	15	Beecher et al., (1995)③
Hay & silage production	6.4			ABARE (2000) [a]③
Oaten hay	8.7	6.7	11.5	Inland Agricultural (1997)③
Fibres				
Cotton	7.2	5	10	M Parker, pers. comm. ④
	6	5.4	6.9	Inland Agricultural (1997)③
Vegetables				
Tomatoes		60	120	D Muldoon and M Hickey, pers. comm. ④
	63	60	79	Beecher et al., (1995)③
Lettuce		30	40	D Muldoon and M Hickey, pers. comm. ④
Melons		30	40	D. Muldoon and M. Hickey, pers. comm. ④
Onions		50	70	D Muldoon and M Hickey, pers. comm. ④
Fruit				
Citrus	38	20	60	R Hutton, pers. comm. ④
Stone fruit	18-20			J Slack, pers. comm. ④
Nectarines	12			J Slack, pers. comm. ④
Apricots	9			J Slack, pers. comm. ④
Plums	10			J Slack, pers. comm. ④
Peaches	12			J Slack, pers. comm. ④
Grapes				
White	16	9	30	H Creecy, pers. comm. See also Appendix 14.11.
Red	14	9	23	H Creecy, pers. comm. See also Appendix 14.11.

[a] Relative Standard Error = RSE[14]. Yield was calculated by dividing tonnes produce (t) by area (ha) and the RSEs for these values were: **barley** 28, 32; **grain sorghum** 88, 72; **oats** 34, 32; **wheat** 17, 19; r**ice** 13, 13; o**ilseeds** 25, 24; **grain legumes** 62, 59; **lucerne** 34, 53; **hay & silage**, 38, 21.

[14] The Relative Standard Error or RSE is the standard error divided by the actual data value. The result is dimensionless. The RSE shows how big the standard error is as a proportion of the actual data value.

Figure 12. Rice yields in the Murrumbidgee catchment, 1979–98



Source: M Hedditch, pers. comm. ①

5.7 Value of irrigated production (all sources)

According to Donovan (2000), of the $1.14 billion produced in 1996–97 from all agriculture in the Murrumbidgee catchment including dryland and irrigation, $476 million (42%) could be attributed to irrigation alone ③ (Appendix 14.12) ③. Irrigated values ranged from 31% to 42% of the total value over the last decade (Figure 13).

The value of irrigated agriculture for specific areas within the catchment is as follows:

- MIA – $325 million in 1996–97 (MIA & Districts Land and Water Management Plan Working Group 1997, reliability unknown).
- CIA – $57 million in 1996–97 (CIA LWMP Committee 1997), reliability unknown.
- Batlow region – $66.5 million in 1996–97. Considerable income was generated from a range of horticultural products such as apples, pears, berries, stone fruit, grapes and fodder for stock (Batlow Unregulated Stream Water Users Committee 1997, reliability unknown).

The above data suggest that approximately 80% of the total value is due to irrigated agriculture within the MIA and CIA.

Irrigated commodity values from Donovan (2000) ③ should be treated with some caution as they are derived synthetically.

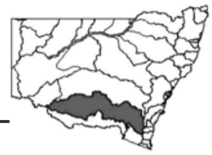
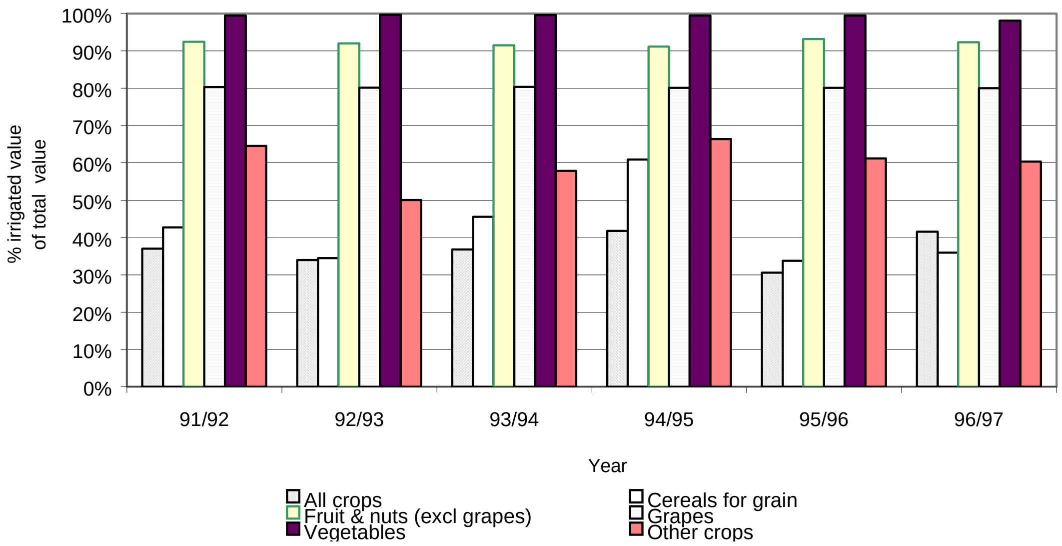


Figure 13. Percentage of the total value of agriculture that can be attributed to irrigation in the Murrumbidgee catchment



Source: Donovan (2000) ③.

- The individual irrigated commodity values for Australia were determined by estimating the percentage of the total commodity value that could be attributed to irrigation. The irrigated percentage was determined from numerous agency reports, and wide consultation with industry bodies (DWC 1990). These individual commodity percentages were then applied to the total NSW commodity value data from the ABS for each SLA between 1991 and 1997 (Donovan 2000) ②[15]). These estimated irrigated commodity values were then summed to provide synthetically generated estimates of the total value of irrigated agriculture for each catchment.

  The reliability of the estimated percentage value for individual commodities may vary from crop to crop. For example, grape values are more likely to be reliable than wheat values. This is because grapes are usually irrigated with high-security water that helps to ensure yields and areas remain reasonably static. Cereal areas and yields can, by comparison, vary markedly according to climate and water availability. The overall reliability rating for these data is ③[16].

- The SLA composition used by Donovan to construct a profile of the Murrumbidgee catchment is different to that used in this report (Appendix 14.13). Caution should be exercised when comparing ABS information on areas irrigated and the number of enterprises irrigating with data on the value of irrigated agriculture from Donovan (2000).

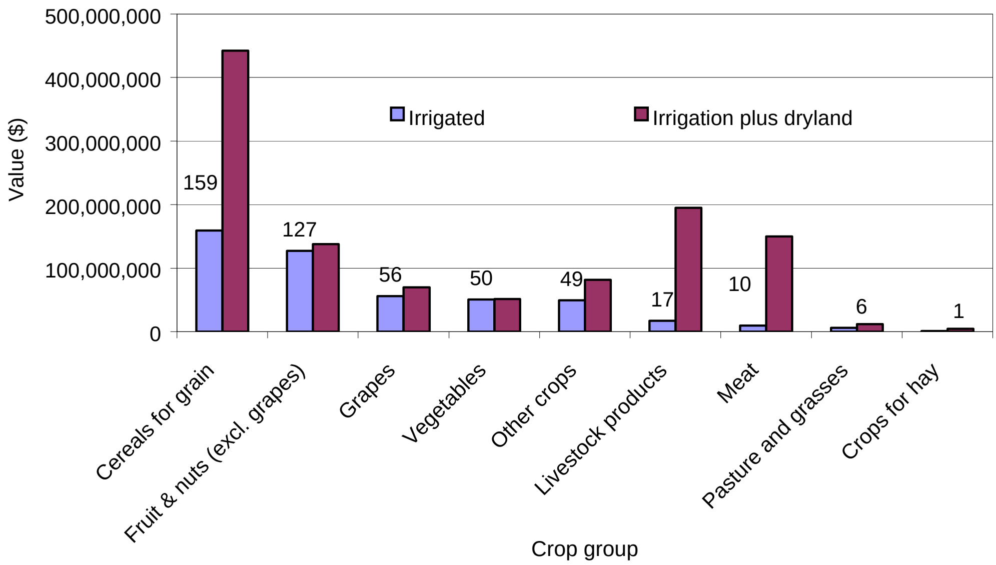
[15] These data have not been manipulated by Donovan and receive a reliability rating of ②.

[16] These data have been manipulated by Donovan and receive a lower reliability rating accordingly.

Regardless of the problems noted above, data from Donovan (2000) represent the most comprehensive source if information. These data show the following:

- Cereals were the most valuable irrigated crop class in the catchment (Figure 14), due mostly to the inclusion of rice in this group. Of the total value of irrigated agriculture in 1996–97 ($476 million), around 33% ($159 million) was generated from cereals (Appendix 14.12) ③. Of the value of irrigated cereals, $127 million came from rice production. Rice values ranged from $68 million to $127 million over the period between 1991–92 and 1996–97③. According to information on the MIA (excluding the CIA), rice was valued at $73 million in 1996–97 (Appendix 14.14) (reliability unknown). Rice recorded average gross margins (GM) of $ 2065/ha. By comparison, irrigated wheat, barley and maize were returning averages of GM/ha of $615, $817 and $1 056 respectively. On a GM/ML basis, all cereal crops performed similarly and values ranged from $179 (rice), $140 (maize), 142 (wheat), and $470 (barley) (see Appendix 14.8) (Beecher et al. 1995) ③.

Figure 14. Value of commodities produced using all agricultural practices (dryland and irrigation), and using irrigation only, 1996–97, Murrumbidgee catchment



Source: Donovan (2000) ③ 'Other crops' include oilseeds, legumes and nurseries.

- Fruit and nuts (excluding grapes) were the next most valuable irrigated category in the Murrumbidgee catchment totalling $127 million (Figure 14)③. The citrus industry in the MIA alone was worth $44.2 million in 1996–97 (MIA & Districts Land and Water Management Plan Working Group 1997, reliability unknown; Appendix 14.14).

- Irrigated grapes were the next most valuable crop at $56 million (Donovan 2000) ③ and these have been increasing in value steadily since 1991–92 (Appendix 14.12) ③. According to the MIA & Districts Land and Water Management Plan Working Group (1997), $38 million was produced in the MIA alone in 1996–97 (Appendix 14.14, reliability unknown). These data seem spurious, given that most of the grape growing occurs in the MIA. Either the catchment value for irrigated grapes is too high or the value for irrigated grapes in the MIA is too low.

- Vegetables closely followed grapes and were valued at $50 million in 1996–97 ③ (Figure 14). Like grapes, vegetable values have been increasing since 1991–92. Again a significant proportion of this value ($28 million) could be attributable to irrigated agriculture in the MIA (1996–97 data, MIA & Districts Land and Water Management Plan Working Group 1997, reliability unknown; see Appendix 14.14). Again, these data may be incorrect, given that most of the vegetable growing occurs in the MIA. Either the catchment value for irrigated vegetables is too high or the value for irrigated vegetable production in the MIA is underestimated. Vegetables have very high GM/ha and GM/ML, compared to other broadarea crops retuning averages of $4 327/ha and $633/ML (Beecher et al. 1995)③.

6. IRRIGATION FROM REGULATED RIVERS

6.1 About the regulated water supply

Like most major inland catchments in NSW, large dams and weirs have been constructed to regulate the flow of water for irrigation. The Murrumbidgee River is regulated by Burrinjuck and Blowering dams, and water is supplied to the MIA and CIA and licensed irrigators along the course of the river (see Section 5.1).

Licence holders using water from the regulated system underwent conversion from area to volume in 1983. Prior to 1983, licence holders could irrigate a specified area of land. Currently, licence holders have a specific volume that can be used to irrigate crops. This conversion process is much the same as that which occurred for licence holders on unregulated streams (for details see Section 7 or DLWC (2000d). Conversion rates for regulated streams were either 6 ML/ha (general security) or 12 ML/ha (high security) with minor variations (WRC 1983). (For unregulated licences, conversion rates were based on crop type). The result is an entitlement for each licence that can be summed to provide an entitlement for the whole catchment.

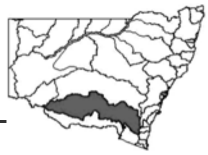
The total storage capacity within the Murrumbidgee catchment for all purposes is 2 658 000 ML. This figure is the combined total of the capacity of Burrinjuck Dam (1 026 000 ML) on the Murrumbidgee River and Blowering Dam (1 632 000 ML) on the Tumut River. Burrinjuck receives inflows from the upper catchment while Blowering Dam receives most of its inflow from the Snowy Mountains Hydro-Electric Scheme (Ebsary 1994). A description of this scheme can be found in section 4.1.

The catchment also has seven weirs and one off-river storage. Licensed users along the river are supplied with water that has been released from Burrinjuck and Blowering dams. Water is then diverted from the Murrumbidgee River at Berembed and Gogeldrie weirs to supply the major Irrigation Areas through irrigation canals. These weirs operate by lifting water to a height sufficient to allow water to gravitate to the irrigation canals. Yanco Weir diverts water down the Yanco/Colombo/Billabong creek system and to the CICL. Water is pumped from the river by authorised water extractors including the Hay Irrigation Area. The Hay weir 're-regulates' water by storing surplus flow in the system for later use along the Murrumbidgee River. Maude, Redbank and Balranald Weir are on the lower reaches of the Murrumbidgee River. Tombullen storage also operates as a re-regulator (DLWC 1996).

Of the possible 2 658 000 ML in storage, the amount committed to irrigation in the Murrumbidgee catchment is 2 462 500 ML. This figure is calculated from:

- 88% of Blowering Dam, or 1 437 000 ML. Twelve per cent of Blowering Dam is reserved as airspace for emergency power generation by the Snowy scheme; and,
- 100% of Burrinjuck Dam, or 1 026 000 ML.

In 1999–00, there were 118 000 ML of off-allocation water.
With the embargos on new irrigation licences across the State, water can only be obtained through improved on-farm and scheme irrigation management or through



water trading. A number of general rules applying to trading are being adapted to local catchment conditions through the water planning process. For example:

- temporary and permanent transfers of regulated flow entitlements can be made within the catchment
- only permanent transfers are permitted when trading from regulated to unregulated rivers within the catchment. Transfers from unregulated to regulated rivers are not permitted
- transfers from regulated to groundwater systems can only be made if the systems are connected hydrologically.

Table 8 shows available irrigation data relating to regulated water supplies. Again, the matrix demonstrates a lack of data on the number of enterprises irrigating, the area irrigated in total and by crop type, the volume of water used on different crops and the value of irrigation.

Table 8. Summary of irrigation data in the Murrumbidgee catchment (regulated supply)

Year June to July	No. ent. irrigating in catch't[a]	Total area irrigated in catch't (ha) [a]	Total rice area irrigated in catch't (ha)	Total rice area in MIA and CIA (ha)	Total water diverted* by irrigation in catch't (ML)① [c]	Total volume of water used on rice in catch't (ML)	Total water used on rice in MIA and CIA (ML)	Yield of rice in catch't (t/ha)	Value of irrigation in catch't ($ m)	Value of rice in catch't ($ m)
1988–89	-	-	-	62 119[b]	-	-	825 222[b]	8.2[d]	-	-
1989–90	-	-	61 565[b+f]	59 775[b]	-	804 530[b+f]	786 094[b]	8.6[d]	-	-
1990–91	-	-	46 277[b+f]	44 462[b]	2 117 583	674 758 [b+f]	651 433[b]	9.3[d]	-	-
1991–92	-	-	64 719[b+f]	59 381[b]	2 433 470	936 069 [b+f]	870 036[b]	9.4[d]	-	-
1992–93	-	-	64 438[b+f]	56 845[b]	1 729 037	658 951 [b+f]	590 319[b]	8.3[d] 8.1[b]	-	-
1993–94	1 851	315 007	67 172[b+f]	56 930[b]	2 026 993	814 325 [b+f]	717 472[b]	8.4 [d] 8.3 [b]	-	-
1994–95	-	-	70 797[b+f]	57 646[b]	2 487 424	921 347 [b+f]	792 255[b]	9.2 [d] 9.0 [b]	-	-
1995–96	-	-		60 416[b]	2 169 416		713 176[b]	7.1 [d] 6.6 [b]	-	-
1996–97	-	-		60 331[b]	2 648 188		789 709[b]	10.2 [d] 8.9[e] 8.4 [b]	-	-
1997–98	-	-		58 972[b]	2 433 345		786 948[b]	12.0 [d] 9.7 [b]	-	-
1998–99	-	-		57 861[b]	-		742 948[b]	9.4 [b]	-	-
1999–00	-	-			-	-	630 168[b]	-	-	-
00–01	-	-	-		-	-	759 698[b]	-	-	-
Refer to section	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.7	6.8	6.8

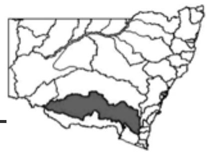
[a] ABS (1998) ③ [b] Caldwell (2000) [c] DLWC (1998b) ① - summary of catchment water use from DLWC (no breakdown of water diverted to Irrigation Areas and Districts and river pumpers provided) [d] M Hedditch, pers. comm. ①. Data are for the whole catchment. [e] ABARE (2000) ③ [f] DLWC (1998a)

∗ The volume presented in Table 8 is the diverted volume. In other words, it includes the volume lost in conveyance and the volume used on farms. Water authorities acknowledge this volume by providing the MIA and CIA with an entitlement for losses which is 384 000 ML. Conveyance losses include evaporation and seepage and may include a component that is related to meter inaccuracies.

6.2 Number of volumetric licences for irrigation (regulated)

There were 904 licences for all purposes in the Murrumbidgee catchment. Most of these (801) were for irrigation (DLWC 1999a)①). (See Figure 5 for location of these licences.) Between 50% and 60% of licences with a purpose of irrigation had a water use record in any one year (DLWC 1998a)③[17]. A number of groups or organisations had one licence only but supplied many irrigators, for example, MI and CICL.

[17] Not all licence details have been entered into the licence administration database. This data cannot be used to determine the number of sleepers and dozers each year, and work is being carried out to rectify this problem.



6.3 Volumetric entitlement (regulated)

The total licensed entitlement (not including operational losses) for all extractive purposes (irrigation, stock and domestic, towns and industry) is 2 405 200 ML (see Table 9).

Table 9. General and high-security entitlement for all purposes

Administrative body	Irrigation Area or District	Entitlement (general security) for all purposes (ML)	Entitlement (high security) for all purposes (ML)	Total entitlement (ML)	No. of farms
MI	Yanco Irrigation Area	345 000	68 000	413 000	1 173
	Mirrool Irrigation Area	278 000	174 800	452 800	1 249
	Benerembah Irrigation District	202 000	400	202 400	138
	Tabbita Irrigation District	23 000	400	23 400	22
	Wah Wah Irrigation District	120 000	5 000	125 000	151
	MI Total	968 000	248 600	1 216 600	311
CI	Coleambally Irrigation Area	482 000	8 500	490 500	345
DLWC	Licensed irrigators	642 000	56 100	698 100	
Subtotal	**MI plus CI plus DLWC**	**2 092 000**	**313 200**	**2 405 200**	
Losses	MIA			243 000	
	CIA			141 000	35
	Losses total			384 000	
Total	**Including losses**	**2 092 000**	**313 200**	**2 789 200**	

Source: DLWC (1998b) ①

When operational losses are included, the figure increased to 2 789 200 ML (DLWC 1999a). Operational losses include:

- 141 000 ML for the CIA. Of this total, 130 000 ML is for losses within CIA, while 11 000 ML is a high-security contingency for the CIA Outfall Drain (DLWC 1998b)
- 243 000 ML for losses in the MIA.

Most of the water from the regulated system is entitled or set aside for use by the irrigation industry.

Of the total water entitled for irrigation including losses, 75% is for irrigation inside the MIA and CIA and the remaining 25% is for licensed irrigators along the river (Table 9) (DLWC 1998b)①.

The total entitled volume includes a high-security component of 313 200 ML (Table 9) (DLWC 1998b)①. The total entitlement figure may vary as these are finalised, pending negotiations between the DLWC and the corporatised Irrigation Areas and Districts. The figures may also vary from year to year as water is permanently transferred from low to high security. High-security water is used for irrigating perennial crops such as citrus, grapes and stone fruit

The general security component of 2 092 000 ML (Table 9)[18] is used to irrigate annual crops such as rice, lucerne, pasture and wheat. General security licences receive water when and if it becomes available. Due to variability in rainfall, the availability of water changes from year to year (see Appendix 14.5). The announced allocation is a percentage of the total licence entitlement. For example, if the announced allocation is 80%, then a licensee entitled to 100 ML would receive 80 ML. High security licences are guaranteed to receive the allocated water for permanent plantings every year.

6.4 Number of enterprises irrigating (regulated)

Based on ABS data, there were 1851 enterprises irrigating in 1993–94④ from regulated supplies. As noted in the Executive Summary, this figure is likely to be an overestimate. The ABS questionnaire did not clearly differentiate between regulated and unregulated watercourses (see Appendix 14.15) and, as a result, some respondents, for example in the Cooma-Monaro SLA, where there are no regulated rivers, recorded that they used water from regulated rivers.

6.5 Area irrigated and water used in the Murrumbidgee catchment (regulated)

The following section will provide information about the area irrigated and water used in the Murrumbidgee catchment as a whole, followed by the individual Areas and Districts and licensed irrigators along the regulated river system.

6.5.1 The whole catchment

Area irrigated – The total area irrigated from regulated supplies in the Murrumbidgee catchment was estimated to be 315 007 986 ha in 1993–94 (ABS

[18] A second figure for the general security component is 2 094 000 ML (DLWC 1999a). Reasons for this difference are not known.

1998③ and Table 8). Once again, this figure is likely to have been overestimated for the reasons stated in Section 6.4.

A more comprehensive picture of area irrigated from regulated supplies in the catchment is not available (Table 8). The reason for this scarcity is largely due to the different collection strategies of the various water administration groups (MI, CICL and DLWC). There are, for example, significant gaps in knowledge regarding the area irrigated in some of the Areas and Districts during the 1990s. Further details of data availability and reliability can be found in the following sections on irrigation groups (Areas and Districts). To summarise:

- During the 1990s, detailed information on crop areas and therefore total area were not collected for the MIA (MI 2001). The collection of crop information was greatest between the 1960s and 1980s (Appendix 14.16).
- Detailed information (with the exception of rice as shown in Table 8 on crop areas for the CIA began to be collected in 1997–98 (Appendix 14.16). However, these data combine both groundwater and regulated supplies. Some farms in this area irrigate from groundwater and surface supplies. Separation into the regulated-only component is not possible.
- The DLWC collected crop statistics and total area irrigated between 1989–90 and 1994–95.
- The rice industry maintains good records of areas irrigated (Table 8). Irrigated areas ranged from approximately 46 000 ha to 70 000 ha between 1992–93 and 1998–99. Far less data were available on the rice industry outside the Irrigation Areas and Districts.

