NSW Mid-Coast Region Irrigation Profile

Incorporating Hunter, Manning, Karuah and Central Coast catchments

compiled by Meredith Hope
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, NSW Agriculture, for the Water Use Efficiency Advisory Unit, 37 Carrington Street, Dubbo, NSW, 2830.

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1. EXECUTIVE SUMMARY

The NSW Mid-Coast Region Irrigation Profile was developed from a study to obtain regional and industry-based assessments of water use efficiency. The *Profile* details (where possible, by water source) 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
- irrigated crop yields
- irrigation methods
- the value of irrigated agriculture

in the NSW Mid-Coast region.

The NSW Mid-Coast region includes the Manning catchment, the Karuah, Great Lakes and associated catchments, the Hunter catchment, and Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments (also known as the Central Coast catchments). Irrigation data in the public domain were collected from State and Commonwealth sources, published research and industry reports and unpublished reports.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).

This report does not attempt to calculate or analyse regional and industry-based estimates of WUE. This will be carried out in a subsequent report.

1.1 An overview of NSW Mid-Coast irrigation

Approximately 80% of the irrigated area in the NSW Mid-Coast region is in the Hunter catchment. The remainder is scattered along the major rivers and streams throughout the Manning, Karuah, Great Lakes and associated catchments and the Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments. Approximately 14% of the State's irrigation licences exist in the NSW Mid-Coast region and 12% of the enterprises that irrigate are this region. Only 2% of the total area irrigated in New South Wales is in the NSW Mid-Coast region (Table 1).

Wine grapes and pasture for dairy cows are the two most important irrigated industries in the region. Eighty percent of the total area irrigated in the NSW Mid-Coast region is pasture, and 7% is wine grapes. The area irrigated on individual farms is small compared with the rest of the State. Broadarea and dairy properties in the NSW Mid-Coast region irrigate an average of 43 ha, compared with 189 ha on broadarea and dairy farms in the rest of New South Wales. A typical vineyard may irrigate 50 ha. The dominant method used to water pasture and lucerne is spray irrigation, while wine grapes are irrigated using drip.

Table 1. Summary of irrigation data for the NSW Mid-Coast region in 1996–97

Source of water	Total irrigated area (ha)	Total water used by irrigated agriculture (ML)	Number irrigation licences	Number enterprises irrigating	Yield of major irrigated crop (t/ha)	Value of irrigation ($ m)
NSW total	1,150,000	7,700,000	24,000	7,846	cotton 1.8	2,496
All sources, NSW Mid-Coast region	26,582	nd *Estimate 114,700–146,400*	3,347	972	perennial pasture 15	nd *57, Hunter catchment only*
Regulated, NSW Mid-Coast region	nd *10,704 – 22,053 (1989–90 to 1990–91)*	nd *25,638 (1989–90)*	788	nd *reg & unreg. 1,414 (1993–94)*	nd	nd
Unregulated, NSW Mid-Coast region	17,298 (40% is perennial pasture)	nd *13,099 to 44,758 (1989–95)*	1,759		nd	nd
Groundwater, NSW Mid-Coast region	nd *7,817 (1993–94)*	nd *76,000 (1980)*	800	nd *228 (1993–94)*	nd	nd
Farm dams, NSW Mid-Coast region	nd *4,829 (1993–94)*	nd	na	nd *232 (1993–94)*	nd	nd
Town water supply, NSW Mid-Coast region	nd *262 (1993–94)*	nd	na	nd *32 (1993–94)*	nd	nd

nd = No data, na = Not applicable

The total value of irrigated agriculture in the Hunter catchment was $57 million in 1996–97. This represented roughly 2% of the total value of irrigated agriculture in New South Wales. A large proportion of this irrigated value can be attributed to livestock products ($31 million). Wine grapes were the next most valuable industry ($14 million).

1.2 Irrigation data issues

There were a number of data issues raised in the NSW Mid-Coast region Irrigation Profile. Generally, these relate to the scarcity of data, the lack of data at useful scales and the reliability of available data.

1.2.1 Scarcity of data

In the past, data have been collected for purposes (for example, DLWC billing and regulation requirements) which are different from the current needs for natural resource planning and for the planning and management of irrigation industry: data collected for these purposes are scant or missing.

Collection strategies affect the usefulness of data. Strategies employed by the ABS (Australian Bureau of Statistics) mean that only years with the same EVAO[1] can be compared.

1.2.2 Lack of data at useful scales

Point-scale data collected by ABS and ABARE (Australian Bureau of Agricultural Resource Economics) are confidential and have been reported at SLA, catchment or Agro-Ecological Region scales (AER). These scales limit how usable these data are for local users, who often need information at much smaller scales such as river reach or subcatchment.

1.2.3 Reliability

Reliability varied with collection strategy and by source of water. For example, irrigation data from regulated rivers were more reliable compared with irrigation data from unregulated, groundwater and farm dam sources. Extraction from regulated rivers is metered and data are collected for DLWC billing purposes. For all other sources, there has been no requirement by the DLWC to collect information about extraction. Voluntary surveys were used to collect data from the unregulated system. Poor survey return rates and farmer estimates of water use (rather than metered water use) reduce the reliability of the captured data.

The reliability of data is not always reported by State agencies. It is difficult to know what level of confidence to place in data-sets obtained from agencies.

Animosity by irrigators toward data-collecting agencies may downgrade the reliability of captured data.

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[1] The population to be surveyed is determined from the Estimated Value of Agricultural Operations or EVAO is estimated from a procedure that takes into account the value of the area of crops sown and the numbers 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.

1.2.4 Storage of data not centralised

Storage of data is not centralised. Information on yields, areas, water use, methods and value were drawn from many different sources.

1.3 Conclusion

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

- Crop data are needed, that is, crop water use and irrigated area. Better monitoring is needed to help develop strategies to manage and effectively balance environmental and irrigation industry water needs.
- Data are needed at scales that are large enough to protect point-scale confidentiality (for example, enterprise level) but small 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 will help users make better decisions about the usefulness of the data and will help prevent users manipulating data inappropriately.
- 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 assist them make better water management decisions. This could in turn, over time, improve the reliability of information that is collected from irrigators.

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.

2. INTRODUCTION

During 1998, a desktop study was undertaken to develop a comprehensive database of NSW irrigation statistics. This was done to obtain regional and industry-based assessments of on-farm water use efficiency (WUE). From this study, Irrigation Profiles, or situation statements of irrigation, were developed for each of the major regions in New South Wales.

This *Profile* focuses on the NSW Mid-Coast region (Figure 1) and attempts to document what is known about the number of irrigators, the area irrigated and water used in total and by crop, irrigated yield, irrigation methods and the value of irrigated agriculture.

This Profile does not attempt to calculate WUE from these data and analyse their reliability and accuracy. This analysis will be carried out in a subsequent report.

2.1 Background

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

1980	An assessment of irrigation was undertaken by the Water Resources Commission (WRC 1980) in NSW.
1986	The Water Resources Commission (WRC 1986) undertook a comprehensive assessment of irrigation in New South Wales. The study highlighted a lack of data on crop areas irrigated, water used, irrigated yields and financial returns.
1980–89	A report on crop areas irrigated, yields of irrigated crops and the values of individual irrigated commodities between 1980 and 1989 was developed for NSW (DWC 1990).
1988–92	Sloane (1993) provided an overview of the number of farms and the area irrigated in four broad agricultural regions in New South Wales between 1988 and 1992.
1986–2002	The Australian Bureau of Statistics (ABS) has been collecting information on irrigation for various years since 1986 (ABS 1998a).
1950s–2002	The NSW Department of Land and Water Conservation (DLWC) and its predecessors have also collected information over the last 50 years on the area irrigated and water used by irrigated agriculture across New South Wales.
1996–97	More recently, the Australian Bureau of Agricultural Resource Economics (ABARE 2000) completed a survey of broadarea and dairy enterprises in each of the major catchments in New South Wales.

INTRODUCTION

Despite the apparent collection of ample statistics in New South Wales 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 on:

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 have been added to the list: the crop type, the irrigated yields that are being obtained, the irrigation methods being used and the value of irrigated agriculture.

Accurate and reliable irrigation data are needed for planning purposes and to assess the impacts of management rules on the irrigation industry.

- 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 year 5. Draft water-sharing plans developed for the region (DLWC 2002) include the Central Coast unregulated river source (Jillby Jillby Creek and Ourimbah Creek); the Kulnura Mangrove Mountain groundwater source; the Regulated Hunter River and Glennies Creek water source and Paterson River water source; the Tomago Tomaree Stockton groundwater source; and the Lower North Coast (Karuah River) water source.

- 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, for example the Lower North Coast Catchment Management Board Draft Catchment Blueprint (LNCCMB 2001), require data on irrigation to enable the impact of these plans to be assessed.

- In all Australian states, programs have been initiated to improve WUE and IE in irrigated agriculture. In NSW, WUE officers have been appointed across the State to help calculate farm WUE and IE and to help improve farm water management.

- A structural adjustment package (RAA and NSW Agriculture 2002), jointly managed by NSW Agriculture and the NSW Rural Assistance Authority, aims to help irrigators adjust to new water sharing arrangements. Irrigation data are needed to describe the situation now and after the package is implemented.

In summary, more accurate and reliable irrigation data are needed to help strategically focus efforts to improve WUE, provide communities with information on irrigation to aid decision making, 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 from State sources, including the DLWC, and from Commonwealth sources including the ABARE and the ABS. Electronic data collected include:

1. ABS Irrigation Statistics Catalogue, AgStats (ABS 1998a). The ABS has collected information by Statistical Local Area (SLA), and in most instances, these units can be aggregated into the NSW Mid-Coast region. For a definition of an SLA see Appendix 14.1. For the grouping of SLAs used in the NSW Mid-Coast region, see Figure 2.

   The NSW Mid-Coast region comprises four main areas (WRC 1980; EPA 1997):

   - Manning catchment
   - Karuah, Great Lakes and associated catchments
   - Hunter catchment
   - Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments (also known as the Central Coast catchments).

   Only the most current years (1993–94, 1995–96 and 1996–97) with the same Estimated Value of Agricultural Operations (EVAO)[2] and the same collection method have been compared (Table 2).

   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 still being collected).

   Catchment totals may be over-estimated when SLAs cross into other catchments. A surface licence-based concordance was used to proportion data within SLAs to catchments (appendix 14.2). Port Stephens is a notable example: it lies in both the Karuah, Great Lakes and associated catchments and in the Hunter catchment, but all its irrigation licences occur within the Hunter catchment. For this Profile, 100% of the data from Port Stephens SLA are included in the Hunter catchment.

   Only 30.14% of surface licences in the Gosford SLA fell inside the Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments. The remainder fell within the

[2] The population to be surveyed is determined from the Estimated Value of Agricultural Operations, or EVAO. That value is estimated from a procedure that takes into account the value of the area of crops sown and the numbers of livestock on holdings at a point in time as well as the crops produced and the livestock turn-off during the year. The aggregation of these commodity values is the EVAO.

Hawkesbury–Nepean catchment. For this Profile, only 30.14% of the data in the Gosford SLAs has been included (appendix 14.2).

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 NSW Mid-Coast region is the reporting unit for the 1996–97 survey of irrigators by ABARE. These data (ABARE 2000) cannot be disaggregated into smaller units such as SLAs or catchments.
3. a DLWC database of crop area and water use, developed for use by NSW Agriculture (DLWC 1988b). The DLWC has collected information on water use and area by crop type and by licence and these data can be aggregated to any small scale: stream reach, subcatchment or any large scale (catchment scales)
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. A preliminary irrigation profile or situation statement of irrigated industries operating within the NSW Mid-Coast region was developed from this information. The profile was further developed in collaboration with NSW Agriculture staff in regional offices. As these staff uncovered regional data (for example, unpublished reports), those data were incorporated into the profiles.

Table 2. EVAOs 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
1999–00	22,500	AER
2000–01	5,000	SLA

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

Figure 1. The NSW Mid-Coast region

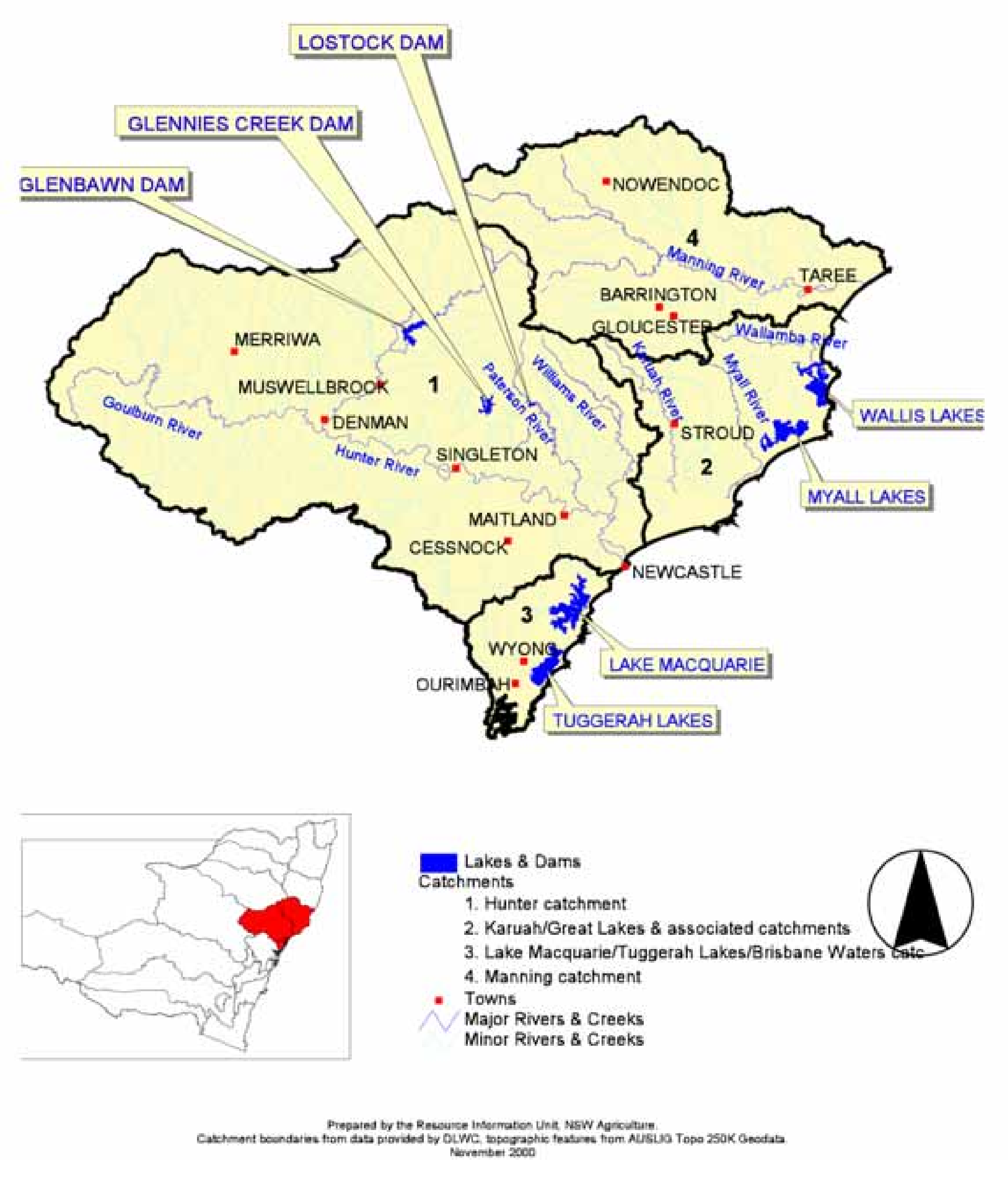

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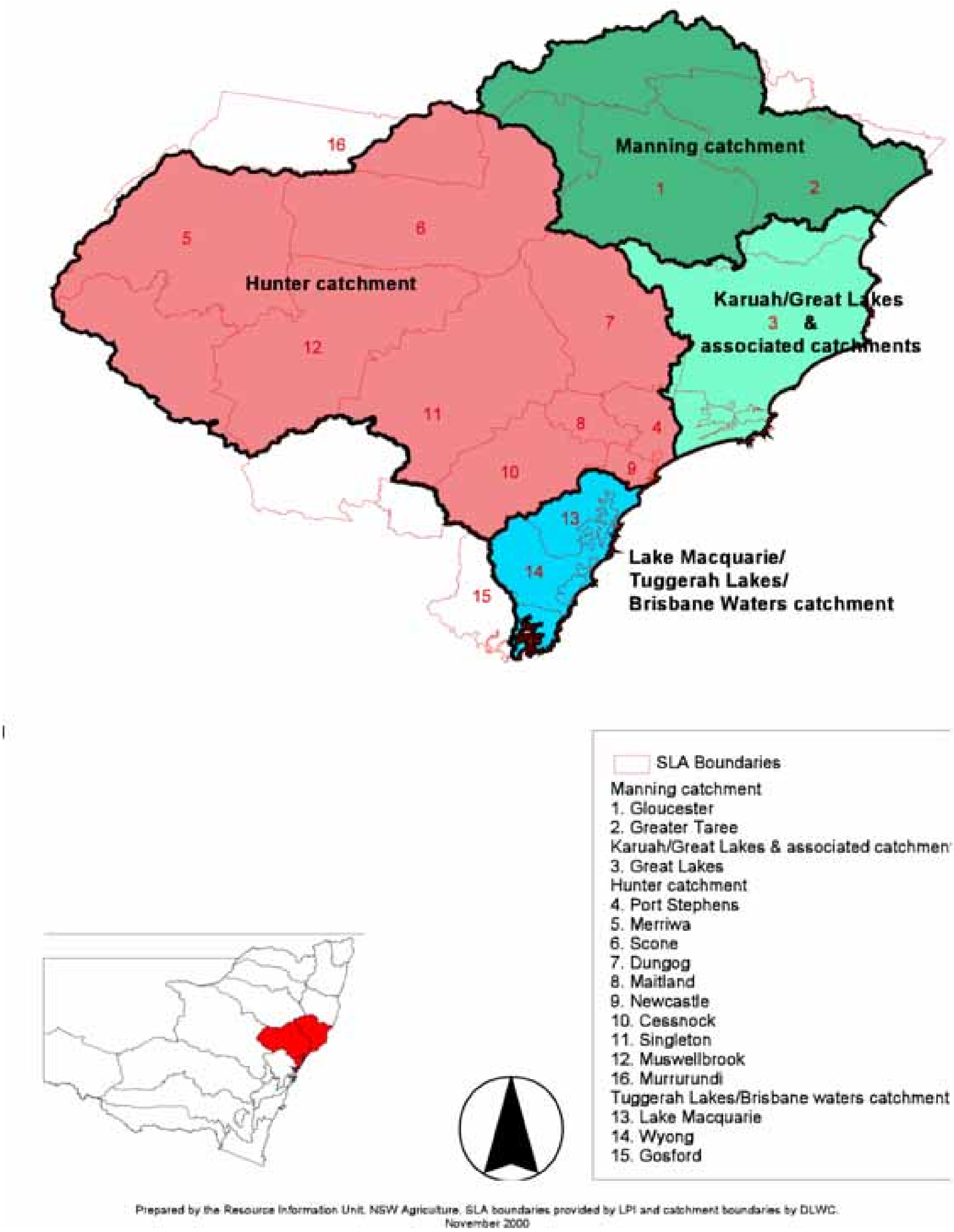
Figure 2. SLAs and catchments in the NSW Mid-Coast region



3.2 Rating data reliability

The reliability of these 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 (that is, a survey that lacks detailed investigation or modelling, a preliminary survey).
4. **Class D:** 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 irrigation enterprises in the Hunter region was 1,038 (ABS 1998a, ②)'.

3.3 Structure of Profile

This report summarises the availability and reliability of data for five water sources: regulated rivers; unregulated rivers; groundwater; farm dam supply; and town water (reticulated) supplies. The data have been presented by water source because availability and reliability varied markedly for different water sources.

A description of these sources follows.

Regulated rivers[3] are those rivers that have been declared by the Minister, by order published in the *Gazette*, to be a regulated river. Regulated rivers have their flows

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[3] **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) or any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows; and, controlled by major government-owned dams (*Water Management Act 2000* (NSW)). These capture water that is then released to users downstream when needed (DLWC 1999a). The Hunter catchment has the only regulated rivers in the NSW Mid-Coast region: the Hunter River, Glennies Creek and parts of the Paterson River.

Unregulated rivers are all other 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 1999a).

Groundwater is contained within an aquifer. An aquifer is a geological structure or formation, or an artificial landfill, which is permeated with water or is capable of being permeated with water (*Water Management Act 2000* (NSW)).

Farm dam water is water from dams that exists on first, second or third order water courses as shown on topographic maps or that has been captured from overland run-off (DLWC 1999g).

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

This report summarises (where available, by water source and by region):

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. irrigated yield
7. value of irrigated production.

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

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

4. REGIONAL IRRIGATION OVERVIEW

4.1 Region description

The NSW Mid-Coast region is north of Sydney, along the centre of the New South Wales coast (Figure 1). The region is bordered in the north by the Hastings catchment; in the south by the Hawkesbury-Nepean; by the Great Dividing Range in the west; and the Pacific Ocean in the east.

