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Namoi Region

Water for the Future Strategy

Volume 1: Water Resources

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A – Data Register

Acronyms

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AWD	Available Water Determination
CtP	Cease to Pump
DPC	Department of Premier and Cabinet
GAB	Great Artesian Basin
GHG	Green House Gas Emissions
GRP	Gross Regional Product
HEW	Held Environmental Water
JO	Joint Organisation
LGA	Local Government Area
MDBA	Murray Darling Basin Authority
NARClim	NSW and ACT Regional Climate Modelling
PEW	Planned Environmental Water
REDS	Regional Economic Development Strategies
RPA	Resource Plan Area
SAP	Special Activation Precincts
SDL	Sustainable Diversion Limits
WAL	Water Access Licence
WMA 2000	Water Management Act 2000

1 Introduction

In January 2019, Namoi Unlimited commissioned a Water for the Future Strategy aimed at identifying the opportunities and constraints associated with regional water resources and use, to both current and future regional development. The strategy has been developed as a two-volume report:

- **Volume 1** (this document) of the report forms the basis of the strategy, providing a review and summary of the strategy development methodology, data, issues and findings related to water use and management within the Namoi region
- **Volume 2** (**Analysis and Strategy**) provides an analysis of the data and issues identified within Volume 1 and presents the recommended strategy and actions to be undertaken to improve the availability, security and use of water within the region to support its economic growth and development.

1.1 Study Area

The five member councils' local government areas (LGAs) of the Namoi Unlimited JO are shown in **Figure 1-1** and **Figure 1-2.** The JO covers over 35,000 km^2 in the New England north-west of New South Wales. The study area ("the Namoi JO") runs predominantly north – south, extending from south of Quirindi to north of North Star, near Boggabilla and the Queensland border. Its western extent stretches from Mullaley, Gunnedah to the eastern boundary of the Walcha LGA and the Carrai National Park (approximately 100km from Port Macquarie). The study area represents some of the most productive and valuable agriculture land within NSW and Australia.

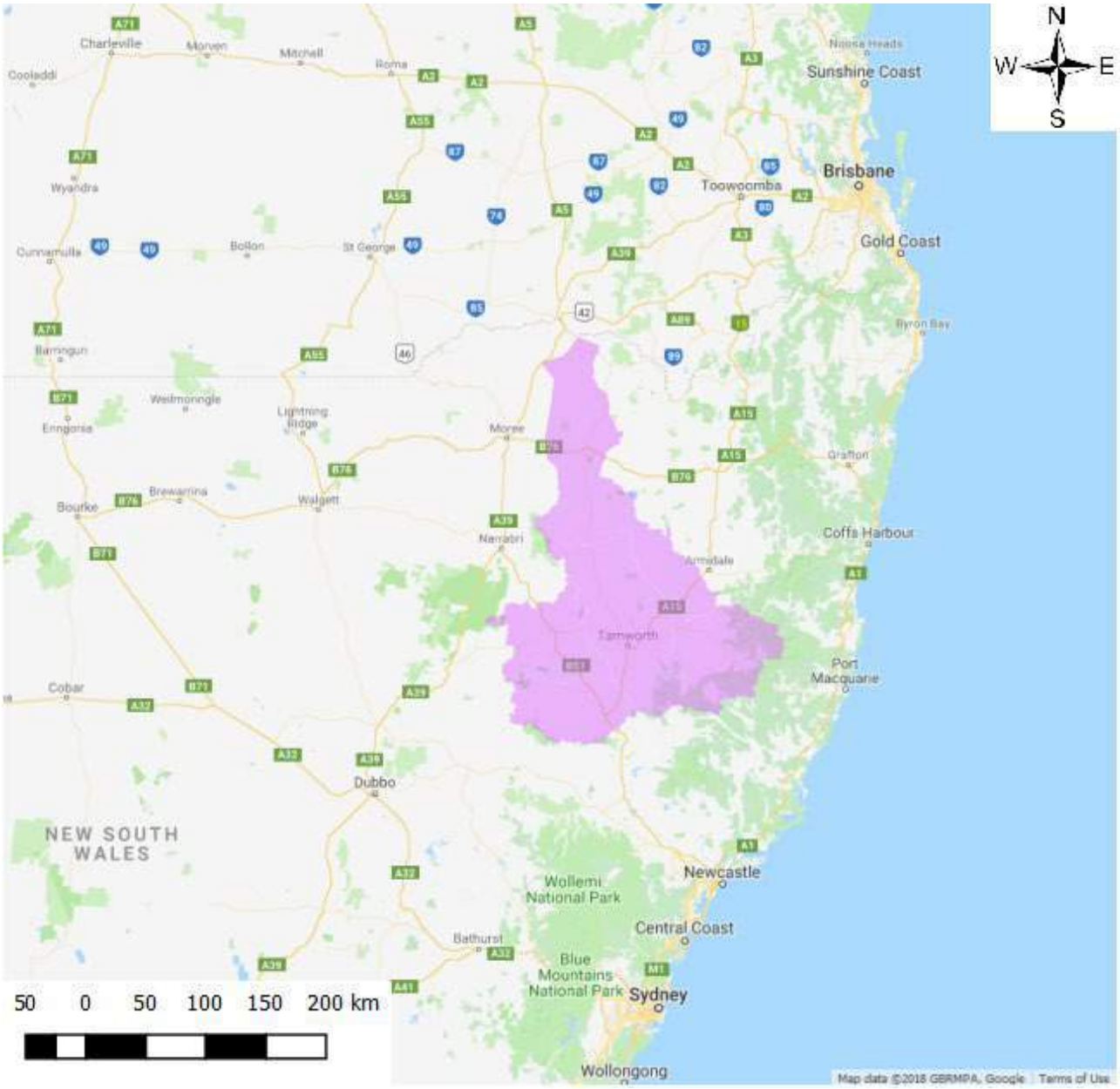


Figure 1-1: Geographic extent of Namoi Unlimited[1]

[1] Imagery from Google Maps

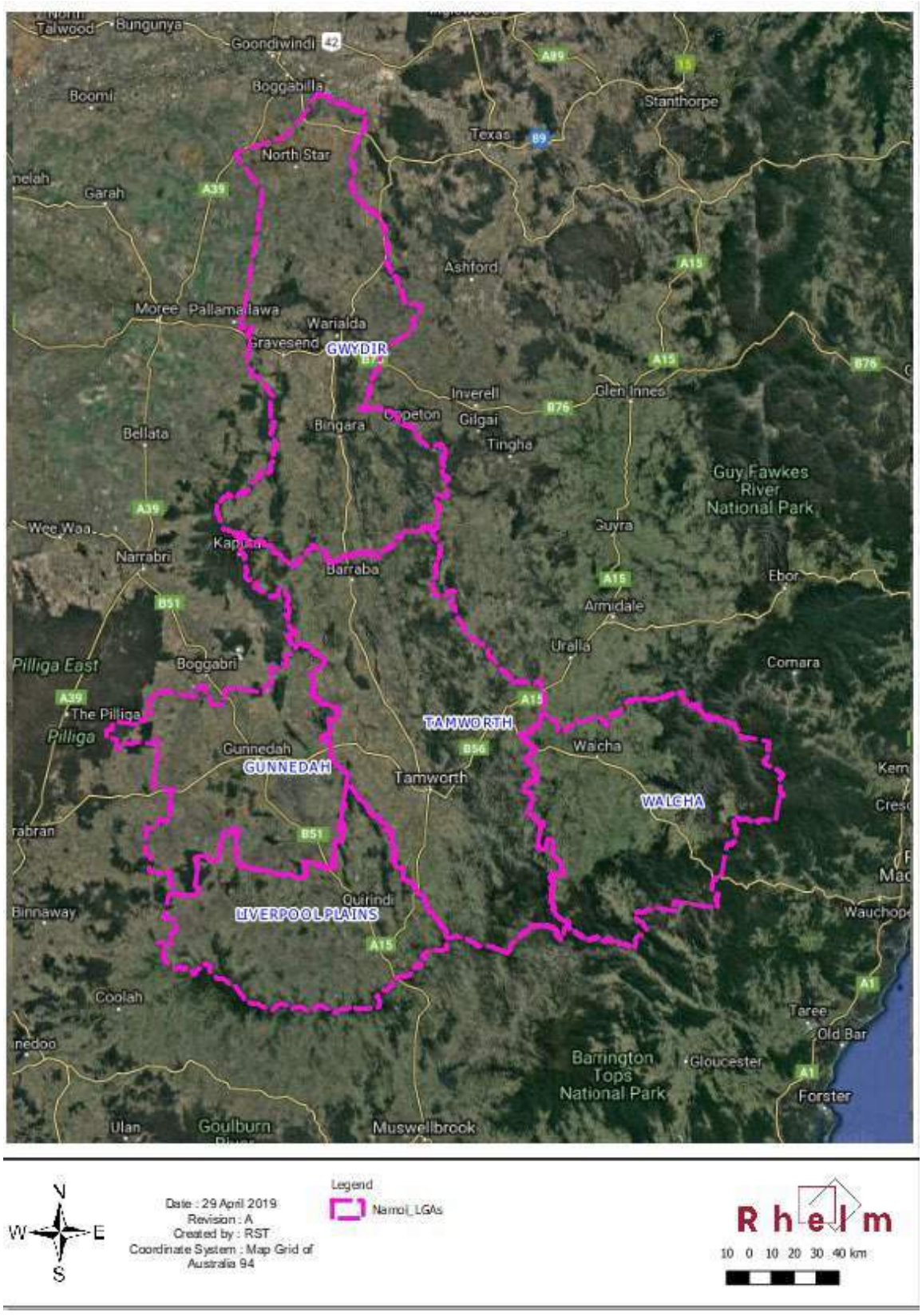


Figure 1-2: Member councils of Namoi Unlimited[2]

[2] Imagery from Google Maps

1.2 Namoi Unlimited

The Namoi Joint Organisation of Councils trading as Namoi Unlimited was established in mid-2015 as part of the NSW Government's pilot program to form new entities, called Joint Organisations, to facilitate collaboration among neighbouring Councils.

Namoi Unlimited represents five Local Government Areas located in the New England North West of NSW:

- Gunnedah Shire Council
- Gwydir Shire Council
- Liverpool Plains Shire Council
- Tamworth Regional Council
- Walcha Council.

The commitment and collaboration of Joint Organisations in NSW and their Members is framed in the *NSW Local Government Act 1993*. The principles of operating the organisation are published in its Charter (Namoi Unlimited, 2018b).

1.2.1 Purpose and vision

The NSW Government established Joint Organisations of Councils in 2017 by amendment to the *NSW Local Government Act 1993*.

The role of Namoi Unlimited is to engage and collaborate with the NSW Government, working together to build stronger councils and communities. The vision for the region captured by the JO (the "Namoi Region") is that it shall be:

- A productive, smart and liveable region
- A region recognised for its strong leadership, innovation, and excellence in regional collaboration.

1.2.2 Principal Functions

The core function of Joint Organisations of Councils is collaboration - collaboration between Councils, the NSW Government and the Australian Government. Joint Organisations are also enabled to establish collaborative arrangements with key agencies and organisations with similar functions, values and activities.

The principal functions of Namoi Unlimited are:

A. Establish strategic regional priorities for the joint organisation area and develop strategies and plans for delivering these priorities
B. Provide regional leadership for the joint organisation area and to be an advocate for strategic regional priorities
C. Identify and take up opportunities for intergovernmental collaboration on matters relating to the joint organisation area.

1.2.3 Shaping the Future in the Namoi

Following establishment, Namoi Unlimited undertook a Shaping the Future of the Namoi study (Regional Australia Institute, 2015) to identify those things that had, or would have, the most profound impact on the region into the future and shape the direction and actions of Namoi Unlimited. The report identified six critical future factors:

- National and global cycles in commodity markets
- Maximising innovation in agricultural production
- Seeking international investment, on the right terms
- Engaging the Namoi in major overseas markets
- Urbanisation
- Leveraging regional brand marketing to attract people to live and work in the Namoi.

It was seen that the factors relating to innovation in agriculture, securing investment, engaging in markets, and promotion with a trusted and energised regional brand were the areas in which Local Governments and Namoi Unlimited could be most relevant, proactive and generate positive regional impacts.

1.2.4 Namoi Unlimited Strategic Regional Plan

Based on the findings of the Shaping the Future in the Namoi study, Namoi Unlimited developed a Strategic Regional Plan (Namoi Unlimited, 2018a) focused on three, interlinked, Strategic Regional Priorities:

- Water for Future
- Enabled and Connected Infrastructure
- Engaged People Seeking Skills for the Future.

1.2.4.1 Water for the Future

Agriculture, agricultural products, commodities and services underpin the economies of the Namoi region.

The dynamics of global markets, climate change and changing consumer demand, mean our core industry must evolve and adapt.

The availability, security and access to water underpin every facet of agriculture.

Water is also critical to the other two priorities identified in the Namoi Unlimited Strategic Regional Plan. Water is the critical enabler for industry, business, communities, lifestyle, tourism and the environment. Namoi Unlimited will target actions towards growth and development.

1.2.4.2 Enabled and Connected Infrastructure

The provision of goods and services, connecting people and business, and addressing the perception of remoteness and isolation in regional areas are all dependent on having fully functional and connected infrastructure.

Roads, rail, air infrastructure, energy and telecommunications infrastructure are critical for the future growth and the development of the region.

The role of Namoi Unlimited is to understand the capacity and capability of existing infrastructure and networks, and then take a future focussed approach to prioritising, investing and advocating for critical and necessary infrastructure, necessary to enabling and supporting growth.

1.2.4.3 Engaged People Seeking Skills for the Future

People and their skills are fundamental to the growth of economies, communities and lifestyle.

Local Government is one of the largest employers in the Namoi region and has an important role to play in the attraction of people to the region, and the development of skills to meet the future demands of the region's workforce.

The members of Namoi Unlimited will identify, promote and engage in opportunities to address skill shortages within both Councils and across communities.

1.3 Water for the Future Strategy: Objectives and Purpose

As part of the Water for the Future Strategic Regional Priority, Namoi Unlimited identified the following objectives to be pursued to support the regional plan:

- Audit, analyse, identify and prioritise the key constraints, opportunities and innovations to secure the supply of water for communities, businesses and Local Government
- Audit, analyse, identify and prioritise opportunities and partnerships for agriculture, agricultural products, commodities, supply and value chains, as well as services
- Identify the potential impacts of change on agriculture in the region
- Identify and facilitate opportunities to address change, by diversifying, opening and establishing and new markets for producers.

Consistent with these objectives, this Water for the Future Strategy report provides an initial review and consolidation of the strengths, weakness, opportunities and threats to regional economic development in response to current and future water supply, availability and security. The strategy aims to:

▪ Summarise the existing water sources and uses within the region and how this may change into the future ▪ Identify water security and reliability issues within the region and how this may change into the future ▪ Evaluate the dependency of the region and economic activities therein on water availability and use	Volume 1 (this report)
▪ Identify the strengths, weakness, opportunities and threats to the region and economic activities therein in response to water supply and demand ▪ Provide high-level recommendations for subsequent studies, policies and water infrastructure projects to be considered by the JO and member councils that would support the continued economic prosperity of the region.	Volume 2

1.4 Structure of Report

This Volume 1 report is broken into the following key sections:

- **Section 1 – Introduction**: A contextualisation of the Water for the Future Strategy
- **Section 2 – Data Availability and Stakeholder Engagement**: An overview of the key data that was collated and considered as a part of this study and an overview of the stakeholders that assisted in the data collation
- **Section 3 – Climate**: An overview of the regional climatic characteristics, historic and future
- **Section 4 – Water Management Framework**: An overview of the water management framework applicable to various catchments across the Namoi Region.
- **Section 5 – Water Sources**: A review of water sources present within the study area
- **Section 6 – Current Land-use and Water-Use**: A description of current land use practices and associated water use demand
- **Section 7 – Future Development and Growth**: A review of likely changes to land-use across the region

- **Section 8 – Water Security**: A discussion on the level of water security received by urban and rural water users across the region
- **Section 9 – Agricultural Trends and Water Resource Issues:** provides a summary of key agricultural trends and water resource issues across NSW
- **Section 10 – Water Dependency of the Economy:** an analysis of how sensitive the regional economy is to the supply and security of water.

2 Data Availability and Stakeholder Engagement

Due to the importance of the Namoi Region in agricultural production and its role within the NSW economy a significant volume of literature and data exists for the region in terms of land use, economic activity and water resources. In particular, the majority of the project study area (**Figure 1-1**) falls within the headwaters of the Darling River and is captured within the Murray Darling Basin Authority management area, there is an extensive suite of publicly available data and reports regards water management and use. An extensive literature and desktop database study was undertaken as part of the project to collate and categorise the available data of relevance to the region. This was supplemented by data and reports held by the individual member local governments of the JO. Beyond the stakeholder engagement activities undertaken (**Section 2.2**), no primary data acquisition was undertaken to support the development of this strategy document. Rather it represents a synthesis of current information available at the time of development.

2.1 Data and Literature

Appendix A provides a listing of the data sources interrogated as part of strategy development, the content of each data source and, where relevant, access links[3] to the data.

It is noted that this strategy has considered a number of planning, management and policy documents currently in force and that alignment with these has formed a key aspect in shaping the Water for the Future Strategy. Key documents that shaped the scope and recommendations of this Strategy are outlined in brief in the following sections.

2.1.1 Water Sharing Plans

Water Sharing Plans (WSPs) are being progressively developed for rivers and groundwater systems across New South Wales following the introduction of the *Water Management Act 2000* (WMA 2000). These plans protect the health of rivers and groundwater while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water. WSPs can address regulated, unregulated and groundwater water sources. Rather than standalone policy documents, the WSPs consist of a legislated set of provisions under the WMA 2000, allocating water for the environmental health of rivers and groundwater systems, while also providing licence holders with more secure access rights to water and greater opportunities to trade water through the separation of water access from land title. The WSPs are typically accompanied by a set of documentation produced as part of WSP establishment for a particular water management area or source including:

- **Background Document** – providing a physical description of the relevant water source / catchment areas including land and water use, a process plan for development of the WSP and activities associated with implementation, monitoring and review of the plan
- **Sharing Plan Rules Summary** – an outline of the relevant access rules, trading rules and management rules applicable to specified water sources
- **Status Reports and Catchment Water Accounting Reports** – Summary of the status of water source condition, availability and use as part annual reporting and evaluations of the efficacy of the WSPs sustainable implementation.

[3] Links current at the time of writing. Rhelm does not guarantee the validity of any provided access links beyond the publishing date of this report.

The following Water Sharing Plans are implemented within the project study area and the associated documentation was reviewed as part of this study:

- Upper and Lower Namoi Groundwater Sharing Plan
- Upper Namoi and Lower Namoi Regulated River Sharing Plan
- Peel Valley Regulated – Unregulated – Alluvial and Fractured Rock Sharing Plan
- Gwydir Unregulated and Alluvial Sharing Plan
- Macleay Unregulated and Alluvial Sharing Plan
- Namoi Unregulated and Alluvial Sharing Plan
- NSW Border Rivers Regulated River Sharing Plan
- NSW Border Rivers Unregulated and Alluvial Sharing Plan
- NSW Murray Darling Basin Fractured Rock Groundwater Sources Sharing Plan
- NSW Murray Darling Basin Porous Rock Groundwater Sources Sharing Plan
- NSW Great Artesian Basin Groundwater Sources Sharing Plan

Further details on the WSPs and their relevance to the project study area are provided in **Section 4.2**. In particular, the WSPs define many of the access entitlements (for both Councils and private land-owners) which currently derive measures of water security. For the purpose of this study it is assumed that the Water Sharing Plans will not significantly alter from their current form into the future.

2.1.2 Water Resource Plans

The NSW Government is developing water resource plans as part of implementing the Commonwealth Government Basin Plan 2012 to manage the water resources of the Murray-Darling Basin. Under the Basin Plan, the Murray-Darling catchment is divided into a series of Water Resource Plan Areas. The project study intersects with three Water Resource Plan Areas:

- Namoi Water Resource Plan Area (combining the Upper and Lower Namoi and Peel Regulated, Unregulated and Alluvial Water Sharing Plan areas)
- Gwydir Resource Plan Area (capturing the Gwydir Unregulated and Alluvial Sharing Plan
- Border Rivers Resource Plan Area (capturing the NSW Border Rivers Regulated, Unregulated and Alluvial Sharing Plans)

Within each Water Resource Plan Area, Water Resource Plans for both groundwater and surface waters are prepared. The water resource plans will align basin-wide and state-based water resource management in each Water Resource Plan Area. The Plans will recognise and build on the existing water sharing plans planning and management framework that has been established in NSW. As part of 10 year reviews of the Water Sharing Plans, consistency will be sought between the Water Sharing Plans and relevant Water Resource Plans to ensure NSW State policy is consistent with the Commonwealth Basin Plan.

2.1.3 Regional Economic Development Strategies

The member Councils of Namoi Unlimited participate in three separate Regional Economic Development Strategies (REDS). Consideration of REDS recommendations and development pathways and the associated implications for water demand and security are discussed further in **Sections 5 to 8**.

Lower North West Regional Economic Development Strategy 2018 – 2022

The Lower North West REDS incorporates Gunnedah, Tamworth and Liverpool Plains. It identifies four core strategies to support regional development:

A. Deliver key infrastructure as a foundation for growth
B. Provide a positive, supportive environment to facilitate business growth and investment
C. Support and leverage key sectors
D. Position and promote the Lower North West Region as a location of choice.

The Water for the Future Strategy is seen to be consistent with the objectives of Strategy B and C, with a key objective listed as to "*Protect productive agricultural land and water resources within the Region and advocate for on-going water security*".