Water use –The total average annual volume of water diverted to irrigation in the catchment was 2 255 682 ML (1990–91 to 1997–98), representing roughly 81% of the total entitlement to irrigation including the volume entitled for losses between diversion structures and the farm gate (see Table 8). Information on volumes of irrigation water diverted from the regulated river system is much more comprehensive than the area information. These volume data must be collected by the DLWC for billing purposes.

The difference between diverted and delivered volumes is unaccounted for or ‘lost’ and is between 350 000 ML and 450 000 ML. This difference may be due to measurement inaccuracies or seepage and evaporation during conveyance. According to Bewsher Consulting (1999), only a proportion of this ‘lost’[19] water may be retrievable. The report estimated the average cost of recovery to be $1 million per 1000 megalitres ($1000/ML).

[19] Water that has seeped into a deeper aquifer from an irrigated farm may be ‘lost’ to the individual owner but not necessarily to the catchment. A project is being undertaken by NSW Agriculture to try and estimate the volume of ‘lost’ water that is reused in the Murrumbidgee and Macquarie catchment(Mitchell 2002).

Comprehensive water use information has also been kept on the rice industry in the MIA and CIA since the 1980s. See for example Appendix 14.17 and 14.18. Between 600 000 ML and 1 000 000 ML have been used on rice in the catchment each year (Table 8). Rice is mostly grown inside the MIA and CIA. For example in 1997–98, 536 995 ML were used to grow rice (Table 10). (It should be noted that the 1997–98 figure shown in Table 8 was 742 948 ML (Caldwell 2000). Reasons for this difference are not known.) The volume used to grow rice outside the Areas and Districts was 129 000 ML in 1994-95. (Data for 1997–98 was not collected). It is worth noting that the volume of water used on rice outside the MIA and CIA appears to have increased dramatically between 1989–90 and 1994–95.

Table 10. Water used in the MIA and CIA, 1997–98 (regulated)

*	Rice	Pasture	Other	Total
MIA[a]	212 488	130 180	186 563	529 231
CIA[b]	324 507	32 501	103 869	460 877
Total	**536 995***	**162 681**	**290 432**	**990 108**

[a] L Parker, pers. comm., [b] W Bolsch, pers. comm. Note: these figures do not include losses between diversion structures at the river and the farm gate. *It should be noted that the 1997–98 figure 536 995 ML in Table 10 does not compare well to the same figure in Table 8 of 786 948 ML. Reasons for this difference are not known.

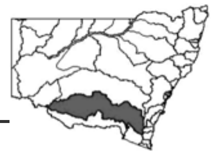
While comprehensive data are available on rice, information for other crops is much scarcer. To summarise:

- Data on crop water use by licences outside the MIA and CIA were available for the period between 1989–90 and 1994–95. Collection of these irrigation data ceased after 1994-95.
- Data on crop water use in the MIA were available for the 1990s (Appendix 14.16).
- Data on crop water use in the CIA were available from 1997–98 (Appendix 14.16). Data can be obtained from the CICL on request and are shown for 1997–98 in Appendix 14.25.

6.5.2 Yanco Irrigation Area

Area irrigated – The median area irrigated each year between 1976 and 1987 was approximately 59 000 ha, of a total scheme area of 88 760 ha. Of this, cereals (28%), pasture (27%) and rice (25%) were the dominant irrigated crops (DWR 1998)② (Appendix 14.19). Gaps in area information exist for the 1960s, part of the 1970s, the late 1980s and all of the 1990s.

Water use –Water use data were available for the period between 1960 and 1975 (DWR 1998)② and between 1988 and 1998 (L Parker, pers. comm.) ② but not for the late 1970s and 1980s. During the 1960s and 1970s, the median total water used each



year by irrigated agriculture was 255 000 ML. This was mostly used on rice (46%) and pasture (34%). Between 1989–90 and 1994–95, the average water used increased to 280 000 ML and a substantial proportion was used on rice (61%) (Appendix 14.19).

6.5.3 Mirrool Irrigation Area

Area irrigated – The total median area irrigated each year between 1976 and 1987 in the Mirrool Irrigation Area was approximately 55 000 ha of 74 791 ha. Of this total, cereals (25%), rice (23%) and pasture (19%) were the predominant crops (Appendix 14.20) (DWR 1998)②. Gaps in area information exist for the 1960s, part of the 1970s, the late 1980s and all of the 1990s.

Water use – Water use data were available for the period between 1989 and 1998 only. These data show the median volume used by irrigated agriculture was 223 000 ML. Most of this was used on rice (67%) and pasture (25%) (L Parker, pers. comm.) ② (Appendix 14.20).

6.5.4 Benerembah Irrigation District

Area irrigated – The median total area irrigated each year in the Benerembah Irrigation District between 1960 and 1975 was approximately 26 000 ha. The total scheme area is 44 235 ha. Pasture (56%) and cereals (22%) were the major crops grown. At that stage, rice was less important, representing only 10% of the total area irrigated (Appendix 14.21). By the late 1970s, and 1980s, rice increased nearly four-fold in area to represent 22% of the total area irrigated (DWR 1998)②. Pasture and cereals were still the major irrigated crops grown representing 32% each (Appendix 14.21). Irrigated area data were not collected during the 1990s.

Water use – During the 1960s and 1970s, the median water use in the District was 80 500 ML and 38% of this was used on rice (DWR 1998)②. There were no data for the late 1970s or the 1980s. By the 1990s, the average volume of water used was 202 500 ML and 57% of this was used by rice (Appendix 14.21) (L Parker, pers. comm.) ②.

6.5.5 Tabbita Irrigation District

Area irrigated – Tabbita Irrigation District has a total scheme area of 10 473 ha. During the 1960s and 1970s, only 3700 ha was irrigated annually and most of this was either pasture (59%) or cereals (23%). Rice had a relatively small area (4%). By the late 1970s and the 1980s, the total area irrigated had increased to 5400 ha, and rice area had increased to 10% of this. Again, pasture was the dominant crop type (41%) (DWR 1998)②. Area data were not collected in 1990s.

Water use – The median water used in the 1960 to 1970s was only 11 000 ML (DWR 1998)②. Pasture and, later, rice used 64% and 20% of this total respectively. By the 1990s, this volume had increased to around 20 000 ML (L Parker, pers. comm.)② (Appendix 14.22). Once again, water was mostly used on either pasture or rice. Data were not collected between 1976 and 1987.

6.5.6 Wah Wah Irrigation District

Area irrigated – During the 1960s and 1970s, the total area irrigated was 12 000 ha and the predominant crop was pasture (38%) (Appendix 14.23). The total area of Wah Wah Irrigation District is 261 955 ha. According to the records shown in Appendix 14.23, there was no rice grown. This is clearly anomalous given that the median water use over this period was 32 000 ML and 58% of this was used on rice. By the late 1970s and the 1980s, the area irrigated had increased to 18 700 ha. This time cereal was the predominant crop (38%) while pasture and rice represented only 30% and 9% respectively (DWR 1998)② (Appendix 14.23). Data on area irrigated were not collected for the 1990s.

Water use – Water for Wah Wah Irrigation District comes from the drainage water from Yanco and Mirrool Irrigation Areas. By the 1990s, the volume of water used in Wah Wah increased dramatically to around 120 000 ML, or roughly four times the volumes used in the 1960s and 1970s (L Parker, pers. comm.) ②. Pasture used most around half the water and rice used 31% (Appendix 14.23).

6.5.7 Hay Private Irrigation District

Area irrigated – Around 1000 ha were irrigated in the Hay Irrigation District (now Hay Private Irrigation District) during the late 1970s and the 1980s and most of this was pasture (87%) (DWR 1998)②. The total area of the District is 2460 ha. There were no data on area irrigated for the 1960s, part of the 1970s, the late 1980s or the 1990s.

Water use – Water use data for 1996–97 show that 900 ML were used in the Area (Appendix 14.24). Further data for this site have not been collected.

6.5.8 Coleambally Irrigation Area

Area irrigated – The average total area irrigated in the CIA in the late 1970s and 1980s was 52 000 ha[20] and most of this was rice (42%) or pasture (27%) (DWR 1998)② (Appendix 14.25). Information for most of the 1990s could not be sourced. In 1997–98, the total crop area irrigated was 71 000 ha, suggesting that the intensity of irrigated agriculture increased during the 1990s (W Bolsch, pers. comm.) ②.

Water use – Around 461 000 ML was used in 1997–98 (Appendix 14.25). Rice used 324 507 ML of this total volume. A further 33 876 ML was used on wheat and 33 850 ML on soybeans.

6.5.9 Coleambally Outfall Drain

Area irrigated – The area irrigated was estimated to be around 32 000 ha in 1997–98 (K O'Flaherty, pers. comm.). The main crops irrigated were winter cereals, rice and pasture.

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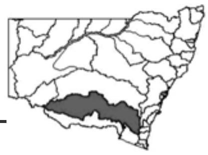
[20] This figure includes groundwater.



Water use – Data on water use and area were not available.

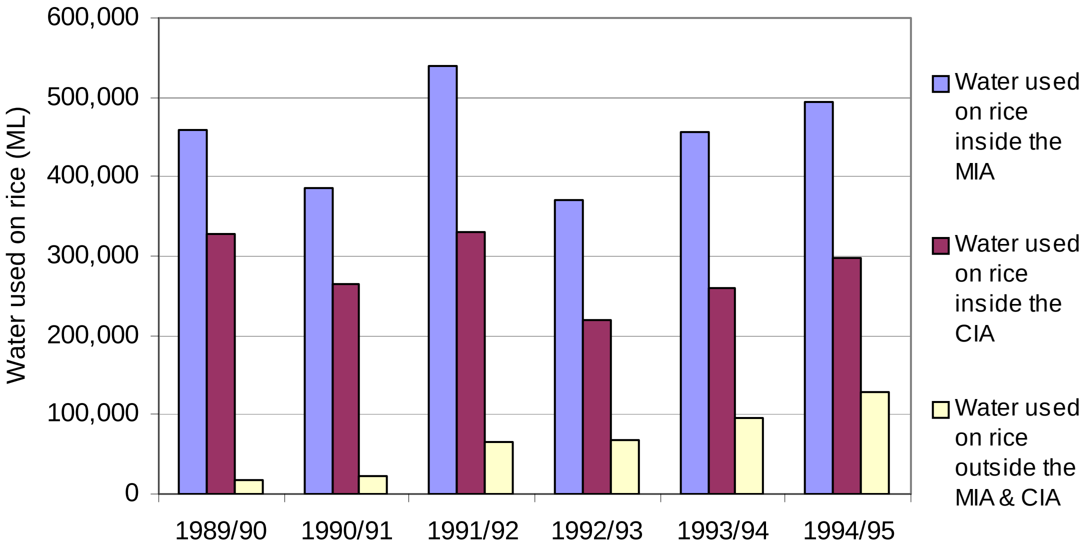
6.5.10 Licensed irrigators

Area irrigated – Between 1989–90 and 1994–95, around 78 000 ha of land were irrigated each year directly from the river (Appendix 14.26). Winter and summer pasture had the largest crop areas. As noted earlier, rice areas increased dramatically between 1989–90 and 1994–95 (Appendix 14.26).

Water use – Between 1989–90 and 1994–95 licensed irrigators used 422 000 ML (Appendix 14.26). According to the DLWC (1996), the volume extracted (all purposes) was 441 000 ML for the same period. Nearly half of this water was used on pasture (winter and summer) (DLWC 1998a)②. Water used on rice steadily increased from 18 000 ML in 1989–90 to 129 000 ML in 1994–95 representing a seven-fold increase in six seasons (Figure 15).

Crop area and volume data after 1994–95 were not collected (DLWC 1998a)② (Appendix 14.26).

Figure 15. Water used on rice, inside and outside the MIA and CIA



Source: Rice water use inside the MIA and CIA - (RGA 2002). Rice water use outside the MIA & CIA (DLWC 1998a)

6.5.11 Information on irrigation application rates

The volume of irrigation water applied on a per hectare basis can be determined for limited years only over the last decade. Based on available information, these calculations are possible for specific groups of irrigators in the Murrumbidgee catchment only (Appendix 14.16). In other words, application rates can be calculated where the only source of irrigation water used is regulated supplies.

6.6 Irrigation methods (regulated)

There is no single dataset that identifies the methods used to irrigate crops from regulated supplies in the Murrumbidgee catchment (see Section 5.5 for information on methods used across the catchment from all sources).

6.7 Irrigated yields (regulated)

Data on irrigated yields have not been specifically collected. Since irrigation in the catchment is mostly reliant on water from regulated supplies, the data provided in section 5.6 can be used.

6.8 Value of irrigated production (regulated)

There were no data showing the total value of crops irrigated specifically from regulated supplies.

7. IRRIGATION FROM UNREGULATED RIVERS

7.1 About the unregulated water supply

7.1.1 Irrigation from unregulated water supplies

There are numerous unregulated subcatchments in the undulating hills of the upper Murrumbidgee catchment (see Appendix 14.27). The greatest volumes of water for irrigation are extracted from Tarcutta, Adelong and Jugiong creeks below Burrinjuck Dam. Licences are also scattered along the tributaries of the Murrumbidgee River below the dams.

Water flow in these unregulated streams is highly variable and irrigators cater for this either by building farm dams or by supplementing river water with groundwater. Nearly all unregulated streams can stop flowing during dry times and licensed irrigators are prohibited from pumping during these periods (EPA 1997).

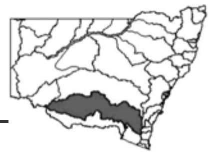
Existing area-based licences along unregulated streams were converted from area-basis to volume-basis in 2000 (DLWC 2000d). Previously, licence holders were restricted to irrigating their authorised area and were entitled to extract as much or as little water as required from unregulated streams and rivers. The conversion to volume-based licences means that licence holders are restricted by an available volume of water. It is envisaged that this conversion process will enable trading of water between licences across the catchment and will help stimulate interest in improved on-farm management (DLWC 1999b). Where water is limited, growers are more likely to implement plans to improve the efficiency of water use. See Appendix 14.7 for conversion rates.

7.1.2 Lowbidgee Flood Control and Irrigation District

An unusual set of licences exists in the lower Murrumbidgee catchment: they are neither area-based nor volume-based. The Lowbidgee Flood Control and Irrigation District was established 1945 and is controlled by the DLWC. It is located at the far western end of the catchment, upstream of Balranald. These licences are an exception to area-based licences using water from unregulated supplies. These licences have a rated area, which means that they pay for the area of land that is commandable for flooding.

There are two distinct areas of irrigation: the area supplied by Maude Weir to the south of the Murrumbidgee River and the area supplied by Redbank Weir both north and south of the Murrumbidgee River. With the implementation of environmental flows, the security of water supply to the area is being reviewed.

The water applied in the Maude-supplied area is mainly flooded onto land for winter cereals, canola and pasture. Flooding occurs in the winter/spring when surplus flows



are available. Larger floods will also inundate large parts of Lowbidgee. Flood irrigation saturates the soil profile. This soil water is then used for deep rooting cereals and pasture cropping as well as flooding red gum forests around Redbank Weir.

Table 11 summarises irrigation data relating to unregulated supplies. The matrix demonstrates a lack of information on the number of enterprises irrigating, water used, irrigated yields and values.

Table 11. Summary of irrigation data (unregulated supplies)

Year	Number enterp's irrigating from unreg streams[c]	Total irrigation area from unreg streams (ha)	Area of winter and summer pasture irrig'd (ha)	Total water used from unreg streams (ML)	Water used by winter and summer pasture	Yield of winter and summer pasture (t/ha)	Value of irrigation ($ m)	Value of winter and summer pasture ($ m)
1988–89	-	-	-	-	-	-	-	-
1989–90	-	3 044[a]	1 733[a]	13 473[a]	-	-	-	-
1990–91	-	4 434[a]	2 518[a]	19 879[a]	-	-	-	-
1991–92	-	5 510[a]	2 287[a]	26 670[a]	-	-	-	-
1992–93	-	5 065[a]	3 826[a]	20 926[a]	-	-	-	-
1993–94	520	4 005[a] 6 949[b] 113 277[c]	2 138[a] 2 154[b]	19 070[a]	-	-	-	-
1994–95	-	7 512[b]	2 435[b]		-	-	-	-
1995–96	-	7 748[b]	2 180[b]		-	-	-	-
1996–97	-	8 335[b]	2 275[b]		-	-	-	-
1997–98	-	10 836[b]	2 309[b]		-	-	-	-
1998–99	-	10 872[b]	1 501[b]		-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to section	7.3	7.5	7.5	7.5	7.5	7.7	7.8	7.8

a DLWC (1998a) ④. Data on irrigation from unregulated streams were collected by crop return survey. Not all growers returned the survey to DLWC and the figures above should be used as a guide only.

b DLWC (2000c) ②

c ABS (1998) ③

7.2 Number of licences (unregulated)

The 1999 estimate of the total number of licences for all purposes was 792 and the number that had an authorisation to irrigate land was 502 (DLWC 1999a)①.

7.3 Number of enterprises irrigating (unregulated)

The number of enterprises that irrigated from unregulated water supplies was estimated to be 520 in 1993–94 (ABS 1998)③. This figure is likely to be an underestimate for the reasons given in Section 6.4. Respondents recorded usage in regulated streams where there are no regulating structures. The enterprises in these SLA are likely to be using unregulated water supplies. The reliability rating for this figure was reduced.

7.4 Area authorised for irrigation (unregulated)

A total of 26 985 ha have been authorised for irrigation in the Murrumbidgee catchment (DLWC 1999a)①. This does not include the Lowbidgee Flood Control and Irrigation District. Conversion from area to volume is still being finalised across the State and the entitled volume has not been provided in this document.

7.5 Area irrigated and water used (unregulated)

Area irrigated - The area irrigated from unregulated water supplies was 10 800 ha in 1998–99 (DLWC 2000c)②. This figure was determined in a recent survey of all irrigators using water from unregulated supplies across the State.

When comparisons between datasets could be made, a wide variation in area irrigated was obtained. In 1993–94, the area irrigated from unregulated supplies was either:

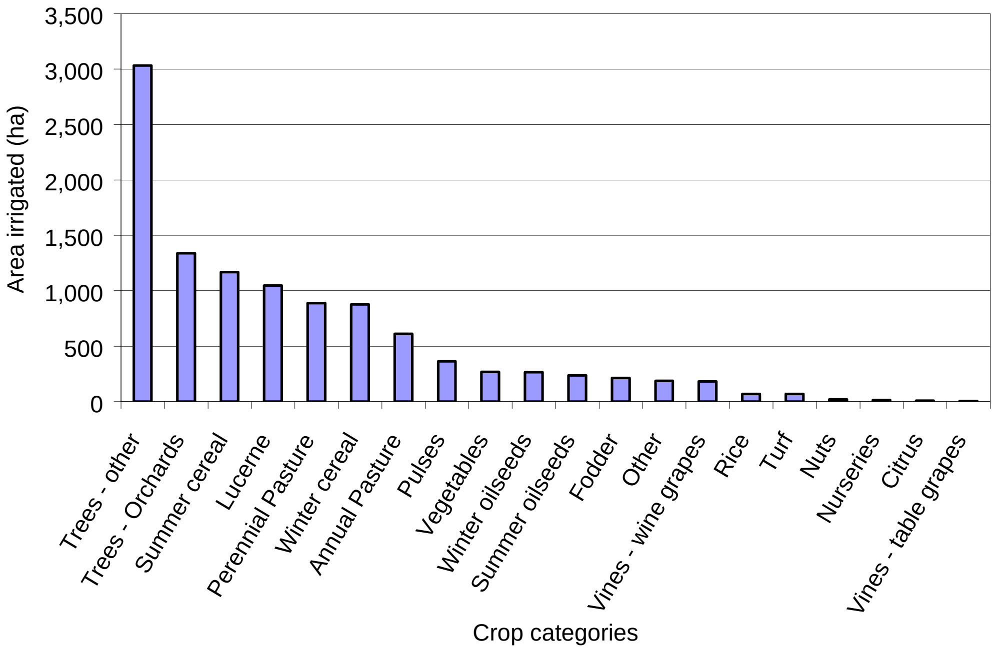
- 6 949 ha (DLWC 2000c)②
- 113 277 ha (ABS 1998)③, or
- 4 005 ha (DLWC 1998a) ④

The second estimate is more than an order of magnitude higher than the other two. Reasons for this difference are not known. The reason for the difference between the first and third references relates to survey collection strategies. The first estimate was based on a survey undertaken as part of conversion of licences to volume-basis. These data are considered relatively comprehensive due to high return rates. The third estimate was based on data from annual survey forms returned by irrigators to the DLWC. Since not all irrigators returned this survey form, the data are incomplete and therefore likely to be less than the first estimate.

During the early 1990s, pasture contributed around half of the area irrigated. By the late 1990s, other crops appear to have become more dominant (Table 11). Based on data from between 1993–94 to 1998–99 from the DLWC (2000c) ②, tree crops (for example, eucalyptus plantations) had the largest irrigated area, followed by orchards (stone and pome fruit) and summer cereals (Figure 16). Trees and summer cereal crops increased significantly in irrigated area between 1993–94 and 1998–99 while the area irrigated for most other crops remained did not change significantly (Appendix 14.28). As in many other catchments, high-value vineyards have gradually increased in area over this period although their area in the Murrumbidgee catchment remains very small.

In the Lowbigeee Flood Control and Irrigation District, more than 20 000 ha of winter cereals and pasture are flood-irrigated each year (T Clarke, pers. comm.) ④.

Figure 16. Area irrigated from unregulated steams in 1998–99



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e: (DLWC 2000c)② . 'Trees – other' refers to irrigated hard and softwood plantations.

Water use – Irrigation water use ranged from 13 500 ML in 1989–90 to 26 700 ML in 1993–94 (DLWC 1998a)④.

These data are based on crop return cards, or cards that are filled in by the irrigator and returned to the DLWC and can result in incomplete information. This Profile did not attempt to account for irrigators who failed to complete return cards.