The following sections describe each of the catchments in sequence from north to south.

4.1.1 Manning catchment

The Manning catchment (Figure 1) has an area of 8,400 km^2 and consists mainly of rugged slopes with few lowland areas and alluvial flats. Approximately 22% of the catchment is heavily timbered and most of this is very steep country (15 degrees or more) (DLWC 1999f).

The Manning River receives water from:

- Nowendoc, Cooplacurripa, Mummel and Rowleys rivers, which drain water from the north-eastern sections of the catchment
- Barnard River, which drains water from the western portion of the catchment
- Barrington and Gloucester rivers, which drain water from the south-eastern sections of the catchment

The Manning River is 250 km long and its catchment has the largest annual discharge of any of the rivers in the NSW Mid-Coast region (Table 3). It has the third largest annual average discharge on the New South Wales coast (EPA 1997). The middle and lower sections of the catchment are highly fertile due to the weathering of volcanic deposits in elevated areas and this is where most agricultural activities occur (DLWC 1999f). The major population centres include Wingham, Nowendoc, Barry, Barrington and Gloucester.

Significant industries in the area include oyster production, farming, forestry, fishing, manufacturing and gravel quarries. Coal exploration also takes place (DLWC 1999f).

4.1.2 Karuah River, Great Lakes and associated catchments

The Karuah River, Great Lakes and associated catchments (Figure 1) are 4,480 km^2 and have the third largest average annual discharge in the region (Table 3). The major towns in the catchment are Stroud, Bulahdelah, Karuah, Nabiac and Forster.

This group of catchments is characterised by an extensive section of riverine plain that stretches inland about 20 km, and a 'drowned' coastline that consists of a series of lagoons including Boolambayte Lake, Myall Lake, Smiths Lake and Wallis Lakes. The catchment has river valleys that can be 1.5 km wide in the upper reaches and up to 7 km wide in the lower reaches.

Table 3. Flow characteristics of major rivers in the NSW Mid-Coast region

Catchment	Manning	Karuah, Great Lakes and associated catchments	Hunter	Lake Macquarie, Tuggerah Lakes, Brisbane Waters
Ann. Discharge (× 1000 ML)	2,270	1,300	1,680	366
Max. ann. discharge ÷ mean ann. discharge	2.95	2.9	5.5	2.9
Min. ann. discharge ÷ mean ann. discharge	0.12	0.11	0.07	0.24
Evaporation (min–max, mm)	800–1,000	800–1,000	950–1,400	900–1,000
Ann. rainfall (min–max, mm)	660–1,840	1,080–1,250	560–1,150	1,070
Av. ann. run-off (mm)	270	290	76	225
Rainfall pattern	Summer-dominant, December through to April. Dry from July to Nov.	Summer-dominant. Low rainfall in winter and spring.	Uniform throughout the year.	Summer-dominant with lower rainfall in spring.

Source: DWR 1995

Three main tributaries from north to south are:

- Wallamba River, which drains directly into Wallis Lake (EPA 1997).
- Myall River, which drains into Myall Lake.
  This watercourse then drains water south to Port Stephens via Myall Lake.
- Karuah River, which drains directly into Port Stephens.

Beef cattle farming is the dominant agricultural practice in the Karuah, Great Lakes and associated catchments (Hassall & Associates 1996). Poultry and dairying are also important. The rise of the poultry industry[4] has followed the recent decline of the dairy industry around the upper and middle sections of the catchment (DLWC 2000a). Other important industries include oyster farming and fishing (worth $10 million annually) and tourism around Port Stephens. Coal mining has been proposed at Stroud Road area (DLWC 2000a).

4.1.3 Hunter catchment

The Hunter catchment (Figure 1) extends further inland than any other coastal catchment in New South Wales. It is 22,000 km^2 (DWR 1995). The main population centres include Newcastle (approximately 500,000) Maitland (47,000), Cessnock (30,000), Singleton (12,000) and Muswellbrook (10,000) (EPA 1997).

The Hunter River may swell to more than five times the average annual discharge in extreme years (Table 3) and the catchment has the second largest average annual discharge in the region, after the Manning catchment (Table 3).

Large floods have formed broad, fertile, alluvial fans (Garman 1980) that commence near Scone and around Merriwa in the western part of the valley (DWR 1995). The floodplains range from 3 to 24 km in width (DLWC 2000a) and approximately 1,000 km^2 of land is protected by flood levees (DWR 1995). The largest flows occur on the Hunter River at Singleton and Maitland (Table 4).

The floodplains of the Hunter catchment are regarded as prime agricultural land and were developed because they were flat, fertile, and had good access to surface water and groundwater. These flat lands were also close to townships and good transport. Coal associated with the central lowlands is mined from these flat lands (Garman 1980). When the area was first settled in 1804 maize was grown and shipped to England. Dairy and vegetable farms were established in the mid-1800s (DWR 1995). Today, agricultural activities include cattle, dairy, eggs, poultry, wool, sheep, race horses, cereal crops and wine grapes. Grazing by cattle occurs throughout the northern half of the catchment (DLWC 1995) and olives are emerging as an important crop (HVRC 1999).

The Hunter catchment is one of the most highly developed agricultural and industrialised regions in Australia (Hunter Regulated River Management Committee 1998). Its main activities include power generation, coal mining, heavy industry, agriculture and fisheries (DLWC 1999c). The Hunter catchment has, in Newcastle, the second largest urban area in New South Wales.

[4] There have been no instances of Newcastle Disease in the Karuah, Great Lakes and associated catchments.

Table 4. Average yearly flows in the Hunter catchment

River	Flow (ML/ann.)
Goulburn River at Sandy Hollow	210,000
Wollombi Brook at Warkworth	160,000
Paterson River at Gostwyck	285,000
Williams River at Glen Martin	355,000
Hunter at Glenbawn	165,000
Hunter at Muswellbrook	330,000
Hunter at Singleton	860,000
Hunter at Maitland	870,000
Total long-term average annual run-off	1,680,000

Source: DWR 1995

A credit scheme initially proposed by Eberhardt and Wright (1995) creates the opportunity to reduce saline discharge from mine sites by improved operations or on-site treatment of water (EPA 2000). The scheme described by DLWC (1995) protects irrigated crops by timing the discharge of saline mine water. The method was first carried out on a trial basis by Harris and Hunter Water Quality Task Group (1994) and only allows saline mine water to be discharged during high flow events in the Hunter River. The scheme is now being formalised under the Protection of the Environment Operations Act 1997. The draft regulation is called the Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation.

4.1.4 Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments

Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments is 1,876 km^2 (Figure 1) and the main towns are Cardiff, Belmont, Swansea, Avondale, Wyong and Tumbi Umbi. Flooding is a threat to development within the catchment and there is an extensive system of mitigation works to protect the fertile alluvial floodplains and urban centres from damage (DLWC 1999e).

The main industries in the area include power generation, coal mining, sandstone and sand mining, heavy industry, agriculture, tourism, food and textiles, infrastructure and fisheries (DLWC 1999e). The main agricultural activities include dairy, beef cattle, poultry, citrus, orchards, wine grapes and horse and cattle studs (DLWC 1999e). Nurseries are also an important industry in the area (B. Yiasoumi, pers. comm.).

4.2 Climate

The NSW Mid-Coast region ranges from subtropical in the northern catchments, especially along the coast, to extremely dry and temperate in the inland areas. The Manning catchment is subtropical with average annual rainfalls of 1,840 mm along the coast. Snowfalls can occur in the Barrington Tops and Nowendoc areas (DLWC 2000a). Rainfall decreases from east to west (DLWC 1999f) and the western inland fringes receive annual average falls of 660 mm (Table 3). The catchment has a summer-dominant rainfall pattern with drier periods between July and November (Table 3; appendix 14.3). The Karuah, Great Lakes and associated catchments experience humid, subtropical weather with an annual rainfall of between 1,080-1,250 mm (Table 3). Inland, the climate tends to be drier and more temperate and rainfall may be as low as 660 mm (DWR 1995). Rainfalls are highest between January and March and then again in June and are lowest in spring (appendix 14.4). At Nelson Bay, the mean maximum for January is 27.5^{o}C and the mean minimum for July is 7.7^{o}C (DLWC 2000a). The Hunter catchment is relatively dry, especially in the western regions, compared with other coastal catchments (EPA 1997). Rainfall can be erratic and the catchment suffers from periodic droughts and floods.

Again, rainfall decreases progressively from east to west (Bureau of Meteorology 2000; Day 1982a). The Goulburn Valley receives an average of 700 mm/annum (DWR 1995) whereas coastal regions receive 1,150 mm. Most of the run-off is sourced from the Mount Royal Ranges and Barrington Tops highland area, which contributes 40% of the catchment's run-off but only constitutes 13% of the land area (DWR 1995).

Rainfall is more evenly distributed throughout the year in the Hunter catchment than in catchments further north. However, the region still experiences summer-dominant rainfall, with less rainfall between May and September (DWR 1995; Clewett et al. 1999; appendix 14.5). Evaporation increases progressively from east to west. The Goulburn Valley has double the evaporation (1,800 mm/yr) (DWR 1995) of the coast and highlands (800 mm/yr) (DWR 1995). Maximum average temperatures inland are around 30^{0}C to 33^{0}C, while the night-time average minimum is 17^{0}C. Coastal temperatures are generally milder but temperatures can range from –8^{0}C to 49^{0}C in extreme conditions (DWR 1995). River flows are least in spring and most in winter and summer (DWR 1995). Peak irrigation requirements are greatest over spring and summer (Figure 3).

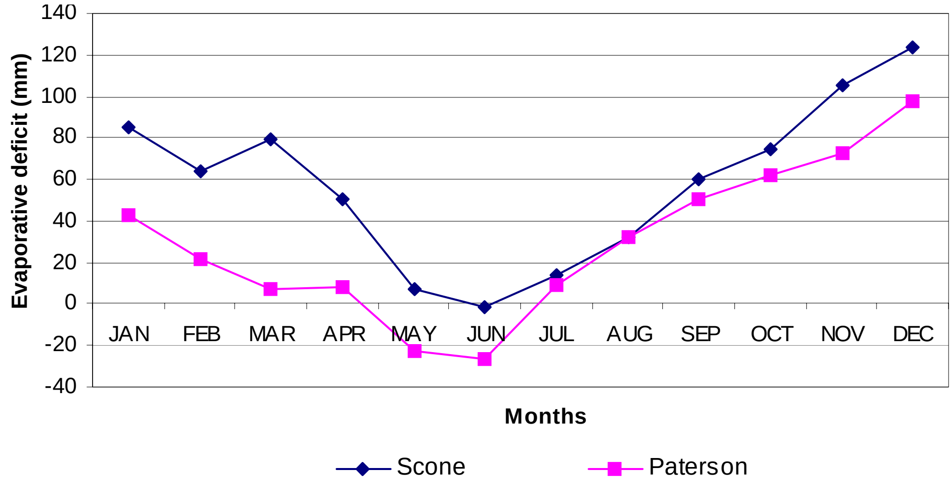
The climate of Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments varies depending on elevation and proximity to the coast (DLWC 1999e). This group of catchments has an average annual rainfall of 1,070 mm/yr and the smallest annual discharge of any catchment in the NSW Mid-Coast region (Table 4). This is mostly because it has the smallest area of all the catchments in the region. The rainfall decreases with distance inland (DLWC 1999e). Rainfall is summer-dominant with the highest rainfall occurring between December and June while the lowest rainfall occurs in the spring months (appendix 14.6).

4.3 Population

The population of the NSW Mid-Coast region in 1996 was 844,404, representing 14% of the total population in New South Wales. Most people in the Hunter catchment live in the towns of Maitland, Cessnock, Raymond Terrace, Singleton, Kurri Kurri, Muswellbrook, Scone, Branxton Greta and Newcastle (DLWC 2000a; DWR 1995). The population growth rate is highly variable, with major growth centres from 1986 to 1991 being Dungog and Singleton, contrasting with a long-term decline in Newcastle (DLWC 2000a).

Figure 3. Evaporative deficit at Scone and Paterson weather stations

Evaporative deficit = reference evapotranspiration[5] – rainfall



Source: Climatic data from the Bureau of Meteorology (2000)

The population has grown in all catchments between 1986 and 1996, with the Karuah, Great Lakes and associated catchments and Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments showing the greatest growth (ABS 1999b; appendix 14.7). Most of the population in the Karuah, Great Lakes and associated catchments is located around Port Stephens: this area is experiencing an annual growth rate of approximately 4% per year (DLWC 1999d) or 42% between 1986 and 1996 (ABS 2000). In Lake Macquarie, Tuggerah Lakes and Brisbane Waters catchments, the SLAs of Wyong and Gosford showed the largest increases (41% and 32% respectively) between 1986 and 1996. The population in the Wyong Shire is expected to continue to increase over the next 20 years from 123,139 in 2001 to 200,000 in 2020 (DLWC 1999e). In contrast, the city of Gosford is expected to experience a decline in population (DLWC 1999e).

[5] The evapotranspiration from a clipped grass surface having 0.12-m height and bulk surface resistance equal to 70 sm^{-1} (Allen *et al.* 1998).

In 1996, approximately 22% of the population were either under 15 or between 30 and 44 years of age (ABS 2000). Around 0.2% of the population were born overseas, a much lower figure than in other regions such as the Hawkesbury–Nepean (4%) and the South Coast (2%).

5. IRRIGATION FROM ALL SOURCES

5.1 Description of irrigation

Irrigated agriculture occurs throughout the region along the major rivers and tributaries, although most irrigated land (80%) is concentrated in the Hunter catchment (ABS 1998a). The location of irrigated crops is summarised in Table 5.

Table 5. Location of main irrigation crops in the NSW Mid-Coast region

Crop	Location	References
Pasture for dairy	Along the Manning River in the Manning catchment	DLWC 1999f
	Upper and middle sections of Karuah River, Great Lakes and associated catchments	DLWC 1999d
	Along the Hunter River from above Scone to below Maitland in the Hunter catchment	DWR 1995
	Downstream of the Oakhampton Bridge and for the full length of the tidal reach along the Paterson River in the Hunter catchment	DWR 1995
	Scattered through Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments	DLWC 1999e
Vineyards	Alluvial flats of the Hunter catchment	Catt and Beckingham 1988a; 1988b
Turf	Downstream of the Oakhampton Bridge and for the full length of the tidal reach along the Paterson River in the Hunter catchment	DWR 1995
Maize	Hunter alluvium	A. Richards, pers. comm.
Vegetables*	Downstream of the Oakhampton Bridge and full length of tidal reach along the Paterson River in the Hunter catchment	A. Richards, pers. comm. DWR 1995

* vegetables: cabbages, cauliflowers, melons, potatoes, pumpkins

The following section provides a description of irrigation in each of the NSW Mid-Coast region's catchments and is presented in sequence from north to south.

5.1.1 Manning catchment

The Manning catchment has the highest concentration of dairy farms in New South Wales (Hassall & Associates 1996). At last count there were 159 dairies in the catchment representing a large decrease from 230 dairies in 1999 (N. Bullock, pers. comm.) Dairy farmers use irrigation to ensure high quality pasture for milk production or to supply emergency feed during drought (Griffiths 1995). Cereals and vegetables are also grown in the region.

5.1.2 Karuah River, Great Lakes and associated catchments

Pasture is the most important irrigated crop in the Karuah River, Great Lakes and associated catchments. Again, irrigation is used to ensure high quality pasture for milk production or to supply emergency feed during drought (Griffiths 1995). Fruit and nuts are grown in the Port Stephens SLA (ABS 1998a).

5.1.3 Hunter catchment

Irrigation is scattered throughout the Hunter River system, concentrating along the Goulburn River systems. It occurs downstream along the major tract of the Hunter floodplain to the Paterson confluence and along the Paterson River (Day 1982b). The Hunter Valley Wine Country Private Irrigation District has just come into operation in 2001 and supplies water pumped from the Hunter River from Whittingham to 400 irrigators (*pers. comm.* N. Cross) ④. The Broke Fordwich PID was established in 2001 pumps water from Mount Thorley to about 180 irrigators (*pers. comm.* N. Cross)④.

Irrigation in the Hunter catchment is used to help grow pasture and lucerne for dairy farms. These farms are located mainly along the Hunter River above Scone and below Maitland and along the Williams River and Paterson River (below Lostock Dam). Dairy enterprises are also located along the Goulburn River, Wollombi Brook and Pages River (Table 5) and along the Williams River (Brennan 1998). A typical dairy farm in 1983 was 161 ha, of which 36 ha was irrigated, and produced 370,000 litres of milk per farm per annum (Hassall & Associates 1983). More recent figures suggest that the average volume of milk produced per dairy farm is 678,000 litres (McKenzie 1998). This figure relates to the Hunter catchment and Sydney metropolitan area. ABS figures suggest that the average area of pasture irrigated on enterprises in the Hunter catchment was 47 ha in 1993–94 and 37 ha in 1996–97 (ABS 1998a).

Farmers irrigate pasture to ensure establishment of newly sown pasture, the survival of sensitive perennial pasture during dry times (Griffiths 1995; Nott 1981) or good growth of annual pasture. During spring and summer, 75–85% of all milk production is estimated to come from grazing lucerne. About 1,500,000 bales of lucerne are produced each year for on-farm consumption and off-farm sale (Nott 1981) or around 37,500 tonnes. Between 8,000 and 10,000 ha of lucerne were irrigated in the Hunter catchment in the early 1980s (Nott 1981). More recent 1995–96 ABS statistics show that around 59,300 tonnes of lucerne were produced from 10,000 ha of land.

Feed for dairy cows also includes paspalum, sorghum and kikuyu. Grains grown during summer are also harvested to supply winter rations for these dairy farms (Hassall & Associates 1983).

Vineyards are an important irrigated enterprise in the Hunter catchment. They are located along the Goulburn River and Wollombi Brook (pers. comm. P. Brock) and on the alluvial flats of the Hunter. Vineyards are highly capital-intensive and profitability is sensitive to interest rates, outside the immediate control of management, and levels of equity (Catt and Beckingham 1988a; 1988b). In the late 1980s, vineyards in the lower Hunter catchment had a maximum size of about 300 ha. On average, these each cultivated 100 ha of wine grapes and typical farms grew Shiraz, Semillon or Chardonnay varieties. Some vineyards remained unirrigated while others were highly dependent on irrigation. Data from Catt and Beckingham (1988b) suggest that, of the 100 ha of grapes cultivated on a typical property, an average of 53 ha was irrigated. Current data (④) suggest that between 70% and 90% of the area on a typical property is now irrigated (pers. comm. A. Richards; pers. comm. N. Cross).

Other less significant irrigated crops include turf, cereal, wheat and vegetables (EPA 1997). Cropping of maize and vegetables in the Hunter catchment occurs mostly along the Hunter River, around Scone and between Merriwa and Cassilis (DLWC 1995).

5.1.4 Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments

Irrigation in Lake Macquarie, Tuggerah Lakes, and Brisbane Waters is on a minor scale compared with other NSW mid coast catchments. Irrigated crops include fruit and nuts, vegetables and irrigated pasture for dairy (ABS 1998a) and turf.

5.1.5 Irrigation from all sources: summary

Table 5 and Table 6 provide a summary of the data that are available for all sources of water. There is a lack of information on the total amount of water used in the region. This is largely due to a lack of collection of data on water used from unregulated, groundwater, farm dams and reticulated supplies.

Table 6. All sources: summary of irrigation data, the NSW Mid-Coast region

Year	Number enterprise irrigating	Total irrigated area (ha) [a]	Area of major crop irrigated (ha) [a]	Water used by irrigated ag. (ML)	Water use by lucerne (ML)	Yield of major crop (t/ha)	Value of irrigation ($ m), Hunter catchment only	Value of major crop ($ m), Hunter catchment only – livestock products
1988–89	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-
1990–91	-	-	-	-	-	-	-	-
1991–92	-	-	-	-	-	-	49	22
1992–93	-	-	-	-	-	-	55	24
1993–94	1,201	36,659	34,450	-	-	-	44	26
1994–95	-	-	-	-	-	-	51	29
1995–96	785	22,847	-	-	-	-	51	31
1996–97	972	26,582	21,483	-	79,200	-	57	31
1997–98	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to	S 5.2	S 0	S 0	S 0	S 0	S 5.5	S 5.6	S 5.6

[a] ABS 1998a, [b] ABARE 2000, [c] Donovan 2000 ③

Number of licences (all sources)

There are estimated to be 3,347 licences with the purpose of irrigation in the NSW Mid-Coast. Most of these are area-based (now volume-based) licences on unregulated streams (Table 7).

Table 7. Number of licences by source of water

Source of water	Licence number and reliability rating	Reference
Regulated	788 ①	DLWC 2000b
Unregulated	1,759 ①	Sum of DLWC 1999c; 1999d; 1999e; 1999f
Groundwater	800 ①	DLWC 2000a
TOTAL	**3,347**	

About 100 irrigators in the tidal areas of the Hunter and Paterson rivers are not required to have a licence to irrigate. In the past they could not be guaranteed a fresh supply of water and were only required to obtain a pumping permit (N. Cross, pers. comm.). However, with the provision of end-of-system flows in the Hunter and Paterson rivers, the frequency of periods of acceptable water quality in the river has increased. As a result, enterprises have expanded to utilise this resource (DLWC 2000a).