Southern New England High Country REDS 2018 – 2022

The Southern New England High Country REDS includes Uralla Shire, Walcha Shire and Armidale (n.b. Uralla and Armidale are outside of the study area for this project). It has five key strategies to support regional development:

1. Strengthen the region's connectivity
2. Secure the inputs for growth
3. Strengthen, consolidate and grow key sectors
4. Promote an attractive, desirable lifestyle
5. Effective marketing and promotion.

The Water for the Future Strategy is consistent with the identified priorities of Strategy 2 of the Southern New England High Country REDs, including "*invest in infrastructure that will support and facilitate growth, including water, power and commercial and industrial land*" and the ensure investment in "*water and power infrastructure is in to support horticulture development*". In particular, the REDS makes reference to the need for additional off creek storage capacity to drought proof Walcha.

Upper North West REDS 2018 – 2022

The Upper North West REDS incorporates Gwydir Shire Council, as well as Narrabri Shire Council and Moree Plains Shire Council (n.b. both Narrabri and Moree shires are not part of this current project). It identifies four key strategies to support regional development:

A. Improve freight efficiency in the engine industries of agriculture and mining
B. Encourage investment, increased productivity and value adding
C. Invest in people, skills, community and lifestyle to address the region's skills gap
D. Diversify the economy through emerging industry sectors.

The Water for the Future Strategy is consistent with the REDS Strategy B, with the significant agricultural production of this region being tightly dependent upon water security of water supply. The REDS notes that the Region currently produces 40 percent of NSW's cotton and that changes to water access (either via allocation policy or water availability) will have a significant impact on its economy.

Local Economic Development Strategies and Water Planning

Local economic development strategies provide an overview of key objectives and strategies for the different LGAs in achieving growth. These are generally higher-level documents that do not go to the detail of specific infrastructure projects. They provide context as to how addressing water security can fit into an overall growth strategy. The following development strategies have been reviewed as part of this study:

- Gunnedah Economic Development Strategy (Jenny Rand & Associates, 2014)
- Tamworth Tomorrow 2016 – 2021 (Business Sense, 2016)

- Liverpool Plains Shire Economic Development Strategy 2017 – 2020 (Jenny Rand & Associates, 2017).

In line with these policies, Council's maintain an array of water policy, management and project development plans to address LGA-based water resource issues, including amongst others:

- Integrated Water Cycle Management studies
- Water Conservation and Demand Management Studies
- Drought Management Plans
- Water Source Yield Studies
- Water Infrastructure Option Studies (e.g. Tamworth Bulk Water Supply – Long Term Augmentation Options Review, Apsley Dam Economic Benefit Study).

2.1.4 Special Activation Precincts

A Special Activation Precinct is a dedicated area in a regional NSW location that has been identified by the NSW Government to become an economic hub, creating jobs, attracting businesses and investors, and fuelling economic development in regional NSW to ensure regions are well placed to grow and meet future economic needs. The NSW Government established the Special Activation Precincts initiative as part of its 20-Year Economic Vision for Regional NSW, with funding made available in the $4.2 billion Snowy Hydro Legacy Fund. The Special Activation Precincts will focus on supporting industries including agribusiness, forestry, mining, and freight and logistics.

As these represent key economic sectors within the Namoi Region, the potential future implementation of a Namoi Region Special Activation Precinct is currently under-consideration by the State Government. Water availability and security will be critical to the success of any such broad-scale planning initiatives and the potential for such future land-use development options has been considered within the Water for the Future Strategy.

2.2 Stakeholder Engagement

As part of strategy development, Rhelm undertook a series of stakeholder engagement meetings with relevant local and regional individuals / agencies to identify the current use and demand for water and concerns regarding its on-going management into the future. Stakeholders that were consulted included:

- Local Government
- State Government agencies
- Agricultural industry bodies
- Individual land-owners.

As part of further community engagement, this report may be made available on the websites for each member Council and community members provided with an opportunity to provide additional comment / suggestions to supplement the recommendations of the report.

2.2.1 Local Government

The local governments of the Namoi JO were engaged at two levels:

- Governance: Between February and June 2019, Rhelm met with the Mayor and, where relevant, Deputy Mayor of each member Council through:
    - One-on-one meetings to discuss water management and security issues within the LGA
    - Namoi JO monthly board meetings to discuss the overall Namoi Region Water for the Future Strategy and regional water issues.

- Operational and Technical: Between February and June 2019, Rhelm met with the General Manager and relevant technical discipline leads of each member Council through:
    - One-on-one meetings to discuss Council water operations, infrastructure (current and proposed), demand and water licencing and water security and management studies for the LGA
    - Attendance at two monthly meetings of the Namoi Water Alliance, with technical representation from each Council, to discuss the overall Namoi Region Water for the Future Strategy and regional water issues.

The information, data and opinions obtained through this process formed the backbone of much of the assessment within the Namoi Region Water for the Future Strategy.

2.2.2 State Government

Individual meetings were held with the following Government agencies:

- NSW Department of Primary Industries – Lands and Water Division
- NSW Department of Premier and Cabinet.

The meetings were aimed at describing the results and findings of the project and identification of additional factors for consideration within the analysis and further recommendations for studies to be undertaken.

In addition, a number of stakeholder agencies were engaged as part of larger stakeholder forums for the Namoi Water for the Future Strategy, including:

- NSW Office of Environment and Heritage
- NSW Department of Planning and Environment
- NSW Department of Primary Industries.

Relevant stakeholders were provided with an overview of preliminary findings as part of a government stakeholder teleconference (14th February 2019) and the opportunity to provide feedback and recommended direction for further strategy consideration. In addition, a number of Government stakeholders were present as part of monthly Namoi JO board meetings, receiving regular progress updates over the course of the project.

2.2.3 Agricultural Industry Bodies

The following industry organisations were consulted via face-to-face meetings or teleconference to obtain data regarding water use/demand as well as their opinions as to the threats and issues associated with water management currently and into the future:

- Peel Valley Irrigators
- Namoi Water (peak industry body for irrigators within the Namoi Valley).

2.2.4 Land-owners

A series of one-on-one interviews were undertaken with land-owners representing different agricultural land-uses across the region. Land-owners were identified through Council as those having a strong understanding of industry wide issues and practices. Agricultural activities captured within the study focussed on those not likely to be captured within the irrigator bodies, including:

- Grass-fed cattle production
- Grain-fed cattle production
- Chicken production

- Lamb, sheep and wool producers
- Turf production.

3 Climate

The following sections provide an overview of the major climate drivers for the region.

3.1 Topography

The Namoi JO extends some 300 kilometres east to west and over 400 kilometres north to south. Over this large area, the topography varies considerably, with the eastern portion of the Namoi JO straddling the Great Dividing Range (**Figure 3-1**).

Walcha LGA and portions of the Tamworth LGA extend up into the Great Dividing Range, with elevations in excess of 1,000 mAHD. Walcha LGA incorporates areas sloping westwards to the Namoi River and also areas sloping eastwards to the coastline, on the eastern side of the ranges. The southern part of Liverpool Plains also rises up to over 1000m AHD.

A localised ridge line is associated with Mt Kaputar (at nearly 1500m AHD) near the border of Narrabri, Gwydir and Tamworth LGAs.

With the exception of the eastern part of Walcha, the majority of the Namoi JO falls towards the lower lying areas in the west. From a hydrological viewpoint, the key outflow points are via the Namoi River, towards Narrabri, and on the Gwydir River west of Warialda.

The northern parts of Gwydir LGA, together with the central portions of Gunnedah and Liverpool Plains, have relatively low relief, resulting in relatively flat plains. These areas are dominated by cropping and irrigation uses. This is in comparison to areas around Walcha, for example, where the steeper terrain is better suited to livestock. Further discussion on the types of agricultural output are provided in **Section 6**.

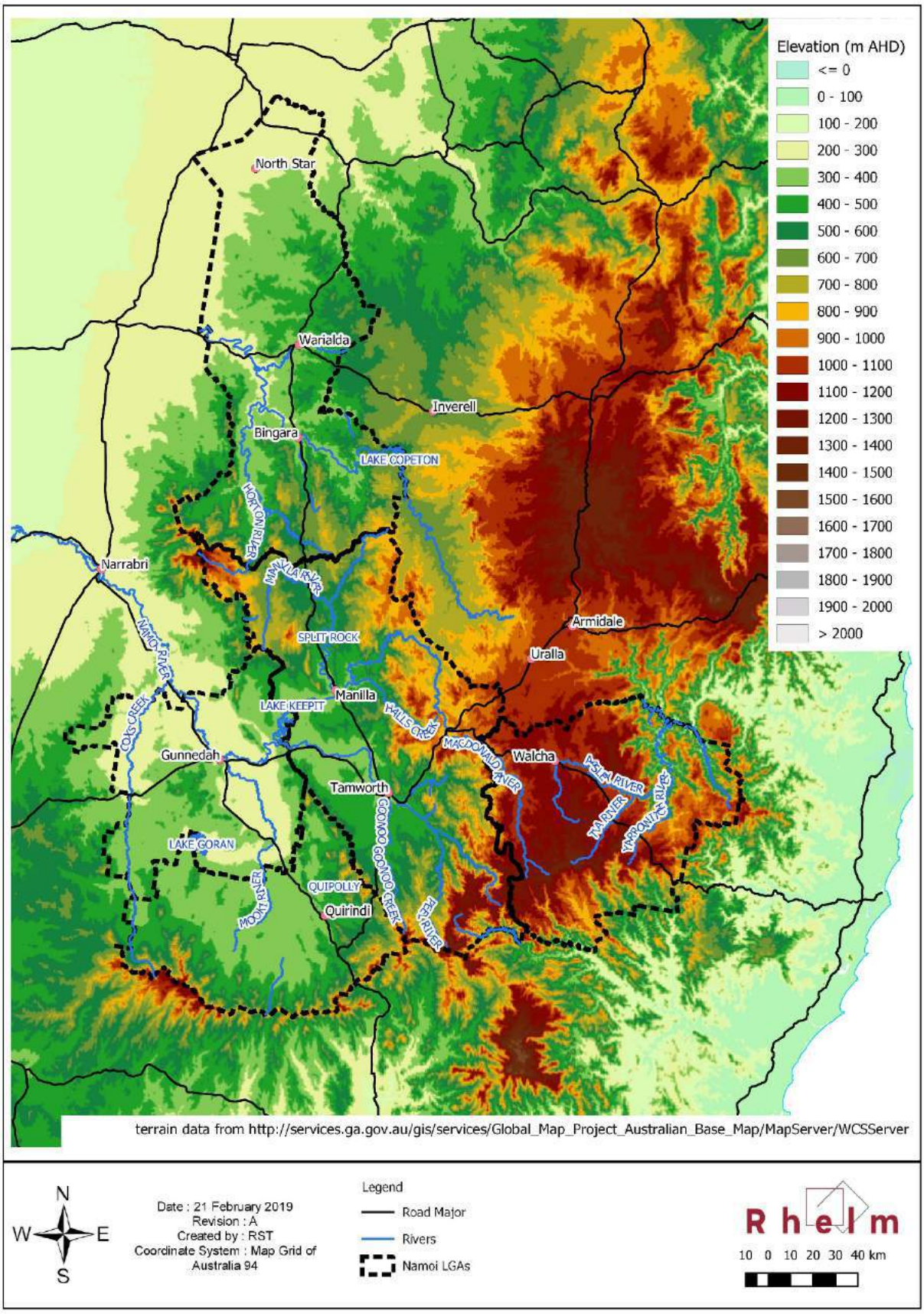


Figure 3-1: Overview of Topography

3.2 Rainfall

Rainfall across the catchment generally has an east-west gradient, with higher rainfall in the east versus the west. A general overview of the annual average rainfall is provided in **Figure 3-2**, along with the average rainfall for the wet (October – April) and dry (April to November) periods.

Figure 3-3 provides the statistics for the annual average rainfall across each of the LGAs. This shows the variation in average annual rainfall across the LGA areas, with the minimum values tending to be toward the western boundaries and the maximum values being toward the eastern boundaries.

Tamworth and Walcha have the highest rainfalls across the study area. Walcha having the highest rainfall, , which incorporates area to the east of the ranges receives much higher rainfalls (the average and maximum annual average rainfall in Walcha is nearly twice that of Gunnedah).

Figure 3-4 shows the monthly average rainfalls for selected locations throughout the Namoi JO. The overall trend is consistent throughout the study area, with lower rainfalls through winter and higher rainfalls in summer.

While annual averages provide an indication of overall rainfall behaviour across the study area, a key factor is variability of annual rainfall over time. Droughts and longer periods of low rainfall have an impact on overall agricultural output. Annual rainfall anomaly, which is a measure of the annual average relative to the annual average, is provided for Barraba in **Figure 3-5**. Following a relatively wet period from 1995 to 1999, only around 4 years have seen above average rainfall in the 20 years since.

However, it is also worth noting that the first 50 years of the record indicated a number of prolonged below average rainfall years (including the Federation drought). **Figure 3-6** shows the 30 year moving average rainfall anomaly for three long term gauges within the Namoi JO, including Croppa Creek in the north of Gwydir LGA, Barraba in the northern part of Tamworth LGA, and Carrol near the border of both Gunnedah and Liverpool Plains. All three of these locations show similar trend in terms of below average long-term rainfall prior to 1950.

Keepit Dam was completed in 1960 (**Section 5.5.2**), representing the key point in time when regulated irrigation flows were managed in the Namoi Valley. The 50 years following this appear to have been generally in a wetter period than the pre-1950s.

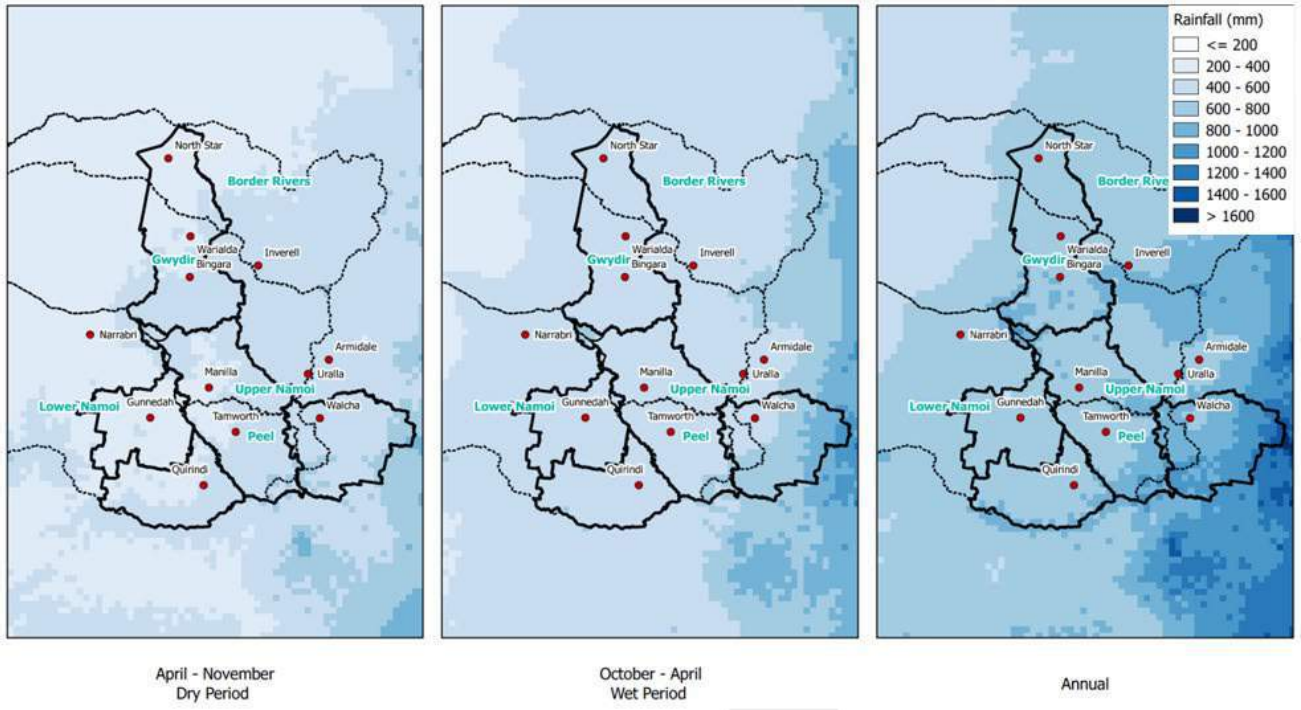


Figure 3-2: Long Term Average Annual Rainfalls (1961 – 1990)[4]

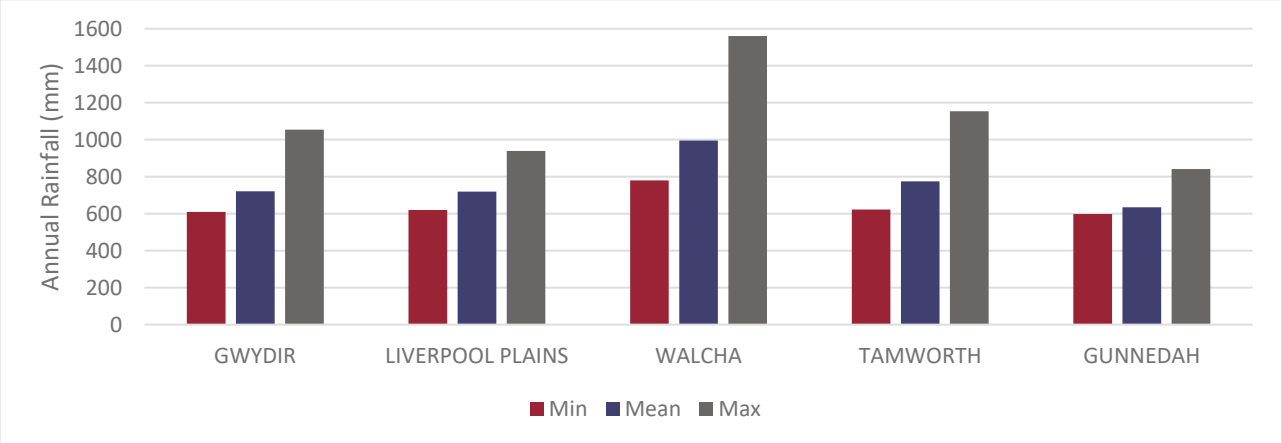


Figure 3-3: Long Term Annual Rainfall Statistics (1961 - 1990)[5]

[4] Bureau of Meteorology (2009), gridded average rainfall (http://www.bom.gov.au/climate/averages/climatology/gridded-data-info/metadata/md_ave_rain_1961-90.shtml), accessed on 21 February 2019

[5] Statistics based on the gridded rainfall data available from Bureau of Meteorology (refer Figure 3-3)

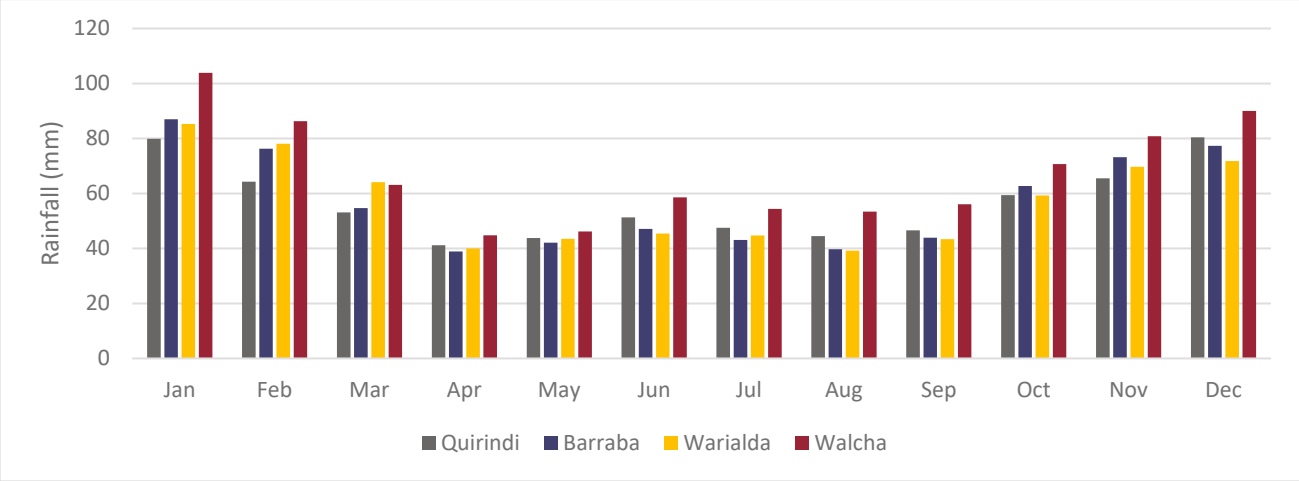


Figure 3-4: Long Term Average Monthly Rainfall Statistics for Selected Locations[6]

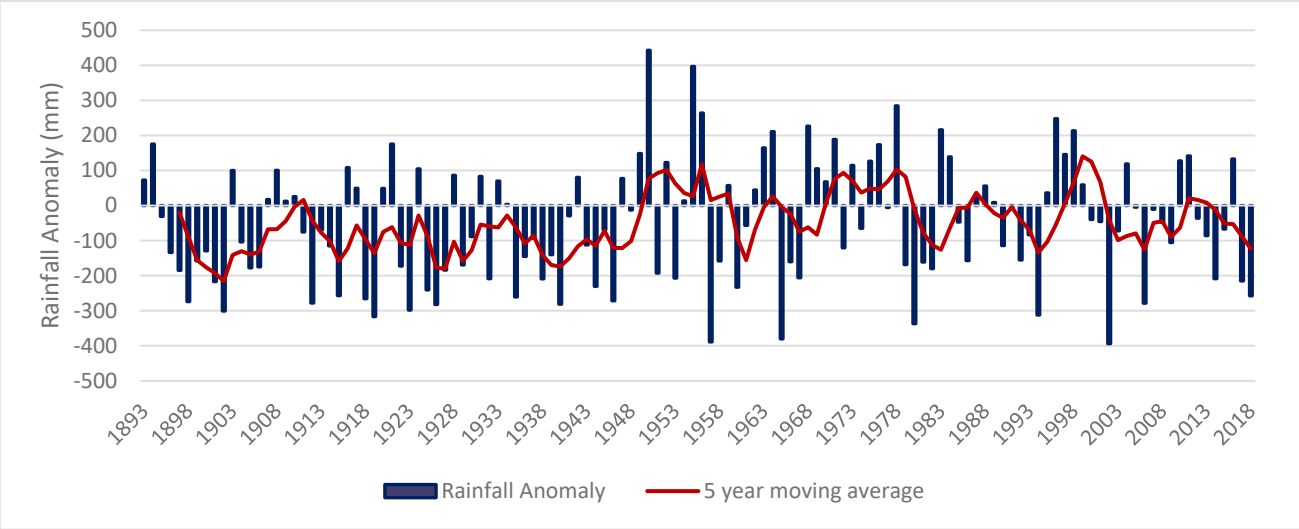


Figure 3-5: Annual Rainfall Anomaly at Barraba[7]