No data were collected on the total amount of water used on different crops – therefore rates of irrigation water applied cannot be determined. Theoretical crop water requirements must suffice until better records can be obtained. See Appendix 14.7 for long-term average irrigation requirements for climatic zones in the Murrumbidgee catchment (DLWC 2000d).

7.6 Irrigation methods (unregulated)

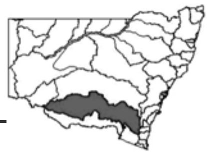
Data have not been collected on methods used to irrigate crops using water from the unregulated rivers of the Murrumbidgee catchment (see Section 5.5 for methods used to irrigate crops from all sources).

7.7 Irrigated yields (unregulated)

Data have not been collected on yields of crops reliant on unregulated rivers alone (see Section 5.5 for yields attained from crops irrigated using water from all sources).

7.8 Value of irrigated production (unregulated)

The value of irrigation dependent on unregulated systems in the Murrumbidgee catchment has not been collected.



8. IRRIGATION FROM GROUNDWATER

8.1 About groundwater supplies in the Murrumbidgee catchment

Most groundwater extraction for the purpose of irrigation in the Murrumbidgee catchment occurs along the Tumut River, Muttama Creek and along the Murrumbidgee River especially around Darlington Point. In order to simplify data collection and management, the catchment has been broken into three areas: the Upper, Mid and Lower Groundwater Management Areas. These planning areas cover the same zones used for the development of water sharing plans.

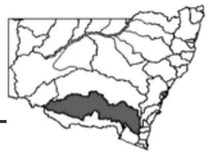
- **The Upper-Murrumbidgee Groundwater Management Area** is the area east of Gundagai. Recharge is mainly associated with fractured rock typical of the eastern most part of the catchment and is poorly mapped and understood.

- **The Mid-Murrumbidgee Groundwater Management Area** follows the Murrumbidgee River between Gundagai and Narrandera. This area is associated with recharge that is closely linked to river flows and has some history of extraction for irrigation purposes. The majority of water is extracted from the alluvial aquifers. Bores outside this alluvial plain are not included in the dataset reported in this Profile (A Carter, pers. comm.). They are not used for irrigation, are not licensed and are not monitored.

- **The Lower-Murrumbidgee Groundwater Management Area** covers roughly the western half of the catchment, or an area of more than 31 000 km^2. Here, the aquifers of the Murrumbidgee Alluvial Fan are low in salinity and high yielding. There are three main layers that are not distinct aquifers, but represent a gradual layering of water bearing deposits. Within each of these layers, there may be any number of aquifers at any given location. For this reason, they are referred to as ‘groups’ or ‘formations’, and not aquifers. The three layers of water-bearing deposits in the Lower Murrumbidgee Groundwater Management are, from oldest to youngest, the Shepparton Formation, the Calivil Formation and the Renmark Group. The combined thickness of these formations is about 400 m at Balranald and 170 m at Narrandera (Lawson 1995). The most intense groundwater extraction by irrigation in the Murrumbidgee catchment occurs around Darlington Point on the Murrumbidgee River (Woolley and Kalf 1981). This is still the case in 2002.

All bores in the catchment require a licence, a flow meter and have a known volume entitlement. However, the quality of records for water use varies between these three management zones. For example, there is a longer history of record keeping in the Lower Groundwater Management Zone, while the upper zone has the poorest data set of the three areas.

Currently the NSW Government is developing a Groundwater Structural Adjustment Program for the Lower Murrumbidgee groundwater system. The program aims to



assist high-level groundwater users to adjust to reduction in groundwater access over the ten years of the water sharing plan through financial assistance and supplementary water.

Table 12 summarises of the availability and reliability of groundwater irrigation data in the Murrumbidgee catchment. Even though there may be few data for the whole catchment, data were available for individual management zones.

Table 12. Summary of irrigation data (groundwater)

Year	Number enterprises irrigating[a]	Total area irrigated (ha)	Major crop area irrigated (ha)	Total water use by irrigated ag. (ML)①	Total volume of water used on rice (ML)	Yield of major crop (t/ha)	Value of irrigation ($ m)	Value of major crop ($ m)
1988–89	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-
1990–91	-	-	-	-	-	-	-	-
1991–92	-	-	-	-	-	-	-	-
1992–93	-	-	-	-	-	-	-	-
1993–94	78	11 118	-	-	-	-	-	-
1994–95	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to Section	8.3	8.5	8.5	8.5	8.5	8.3	8.7	8.8

[a]ABS (1998) ②. Note that figures for individual sections of the Murrumbidgee catchment are more comprehensive. These statistics are provided where possible in the text.

8.2 Number of licences (groundwater)

There are 4349 licences for all purposes (665 renewable bores and 3684 non-renewable bores[21]) in the Murrumbidgee catchment. Of these, 747 have a purpose of irrigation. The number of licences in each zone is not known. In addition, the activity of each of these 747 irrigation licences is not known.

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[21] Most town, irrigation and industrial licences are considered to be renewable. Most non-renewable bores are stock and domestic bores.

8.3 Number of enterprises irrigating (groundwater)

There are 78 enterprises using water from groundwater supplies in the Murrumbidgee catchment (ABS 1998)② and most of these enterprises exist in the SLAs of Murrumbidgee, Wagga Wagga and Conargo (Figure 17). This puts the number of licences per enterprise at 12, a figure that appears to be high. This figure of 12 was calculated by dividing the number of licences by the number of enterprises, based on ABS figures (ABS 1998)②.

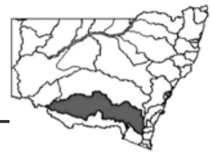
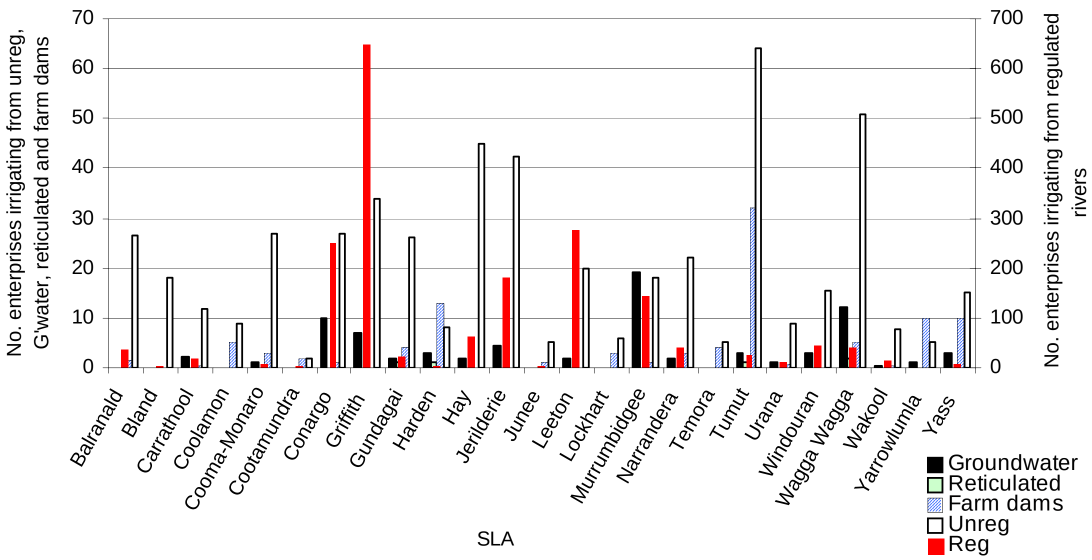
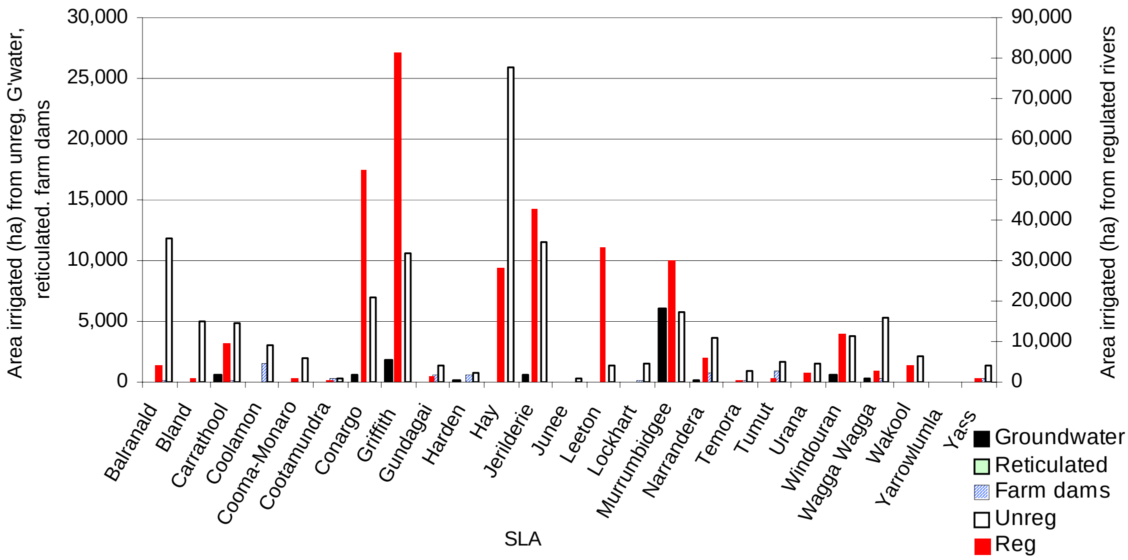


Figure 17. The number of enterprises and area irrigated from different sources in the Murrumbidgee catchment





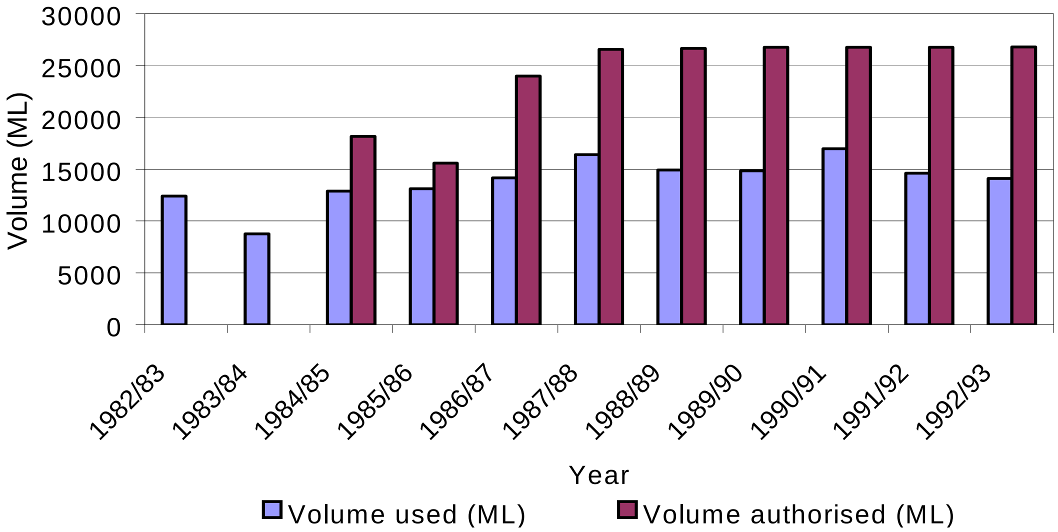
Source: ABS (1998) ②

8.4 Volumetric entitlements (groundwater)

The total volume of water allocated for all purposes from groundwater supplies in the Murrumbidgee catchment is 554 000 ML. The entitlement has been broken into the three management zones - around two thirds is allocated to the Lower Murrumbidgee Groundwater Zone.

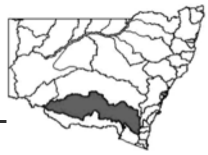
- The volume entitled for all purposes in the Upper Murrumbidgee Groundwater Management Zone is around 36 000 ML. This figure includes some low-volume stock and domestic licences that lie in the mid-catchment, but outside the groundwater management corridor.
- The volume entitled for all purposes in the Mid-Murrumbidgee Groundwater Management Zone is approximately 24 000 ML (Lawson 1995) (Figure 18). There are some low-volume stock and domestic bores which are outside this corridor and which are included in the Upper Murrumbidgee Groundwater Management Zone. These function more like the bores in the upper part of the catchment and are grouped in this zone accordingly.

Figure 18. Annual groundwater allocation and usage in the Mid-Murrumbidgee Groundwater Zone



Source: Lawson (1995) ①

- Groundwater allocations in the Lower Murrumbidgee Management Zone totalled 494 000 ML in 1997–98, a substantial increase from 125 000 in 1982–83. Because of the danger of over-allocating the resource in the Lower Murrumbidgee, a 12-month moratorium on new licences was introduced in September 1997. This has since been extended and remains current.



8.5 Total area irrigated and water used (groundwater)

Area irrigated – In 1993–94, according to the ABS, the total area irrigated was 11 118 ha (ABS 1998)② . Over half of this was in the Murrumbidgee SLA (Figure 17) [22]. For individual zones, the following information was available:

- Upper Murrumbidgee Groundwater Management Zone – No data but likely to be very small
- Mid-Murrumbidgee Groundwater Management Zone – No data
- Lower Murrumbidgee Groundwater Management Zone - In 1995–96, nearly 27 000 ha were irrigated from groundwater supplies in the Lower Murrumbidgee Groundwater Management Zone alone (Figure 19). It should be noted that these data are greater than the ABS estimate of the total area irrigated for the whole catchment (11 118 ha in 1993-94). Of this area, rice had the largest proportion, representing around 63% of the total area irrigated or 17 000ha (Figure 19).

Water use – The total volume of water used from groundwater sources across the Murrumbidgee catchment is likely to be around 150 000 ML, representing a large increase from 4300 ML in 1980 (WRC 1980)③ (Table 13).

Table 13. Annual usage (ML), 1980, Murrumbidgee catchment

Extraction by salinity category	Urban[23]	Irrigation	Other	Total
0-1000 mg/L	18 300	4 300	4 000	26 600
1000-3000 mg/L	0	0	8 000	8 000
3000-7000 mg/L	0	0	2 800	2 800
7000–14 000 mg/L			800	800
Total	**18 300**	**4 300**	**15 600**	**38 200**

Source: WRC (1980) ③

The estimate of 150 000 ML is based on data from each groundwater management zone:

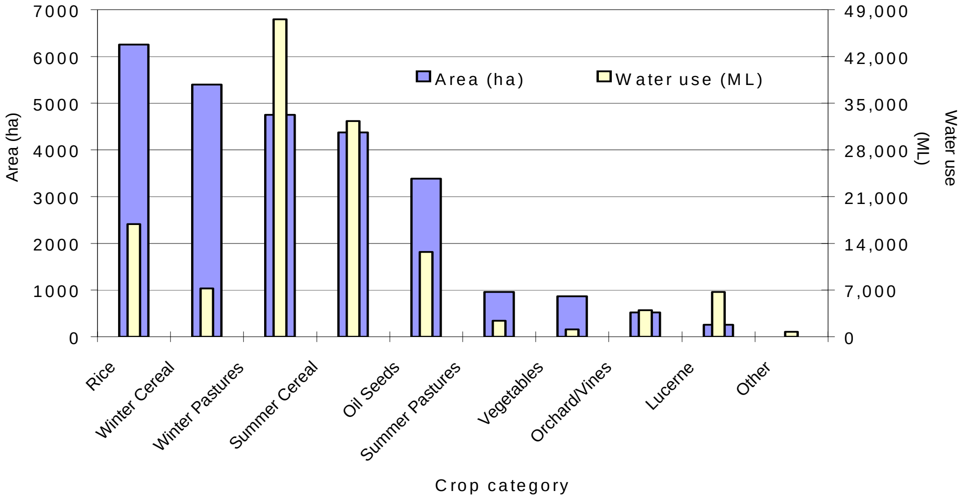
- Upper-Murrumbidgee Groundwater Management Zone – no data but use by irrigation likely to be very small (*ie* less than 5000 ML).

[22] Data on the area irrigated from groundwater are available for other years (1987, 1990 and 1991) (ABS 1998), but were collected using different EVAOs. It is therefore not possible to use these data to show trends in the area irrigated over long periods.

[23]Urban refers to urban water supplies

- Mid-Murrumbidgee Groundwater Management Zone – 15 000 ML were used by irrigation between 1982–93 and 1992–93 (Lawson 1995) (Figure 18).
- Lower-Murrumbidgee Groundwater Management Zone – 131 000 ML were used in 1995–96 representing a large increase from 21 000 ML in 1978–79 (Woolley and Kalf 1981). Most of the water used was on winter pasture (Figure 19). This zone has the longest history of intense groundwater use for irrigation, dating from the mid-1970s to the present.

Figure 19. Area irrigated and water used by crop type (groundwater supplies) in the Lower Murrumbidgee Groundwater Management Zone, 1995–96



Source: S Lawson (pers. comm.)②

8.6 Irrigation methods (groundwater)

Data were unavailable on methods used to irrigate crops with water from groundwater supplies (see Section 5.5 for methods used to irrigate crops from all sources).

8.7 Irrigated yields (groundwater)

Data on irrigated yields from groundwater supples in the Murrumbidgee catchment have not been collected. See Section 5.6 for yields obtained from crops irrigated by all sources.

8.8 Total value of irrigation (groundwater)

Data on the value of irrigation dependent on groundwater supplies in Murrumbidgee catchment have not been collected.

9. IRRIGATION FROM FARM DAMS

9.1 About farm dams

In 1993–94, the ABS indicated limited extraction of water from farm dams by the irrigation industry in the Murrumbidgee catchment (ABS 1998)②. Most enterprises are scattered across the upper half of the catchment in the unregulated river sections. Irrigation enterprises on the riverine plains that pump water into large on-farm storages are not considered in this Profile to be 'on-farm' storages. Farm dams are those structures that capture water by gravity from watercourses or from overland run-off.

There have been considerable changes to the way the DLWC manages farm dams. In the past, a dam of up to 7 ML could be built without a licence, providing the water was used for non-commercial purposes. This limit was considered inappropriate in many areas of NSW because there was no allowance for the size of the property or for climatic variation and no restriction on the number of dams that could be built on a property. Part 10 of the Water Act 1912, which came into operation on 1 January 1999, created a Harvestable Right. This gives landholders the right to capture and use for any purpose 10% of the average regional yearly rainfall run-off for their property, regardless of the dam's purpose (DLWC 1999d). Harvestable rights are now addressed in Chapter 3, Division 2 of the *Water Management Act 2000*.

Table 14 summarises irrigation data relating to farm dams in the Murrumbidgee catchment and demonstrates the lack of information across this water source category.

9.2 Number of licences (farm dams)

These data are not available as farm dams are currently being licensed.

9.3 Number of enterprises irrigating (farm dams)

There were only 100 enterprises irrigating from farm dams according to the ABS (1998) ② in 1993–94. Most enterprises are scattered across the upper half of the catchment in the SLAs of Tumut, Harden, Yarralumla and Yass (Figure 17). This figure is likely to be an underestimate given the numerous dams in the catchment and their use as water supplies for irrigation enterprises.

Table 14. Summary of irrigation data (farm dams)

Year	Number enterprises irrigating[a]	Total area irrigated (ha) [a]	Major crop - area irrigated (ha)	Total water use by irrigated ag. (ML)①	Total volume water on major crop (ML)	Yield of major crop (t/ha)[c]	Value of irrigation ($ m)	Value of major crop ($m)
1988–89	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-
1990–91	-	-	-	-	-	-	-	-
1991–92	-	-	-	-	-	-	-	-
1992–93	-	-	-	-	-	-	-	-
1993–94	100	5881	-	-	-	-	-	-
1994–95	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to Section	9.3	9.4	9.4	9.4	9.4	9.6	9.7	9.7

[a]ABS (1998) ②

9.4 Area irrigated and water use (farm dams)

Area irrigated – There was 5881 ha irrigated in 1993–94 (ABS 1998)② and most of this land was located in the SLAs of Coolamon, Tumut and Narrandera. A possible explanation for larger areas being irrigated in Narrandera SLA is the response from enterprises in intensive irrigation areas that have ponded water in large on-farm storages. These large storages are generally filled with water that has been pumped from the river and, as noted in the Methods section, they are not considered farm dams. Care should be exercised when using these numbers.

There were no data on the area of crops irrigated using farm dam water.

Water used – There were no data on the amount of water used in total or by crop type.

9.5 Irrigation methods (farm dams)

See Section 5.5 for irrigation methods used to irrigate crops from all sources of water.

9.6 Irrigated yields (farm dams)

See Section 5.6 for irrigation yields obtained from crops irrigated using all sources.

9.7 Value of irrigated production (farm dams)

There are no data on the value of irrigated production from farm dams.

10. IRRIGATION FROM RETICULATED WATER SUPPLIES

10.1 About reticulated water supplies

Irrigation from reticulated water supplies is very limited due to the expense involved in obtaining water. Some extraction occurs in the SLA of Wagga Wagga where urban rates are $650 /ML and rural rates are $770/ML. For this reason, only industries that are high value but that require small volumes of water and have small areas are likely to flourish (for example, nurseries and hydroponic farms). There were limited data regarding irrigation from reticulated water supplies and a summary table has not been provided. Only information from 1993–94 from the ABS was available and is reported below in the text.

10.2 Number of enterprises irrigating (reticulated water)

Five enterprises were irrigating using reticulated water in the Murrumbidgee catchment. Two of these were in the Wagga Wagga SLA (ABS 1998) ② while Tumut, Gundagai and Harden had one each. There were no data on the crop areas irrigated with this water.

10.3 Area irrigated and water used (reticulated water)

Area irrigated – There were 27 ha of land irrigated using reticulated water supplies in the Murrumbidgee catchment and 21 ha were in the SLA of Wagga Wagga (Figure 17) (ABS 1998)②.

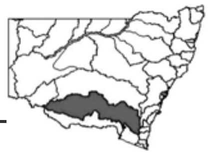
Water used – There were no data on the volume of water used from reticulated water supplies by irrigated agriculture in total or by crop type.

10.4 Irrigation methods (reticulated water)

There were no data on the methods used to irrigate crops from town water supplies. As noted above, the most likely industries to be irrigating with reticulated water supplies are nurseries and hydroponic farms. Usually, top watering systems (fixed overhead sprinklers, mobile booms, hand watering or drip systems) or bottom watering systems (flood floors, troughs, capillary matting or sand beds) are used (Rolfe et al. 2001).