5.2 Number of enterprises using irrigation (all sources)

The NSW Mid-Coast region has an estimated 972 enterprises irrigating (ABS 1998a, ②). Most of these are concentrated in the Hunter catchment SLAs of Muswellbrook, Scone, Singleton and in the Manning catchment SLA of Greater Taree. (ABARE 2000) indicate that of these, 600 are broadarea or dairy farms[6].

[6] Care should be taken when comparing ABARE and ABS figures since each agency used different collection cut-offs (EVAO). ABARE used an EVAO of $22,500 while ABS used an EVAO of $5,000.

IRRIGATION FROM ALL SOURCES

The total number of enterprises irrigating, by catchment, are provided in Table 8. Comparisons between different sources of data have a generally close result.

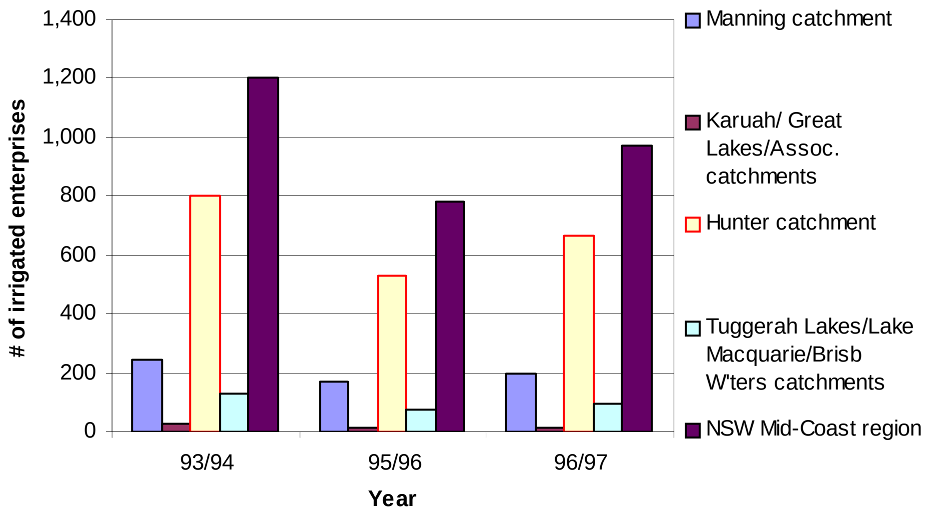
Table 8. Number of enterprises irrigating in each catchment

Catchment	Number of enterprises irrigating	Reference and reliability rating
Manning	171 enterprises	EPA 1997, ④
	194 enterprises	ABS 1998a, ②
Karuah, Great Lakes and assoc. catchments	15 enterprises	Hassall & Associates 1996, reliability rating unknown
	15 enterprises	ABS 1998a, ②
Hunter	669 enterprises	ABS 1998a, ②
Lake Macquarie, Tuggerah Lakes, Brisbane Waters	94 enterprises	ABS 1998a, ②

Both the number of enterprises irrigating crops (Figure 4, ②) and the total area irrigated (see, ②) have decreased in each SLA in the NSW Mid-Coast region between 1994 and 1997. See also appendix 14.8. This drop is a trend that has occurred in most SLAs across the State. Climatic factors do not explain the drop (appendix 14.9). Rainfall was above the long-term average for 1993–94, 1994–95 and 1996–97. In the Hunter catchment, the allocation from the Glenbawn Dam at the beginning of the irrigation season (spring) was similar for all three seasons (appendix 14.10).

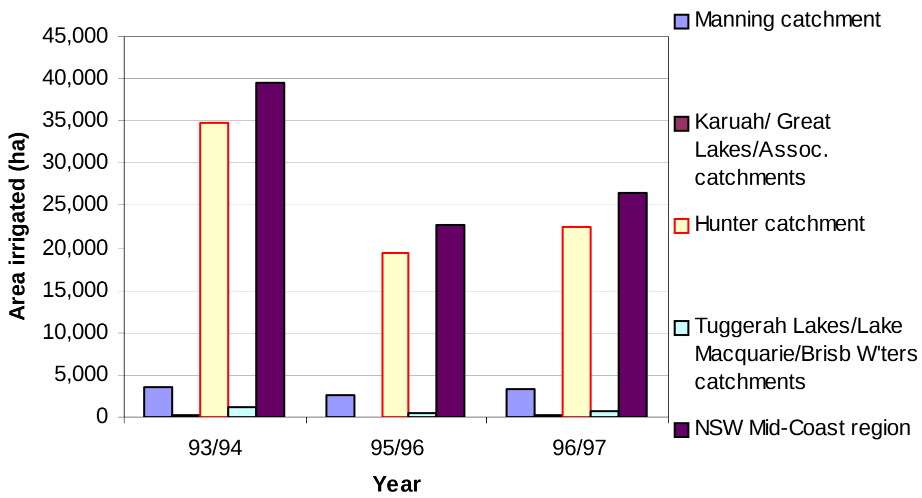
A possible explanation is that the 1996–97 irrigation season was the first year that information on the volume of water used was sought by the ABS. Data on the irrigated area were also collected from these enterprises. In surveys before the 1996–97 census, only irrigated area data were collected. Many irrigators do not know how much water they apply and this question alone may reduce the response rate to other irrigation questions generally (M. Raine 2000, pers. comm., July).

Figure 4. Number of enterprises irrigating in the NSW Mid-Coast region



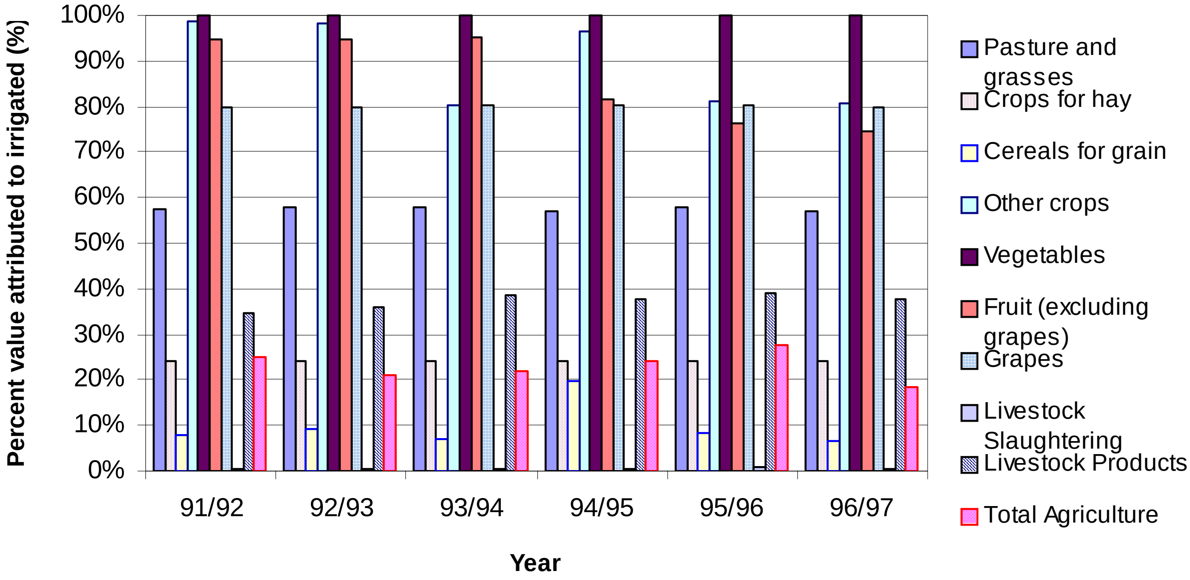
Source: ABS 1998a, ②

Figure 5. Area irrigated (ha) in the NSW Mid-Coast region



Source: ABS 1998a ②

Figure 6. Total value of produce (%) that can be attributed to irrigation in the Hunter catchment



Source: Donovan 2000, ③

Figure 7. Area of irrigated pasture (ha) in the NSW Mid-Coast region

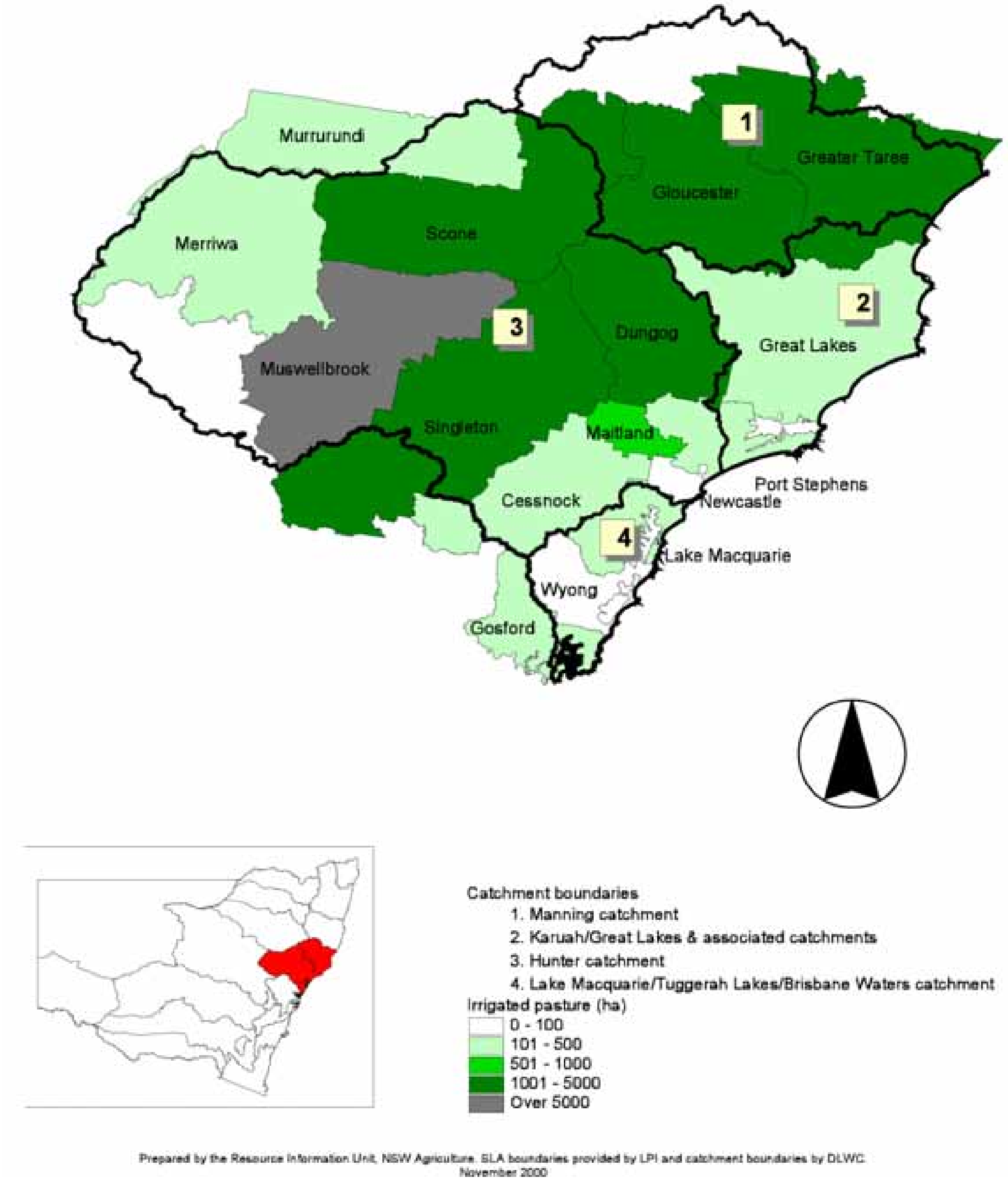
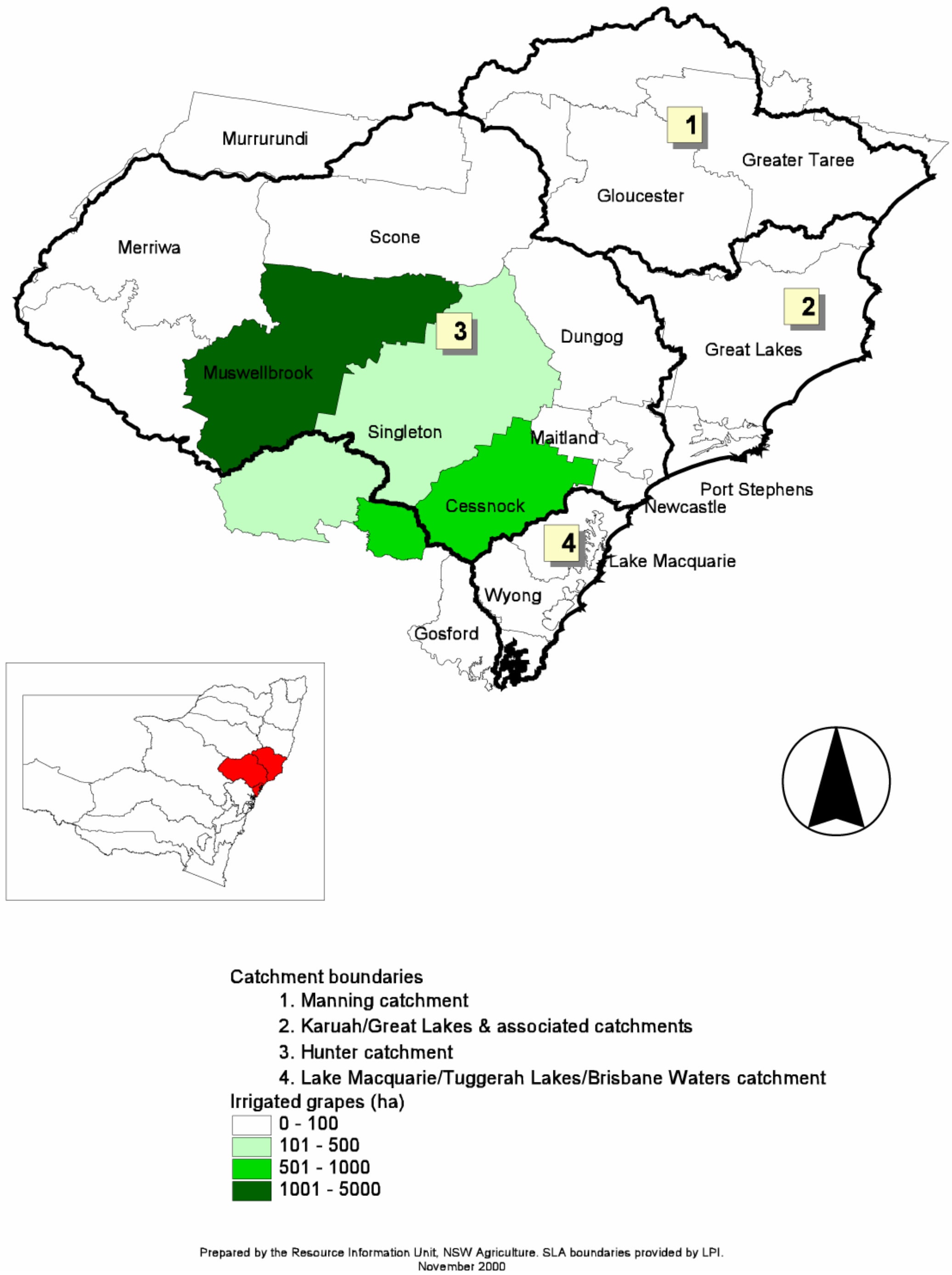


Figure 8. Area of irrigated grapes (ha) in the NSW Mid-Coast region



5.3 Area irrigated and water used (all sources)

5.3.1 NSW Mid-Coast region

Area irrigated - In 1993–94 the total area irrigated from all sources of water in the NSW Mid-Coast region was 36,659 ha; by 1996–97 it had decreased to 26,582 ha (ABS 1998a) ② (Figure 8). The later data may underestimate the irrigation area for reasons given in section 5.2.

The major irrigated crops in the NSW Mid-Coast region are pasture and grapes.

Approximately 80% of the irrigated land in the NSW Mid-Coast region in 1996–97 was pasture, concentrated in the SLAs of Muswellbrook, Singleton and Scone in the Hunter catchment (appendix 14.11). Although the number of enterprises irrigating pasture and the area of pasture irrigated appear to have decreased between 1993–94 and 1996–97 (ABS 1998a) ②, as noted in section 5.2, this may not reflect the true situation.

In 1996–97 grapes represented roughly 7% of the total area irrigated in the NSW Mid-Coast region. Grapes are concentrated in the SLAs of Muswellbrook and Cessnock (Figure 8). Unlike other crops, the area of grapes irrigated and the number of enterprises irrigating grapes increased between 1993–94 and 1996–97 (ABS 1998a) ② (appendix 14.11).

Water use – There are no data on the total volume of water used from all sources in the NSW Mid-Coast region. This is because total volumes extracted by irrigation are rarely collected and, where data are collected, the information is only available for a limited number of years.

Information on water use for different crops is poor. ABARE (2000) provides the only information on water use from all sources by broadarea and dairy farms only. In other words, enterprises growing only vines, fruit or vegetables were excluded. These data show that:

- lucerne used 79,200 ML in 1996–97 (ABARE 2000) ③. In 1983, it was estimated that the application rate for lucerne was 10.9 ML/ha (Hassall & Associates 1983) ③. In 2000, the average irrigation requirement[7] (IR) for lucerne was estimated at 6.6 ML/ha (C. Rose 1999, pers. comm., June, ④). Theoretical irrigation requirements for the NSW Mid-Coast region range from 4.5 ML/ha to 6.5 ML/ha (Table 9).

- pasture used 49,800 ML in 1996–97 (ABARE 2000, ③) and, on average, 4 ML/ha of irrigation water were applied (ABARE 2000, ③) (RSE 10). Other sources suggest

[7] 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 (ML/ha or mm).

that the irrigation requirement for pasture is 6 ML/ha (A. Wilson 1999, pers. comm., June) ④. Theoretical irrigation requirements for the NSW Mid-Coast region ranged from 4.5 ML/ha to 7.5 ML/ha depending on pasture management and climatic zone (Table 9, see also appendix 14.12, ④).

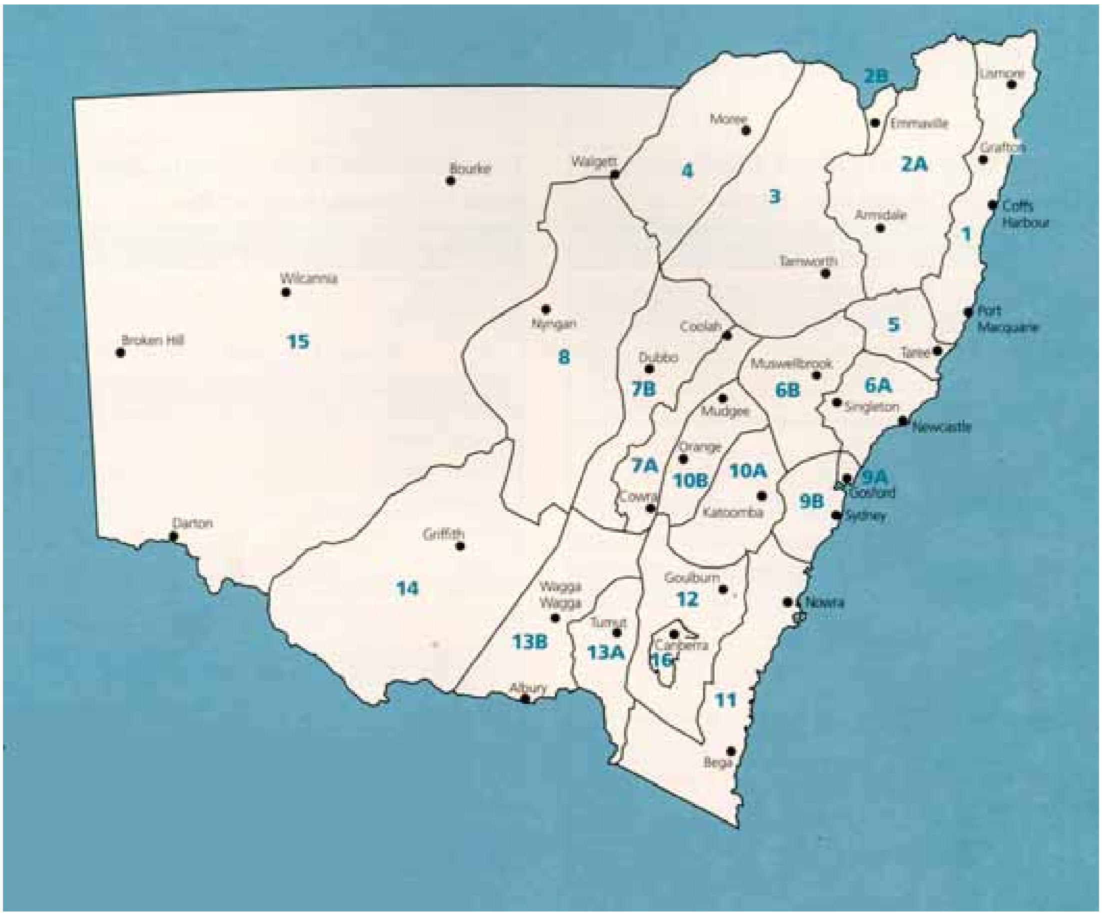
Table 9. Irrigation requirements (ML) of crops in the NSW Mid-Coast region

Crop description	1	5	6A	6B	9A
Annual pasture	3	3	3.5	4	2
Citrus	3.5	5	6		3.5
Lucerne	4.5	5	6	6.5	4.5
Nurseries		20	20	20	
Nuts	5.5	6.5	8	9.5	6
Olives	4		5	6.5	3.5
Perennial pasture, extensive grazing	4.5	5	5	5.5	5
Perennial pasture: dairy	6.5	7	7	7.5	7
Pulses	4	4	5		3
Summer cereal	2	3	4	5	3
Summer oilseeds	2	3	4		
Trees: orchards	5.5	6.5	8	9.5	6
Turf	10	11	11	11.5	10
Vegetables	6	6.5	8	9.5	5.5
Vines: table grapes			3		
Vines: wine grapes	1.5		3	4.5	1.5
Winter cereal	2.5	2.5	3	3	
Winter oilseeds	3.5			4	

Values represent the average irrigation requirement for each climatic zone (see Figure 10). The figures are the amount of water required by each crop class after rainfall. An efficiency of 70% has been assumed.