[6] Based on data acquired from Bureau of Meteorology (accessed on 22 February 2019). All gauges have a similar operational period from around the 1880s to present. The exception is Warialda which ceased operation in 1996.
[7] Bureau of Meteorology (bom.gov.au), accessed 21 February 2019

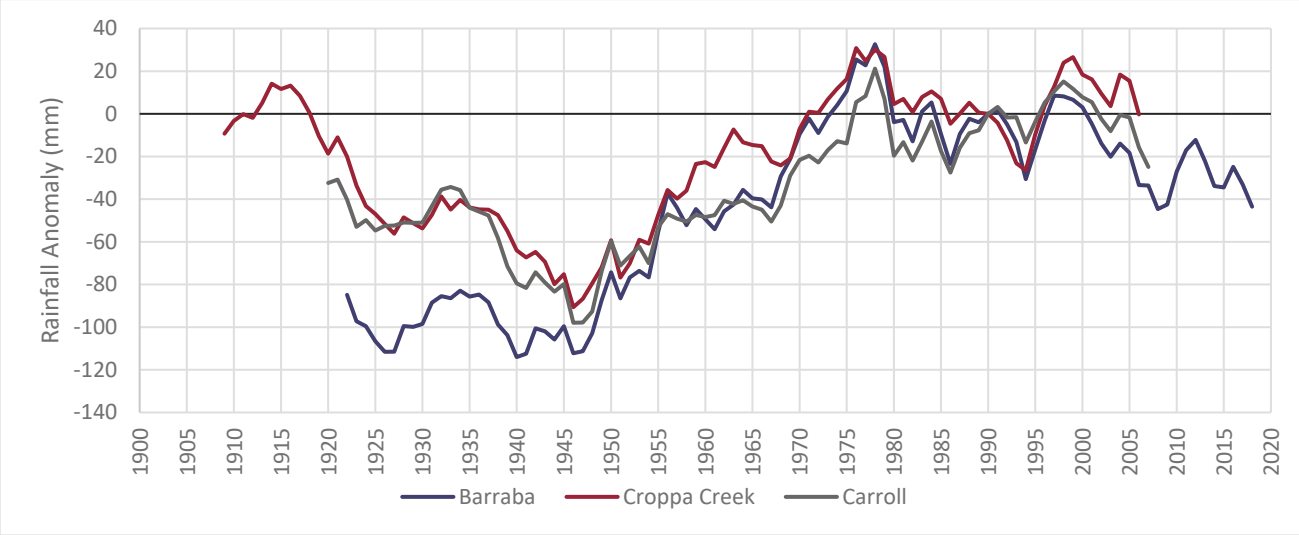


Figure 3-6: 30 year Moving Average Rainfall Anomaly at Different Gauge Locations[8]

3.3 Evaporation

Evaporation across the Namoi JO follows a similar pattern to rainfall, with an east-west trend. Long term pan evaporation averages are provided in **Figure 3-7** while summary statistics for the annual evaporation statistics across the LGAs are provided in **Figure 3-8**.

Evaporation is an important consideration both in terms of irrigation requirements for agriculture, as well as reservoir storage needs. Annual average evaporation is generally in the order of 1600mm to 1900mm across the Namoi JO. The exception is Walcha LGA, which ranges from around 1100mm to 1600mm.

Evaporation anomaly, which is measured as the difference between the evaporation in a given year relative to the long term mean, is provided at the Gunnedah measurement station in **Figure 3-9**. This is compared with rainfall anomaly from Barraba. As expected, periods of higher than average rainfall coincide with periods of lower than average evaporation.

[8] Represents the 30 year average for the 30 years prior to the date shown. Derived based on rainfall data available from Bureau of Meteorology (bom.gov.au), accessed 28 February 2019.

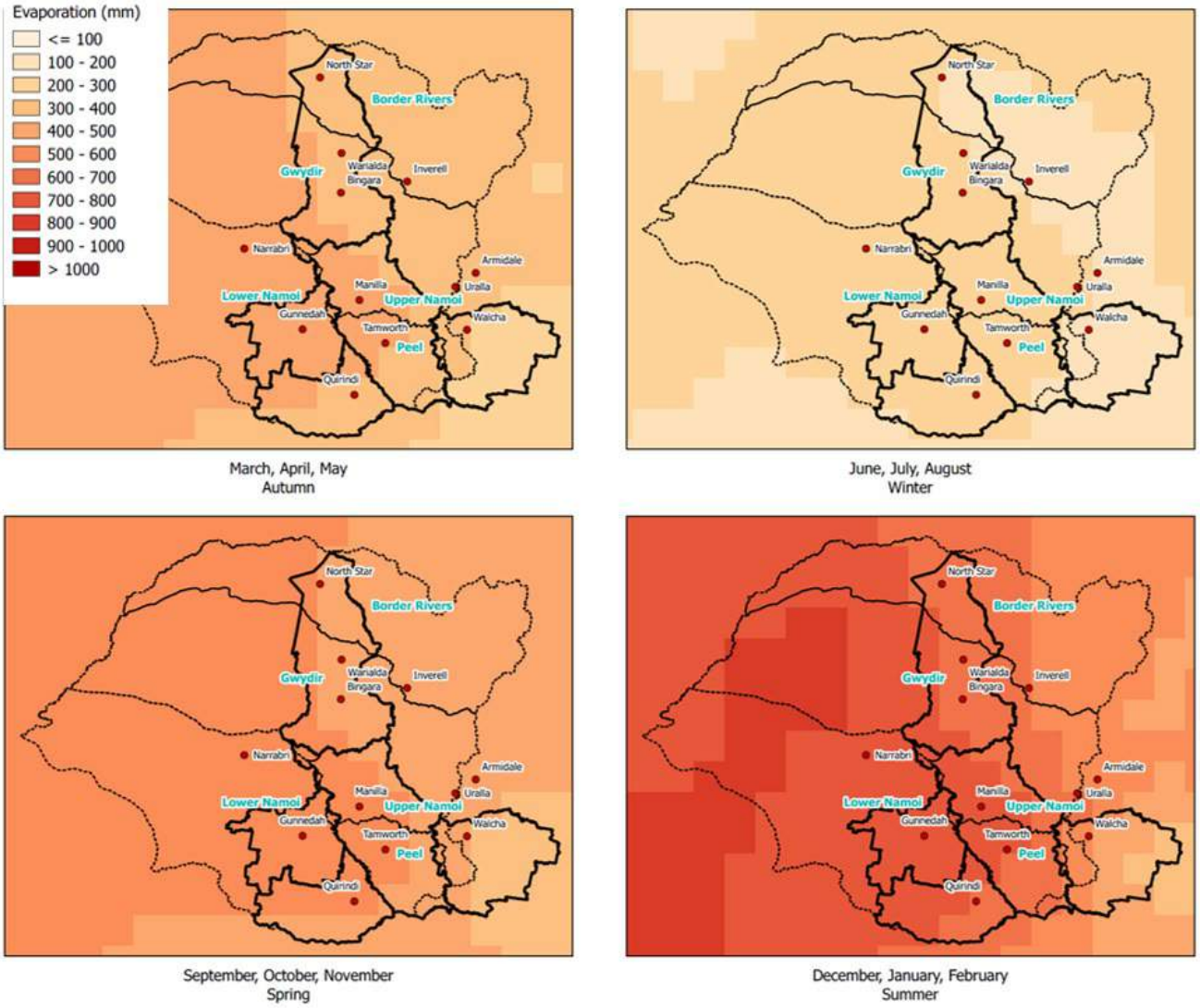


Figure 3-7: Long Term Average Pan Evaporation (1975 - 2005)[9]

[9] Bureau of Meteorology (2008), Gridded Average Evaporation (http://www.bom.gov.au/climate/averages/climatology/gridded-data-info/metadata/md_ave_evaporation_1975-2005.shtml), accessed on 21 February 2019

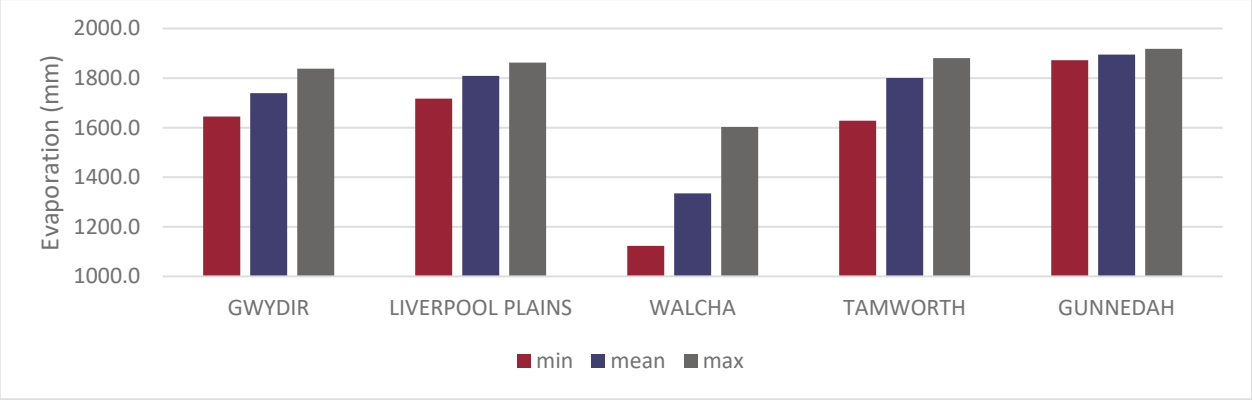


Figure 3-8: Long Term Annual Pan Evaporation Statistics for LGAs[10]

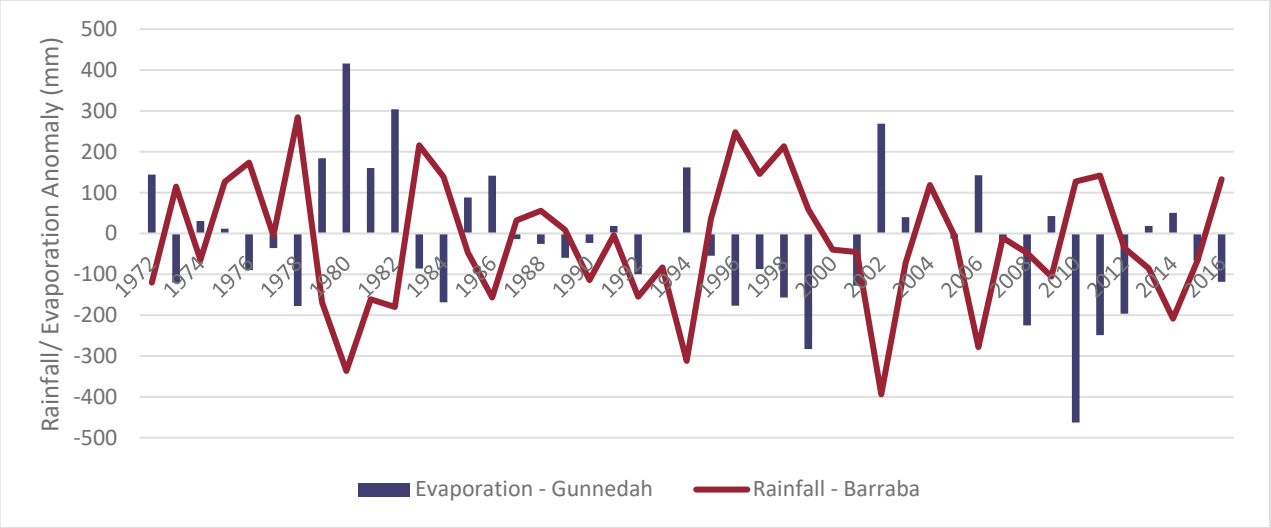


Figure 3-9: Long Term Pan Evaporation Anomaly (1972 – 2016) at Gunnedah[11]

3.4 Climate Change

Climate change leads to greater uncertainty in planning for the future. This is particularly relevant to the Namoi Region Water for the Future Strategy. Climate change has the potential to impact rainfall, evaporation and other factors contributing to water usage in the region.

The *New England North West Climate Change Snapshot* (OEH, 2014) provides a snapshot of the expected climate behaviour for the region based on the NSW and ACT Regional Climate Modelling (NARClim) project. The NARClim project takes global climate change model outputs, and downscales them to provide finer, higher resolution climate projects for a range of meteorological variables (OEH, 2014). There is a total of 12 climate models that were run to inform the climate projects.

The climate change projections in OEH (2014) are presented as 'Near Future' and 'Far Future'. Near Future (described as representative of 2030) is based on average climate change projections for the 20-year period

[10] Statistics based on the gridded evaporation data available from Bureau of Meteorology (refer Figure 3-8). Annual rainfall anomaly is the measure of the difference in rainfall observed relative to the long term average..

[11] Bureau of Meteorology (http://www.bom.gov.au/cgi-bin/climate/hqsites/site_data.cgi?variable=evap&area=aus&station=055024&period=annual&dtype=anom&ave_yr=0) accessed on 21 February 2019

2020 – 2039. Far Future (described as representative of 2070) is based on the average climate change projects for the 20-year period 2060 – 2079. The results from OEH (2014) are summarised in **Table 3-1**.

The results of the climate modelling for rainfall varies. For annual rainfall, the majority of models suggest an increase in rainfall for both the Near Future and the Far Future. However, the spread of this across the year varies, with the strongest trend an increase in rainfall in autumn and a general decrease in winter rainfall. Summer rainfall, which is the largest rainfalls for the region (**Section 3.2**) and important for agriculture, is forecast to decrease in the Near Future but increase into the Far Future.

A further consideration is the outlook for temperature. This has an influence on the evaporation, which, in turn, impacts on above ground water storages and soil moisture (which influences the amount of irrigation water required for farming). Soil moisture can also influence the soil loss experienced during rainfall events, leading to lower runoff during rainfall (and therefore influencing river flows and flows into storages). Temperatures are expected to increase by 0.7°C for the Near Future and 2.2°C for the Far Future, with an associated increase in the number of 'hot days' (those above 35°C).

A review of the mean annual temperature was also undertaken for the Gunnedah gauge (**Figure 3-10**). This shows a similar trend with increasing mean annual temperatures (observed through the 10-year moving average). There has been an approximate 1.2°C increase in mean annual temperature over the last 50 years or so.

Table 3-1. Climate Change Projections (OEH, 2014)

	Near Future (2030)	Far Future (2070)
Temperature		
Maximum (°C)	+0.7	+2.2
Minimum (°C)	+0.7	+2.3
Hot Days[12]	+10	+24
Rainfall		
Annual	Increase (-9% to +13%)	Increase (-8% to +24%)
Summer	Decrease (-15% to +14%)	Increase (-10% to +42%)
Autumn	Increase (-9% to +47%)	Increase (-1% to 49%)
Winter	Decrease (-26% to +15%)	Neutral (-29% to +30%)
Spring	Increase (-11% to +19%)	Neutral (-21% to -18%)

[12] Measured as the number of days above 35°C

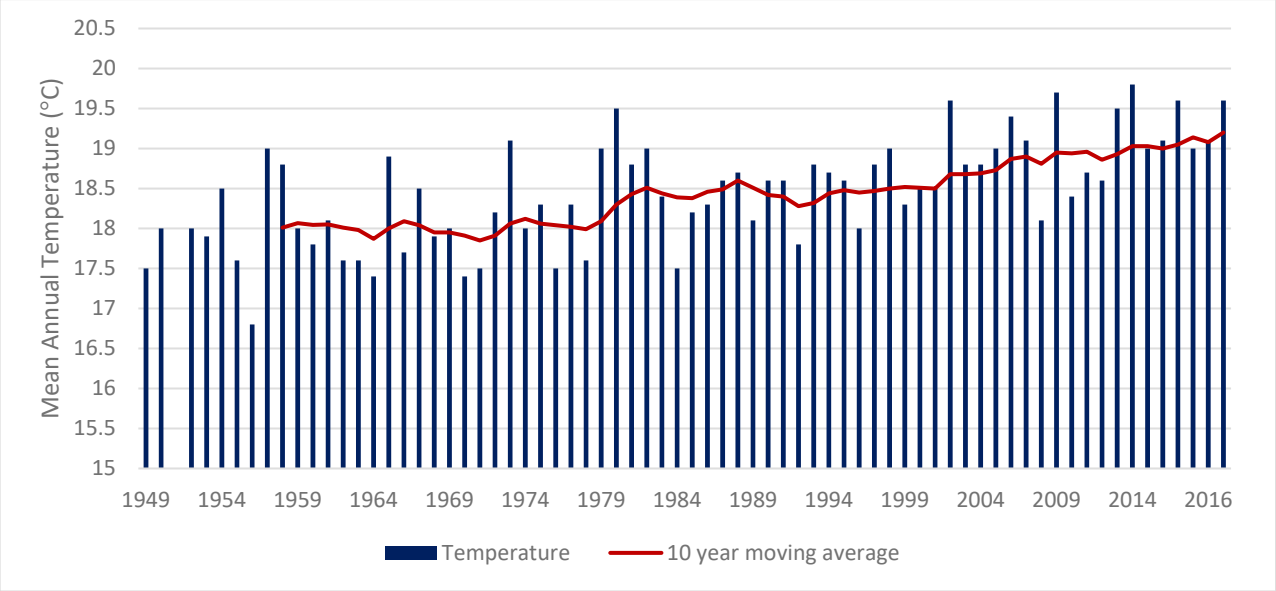


Figure 3-10. Mean Annual Temperature - Gunnedah[13]

[13] Temperature data for Gunnedah gauge (055024). Downloaded from bom.gov.au on 28 February 2019.

4 Water Management Framework

This section outlines the water management framework that is applicable to the Namoi region. The management structure is primarily a function of:

- The rainfall catchment areas which support the water sources of the Namoi JO
- The management and access requirements applicable to those catchment areas.

4.1 Rainfall Catchments

The project study area falls within six broad surface water catchment areas (**Figure 4-1**), consisting of:

- Border Rivers
- Gwydir
- Namoi
- Macleay
- Hastings
- Manning.

Of these, the vast majority of the study area falls within the Border Rivers, Gwydir and Namoi River Catchments, with the majority of the member LGAs sharing parts of one or two catchments (**Table 4-1**). It can be seen that the Namoi Catchment extends across the greatest number of LGAs. Walcha, located at the headwaters of numerous catchment areas, is unique in that is has a significantly greater diversity of water sources and the potential to impact a wider array of downstream receivers.

Table 4-1: Catchment areas within Namoi Unlimited extent

LGA	Catchment (% of LGA area)					
	Border Rivers	Gwydir	Namoi	Macleay	Hastings	Manning
Gunnedah			100%			
Gwydir	32%	68%				
Liverpool Plains			100%			
Tamworth		2%	95%			3%
Walcha			18%	56%	4%	23%

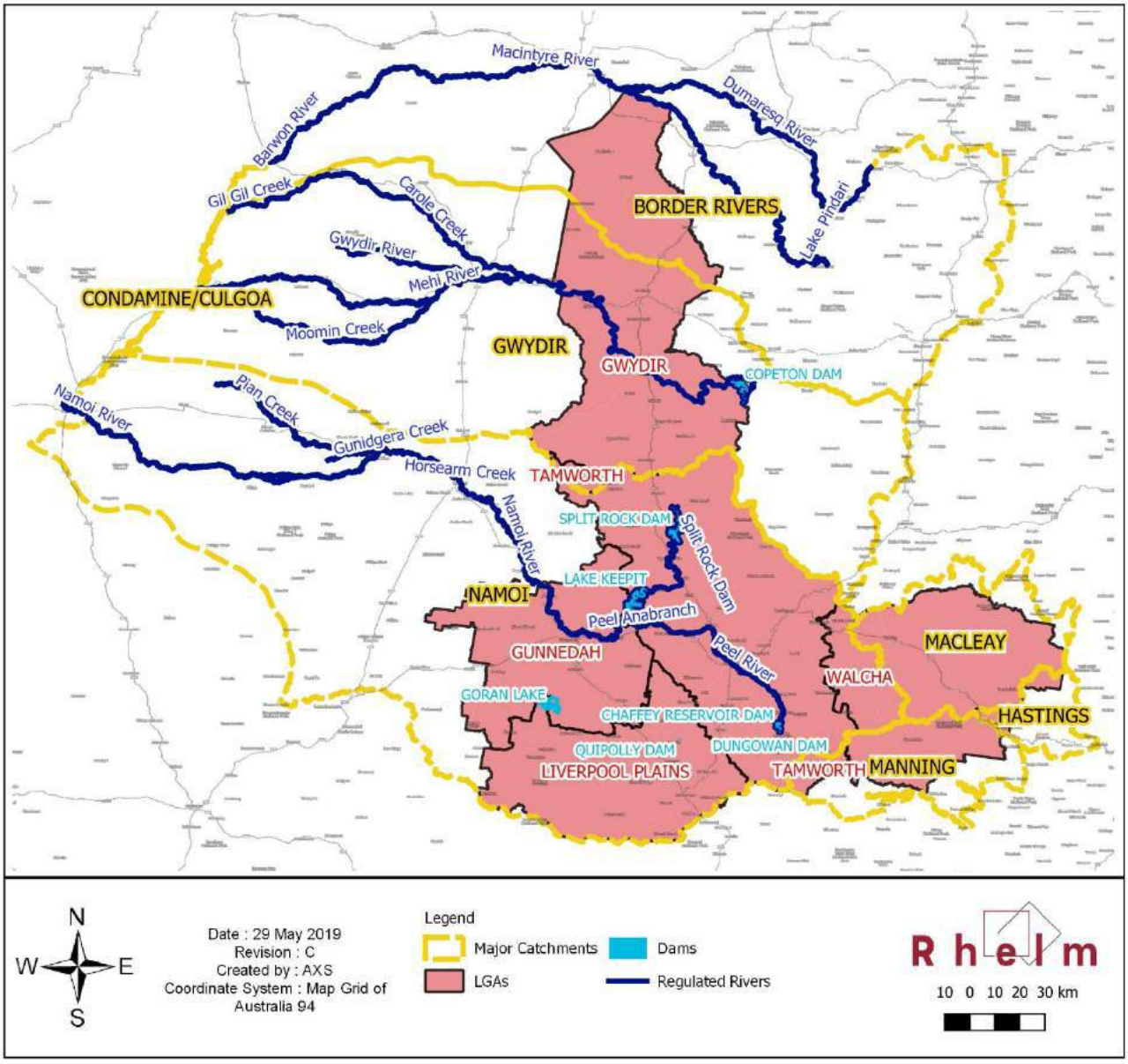


Figure 4-1: Catchment areas within the Namoi Unlimited extent[14]

4.1.1 Border Rivers

The Border Rivers comprise the catchments of the Dumaresq, Severn, Macintyre and Barwon Rivers, all of which drain east-west from the Great Dividing Range between Inverell, New South Wales and Warrenbayne in Queensland. The catchment occupies an area of 49,500 km^2 of which approximately 24,500 km^2 is situated within NSW (DPI, 2012). Of this, approximately 2,970km^2 is located within the Gwydir LGA (**Figure 4-2**).