10.5 Irrigated yields (reticulated water)

There were no data on irrigation yields used to irrigate crops from reticulated water.



10.6 Value of irrigated production (reticulated water)

There were no data on the value of irrigated agriculture dependent on reticulated water supplies.

11. OPPORTUNITIES AND ISSUES

11.1 Improving data collection, storage and retrieval

Opportunities for improving the quantity and quality of irrigation data will arise as new water sharing rules are implemented. The opportunity exists to collect irrigation data at more useful scales and to facilitate a two-way flow of information between irrigators and data collecting agencies and between different government agencies.

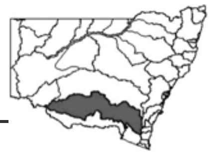
- **Reliable and comprehensive irrigation information will be needed to help measure change as a result of new water sharing rules.** As water sharing plans are finalised and signed-off, comprehensive and reliable irrigation data will be needed to assess the future impact of management rules on the environment and the irrigation industry. This will help to increase the base of knowledge regarding irrigation generally.

- **Volumetric conversion of area-based licences will lead to better information regarding usage of water from unregulated streams.** As a result of this volumetric conversion, users will no longer be billed on authorised area but on the actual volume used. Water use will therefore eventually be metered and recorded by the DLWC. This will improve knowledge regarding water use and patterns of extraction on unregulated streams.

- **Reporting data at scales that are more useful to resource managers.** The opportunity exists to provide agencies and communities with data that can be aggregated to useful scales (river reach or subcatchment) through Geographic Information Systems. The challenge would be to continue to maintain data confidentiality (licence and enterprises information) while maximising data usefulness to resource managers. The ABS is currently considering geo-coding irrigation information.

- **Developing better data-sharing arrangements between government and irrigators.** DLWC crop area and water use information collected from NSW regulated rivers between 1989–90 and 1994–95 is the most comprehensive in the State. However, these data are no longer collected. Should collection resume, the information could be returned to irrigators in formats that might potentially stimulate interest in farm WUE. For example, efficiencies could be calculated and provided as benchmarking material to irrigators each year.

- **Developing better data-sharing arrangements between government agencies**. The DLWC has collected large quantities of data in the past, for example, crop areas and volumes of water used by crops (DLWC 1998a). These data are extremely valuable to other Departments such as NSW Agriculture and could be used to help locate areas of excessive water use of irrigation water or to identify areas where crops are being under-watered. For example, NSW Agriculture staff working closely with irrigators (water use efficiency officers or WaterWise on the Farm facilitators) would benefit from being able to easily access the wealth of information already collected by the DLWC.



11.2 Opportunities for irrigation

- **Agroforestry to manage salinity and waterlogging.** With salinity a concern in the catchment, the opportunity exists to develop an agroforestry industry. Deep-rooted perennial trees could be used to reduce localised shallow watertables, minimise salinity and at the same time produce income. There has been increasing interest in agroforestry around the Tumut area of the catchment - the total irrigated area of this crop based on data from the unregulated system has been increasing since 1993-94.

- **Reducing losses in supply systems.** There is a large difference between the volume of water diverted from the river and the amount delivered to farms in the MIA and CIA. Between 350 000 and 400 000 ML are thought to be lost either as seepage or evaporation. General measurement inaccuracies are also thought to contribute to this difference. Sealing channel systems may help increase the volume of water available to farms. It should be noted that Bewsher Consulting (1999) suggest that $1 million is required to liberate 1000 ML, or 1 GL.

- **Improving WUE will help liberate water.** Improved farm water management will liberate water for expansion of existing enterprises or for trade.

11.3 Data issues

- **There was no central repository of irrigation data in the Murrumbidgee catchment.** Information on the MIA and CIA had to be sourced from the administrative authorities MI and CICL. Irrigation data for enterprises using groundwater and river water outside the MIA and CIA could only be obtained from the DLWC. In the CIA, some farms irrigate with groundwater and surface water. When CICL provide numbers on the total water used by rice, they can only report the amount of surface water. Groundwater records must be obtained from the DLWC. At this stage, there seems to be little integration of groundwater and surface supply datasets. CICL are trying to rectify this problem.

- **There is a scarcity of information about irrigation.** Since the implementation of water reforms and the development of water sharing plans, a much greater range of irrigation data are needed than are currently available (data on crop areas, crop water use, yield, value of production and irrigation methods). In the past, agency and community data needs were fewer and therefore fewer data were collected. For example, only details of the volume of water extracted from regulated rivers were collected by the DLWC for billing, operation or reporting purposes from each licence holder. There were no requirements to record other information such as crop areas and crop water use, yields, irrigation methods or values.

- **There is a scarcity of data on irrigation at useful scales.** Natural resource managers involved in developing water sharing plans require data at planning scales (river-reach or subcatchment). There is a scarcity of data at, or less than, these scales, particularly with respect to yield, irrigation method and value of production. These particular data are typically collected by, or determined from, either the ABARE or the ABS. The difficulty with these datasets are as follows:

- ➢ Presentation of data is often much larger than that required by natural resource managers (for example, ABARE reporting data at the Murrumbidgee catchment scale). These data sources contain potentially useful information about yields and methods of irrigation but are of limited value at this coarse scale.

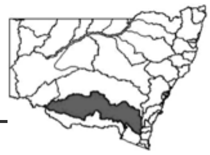
- ➢ Data collection units do not align well with natural resource boundaries (catchments and subcatchments). For example, the ABS has been collecting data on irrigation by SLAs for a number of years. However, these data do not align well with catchment and subcatchment boundaries. Consequently, the area irrigated may be underestimated or overestimated depending on the SLA composition and relationship with catchment boundaries. The ABS ceased collecting data by SLA in 1996–97 and began collecting information by AER in 1997–98 (Table 2). These AERs often span many catchments and cannot be disaggregated into smaller units (such as catchments). This reduces the usefulness of data on the number of enterprises irrigating and area irrigated.

- **Data about irrigators and irrigation enterprises are limited.** Due to the difference between ABS and DLWC definitions of regulated and unregulated water supplies, the number of enterprises using water from these water sources could not be determined with any accuracy.

- **The last season in which the ABS collected irrigation data by source of water was 1993–94.** Data about irrigation dependent on water from unregulated streams and groundwater systems are needed for the development of water sharing plans. The most recent survey includes this information but has not yet been made publicly available.

- **Data reliability ratings need to be provided to users by data collection agencies.** The National Land and Water Resources Audit provides reliability ratings and metadata (data about the data) for public information. There is currently no systematic data reliability rating system used by State information providers. Without such a rating system, data may be inappropriately manipulated and analysed.

- **Collection strategies can limit data usefulness.** The ABS has collected irrigation data at three different EVAOs or survey cut-off points over the last 13 years (Table 2). This makes it difficult to show trends in the area irrigated or enterprise number. For example, changes in the area irrigated between 1992–93 and 1993–94 may be due to a change in the EVAO rather than actual change in the area irrigated. The ABS has the ability to re-estimate their data so that years with different EVAOs can be compared. This was not attempted in this document. Only data between 1993–94 and 1996–97 were compared in this Profile.



11.4 Issues for irrigated agriculture

- **Irrigation development in the top of the catchment is limited by an immature water market.** There is an embargo on the provision of new irrigation licences such that the only way water can be obtained is through water trading. There is still a great deal of uncertainty regarding access to water and this is limiting the amount of trading that is occurring. Trading is dependent on the implementation of water sharing plans and on finalising conversion of licences on unregulated streams from area to volume-basis.
- **Measuring water use to manage water use.** The quality of water use records varies from water source to water source depending on the value of water, the level of investment in irrigation infrastructure and organisational reporting and management needs. Over the last decade, many of the Areas and Districts of the mid-Murrumbidgee catchment did not collect crop area data. The rate at which irrigation water is applied to crops (with the exception of rice) can therefore not be determined accurately. This situation has been improved substantially with the introduction of benchmarking activities, especially in the MIA.
- **Salinisation and waterlogging continue to be of concern for the major Irrigation Areas and Districts of the Murrumbidgee catchment**. Inefficient practices resulting in large volumes of water draining from irrigated paddocks, as well as from delivery and drainage systems, into so-called perched watertables and shallow aquifers have partially caused these problems. Land and water management plans have been developed to help manage these issues.
- **Cost of reducing water losses from seepage and evaporation.** While there may be large losses in the delivery of water from river to farm as shown in the MIA and CIA, reducing these losses is expensive (Bewsher Consulting 1999).

12. SUMMARY

This study highlighted great variability in the availability and reliability of irrigation data across the catchment. Availability and reliability changed with administration group (for example, MI, CICL and DLWC) and with source of water. For some groups of irrigators, there were abundant data on water use and area – see for example, crop area and water use data for licences outside the MIA and CIA collected between 1989-90 and 1994-95. For other groups, information appeared to be comparatively patchy. For example, data on crop area irrigated from the MIA and CIA were nearly non existent. Generally, data for the regulated river system was more reliable and more comprehensive compared to all other water source.

A more comprehensive and consistent approach to the collection of irrigation statistics is indicated. This would help to ensure that data are comparable across different water sources and industries. The following are needed to improve the situation.

- **Increased recognition of the need for comprehensive and reliable crop area and water used data.** These types of irrigation data are needed to support the many water planning committees operating across the State that aim to improve how water is used in NSW. The demand for these irrigation data has increased dramatically with the implementation of the COAG water reforms. In all Australian states, programs have been initiated to improve WUE in irrigated agriculture. These programs desperately need essential irrigation data to underpin debates regarding industry and catchment levels of WUE.

- **Protocols for provision of irrigation data to users.** Information providers need to attach reliability ratings to data to help users make better choices about how the data should be used or manipulated.

- **Two-way flow of information between agencies and irrigators needs to be fostered.** Typically, data have been extracted from irrigators by agencies. These data need to flow back to irrigators in forms that might potentially assist them make better water management decisions.

- **Two-way flow of information between state agencies needs to be fostered.** Establishing better links (for example, developing data sharing agreements over the Internet) between the two organisations and marketing the availability of information would help to enhance the effectiveness of irrigation extension and research programs.

- **Provision of irrigation data at appropriate scales.** Irrigation data need to be collected at scales that are coarse enough to ensure confidentiality of individual enterprises but fine enough to allow users to aggregate information to useful scales.

Finally, such a comprehensive approach can only be developed with the full involvement of the many irrigators, agencies and community groups that require these data.

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14. APPENDICES

14.1 Definitions of statistical units used by the ABS

Extract from ABS Web Page:

> ABS (1999). “Australian Standard Geographical Classification (ASGC) 1999. Chapter 2. Main Structure. The spatial units Statistical Local Area (SLA).” Web page, accessed 14 February 2001, available at http://www.abs.gov.au

An SLA is a general purpose spatial unit. It is the base spatial unit used to collect and disseminate statistics other than those collected from the Population Censuses. SLAs are based on the boundaries of incorporated bodies of local government where these exist. These bodies are the Local Government Councils and the geographical areas which they administer are known as Local Government Areas (LGAs). In the Northern Territory, an incorporated administrative body gazetted under the Northern Territory Local Government Act can take the form of a Community Government Council (CGC). Where there is no incorporated body of local government, SLAs are defined to cover the unincorporated areas

An LGA is an SLA if:

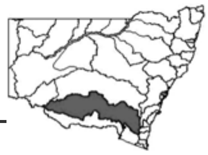
- the LGA fits entirely within an Statistical Subdivision (SSD) and
- the LGA is broadly similar in size, economic significance and user needs for statistics to other LGAs in Australia

An LGA forms two or more SLAs when the two conditions above are not met. This can occur when:

- an LGA is divided by the boundary of one or more SSDs. The LGA is split into two or more SLAs each of which falls within the relevant SSD or
- an LGA is substantially different in size, economic significance and user needs for statistics to other LGAs. The LGA is split into two or more SLAs which generally correspond to one or more suburbs (as occurs in the predominantly urban LGA of the City of Brisbane) or other areas of interest

For those parts of Australia which are not administered by incorporated local government bodies, an SLA is an unincorporated area. Unincorporated SLAs cover the following areas:

- unincorporated on-shore area(s) and/or off-shore island(s) in an SSD
- that part of an unincorporated area which is considered of sufficient economic significance as to warrant the formation of a separate SLA



- Off-Shore Areas & Migratory SLAs, formed for census purposes for all S/Ts except the Australian Capital Territory and Other Territories to encompass off-shore, shipping and migratory CDs (off-shore, shipping and migratory CDs are explained in chapter 2)
- the entire area of the Australian Capital Territory. Each SLA is either a suburb, a locality or the non-urban area of an SSD and
- the unincorporated part of the Northern Territory. In some SSDs (e.g. Daly, Bathurst-Melville) the entire area is covered by one unincorporated SLA. In other SSDs (e.g. East Arnhem), the unincorporated area is split into several SLAs to distinguish an economically significant town (e.g. Nhulunbuy), island (e.g. Groote Eylandt) or administrative region

14.2 Naming conventions for SLAs

Extract from ABS Web Page

> ABS (1999). “Australian Standard Geographical Classification (ASGC) 1999. Chapter 2. Main Structure. The spatial units Statistical Local Area (SLA).” Web page, accessed 14 February 2001, available at http://www.abs.gov.au

An SLA which is a whole LGA adopts the name of the LGA including its LGA status as a suffix. Thus, Northam (S) and Northam (T) in Western Australia are separate SLAs. The various LGA types currently in use by States and the Northern Territory are specified in chapter 3. For example:

- Ballina (A) — New South Wales Area
- Queenscliffe (B) — Borough
- Liverpool (C) — City
- Coomalie (CGC) — Community Government Council
- Mid Murray (DC) — District Council
- Roxby Downs (M) — Municipality
- Murray Bridge (RC) — Rural City
- Broome (S) — Shire and
- Roma (T) — Town.

An SLA which is part of an LGA may adopt a hyphenated name the first part of which is the name of the LGA. For example:

- the LGA of Stirling (C) in Western Australia is split into three SLAs;
- Stirling (C) – Central
- Stirling (C) – Coastal and
- Stirling (C) - South-Eastern

If the name includes - Pt A, - Pt B, or - Pt C, this indicates the SLAs were formed by splitting an LGA between one or more SSDs (see example below). In this case, - Pt A usually denotes the more urban part of the split LGA.

If the name includes - Pt A, - Pt B, or - Pt C, this indicates the SLAs were formed by splitting an LGA between one or more SSDs (see example below). In this case, - Pt A usually denotes the more urban part of the split LGA. For example:

- the LGA of the Municipality of Latrobe in Tasmania is split into two SLAs
- Latrobe (M) - Pt A and
- Latrobe (M) - Pt B.

An SLA which is part of an LGA may adopt a locality or suburb name. For example:

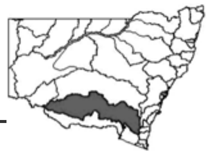
- the LGA of the City of Brisbane in Queensland is split into many SLAs, including:Acacia Ridge; Albion; Yeronga; and Zillmere.

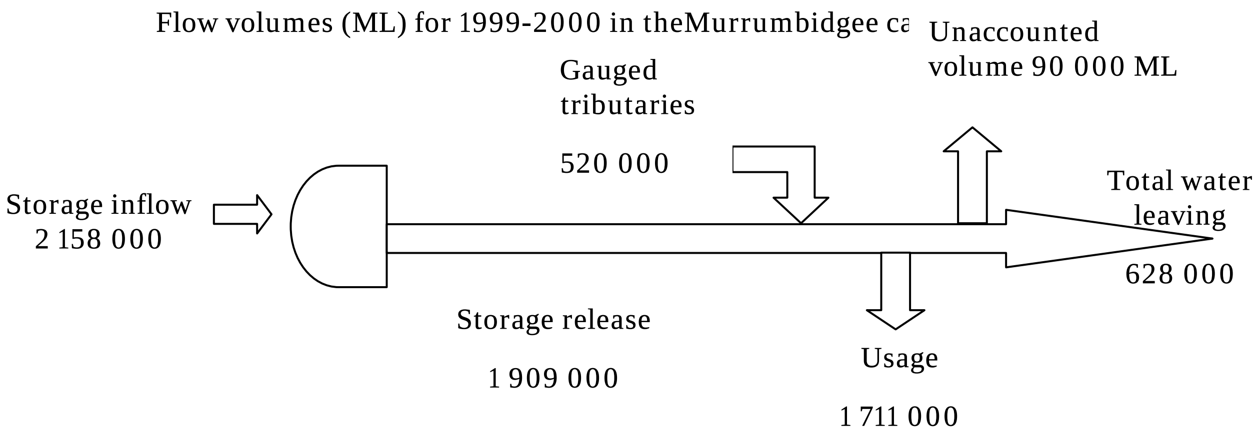
An SLA which covers an unincorporated area does not contain LGA type. In New South Wales, Queensland and South Australia the SLA name may include Unincorp:

- West Arnhem (in Northern Territory)
- Bruce (in Australian Capital Territory) and
- Unincorp. Far West (in New South Wales)

A small number of SLA names are duplicated across S/Ts and one SLA name is duplicated within an S/T. These names become unique when used in conjunction with SLA codes.

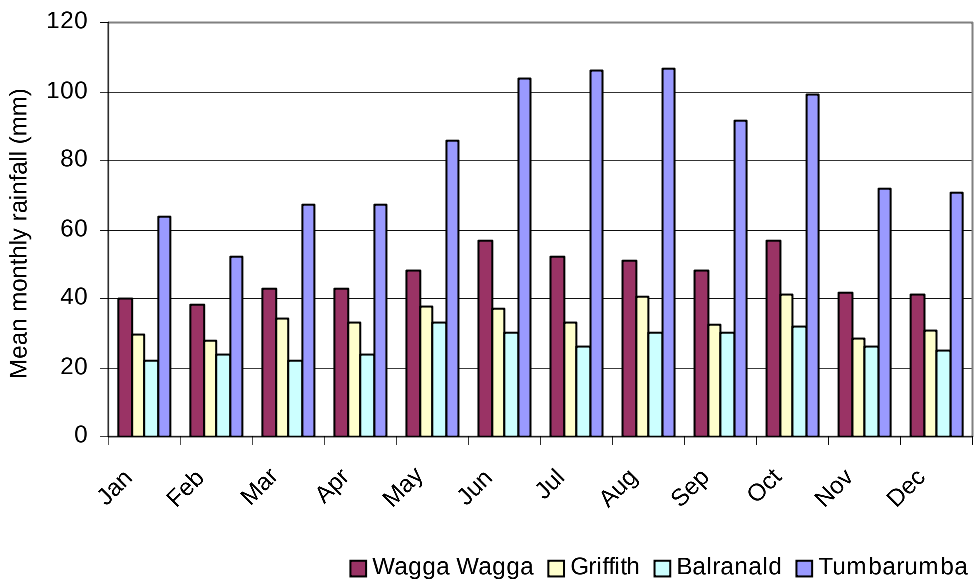
- City (Queensland and Australian Capital Territory)
- City - Inner (Queensland and Northern Territory)
- City - Remainder (Queensland and Northern Territory)
- Kingston (Queensland and Australian Capital Territory)
- Oxley (Queensland and Australian Capital Territory)
- Red Hill (Queensland and Australian Capital Territory) and
- West End (Townsville (C) and Brisbane (C))





Source: DLWC (2000a)

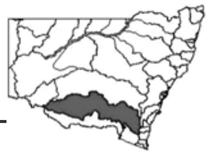
14.3 The long-term monthly mean rainfall in selected locations of the Murrumbidgee catchment

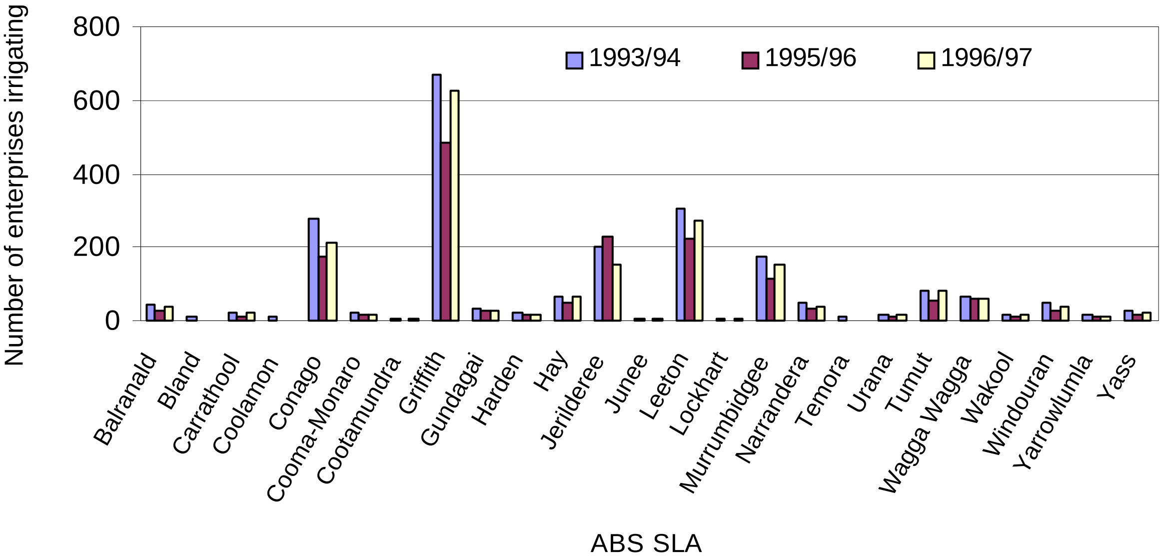


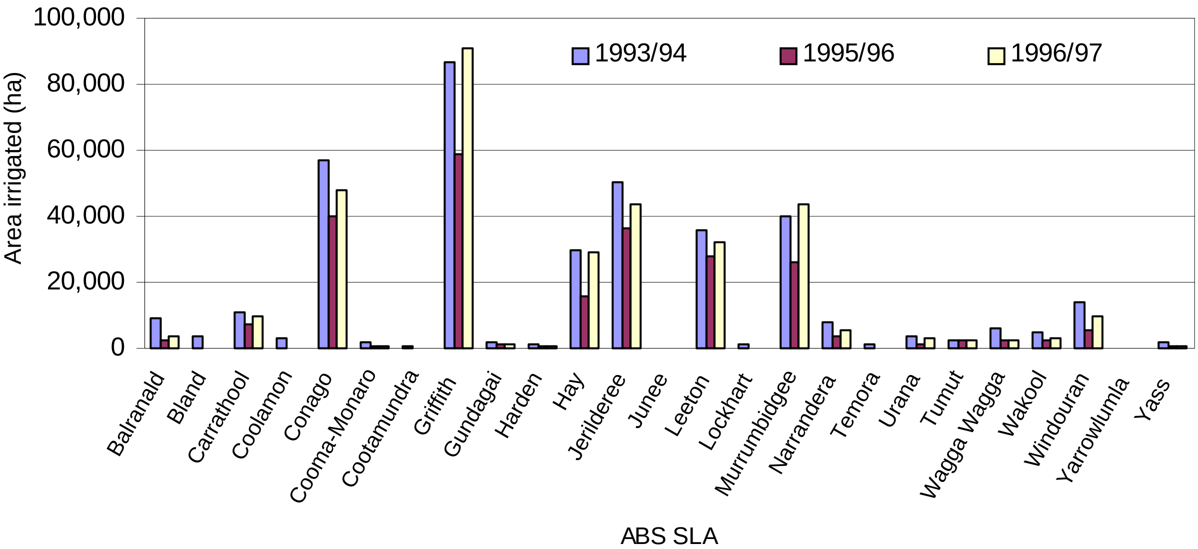
Source: Clewett et al. (1999) ①

14.4 Change in the number of irrigated enterprises and area irrigated between 1993–94 and 1996–97 in the Murrumbidgee catchment