Source: DLWC 2000d

Figure 9. Climatic zones used for volumetric conversion



5.3.2 Manning catchment

Area: Approximately 12% of the total area irrigated in the NSW Mid-Coast region occurs in the Manning catchment (appendix 14.8). Pasture and cereals are the main irrigated crops.

Water use: No data were available on the total volume of water used from all sources in the Manning catchment. The highest volume is likely to be used on pasture and cereals, although there are no statistics to support this.

5.3.3 Karuah River, Great Lakes and associated catchments

Area: The Karuah River, Great Lakes and associated catchments account for about 2% of the total area irrigated in the NSW Mid-Coast region. Pasture is the main irrigated crop.

Water use: There were no available data on the total volume of water used in the Manning catchment, nor were there data on the amount of water used on different crops.

5.3.4 Hunter catchment

Area: Around 21,438 ha were irrigated in the Hunter catchment in 1996–97 (ABS 1998a, ②[8]). Irrigation has expanded considerably since the 1980s. In 1985, the total area irrigated was 8,500-9,000 ha and was predicted to rise to 37,000 ha by 2000 (Dragun 1985).

Pasture, followed by grapes and cereals, was the main irrigated crop in the Hunter catchment. In 1996–97, approximately 17,000 ha of pasture were irrigated, representing around 80% of the total area (ABS 1998a, ②[9]). Pasture areas decreased significantly in the SLAs of Cessnock, Maitland, Murrurundi and Merriwa (appendix 14.11). As noted previously, this apparent decline in irrigated area and also in the number of enterprises irrigating was evident across the NSW Mid-Coast region and across the State and may reflect unreliable data.

Water use: Most of the information on water usage in the NSW Mid-Coast region relates to the Hunter catchment alone. In the Hunter catchment, total usage of water by all industries (mining, agriculture, domestic, and others) is between 200,000 and 250,000 ML/yr, which is 12–15% of the average annual discharge (DWR 1995). Power generation uses about 70,000 ML/yr while domestic users consumed 85,000 ML/yr (EPA 1997).

In 1985, it was estimated that irrigation in the Hunter catchment used about 70,000 to 80,000 ML/yr (Day 1985) and that by 2000 it could be as much as 211,000 ML/yr (Dragun 1985)[10]. However, in 1995, irrigated agriculture in the Hunter catchment used between 40,000 and 100,000 ML/yr (DWR 1995, reliability rating unknown). Licence amnesties may have had an impact on the expansion of the irrigation industry in the region.

There are no data on total crop water use in the Hunter catchment, as the availability of data varies from water source to water source.

5.3.5 Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments

Area irrigated: Around 1,000 ha of land were irrigated in Lake Macquarie, Tuggerah Lakes and Brisbane Waters catchment. By 1996-97, the area had dropped to 744 ha. Pasture and fruit and nuts were the dominant irrigated crops in the catchment.

Water used: There were no data available on water used in total and by crop type.

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[8] The reliability of ABS data is questionable for the reasons provided in section 5.2. The area irrigated in the Hunter Catchment could be more than is shown.

[9] The reliability of ABS data is questionable for the reasons provided in section 5.2. The area irrigated in the Hunter Catchment could be more than is shown.

[10] It is not clear if the estimated 211 GL/yr includes extraction from off allocation (Dragun 1985).

5.4 Irrigation methods (all sources)

The predominant method in the NSW Mid-Coast region is spray irrigation. Nott (1981) estimated that about 70% of the State's sprinkler irrigation occurred in the Hunter catchment and more recent information suggests that this irrigation practice is still widespread (DWR 1995, reliability rating unknown; ABARE 2000, ③; and Griffiths 1995). The most common systems in the Hunter and Manning catchments were hand-shift pipes and high and low pressure travelling irrigators (Griffiths 1995; pers. comm. A. Richards), with a growing interest in bike shift based on semi-permanent long laterals. Most sprinkler irrigation occurs on the alluvial soils adjoining the Hunter River and its tributaries.

Data for the NSW Mid-Coast region suggest the following the systems being used to irrigate crops:

- Micro-irrigation is being used for citrus, kiwi fruit, stone and tropical fruits (S. Hardy 1999, pers. comm., June, ④).
- Hand-shift systems are used for pasture and lucerne, vegetables (P. Brock November 2000; A. Wilson June 1999; A. Richards November 2000; C. Rose June 1999; all pers. comm., ④).
- Vegetables are being irrigated using fixed systems and surface irrigation (P. Brock 2000, pers. comm., November, ④).
- Wine grapes throughout the Hunter catchment and in the Hunter Valley Wine Country Private Irrigation District are irrigated by drip (Beckingham et al. 1990; A. Richards 2000, pers. comm., November, ④). This system is also used for fruit trees, citrus and avocadoes around Mangrove Mountain (P. Brock 2000, pers. comm., November, ④).

5.5 Irrigation yields (all sources)

Information from formal data collection on irrigated crop yields is scant, although some data are available from a survey of NSW Agriculture staff ④ as shown in appendix 14.12 and from a selection of published reports. To summarise, the average, minimum and maximum yields for a range of crops are:

- citrus: 30 t/ha (range: 20–40 t/ha)
- stonefruit: 20 t/ha (13–26)
- lucerne: 11 to 15 t/ha (5–20)
- cereals: 2 t/ha (1–3)
- vegetables (melons): 30 t/ha (20–40)
- vegetables (potatoes): 25 t/ha (15–30)
- vegetables (pumpkins): 20 t/ha (10–30)

- vegetables (cabbage): 5.5 t/ha
- vegetables (cauliflower): 3.6 t/ha
- pasture: 10 to 15 t/ha

5.6 Value of irrigated production (all sources)

There is little information on the value of irrigated agriculture in the NSW Mid-Coast region as a whole. What information does exist relates mostly to the Hunter catchment.

Neither the Karuah River, Great Lakes and associated catchments nor the Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments have any readily available data on value of production.

In the Manning catchment, the value of irrigated production was estimated to be $18 million (Hassall and Associates 1996; EPA 1997). No breakdown of commodity value was available.

5.6.1 Hunter catchment

The value of all agriculture (dryland and irrigation) in the Hunter catchment varied from $188 million to $304 million (Donovan 2000, ③) with periods of depressed value during the drought period 1993–94 to 1995–96. Other sources suggest agriculture is worth $410 million (DLWC 1995, reliability unknown). The catchment is heavily dependent on livestock slaughtering products[11] ($179.1 million), followed by livestock products ($81.6 million) (Donovan 2000).

The value of irrigated agriculture in the Hunter catchment varied from $44.8 – 56.7 million dollars between 1991 and 1997 (appendix 14.13), (Donovan 2000, ③).

The value of irrigation has been derived synthetically by Donovan (2000) using ABS information:

1. The individual irrigated commodity values for Australia were derived 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, reliability unknown).
2. These individual commodity percentages were then applied to the total New South Wales commodity value data from the ABS for each SLA over the period between 1991 and 1997 (Donovan 2000, ②). Data post-1997 are not available because the ABS converted to collecting information by large scale AER which could not be used by (Donovan 2000) to create catchment scale snapshots.

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[11] Livestock slaughtering products are cattle and calves, sheep and lams, pigs, poultry, goats and other.

3. 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 because grapes are a perennial crop irrigated with high security water, and grape areas remain reasonably static. Cereal areas and yields can, by comparison, vary markedly with climate and water availability.

The overall reliability rating for these commodity data is ③.

Generally, irrigation values did not fluctuate widely as a percentage of the total value of that industry each year with the exception of irrigated cereals, vegetables and other crops[12] (Figure 7).

The value of livestock products dependent on irrigation (mostly dairy in the Hunter catchment) had the highest value ($22 million to $31 million) and was roughly 50% of the value of all irrigated produce (Donovan 2000, ③[13]). In 1996–97, $29.9 million could be attributable to milk production from irrigated pasture. Livestock products from irrigation showed a steady increase alongside the total value of livestock products. Livestock products include wool, milk, eggs, honey and beeswax. Irrigation is only used in the production of wool and milk production and in the Hunter catchment, milk production is the most important irrigated commodity in this category. The value of milk production based on irrigation been reasonably stable (appendix 14.13), although this may change with deregulation. Deregulation and water reforms will have a significant impact on dairy farm profitability. Irrigation of pasture for turf is thought to be increasing in importance in the area (A. Richards, pers. comm., ④).

The value of irrigated wine grapes varied between 1991 and 1997 from $5 million to $14 million (appendix 14.13, Donovan 2000, ③). In 1993–94 and 1994–95, a glut of multipurpose grapes on the market may have depressed values in the NSW Mid-Coast region.

Irrigated vegetable values declined from $4.9 million to $2.7 million between 1991–92 and 1996–97 (appendix 14.13).

Crops grown and sold for fodder increased in value during 1993–94 and 1994–95 as other areas around the State suffered from drought and were forced to buy supplementary feed from regions including the Hunter (appendix 14.13).

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[12] 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 (ML/ha or mm). Average, minimum, and maximum figures correspond to irrigation requirements in normal, wet and dry seasons respectively.

[13] These figures do not include the value of horse studs.

6. IRRIGATION FROM REGULATED RIVERS

6.1 Description of the regulated water supply

The Hunter catchment contains the only regulated water supplies in the NSW Mid-Coast region. Therefore the figures presented in this section relate only to the Hunter catchment. The data in this section therefore relate only to the Hunter catchment. Regulated supplies used to control flows for power generation[14] and irrigation (DLWC 1999c). Water is controlled by three dams: Glenbawn, Glennies Creek and Lostock dams.

- **Glenbawn Dam -** The Hunter River is regulated from below Glenbawn Dam to Maitland. Glenbawn Dam was built in 1958 with a storage capacity of 228,000 ML. In 1987, it was enlarged to hold 750,000 ML plus 120,000 ML for flood mitigation (DLWC 2000a), giving a total capacity of 870,000 ML (EPA 1997). As a result of the enlargement, a further 48,500 ML was made available to users downstream of Glenbawn and Glennies Creek dams in June 1992 (DWR 1995). Glenbawn Dam has the greatest influence on the Hunter River between the dam and the confluence with Glennies Creek. After this junction, Glennies Creek Dam has more control over the river.

- **Glennies Creek Dam -** Glennies Creek, regulated from the upper limit of the storage of Glennies Creek Dam downstream to the Hunter River. Glennies Creek Dam was built in 1983 to augment water supplies from Glenbawn Dam (WRC 1985), following commitment of all available water resources in 1981 (DWR 1995). The dam has a storage capacity of 283,000 ML (DLWC 2000a).

- **Lostock Dam -** Paterson River, regulated from Lostock Dam to Gostwyck upstream of Paterson township. Built in 1971, Lostock Dam has a storage capacity of 20,200 ML. It regulates the section of river between the dam and the confluence of the watercourse with the Hunter River.

The regulation of rivers creates increased flows during dry times (Hunter Regulated River Management Committee 1998) and reduces flooding.

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[14] The Barnard Scheme in the Manning catchment can operate to provide water for Macquarie Generation in the Hunter catchment during dry years. The scheme transfers water from the Manning catchment to the Hunter catchment via a pipeline.

Table 10 is a summary of the irrigation data that relate to the regulated supply only. Of note is that there were no data on the number of enterprises or on the value of irrigation based on this water supply.

Table 10. Regulated supply: summary of irrigation data

Year	Number enterprises irrigating [a]	Total irrigated area (ha) [a]	Area of lucerne irrigated (ha) [a]	Total water used by irrigated agriculture (ML)	Water use by lucerne (ML)	Yield of major crop (t/ha)	Value of irrigation ($ m), Hunter catchment only	Value of major crop ($ m), Hunter catchment only, livestock products
1988–89	-	-	-	-	-	-	-	-
1989–90	-	10,704	6,678	25,638	18,873	-	-	-
1990–91	-	22,053	2,644	52,339	-	-	-	-
1991–92	-	-	-	48,864	-	-	-	-
1992–93	-	-	-	49,213	-	-	-	-
1993–94	-	-	-	46,502	-	-	-	-
1994–95	-	-	-	83,709	-	-	-	-
1995–96	-	-	-	59,555	-	-	-	-
1996–97	-	-	-	55,453	-	-	-	-
1997–98	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-		-	-	-	-
Refer:	S. 6.3	S. 6.5	S. 6.5	S. 6.5	S. 6.5	S. 6.7	S. 6.8	S. 6.8

[a]DLWC 1998b, ②

6.2 Number of licences with the purpose of irrigation (regulated)

There are 875 surface water licences using water from the regulated system for all purposes. Of these, 788 are for the purpose of irrigating (DLWC 2000b, ①; DLWC 2001a, ②).

6.3 Number of enterprises using irrigation (regulated)

The number of enterprises using irrigation in the Hunter catchment is estimated to be less than the total number of licences with the purpose of irrigation (788) ④. However, there are no data to support this statement.

In 1993–94, the ABS attempted to collect information on the number of enterprises using irrigation from different sources. ABS figures show 1,414 enterprises were irrigating using water from surface supplies (regulated and unregulated), mostly in the Hunter catchment. Figures for regulated supplies only cannot be used since the DLWC definition of regulated rivers (see section 3.2) does not match that used by the ABS to collect data (appendix 14.14). The ABS collected data on activities of irrigation extracting water from rivers or streams 'controlled by a water board or a water resources commission dam or weir'. In other words, data were collected from rivers controlled by government-owned dams and private dams and the division between regulated and unregulated is not provided. The collection strategy used by the ABS means the number of enterprises dependent on unregulated water supplies could be underestimated while the number of enterprises dependent on regulated supplies could be overestimated.

6.4 Volumetric entitlement to irrigation (regulated)

Of all the industries that use water from regulated systems in the Hunter catchment, irrigation has the largest volumetric entitlement. Most of the water allocated in the Hunter catchment is for low security annual plantings or high security permanent plantings such as vineyards (Figure 13). Approximately 91% of the regulated water supplies were allocated to activities along the Hunter River and a much smaller proportion was allocated to irrigation along Glennies Creek and Paterson River (appendix 14.15).

The Hunter Wine Country Private Irrigation District has an allocation of 5,000 ML while the Broke Fordwich PID has a licence for about 3,000ML (*pers. comm*. N. Cross) ④. There is a proposal to construct a town water supply pipeline from Glenbawn to Scone which will be able to provide water for irrigation (*pers. comm*. N. Cross) ④.

Power generation has the next largest allocation (Figure 13). However, it should be noted that Macquarie Generation relies heavily on both on- and off-allocation[15] water, and actual use by this industry may well exceed the allocated volume.

[15] Rainfall results in river flows being surplus to requirements in any year. A period of off-allocation can be declared. This allows water users to access water in that period without debit against their allocations.

6.5 Area irrigated and water used (regulated)

Area irrigated: The total area irrigated in the Hunter catchment in 1991–92 was 22,053 ha and the dominant crop was lucerne (62%) (appendix 14.16) (DLWC 1998b, ②). Crop area statistics have not been collected by the DLWC since 1990–91.

Water used - The total volume of water used by irrigated agriculture was estimated to be 25,638 ML in 1989–90 (appendix 14.17) (DLWC 1998b) ①.

ABARE figures show 165,000 ML in 1996–97 (ABARE 2000, ③, Relative Standard Error[16] 16). These figures relate to water used by broadarea and dairy farms only and exclude use for vegetables and fruit. It should be noted that this volume is greater than the estimated total water used from all sources by broadarea and dairy farms (119,400 ML) ③ (RSE 24). It is also more than the volumetric allocation to irrigation. One would expect the total water use from regulated system to be less than the sum of all the sources. This disparity results from the way data have been collected, analysed and summarised by ABARE.

In 1989–90, 74% of the total water extracted was used to irrigate dairy fodder while smaller portions were used on vines (appendix 14.17). It is highly likely that this level of extraction for lucerne and pasture still occurs in the catchment, as dairying is the largest irrigated industry.

6.6 Irrigation methods (regulated)

There are no data on methods used to irrigate crops with water specifically from regulated rivers. Pasture is the dominant irrigated crop and spray methods are the most prevalent (see section 5.4 for methods used from all sources of water).

6.7 Irrigated yields (regulated)

There are no data on yields of crops grown specifically from regulated supplies (see section 5.5 for yields from all sources).

6.8 Value of irrigated production (regulated)

There are no data on the value of irrigated agriculture solely from regulated supplies in the region.

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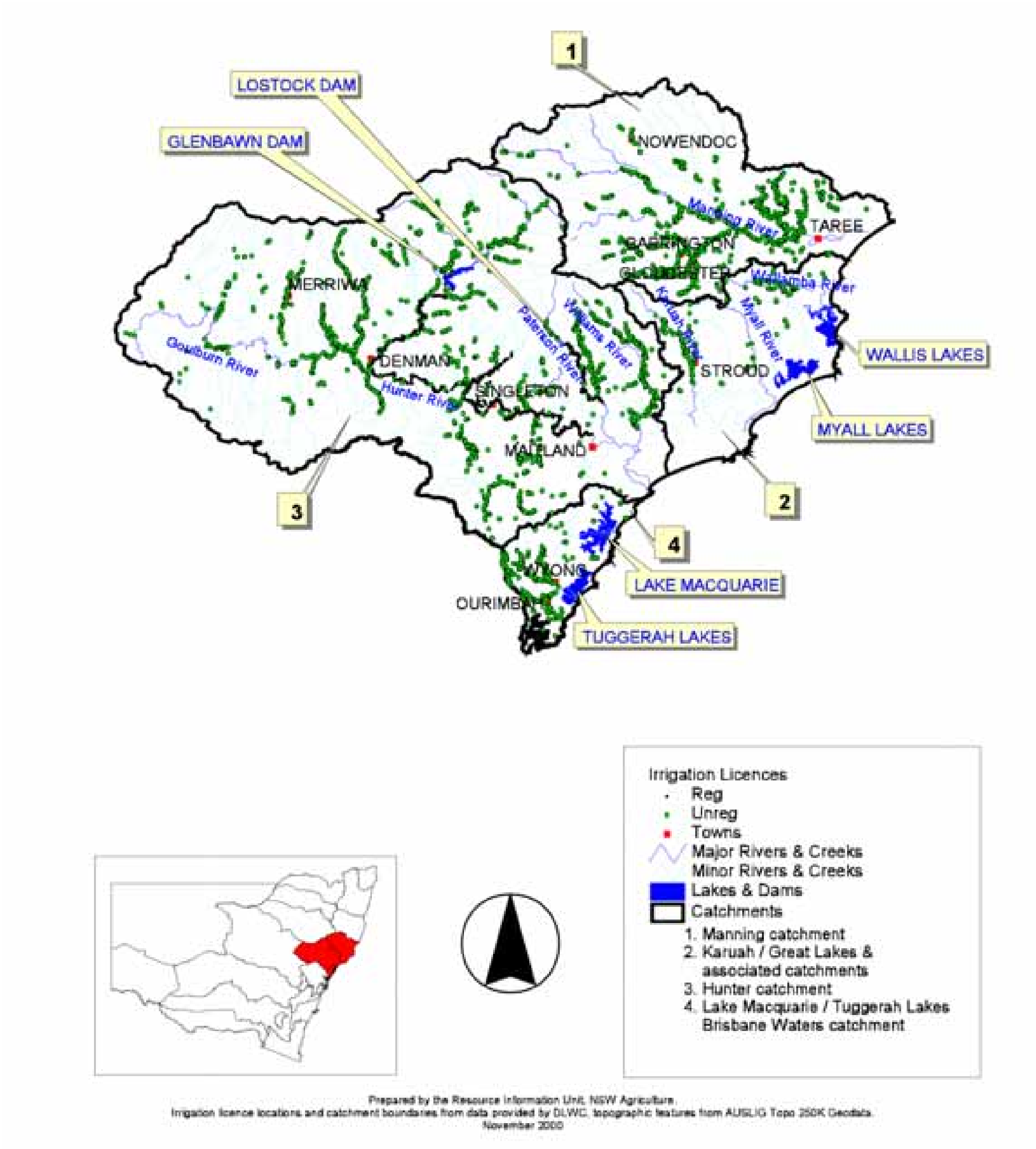
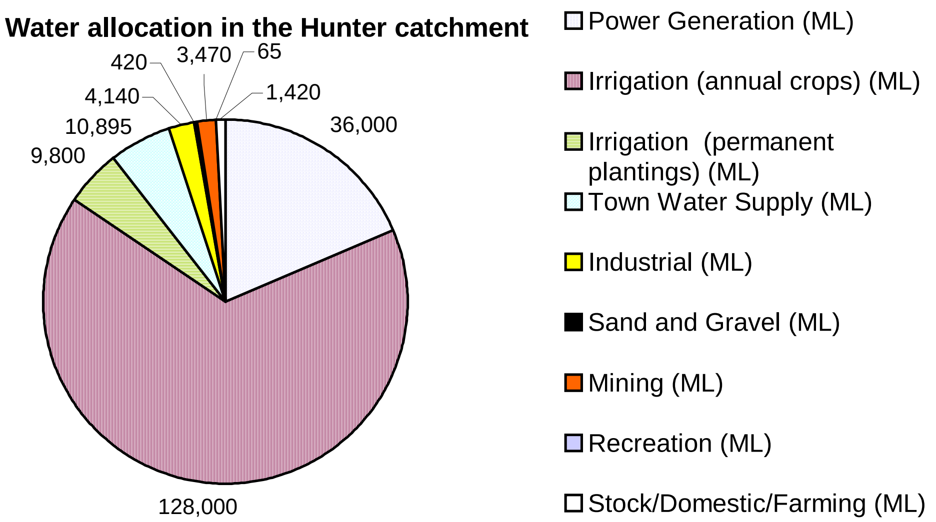
[16] The Relative Standard Error (RSE) is the standard error divided by the actual data value. The result is dimensionless. The RSE shows how big the standard error is as a proportion of the actual data.