[14] Imagery from Google Maps

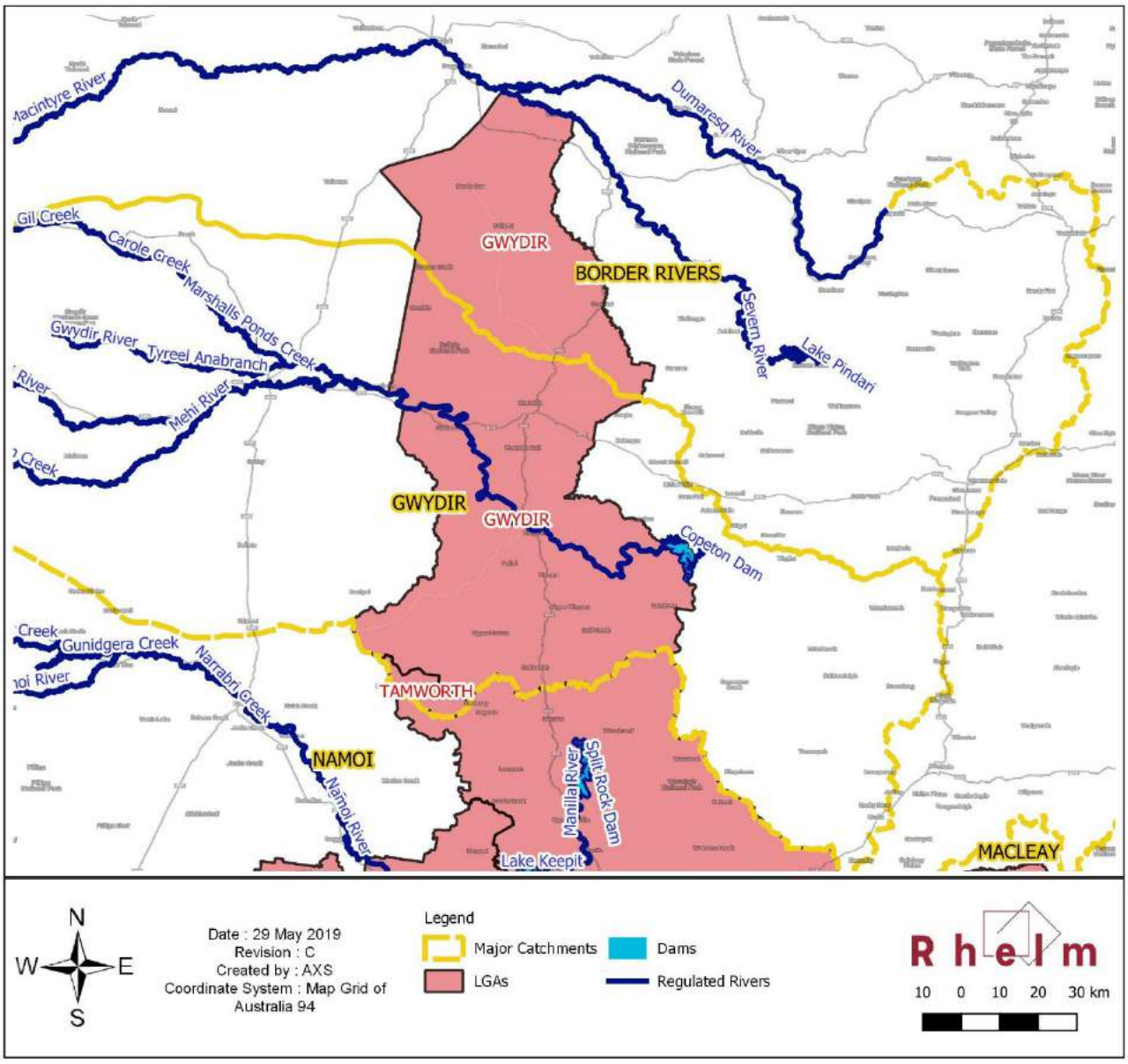


Figure 4-2: Border Rivers and Gwydir catchments within the project area

The Border Rivers are regulated by three dams – Glenlyon Dam on Pikes Creek (QLD), Coolmunda Dam on Macintyre Brook (QLD), and Pindari Dam on the Severn River (NSW). Pindari Dam (shown as Lake Pindari on **Figure 4-2**) is located to the east of the Gwydir LGA at the headwaters of the Severn River, which joins the Macintyre River near Wallangra. The 319km Macintyre River is the longest of the Border Rivers in NSW and begins on the western slopes of the Great Dividing Range, approximately 50 km south west of Inverell. The river flows west through Inverell, north west, along the northern boundary of Gwydir LGA, through Boggabilla and Goondiwindi, then south west to its confluence with Weir River north of Mungindi, forming the Barwon River and ultimately connecting to the Darling River and supporting the Murray-Darling Basin.

The catchment area within the Gwydir LGA consists of a flat plain region of anabranching channels forming a flat alluvial plan. Major and intermittent water courses within this area include, Croppa Creek and Ottleys Creek (**Figure 4-2**).

In NSW the population supported by the catchment (approximately 30,000 people) is concentrated in the major centres of Glen Innes, Inverell, and Tenterfield. By comparison, the largest urban area within the Gwydir LGA portion of the Borders Rivers Catchment is North Star (population: 327). As a whole, the main agricultural use of land is for grazing and dryland cropping, which covers approximately ninety per cent of the catchment. Irrigation for the production of cotton occurs predominantly on the western plains between Goondiwindi and Mungindi. Agricultural land use within the Gwydir portion of the catchment is dominated by grain cropping (refer to **Section 6.3** for further details).

4.1.2 Gwydir

The Gwydir catchment is bounded to the north by the Border Rivers Catchment and the Namoi Catchment to the south. Consisting of upland (upstream of Copeton Dam), mid-land (Copeton Dam to Moree) and lowland (downstream of Moree) sections, the catchment drains east to west from the New England headwaters around Guyra and Uralla. The Gwydir River is the major river of the catchment, capturing a catchment area of approximately 26,000 km^2. Of this, approximately 6,285km^2 is located within Gwydir LGA and 190km^2 within the Tamworth LGA.

The Gwydir River is regulated by a series of dams and weirs, with Copeton Dam representing the major dam and regulatory source, upstream of the Gwydir and Tamworth LGAs (**Figure 4-2**). From Copeton Dam, the river flows westwards across the Gwydir LGA, gradually reducing in altitude to the flat floodplains near Gravesend. This broad alluvial floodplain characterises the lower half of the catchment and continues west to the Barwon River at Collaranebri. Major tributaries which join the Gwydir River within this region include the Cobbadah Creek, Horton River, Warialda Creek and Halls Creek, all of which provide substantial unregulated flows to the regulated section of the Gwydir River.

The population supported by the catchment (approximately 25,000 people) is concentrated in the major centre of Moree to the west of the Gwydir LGA. The largest urban area within the Gwydir and Tamworth LGA portions of the Gwydir Catchment are Bingara (population: 1,428) and Warialda (population: 1,120). As a whole, the main agricultural use of land within the catchment is for grazing and dryland agriculture, which covers approximately eighty-six per cent of the catchment. Agricultural land use within the Gwydir and Tamworth portion of the catchment is dominated by beef cattle grazing and some sheep grazing, supported by some irrigated areas of lucerne and pasture within the alluvial floodplain areas (refer to **Section 6.3** for further details).

4.1.3 Namoi

The Namoi catchment is bounded to the north by the Gwydir catchment, the Macleay and Manning catchments to the east, and the Castlereagh, Macquarie-Bogan and Hunter catchments to the south. Capturing over 43,000km^2 of catchment area, the Namoi has historically been sub-divided into three sub-catchments:

- Peel River (Upstream of the confluence of the Peel River with the Namoi River)
- Upper Namoi (upstream of Keepit Dam)
- Lower Namoi (downstream of Keepit Dam).

Key features within the study area for this catchment are shown in **Figure 4-3**.

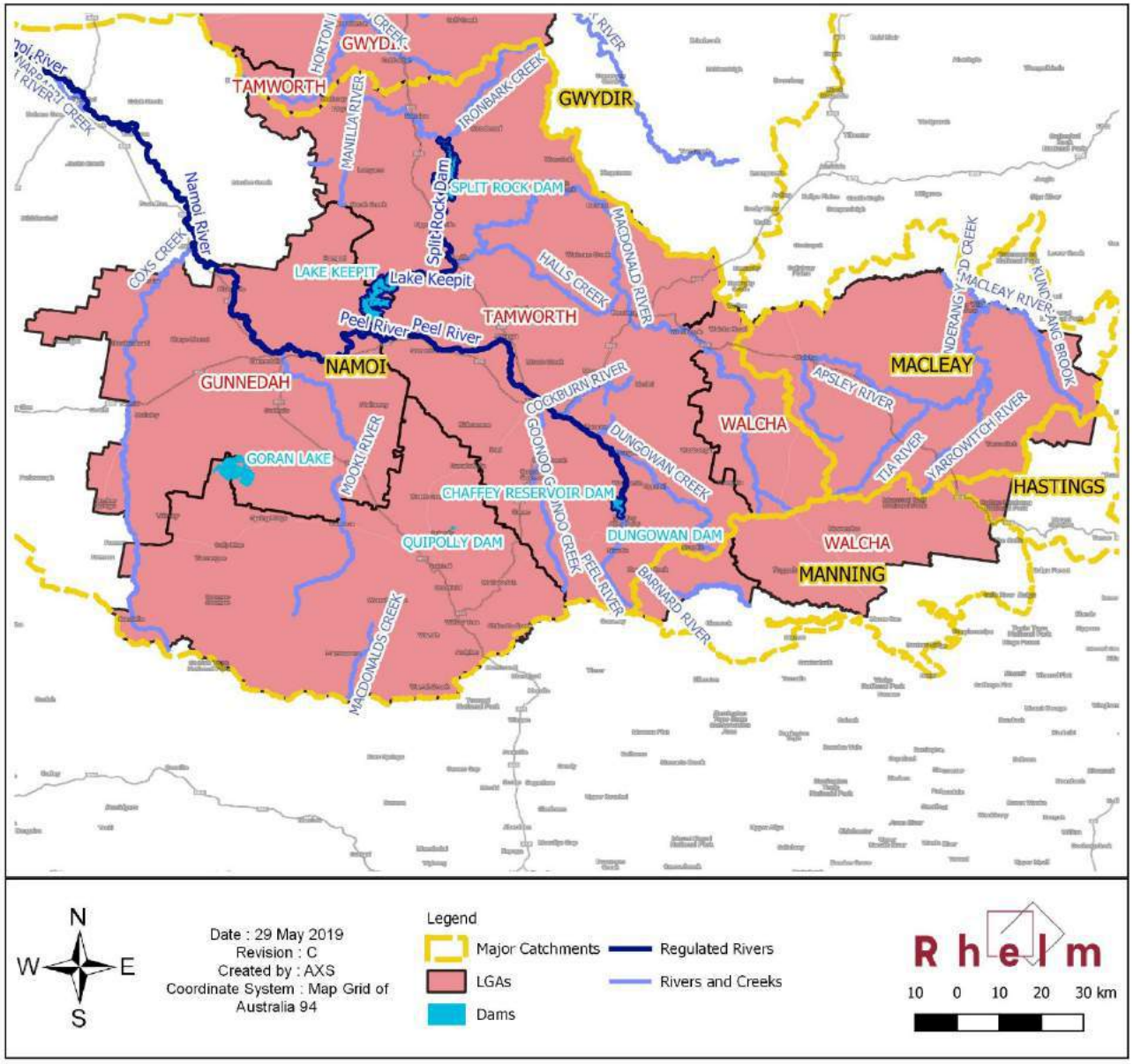


Figure 4-3: Namoi, Manning, Hastings and Macleay Catchments

The Peel River is a major regulated tributary to the Namoi River with a catchment area of around 4,700 km^2. It is regulated for much of its length through Chaffey Dam, located upstream of Tamworth. The Peel River supports a narrow floodplain, supporting a range of irrigated agricultural activity mostly lucerne and grain which supports the cattle and sheep grazing the forms the majority of land use areas beyond the floodplain. Although a relatively small catchment, the Peel River passes through, and is the major water source of, Tamworth (population: 41,000). A number of unregulated tributaries flow into the Peel River, including the Cockburn River, Dungowan Creek (including an unregulated dam managed by Tamworth Regional Council) and Goonoo Goonoo Creek. The Peel catchment is entirely within the Tamworth LGA.

The Upper Namoi catchment describes the area upstream of the Keepit Dam wall, capturing the headwaters of the Namoi River within the Great Dividing Range. The Namoi River commences at the junction of the Macdonald River and Boundary Creek in the upper tablelands portion of Tamworth, before heading west

towards Manilla. It is joined at Manilla by the Manilla River, which is regulated from Split Rock Dam further to the north, which is fed by Iron Bark Creek to the east and the upper Manilla River catchment which passes through the rural town of Barraba. The Namoi River, between its confluence with the Manilla River and Keepit Dam, is regulated. The Upper Namoi includes the regulated section of the Manilla River from Split Rock Dam to its confluence with the Namoi Keepit Dam to the south west.

As with the Peel River catchment, the Upper Namoi catchment comprises predominantly grazing land for sheep and cattle with a number of smaller irrigation farmers producing irrigated lucerne and grain (sorghum, maize, wheat), as well as some cotton. Manilla (population: 2,550) and Barraba (population: 1,410) represent the major urban centres within the catchment. The Upper Namoi is located predominantly within the Tamworth LGA, with the upper catchment of the Macdonald River extending into the Walcha LGA. Keepit Dam is located just within the eastern border of the Gunnedah LGA.

The Lower Namoi represents the regulated portion of the Namoi River catchment from Keepit Dam to the Namoi-Barwon River confluence with Pian and Gunidgera Creeks. Running west from the Keepit Dam, the Namoi River passes through the Gunnedah LGA, passing close to the town of Gunnedah, before heading north towards Boggabri and Narrabri and further west to its confluence with the Barwon River. Gunnedah represents the largest urban centre along the river (population: 9,726), with other major urban centres including Narrabri, Wee Waa and Walgett. Major tributaries to the Namoi River within this sub-catchment within the Namoi JO study area are the Mooki River and Coxs Creek, both of which run northwards from the Liverpool Plains LGA. These tributaries represent the major sub-catchments and surface water sources within the Liverpool Pool LGA and Gunnedah LGA. Goran Lake is also located along the Mooki River and is listed as a wetland of national significance. Within the Namoi JO area of the Lower Namoi catchment, irrigated crop production represents a major land use within the catchment along with dryland cropping and livestock grazing. The majority of towns within the Liverpool Plains and Gunnedah LGA do not directly extract water from the Namoi or its tributaries.

4.1.4 Macleay

The Macleay Catchment covers an area of 11,450 square kilometres, draining west to east from the top of the northern tablelands around Walcha to the coastal plains around South West Rocks. Of this, approximately 3,494km^2 falls within the Walcha LGA. It is bounded to the north by the Nambucca catchment, to the south by the Hastings River catchment, and to the west by the Namoi catchment. All rivers within the catchment are unregulated, although there are numerous control structures within the watercourses.

The major river within the catchment is the Macleay River, with major tributaries of the Macleay River within the Walcha LGA consisting of the Apsley River and Tia River. Land use within the catchment is predominantly dryland agriculture and grazing, with increasing dairying towards the eastern portion of the catchment. Within the Walcha LGA the catchment is predominantly used for State Forest/National Park and grazing lands (refer to **Section 6.3** for further details). Walcha (population: 1,451) is the largest town along the Apsley River.

4.1.5 Hastings

The Hastings Catchment (**Figure 4-3**) covers an area of 4,484 square kilometres, draining west to east from the New England tablelands to the coastal plains and Pacific Ocean. Of this, approximately 234km^2 falls within the Walcha LGA. There are two major rivers within the catchment: the Hastings River and the Camden Haven River, neither of which are regulated rivers. The headwaters of the Hastings River extend into the Great Dividing Range, with its upper tributaries (e.g. Forbes River, Fenwicks Creek, Big Hill Creek) falling within the Walcha LGA. Land use within the Walcha LGA portion of the catchment is predominantly occupied by the

Cottan-Bimbank National Park, Werrikimbe National Park and some smaller areas of logging activity and dryland agriculture. No major settlements occur within the Walcha LGA portion of the catchment.

4.1.6 Manning

The Manning Catchment (**Figure 4-3**) covers an area of 8,420 square kilometres, draining west to east from the Great Dividing Range within the Walcha and Tamworth LGAs, to the coastal floodplains around Taree. The catchment is bordered in the north-east by the Hastings catchment, to the north by the Macleay Catchment, the north-west by the Namoi catchment and south by the Hunter and Karuah catchments. Approximately 1,421km^2 of the catchment falls within the Walcha LGA and 341km^2 within the Tamworth LGA. A number of major tributaries to the Manning River (e.g. the Nowendoc River, Mummel River) have their headwaters within the southern boundaries of the Walcha LGA and Tamworth LGA. Land use within these southern areas is predominantly dryland sheep and cattle grazing, with areas of forestry, State Forest and National Park. No major settlements are located within these areas of the catchment.

4.2 Water Resource Management

The water resources within and between each of these catchment areas is regulated by a suite of State and Federal management legislation and policies that attempt to balance the right to water of individuals with environmental, agriculture, industry and town demand for water.

4.2.1 Right to Water

Within NSW the State Government has the right to the control, use and flow of all water in rivers, lakes and aquifers within NSW. Under the *Water Management Act (2000)* the State Government establishes a system of regulation and licencing to manage the competing demands for water. However, within this there are rights to water resource access of individuals which permit individuals to access water without issue of an approval or licence from the State Government: Basic Landholder Rights. There are three types of Basic Landholder Rights within NSW[15]:

- Domestic and stock rights: Owners or occupiers of land overlaying an aquifer or that have river, estuary or lake frontage can take water without a licence for domestic (household) purposes or for stock water.
- Harvestable rights – dams: Harvestable right water allows landholders in most rural areas to collect a proportion of the run-off on their property and store it in one or more farm dams up to a certain size. A series of conditions and exemptions apply to the situation in which a dam can be established. In general, a dam can be established on minor streams and capture 10% of the average regional rainfall run-off within the Namoi JO or be less the 1ML in size.
- Native Title: Anyone who holds native title with respect to water, as determined under the Commonwealth Native Title Act 1993, can take and use water for a range of personal, domestic and non-commercial purposes.

Due to the restrictions on use (typically household or stockwatering purposes) and dam size limitations, the potential for Basic Landholder Rights to be utilised as a way to support water intensive agricultural or commercial operations is considered negligible. It is noted that these rights apply within urban as well as rural landholder settings (e.g. rainwater tanks (up to a certain size and use purpose) are able to be installed without requiring a licence). In order to access groundwater within an aquifer (or to access water a water source

[15] For further details see: https://www.waternsw.com.au/customer-service/water-licensing/basic-water-rights

beyond the property boundary), although an access licence may not be required, a water supply work approval would be needed in order to construct the associated bore.

4.2.2 Water Access Licences

For all other access beyond Basic Landholder Rights (and associated exemptions), individuals are required to obtain a Water Access Licence to extract water from a water source, with all water sources managed through a Water Sharing Plan. A Water Access Licence (WAL) entitles holders:

- To specified shares in the available water within a particular water management area or water source (**the share component**)
- To take water at specified times, rates or circumstances from specified areas or locations (**the extraction component**).