	1993–94		1995–96		1996–97	
Region	**Area(ha)**	**Number of enterprises**	**Area (ha)**	**Number of enterprises**	**Area(ha)**	**Number of enterprises**
Balranald	9 292	42	2 560	28	3 352	40
Bland	3 451	12	80	1	180	2
Carrathool	10 917	23	7 352	13	9 856	19
Coolamon	2 975	10	7	1	11	2
Conago	56 947	275	40 083	172	47 636	213
Cooma-Monaro	1 564	23	715	14	574	16
Cootamundra	632	5	10	2	43	5
Griffith	86 413	670	59 053	483	91 091	627
Gundagai	1 801	30	1 032	25	940	27
Harden	1 294	22	607	14	742	19
Hay	29 489	67	15 520	48	29 009	65
Jerilderee	50 257	202	36 509	227	43 513	155
Junee	243	6	42	2	91	5
Leeton	36 020	305	27 764	223	31 843	272
Lockhart	1 033	7	94	2	16	3
Murrumbidgee	39 804	173	25 820	114	43 678	152
Narrandera	8 143	51	3 600	33	5 651	36
Temora	1 270	9	48	2	17	2
Urana	3 375	18	1 481	9	3 050	15
Tumut	2 495	84	2 249	55	2 150	79
Wagga Wagga	6 329	65	2 552	59	2 707	58
Wakool	4 778	17	2 372	11	3 131	14
Windouran	13 709	51	5 319	25	9 512	40
Yarralumla	108	14	64	11	43	9
Yass	1 642	26	325	14	368	21
TOTAL	**373 978**	**2 207**	**235 256**	**1 588**	**329 201**	**1 896**



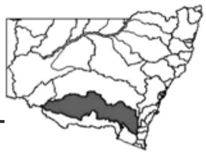




Source: ABS (1998) ②

14.5 Murrumbidgee River allocation announcement history

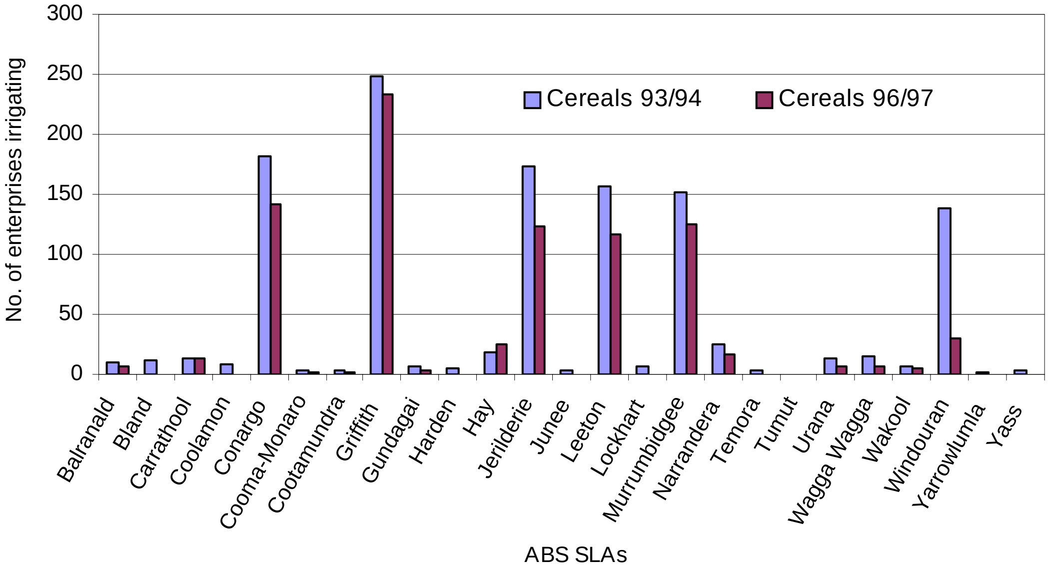
Year	Date Announced	Allocation Announced	Overdraw Next season	Carryover Last season	Carryover Used By	Comments
1980–81[a]	15/08/1980	67%	0%			Temporary scheme this season.
	3/10/1980	85%	0%			
	6/11/1980	95%	0%			
	24/12/1980	100%	0%			
1981–82 [a]	1/07/1981	Not Applicable	0%			No restriction this season.
1982–83 [a]	1/09/1982	100%	0%			Temporary scheme this season.
1983–84 [a]	4/08/1983	40%	0%			Volumetric allocation scheme commenced.
	23/08/1983	50%	0%			
	29/08/1983	65%	0%			
	14/09/1983	75%	0%			
	4/10/1983	80%	0%			
	14/10/1983	90%	0%			
	31/10/1983	100%	0%			
	18/11/1983	120%	0%			
1984–85 [a]	3/07/1984	100%	0%			
	25/09/1984	140%	0%			
1985–86 [a]	9/07/1985	100%	0%			
	16/08/1985	110%	0%			
	22/08/1985	120%	0%			
1986–87 [a]	10/07/1986	100%	0%			
	24/09/1986	120%	0%			
1987–88 [a]	13/07/1987	100%	0%			
	11/09/1987	120%	0%			
	17/01/1988	120%	20%			
1988–89 [a]	19/07/1988	120%	0%			
1989–90 [a]	1/08/1989	120%	0%			
1990–91 [a]	26/08/1990	120%	0%			
	31/10/1990	120%	20%			
1991–92 [b]	19/06/1991	120%	0%			Announced early -

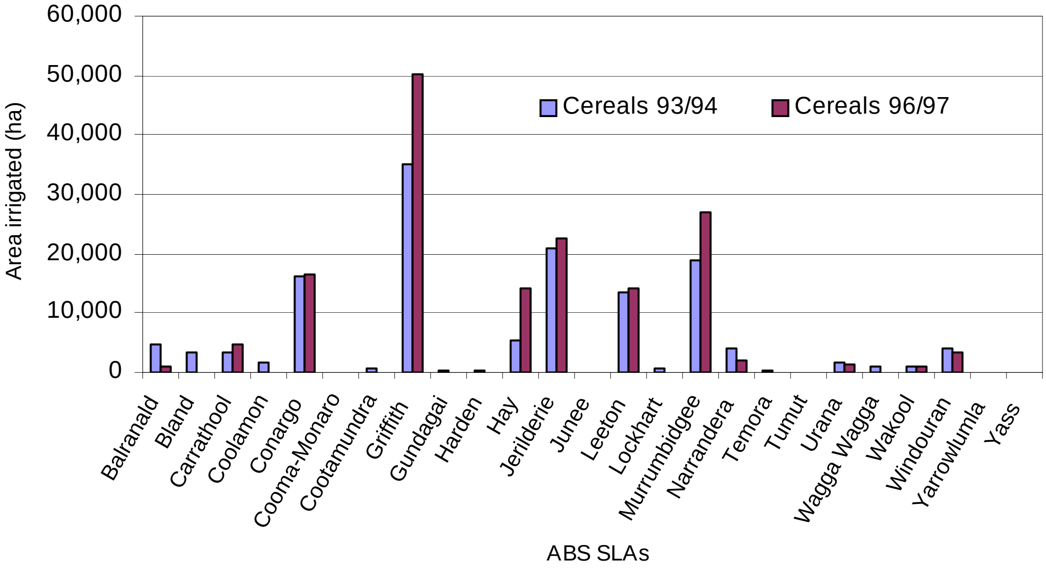


	Date	Allocation	Overdraw	Carryover		
Year	Announced	Announced	Next season	Last season	Used By	Comments
						assisting irrigation planning
1992–93 [b]	7/07/1992	105%	0%			
	13/08/1992	110%	0%			
	1/09/1992	120%	0%			
1993–94 [b]	11/09/1993	120%	0%			
1994–95 [b]	6/09/1994	100%	20%			Rate of supply was restricted because of inability to deliver announced allocation in the normal demand period
1995–96 [b]	3/08/1995	100%	0%			
	15/09/1995	105%	0%			
	16/11/1995	105%	5%			
	22/12/1995	105%	15%			
1996–97	23/07/1996	100%				
1997–98	5/08/1997	75%				
	21/08/1997	80%				
	9/09/1997	88%				
	1/10/1997	90%				
1998–99	27/07/1998	40%				Lowest initial allocation since first year of allocation scheme.
	11/08/1998	46%				
	20/08/1998	52%				
	27/08/1998	60%				
	17/09/1998	65%				
	28/09/1998	72%				
	12/10/1998	76%				
	20/11/1998	81%				
	2/02/1999	85%				

Source: DLWC (2000b) ① Announced by [a]Minister, [b] Manager [c]Regional Director

14.6 Number of enterprises irrigating and crop areas irrigated in the Murrumbidgee catchment





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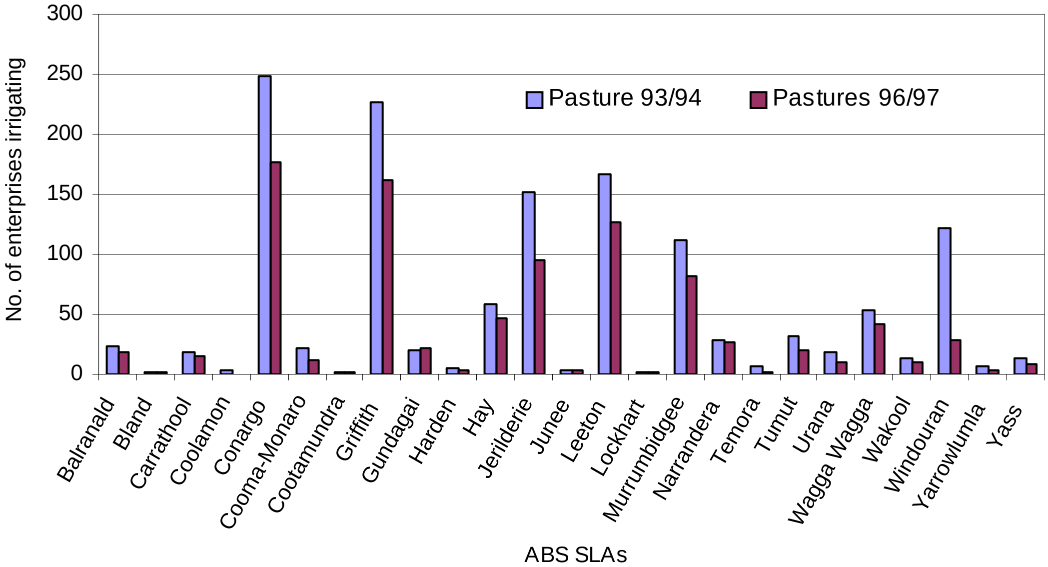

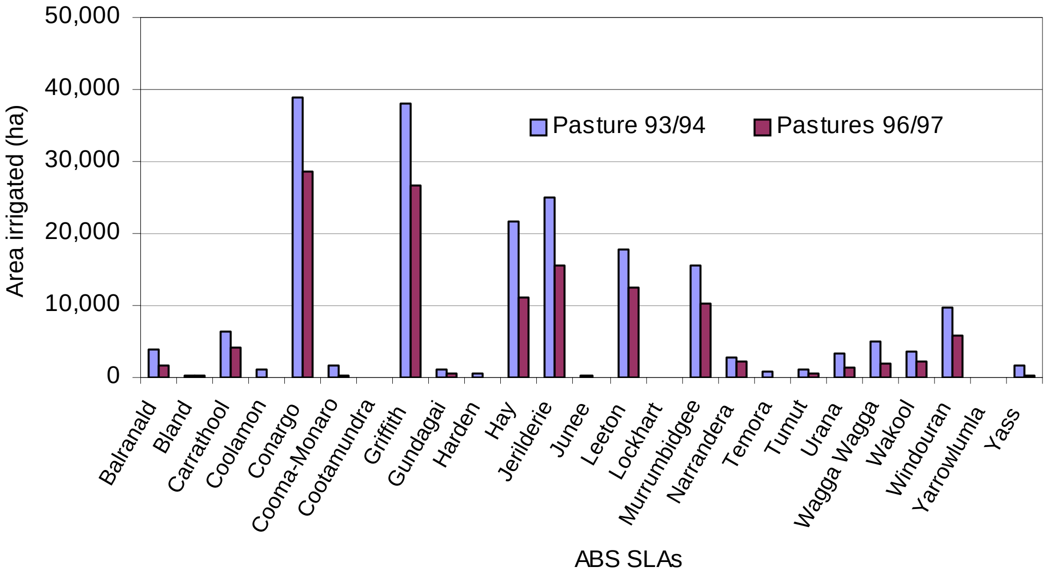

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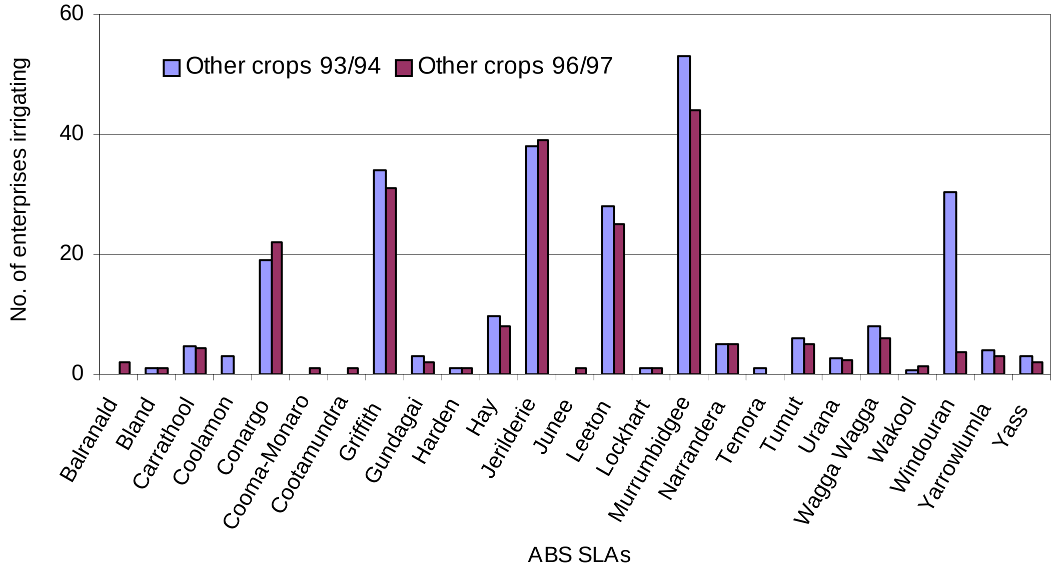

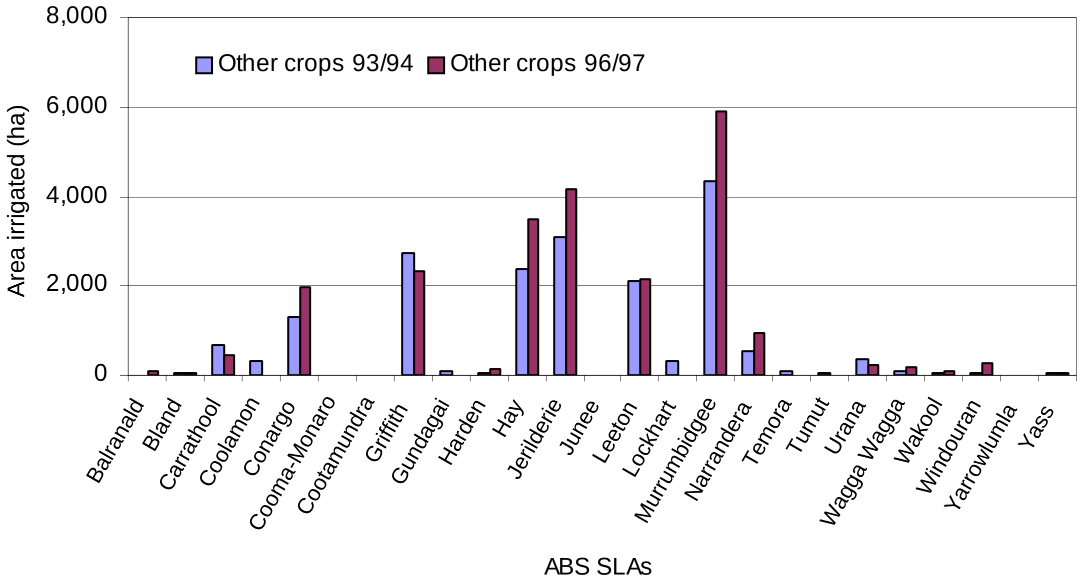

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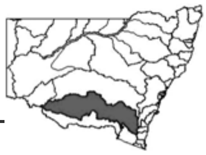
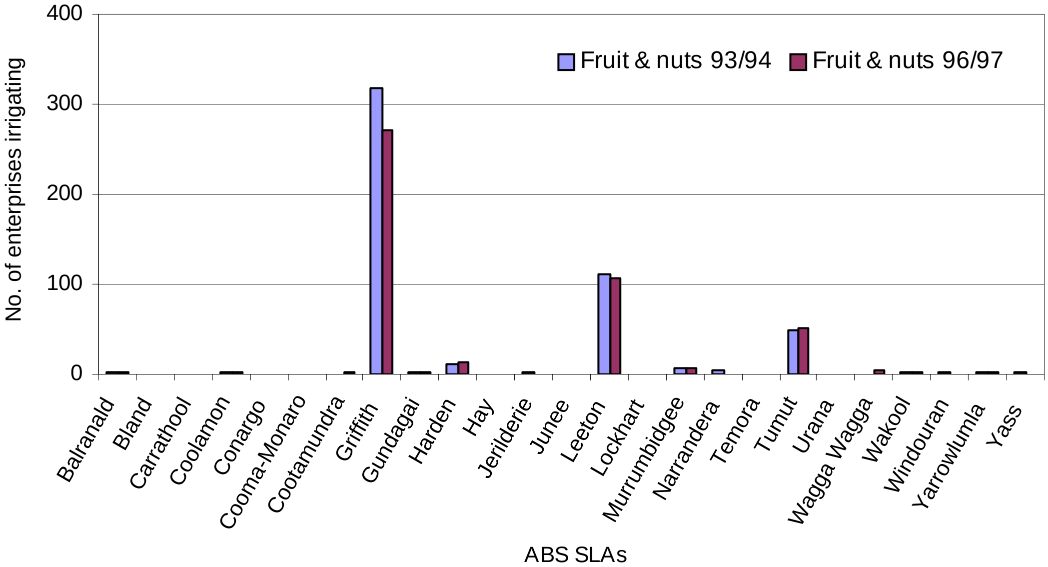
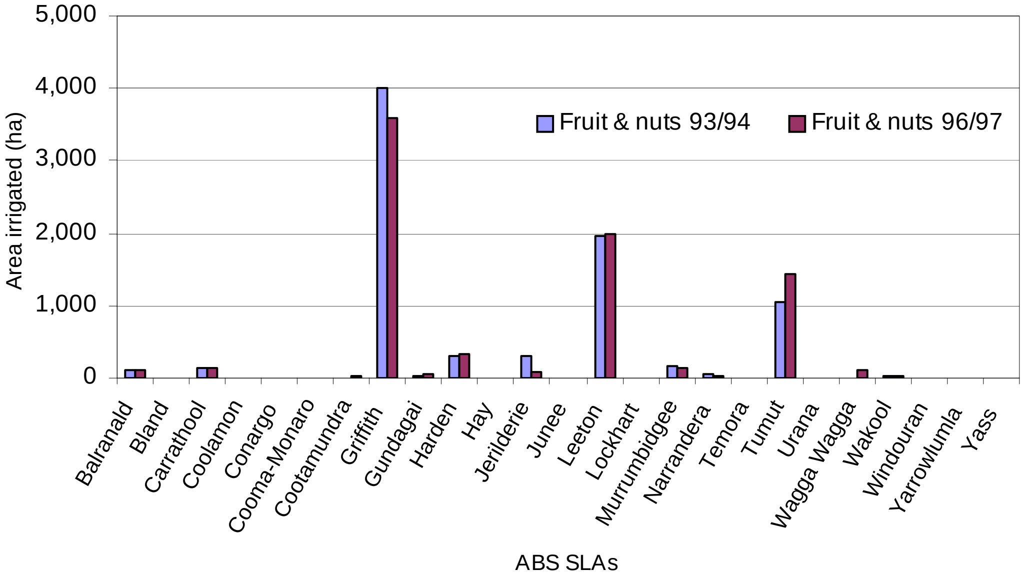






Source: ABS (1998) ②. Note: grapes are not included in this ‘fruit&nut’ category

14.7 Theoretical estimates of crop irrigation requirements in the Murrumbidgee catchment

The theoretical amount of irrigation water required by crops is provided in Table 15. The methodology used to determine these data are provided in DLWC (2000d). Estimates are for well-watered, disease-free, pest-free crops. See Figure 20 for climatic zone location.