Figure 10. Location of surface licences for the purpose of irrigation in the NSW Mid-Coast region



Source: DLWC 2001a, ①

Figure 11. Water allocation to industries in the Hunter catchment



Source: DWR 1995, ①

7. IRRIGATION FROM UNREGULATED RIVERS

7.1 About the unregulated water supply

Unregulated water supplies are an important source of water to the irrigation industry in the NSW Mid-Coast region. Most of the licences for irrigation are located in the Hunter catchment along the Williams and Goulburn rivers and the Wollombi Brook. Crops grown using this water area summarised in Table 11.

Table 11. Characteristics of irrigated agriculture from unregulated streams in the Hunter catchment

	Goulburn River	Pages River	Wollombi Brook
Dominant irrigation enterprises	Dairy, lucerne, cattle, horse studs, vineyards	Dairy, horse studs, hay	Vineyards, hay
Number of irrigation enterprises	70	77	136
Total area irrigated (ha)	3,000	1,380	2,000

Source: EPA 1997 (reliability rating unknown)

Extraction of water for irrigation coincides with periods of low flows in streams (DLWC 2000a). As noted in section 4.2, the evaporative deficit is greatest in spring and summer (Figure 3), over-extraction of water during these periods causing concern for subcatchments in the Mid-Coast region and down the New South Wales coast (Brennan 1998).

The way water is managed in the region has changed over the last decade:

- The DLWC has placed an embargo on the issuing of new licences on unregulated streams. Water can only be accessed through water transfers. This has reduced irrigation development in the region generally (DLWC 1999c).
- Since 1998, WMC have been developing water sharing plans in each catchment across NSW (DLWC 1998a). Subcatchments were assessed for levels of stress in 1999. See for example (DLWC 199c). These ratings are helping to prioritise the development of water sharing plans for the NSW Mid-Coast region.

- Licences on unregulated streams were converted from area-basis to volume-basis in 2000 and it is expected that the volumes of water used by individual irrigators will be metered in the future (DLWC 2000d).

Table 12 is a summary of irrigation data from unregulated rivers in the NS Mid-Coast region. Of note is that there were no data the total volume of water used on different crop types nor were there data on the value of irrigation from this source of water.

Table 12. Unregulated rivers: summary of irrigation data

Year	Number enterprises irrigating [a]	Total irrigated area (ha)	Area of perennial pasture irrigated (ha)	Total water used by irrigated agriculture (ML)[b]	Water use by perennial pasture (ML)	Yield of perennial pasture (t/ha)	Value of irrigation ($ m)	Value of perennial pasture ($ m)
1988–89	-	-	-	-	-	-	-	-
1989–90	-	5,767[b]	2,725[b]	31,681	-	-	-	-
1990–91	-	7,036 [b]	2,835 [b]	21,130	-	-	-	-
1991–92	-	7,621 [b]	3,284 [b]	16,810	-	-	-	-
1992–93	-	6,997 [b]	2,778 [b]	44,758	-	-	-	-
1993–94	-	8,784 [b] 14,937[c]	3,928 [b] 5,666[c]	13,099	-	-	-	-
1994–95	-	10,531 [b] 15,539 [c]	4102[b] 5,928 [c]	17,824	-	-	-	-
1995–96	-	16,614[c]	6,606 [c]	-	-	-	-	-
1996–97	-	17,298 [c]	6,676 [c]	-	-	-	-	-
1997–98	-	17,334 [c]	6,630 [c]	-	-	-	-	-
1998–99	-	16,804 [c]	6,331 [c]	-	-	-	-	-
1999–00	1,055	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to	S 7.3	S 7.5	S 7.5	S 7.5	S 7.5	S 7.7	S 7.8	S 7.8

[a]Figure assumes that 60% of the total number of licences (1,759) (DLWC 2000b, ①) are active. [b]DLWC 1998b ③ [c]DLWC 2000c ②

7.2 Number of licences (unregulated)

There are 2,333 licences for all purposes on unregulated rivers in the NSW Mid-Coast region ①. Of this, 1,759 are for irrigation ①. These data were obtained by summing information provided in the Stressed Rivers Assessment Reports (DLWC 1999c, 1999d, 1999e and 1999f). Most of these licences exist in the Hunter (995) and the Manning (455) catchments ①. As noted, licences have been converted from area-basis to volume-basis in 2000 (DLWC 2000d).

7.3 Number of enterprises irrigating (unregulated)

There were estimated to be 1,055 enterprises irrigating ④. This figure assumes that 60%[17] of licences (1,759) (DLWC 2000b, ①) were active and that one licence equals one enterprise. As noted previously, there is a difference in definitions between DLWC and the ABS (see section 3.2 and appendix 14.14), and so an ABS estimate cannot be provided.

7.4 Area authorised for irrigation (unregulated)

As a result of volumetric conversion, area-based licences with a total authorised area of 25,754 ha ① of land were converted to a volumetric entitlement. This volume is not yet available. Of the total authorised area, 17,000 ha or 66% of this land is in the Hunter catchment. This figure was determined by summing the values from DLWC 1999c, 1999d, 1999e and 1999f. In a more recent estimate the figure for the region is 27,728 ha (DLWC 2000c, ①).

7.5 Area irrigated and water used (unregulated)

Area irrigated: Information on irrigation from unregulated rivers in the NSW Mid-Coast region is available for the last 10 years, although the quality of data varies according to collection strategy. Where comparisons could be made, there was a difference of between 5,000 ha and 6,000 ha (Table 12).

Figures collected by the DLWC between 1989 and 1995 show that 5,700–10,500 ha were irrigated from unregulated sources each year (DLWC 1998b, ③) (appendix 14.18). These figures represent raw data that have not been adjusted for irrigators who did not return survey forms to the DLWC and have a reliability rating of ③.

[17] The value 60% approximates the number of licences that were active as a proportion of the total number of licences (DLWC 2000c).

The total area irrigated in the NSW Mid-Coast region from unregulated river supplies in 1998–99 was 16,804 ha. Between 1993–94 and 1998–99, the area irrigated ranged from nearly 15,000 ha to 17,000 ha (DLWC 2000c). These data, collected by written survey by the DLWC, are the more reliable of the two sources (Table 12). The irrigated area has increased by 12% between 1993–94 and 1998–99 (Table 13).

Table 13. Change in irrigated area by crop type between 1993–94 & 1998–99

Data	Percentage (%) change of the 1993-94 figure
Olives	2500
Vines: table grapes	406
Vines: wine grapes	84
Trees: other	74
Other	45
Trees: orchards	33
Citrus	15
Perennial pasture	12
Lucerne	7
Vegetables	7
Turf	4
Nurseries	3
Annual pasture	2
Fodder	-5
Winter cereal	-6
Summer cereal	-10
Nuts	-36
Pulses	-75
Summer oilseeds	-100
Grand total	**12**

Source: DLWC 2000c, ②. Data from grower response to written survey.

Perennial pasture has the largest area irrigated in the NSW Mid-Coast region followed closely by lucerne, annual pasture and wine grapes (appendix 14.19). Olives, table grapes, wine grapes and trees (excluding orchards) experienced high growth in irrigated area. Nuts, pulses and summer oilseeds declined (Table 13).

Water used: Between 1989–90 and 1994–95, the volume of water extracted from unregulated rivers was estimated to be between 13,099 ML and 44,758 ML (appendix 14.18) ③. Data for individual catchments shows that most of the water is extracted from the Manning and Hunter catchments (Table 14).

Table 14. Water from unregulated rivers used by irrigation in the NSW Mid-Coast region

Catchment	1989–90	1990–91	1991–92	1992–93	1993–94	1994–95
Manning	22,637	8,710	6,156	16,380	6,112	6,716
Karuah, Great Lakes and associated catchments	71	474	194	332	257	251
Hunter	7,839	10,918	9,778	11,255	5,849	9,925
Lake Macquarie, Tuggerah, Brisbane Waters catchment	1,134	1,028	682	16,791	881	931
Total	**31,681**	**21,130**	**16,810**	**44,758**	**13,099**	**17,823**

Source: DLWC 1998b ④

There are no data on the volume of water used to irrigate individual crops from unregulated systems (see Table 9 for estimated volume of irrigation water required by crops).

7.6 Irrigation methods (unregulated)

There is no information on methods used to irrigate crops with water from unregulated supplies. Spray irrigation is most likely to be the dominant method in the region. See section 5.4 for an overview of irrigation methods.

7.7 Irrigated yields (unregulated)

There are no data on yields of crops irrigated from unregulated supplies. See section 5.5 for details of yields obtained from all sources of water.

7.8 Value of irrigated production (unregulated)

There are no data on the value of irrigated production from unregulated systems in the NSW Mid-Coast region.

8. IRRIGATION FROM GROUNDWATER

8.1 About groundwater supplies

The NSW Mid-Coast region has 32,766,000 ML of groundwater, most of which is in the fractured or porous rocks (WRC 1980). Only 1.4% or 443,000 ML of this can be used, as most is too saline. In 1980, it was estimated that 18% of the exploitable reserves were being used in the region, the highest consumer being irrigated agriculture (94%) (Table 15).

Table 15. Groundwater resources and usage in the NSW Mid-Coast region

	Area of aquifer (km^2) Volume in storage	Volume in storage (× 1,000 ML)	annual usage – 1980 (× 1,000 ML)				Exploitable annual yield (x 1,000 ML)
			Urban	Irrigation	Other	Total	
Hunter	26,100	29,249	1.2	58.4	3	62.6	279
Lake Macquarie, Tuggerah Lakes, Brisbane Waters	1,630	2,417	0.05	0.3	0.1	0.45	21
Manning	8,590	321	0	3.2	0.4	3.6	89
Karuah, Great Lakes and associated catchments	4,640	779	0	14.2	0.06	14.26	54
Total	**40,960**	**32,766**	**1**	**76**	**4**	**81**	**443**

Source: WRC 1980 (reliability rating unknown)

The Hunter catchment is the largest user of groundwater on the New South Wales coast. Good quality groundwater is generally found within the riverine alluvium of the Hunter River and tributaries and this water is almost fully committed to agriculture. In the Hunter catchment, approximately 29,249,000 ML are reserved in unconsolidated, porous and fractured rocks (WRC 1980) (Table 15) (reliability rating unknown). However, only 1% of this water is economically exploitable due to high salinity (Day 1986). In 1980, most of the 0.2% of groundwater being used was by irrigated agriculture.

IRRIGATION FROM GROUNDWATER

The greatest demand is on alluvial aquifers in the Hunter catchment from near Glenbawn Dam to the confluence with the Goulburn River including the lower reaches of the Pages River, Kingdon Ponds and Dart Brook. About 40% of the bores in this area are used for irrigation (DLWC 2000a; DWR 1995). The potential annual yield from the riverine alluvium is 63,000 ML and most of this has been fully committed to agriculture (DLWC 2000a).

The effect of extraction of groundwater from rivers in the Hunter catchment is unknown. It is believed that alluvial aquifers buffer stream flow by maintaining base flows in dry conditions and then absorbing water from streams when they start to flow. The effects of urbanisation and tree clearing increase run-off and could affect volumes reaching groundwater stores (DLWC 2000a). Groundwater stores beneath estuarine flats are difficult to use due to problems in managing saline intrusion after extraction (WRC 1980).

The Manning catchment has the smallest volume of groundwater in storage, but has the second largest exploitable reserve (Table 15). In 1980, 4% of this exploitable volume was being used mostly by irrigated agriculture. The four areas that rely on groundwater for irrigation in the Manning include Kolodong Flats, Tinonee Flats, Taree Estate and Glenthorne. There are 382 registered wells in the area and 53 have the potential to supply water for irrigation. Groundwater is used mostly on pasture and vegetables (DLWC 2000a).

Table 16 is a summary of irrigation data related to groundwater supplies. There is a lack of information on the volume of water used by irrigation from groundwater supplies in total and by crop type. There is also no information on the value of irrigation dependent on this source of water.

Table 16. Groundwater: summary of irrigation data

Year	Number enterprises irrigating [a]	Total irrigated area (ha) [a]	Area of major irrigated crop (ha)	Total water used by irrigated agriculture (ML)	Water use by major irrigated crop (ML)	Yield of major irrigated crop (t/ha)	Value of irrigation ($m)	Value of major irrigated crop ($m)
1988–89	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-
1990–91	-	-	-	-	-	-	-	-
1991–92	-	-	-	-	-	-	-	-
1992–93	-	-	-	-	-	-	-	-
1993–94	225	7784	-	-	-	-	-	-
1994–95	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to	S 8.3	S 8.5	S 8.5	S 8.5	S 8.5	S 8.7	S 8.8	S 8.8

[a] ABS 1998a

Table 17. Number of enterprises irrigating crops and area irrigated by water source in the NSW Mid-Coast region

	Groundwater		Town		Dams	
	No. enterprises irrigating	Area irrigated (ha)	No. enterprises irrigating	Area irrigated (ha)	No. enterprises irrigating	Area irrigated (ha)
Hunter catchment						
Cessnock	1	1	0	0	42	522
Dungog	2	4	0	0	14	258
Maitland	5	315	0	0	13	108
Merriwa	3	28	0	0	5	1,689
Muswellbrook	58	1,741	3	192	3	650
Murrurundi	3	1,212	0	0	4	178
Port Stephens	18	89	5	9	4	10
Scone	66	3,117	1	2	1	100
Singleton	44	949	0	0	9	67
Subtotal	**200**	**7,456**	**9**	**203**	**95**	**3,582**
Karuah, Great Lakes and associated catchments						
Great Lakes	1	2	0	0	10	107
Subtotal	**1**	**2**	**0**	**0**	**10**	**107**
Manning						
Gloucester	0	0	0	0	16	164
Greater Taree	18	308	11	51	42	329
Subtotal	**18**	**308**	**11**	**51**	**58**	**494**
Lake Macquarie, Tuggerah Lakes, Brisbane Waters catchment						
Wyong	5	18	3	2	31	333
Gosford	0	0	0	0	0	0
Lake Macquarie	1	1	5	3	14	131
Subtotal	**6**	**19**	**8**	**5**	**45**	**464**
TOTAL	**225**	**7,784**	**28**	**259**	**208**	**4,647**

Source: ABS 1998a, ②

8.2 Number of licences with the purpose of irrigation (groundwater)

There are 4,100 licences in the Hunter, Karuah, Great Lakes and associated catchments and Manning catchments, 763 with the purpose of irrigation (DLWC 2001b, ①).

8.3 Number of enterprises irrigating (groundwater)

There were 225 enterprises that irrigated using water from groundwater sources in the NSW Mid-Coast region (ABS 1998a, ②) and most of these were in the Hunter catchment (Table 17).

8.4 Volumetric entitlements (groundwater)

A volumetric allocation scheme is in place in the Hunter catchment and applies to all renewable high yield bores:

- licences along the Hunter River downstream of Aberdeen receive 972 ML/yr.
- licences upstream of Aberdeen receive 486 ML/yr.
- licences using water from sandstone strata receive 486 ML/yr.
- licences using water from other rock strata receive 243 ML/yr (DWR 1995).

Data were unavailable on volumes extracted from groundwater by irrigated agriculture.

8.5 Area irrigated and water used (groundwater)

Area irrigated - There were 6,682 ha irrigated from groundwater in 1993–94 (ABS 1998a) and most of this was in the Hunter catchment (Table 17). More recent information is not available. Information on the area of crops irrigated is also unavailable.

Water used - In 1980, approximately 76,000 ML was extracted from groundwater systems for irrigated agriculture in the NSW Mid-Coast region and most of this was in the Hunter catchment (Table 15) (WRC 1980). In 1985, Dragun estimated that 60,000 ML (reliability rating unknown) of groundwater were used in the catchment by irrigated agriculture. More recent information on groundwater usage is not available. There are no data on the volume of water used on crops from groundwater supplies.

8.6 Irrigation methods (groundwater)

Data on the methods used to irrigate crops with water from groundwater supplies in the region were unavailable (see section 5.4 for irrigation methods from all water sources).

8.7 Irrigated yields (groundwater)

Data on yields from crops irrigated using groundwater supplies were unavailable (see section 5.5 for irrigated yields from all sources).

8.8 Total value of irrigation (groundwater)

There are no data on the value of agriculture irrigated using groundwater.

9. IRRIGATION FROM FARM DAMS

9.1 About farm dam water supplies

Most of the enterprises that extract water from farm dams are located in Manning and Hunter catchments.

Until 1998, a dam of up to 7 ML could be built without needing to be licensed providing the water was used for non-commercial purposes. This limit was considered inappropriate in many areas of New South Wales 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.

The Farm Dams policy, announced in September 1998, allows the collection of 10% of the regional run-off figure from the landholding each year (DLWC 1999a). Landholders who collect more than 10% require a licence.

Based on 1993–94 figures, most of the enterprises using water from farm dams are located in the Manning and Hunter catchment (appendix 14.20, ABS 1998a). Vineyards in the Hunter Wine Country Private Irrigation District (PID) grape growing area are heavily reliant on farm dams for water supply (J. Sayers, pers. comm. ④). Water is piped from the river to the district and stored in the dams.

9.2 Number of licences with the purpose of irrigation (farm dams)

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

9.3 Number of enterprises using irrigation (farm dams)

There were 208 irrigation enterprises using water from farm dams in the NSW Mid-Coast region in 1993–94 and 46% of these were in the Hunter catchment (ABS 1998a) ②. Another 28% were in the Manning catchment (ABS 1998a) ②.

9.4 Area irrigated and water used (farm dams)

Area irrigated - In 1993–94 there were 4,647 ha irrigated from farm dams in the NSW Mid-Coast region (ABS 1998a) ②. Of this total, 77% was in the Hunter catchment (Table 17). There are no data on crop areas.

Water used - There were no data on the amount of water used in total from farm dams and by crop.

9.5 Irrigation methods (farm dams)

Growers in the Hunter Valley Wine Country Private Irrigation District generally irrigate grapes using drip systems (*pers. comm.* A. Richards) ④. Data on other crops irrigated solely from farm dam water were unavailable (see section 5.4 for methods used to irrigate from all sources of water).

Table 18 summarises irrigation data related to farm dam water supplies provided in this section. Note the lack of information on water used by irrigation in total and by crop type. There are no data (yield, method of irrigation and value) on the crops that depend on farm dams.

Table 18. Farm dams: irrigation summary, NSW Mid-Coast region

Year	Number enterprises irrigating [a]	Total irrigated area (ha) [a]	Area of major irrigated crop (ha)	Total water used by irrigated agriculture (ML)	Water use by major irrigated crop (ML)	Yield of major irrigated crop (t/ha)	Value of irrigation ($ m)	Value of major irrigated crop ($ m)
1988–89	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-
1990–91	-	-	-	-	-	-	-	-
1991–92	-	-	-	-	-	-	-	-
1992–93	-	-	-	-	-	-	-	-
1993–94	208	4,647	-	-	-	-	-	-
1994–95	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to	S 9.3	S 9.4	S 9.4	S 9.4	S 9.4	S 9.6	S 9.7	S 9.7

[a]ABS 1998a

9.6 Irrigated yields (farm dams)

There are no data on yields from crops irrigated using water from farm dams (see section 5.5 for irrigation yields obtained using all sources of water).