A WAL provides a defined entitlement to water, as and when available, governed by a Water Sharing Plan (**Section 4.2.3**) that is separate from land ownership. Depending on the water source to which the WAL refers, the entitlement share/extraction component may be able to be traded, sold, or retired. The establishment of "zero share component" WALs has allowed for individuals who do not hold a specific share entitlement in the water source to trade allocations/purchase entitlements from other licence holders who do have a share component. This is particularly of value currently as, in general within NSW, new WAL with share entitlements for commercial purposes (irrigation, industry and mining) are no longer being granted.

The extraction component of a water access licence specifies:

- times, rates and circumstances when water can be taken
- type of water source from which water can be taken, such as a river, lake or surface water run-off, or an aquifer
- whether water can be taken from the whole water source or only from within a specified management zone.

It is an offence to take water under a WAL in contravention of the extraction component of the licence.

There are many different types of WALs available, including:

- Regulated river (high security)
- Regulated river (general security)
- Regulated river (conveyance)
- Unregulated river
- Aquifer (groundwater)
- Estuarine water
- Coastal water
- Supplementary water
- Major utility
- Local water utility
- Domestic and stock (a WAL is required for water taken for commercial activities such as irrigation, aquaculture, feedlots, piggeries, poultry farms, recreation areas etc.).

Table 4-2 provides a summary the surface water and groundwater entitlement volumes across these various licences.

Table 4-2: Entitlement volumes under WALs within the Namoi JO

LGA	Total Entitlement (ML/yr) [1]	
	Surface Water	Groundwater
Gunnedah	65,392 (0)	61,119 (4,202)
Gwydir	37,451 (785)	32,201 (483)
Liverpool Plains	13,479 (1,000)	44,786 (1,466)
Tamworth	86,823 (23,486)	68,093 (1,084)
Walcha	3,577 (389)	19 (10)
Total	**206,722**	**206,217**

[1] () council entitlement volume

4.2.3 Water Sharing Plans

The *Water Management Act 2000* applies to areas of New South Wales that have a water sharing plan that generally last for 10 years. With the development of the Basin Plan (2012) many of the extant water sharing plans will be reviewed and updated and potentially amalgamated within broader Water Resource Plans. The plans principally set out the rules which govern how and when water entitlements may be accessed under a WAL and how they may be traded. Each plan sets out:

- An allocation of "planned environmental water" that provides water for the environment by protecting a proportion of the water available for fundamental ecosystem health and/or including specific environmental rules. This water is of highest priority and the accessibility of other entitlements is secondary to planned environmental water provisions.
- The rules by which "held environmental water" can arise from water recovery projects or by buying water licences. This water can be used at the discretion of the environmental water manager.
- An allocation of water to meet basic landholder rights. As with planned environmental water, this water is of highest priority and the accessibility of other entitlements is secondary.
- Annual limits on water extractions to ensure that water extractions do not increase and therefore erode the water for the environment and also the security of supply to water users.
- What type of additional licences can be granted such as local water utility access licences (for town water supplies) and Aboriginal cultural access licences.
- How water is to be shared among the different types of licensed users by setting the priorities of supply. For example, in dry periods water for domestic purposes has priority over commercial uses.
- Flexibility for licence holders in the way they can manage their water accounts through aspects such as the ability to carry-over some unused account water or through group rostering.
- Rules in groundwater plans to minimise impacts on other groundwater users, dependent ecosystems, water quality and the stability of the aquifer.
- The rules for water trading or dealings.
- The mandatory conditions that apply to licence holders.
- Which parts of the plan can be changed without triggering the compensation provisions of the *Water Management Act 2000*.

- The monitoring and reporting requirements, including indicators against which the performance of the plans is to be monitored.

As noted in **Section 2.1.1** the Namoi JO area encompasses numerous Water Sharing Plans that are currently in place:

- Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003
- Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016
- Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources 2010
- Water Sharing Plan for the Gwydir Unregulated and Alluvial Water Sources 2012
- Water Sharing Plan for the Macleay Unregulated and Alluvial Water Sources 2016
- Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012
- Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2009
- Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012
- Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011
- Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008

The Gwydir Regulated River sharing plan has been replaced by the Gwydir Resource Plan consistent under the Basin Plan (2012).

The introduction of water sharing plans in some areas of the Namoi JO generated a significant alteration to the availability and entitlements of some land-owners under their WALs. The equity of these arrangements and efficacy of the Water Sharing Plans in achieving their stated goals, is not the focus of this study. However, it is acknowledged that regulation through the Water Sharing Plans (and similar structures) does directly affect the ability for councils to prepare for and take advantage of opportunities and threats to water use within their jurisdictions, both currently and into the future.

4.2.4 Murray Darling Basin Authority

The Commonwealth Water Act (2007) is focussed on managing the water resources of Australia in a manner that optimises social, economic and environmental outcomes. The Murray Darling Basin (the Basin) represents the major surface and ground water resource areas within the country, with the Basin covering over 1 million square kilometres, including significant areas of inland New South Wales, Victoria, and the ACT, and parts of Queensland and South Australia (**Figure 4-4**). The Murray Darling Basin Authority (MDBA) was established to be responsible for preparing, implementing, monitoring and enforcing a Basin plan to achieve its objectives.

Figure 4-4: Murray Darling Basin Extent and surface water storage levels (MDBA, 2017)

It is estimated that the Basin supports approximately 41 per cent of the total gross value of Australia's agricultural production, including 46 per cent ($7 billion) of the gross value of national irrigated agriculture, as well as suppling drinking water to approximately 2.1 million people that reside within it, as well as a further 1.3 million people outside of the Basin (Productivity Commission, 2018).

The MDBA established its Basin Plan in 2012, setting for the legal framework for the use of water across the basin and its catchments. Importantly, the Basin Plan incorporates Sustainable Diversion Limits (SDL). The SDL define how much water consumptive uses can take from rivers and groundwater sources. Any water not taken for consumptive use is considered dedicated to the environment. These limits were determined through modelling of water flows, demand and environmental maintenance requirements. The 2012 Plan identified the need for recovery of 2,750 GL (in terms of long-term average yield) from consumptive use at the time (e.g. within NSW from the WAL entitlements). This recovery could be achieved by the Government either through purchasing of entitlements or investing in irrigation infrastructure (i.e. reducing system losses/improved recapture). Within the NSW portion of the Northern Basin (**Figure 4-4**) this included recovery of 156 GL of surface water from local catchment areas and 24 GL from shared catchment areas[16]. As of July 2018 16.4 GL of further recovery is required under the plan, consisting of 9.2 GL in the Namoi, 5.4 GL in the Border Rivers

[16] Local targets must be met by recovering water in a specific Sustainable Diversion Level "resource unit", while the shared targets can be met by recovering water from any resource unit within a connected zone.

and 1.9 GL in the Barwon-Darling. This gain was achieved through a mixture of purchasing back entitlements and irrigation investment. No groundwater recovery was required under the Basin Plan.

The final achievement of the SDL limits is challenging with the Namoi JO area as:

- Many landholders have already participated in on-farm programs and are unlikely to do so again, citing administrative burden, and there is no industry group to facilitate engagement in parts of the region.
- Some landholders are only willing to give up unregulated entitlements to a government program, and these types of entitlements may not be able to be protected in-stream.

The Australian Government announced a new infrastructure program in July 2018 to finalise gap-bridging water recovery and commence additional water recovery through efficiency measures. However, it is noted that in addition to these barriers there has been significant recent public discussion regarding the overall adequacy of the existing SDL targets and there is potential that the existing levels will again be altered.

As part of the Basin Plan (2012) participating State governments agreed to the embedding of key parts of the Plan through their normal water planning and management process through the creation of Water Resource Plans.

4.2.5 Water Resource Plans

The MDBA divided the Basin into 19 surface water (**Figure 4-5**) and groundwater (**Figure 4-6**) "resource plan areas" (RPAs). The Namoi JO area is seen to fall within a number of the resource plan areas as detailed in **Table 4-3** and **Table 4-4**. The majority of the LGAs fall within the Namoi Surface Water RPA with most LGAs also having some Murray-Darling Basin Fractured Rock Groundwater RPA. Gunnedah and Liverpool plains also hold significant areas of Namoi Alluvium Groundwater RPA. It is noted that Gwydir also has significant access to the Great Artesian Basin – Shallow Aquifer (31% of its LGA area), although this not managed under the Basin Plan (2012).

Table 4-3: Water Resource Plan areas for surface water within Namoi JO

LGA	Surface Water Resource Plan Area (% of LGA area)		
	Border Rivers	Gwydir	Namoi
Gunnedah			100%
Gwydir	32%	68%	
Liverpool Plains			100%
Tamworth		2%	95%
Walcha			18%

Table 4-4: Water Resource Plan Areas for Groundwater within the Namoi JO

LGA	Groundwater Resource Plan Area (% of LGA area)					
	Gwydir Alluvium	Namoi Alluvium	NSW Border Rivers Alluvium	NSW Great Artesian Basin Shallow	NSW Murray–Darling Basin Fractured Rock	NSW Murray–Darling Basin Porous Rock
Gunnedah		14%		1%	37%	48%
Gwydir	1%		1%	31%	63%	4%
Liverpool Plains		8%			40%	52%
Tamworth		2%			94%	
Walcha					18%	

Within each Water Resource Plan Area, the NSW State Government will prepare a Water Resource Plan (WRP). The plans consist of at least one WSP and associated water quality, risk assessments and other supporting documents. The WRP does not necessarily replace the WSP but rather ensures alignment of the WSP with the Basin Plan and consistency of WSPs within a WRP area where multiple WSPs are currently in place. WSPs made under the *NSW Water Management Act 2000* remain the primary mechanism for articulating water sharing in NSW. As with the WSP, the WRP will outline the conditions of water use and access within the relevant areas, with a focus on adherence to the Basin Plan conditions. This includes:

- A description of all water rights in the plan area
- Demonstration of how compliance with the SDL prescribed in the Basin Plan will be assessed and maintained
- Inclusion of a water quality management plan
- Provision for environmental water
- Addressing risks to water resources through a risk assessment
- Explanation of how essential human needs will be met in extreme events
- Consideration of Aboriginal people's water-dependent cultural values and uses.

Table 4-5 summarises the various WSPs captured under each of the relevant WRPs for the Namoi JO region. It is noted that all of these plans are currently in development.

Table 4-5: Water Resource Plan and corresponding Water Sharing Plans

Water Resource Plan	Water Sharing Plan
Border Rivers Surface Water	Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2009
Border Rivers Alluvium	Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012
Gwydir Surface Water	Water Sharing Plan for the Gwydir Unregulated and Alluvial Water Sources 2012
Gwydir Alluvium	Water Sharing Plan for the Gwydir Alluvial Groundwater Sources 2019 (This is a new WSP which establishes the rules for water sharing in the two Gwydir Alluvium SDL resource units, and replaces the Water Sharing Plan for the Gwydir

Water Resource Plan	Water Sharing Plan
	Unregulated and Alluvial Water Sources 2012, and the provisions in the Water Sharing Plan for Lower Gwydir Groundwater Sources 2003)
Namoi Surface Water	Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources 2010
Namoi Surface Water	Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016
Namoi Alluvium	Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012
Namoi Alluvium	Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003
Murray-Darling Basin Fractured Rock	Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011
Murray-Darling Basin Porous Rock	Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011
Great Artesian Basin (Shallow)	Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008 (The NSW Great Artesian Basin Shallow WRP covers all groundwater resources above the Great Artesian Basin. While the Great Artesian Basin is a major groundwater resource under the Murray-Darling Basin, its management is not included in the Basin Plan, as the Commonwealth Water Act 2007 excludes groundwater of the Great Artesian Basin from the definition of Basin water resources)

Figure 4-5: Surface Water Resource Plan Areas

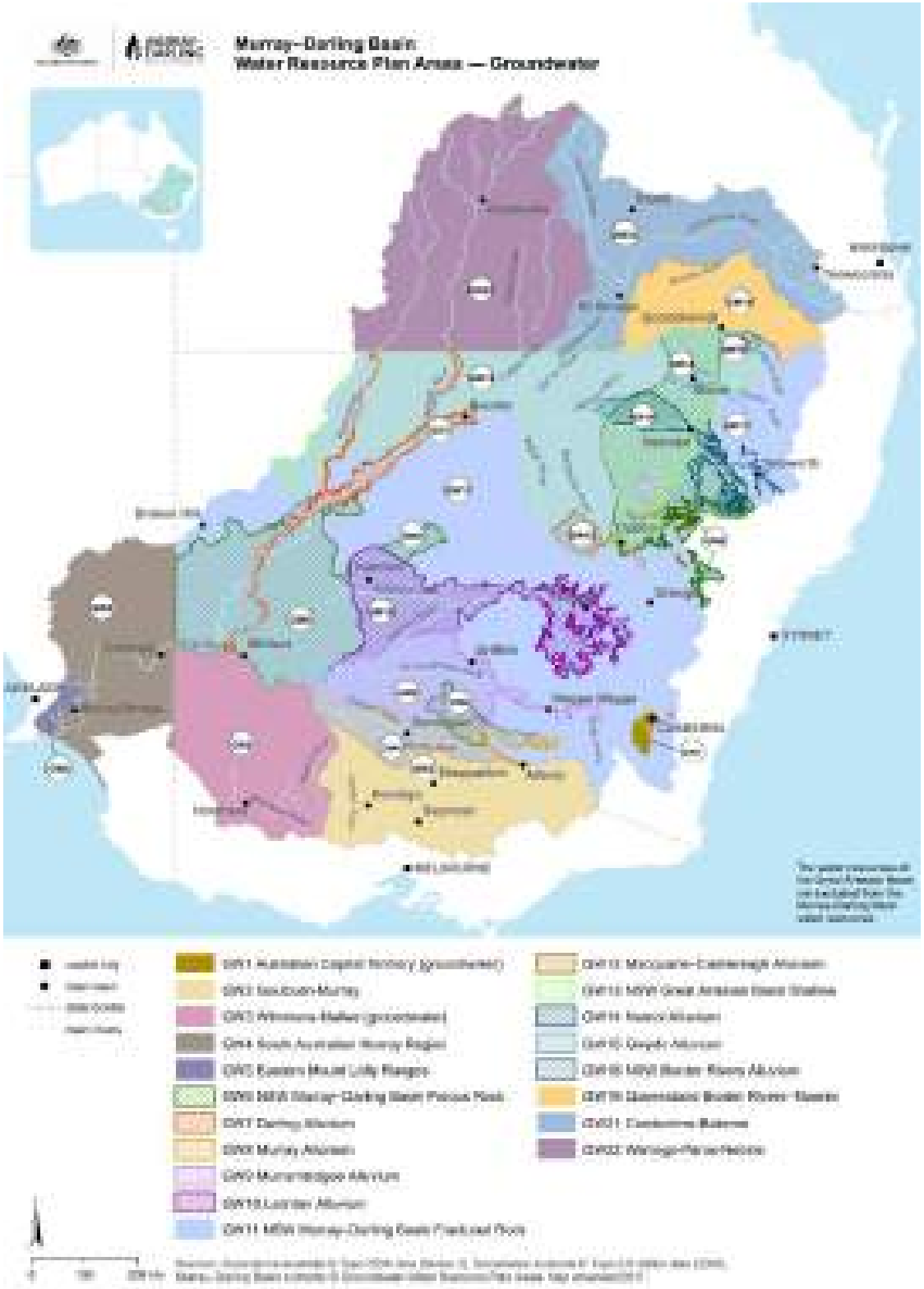


Figure 4-6: Groundwater Resource Plan Areas

4.2.6 Local Water Management Framework

The above sections detail the overall management framework applicable to individual water users within the study area. The overall implementation and regulation of this systems is managed through four main agencies: NSW Department of Industry, WaterNSW, Natural Resources Access Regulator and the Office of Environment and Heritage. Figure 4-6 summarises the major compliance functions undertaken by these agencies in regards to water users. The Office of Environment and Heritage is responsible for the management of environmental water within NSW in accordance with the Water Sharing Plans and Water Resource Plans outlined in the previous sections.

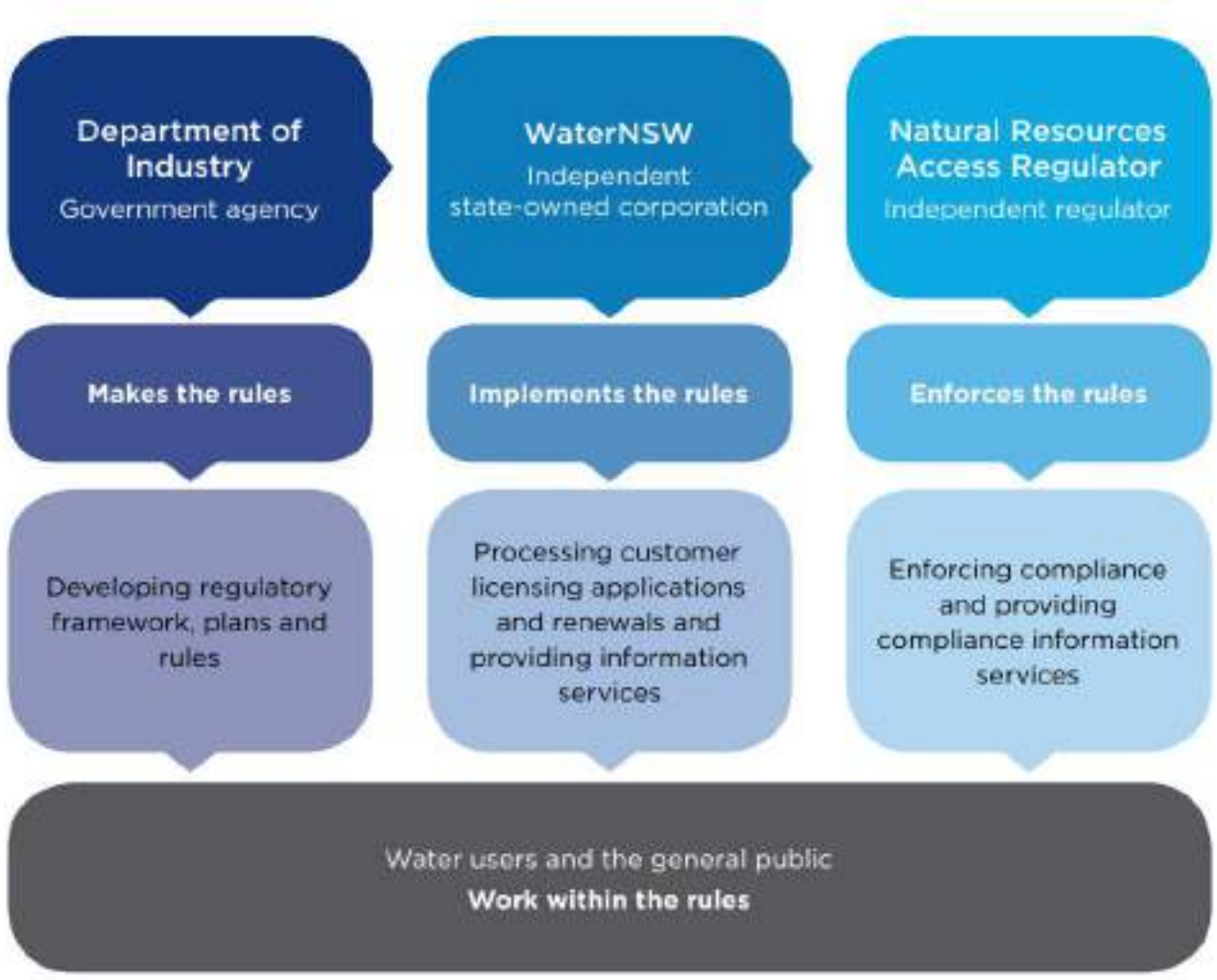


Figure 4-7: NSW Government agency responsibilities regarding water user compliance[17]

Beyond this, a number of water utilities operate across NSW, providing water supply and sewerage services to residential, commercial and industrial properties in the absence of individual WALs (i.e. the utility prevents the need for every individual to obtain and individual WAL to access water and allows water to be provided to locations with no natural access to water). Within, regional NSW, councils provide water supply and sewerage services to local communities. These "Local Water Utilities" are council owners and operated and have the responsibility to ensure water supply quality and security in accordance with the NSW Office of Water's Best

[17] NSW Government (2018) Roles of Water Management Agencies in NSW

Practice Management Guidelines and Performance Reporting. Within the Namoi JO, the five member Council's each operate LGA specific local water utilities, servicing the larger towns and settlements within their boundaries. The five local water utilities also meet together as part of the Namoi Water Alliance, to identify synergies and benefits in regional co-operation and management of local water utility management.

5 Water Sources

Within the catchment areas and under the management framework outlined in Section 4, there a number of major water sources within the Namoi JO (**Figure 5-1**). The four major water sources in use include:

- **Rainfall, water tanks and farm dams** – water that directly nourishes land or is captured prior to entry into a recognised water course.
- **Unregulated rivers** – A recognised river in which downstream flows ARE NOT regulated by a major state-owned storage. Downstream licence holders can access water in accordance with the WAL and applicable Water Sharing Plan conditions.
- **Regulated rivers** – A recognised river in which downstream flows ARE regulated by a major state-owned storage and has been Gazetted as such. Downstream licence holders can order water against a held entitlement.
- **Groundwater** – Water the occurs beneath the ground surface in the saturated zone.

Beyond the use of commercial bottled water and provisioned for trucked supplies during extreme water scarcity no other water sources are present within the Namoi JO. Re-use and recycling on and between properties does occur and it is noted that several of the councils within the Namoi JO operate small water recycling and re-use schemes. Recycled and re-used water is considered secondary water sources for the purpose of this study. Recycling of water while not generating additional water does increase the effective efficiency of water use and lowers demand upon the primary water sources. Given the current small scale of water recycling operations in comparison to overall primary extraction, the analysis within the Namoi Region Water for the Future Strategy does not capture the extent of current recycling activities.

Under the Water Management Act (2000) a river is defined to be any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and any tributary, branch or other watercourse into or from which a watercourse flows.