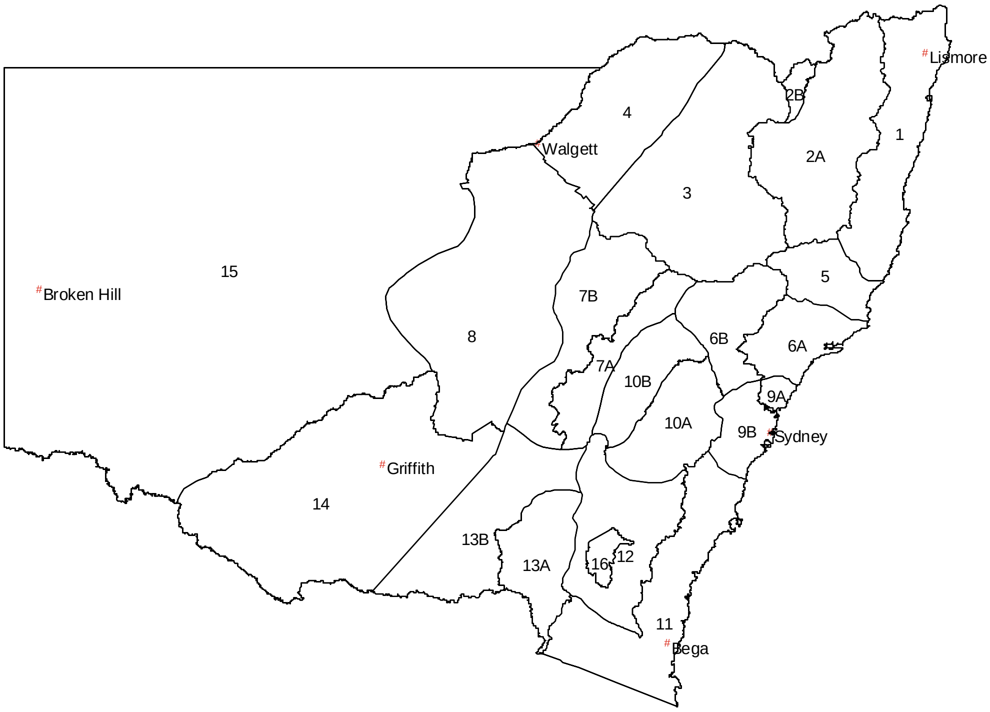
Table 15. The irrigation requirement [24] of crops in the Murrumbidgee catchment (ML/ha)

	Climatic zones		
Crop class	13A	13B	14
Nurseries	20	20	20
Vines	3	5	7.5
Rice			13
Orchards	7.5	9	12
Citrus	4.5		10
Summer cereal	5	7	9.5
Olives	4.5	6.5	9
Perennial pasture –	7.5	7.5	8
Summer oilseeds	5	6.5	8
Vegetables	3.5	5.5	8
Lucerne	6	6.5	7
Perennial pasture –	5.5	5.5	6
Pulses	2	3.5	5.5
Annual pasture	1.5	1.5	3
Winter cereal	1.5	1.5	3
Inactive area	1.5	1.5	2.5
Winter oilseeds	1.5		2.5
Nuts	7.5		
Turf	9.5	11.5	

Source: DLWC (2000d) ③. [a] Crop class refers to the grouping of like crops (such as maize and wheat) within a generic crop class (such as cereals). See zone map (Figure 20).

[24] The irrigation requirement is the depth of water required to satisfy crop water requirement, leaching requirement and system inefficiencies (conveyance, distribution, and application).

Figure 20. Climatic zones for NSW



Source: DLWC (2000d)

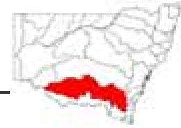
Essentially the depth of water that must be delivered *to the farm* to ultimately satisfy actual crop water use (Ml/ha or mm).

14.8 Irrigated crop information from NSW Agriculture for the Murrumbidgee catchment

Location	Pers. comm.	Crop	IR[b] avg ML/ha	IR min ML/ha	IR max ML/ ha	Y[c] avg t/ ha	Y min t/ ha	Y max t/ ha	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]
Cereals												
Barham/ Wakool	Peter Beale	Barley	1.5	1.0	3.0	3.5	2.0	7.0				
Hillston and Tabbita	Myles Parker	Barley	2.0	1.0	3.0	5.0	2.5	7.0	1.0	1-Jun	170	border-check and contour
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Barley	2.0	1.0	3.0	5.0	2.5	7.0	1.0	1-Jun	170	border-check
Hillston and Tabbita	Myles Parker	Maize	8.0	6.0	12.0	10.0	6.0	15.0	0.9	4-Oct	170	furrow/beds
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Maize	8.5	6.0	12.0	9.5	6.0	15.0	0.9	15-Oct	170	beds

Location	Pers. comm.	Crop	IR[b] avg ML/ha	IR min ML/ha	IR max ML/ ha	Y[c] avg t/ ha	Y min t/ ha	Y max t/ ha	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]
Hillston and Tabbita	Myles Parker	Oats	2.0	1.0	3.0	3.5	2.0	6.0	1.0	1-May	180	border-check and contour
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Oats	2.0	1.0	3.0	3.5	2.0	6.0	1.0	1-May	180	contour
Hillston and Tabbita	Myles Parker	Rice	16.0	13.0	20.0	9.0	6.0	12.0	0.2	15-Oct	174	contour flood
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Rice	14.0	12.0	16.0	9.5	6.0	12.0	0.2	15-Oct	170	contour
Hillston and Tabbita	Myles Parker	Wheat	2.0	1.0	3.0	5.0	3.0	7.0	1.0	15-Apr	180	border-check/ contour
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Wheat	2.0	1.0	3.0	5.0	3.0	7.0	1.0	15-Apr	180	border-check contour beds

Location	Pers. comm.	Crop	IR[b] avg ML/ha	IR min ML/ha	IR max ML/ ha	Y[c] avg t/ ha	Y min t/ ha	Y max t/ ha	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]
Fibres												
Hillston and Tabbita	Myles Parker	Cotton	7.5	6.0	11.0	7.2	5.0	10.0	1.2	10-Oct	195	furrow
Oilseeds												
Hillston and Tabbita	Myles Parker	Canola	2.5	1.0	4.0	2.3	1.5	3.0	1.0	1-May	180	border-check
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Canola	2.5	1.0	4.0	2.5	1.8	3.0	1.0	7-May	180	border-check beds contour
Hillston and Tabbita	Myles Parker	Soy beans	7.0	6.0	9.0	2.4	1.5	4.0	0.4	15-Dec	125	furrow/ border-check
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Soy beans	8.0	6.0	9.0	2.6	1.5	3.8	0.3	5-Dec	125	beds, border-check



Location	Pers. comm.	Crop	IR[b] avg ML/ha	IR min ML/ha	IR max ML/ ha	Y[c] avg t/ ha	Y min t/ ha	Y max t/ ha	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]
Hillston and Tabbita	Myles Parker	Sunflowers										furrow
Hillston and Tabbita	Myles Parker	Tea tree										drip
Pome fruit												
Batlow	Karen O'Malley	Apples	7.3									
Pulses												
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Chick peas										border-check
Hillston and Tabbita	Myles Parker	Field peas										border-check
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Field peas										border-check

Location	Pers. comm.	Crop	IR[b] avg ML/ha	IR min ML/ha	IR max ML/ ha	Y[c] avg t/ ha	Y min t/ ha	Y max t/ ha	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]
Hillston and Tabbita	Myles Parker	Lupins										border-check
Griffith	Rachel Salvestro, Iva Quarisa and David Williams	Lupins										border-check
Stone fruit												
	John Slack	Orchards (high-chill)								1-Sep	240	
Vegetables												
Yanco	Dennis Muldoon and Mark Hickey	Melons		4.0	7.0		30.0	40.0	0.8	15-Oct	90	furrow
Yanco	Dennis Muldoon and Mark Hickey	Onions		4.0	6.0		50.0	70.0	0.5	15-May	210	furrow
Yanco	Dennis Muldoon and Mark Hickey	Salad crops (lettuce)		2.0	4.0		30.0	40.0		15-May	120	furrow

Location	Pers. comm.	Crop	IR[b] avg ML/ha	IR min ML/ha	IR max ML/ ha	Y[c] avg t/ ha	Y min t/ ha	Y max t/ ha	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]
Yanco	Dennis Muldoon and Mark Hickey	Tomatoes (processing)		6.0	10.0		60.0	120.0	0.8	15-Nov	130	furrow

④

a. Crop class refers to a category under which similar crops can be grouped.

b. The depth of water required to satisfy crop water requirement, leaching requirement and system inefficiencies (conveyance, distribution, and application). Essentially the depth of water that must be delivered *to the farm* to ultimately satisfy actual crop water use. Average, minimum, and maximum figures correspond to irrigation requirements in normal, wet and dry seasons respectively.

c. Y Ave, Min and Max – Average, Minimum and Maximum Yield or the total seasonal production derived from the irrigated crop. The unit being considered should be specified (dry matter, grain, fibre, etc).

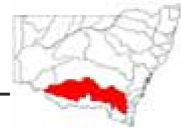
d. Date on which annual crops are typically sown.

e. For field and vegetable crops, the total number of days between sowing and harvesting, for perennial crops usually 365 days.

f. System refers to irrigation system used.

Benchmarking results for the MIA, CIA and river pumpers between Narrandera and Balranald

Crop	Phys. potential (t / ha)	Best t / ha	Average and range t / ha	ML / ha	t / ML	GM $ / ML	GM $ / ha
Wheat[a]	8	7.5	5.3 (4.9–6.2)	4.3 (2.5–6)	1.2 (0.8–2.0)	142 (75–242)	615 (417–968)
Faba beans[b]	9	3.9	4 (2.5–5)	3.2 (best 2.2–low 4.2)	1.4 (0.6–2.3)	240	700
Oaten hay[b]	19.2	10.4	8.67 (6.72–11.5)	1.81 (best 1.88, low 1)	4.79 (4.2–6.7)	346 (245–546)	626 (245–1024)
Soybeans[a]	21.4	4.5	3 (2.3–4.5)	7.3 (5–11)	0.4 (0.2–1.1)	115 (51–333)	853 (463–1739)
Cotton[b]	9.5	6.18	6 (5.4–6.9)	7.8 (best 6.25 and lowest 6.0)	0.8 (0.75–4.43) bales/ML	260 (190–270)	2 040 (1180–2140)
Rice (medium–grain)[a]	12.4	12.5	11.1 (10.2–12.4)	11.7 (9–16)	1 (0.8–1.3)	179 (150–234)	2065 (1862–2444)
Barley[b]	10.0	7.9	4.7 (2.5–5.9)	1.7 (best 1.5–low 2)	2.7 (2.7–4)	470 (190–680)	817 (289–1361)
Sunflowers[b]	7.4	4.4	2.65 (2–3.7)	6.6 (best 7.5–low 7)	0.4 (0.3–0.5)	307 (140–531)	2036 (1049–3186)



Crop	Phys. potential (t/ha)	Best t/ha	Average and range t/ha	ML/ha	t/ML	GM $/ML	GM $/ha
Canola[b]	7.2	4.2	3.2 (1.9–4)	3.4 (1.7–2.6)	1.1 (0.7–2.4)	200 (30–280)	650 (90–740)
Maize (grit waxy)[a]	22.4	17.7	10.2 (8.6–13.6)	8.4 (4.1–10)	1.35 (1–1.9)	140 (62–258)	1056 (525–1695)
Tomatoes[a]	181	100	63 (60–79)	8 (4.5–7.5)	9.2 (8–17.5)	633 (367–2242)	4327 (3933–6628)
Lucerne[a]	32	15	7.3 (5–15)	10 (7–14)	0.7 (0.4–2.1)	101 (44–379)	1 070 (622–2656)

[a] Beecher (1995), [b] Inland Agriculture (1997) ③

14.9 Irrigation methods in the Murrumbidgee catchment – broadarea and dairy enterprises only

Irrigation method	State %	Murrumbidgee catchment %
surface	91.3	91.2
moveable spray	3.5	2.3
travelling irrigator	4.4	5.6
trickle/drip/sub-surface	0.2	0.7
fixed low throw sprinkler	0.02	0.0
fixed micro sprays	0.3	0.0
fixed overhead sprinkler	0.2	0.2
other	0.1	0.0

Source: ABARE (2000) ③

14.10 Rice data from the MIA

Year	Total (ML)	Area (ha)	Yield (t)	t\ML	t\ha	ML\ha
1979–80	609 381	40 091	205 043	0.34	5.11	15.20
1980–81	551 131	37 783	266 378	0.48	7.05	14.59
1981–82	615 213	42 043	289 916	0.47	6.90	14.63
1982–83	512 228	32 870	232 769	0.45	7.08	15.58
1983–84	504 582	41 176	248 913	0.49	6.05	12.25
1984–85	611 492	41 481	292 507	0.48	7.05	14.74
1985–86	499 733	38 318	262 884	0.53	6.86	13.04
1986–87	439 821	34 267	216 091	0.49	6.31	12.84
1987–88	515 879	36 308	266 681	0.52	7.34	14.21
1988–89	482 736	37 876	310 452	0.64	8.20	12.75
1989–90	459 156	36 619	315 802	0.69	8.62	12.54
1990–91	384 906	26 943	250 708	0.65	9.31	14.29
1991–92	540 106	36 213	340 599	0.63	9.41	14.91
1992–93	370 579	35 819	296 908	0.80	8.29	10.35
1993–94	456 901	35 832	299 728	0.66	8.36	12.75
1994–95	485 765	36 566	337 906	0.70	9.24	13.28
1995–96	446 917	42 478	302 666	0.68	7.13	10.52
1996–97	519 318	38 854	396 635	0.76	10.21	13.37
1997–98	489 363	35 109	422 566	0.86	12.04	13.94

Source: M Hedditch, pers. comm.①

14.11 Irrigated yields of white and red wine grapes in the MIA

Yield of western Riverina white wine grape varieties

White wine grape varieties	1997–98 (t/ha)
Chardonnay	9.2
Chenin Blanc	12.5
Colombard	21.4
Daradillo	11.8
Marsanne	30.3
M.G.B	14.9
Palomino	13.9
Riesling	9.8
Sauvignon Blanc	15.6
Semillon	18.7
Traminer	11.2
Trebbiano	13.5
Verdelho	26.9
White Frontignac	13.4
Other White	12

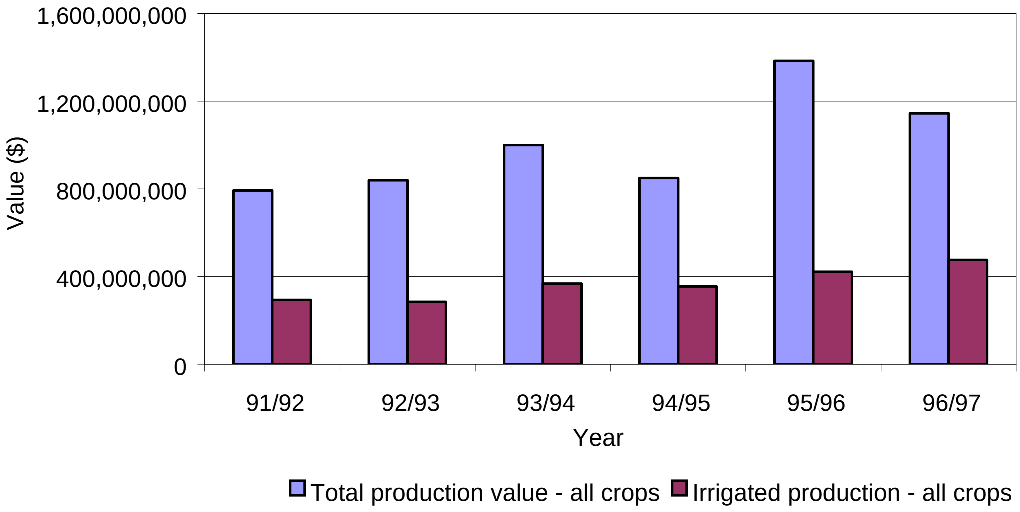
Source: H Creecy, pers. comm.

Yield from western Riverina red wine grape varieties

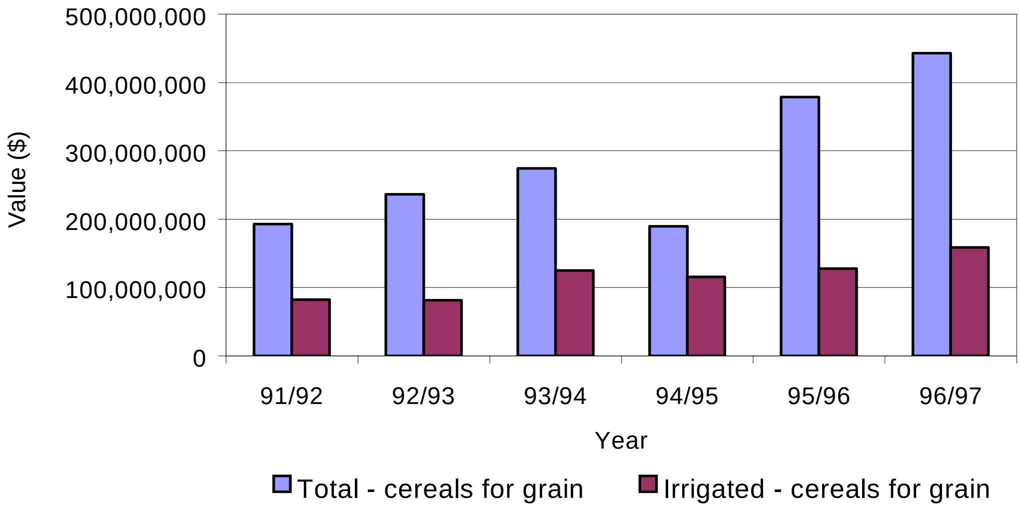
Grape variety	1997–98 (t/ha)
Cabernet Sauvignon	14.1
Durif	22.9
Grenache	7.4
Mataro	13.4
Merlot	9.1
Pinot Noir	15.9
Ruby Cab	9.7
Shiraz	18.4
Zinfandel	
Other	15

Source: H Creecy, pers. comm.

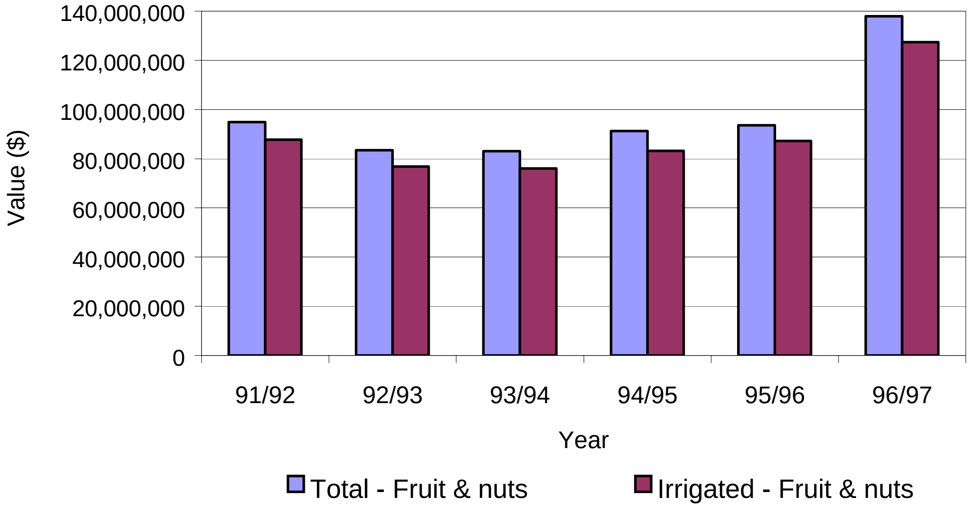
14.12 Value of irrigated agriculture, major crops, Murrumbidgee catchment



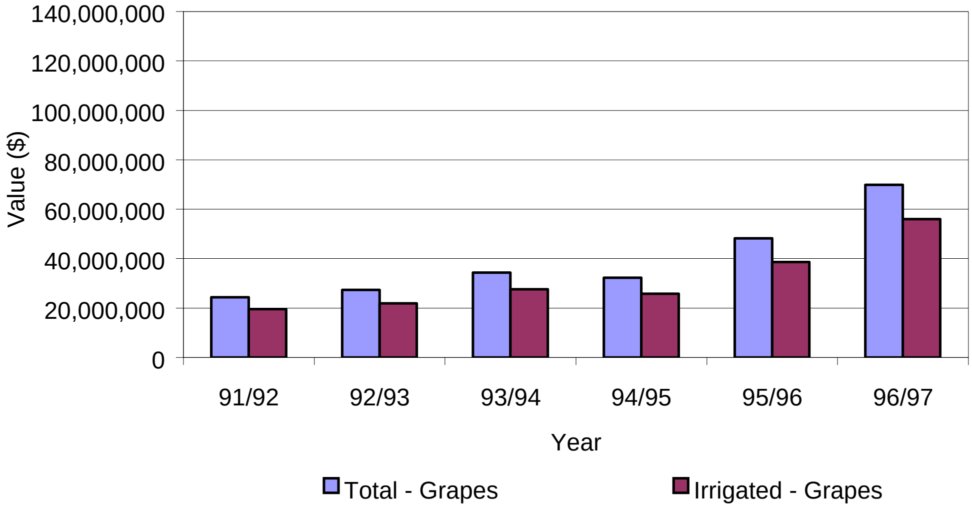
Source: Donovan (2000) ③



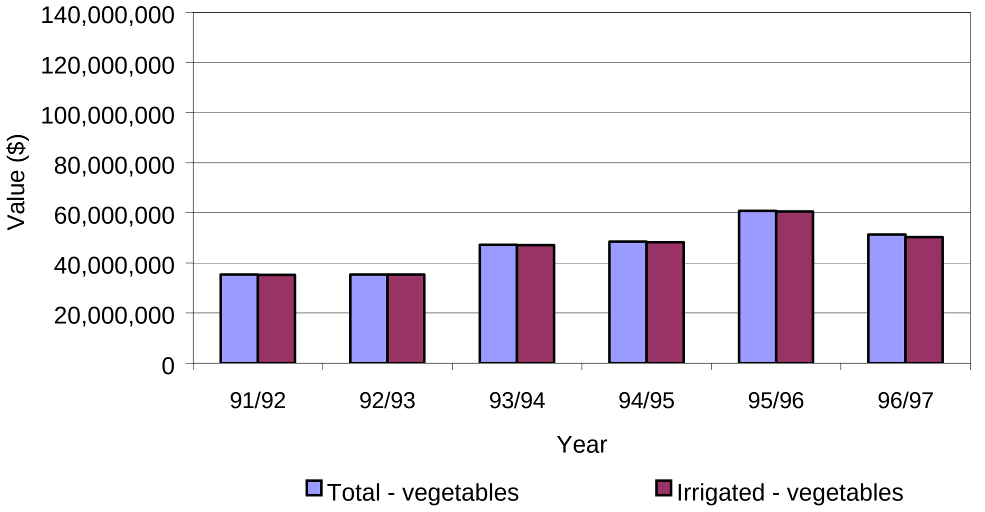
Source: Donovan (2000) ③



Source: Donovan (2000) ③



Source: Donovan (2000) ③



Source: Donovan (2000) ③

14.13 Comparison of SLAs used in this *Profile* and by Donovan (2000)

SLAs used in Profile	SLAs used by Donovan (2000)
Balranald	
Bland	
Carrathool	
Conargo	
Coolamon	Coolamon
Cooma-Monaro	Cooma-Monaro
Cootamundra	Cootamundra
Griffith	Griffith
Gundagai	Gundagai
Harden	Harden
Hay	Hay
Jerilderie	
Junee	Junee
Leeton	Leeton
Lockhart	Lockhart
Murrumbidgee	Murrumbidgee
Narrandera	Narrandera
	Snowy River
Temora	
Tumut	Tumut
Urana	

SLAs used in Profile	SLAs used by Donovan (2000)
Wagga Wagga	Wagga Wagga
Wakool	
Windouran	
Yarralumla	Yarralumla
Yass	Yass

14.14 Value of irrigated agriculture in the MIA

Industry	Irrigated area (ha)	Production (tonnes)	Farm GVP ($ million)
Rice	34 936	290 263	72.8
Wheat	22 382	75 867	13.3
Barley and oats	11 781	28 946	3.1
Citrus	2.09 million trees	137 234	44.2
Grapes	5 012	97 518 (fwt)	38.2
Vegetables	3 774	83 273	27.8
Sheep-meat	459 484		3.1
Sheep-wool		1.8 (million sheep)	7.3
Cattle-meat	60 900		22.4
Poultry, eggs		7.2 (million dozen)	8.3
Poultry, meat		25.9 (million birds)	84.2
Total			**324.7**

Source: MIA & D LWMP WG (1997) (reliability rating unknown)

14.15 ABS Question profile

Part 8. Do you irrigate or use any artificial fertilisers or soil conditioners

	No ☐	Go to part 9
	Yes ☐	*show details below*

a. Pastures and Crops Irrigated – Season 1993-94

Where any area of pasture or crop was irrigated more than once during the season, show this area once only

	Hectares
• Pasture (native or sown)	....
• Cereals	....
• Vegetables for human consumption	....
• Fruit (including nuts)	....
• Grapevines	....
• All other crops	....

b. Source of water – season 1993-94

Where more than one source of water is used on a particular area of pasture or crop, show the area only once according to the main source.