9.7 Value of irrigated production (farm dams)

There are no data on the value of production based on irrigation from farm dams in the NSW Mid-Coast region.

10. IRRIGATION FROM RETICULATED SUPPLIES

10.1 About reticulated water supplies

Most of the enterprises irrigating with reticulated water are located in the Gosford SLA.

The amount of water used for irrigation from reticulated water supplies is small (less than 1% of the total land area irrigated in the region). Enterprises tend to be small-area, high-value industries such as nurseries and cut flowers. Reticulated water is also used by some golf courses and for large landscaped areas such as urban parks (*pers. comm.* N. Cross).

Table 19 is a summary of the irrigation data related to reticulated water supplies in the NSW Mid-Coast region. There are no data on the water used in total and by crop type. Nor are there data on crop areas irrigated, yields and value.

10.2 Number of enterprises using irrigation from reticulated supplies

The number of irrigators using water from reticulated water supplies was estimated to be 28 in 1993–94 ② (ABS 1998a). These enterprises are evenly spread through the Hunter, Manning and Lake Macquarie, Tuggerah Lakes, Brisbane Waters catchment (Table 17). More recent data are not available.

10.3 Area irrigated and water used from reticulated supplies

Area irrigated - The area irrigated from reticulated water supplies in 1993–94 was 259 ha (ABS 1998a) ②. Of this total value, 203 ha were located in the Hunter catchment. There are no data on crop areas.

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

10.4 Irrigation methods (reticulated supplies)

There is no information on methods used to irrigate crops with water from reticulated water supplies (see section 5.4 for methods used to irrigate from all sources of water).

10.5 Irrigated yields (reticulated supplies)

There are no data on yields from crops irrigated using water from reticulated supplies (see section 5.5 for yields from crops irrigated using all sources of water).

10.6 Value of irrigated production (reticulated supplies)

There are no data on the value of production based on irrigation using reticulated water supplies in the NSW Mid-Coast region.

Table 19. Reticulated supplies: irrigation summary, NSW Mid-Coast region

Year	Number enterprises irrigating [a]	Total irrigated area (ha) [a]	Area of major irrigated crop (ha)	Total water used by irrigated agriculture (ML)	Water use by major irrigated crop (ML)	Yield of major irrigated crop (t/ha)	Value of irrigation ($ m)	Value of major irrigated crop ($ m)
1988–89	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-
1990–91	-	-	-	-	-	-	-	-
1991–92	-	-	-	-	-	-	-	-
1992–93	-	-	-	-	-	-	-	-
1993–94	28	259	-	-	-	-	-	-
1994–95	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to	S 10.2	S 10.3	S 10.3	S 10.3	S 10.3	S 10.5	S 10.6	S 10.6

[a]ABS 1998a

11. OPPORTUNITIES AND ISSUES

11.1 Opportunities for the NSW Mid-Coast region

11.1.1 Opportunities for improving irrigation data

- **Changing the scale at which data are reported.** Agencies and communities need data at many different scales (stream reaches, subcatchments, catchments, soil types). The usefulness of data is currently limited by the scales at which data have been reported, for example, SLAs (ABS 1998a), catchments and industries (ABARE 2000). Reporting at this level has been necessary to maintain confidentiality. The opportunity exists to provide agencies and communities with data that can be aggregated to useful scales through use of Geographic Information Systems (GIS). The challenge would be to continue to maintain confidentiality while maximising data usefulness.
- **Reducing the level of suspicion between government and irrigators.** Data collected from irrigators for purposes such as billing, operational and reporting needs are seldom returned to their source. This creates suspicion among irrigators, which in turn may affect the reliability of data. The opportunity exists to return data to irrigators in a useful format with the potential to help improve farm water management.
- **Metering of water use on unregulated rivers will improve knowledge.** Volumetric conversion of area-based licences (DLWC 2000d) will lead to better information regarding usage of water from unregulated streams. Water use will be metered and recorded, leading to a greater understanding of the impact of irrigation on unregulated streams.

11.1.2 Opportunities for irrigation

- **Deregulation of the dairy industry may free water for other industries.** Existing enterprises may be able to expand operations and new enterprises may be able to develop using this ‘freed-up’ water.
- **Irrigated agriculture may expand in certain areas of the NSW Mid-Coast region to service increasing populations.** Opportunities here may include food production using irrigation, such as vegetable crops and orchards. This applies particularly to the Gosford–Wyong area where there has been rapid population growth.

11.2 Issues for irrigation in the NSW Mid-Coast region

11.2.1 Data issues

- **Better data are needed to inform the water-sharing debate.** Population growth and water reform is increasing the competition for water between agriculture, industry and urban users. These pressures are already presenting challenges for communities in the Hunter catchment (Healthy Rivers Commission 1996). This *Profile* has demonstrated many deficiencies in irrigation data, in scope, scale, availability and reliability. Better information about crop water use, extraction patterns, yield, value, area irrigated and irrigation methods are needed for informed decision making.
- **Data have been collected for different purposes in past to those needed now.** 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 (for example, irrigation 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, the DLWC billed people on the total volume of water used from the regulated river system. There were no requirements to record information such as crop area and crop water use, yield, irrigation method and value. As a result, these data tend to be scarce.
- **Confidentiality of point-scale data limits usefulness of information.** Farm-scale financial and physical data have been collected from irrigation farms by the ABS and the ABARE. However, this information remains confidential and is only reported at either SLA scale (ABS) or at region scale (ABARE).
  - The irrigation survey undertaken by ABARE grouped and reported data for the NSW Mid-Coast region. This ‘region’ refers to the aggregation of information for Manning catchment, Karuah, Great Lakes and associated catchments, the Hunter catchment and the Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments. However, each catchment is distinct in terms of climate, socio-economics and irrigated agriculture. Reporting information at the level of the ‘region' limits the data usefulness to groups operating at the catchment and subcatchment scales.
  - ABS have been collecting data on irrigation by SLAs for a number of years. The difficulty with these data are that they do not align well with catchment and subcatchment boundaries. Consequently, the area irrigated may be underestimated or overestimated depending on the SLA composition and their relationship with catchment boundaries.

These issues limit data usefulness. For example, the NSW Water Management Committees (WMC)[18], set up by the State Government to develop water sharing

[18] The committee comprises representatives from government agencies and community bodies.

plans, require point-scale data or data aggregated to scales smaller than SLAs or catchments, for example, river reach or subcatchment. Data need to be reported at a scale that is large enough to protect confidentiality but fine enough to allow users to aggregate information to useful scales.

- **Large cost involved in collecting data.** The cost of obtaining farm-scale data is large. For example, ABARE spent $1000 to collect data from one farm for its 1996–97 survey.
- **Storage of data is not centralised.** It is not possible to access a central repository and retrieve data on yield, value, area, water use and irrigation method. Data are often stored in many formats (electronic, paper or 'in the head) and at many scales (licence, SLA, subcatchment, catchment) and by numerous agences (NSW Agriculture, DLWC, ABS, ABARE). The user is left with the difficult task of drawing together and making sense of these data at multiple scales.
- **Data reliability ratings are needed.** The reliability of irrigation data is not often reported by State agencies such as DLWC. Sometimes there may be more than one database available per variable, for example, area irrigated or water used. The user is faced with the task of choosing the more reliable data set. For example, there are two databases on crop areas irrigated from unregulated streams in New South Wales, the crop statistics database (DLWC 1998b) and the volumetric conversion survey database (DLWC 2000c). These databases yield two different answers to the question of how much land is irrigated in the Hunter catchment in any year. At the Commonwealth level, efforts are being made to provide reliability ratings for irrigation data with National Land and Water Resources Audit (1999). Similar protocols also need to be used by State-level information providers. Collection strategies have limited data usefulness. The ABS has changed the collection cut-off point for its annual surveys a number of times (Table 2). Trends in the area irrigated can only be identified when years with similar EVAOs are used (for example, 1993–94 to 1996–97).

  The ABS gas also changed the way data are collected. Data about irrigation were collecting by SLAs up until 1997 and then by AER (Table 2). These large zones often span a number of catchments and SLA or catchment-scale snapshots of irrigation from 1997 to 2000 cannot be provided. Conversion to AER has also limited the ability of the NSW Irrigators Council to provide catchment-scale information on the value of irrigated agriculture (Donovan 2000). The ABS resumed collecting information by SLA for the 2000–01 irrigation survey.

  The ABS is one of the few sources of information on the area of land irrigated from different sources. However, due to the question format and water source definitions, irrigators reported utilising regulated water supplies where there were none. This issue made it difficult to separate irrigation dependent on regulated and unregulated water sources. Data for regulated supplies will be overestimated while data for unregulated systems will be underestimated. Clarity with respect to water source definitions is needed should these data be collected in future.
- **Animosity toward data collecting agencies.** There is some resistance to providing data on water use, area, yields and methods to agencies. Irrigators fear the information will be used against them. This sentiment is especially heightened

following the implementation of water reforms and development of new water sharing plans that include the environment as a ‘new’ user. This may affect the reliability of any information provided by irrigators.

- **Lack of relevant data on water use and area.** There are no recent data on crop water use or area irrigated from regulated, unregulated, groundwater, farm dams and reticulated supplies. This limits the ability to calculate crop water use efficiencies and irrigation efficiencies in the NSW Mid-Coast region.

11.2.2 Other issues for irrigation in the region:

- **Changing on-farm management practices because of water reform may cause financial strain.** Managing restricted access to low flow water could cause some irrigators financial strain (Brennan 1998). Possible options include building dams to capture and store high flow water or storing feed either through traditional methods or through the introduction of more durable pit silage[19] (Brennan 1998).
- **Impact of rural residential development on irrigation management.** The pressures of urban encroachment into rural areas may reduce the efficacy of messages that aim to improve irrigation practice. This pressure is also evident in neighbouring catchments such as the Haweksbury-Nepean (DLWC 1999b). Coastal land is becoming increasingly valuable and there is tendency for irrigators in other areas, for example, the Hawkesbury-Nepean catchment, to view this land as superannuation (Healthy Rivers Commission 1999) rather than as a profitable enterprise. In other words farmers may choose not to invest in capital works or new skills. Messages that aim to improve water management may be ignored. (For details of subcatchments where rural residential developments are likely to occur, see appendix 14.21.)
- **Expansion of irrigation in some subcatchments is limited in areas where extraction is already high.** Expansion of irrigation will only occur when some water is freed through increased irrigation efficiency, when excessive water use on crops is reduced or when crops that require less water generally are adopted. (For details of subcatchments with already high rates of extraction, see appendix 14.21.).
- **Salinity impacts on irrigated agriculture.** High levels of salt in the lowland tributaries of the Hunter River and the lower portion of the Hunter River limit the

[19] Pit silage is popular method for storing feed. The practice involves burying excess summer fodder for storage. The advantage of this form of silage over other forms is durability. The silage buried in pits can last for a number of years and can be used as drought relief.

development of some irrigation enterprises. For example, salinity decreases the opportunity for growing vegetables on Hunter alluvium. Salinity can also cause damage to existing crops such as vines during drought.

12. SUMMARY

This study highlighted difficulties in obtaining information on irrigation in the NSW Mid-Coast region. To summarise, data were either scarce, unreliable or provided at inappropriate scales.

- **Scarcity of data** - Data have been collected for various purposes in the past that may not necessarily fulfil NSW's present data needs.
- **Reliability** - The reliability of data varied with source of water. Data on irrigation from regulated rivers are more reliable than data from unregulated rivers, groundwater, farm dams and reticulated water supplies.
- **Provision of data at inappropriate scales -** Data have been reported at scales that are of little use to, for example, people engaged in natural resource planning at the subcatchment or river-reach scale.

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

- Crop data (crop water use and irrigated area) are needed. Better monitoring is needed to help develop strategies to manage and effectively balance environmental and irrigation industry water needs.
- Protocols for provision of data to users are needed. For example, information providers need to attach reliability ratings to data to help users make better choices about the reliability and therefore the usefulness of the data.
- 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. This would in turn, over time, improve the reliability of information.
- Data are needed at scales that are large enough to ensure confidentiality of individual enterprises but small 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.

SUMMARY

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14. APPENDICES

14.1 Definitions of statistical units used by the ABS

Extract from the following reference:

ABS 1999, *Australian Standard Geographical Classification (ASGC) 1999*, Chapter 2. Main Structure. The spatial units Statistical Local Area (SLA), web page, accessed 4 December 2001, available at http://www.abs.gov.au/ausstats/abs%40.nsf/66f306f503e529a5ca25697e0017661f/b61577a4a9a88d8bca25697e00184c76!OpenDocument.

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 Surface licence-based concordance with SLAs and catchment boundaries in the NSW Mid-Coast region

Data taken from DLWC (2001a) and ABS 1998a. The concordance was undertaken by NSW Agriculture.

14.2.1 Hunter catchment

	Surface licences within the Hunter and associated catchments (%)				
SLA	Hunter catchment	Hawkesbury-Nepean catchment	Namoi catchment	Macquarie catchment	Manning catchment
Cessnock (C)	100				
Dungog (S)	100				
Maitland (C)	100				
Merriwa (S)	99.01			0.99	
Murrurundi (S)	87.5		12.5		
Muswellbrook (S)	100				
Newcastle (C)	100				
Port Stephens	100				
Scone (S)	97.47				2.53
Singleton (S)	99.61	0.39			

14.2.2 Karuah, Great Lakes and Associated catchments

	Surface licences within the Karuah, Great Lakes and Associated catchments and other adjoining catchments (%)
SLA	Karuah, Great Lakes and associated catchments
Great Lakes	100

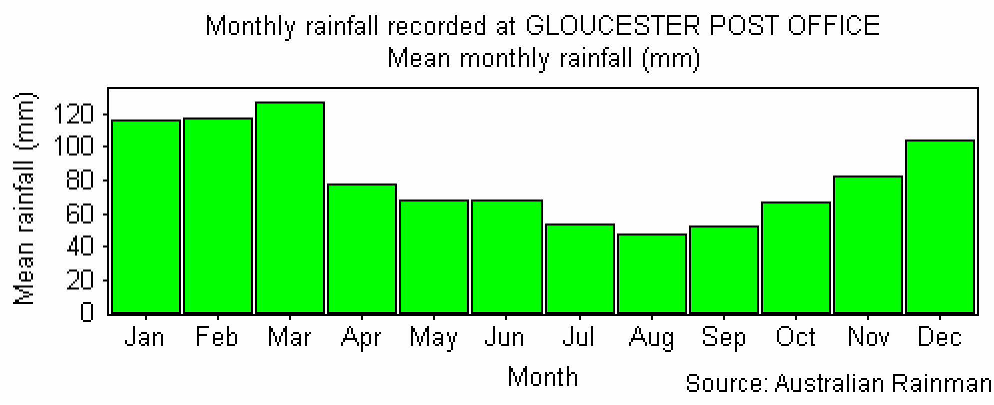
14.2.3 Manning catchment

	Surface licences within the Manning and adjoining catchments (%)		
SLA	Manning Catchment	Hastings	Karuah
Gloucester	99.78		0.22
Greater Taree	74.71	13	12.29

14.2.4 Lake Macquarie, Tuggerah Lakes, Brisbane Waters catchments

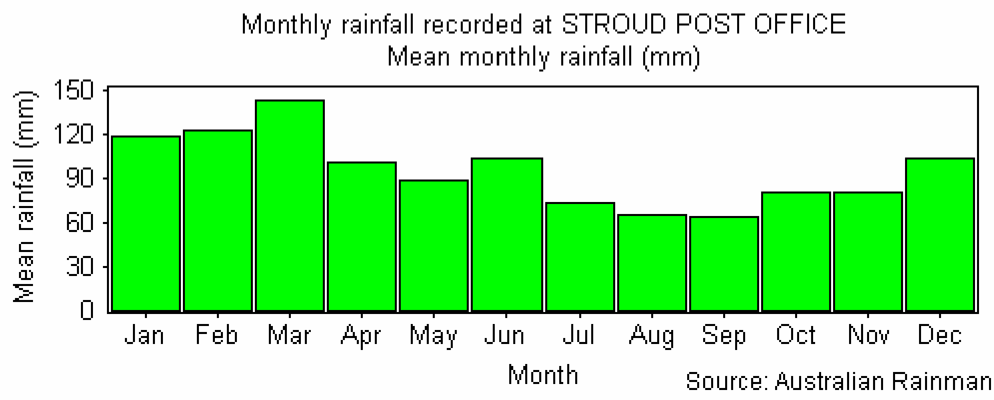
	Surface licences within the Lake Macquarie, Tuggerah Lakes, Brisbane Waters catchments and other adjoining catchments (%)	
SLA	Lake Macquarie, Tuggerah Lakes, Brisbane Waters catchments	Hawkesbury-Nepean catchment
Lake Macquarie	100	
Wyong	100	
Gosford	30.14	69.86

14.3 Rainfall at Gloucester (Manning catchment)



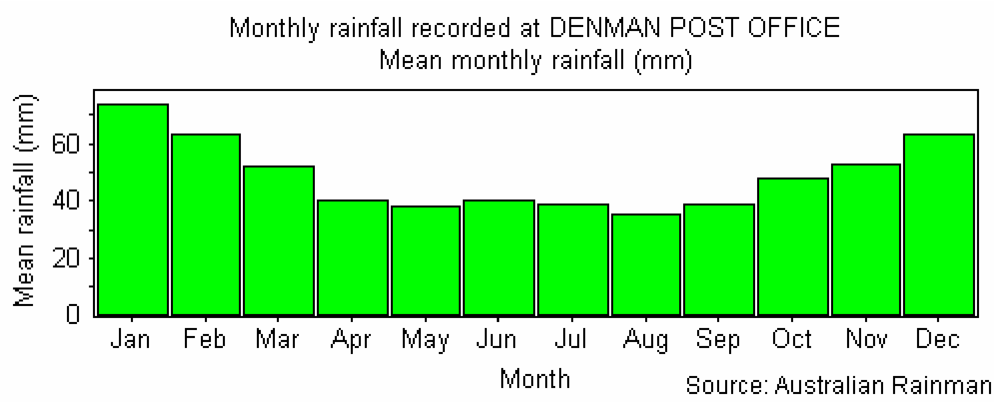
Source: Clewett et al. 1999, ①

14.4 Rainfall at Stroud (Karuah, Great Lakes and associated catchments)



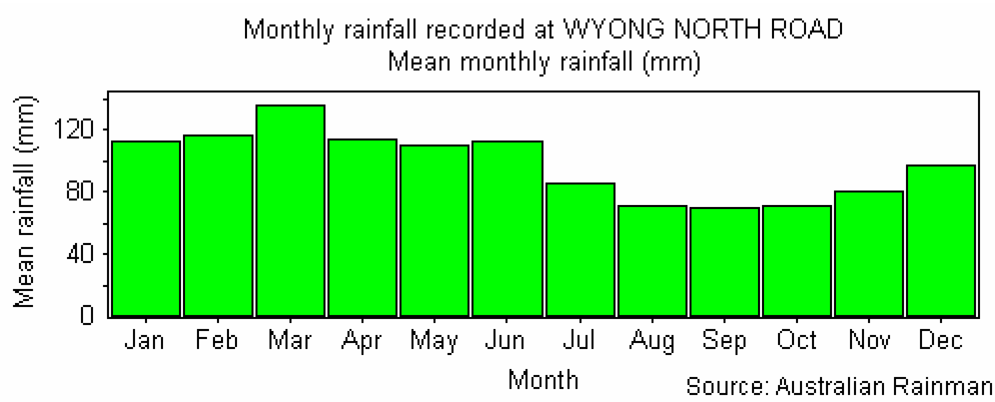
Source: Clewett et al. 1999, ①

14.5 Rainfall at Denman (Hunter catchment)



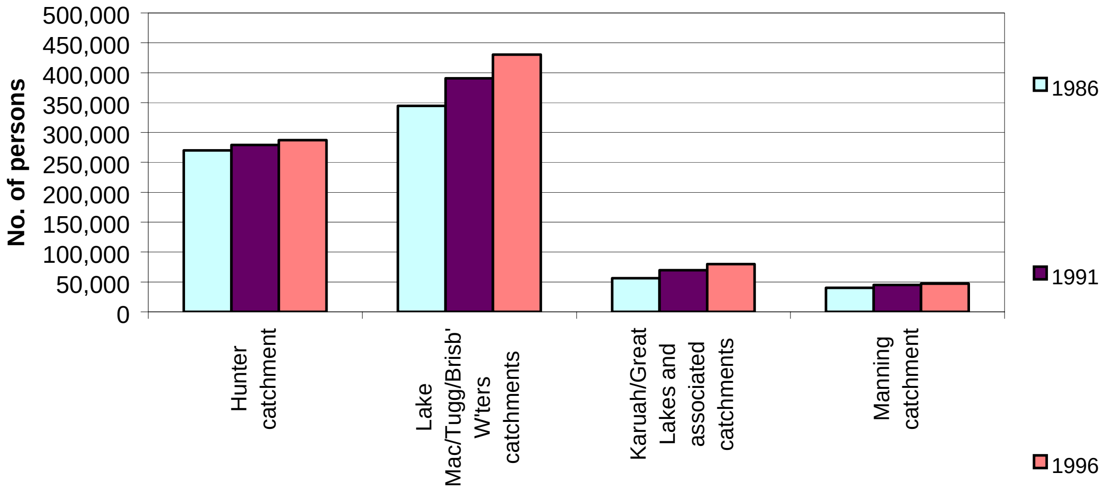
Source: Clewett et al. 1999, ①

14.6 Rainfall at Wyong (Lake Macquarie, Tuggerah Lakes, and Brisbane Waters catchments)



Source: Clewett et al. 1999, ①

14.7 Population in the NSW Mid-Coast region



Source: ABS 1998b, ②

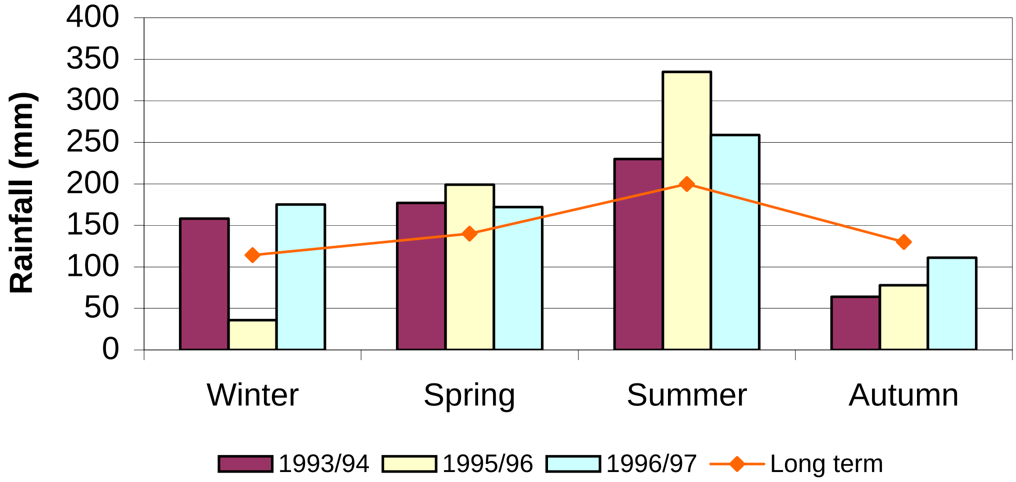
14.8 Area irrigated and number of enterprises irrigating in each SLA in the NSW Mid-Coast region