It is noted that for the purpose of this report the term “water source” assumes a more practical and broader definition to that adopted within the Water Management Act (2000) that defines it to be:

- The whole or any part of:
    - One or more rivers, lakes or estuaries, or
    - One or more places where water occurs naturally on or below the surface of the ground, and
    - Includes the coastal waters of the State.

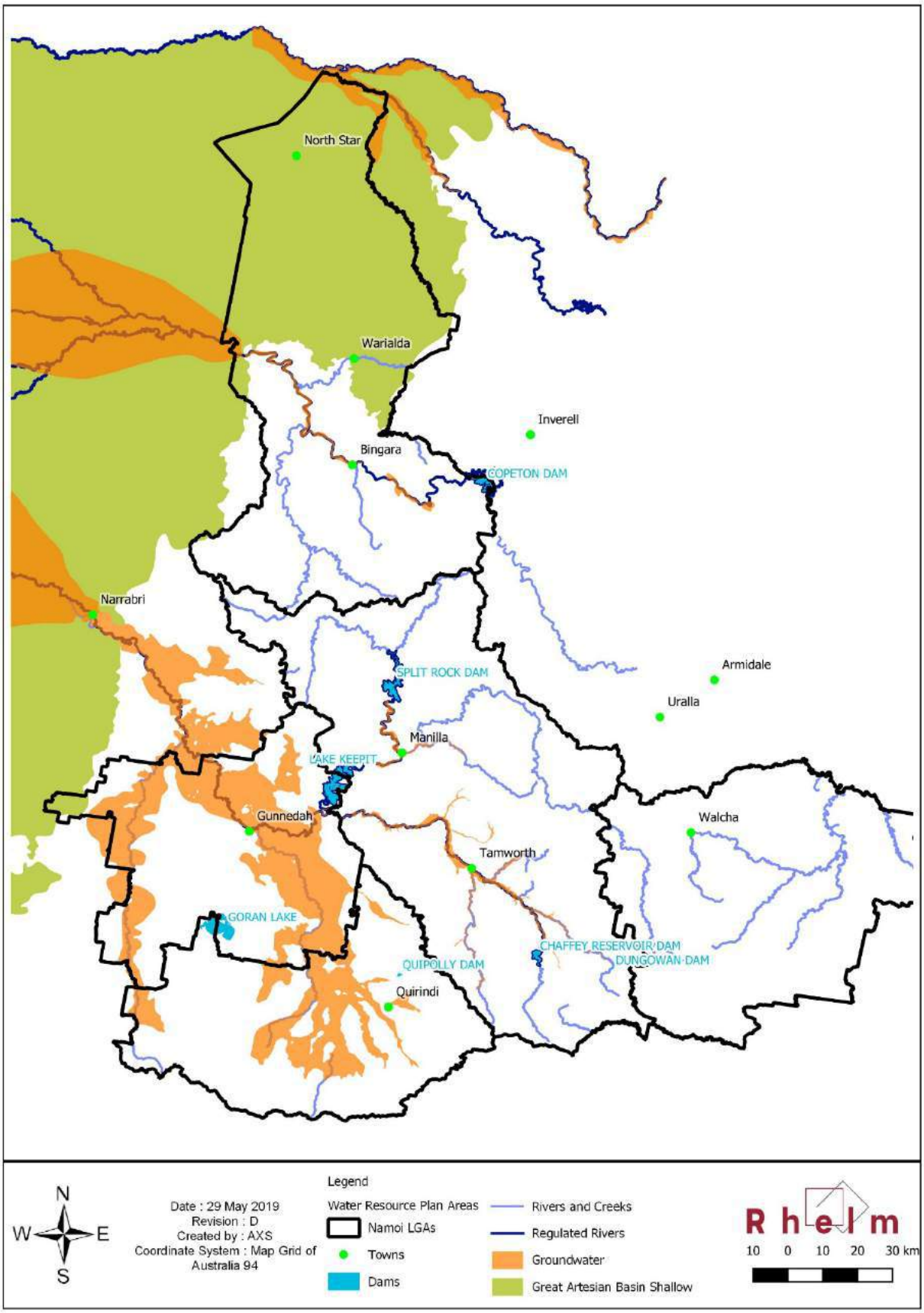


Figure 5-1. Overview of Key Water Sources

5.1 Rainfall, Water Tanks and Farms Dams

Direct rainfall irrigation is critical for dryland agriculture and grazing as it represents the primary water source for crops and feed for livestock. It also represents the primary source of water for domestic gardens maintained adjacent to residential properties and can form the majority water source for urban recreational parks and reserves. The rainfall patterns across the Namoi JO are detailed in **Section 3.1.2**. The proportion of rainfall that passes into creeks or defined surface water bodies, although highly variable, is approximately 2-10% of total rainfall volume, although it is highly variable with location (CSIRO, 2007). This demonstrates that the primary use/loss of water occurs either from capture by vegetation or penetration through to groundwater.

The use and extent of water tank usage within the Namoi JO is poorly documented. State based figures (ABS, 2013) indicates that within Sydney at least 12% of residences has a rainwater tank, increasing to approximately 30% of residences outside of Sydney. The proportion of rainwater tanks increases in rural areas. Rural properties without access to a reticulated water supply will typically require either a rainfall tank and / or access to bore or river water. Within the Namoi JO it is estimated that in excess of 30% of residences do not have access to a reticulated water supply and are likely to utilise rainwater tanks as a direct source of water. Farm properties also utilise rain-fed water tanks as part of stock watering and cleaning processes.

Tank sizes vary pending on the perceived potential use and demand (e.g. garden water, toilet, shower, drinking, etc.) and the size of property and catchment area. Standard sizes for residential properties vary between 2,000L and 10,000L water tanks. Residential properties which are entirely dependent upon rainwater may have tanks in excess of 50,000L

It is estimated that there are in the order of 32,000 farm dams within the Namoi basin alone, diverting some 160 GL/year (approximately 1/3 of the volume capacity of Keepit Dam). This is equivalent to 5ML per dam per year on average. The dams comprise those providing for stock watering and residential use and below the Maximum Harvestable Right size, as well as larger structures requiring licencing to develop and being used for watering and irrigating of land. The size of farm dams varies significantly vary with location, purpose and local climatic, topographic and geological conditions. The majority of farm dams are typically less than 1ML in capacity and are typically associated with stock watering practices.

The catchment yield per hectare plays a significant role in the sizing of farm dams (**Table 5-1**). As seen in **Figure 3-2**, average rainfall with the LGA areas is between 600mm and 800mm per year for all LGA's with the exception of Walcha (approximately 1000mm per year). The majority of farm dams with the Namoi JO are likely to yield 0.5-0.75 ML per hectare per year of catchment, whereas farm dams within Walcha may produce up to 1.45 ML per hectare per year.

Table 5-1: Average dam catchment yield[18]

Average Annual Rainfall (mm)	Average Annual Yield per Hectare of Catchments (ML)
500	0.35
750	0.75
100	1.45
1250	2.00

[18] DPI (2009): Primefacts – Building a Farm Dam

While the number of dams and estimated diverted water is of a significant volume, the issues paper for the Namoi Water Resource Plan (Surface Water) (DPI, 2017) concludes that on a catchment scale, there is a low risk to both water users and environmental assets from the current level of farm dams or potential future growth in the number of farm dams.

5.2 Unregulated Rivers

There are numerous unregulated rivers (and associated unregulated river management zones) within the Namoi JO area that are managed under the relevant WRP/WSP, including:

- 21 rivers and zones within the Namoi WRP area (**Figure 4-3**)
- 11 rivers and zones within the Gwydir WRP area (**Figure 4-2**)
- 2 rivers and zones within the Border Rivers WRP (**Figure 4-2**)
- 2 rivers and zones within the Macleay WSP (**Figure 4-1**)

In addition to these, there are numerous minor watercourses and flow paths that provide ephemeral water sources for local landowners and feed into the regulated, unregulated and groundwater systems. Minor tributaries to the Hastings and Manning catchments in the south of Tamworth and Walcha LGA are also capture under relevant WSPs.

Unregulated surface water sources are typically managed through entitlements under a WAL and applicable Cease to Pump (CtP) rules: the point at which flows in a river drop below a certain level under which use it typically restricted to preserve the health of the river. Some extraction can occur below CtP rules, typically including:

- Local Water Utility access licences
- Unregulated River (Town Water Supply) access licences
- Stock and Domestic (Stock) licences (provided that extraction for stock purposes does not exceed 14 litres per hectare of grazeable area per day);
- Stock and Domestic (Domestic) licences providing that the volume of water does not exceed 1 KL per house per day
- Water taken from run-off harvesting dams or in-river dams
- Water taken under a licence for some specific activities, for example:
    - Fruit washing
    - Cleaning of dairy plant and equipment for the purpose of hygiene
    - Poultry watering and misting
    - Cleaning of enclosures used for intensive animal production for the purposes of hygiene.

For some of the unregulated water sources competition for water during low flows can be an issue between agricultural users and the local water utility, with local water utilities addressing domestic water supply taking priority. A key management issue associated with unregulated creeks is the monitoring of extractions and reliability of creek reference point gauges, against which CtP rules are applied. Temporary trading of allocations between WALs is possible within some areas to help licence owners manage water flows.

Table 5-2 summarises the unregulated rivers within the Namoi JO, their applicable cease to pump rules and associated extraction entitlement. It can be seen that there is significant variation between the licence entitlement to the various unregulated rivers and the cease to pump limits, reflecting both the nature of the

water sources and surrounding land uses. The three rivers with greatest entitlement (and potential usage/dependency within the region include:

- Goran Lake - a large drainage basin, which forms the largest natural water body in the Namoi catchment when it is full, covering more than 60km^2. The lake-bed is privately owned and cropped when the opportunity arises, however, it is primarily an environmental asset and is listed as a wetland of national significance.
- Mooki River - The Mooki River flows north-west from near Quirindi in the Liverpool Ranges and enters the Namoi River upstream of Gunnedah. It is predominantly used to support local agricultural practices. The Mooki River catchment occupies about 9 per cent of the total area of the Namoi catchment.
- Coxs Creek - The Coxs River flows north-west from Tambar Springs in the Warrumbungle Ranges and enters the Namoi River upstream of Boggabri. The Coxs River catchment also covers about 9 per cent of the total Namoi catchment. It contains good agricultural soils and is a highly productive area for agriculture.

Table 5-2: Unregulated Rivers and Management Zones within the Namoi JO area

	Total Entitlement (ML)	**Cease to Pump limit**
Namoi WRP Area		
Blue Vale	1,640	When water level in Gulligal Lagoon is less than 80% of its capacity volume
Cockburn River	4,438	No visible flow
Coxs Creek	17,628.5	15 ML/day at Tourable Gauge 11 ML/day at Boggabri Gauge
Chaffey	400	2 ML/day or no visible flow in tributaries
Goonoo Goonoo Creek	1,061.5	No visible flow
Keepit	750	Not permitted when water level in natural pools is lower than its full capacity
Goran Lake	32,259	Water level at the reference point is equal to or below 294.7 m AHD
Lower Peel River Tributaries	2,541	No visible flow
Maules Creek	1,413	1 ML/day at the refence point
Mid Macdonald River	4,869.5	10 ML/day at the reference point
Mooki River	30,393	50 ML/day at the reference point
Phillips Creek	161	No visible flow
Quirindi Creek	2,785.5	2 ML/day at the reference point
Rangira Creek	1,479	Not permitted when water level in natural pools is lower than its full capacity
Upper Macdonald River	493	Not permitted when water level in natural pools is lower than its full capacity
Upper Manilla	2,110.5	3 ML/day at the reference point

	Total Entitlement (ML)	Cease to Pump limit
Upper Namoi	10,684.5	No flow at the weir crest at Manilla Weir
Upper Peel Tributary Rivers	9,266.5	No visible flow
Warrah Creek	265	No visible flow
Werris Creek	1,321	Not permitted when water level in natural pools is lower than its full capacity
Split Rock	0	Not permitted when water level in natural pools is lower than its full capacity
Gwydir WRP Area		
Keera Creek	192	Not permitted when water level in natural pools is lower than its full capacity
Gil Gil Creek	1,508	Not permitted when water level in natural pools is lower than its full capacity
Halls Creek	575	Not permitted when water level in natural pools is lower than its full capacity
Mackenzies Flat	27	Not permitted when water level in natural pools is lower than its full capacity
Myall Creek	1,424	Not permitted when water level in natural pools is lower than its full capacity
Cobbadah Management Zone	5,653	No visible flow
Lower Horton Management Zone		4 ML/day at the reference point
Upper Horton Management Zone		Not permitted when water level in natural pools is lower than its full capacity
Rocky Creek Management Zone		No visible flow
Warialda Creek	157.5	Not permitted when water level in natural pools is lower than its full capacity
Slaughterhouse Creek	0	Not permitted when water level in natural pools is lower than its full capacity
Mosquito Creek	787	Not permitted when water level in natural pools is lower than its full capacity
Border Rivers WRP Area		
Ottleys Creek	1,849	No visible flow
Croppa Creek and Whalan Creek	6,412	No visible flow
Macleay River WSP Area		
Apsley River	326	1 ML/day at the reference point
Tia River	703	2 ML/day at the reference point

The majority of unregulated creeks within the Namoi JO are ephemeral. However, there are a number of perennial rivers that supply both town and significant agricultural areas, most of which are in the eastern portion of the Namoi JO. The availability of water and extraction is highly variable, depending on seasonal conditions, market influences and cropping opportunities. Many smaller licences are scattered throughout the eastern part of the Namoi WRP area in the upper Namoi and Peel valleys. Water usage is more consistent on these perennial rivers and creeks where there is better rainfall and lower crop requirements (DPI, 2016).

5.3 Regulated Rivers

A regulated river is one in which downstream flows are regulated by a major state-owned storage and has been Gazetted as such. Downstream licence holders can order water against a held entitlement. The state-owned storage (e.g. dam) operator uses the number of orders (water orders are typically released in batches), along with estimated transmission losses, evaporation losses, inflows, weather forecasts, etc. to calculate and coordinate releases, ensuring sufficient volumes are released at the appropriate time to enable the water to reach the various landholders. The system is regulated by the metering of extraction points for WALs and matching that up against orders placed against those WALs. Extraction of water without or beyond a water order volume is a serious offence and can results in significant penalties.

While an **entitlement** may exist under a WAL, the regulation of the river means that the full entitlement may not always be accessible in any one year, depending on environmental conditions. At the beginning of each water year, the regulator reviews current and forecast water availability within the river/regulatory source and sets aside water to enable the delivery of essential requirements in a repeat of the lowest period of inflows. The remaining water held in storage is then distributed to licence holders as **allocation** in accordance with the priority of licence (e.g. a WAL with Regulated River (High Security) entitlement will receive preferential allocation over a Regulated River (General Security) entitlement). This system, theoretically, allows for responsive management to adapt to changing water availability conditions, with the allocation able to be adjusted throughout the year if water resources improve. Temporary trading of allocations between WALs is possible within some areas to help licences owners manage water flows.

However, it is noted that while a licence holder may technically have their full entitlement allocated to them at some point within a year the ability for them to use/extract this water at that point in time may be limited by:

- Timing: There need for water at the time in which the allocation is made available (e.g. the allocation may be able to be ordered, but landholders may have no need for the water at that point in the year) or the costs of doing so (e.g. extraction fees, pumping costs) exceed the benefit of additional water.
- Speed of allocation flow: water orders are released as collective orders, requiring sufficient flow and volumes to ensure water reaches downstream receivers. This can mean that water users higher in the catchment are required to extract at high rates in order to access the flow.
- Sleeper licences: Many landowners have entitlements which may not be actively used or traded for a variety of individual investor choices. This can affect the volume, magnitude and costs of water orders.
- Need and cost: The entitlement volume often captures (or exceeds) an estimate of maximum demand for a land-owner. In dry years, a land-owner is more likely to use a greater proportion of their entitlement, pending the cost of accessing the water.

Further issues regarding the practical and economic issues associated with regulated rivers are discussed in **Section 8**.

There are four regulated rivers within the Namoi JO area:

- Peel River – regulated via Chaffey Dam (**Figure 4-3**)
- Namoi River – regulated via Split Rock and Keepit Dam (**Figure 4-3**)
- Gwydir River – regulated via Copeton Dam (**Figure 4-2**)
- Macintyre River – Regulated via Pindari Dam (**Figure 4-2**).

5.3.1 Peel River

The Peel River is a regulated tributary of the Namoi River, joining downstream of Keepit Dam. It has a catchment area of approximately 4,700 km^2. The regulated section of the Peel River is managed as a separate scheme to the Namoi Regulated River. Regulation of the Peel River is through Chaffey Dam. The river proceeds through a series of narrow valleys, to Chaffey Dam and then broadens out around Tamworth into alluvial plains. A number of unregulated streams flow into the Peel River (e.g. 40% of Peel River annual discharge is from the Cockburn River (DPI, 2017b)) both upstream and downstream of the Dam.

The Namoi Water Resource Plan (DPI, 2017b) indicates that average annual flow within the river is in the order of 253,630 ML per year (**Figure 5-2**). However, the annual flow volumes are highly variable and correlated to rainfall, although the variation has reduced since the installation of Chaffey Dam in 1979 and the start of regulation. Consistent with annual rainfall patterns the majority of flows occur between July and September. It is rare for the Peel River to cease flow altogether although flows do drop to less than 1 ML/day in drier periods.

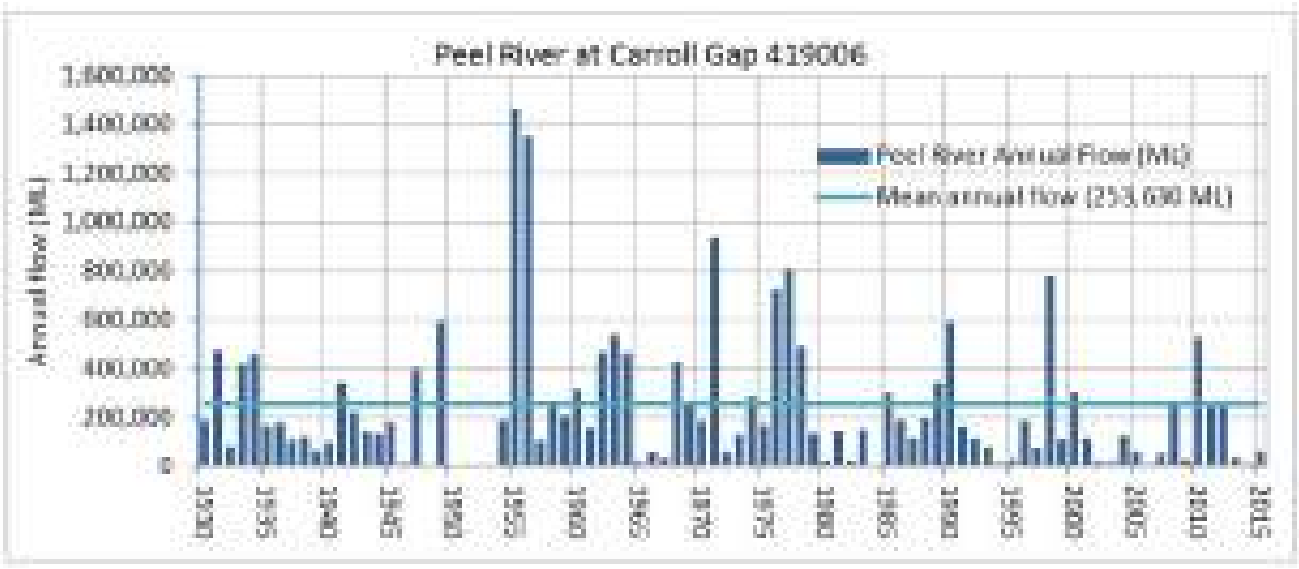


Figure 5-2: Annual flows in the Peel River (1930-2015) (DPI, 2017b)

Table 5-3 summarises the average (2010-2017) Peel River entitlements and usage statistics[19]. It can be seen that within the Peel River, General Security WAL entitlement (64%) and Local Water Utility WAL (35%) represent the major demand sources for water, although the Local Water Utility entitlement is held by a single licence holder (Tamworth Regional Council), making them the largest individual water licence holder within

[19] Data obtained from annual General Purpose Water Accounting reports prepared by DPI NSW for the Peel River

the regulated river. However, total utilisation of entitlement is approximately 47% for general security water users, and only 27% for Local Water Utility users. It is noted that major unregulated rivers within the Peel catchment (i.e. Cockburn Creek and Upper Peel Tributary Rivers) have entitlement levels (13,705 ML per year) of lower but not insubstantial magnitude in comparison to the total entitlement within the Peel River (47,587 ML per year). Total entitlement (all of which is located within the Namoi JO) is approximately 19% of total outflow.

Table 5-3: Average annual entitlement and use metrics for the regulated portion of the Peel River

Licence Type	No. of Licence Holders	Annual Licenced Entitlement (ML)	Annual Water Available (Allocation + Carryover) (ML)	Water Used (excl. trading in and out) (ML)	Total Utilisation (% of entitlement)[20]
Domestic and Stock	11.6	81.0	79.1	14.3	17%
Domestic and Stock [Domestic]	4.0	69.3	66.8	32.6	50%
Domestic and Stock [Stock]	4.0	20.0	19.3	5.8	29%
Local Water Utility	1.0	16400.0	15785.0	4253.1	27%
General Security	182.4	30500.9	20845.8	4894.4	47%
High Security	12.3	801.0	749.6	254.3	44%
High Security [Research]	1.0	3.0	2.9	0.8	25%

5.3.2 Namoi River

The Namoi River rises in the Great Dividing Range to the south-east of Tamworth. There are three major tributaries – the Manilla River (with Split Rock Dam), the Macdonald River and Halls Creek – as well as numerous smaller creeks. In the upper reaches the water flows within well-defined channels and the river has a limited floodplain. The Namoi River becomes regulated at the Split Rock Dam and Keepit Dam. Keepit Dam and Split Rock Dam are operated as a joint water supply system for the Namoi catchment with bulk water transfers occurring from Split Rock to Keepit Dam during times of peak demand. For the purposes of reporting and management the section upstream of Keepit Dam is considered the Upper Namoi (entirely located within Namoi JO), while downstream from Keepit Dam is considered the Lower Namoi (the catchment includes significant areas outside of the Namoi JO).