Area irrigated using:	Hectares
• Channel or pipe supply in an irrigation area or district	....
• Other surface water (*Include* • private group schemes)	....
• A river or stream controlled by water board or a water resources commission dam or weir	....
- An uncontrolled river or scheme	....
- A farm dam with its own catchment and not filled by pumping from a river or stream	....
• Underground water supply (e.g. bore, spear, well)	
- Within State schemes	....
- Other	....

Source: (ABS 1994)

14.16 Availability of information

Crop information (excluding rice) by data collection organisation, Murrumbidgee catchment

		1988–89	1989–90	1990–91	1991–92	1992–93	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99	1999–20	2000–01
Yanco IA	Total area, crop area	-	-	-	-	-	-	-	-	-	-	-	-	MI
	Total water use, crop water used[a]	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI
Mirrool IA	Total area, crop area	-	-	-	-	-	-	-	-	-	-	-	-	MI
	Total water use, crop water used[a]	-	MI	MI	MI	-	-	MI	MI	MI	MI	MI	MI	MI
Tabbita ID	Total area, crop area	-	-	-	-	-	-	-	-	-	-	-	-	MI
	Total water use, crop water used[a]	-	-	MI	MI	-	-	MI	MI	MI	MI	MI	MI	MI
Wah Wah ID	Total area, crop area	-	-	-	-	-	-	-	-	-	-	-	-	MI
	Total water use, crop water used[a]	-	-	MI	MI	-	-	MI	MI	MI	MI	MI	MI	MI
Benerembah ID	Total area, crop area	-	-	-	-	-	-	-	-	-	-	-	-	MI
	Total water use, crop water used[a]	-	-	MI	MI	-	-	MI	MI	MI	MI	MI	MI	MI
MIA total	Total area, crop area	-	-	-	-	-	-	-	-	-	-	-	-	MI
	Total water use, crop water used[a]	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI
Hay IA	Total area, crop area	-	-	-	-	-	-	-	-	-	-	-	-	MI
	Total water use, crop water used[a]	-	-	-	-	-	-	-	-	MI	-	-	-	MI
CIA	Total area, crop area	-	-	-	-	-	-	-	-	-	CI	CI	CI	CICL
	Total water use, crop water used[a]	-	-	-	-	-	DWLC	-	-	-	CI	CI	CI	CICL
Licensed irrigators	Total area, crop area	DLWC (ncd)	DLWC	DLWC	DLWC	DLWC	DLWC	DLWC	-	-	-	-	-	DLWC
	Total water use, crop water used[a]	DWLC (ncd)	DLWC	DLWC	DLWC	DLWC	DLWC	DLWC	DLWC (ncd)	DLWC (ncd)	DLWC (ncd)	DLWC (ncd)	DLWC (ncd)	DLWC

Irrigated area

	Yanco	Mirrool	Tabbita	Wah Wah	Bener'bah	Hay	CIA	Licensed Irrigators
1960–61			DWR	DWR	DWR			
1961–62			DWR	DWR	DWR			
1962–63			DWR	DWR	DWR			
1963–64			DWR	DWR	DWR			
1964–65			DWR	DWR	DWR			
1965–66			DWR	DWR	DWR			
1966–67			DWR	DWR	DWR			
1967–68			DWR	DWR	DWR			
1968–69			DWR	DWR	DWR			
1969–70			DWR	DWR	DWR			
1970–71			DWR	DWR	DWR			
1971–72			DWR	DWR	DWR			
1972–73			DWR	DWR	DWR			
1973–74			DWR	DWR	DWR			
1974–75			DWR	DWR	DWR			
1975–76	DWR	DWR	DWR	DWR	DWR	DWR	DWR	
1976–77	DWR	DWR	DWR	DWR	DWR	DWR	DWR	
1977–78	DWR	DWR	DWR	DWR	DWR	DWR	DWR	
1978–79	DWR	DWR	DWR	DWR	DWR	DWR	DWR	
1979–80	DWR	DWR	DWR	DWR	DWR	DWR	DWR	
1980–81	DWR	DWR	DWR	DWR	DWR	DWR	DWR	
1981–82	DWR	DWR	DWR	DWR	DWR	DWR	DWR	DLWC
1982–83	DWR	DWR	DWR	DWR	DWR	DWR	DWR	DLWC
1983–84	DWR	DWR	DWR	DWR	DWR	DWR	DWR	DLWC
1984–85	DWR	DWR	DWR	DWR	DWR	DWR	DWR	DLWC
1985–86	DWR	DWR	DWR	DWR	DWR	DWR	DWR	DLWC
1986–87	DWR	DWR	DWR	DWR	DWR	DWR	DWR	DLWC
1987–88								DLWC
1988–89								DLWC
1989–90								DLWC
1990–91								DLWC
1991–92								DLWC
1992–93								DLWC
1993–94								DLWC
1994–95								DLWC
1995–96								
1996–97								
1997–98							CIA	
1998–99								

Sources: Code: DWR = (DWR 1998) DLWC = (DLWC 1998a), CIA = W Bolsch, pers. comm.

Note: Total area and crop area data are estimated by water meter inspectors for each licence. Be aware that data from the CIA includes the area irrigated from groundwater supplies.

Availability of crop water use data

	Yanco	Mirrool	Tabbita	Wah Wah	Bener'bah	Hay	CIA	Licensed Irrigators
1960–61	DWR		DWR	DWR	DWR			
1961–62	DWR		DWR	DWR	DWR			
1962–63	DWR		DWR	DWR	DWR			
1963–64	DWR		DWR	DWR	DWR			
1964–65	DWR		DWR	DWR	DWR			
1965–66	DWR		DWR	DWR	DWR			
1966–67	DWR		DWR	DWR	DWR			
1967–68	DWR		DWR	DWR	DWR			
1968–69	DWR		DWR	DWR	DWR			
1969–70	DWR		DWR	DWR	DWR			
1970–71	DWR		DWR	DWR	DWR			
1971–72	DWR		DWR	DWR	DWR			
1972–73	DWR		DWR	DWR	DWR			
1973–74	DWR		DWR	DWR	DWR			
1974–75	DWR		DWR	DWR	DWR			
1975–76								
1976–77								
1977–78								
1978–79								
1979–80								
1980–81								DWLC - ncd
1981–82								DWLC - ncd
1982–83								DWLC - ncd
1983–84								DWLC - ncd
1984–85								DWLC - ncd
1985–86								DWLC - ncd
1986–87								DWLC - ncd
1987–88								DWLC - ncd
1988–89	MI							DWLC - ncd
1989–90	MI	MI						DLWC
1990–91	MI	MI	MI	MI	MI			DLWC
1991–92	MI	MI	MI	MI	MI			DLWC
1992–93	MI							DLWC
1993–94	MI						DLWC	DLWC
1994–95	MI	MI	MI	MI	MI			DLWC
1995–96	MI	MI	MI	MI	MI			DLWC
1996–97	MI	MI	MI	MI	MI	HPID		DLWC
1997–98	MI	MI	MI	MI	MI		CI	DLWC
1998–99								

Code**: DWR =** (DWR 1998), DLWC = (DLWC 1998a), **MI** = Murrumbidgee Irrigation L Parker, pers. comm. **CICL**= Coleambally Irrigation Co-operative Limited (W Bolsch, pers. comm.), **HPID** = Hay Private Irrigation District. **ncd** = no crop data collected. Note that crop water use data are based on information about the total metered water use. In the case of the CIA, water use information will inlcude some groundwater.

Crop irrigation application rates in the Murrumbidgee catchment

	Yanco	Mirrool	Tabbita	Wah Wah	Bener'bah	Hay	CIA	Licensed Irrigators
1960–61			*	*	*			
1961–62			*	*	*			
1962–63			*	*	*			
1963–64			*	*	*			
1964–65			*	*	*			
1965–66			*	*	*			
1966–67			*	*	*			
1967–68			*	*	*			
1968–69			*	*	*			
1969–70			*	*	*			
1970–71			*	*	*			
1971–72			*	*	*			
1972–73			*	*	*			
1973–74			*	*	*			
1974–75			*	*	*			
1975–76								
1976–77								
1977–78								
1978–79								
1979–80								
1980–81								
1981–82								
1982–83								
1983–84								
1984–85								
1985–86								
1986–87								
1987–88								
1988–89								
1989–90								*
1990–91								*
1991–92								*
1992–93								*
1993–94								*
1994–95								*
1995–96								
1996–97								
1997–98							a	
1998–99								

* years where crop irrigation application rates can be determined

a Be aware that crop areas will be reported as the area irrigated by groundwater and surface supplies. Crop water use will be reported as the volume supplied to crops from surface supplies only. In the case of the CIA, irrigation application rates may be underestimated when groundwater extraction is not accounted for.

14.17 Total water used in the MIA

	1988–89	1989–90	1990–91	1991–92	1992–93	1993–94	1994–95	1995–96	1996–97	1997–98
Rice	199 029	332 569	384 906	540 106	127 996	159 273	495 086	446 903	519 262	212 488
Pastures	40 628	101 463	298 906	275 628	45 029	56 173	311 419	186 212	59 176	130 180
Winter cereals	2 496	12 843	20 549	33 377	5 571	2 558	89 161	82 129	16 585	20 900
Summer crops	2 803	6 006	26 013	6 305	2 710	6 957	19 911	5 616	20 900	27 590
Miscellaneous	7 854	1 200	5 452	15 295	203	276	19 722	14 976	3 932	24 875
Vegetables	6 379	21 956	38 190	30 281	4 717	15 175	45 657	32 375	6 606	44 930
Vines	2 913	17 588	26 587	19 171	nd	nd	39 623	36 028	nd	60 866
Citrus	11 363	42 507	42 460	46 235	14 592	20 864	57 692	50 634	28 646	5 579
Deciduous	3 776	1 895	2 571	1 437	nd	nd	5 487	4 298	nd	nd
Hort - small area (assess)	0	22 170	26 008	690	nd	nd	Nd	nd	nd	1 823
Stock & domestic	1 104	436	4 907	31 572	630	922	964	1 070	1 823	1 159
Sub total irrigation	**277 241**	**560 197**	**871 642**	**968 525**	**200 818***	**261 276***	**1 083 758***	**859 171***	**655 107***	**529 231***
Industrial	0	285	348	306	383	259	424	706	774	518
Town water	12 223	12 527	14 833	13 497	10 248	10 767	12 553	2 378	2 758	2 687
Total – all water users	290 568	573 445	891 730	1 013 900	680 795*	832 725*	1 097 699*	863 325*	1 052 025*	958 086*

Source: L Parker, pers. comm. *Total figures do not include water used on deciduous and horticultural crops.

14.18 Availability of data on rice: area and water use

Year	Yanco		Mirrool		Tabbita		Wah Wah		Benerembah		MIA total		Hay		CIA		Licensed Irrigators	
	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml
1960–61		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1961–62		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1962–63		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1963–64		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1964–65		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1965–66		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1966–67		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1967–68		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1968–69		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1969–70		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								

Year	Yanco		Mirrool		Tabbita		Wah Wah		Benerembah		MIA total		Hay		CIA		Licensed Irrigators	
	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml
1970–71		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1971–72		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1972–73		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1973–74		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1974–75		DWR met			DWR aerial	DWR met	DWR aerial	DWR met	DWR aerial	DWR met								
1975–76	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial									
1976–77	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial				DWR aerial		DWR aerial			
1977–78	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial				DWR aerial		DWR aerial			
1978–79	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial				DWR aerial		DWR aerial			
1979–80	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial		RGA aerial	RGA Ord	DWR aerial		DWR aerial			

Year	Yanco		Mirrool		Tabbita		Wah Wah		Benerembah		MIA total		Hay		CIA		Licensed Irrigators	
	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml
	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml
1980–81	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial		RGA aerial	RGA Ord	DWR aerial		DWR aerial	RGA met		
1981–82	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial		RGA aerial	RGA Ord	DWR aerial		DWR aerial	RGA met		
1982–83	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial		RGA aerial	RGA Ord	DWR aerial		DWR aerial, RGA seed	RGA met		
1983–84	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial		RGA aerial	RGA Ord	DWR aerial		DWR aerial, RGA seed	RGA met		
1984–85	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial		RGA aerial	RGA Ord	DWR aerial		DWR aerial, RGA seed	RGA met		
1985–86	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial		RGA aerial	RGA Ord	DWR aerial		DWR aerial, RGA seed	RGA met		
1986–87	DWR aerial		DWR aerial		DWR aerial		DWR aerial		DWR aerial		RGA aerial	RGA Ord	DWR aerial		DWR aerial, RGA seed	RGA met		
1987–88												RGA Ord			RGA seed	RGA met		
1988–89		MI met									RGA aerial	RGA Ord			RGA aerial			
1989–90		MI met		MI met							RGA aerial	RGA Ord			RGA aerial		DLWC survey	DLWC
1990–91		MI met		MI met		MI met		MI met		MI met	RGA aerial	RGA Ord			RGA aerial		DLWC survey	DLWC

Year	Yanco		Mirrool		Tabbita		Wah Wah		Benerembah		MIA total		Hay		CIA		Licensed Irrigators	
	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml	Ha	Ml
1991–92		MI met		MI met		MI met		MI met		MI met	RGA aerial	RGA Ord			RGA aerial		DLWC, survey, RGA seed	DLWC
1992–93		MI met									RGA aerial	RGA Ord			RGA aerial		DLWC Survey, RGA seed	DLWC
1993–94	MI	MI met	MI		MI		MI		MI		RGA aerial	RGA Ord			RGA aerial	MI met	DLWC Survey, RGA seed	DLW
1994–95	MI	MI met	MI	MI met	MI	MI met	MI	MI met	MI	MI met	RGA aerial	RGA Ord			RGA aerial		DLWC Survey, RGA seed	DLW
1995–96	MI	MI met	MI	MI met	MI	MI met	MI	MI met	MI	MI met	RGA aerial	RGA Ord			RGA aerial		DLWC Survey, RGA seed	
1996–97	MI	MI met	MI	MI met	MI	MI met	MI	MI met	MI	MI met	RGA aerial	RGA Ord		MI met	RGA aerial		DLWC Survey, RGA seed	
1997–98	MI	MI met	MI	MI met	MI	MI met	MI	MI met	MI	MI met	RGA aerial	RGA Ord			RGA aerial, CIL aerial	CIL met	DLWC Survey, RGA seed	

Sources and code: DWR = (DWR 1998), MI = Murrumbidgee Irrigation (L Parker, pers. comm.), DLWC = (DLWC 1998a), CI = Coleambally Irrigation (W Bolsch, pers. comm.), RGA = Rice Growers Association (M Hedditch, pers. comm.), C = crop statistics available, Survey = area irrigated is surveyed by meter inspectors who visit farms to record water use, Aerial = aerial photos are used to determine rice areas each year, Seed = area estimated from seed ordered. Ord = ordered water. These data represent the amount of water that a farmer ordered to irrigate a certain amount of land. Met = metered water. Where metered information is provided, the meter provides an estimate of the total volume of water used. Seed = area estimated from seed metering.

14.19 Area and water use data: Yanco Irrigation Area

Area irrigated (ha)

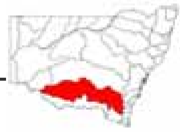
Crop type	Median area irrigated (ha) 1976 – 1987	Standard deviation (ML)	Std dev. %	% of total area
Cereals(grain)	16 653	4 030	24	28
Pastures(total)	15 924	2 530	16	27
Rice	14 636	1 189	8	25
Miscellaneous	7 546	1 887	25	13
Orchards	2 270	230	10	4
Fodder crops	1 197	598	50	2
Vines	429	49	11	1
Lucerne	384	257	67	1
Vegetables	302	258	85	1
Oil seed	70	405	578	0
Total (sum)	58 810	6 525	11	

Source: DWR (1998) ②

Water used (ML)

Crop type	Median water used (ML) 1960 – 1975	Standard deviation (ML)	Std. dev. %	% of total water use
Rice	117 378	14 117	12	46
Pastures (total)	85 502	26 816	31	34
Orchards	22 631	4 202	19	9
Fallow	20 552	8 497	41	8
Cereals (grain)	10 538	9 002	85	4
Lucerne	4 016	7 840	195	2
Miscellaneous	3 080	2 277	74	1
Vegetables	2 561	627	24	1
Stock & domestic	799	1 119	140	0
Fodder crops	756	1 040	138	0
Vines	278	334	120	0
Total (sum)	254 873	32 770	13	

Source: DWR (1998) ②



	Water used (ML)									
Crop category	**88–89**	**89–90**	**90–91**	**91–92**	**92–93**	**93–94**	**94–95**	**95–96**	**Av. water use**	**% of total water used**
Rice	199 029	189 008	146 032	192 672	127 996	159 273	181 464	158 343	169 796	61
Pastures	40 628	50 420	71 699	78 593	45 029	56 173	87 694	45 554	58 298	21
Citrus	11 363	22 976	16 279	24 108	14 592	20 864	25 746	22 629	21 802	8
Winter cereals	2 496	10 630	6 692	12 367	5 571	2 558	17 097	8 387	9 847	4
Vegetables	6 379	8 150	8 225	9 607	4 717	15 175	16 452	12 809	9 149	3
Summer crops	2 803	3 000	5 426	4 118	2 710	6 957	4 377	5 616	7 616	3
Vines	2 913		3 223						3 068	1
Hort – small area (assess)									2 878	1
Miscellaneous	7 854	1 200	4 861	791	203	276	337	1 185	2 389	1
Deciduous	3 776		569						2 173	1
Total	277 241	285 384	263 006	322 256	200 818	261 276	333 167	254 523	280 234	

Source: L Parker, pers. comm②

14.20 Area and water use data: Mirrool Irrigation Area

Area irrigated (ha)

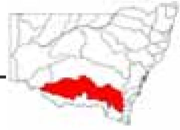
Crop type	Median area irrigated (ha) 1976 – 1987	Standard deviation (ML)	Std. dev. %	% area irrigated of total
Cereals(grain)	13 795	2 378	17	25
Rice	12 962	908	7	23
Pastures(total)	10 724	1 968	18	19
Miscellaneous	5 178	1 729	33	9
Orchards	4 221	376	9	8
Vines	4 184	115	3	8
Vegetables	1 433	789	55	3
Fodder crops	1 072	417	39	2
Oil seed	471	358	76	1
Lucerne	412	133	32	1
Total (sum)	**55 219**	**4 214**	**8**	

Source: DWR (1998) ②

Water used (ML)

	Water used (ML)										
Crop category	**89–90**	**90–91**	**91–92**	**92–93**	**93–94**	**94–95**	**95–96**	**96–97**	**97–98**	**Ave WU**	**% total**
Rice	143 561	123 953	164 986			159 019	140 887	162 200	155 318	149 989	67
Pastures	51 043	76 699	57 360			73 813	40 835	48 888	37 903	55 220	25
Vines	17 588	23 243	19 171			39 623	36 028	44 918	49 018	32 798	15
Citrus	19 531	26 181	22 127			31 946	28 005	32 220	30 827	27 262	12
Winter cereals	2 213	1 165	11 548			21 500	25 215	40 474	37 415	19 933	9
Hort - small area (assess)	22 170	25 344	690							16 068	7
Vegetables	13 806	18 003	13 075			16 817	8 723	7 068	7 146	12 091	5
Summer crops	3 006	16 407	783			15 534				8 933	4
Miscellaneous		127	7 663			9 009	5 548	11 261	8 980	7 098	3
Deciduous	1 895	2 002	1 250			5 483	4 298	5 405	4 388	3 532	2
Total	274 813	313 124	298 653			372 744	289 539	352 434	330 995	223 230	