	1994		1996		1997	
SLA	**Area irrigated (ha)**	**Number irrigated enterprises irrigating**	**Area irrigated (ha)**	**Number irrigated enterprises irrigating**	**Area irrigated (ha)**	**Number irrigated enterprises irrigating**
Hunter catchment						
Cessnock	743	54	591	31	707	65
Dungog	2,401	109	1,463	72	1,894	81
Maitland	1,774	74	935	49	1,058	54
Merriwa	5,101	20	169	10	271	12
Murrurundi	3,726	16	1,605	7	519	6
Muswellbrook	8,661	158	5,777	103	7,694	130
Newcastle	1	2	5	1	62	4
Port Stephens	534	49	590	34	433	36
Scone	6,073	147	3,967	100	4,680	122
Singleton	5,762	171	4,372	122	5,072	159
Sub total	**34,775**	**800**	**19,476**	**529**	**22,390**	**669**
Karuah / Great Lakes catchment						
Great Lakes	**319**	**27**	**108**	**14**	**129**	**15**
Manning catchment						
Gloucester	1,603	89	1,388	66	1,698	82
Greater Taree	1,861	156	1,312	101	1,620	112
Sub total	**3,464**	**245**	**2,700**	**167**	**3,318**	**194**

	1994		1996		1997	
SLA	**Area irrigated (ha)**	**Number irrigated enterprises irrigating**	**Area irrigated (ha)**	**Number irrigated enterprises irrigating**	**Area irrigated (ha)**	**Number irrigated enterprises irrigating**
Lake Macquarie, Tuggerah Lakes, Brisbane Waters catchments						
Wyong	597	65	286	37	373	53
Gosford	298	39	206	24	256	31
Lake Macquarie	206	25	70	14	116	10
Sub total	**1101**	**129**	**563**	**75**	**744**	**94**
Grand total	**39,659**	**1,201**	**22,847**	**785**	**26,582**	**972**

Source: ABS 1998a, ②

14.9 Rainfall in 1993–94, 1994–95 and 1996–97 and the long-term mean rainfall in the NSW Mid-Coast region



Source: Clewett et al. 1999, ②

14.10 Allocation from Glenbawn Dam in the Hunter catchment

Year	Date Announced	Allocation
1981–82 [a]	8/09/1981	100%
	1/10/1981	120%
1982–83 [a]	19/08/1982	120%
1983–84 [a]	22/07/1983	100%
1984–85 [a]	19/07/1984	100%
1985–86 [a]	19/07/1985	100%
1986–87 [a]	30/07/1986	85%
	26/08/1986	100%
1987–88 [a]	24/07/1987	100%
1988–89 [a]	27/07/1988	100%
1989–90 [a]	13/07/1989	100%
1990–91 [a]	19/07/1990	100%
1991–92 [b]	8/08/1991	100%
1992–93 [b]	8/09/1992	100%
	7/01/1993	120%
1993–94 [b]	23/09/1993	100%
	14/01/1994	120%
1994–95 [b]		
1995–96 [b]		100%
1996–97 [b]	28/05/1997	100%
1997–98 [b c]	20/04/1998	100%
1998–99		

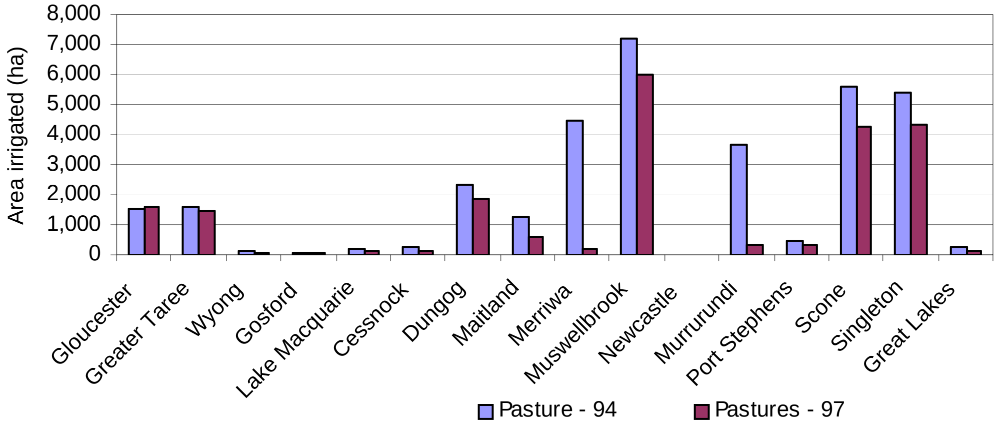
Source: DLWC 2000b ① All years - overdraw for following season was 0%.

[a] Minister announced allocation [b] Manager announced allocation

[c] Allocation announcement imminent. 100% likely.

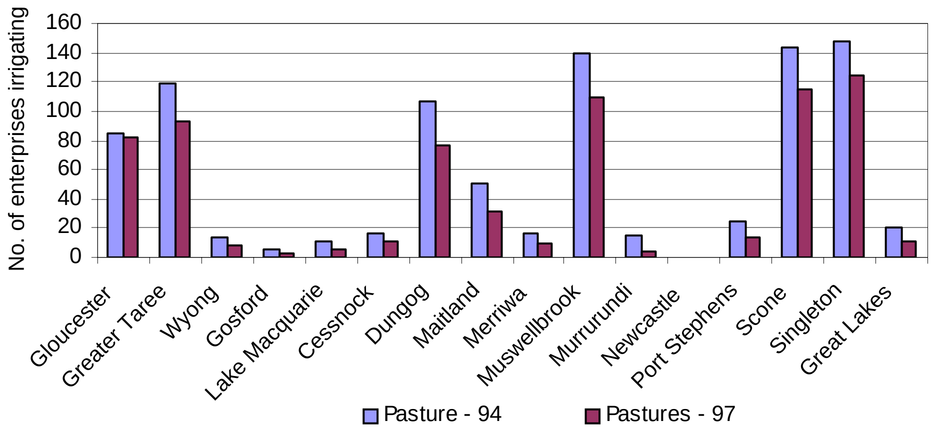
14.11 Area irrigated and the number of enterprises using irrigation in the NSW Mid-Coast region

14.11.1 Area: pasture



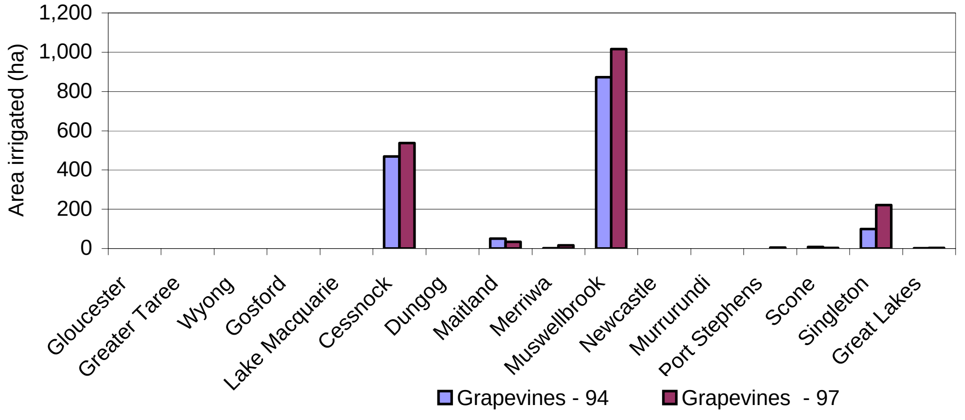
Source: ABS 1998a, ②

14.11.2 Number of enterprises: pasture



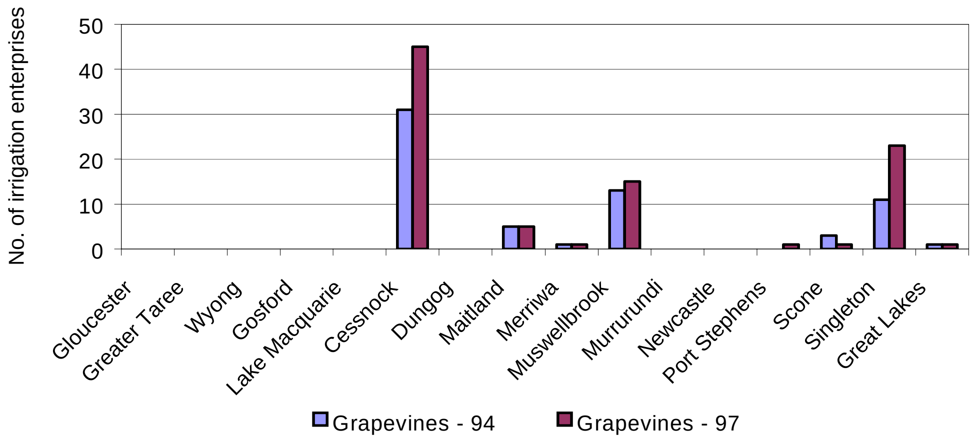
Source: ABS 1998a, ②

14.11.3 Area irrigated: vines



Source: ABS 1998a, ②

14.11.4 Number of enterprises, vines



Source: ABS 1998a, ②

14.12 Crop information from the NSW Mid-Coast region

Location	Name	Position	Crop class [a]	Crop	CWR ave (ML/ha) [b]	CWR min (ML/ha) [b]	CWR max (ML/ha) [b]	IR ave (ML/ha) [bc]	IR min (ML/ha) [bc]	IR max (ML/ha) [bc]	Y ave (t/ha) [d]	Y min (t/ha) [d]	Y max (t/ha) [d]	Sowing date [e]	Time of growth total [f]	System [g]
Scone	Carol Rose	District Agronomist	Cereals	Maize										15-Dec		
Hunter (Maitland alluvial flats)	Alan Richards	Irrigation Officer	Cereals	Maize (Seed)	1.0	0.8	1.2	0.6	0.3	1.0	2.0	1.0	3.0	1-Nov		
Gosford	Sandra Hardy	District Horticulturalist	Citrus	Grapefruits	3.5	2.5	5.0	4.0	3.0	5.5	30.0	20.0	40.0		325	micro
Gosford	Sandra Hardy	District Horticulturalist	Citrus	Lemons	3.5	2.5	5.0	4.0	3.0	5.5	30.0	20.0	40.0		325	micro
Gosford	Sandra Hardy	District Horticulturalist	Citrus	Limes	3.5	2.5	5.0	4.0	3.0	5.5	30.0	20.0	40.0		325	micro
Gosford	Sandra Hardy	District Horticulturalist	Citrus	Mandarins	3.5	2.5	5.0	4.0	3.0	5.5	30.0	20.0	40.0		325	micro
Gosford	Sandra Hardy	District Horticulturalist	Citrus	Oranges	3.5	2.5	5.0	4.0	3.0	5.5	30.0	20.0	40.0		325	micro
Gosford	Sandra Hardy	District Horticulturalist	Misc.	Kiwi fruit	2.5	2.0	3.0	3.0	2.5	3.5	3.0	2.5	3.5		265	micro
Scone	Carol Rose	District Agronomist	Pasture	Lucerne	10.6			6.6	2.0	13.0	11.0	5.0	20.0	1-Sep	288	hand shift
Hunter (Maitland alluvial flats)	Alan Richards	Irrigation Officer	Pasture	Perennial (Lucerne)	1.0	0.8	1.2	0.8	0.3	0.8	15.0	10.0	20.0	1-Apr	365	
Gosford	Sandra Hardy	District Horticulturalist	Stone fruit	Nectarine	2.5	2.0	3.0	3.0	2.5	3.0	20.0	13.0	26.0		265	micro
Gosford	Sandra Hardy	District Horticulturalist	Stone fruit	Peaches	2.5	2.0	3.0	3.0	2.5	3.5	20.0	13.0	26.0		265	micro
Gosford	Sandra Hardy	District Horticulturalist	Stone fruit	Plums	2.5	2.0	3.0	3.0	2.5	3.0	20.0	13.0	26.0		265	micro
	John Slack	District Horticulturalist	Stone fruit	Orchards (Low Chill)									1-Jul	300		
Gosford	Sandra Hardy	District Horticulturalist	Tropical fruits	Avocados	7.5	5.0	9.5	8.0	5.5	10.0	10.0	7.0	15.0		365	micro

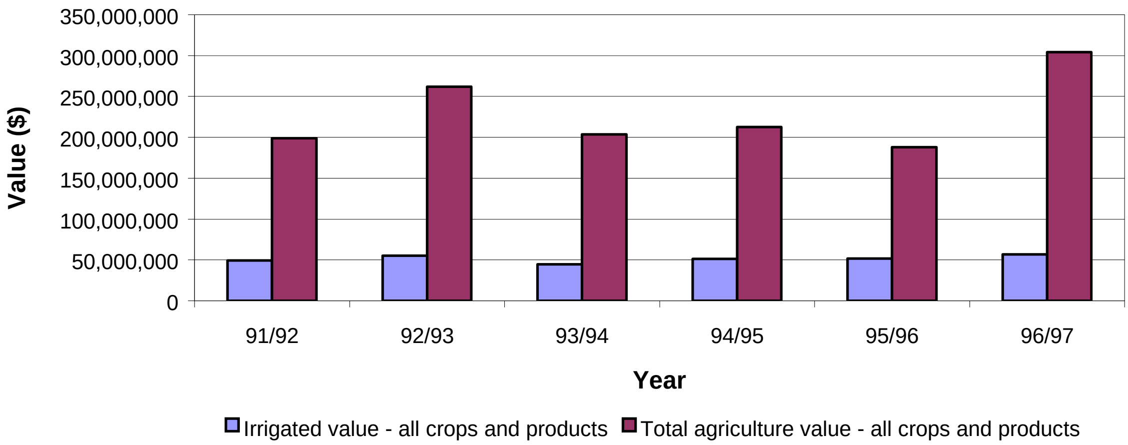
Location	Name	Position	Crop class[a]	Crop	CWR ave (ML/ha)[b]	CWR min (ML/ha)[b]	CWR max (ML/ha)[b]	IR ave (ML/ha)[bc]	IR min (ML/ha)[bc]	IR max (ML/ha)[bc]	Y ave (t/ha)[d]	Y min (t/ha)[d]	Y max (t/ha)[d]	Sowing date[e]	Time of growth total[f]	System[g]
Hunter (Maitland alluvial flats)	Alan Richards	Irrigation Officer	Veg.	Cabbage							5.5				84	
Hunter (Maitland alluvial flats)	Alan Richards	Irrigation Officer	Veg.	Cauliflower							3.6				112	
Hunter (Maitland alluvial flats)	Alan Richards	Irrigation Officer	Veg.	Melons	0.7	0.5	1.0	0.2	0.1	0.4	30.0	20.0	40.0	1-Nov	84	
	Stephen Wade	District Horticulturalist	Veg.	Potatoes										15-Jun	169	
	Stephen Wade	District Horticulturalist	Veg.	Potatoes										1-Feb	89	
Hunter (Maitland alluvial flats)	Alan Richards	Irrigation Officer	Veg.	Potatoes	1.0	0.8	1.2	0.8	0.5	1.3	25.0	15.0	30.0	1-Aug	84	
Hunter (Maitland alluvial flats)	Alan Richards	Irrigation Officer	Veg.	Pumpkins	0.7	0.5	1.0	0.2	0.1	0.4	20.0	10.0	30.0	1-Oct		
Taree	Adam Wilson	District Agronomist	PASTURE	Annual				6.0			10.0				210	bike shift
Taree	Adam Wilson	District Agronomist	PASTURE	Perennial				6.0			15.0				210	bike shift

Source: NSW Agriculture (1999)

[a] Crop class refers to a category under which similar crops can be grouped.
[b] CWR – Crop Water Requirement is the depth of water needed to meet the water loss through evapotranspiration of a disease-free crop, growing in a large field under non-restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment. Note, this figure excludes leaching fractions and does not allow for system inefficiencies. Average, minimum, and maximum figures correspond to water requirements in normal, wet and dry seasons respectively.
[c] 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.
[d] 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 (e.g. dry matter, grain, fibre etc).
[e] Date on which annual crops are typically sown.
[f] For field and vegetable crops, the total number of days between sowing and harvesting. For perennial crops usually 365 days.
[g] System refers to irrigation system used. [h] Effic – Irrigation efficiency, the ratio between crop water requirement and the irrigation water delivered *to the farm*. It therefore describes losses due to leaching requirement and conveyance (deep percolation and evaporation), distribution, and application inefficiencies.