Downstream of Keepit Dam the Namoi River is supplemented by the Peel River and a number of significant unregulated rivers within the Namoi JO including the Mooki River and Coxs Creek.

The Namoi Water Resource Plan (DPI, 2017b) indicates that water flows within the catchment have altered significantly since the construction of the dams and that the current regulated rules have led to an overall reduction in average total flows (**Figure 5-3**). Average annual flow within the river (measured from Gunnedah) is in the order of 653,000 ML per year. The lowest recorded annual flow was 33,270 ML in 1902. In comparison

[20] Includes water trades into and out of the system in its calculation. (i.e. (Water Used + Trade Out) / (Annual Water Available + Trade In))

to the Peel River, the upper section of the Namoi River is a considerably larger and a more reliable water source, although they share similar seasonality patterns.

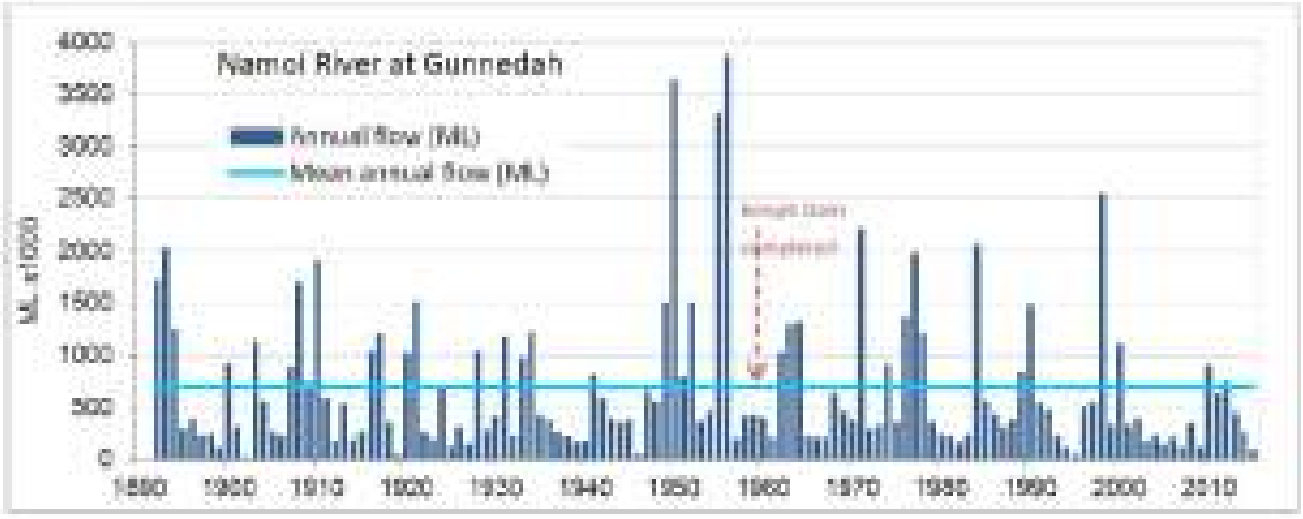


Figure 5-3: Annual flows in the Namoi River (1892-2016) (DPI, 2017b)

Table 5-4 and **Table 5-5** summarise the average (2010-2017) upper and lower Namoi River entitlements and usage statistics[21]. It can be seen that within the Namoi, General Security WAL entitlement is the largest demand source for water (94% and 97% respectively for the upper and lower Namoi reaches). The majority of entitlement holders within the lower Namoi River fall outside the Namoi JO area and the majority of water usage from the lower Namoi River does not occur within the Namoi JO. Total utilisation of entitlement for General Security users within the upper Namoi River (78%) is significantly higher than utilisation of general security entitlements in the lower Namoi River (47%), potentially reflecting both allocation reliability differences between catchment areas and land-use.

Table 5-4: Average annual entitlement and use metrics for the regulated portion of the Upper Namoi River

Licence Type	No. of Licence Holders	Annual Licenced Entitlement (ML)	Annual Water Available (Allocation + Carryover) (ML)	Water Used (excl. trading in and out) (ML)	Total Utilisation (% of entitlement)[22]
Domestic and Stock	14	75	75	1	1%
Domestic and Stock [Domestic]	5	11	11	1	10%
Domestic and Stock [Stock]	1	5	5	5	100%
Local Water Utility	2	469	427	98	20%
General Security	92	9886	9410	3678	78%
High Security	5	80	80	27	39%

[21] Data obtained from annual General Purpose Water Accounting reports prepared by DPI NSW for the Peel River
[22] Includes water trades into and out of the system in its calculation. (i.e. (Water Used + Trade Out) / (Annual Water Available + Trade In))

Table 5-5: Average annual entitlement and use metrics for the regulated portion of the Lower Namoi River

Licence Type	No. of Licence Holders	Annual Licenced Entitlement (ML)	Annual Water Available (Allocation + Carryover) (ML)	Water Used (excl. trading in and out) (ML)	Total Utilisation (% of entitlement)
Domestic and Stock	103	1741	1750	761	43%
Domestic and Stock [Domestic]	5	18	18	6	31%
Domestic and Stock [Stock]	22	257	257	85	33%
Local Water Utility	1	2271	2271	770	34%
General Security	262	246127	268929	103515	47%
High Security	11	3418	3418	616	93%

5.3.3 Gwydir River

The Gwydir River is regulated by a number of dams and weirs. The catchment's major water storage is Copeton Dam on the eastern border of the Gwydir LGA, about 35 km south-west of Inverell. The river and dam supplies water to users along the Gwydir River and divergent streams of Carole Creek, Moomin Creek and Mehi River outside of the Namoi JO area. From Copeton Dam, the Gwydir River flows westward linking a number of catchments including Keera Creek, Halls Creek, Myall Creek, and Warialda Creek. The Horton River, the major tributary of the Gwydir and located within the Namoi JO, rises in the south from the Nandewar Ranges and enters the river between Bingara and Gravesend. Downstream of Gravesend, the river floodplain widens, and the river becomes a slow moving, undulating series of divergent streams, anabranches and tributaries (DPI, 2018a).

The Gwydir Resource Plan (DPI, 2018a) indicates that the introduction of regulation through Copeton Dam has significantly altered the moderate and high flows along the river, particularly for the lower reaches of the river beyond the catchment. Upstream of Copeton Dam average annual flow is in the order of 327,000 ML per year (**Figure 5-4**), increasing to over 730,000 ML per year downstream of the dam, upstream of Moree, reflecting the large number of unregulated tributaries that support the river. High flows periods are typically greatest from August through to December, although flow levels remain reasonable consistent throughout the year (DPI, 2018a).

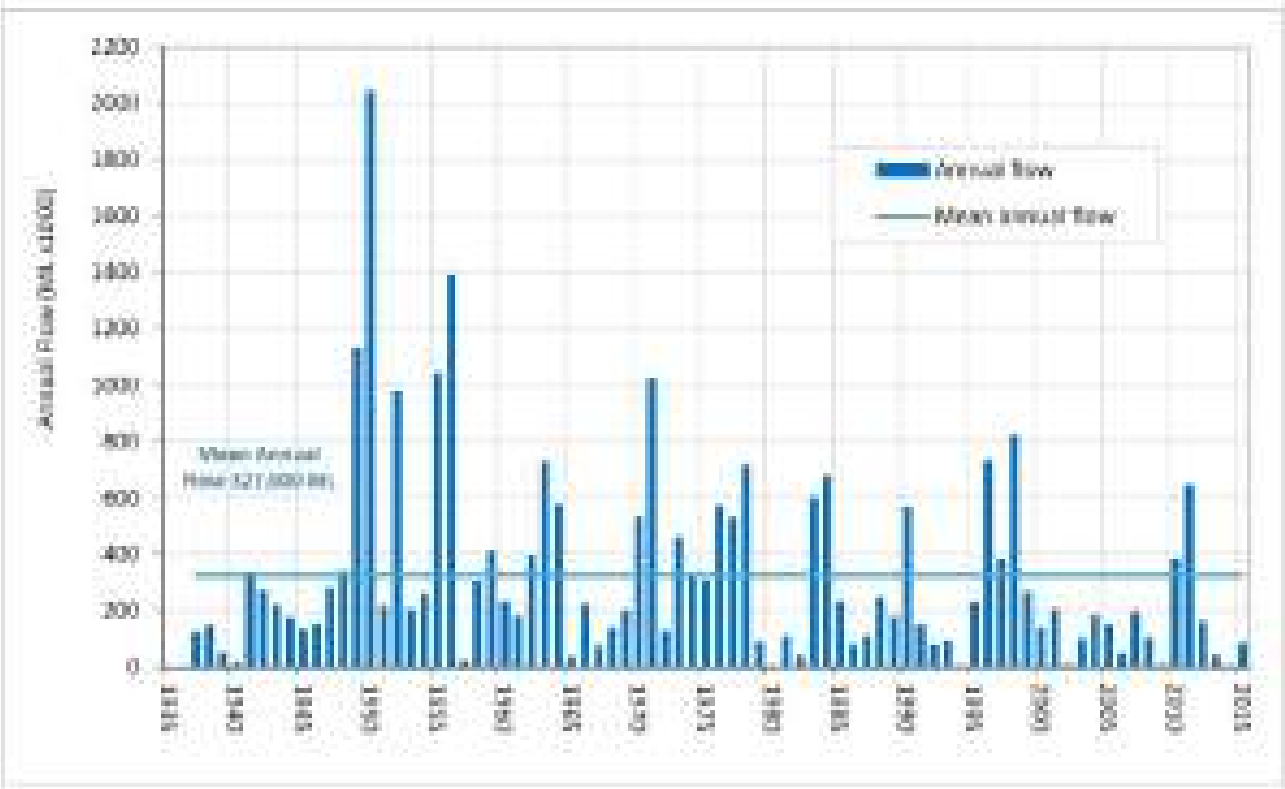


Figure 5-4: Annual flows in the Gwydir River at Bundarra (1937-2015) (DPI, 2018)

Table 5-6 summarises the average (2010-2017) Gwydir River entitlements and usage statistics[23]. It can be seen that, within the Gwydir River, General Security WAL entitlement account for 95% of water entitlement licences. Of this, the majority falls outside of the Namoi JO area. The overall scale of entitlement from the regulated portion of the Gwydir River significantly exceeds that of the Namoi and Peel Rivers combined, despite having a catchment area of approximately half the size. This reflects the difference in rainfall, topography, land ownership patterns, SDL limits and the diversity of unregulated sources which support the Gwydir River. However, total utilisation of the overall entitlement is approximately 47% for general security water which closely aligns with the utilisation observed within the Lower Namoi.

Table 5-6: Average annual entitlement and use metrics for the regulated portion of the Gwydir River

Licence Type	No. of Licence Holders	Annual Licenced Entitlement (ML)	Annual Water Available (Allocation + Carryover) (ML)	Water Used (excl. trading in and out) (ML)	Total Utilisation (% of entitlement)[24]
Domestic and Stock	69	2506	2501	1033	41%
Domestic and Stock [Domestic]	3	31	21	0	0%

[23] Data obtained from annual General Purpose Water Accounting reports prepared by DPI NSW for the Peel River

[24] Includes water trades into and out of the system in its calculation. (i.e. (Water Used + Trade Out) / (Annual Water Available + Trade In))

Licence Type	No. of Licence Holders	Annual Licenced Entitlement (ML)	Annual Water Available (Allocation + Carryover) (ML)	Water Used (excl. trading in and out) (ML)	Total Utilisation (% of entitlement)[24]
Domestic and Stock [Stock]	27	230	230	66	29%
Local Water Utility	4	3836	3830	2444	64%
General Security	186	509665	480191	169538	47%
High Security	20	17481	16709	8570	90%

5.3.4 Macintyre River

The Macintyre River is the longest rivers within the Border Ranges WRP. Beginning on the western slopes of the Great Dividing Range near Inverell, in flows north-west towards Boggabilla along the Gwydir LGA border. Within NSW, the river is regulated via Pindari Dam on the Severn River, and upstream tributary to the Macintyre. The regulated Dumarseq River also joins the Macintyre, but downstream of the Namoi JO, immediately north of the Gwydir LGA. The average annual stream flow is in the order of 889,656 ML per year at Boggabilla, downstream of the confluence of the Macintyre and Dumarseq rivers (**Figure 5-5**). Annual average stream flow within the Macintyre River portion along the Gwydir LGA is estimated to roughly half this amount.

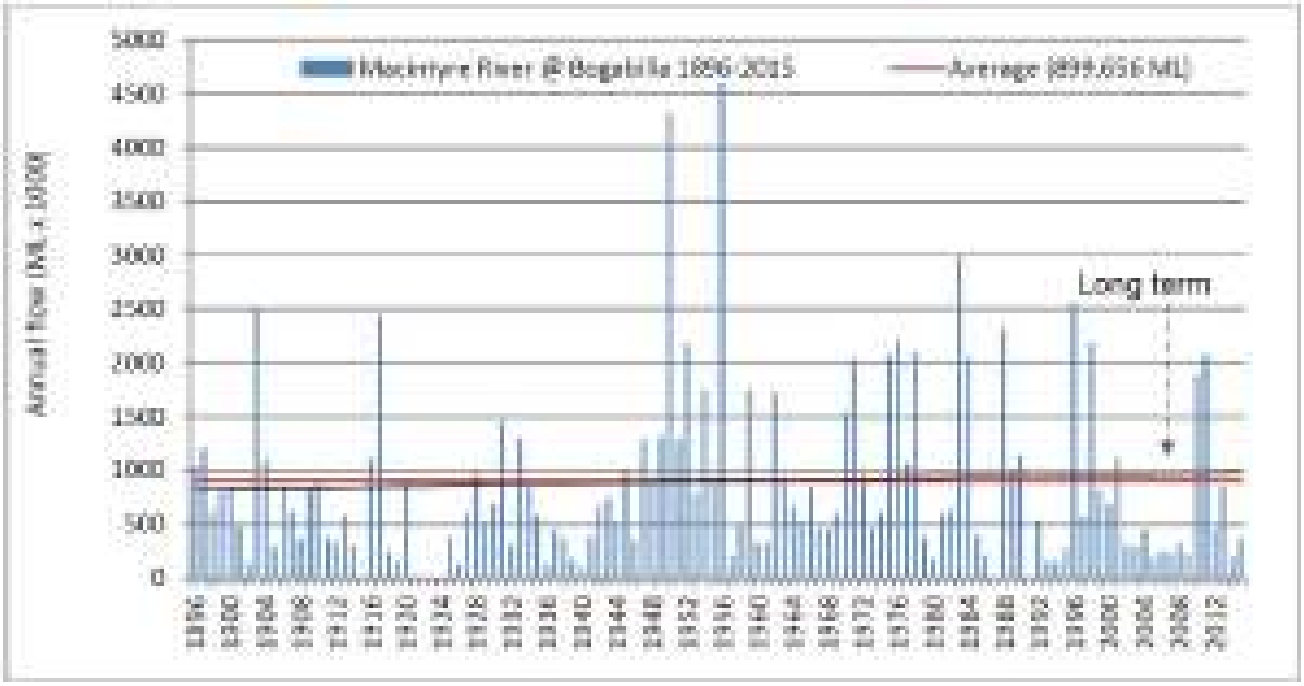


Figure 5-5: Annual flows in the Macintyre River at Boggabilla (1896-2015) (DPI, 2018b)

Table 5-7 summarises the average (2010-2017) Border Rivers regulated entitlements and usage statistics[25]. It can be seen that, within the Border Rivers, General Security (A & B) WAL entitlement account for 98% of water entitlement licences. Of this, the majority of entitlement relates to entitlements outside of the Namoi JO. The

[25] Data obtained from annual General Purpose Water Accounting reports prepared by DPI NSW for the Peel River

overall scale of entitlement from the regulated portion of the Border Rivers WRP is of similar magnitude to the Namoi WRP. As with both the Gwydir and Lower Namoi, the total General Security entitlement utilisation is approximately 47%.

Table 5-7: Average annual entitlement and use metrics for the Regulated portion of the Borders Rivers

Licence Type	No. of Licence Holders	Annual Licenced Entitlement (ML)	Annual Water Available (Allocation + Carryover) (ML)	Water Used (excl. trading in and out) (ML)	Total Utilisation (% of entitlement)[26]
Domestic and Stock	29	845	847	587	69%
Domestic and Stock [Domestic]	14	52	52	3	6%
Domestic and Stock [Stock]	15	100	100	55	29%
Local Water Utility	4	623	619	499	80%
General Security (A)	126	22024	22070	13817	83%
General Security (B)	108	241211	221299	78939	47%
High Security	10	1500	1499	333	92%

5.3.5 Surface Water License Data

Surface water license data, which includes both regulated and unregulated water sources, was provided for use in this study on 22 March 2019 by Water NSW in a spatial format. This data was provided in a spatial (GIS) format and provides a usual understanding of the spatial variation of entitlement across the study area.

A representation of this data is provided in **Figure 5-6**, which shows the total entitlement within a 2.5km radius of a point on the map. This provides a good indication of the spatial distribution of water licensing within the study area.

[26] Includes water trades into and out of the system in its calculation. (i.e. (Water Used + Trade Out) / (Annual Water Available + Trade In))

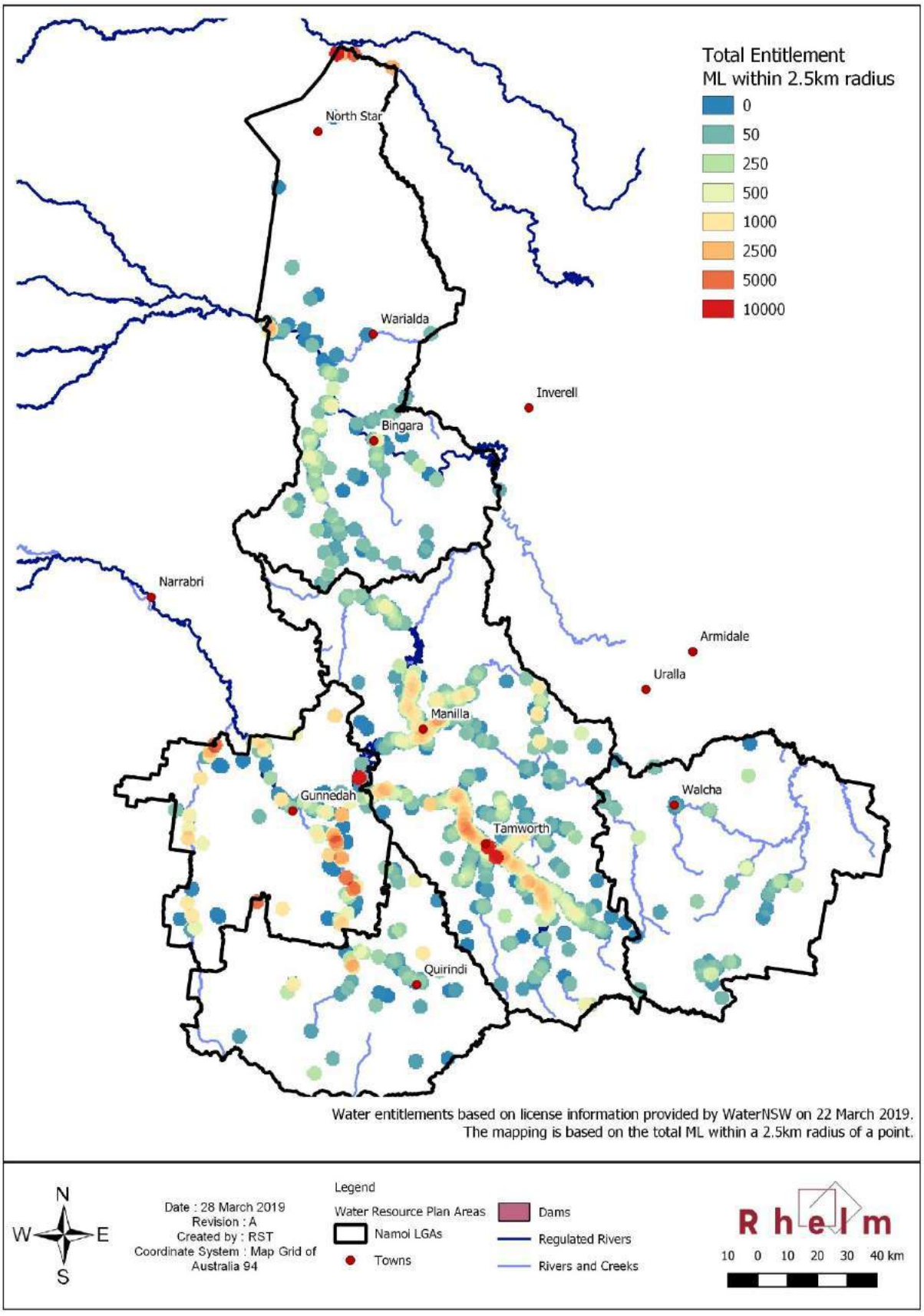


Figure 5-6. Surface Water Entitlement

5.4 Groundwater

Groundwater systems within the Namoi JO represent the largest permanent water source within the Namoi JO. However, due to the difficulty and cost associated with defining the extent and interactions of groundwater systems, there is higher uncertainty in defining its relative abundance and long-term sustainability and the extent to which it can truly be considered “permanent”.