Source: L Parker, pers. comm②



14.21 Area irrigated and water used: Benerembah Irrigation District

Area irrigated (ha)

Crop type	Median area irrigated (ha) 1960–75	Standard deviation (ML)	Std dev. %	% of total area irrigated
Pastures (total)	14 842	2 311	16	56
Cereals (grain)	5 844	1 889	32	22
Fallow	4 181	1 534	37	16
Miscellaneous	2 786	1 577	57	11
Rice	2 523	844	33	10
Lucerne	664	124	19	3
Fodder crops	563	486	86	2
Vegetables	108	152	141	0
Total (sum)	26 385	3 746	14	

Source: DWR (1998) ②

Crop type	Median area irrigated (ha) 1976–87	Standard deviation (ML)	Std dev. %	% of total area irrigated
Pastures (total)	11 755	2 632	22	32
Cereals (grain)	9 161	1 741	19	25
Rice	8 117	593	7	22
Miscellaneous	4 690	1 158	25	13
Vegetables	836	560	67	2
Fodder crops	674	269	40	2
Oil seed	558	519	93	2
Lucerne	234	133	57	1
Total (sum)	36 921	3 266	9	

Source: DWR (1998) ②

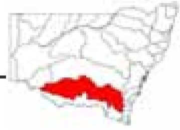
Water used (ML)

Crop type	Median water used (ML) (1960–75)	Standard deviation (ML)	Std dev. %	% total water use
Pastures (total)	39 390	13 386	34	49
Rice	30 318	6 295	21	38
Fallow	7 123	3 701	52	9
Cereals (grain)	5 380	3 887	72	7
Miscellaneous	2 107	2 345	111	3
Lucerne	1 809	698	39	2
Vegetables	583	611	105	1
Fodder crops	563	970	172	1
Stock & domestic	219	1	0	0
Total (sum)	80 495	13 722	17	

Source: DWR (1998) ②

	Water used (ML)									
Water use (ML) by crop type	1990–91	1991–92	1992–93	1993–94	1994–95	1995–96	1996–97	1997–98	Average	% of total water use
Rice	93 482	141 420			109 217	108 279	122 945	115 618	115 160	57
Pastures	71 056	48 438			52 239	41 659	43 626	29 238	47 709	24
Winter cereals	7 428	6 689			32 644	24 695	41 373	30 730	23 927	12
Vegetables	11 223	7 333			12 081	10 375	9 401	8 253	9 778	5
Miscellaneous	310	2 696			3 559	3 010	7 100	5 165	3 640	2
Summer crops	2 455	775							1 615	1
Hort - small area (assess)	561								561	0
Deciduous		187					174		72	0
Vines	121						12	1	27	0
Citrus										0
Total	186 636	207 538			209 740	188 018	224 631	189 005	202 489	

Source: L Parker, pers. comm②



14.22 Area and water used: Tabbita Irrigation District

Area irrigated (ha)

Crop type	Median area irrigated (ha), 1960–75	Standard deviation (ML)	Std dev. %	% of total area irrigated
Pastures (total)	2 173	485	0	59
Cereals (grain)	837	506	1	23
Fallow	319	204	1	9
Lucerne	229	146	1	6
Rice	166	70	0	4
Vegetables	31	22	1	1
Total (sum)	3 700	760	0	

Source: DWR (1998) ②

Crop type	Median area irrigated (ha) 1976–87	Standard deviation (ML)	Std dev. %	% of total area irrigated
Pastures (total)	2 200	361	16	41
Cereals (grain)	1 573	562	36	29
Rice	539	92	17	10
Fallow	450	364	81	8
Fodder crops	191	134	70	4
Lucerne	180	189	105	3
Oil seed	71	50	71	1
Vegetables	20	18	95	0
Total (sum)	**5 407**	**790**	**15**	

Source: DWR (1998) ②

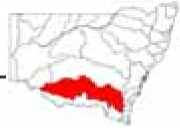
Water used (ML)

Crop type	Median water used (ML) 1960–75	Standard deviation (ML)	Std dev. %	% of total water use
Pastures (total)	6 831	2 403	0	64
Rice	2 102	602	0	20
Cereals (grain)	972	614	1	9
Lucerne	854	372	0	8
Vegetables	170	185	1	2
Fodder crops	155	140	1	1
Stock & domestic	55	7	0	1
Total (sum)	**10 705**	**2 203**	**0**	

Source: DWR (1998) ②

	Water used (ML)									
Crop category	**1990–91**	**1991–92**	**1992–93**	**1993–94**	**1994–95**	**1995–96**	**1996–97**	**1997–98**	**Average**	**% of total water use**
Pastures	13 240	11 767			16 559	9 282	11 744	5 253	11 308	57
Rice	3 576	7 117			5 616	4 665	5 723	5 131	5 305	27
Winter cereals	2 328	335			2 211	1 765	2 228	4 580	2 241	11
Miscellaneous		878			483	278	389	847	575	3
Vegetables	540	266			307	468	626	459	444	2
Hort – small area (assess)	103								103	1
Vines								18	6	0
Total	**19 787**	**20 363**			**25 176**	**16 458**	**20 710**	**16 288**	**19 982**	

Source: L Parker, pers. comm②



14.23 Area irrigated and water used: Wah Wah Irrigation District

Area irrigated (ha)

Crop type	Median area irrigated (ha) 1960–75	Standard deviation (ML)	Std dev. %	% of total area
Pastures (total)	4 587	956	0	38
Cereals (grain)	2 754	920	0	23
Fallow	2 746	1 467	1	23
Miscellaneous	1 271	801	1	10
Lucerne	676	129	0	6
Fodder crops	274	177	1	2
Vegetables	36	4	0	0
Cotton	32	5	0	0
Total (sum)	**12 183**	**3 008**	**0**	

Source: DWR (1998) ②

Crop type	Median area irrigated (1976 –87)	Standard deviation (ML)	Std dev. %	% of total area irrigated
Cereals (grain)	7 042	3 079	44	38
Pastures (total)	5 632	2 194	39	30
Miscellaneous	2 671	1 074	40	14
Rice	1 649	957	58	9
Fodder crops	528	269	51	3
Oil seed	426	468	110	2
Lucerne	165	179	109	1
Total (sum)	18 558	4 566	25	

Source: DWR (1998) ②

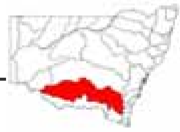
Water used (ML)

Crop type	Median water used (ML) (1960–75)	Standard deviation (ML)	Std dev. %	% of the total volume irrigated
Rice	18 654	4 607	0	58
Pastures (total)	8 567	5 329	1	27
Fallow	5 915	1 453	0	19
oil seed	4 850	3 963	1	15
Miscellaneous	2 477	1 717	1	8
Lucerne	2 277	807	0	7
Cereals (grain)	971	854	1	3
Stock & domestic	353	4 297	10	1
Cotton	312	127	0	1
Vegetables	212	92	0	1
Fodder crops	206	69	0	1
Total (sum)	**31 901**	**12 519**	**0**	

Source: DWR (1998) ②

	Water used (ML)									
Crop category	**1990–91**	**1991–92**	**1992–93**	**1993–94**	**1994–95**	**1995–96**	**1996–97**	**1997–98**	**Avg**	**% of total water used**
Pastures	66 212	79 470			81 114	48 882	49 054	58 814	63 924	53
Rice	17 863	33 911			39 771	34 729	48 044	49 581	37 317	31
Winter cereals	2 936	2 438			15 709	22 067	29 220	16 978	14 891	12
Miscellaneous	154	3 267			3 334	4 955	4 908	3 085	3 284	3
Summer crops	1 725	629							1 177	1
Vegetables	199						1 174	489	466	<1
Vines								16	5	<1
Deciduous					4			1	1	<1
Citrus										
Hort – small area (assess)										
Total	**89 089**	**119 715**			**139 932**	**110 633**	**132 400**	**128 964**	**121 065**	

Source: L Parker, pers. comm ②



14.24 Area irrigated and water used: Hay Private Irrigation District

Area irrigated (ha)

Crop type	Median area irrigated (ha) (1976 and 1987)	Standard deviation (ML)	Std dev. %	% of total area irrigated
Pastures (total)	834	135	16	87
Cereals (grain)	53	114	215	6
Fodder crops	24	14	59	2
Lucerne	21	11	51	2
Total (sum)	**961**	**86**	**9**	

Source: DWR (1998) ②

Water used (ML)

	Average water used per rotation (ML) (1996–97)	% of total water used
Paspalum	716.7	81
Subclover and rye grass	104.6	12
Lucerne	37.6	4
Wheat	14.4	2
Oats	6.6	1
Total	**879.8**	

Source: J Bissett, pers. comm

14.25 Area and water used: Coleambally Irrigation Area

Area irrigated (ha)

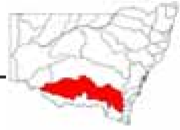
Crop type	Median area irrigated 76 & 1987	Standard dev. (ML)	Std dev. %	% of total area irrigated
Rice	21 919	1 728	8	42
Cereals (grain)	14 262	4 128	29	27
Pastures (total)	9 139	4 113	45	17
Miscellaneous	6 199	2 053	33	12
Oil seed	498	605	122	1
Fodder crops	368	554	151	1
Lucerne	203	234	116	<1
Vegetables	182	103	57	<1
Vines	51	7	13	<1
Orchards	38	132	347	<1
Total (sum)	**52 305**	**6 281**	**12**	

Source: DWR (1998) ②

Area irrigated (ha) and water used (ML) in 1997–98

Crop	Total Crop Area (ha) (includes surface water and groundwater)	% of total area	Total Water Used (ML) (surface water only)	% of total volume
Rice	24 624	35	324 507	70
Wheat	14 943	21	33 876	7
Winter Pasture	9 964	14	28 062	6
Soybeans	4 998	7	33 850	7
Barley	4 080	6	1 011	0
Summer Pastures	2 883	4	4 439	1
Fallow	2 733	4	3 653	1
Oats	2 680	4	3 505	1
Other	1 649	2	6 241	1
Canola	1 469	2	2 053	0
Maize	1 006	1	7 363	2
Triticale	890	1	550	0
Corn	672	1	3 519	1
Sorghum	502	1	4 489	1
Clover	435	1	1 406	0
Millet	239	0	658	0
Potatoes	156	0	564	0
Lucerne	117	0	627	0
Grapes	100	0	134	0
Citrus	10	0	183	0
Carrots	5	0	10	0
Totals	**71 241**		**460 877**	

Source: W Bolsch, pers. comm②



14.26 Area and water used by licensed irrigators outside the Irrigation Areas and Districts

	1989–90		1990–91		1991–92		1992–93		1993–94		1994–95	
Crops	**Area (ha)**	**Water used (ML)**	**Area (ha)**	**Water used (ML)**	**Area (ha)**	**Water used (ML)**	**Area (ha)**	**Water used (ML)**	**Area (ha)**	**Water used (ML)**	**Area (ha)**	**Water used (ML)**
Winter pasture	33 443	125 667	44 388	177 908	46 520	219 588	34 661	156 118	31 053	165 103	32 441	181 102
Summer pasture	20 502	85 232	15 820	102 184	17 474	104 653	7 754	32 607	9 277	42 395	20 562	87 504
Rice	1 790	18 436	1 815	23 325	5 338	66 033	7 593	68 632	10 242	96 853	13 151	129 092
Maize			3 061	23 063	1 569	17 332	2 264	6 863	2 034	9 953	4 556	31 238
Millet	3 220	15 765	878	3 624	852	4 593	262	672	890	2 679	4 266	23 400
Summer cereal	4 133	31 639	2 485	24 818	2 332	26 011	2 474	25 994	2 605	13 531	4 045	29 680
Winter cereal	867	2 208	136	342	661	1 158	660	2 285	445	1 698	2 958	6 592
Lucerne	2 338	10 749	1 874	12 735	2 020	14 457	2 517	9 706	2 260	8 642	2 800	16 850
Vegetables	2 124	11 991	2 387	16 987	2 272	14 275	1 520	5 186	2 973	7 768	2 191	10 271
Oats	578	1 404	540	1 389	728	1 037	318	384	378	529	1 503	4 473
Pre irrigation	87	52	928	1 602	893	1 317	1 042	2 178	1 490	2 909	1 315	1 242
Sorghum	549	3 162	324	3 553	172	669	60	219	517	7 263	1 274	4 055
Citrus	58	96	100	383	251	2 361	326	943	316	1 268	1 129	5 439
Winter grains											1 078	5 071
Cotton					60	89	300	2 836	2 120	13 242	1 000	2 655
Canola	250	738							508	2 029	755	3 036
Summer grains											670	1 246
Fodder	46	152	32	114	93	211	31	36	27	27	552	1 823
Wheat	913	1 311	1 618	2 998	1 733	5 541	494	1 164	1 422	4 341	523	3 082
Soy beans	426	2 344	676	4 836	538	4 662	374	1 247	1 745	12 502	298	899
Orchard	119	477	130	620	120	350	137	287	314	548	245	1 146
Sudax			29	93	110	703	5	3	85	189	123	219
Vines	7	52	50	378	32	297	8	56	25	221	72	324
Triticale			157	866	22	129			16	10	47	131
Rape	12	23	171	367	581	1 545	260	889	106	282	21	16
Turf			4	50	12	81	12	60	16	86	18	141
Barley	20	39	18	16		17			16	15		
Chickpeas					10	7						
Fababeans					933	2 970			108	1 265		
Legumes	8	5							76	123		
Lupins					25	50						
Nursery					3	11						
Storage		4 290	20	10 388	20	10 236		1 561		1 944		10 324
Sunflower	881	6 468	677	5 742	401	4 141	1 562	4 349	818	3 078		
Total	**72 371**	**322 298**	**78 316**	**418 378**	**85 772**	**504 524**	**64 632**	**324 275**	**71 878**	**400 491**	**97 589**	**561 052**

Source: DLWC (1998a) ②

Volume extracted by irrigators along the river

Year	Volume metered (ML)
1983–84	254 206
1984–85	282 249
1985–86	352 242
1986–87	315 431
1987–88	388 970
1988–89	236 400
1989–90	333 244
1990–91	407 394
1991–92	519 030
1992–93	336 316
1993–94	454 923
1994–95	595 021

Source: DLWC (1996)

14.27 Stressed stream classification in the Murrumbidgee catchment

An environmental stress rating or each of the freshwater subcatchments within the Murrumbidgee catchment was determined using the following environmental indicators:

- extent of riparian vegetation;
- geomorphological health;
- presence of major dams;
- barriers to fish passage;
- gully erosion;
- dryland salinity;
- presence of acid sulfate soils; and,
- water quality (indicative purposes only – not used in decision tree).

Following the analysis of these indicators, an overall environmental stress rating for each subcatchment was made. The environmental stress was determined using a decision tree method. This method was used for both the estuarine and freshwater indicators. Where two-thirds of the environmental indicators returned a high classification for a particular subcatchment, the overall environmental stress was assessed to be high. Where two thirds of environmental indicators returned a low classification for a particular subcatchment, the overall environmental stress was determined to be low. The remaining subcatchments were classified as being of medium environmental stress.

The hydrological stress of a subcatchment was calculated as the estimated proportion of daily flow that has been made available for extraction under existing licences. This required estimation of streamflow and water use.

Streamflow estimation was made using information available through DLWC's flow gauging network and a range of hydrologic predictive techniques to extend estimates into rivers without local gauging sites. Estimates of the peak monthly water extractions have been made using the surface water returns lodged by licence holders. However, not all survey cards are returned to DLWC and the volumes were adjusted for the proportion of licence holders who have chosen not to lodge a return. A hydrologic index (indicating hydrologic stress) was derived for each subcatchment for current use and full water use development by proportioning estimated water extraction to the estimated streamflow. Each subcatchment was then classified as being of low (0 to 30% extraction of flow), medium (40 to 60% extraction) or high (70 to 100% extraction) hydrologic stress. The data that were used to generate hydrological and environment stress ratings and therefore management options were not always reliable. For example, the hydrological stress rating was determined using crop return card information and is a source that is known to be unreliable. Despite underlying difficulties and concerns with the data, the assessment provides the most comprehensive overview of the land and water resources of subcatchments in the Murrumbidgee catchment.

The matrix showing stress categories and the ratings given to individual subcatchments in the Murrumbidgee catchment are provided in Table 16 and Table 17 respectively.

Table 16. Stress matrix

	Low environmental stress	Medium environmental stress	High environmental stress
High proportion of water extracted	**CATEGORY U1.** Despite high levels of water extraction, the river seems reasonably healthy. However, more detailed evaluation should be undertaken to confirm. It is also likely that conflict between users may be occurring during critical periods.	**CATEGORY S3.** Water extraction is likely to be contributing to environmental stress.	**CATEGORY S1.** Water extraction is likely to be contributing to environmental stress.
Medium proportion of water extracted	**CATEGORY U2.** There is no indication of a problem and, therefore, such rivers would be a low priority for management action.	**CATEGORY S4.** Water extraction may be contributing to environmental stress.	**CATEGORY S2.** Water extraction may be contributing to environmental stress.
Low proportion of water extracted	**CATEGORY U4.** There is no indication of a problem and, therefore, such rivers would be a low priority for management action.	**CATEGORY U3.** Environmental stress is likely to be due to factors other than water extraction and, as stress is not high, these rivers would be a low priority for management action.	**CATEGORY S5.** While environmental stress is likely to be due to factors other than water extraction, the high level of environmental stress means it is important to ensure extraction is not exacerbating the problem.

Source: DLWC (1999d)

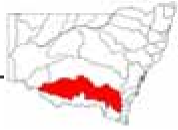


Table 17. Stress ratings for subcatchments in the Murrumbidgee catchment

Subcatchment	Environmental stress	Hydrologic stress	Management Class	Future risk
Queanbeyan	low	low	U4	none
Goodradigbee	low	low	U4	none
Tantangara	low	low	U4	none
Molonglo	medium	low	U3	none
Bredbo	medium	low	U3	none
Goobarragandra	medium	low	U3	none
Billabung	medium	low	U3	none
Bombowlee/Brungle/ Adjungbilly	high	low	S5	none
Yass (lower)	high	low	S5	none
Houlaghans	high	low	S5	none
Kyeamba	high	low	S5	none
Upper Mirrool	high	low	S5	none
Lower Mirrool Creek	high	low	S5	none
Numeralla (east)	medium	medium	S4	none
Murrumbidgee I	medium	high	S3	none
Gilmore/Sandy	medium	high	S3	none
Adelong	medium	high	S3	none
Burkes/Bullenbung	medium	low	S3	none
Numeralla (west)	high	medium	S2	none
Tarcutta	high	medium	S2	none
Hillas	high	medium	S2	none
Muttama	high	medium	S2	none
Murrumbidgee II	high	high	S1	none
Burra/Googong	high	high	S1	none
Jugiong	high	high	S1	none
Yass (upper)	high	high	S1	none

Source: DLWC (2000c) ② Unres = unresolved

14.28 Area of crops (ha) irrigated from unregulated supplies in the Murrumbidgee catchment

	Area irrigated (ha)					
Crop	**1993–94**	**1994–95**	**1995–96**	**1996–97**	**1997–98**	**1998–99**
Trees - other	16	16	16	8	1 525	3 033
Trees -orchards	1 182	1 246	1 278	1 374	1 416	1 338
Summer cereal	114	112	180	344	1 034	1 168
Lucerne	1 263	1 257	1 102	1 065	942	1 047
Perennial pasture	1 032	1 079	900	1 029	972	888
Winter cereal	710	789	1 003	1 060	1 143	879
Annual pasture	1 122	1 356	1 280	1 246	1 337	613
Pulses	140	100	226	236	246	365
Vegetables	470	455	621	600	586	269
Winter oilseeds	30	45	108	288	40	266
Summer oilseeds	0	5	11	30	456	236
Fodder	278	392	316	315	247	213
Other	220	179	166	144	209	188
Vines - wine grapes	107	119	124	143	180	183
Rice	160	255	305	320	370	70
Turf	61	63	68	68	68	68
Nuts	20	20	20	20	19	19
Nurseries	14	14	14	14	15	15
Citrus	10	10	10	30	30	10
Vines - table grapes	0	0	2	2	2	5
TOTAL	**6 949**	**7 512**	**7 748**	**8 335**	**10 836**	**10 872**

Source: DLWC (2000c) ②. Area (ha) and water use (ML) of crops irrigated in the Murrumbidgee Catchment from unregulated rivers (DLWC 1998) for theJuly to June water year (based on raw and incomplete data).

Crops	1989–90	1990–91	1991–92	1992–93
Winter pasture (ha)	1 052	2 024	1 428	3 419
Other (ha)	427	585	453	539
Summer pasture (ha)	681	494	859	407
Lucerne (ha)	284	466	869	396
Vines (ha)	22	67	100	124
Vegetables (ha)	149	190	288	51
Summer cereal (ha)	217	177	477	46
Summer oil (ha)		170	77	45
Winter cereal (ha)	226	125	841	39
Winter oil (ha)		78	28	
Citrus (ha)		60	83	
Wheat (ha)	15		10	
Total area (ha)	3 044	4 434	5 510	5 065
Water usage (ML)	13 473	19 879	26 670	20 926

Source: DLWC (1998a) ④

Crops	1993–94	1994–95
Citrus (ha)	10	
Grapes (ha)	5	
Lucerne (ha)	758	142
Millet (ha)	53	
Oats (ha)	10	
Orchard (ha)	638	38
Other crops (ha)	8	3
Other vegetables (ha)	48	2
Potatoes (ha)	14	
Rice (ha)	122	
Sorghum (ha)	75	
Soybeans (ha)		77
Summer pasture (ha)	409	
Sunflower (ha)		152
Turf (ha)	14	
Vines (ha)	102	14
Winter cereal (ha)	10	
Winter pasture (ha)	1 729	35
Total area irrigated (ha)	**4 005**	**462**
Water usage (ML)	*19 070*	*631*

Source: DLWC (1998a) ④