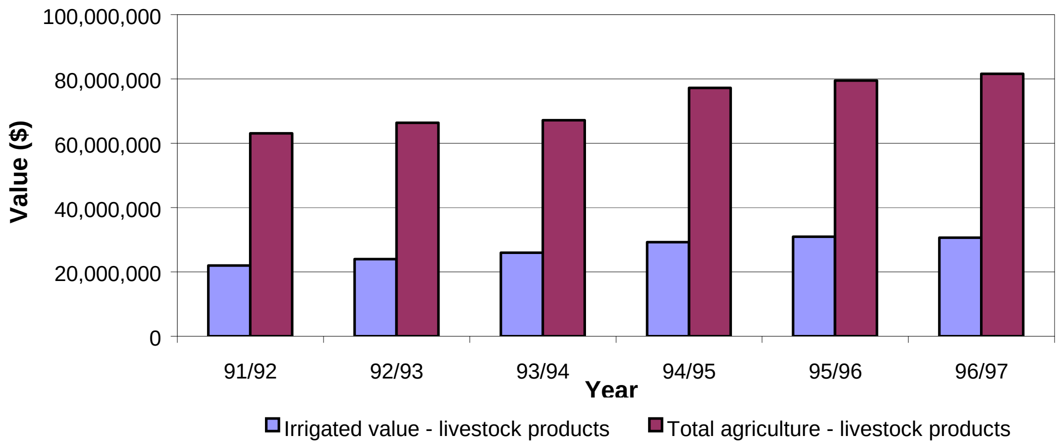
14.13 Value of irrigated agriculture relative to total agriculture in the Hunter catchment

14.13.1 Value: all crops and products



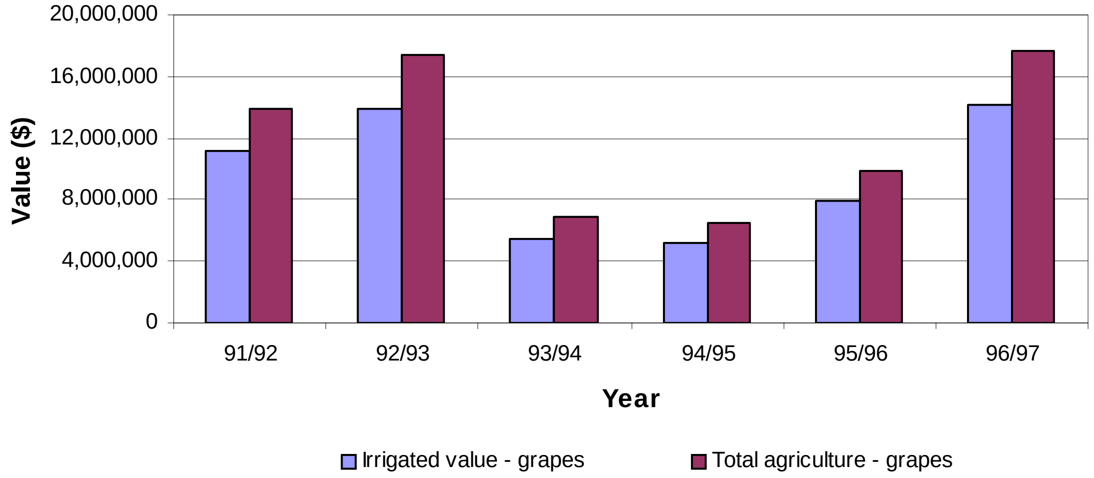
Source: (Donovan 2000) ③

14.13.2 Value: livestock products



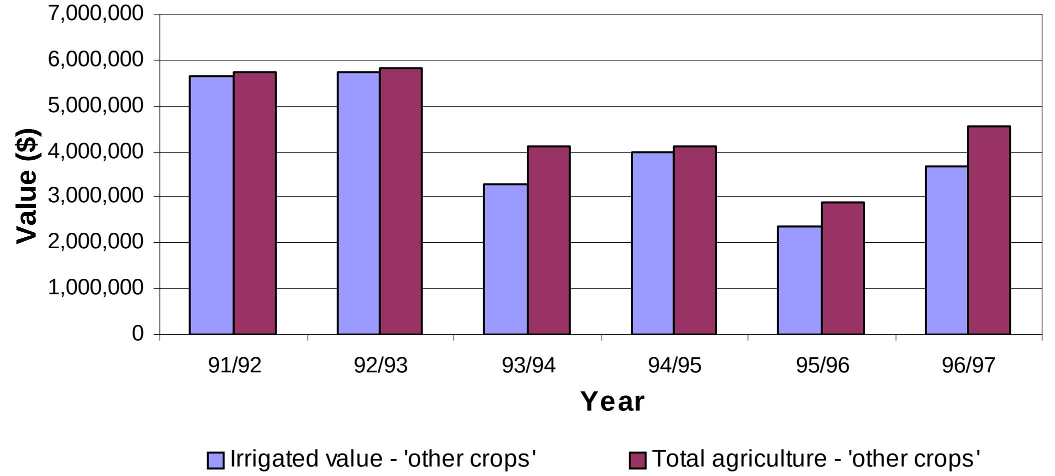
Source: (Donovan 2000) ③

14.13.3 Value: grapes



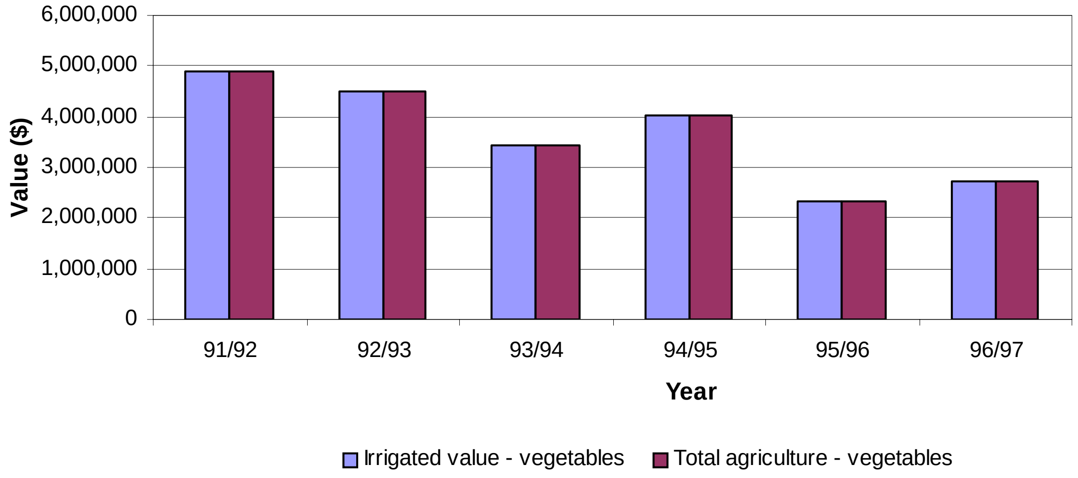
Source: (Donovan 2000) ③

14.13.4 Value: other crops



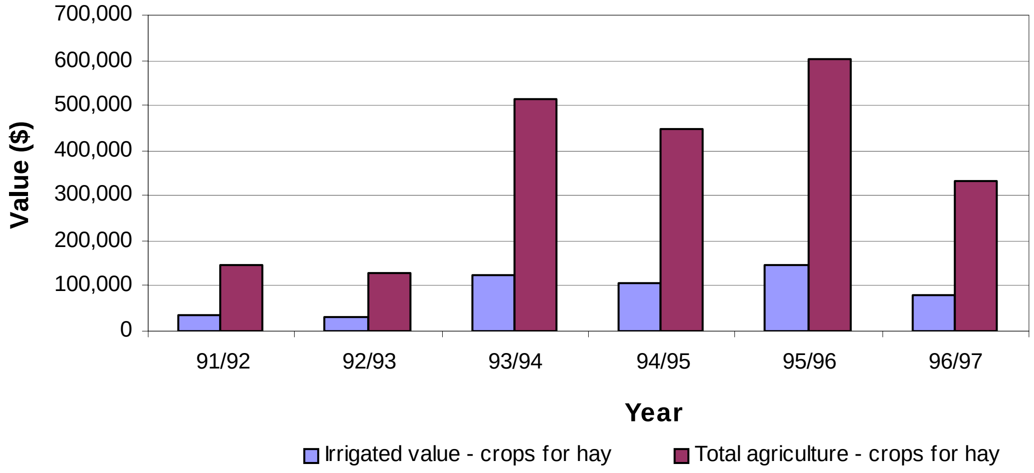
Source: (Donovan 2000) ③

14.13.5 Value: vegetables



Source: (Donovan 2000) ③

14.13.6 Value: crops for hay



Source: (Donovan 2000) ③

14.14 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)

14.15 Water allocated in the Hunter catchment (ML/ann.)

	Hunter River	Glennies Creek	Paterson River	Total
Power generation	36,000			36,000
Irrigation (annual crops)	111,920	6,900	9,180	128,000
Irrigation (permanent plantings)	9,440	215	145	9,800
Town water supply	10,800		95	10,895
Industrial	4,110	20	10	4,140
Sand and gravel	420			420
Mining	2,990	480		3,470
Recreation	65			65
Stock/domestic/farming	1,192	180	48	1,420
Total (ML)	**176,937**	**7,795**	**9,478**	**194,210**

Source: DWR 1995, ①. These figures do not include off-allocation.

14.16 Area irrigated from regulated rivers, Hunter catchment (ha)

Crops	1989–90	1990–91
Lucerne	6,678	7,605
Summer pasture	2,644	3,147
Vines	731	1,017
Summer cereal	241	348
Vegetables	128	134
Pecan nuts	72	82
Wheat	54	0
Oats	50	138
Orchard	36	2
Sorghum	20	16
Triticale	20	0
Sudax	19	57
Winter pasture	10	253
Citrus	2	2
[No crop specified]	0	9,136
Chickpeas	0	22
Winter cereal	0	75
Total	**10,704**	**22,053**

Source: DLWC 1998b, ②

14.17 Volume from regulated rivers used by crops, Hunter catchment (ML/ann.)

Crops	1989–90
Lucerne	18,873
Summer pasture	4,877
Vines	583
Summer cereal	389
Pecan nuts	344
Vegetables	251
Orchard	116
Oats	80
Wheat	40
Sorghum	32
Sudax	23
Triticale	16
Winter pasture	8
Nursery	3
Citrus	2
Total	**25,638**

Source: DLWC 1998b, ②

14.18 Area (ha) of crops irrigated in the NSW Mid-Coast region from unregulated rivers, and water use

14.18.1 Crops, 1989–1993

Crops	1989–90	1990–91	1991–92	1992–93
Summer cereal	86	120	162	141
Winter cereal	115	318	296	235
Summer oilseeds	12	32	30	0
Winter oilseeds	0	16	33	10
Cotton	0	0	0	9
Citrus	95	73	73	53
Lucerne	810	949	1157	1092
Summer pasture	2725	2835	3284	2778
Winter pasture	1230	1906	1987	1973
Vegetables	107	118	107	178
Vines	151	363	348	471
Wheat	0	0	0	13
Other	434	307	145	295
Total area (ha)	**5767**	**7036**	**7621**	**6997**
Water usage (ML)	**31681**	**21130**	**16810**	**44758**

14.18.2 Crops, 1993–1995

Crops	1993–94	1994–95
Adzuki beans	0	0
Barley	37	51
Carrots	0	0
Citrus	86	107
Cotton	0	0
Garlic	8	20
Grapes	0	0
Hybrid seed	0	0
Lucerne	879	1254
Maize	0	0
Millet	0	0
Oats	11	38
Orchard	86	73
Other crops	82	108
Other vegetables	32	40
Peas	0	0
Potatoes	2	2
Pumpkins	0	0
Rice	0	0
Safflower	0	0
Sorghum	735	677
Soybeans	6	4
Summer cereal	5	4
Summer grains	0	19
Summer pasture	3928	4102
Sunflower	0	8
Sweet corn	0	0

Crops	1993–94	1994–95
Tomatoes	7	11
Triticale	0	0
Turf	74	111
Vegetables	0	0
Vines	521	730
Wheat	4	1
Winter cereal	0	1
Winter grains	0	0
Winter pasture	2196	3170
Total area irrigated (ha)	**8784**	**10531**
Water usage (ML)	**13099**	**17824**

Source: DLWC 1998b, ③

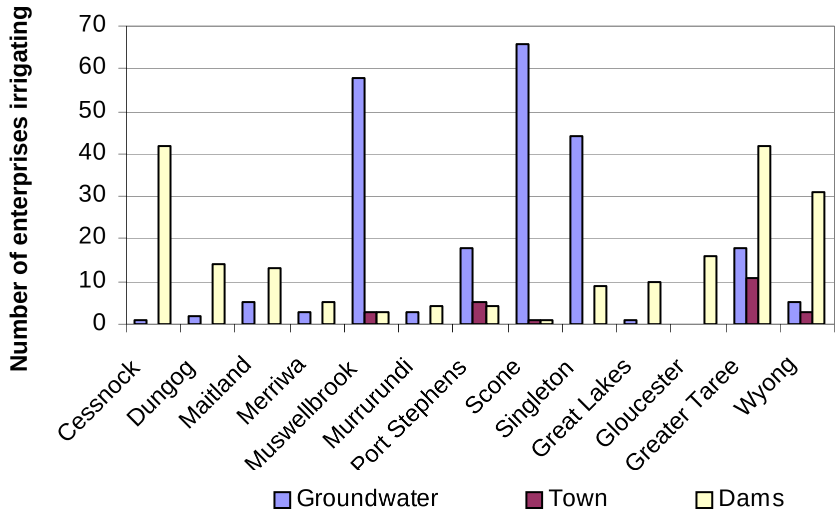
14.19 Total area in the NSW Mid-Coast region irrigated from unregulated rivers, by crop type

	93–94	94–95	95–96	96–97	97–98	98–99
Perennial pasture	5,666	5,928	6,606	6,676	6,630	6,331
Lucerne	3,202	3,270	3,568	3,571	3,606	3,440
Annual Pasture	2,282	2,531	2,487	2,594	2,484	2,330
Vines - wine grapes	829	868	983	1,310	1,386	1,526
Winter cereal	955	960	903	914	908	901
Fodder	626	620	640	735	667	596
Other	353	380	416	453	518	510
Summer cereal	289	270	268	252	284	261
Turf	189	178	192	198	200	197
Vegetables	144	164	162	178	150	154
Citrus	128	123	109	110	110	147
Trees (orchards)	102	102	101	108	126	135
Trees (other)	75	78	87	99	100	130
Winter oilseeds	0	0	0	6	46	46
Nurseries	38	30	35	36	35	39
Olives	1	1	1	19	24	26
Vines - table grapes	4	4	4	4	18	18
Pulses	37	15	31	16	32	9
Nuts	13	13	13	14	7	8
Cotton	0	0	0	0	0	0
Summer oilseeds	5	5	7	6	2	0
Grand total	**14,937**	**15,539**	**16,614**	**17,298**	**17,334**	**16,804**

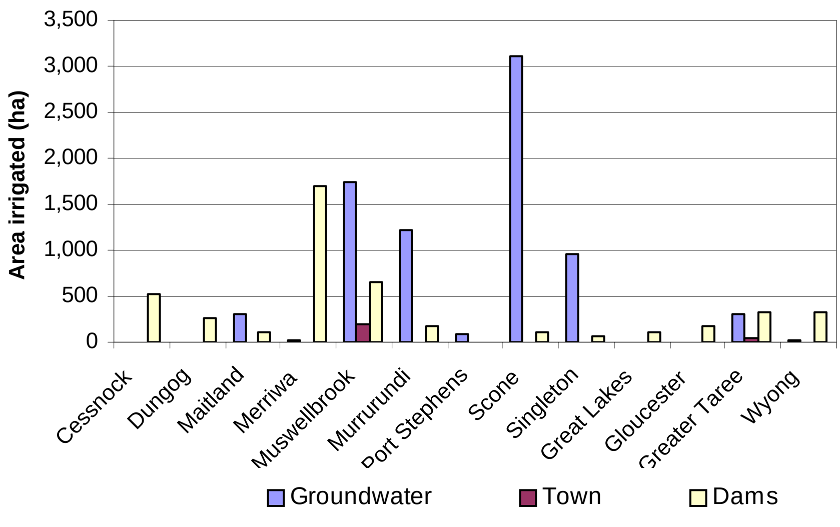
Source: DLWC 2000c

The average area irrigated for each crop type was determined using data from 1993–94 to 1998–99. Data were obtained from growers by written survey.

14.20 Number of enterprises and area irrigated (ha) by water source in the NSW Mid-Coast region



Source: ABS 1998a, ②



Source: ABS 1998a, ②

14.21 Stressed stream classification of subcatchments in the NSW Mid-Coast region

The DLWC undertook a desktop assessment of the environmental and hydrological stress of subcatchments in the NSW Mid-Coast region. An environmental stress rating for each of the freshwater subcatchments within each catchment was assessed using a series of environmental indicators. 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. The indicators are as follows:

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

This method was used for 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 were made using the surface water returns lodged by licence holders. However, not all survey cards were returned to DLWC and the volumes were adjusted for the proportion of licence holders who chose 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. For borderline subcatchments, that is, those with 30% to 40% or 60% to 70% extraction of flow, additional local information was used to place them into the higher or lower category.

The data 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. This source can be incomplete as not all growers return the information to the DLWC (DLWC 1999d). The raw data were adjusted up to account for these growers. 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 NSW Mid-Coast region.

Catchment	Subcatchment	Environmental stress	High extraction	Future risk considerations	# licences (all purposes)	# of irrigation licences	authorised area	80th percentile	50th percentile
Hunter	Mangrove Creek	High	High	Poor water quality	351			17.3	56.6
Hunter	Tributaries that flow into Brisbane Waters	Medium	Low	High risk of significant development. Include urban, rural residential, agricultural, highway construction, industrial.	16	11	60	5	6
Hunter	Mooney Mooney Creek	Low	High					5.8	14.3
Hunter	Allyn River	Medium	High	No threats	82	77	797	7	39
Hunter	Bearami Creek	Medium	High	No threats	11	11	330	0	1
Hunter	Black Creek including Pokolbin Creek	High	High	Urban, mining, rural-residential, agriculture, highway construction, industrial and other development	59	54	885	3	5
Hunter	Bow River	Medium	Low	No threats	6	5	57	1	4
Hunter	Bylong River and Crowee River	High	High	Medium risk from significant development	4	4	23	0	0
Hunter	Dart Brook, Middle Brook and Kindon Ponds	High	High	High risk from significant development	57	32	306	0	4
Hunter	Hunter River and its tributaries upstream of Glenbawn Dam	Medium	Low	Low risk of significant development	62	57	802	64	194
Hunter	Tributaries of Glennies Creek downstream of Lake St Clare	High	Low	Medium risk from significant development	9	8	57	3	12
Hunter	Goulburn River	High	High	Medium risk from significant development	73	68	2723	7	33
Hunter	Halls Creek including Giants Creek	High	High	Low risk of significant development	40	37	566	1	4
Hunter	Small tributaries that flow into the Hunter Estuary including Wallis Creeks	High	Low	High risk from significant development	11	9	124	5	11
Hunter	Small tributaries that flow into the Hunter River downstream of Glenbawn Dam	High	High	High risk of significant development including urban, mining, rural residential, agricultural, highway construction, hydro-electric power generation industrial.	98	78	730	<1	10
Hunter	Krui River	Medium	High	Low risk of significant development	13	13	252	1	4
Hunter	Fal Brook and Carrow Brook	Low	Low	Low risk of significant development	nd	nd	nd	5	13
Hunter	Patterson River upstream of Lostock Dam	Low	Low	Low risk of significant development	6	6	45	24	70
Hunter	Martindale Creek and Doyles Creek	Medium	High	Low risk of significant development	25	25	622	0	3
Hunter	Merriwa River and Woorndoo Rivulet	Medium	High	Medium risk from significant development	54	52	960	3	6
Hunter	Munmurra River	Medium	Low	Low risk of significant development	2	1	20	4	7
Hunter	Pages River and Isis River	High	High	Medium risk from significant development	81	57	1339	3	30
Hunter	Rouchel Brook	Low	Medium	Low risk of significant development	24	23	204	4	36
Hunter	Widden Brook	Medium	Medium	Medium risk from significant development	4	4	626	3	12
Hunter	Williams River and Chichester River	Medium	High	High risk of significant development	163	150	1696	27	115

Catchment	Subcatchment	Environmental stress	High extraction	Future risk considerations	# licences (all purposes)	# of irrigation licences	authorised area	80th percentile	50th percentile
Hunter	Wollar Creek	Medium	Low	Low risk of significant development	4	3	34	0	1
Hunter	Wollombi Brook and Congewai Creek	High	High	High risk from significant development. Urban, mining, rural residential, agriculture, industrial, sand or gravel extraction from the river and other development.	147	134	2099	0	23
Hunter	Wybong Creek	High	High	Low risk of significant development	91	88	1700	1	5
Karuah, Great Lakes	Karuah River and its tributaries	Medium	Medium	High risk of significant development.	63	56	767	16	70
Karuah, Great Lakes	Myall Lake and its tributaries including Myall River	Medium	High	Low risk of significant development	7	6	59	2	13
Karuah, Great Lakes	Wallis Lake and its tributaries	Low	High	High risk of significant development. Risks include urban, rural residential, agricultural, highway construction and other development	39	34	394	<1	6
Macquarie,Tuggerah Lakes	Jiliby Jiliby Creek	High	High	High risk of significant development	27	25	215	<1	3
Macquarie, Tuggerah Lakes	Lake Macquarie and its tributaries	Medium	High	High risk of significant development. Development includes urban, mining, rural-residential, agricultural, highway construction, industrial.	27	21	250	<1	4
Macquarie, Tuggerah Lakes	Wyong River downstream of Bunning Creek confluence	Low	High	High risk of significant development	62	57	560	6	23
Macquarie, Tuggerah Lakes	Ourimbah Creek	Medium	High	Medium risk of significant development	83	72	474	18	22
Macquarie, Tuggerah Lakes	Wyong River upstream of Bunning Creek confluence	Low	Medium	Medium risk from significant development	19	19	160	3	12
Manning	Manning River upstream of Gloucester River confluence including the Barnard River	Medium	Low	Low risk of significant development	46	42	620	86	220
Manning	Barrington River and the Low Gloucester River	Medium	Low	High risk of significant development. Developments include rural residential, agricultural, sand or gravel extraction from the river and other developments.	119	106	1529	113	416
Manning	Dingo Creek, Caparra Creek and Cedar Party Creek	Low	High	High risk of significant development. Development includes rural residential and agricultural.	134	127	1217	14	62
Manning	Gloucester River upstream of Barrington River confluence including the Avon River	Medium	High	High risk of significant development. Includes urban, mining, rural-residential, agricultural, ind. & other dev.	105	92	1181	15	59
Manning	Central section of the Manning River	Medium	Low	Low risk of significant development	55	51	665	330	1293
Manning	Tributaries that flow into the Manning Estuary including Lansdowne River and Dawsons River	Medium	High	High risk of significant development. Development includes urban, rural residential, agricultural, highway construction, industrial, sand or gravel extraction from the river.	28	20	278	2	10
Manning	Nowendoc River	Low	Low	Low risk of significant development	18	17	251	101	265
	TOTAL				**2333**	**1759**	**25753**		