Within the Namoi JO there are five groundwater sources defined with the WRP areas:

- Border Rivers Alluvium
- Gwydir Alluvium
- Namoi Alluvium
- Murray-Darling Basin Fractured and Porous Rock Alluviums
- Great Artesian Basin.

An overview of these groundwater sources is provided in **Figure 5-7**. These five sources are broken down into a series of localised sources (**Figure 5-8**) and zones.

Groundwater WALs typically function in a similar manner to WAL for Regulated Rivers in that the licence will outline a Share Component and an Extraction Component (**Section 3.3.2**) and, on an annual basis, Available Water Determinations (AWDs) are made at the start of each water year for to outline the proportion of entitlement able to be accessed based on the known recharge rates attributable to the water source and minimum required to sustain environmental and critical human needs. Total extractions within the groundwater source are designed to meet long-term average annual extraction limits (i.e. equivalent to SDL of WRPs). Groundwater WALs typically fall across a number of licence types, including:

- Domestic and stock access licences
- Local utility access
- Aquifer access licence
- Aquifer (high security) access licence.

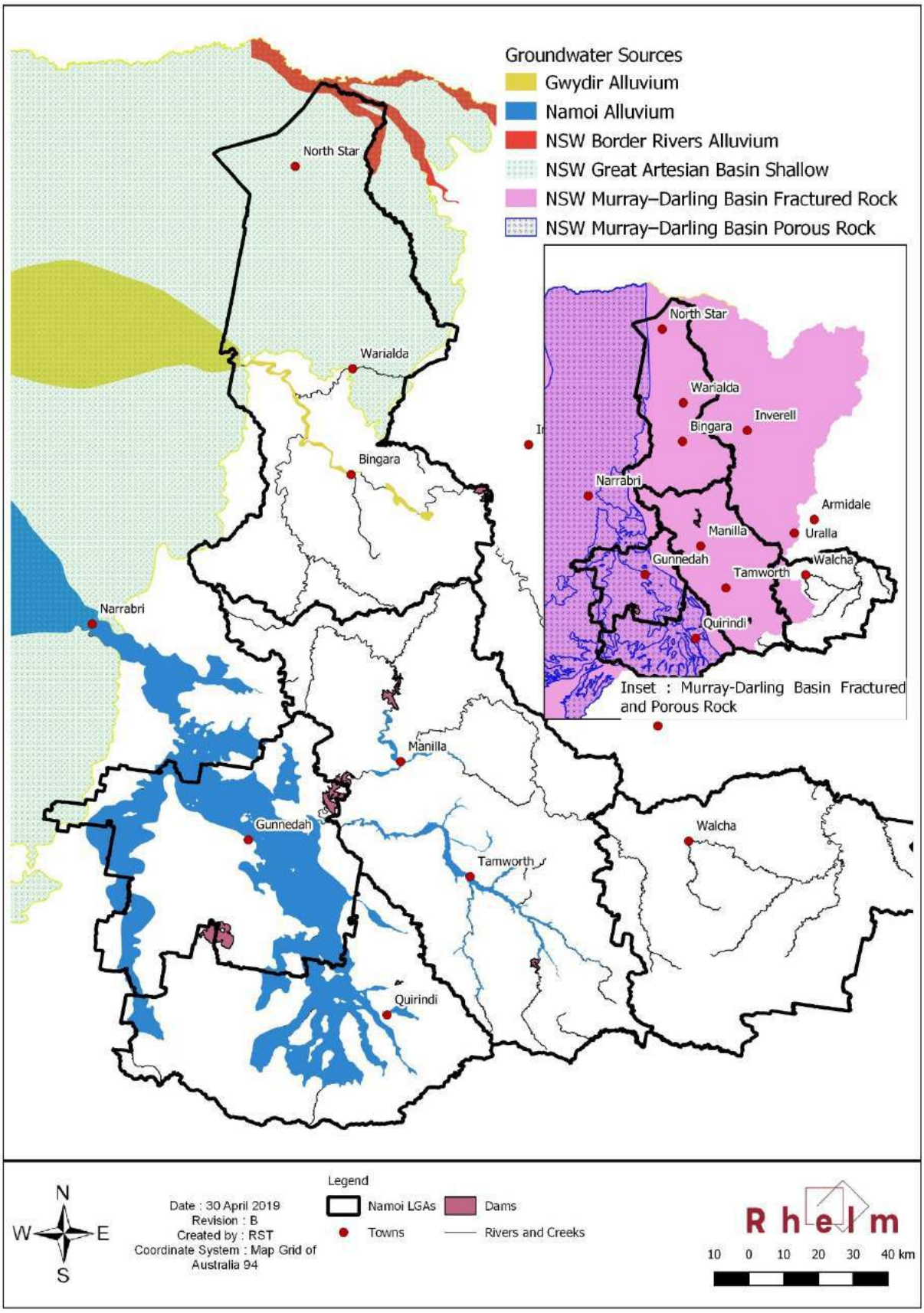


Figure 5-7. Key Groundwater Sources

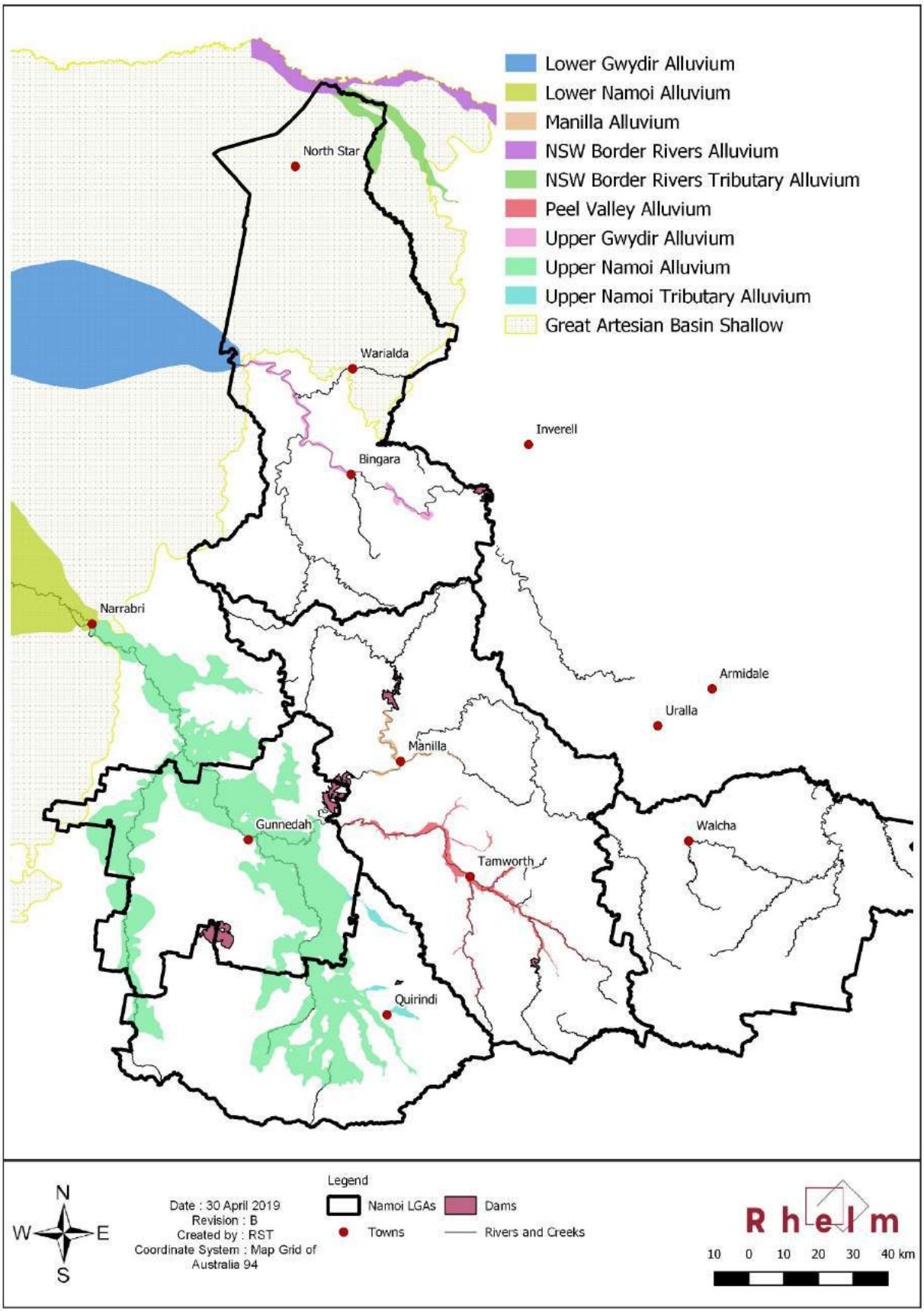


Figure 5-8. Localised sources within each broader groundwater body

5.4.1 Border Rivers Alluvium

The NSW Border Rivers Alluvial Groundwater Sources is a combination of a number of individual, inter-related water sources, including the:

- Macintyre Alluvial Groundwater Source
- Ottleys Creek Alluvial Groundwater Source
- NSW Border Rivers Downstream Keetah Bridge Alluvial Groundwater Source
- NSW Border Rivers Upstream Keetah Bridge Alluvial Groundwater Source.

Of these, the first three occur along the northern border of the Gwydir LGA, predominantly within the Ottleys Creek Alluvium. However, the vast majority of groundwater use and extraction within the Borders River Alluvium is undertaken within the NSW Border Rivers Upstream Keetah Bridge Alluvial Groundwater Source. The number of licenced users within the other sources is minimal although some land-owners may access unlicensed basic landowner water rights (**Table 5-8**). As can be seen, the Ottleys Creek Alluvium, representing the largest area groundwater component within the Gwydir LGA is not utilised by either Council of landholders beyond basic landholder rights usage.

Table 5-8: Average annual entitlement and use metrics for NSW Border Rivers (DPI, 2015)

	Macintyre Alluvium	**Downstream Keetah Bridge Alluvium**	**Ottleys Creek Alluvium**	**Upstream Keetah Bridge Alluvium**
Local Water Utility Access Licence	35	0	0	0
Aquifer Access Entitlement (ML or Shares)	1,558	485	0	15,392
Basic Landholder Right (estimate) (ML/day)	0.29	0.18	0.08	0.49
Long-term Average Annual Extraction Limits (LTAAEL) (ML/yr)	373.0	316.4	29.7	8,053.3

The Macintyre Alluvium is comprised of sediments ranging from cobbles, to gravels, to sands to silt and clay. Bore yields are generally low, up to 11.3 L/s is common. The floodplain ranges from 700 m to 4.8 km wide and the sediments have a maximum thickness of 42 m. The Macintyre Alluvium is recharged by rainfall, some side slope run off and streamflow leakage from the regulated Macintyre River (DPI, 2015). There are interactions between the Macintyre Alluvium Groundwater Source and the Macintyre Regulated River. In recognition of this, the annual AWD for this groundwater source is partially based (70%) off the AWD for high security access entitlements within the Macintyre Regulated River. The limited bore monitoring available for the Macintyre Alluvium shows that the groundwater in the Macintyre Alluvium responds to the climate in the Macintyre River with fluctuations in response to climate and the river. Hydrographs for the alluvium show that it is in decline, lowering by approximately 1m since 1987.

Similarly, the Downstream Keetah Bridge Alluvium is comprised of sediments ranging from cobbles, to gravels, to sands to silt and clay. Bore yields are low, up to 4.5L/s is common. The floodplain ranges from 500m to 7km wide and the sediments have a maximum thickness of 35 m. The Downstream Keetah Bridge Alluvium is recharged by rainfall, some side slope run off and streamflow leakage from the regulated Dumaresq and Macintyre Rivers. Of the limited monitoring bores, hydrographs demonstrate that groundwater levels are fairly stable with fluctuations in response to climate (DPI, 2015).

The Ottleys Creek Alluvium is a shallow unconfined system, comprised of sediments ranging from gravels, to sands to silt and clay. Bore yields are low, up to 1.3L/s is common. The floodplain ranges from 230m to 4.7 km wide and the sediments have a maximum thickness of 24 m. The Ottleys Creek Alluvium is recharged by rainfall, some side slope run off and streamflow leakage from the regulated Macintyre River. The bore monitoring hydrograph shows that the alluvium is fairly stable, although fluctuating in response to climate.

All three of these alluvial sources are underlaid by the Great Artersian Basin (GAB). The GAB is at higher pressure than the alluvium. However, the long term trend shows that the GAB appears to be in decline, potentially through greater extraction, although fluctuations in level in response to climate are noticeable.

5.4.2 Gwydir Alluvium

The groundwater sources of the Gwydir Alluvium include the major alluvial deposits associated with the Gwydir River, extending from downstream of Copeton Dam, north-west through Bingara to Biniguy and continues approximately 45 km west of Moree. The two major sources within the Alluvium are the:

- Lower Gwydir Groundwater Source (Lower Gwydir Alluvium)
- Upper Gwydir Alluvial Groundwater Source (Upper Gwydir Alluvium).

Of these, the Gwydir LGA overlays much of the Upper Gwydir Alluvium, predominantly associated with the valley infill alluvial sediments from the Gwydir Regulated River. Consisting of clay, silt, sand and gravel, the alluvium is generally less than 30 m thick (DPI, 2018c). The Upper Gwydir Alluvium is in hydraulic connection with the Gwydir Regulated River along its length. Conceptually, the dominant recharge processes are direct rainfall infiltration and leakage from Gwydir River as well as side slope run on. Studies have suggested that groundwater discharges to most streams in the higher ground to the east and is recharged by streams in the lower lying areas to the west, although such relationships may be reversed in some places depending on flow levels (DPI, 2018c).

Historically there has been little groundwater-based development in the Upper Gwydir Alluvium. There is currently no groundwater level information available for the Upper Gwydir Alluvium; however, groundwater flow direction is likely to be north - west in the same direction as the Gwydir River. The limited available information for the Upper Gwydir Alluvium indicates bore yields are likely to be less than 10 litres per second and of similar small magnitude to many of the Border Rivers Alluvium sources. Irrigation development from groundwater in the Upper Gwydir Alluvium is relatively small by comparison to other larger groundwater sources in NSW such as the Lower Gwydir Alluvium. As with the Border Rivers Alluvium, the annual AWDs determination for high security aquifer access licences in the Upper Gwydir Alluvium is linked to the available water determination for the high security regulated river licences (**Table 5-9**). Since the commencement of the water sharing plan this has been 100 per cent access. No hydrographs are available for the Upper Gwydir Alluvium. However, hydrographs for the Lower Gwydir Alluvium indicate high variability in drawdown over time.

Table 5-9: Average annual entitlement and use metrics for Gwydir Alluvium (DPI, 2018c)

	Upper Gwydir Alluvium	Lower Gwydir Alluvium
Local Water Utility Access Licence (ML/yr)	60	3,572
Aquifer Access Entitlement (ML or Shares)	1,133	28,858
Sustainable Diversion Limits (ML/yr) (incl. basic landholder rights)	720	33,000
Long-term Average Annual Extraction Limits (LTAAEL) (ML/yr)	721	33,000

5.4.3 Namoi Alluvium

In contrast to the Border Rivers Alluvium and Gwydir Alluvium, the Namoi Alluvium represent the most intensively developed groundwater resources in NSW, with one of the highest levels of groundwater extraction in the Murray Darling Basin (DPI, 2017b). The Namoi Alluvium can be broadly separated into:

- Upper Namoi Alluvium – the alluvial sediments associated with the floodplains of Coxs Creek and the Mooki River and its tributaries in the south, and the Namoi River and its tributaries upstream of Narrabri below Keepit Dam in the north-west. The Alluvium consists of a shall aquifer up to 40m deep and a deep aquifer up to 150m thick. The average depth of groundwater level below the surface is approximately 12m. The Upper Namoi Alluvium comprises 12 separate groundwater sources (zones) with differing management and use requirements.
- Lower Namoi Alluvium – The alluvial fan deposited by the Namoi River and its tributaries west from Narrabri to Walgett. The average depth of groundwater level below the surface is approximately 21m.
- Peel Valley Alluvium – Shallow unconfined alluvial system associated with the Peel River. The average depth of groundwater level below the surface is approximately 5m.
- Manilla Alluvium - Shallow unconfined alluvial system associated with the Manilla River. The average depth of groundwater level below the surface is approximately 5m.
- Upper Namoi Tributary Alluvium – Shallow unconfined alluvial system associated with the Manilla River. The average depth of groundwater level below the surface is less the 10m. The Upper Namoi Tributary Alluvium comprises three separate groundwater sources (zones) with differing management and use requirements.

Of these, the Lower Namoi Alluvium is located outside of the Namoi JO area. For all sources, the main recharge mechanism is via rainfall infiltration, side slope run-off, streamflow and flooding. The aquifers themselves are intersecting and there is flow through down gradient between adjacent sources. The direction of groundwater flow in the Manilla Alluvium and the Upper Namoi Tributary Alluvium generally follows the topography and that of the parent river. Similarly, the Peel Valley Alluvium follows the course of the Peel River, flowing south-east to north-west. While this is also true for the shallow aquifer of the Upper Namoi Alluvium, the deep aquifer, is more south to north and north-west (DPI, 2017b).

The Upper Namoi Alluvium provides the greatest average yields within the Namoi JO area, more than double that of the Peel Alluvium (**Table 5-10**). Unsurprisingly, the Upper Namoi Alluvium also represents the groundwater source with greatest entitlement and annual usage. It can be seen that although there is a significant entitlement within the Peel Valley Alluvium, only a small portion of this tends to be used in any one year.

Table 5-10: Average annual entitlement and use metrics for Namoi Alluvium within Namoi JO area (DPI, 2017b)

	Upper Namoi Alluvium	Peel Valley Alluvium	Manilla Alluvium	Upper Namoi Tributary
Average yield (L/s)	20	10	5	5
Local Water Utility Access Licence (ML)	6,280	660	0	0
Aquifer Access Entitlement (ML or Shares)	109,999	51,253	3,475	3,635
Basic Landholder Right (estimate) (ML/year)	2,832	241	24.7	35.8
Average Annual usage (ML/year)	83,121	6,113	206	268

The high volume of extraction within the Upper Namoi Alluvium has a marked effect on groundwater levels, although the levels also reflect climatic conditions. The seasonal drawdowns are greatest within the deep aquifer of the Upper Namoi Alluvium, exceeding 15m of drawdown within a season in some locations (**Figure 5-9**). Hydrograph data for the Upper Namoi indicates a potential long-term decline in groundwater levels since monitoring commenced, and the potential influence of climate conditions (**Figure 5-10**). Similarly, **Figure 5-11** shows variation in groundwater levels over time within the Peel Valley Alluvium, shower a lesser overall reduction in levels and higher variation. It is important to note that within all systems there can be significant internal variation as to groundwater level and source thickness.

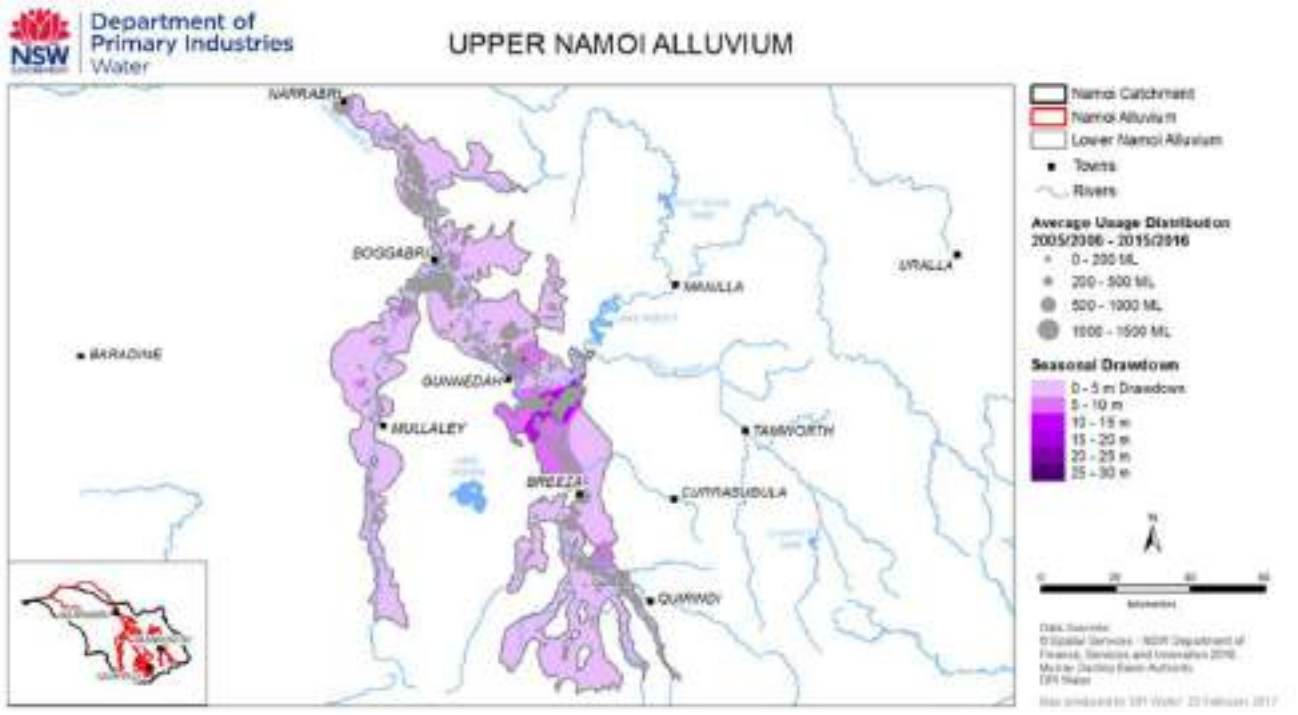


Figure 5-9: Upper Namoi Alluvium seasonal pumping drawdown in the deep aquifer system during the 2015/2016 water year (difference between pumping and non-pumping period groundwater levels in the same year) (DPI, 2017b)

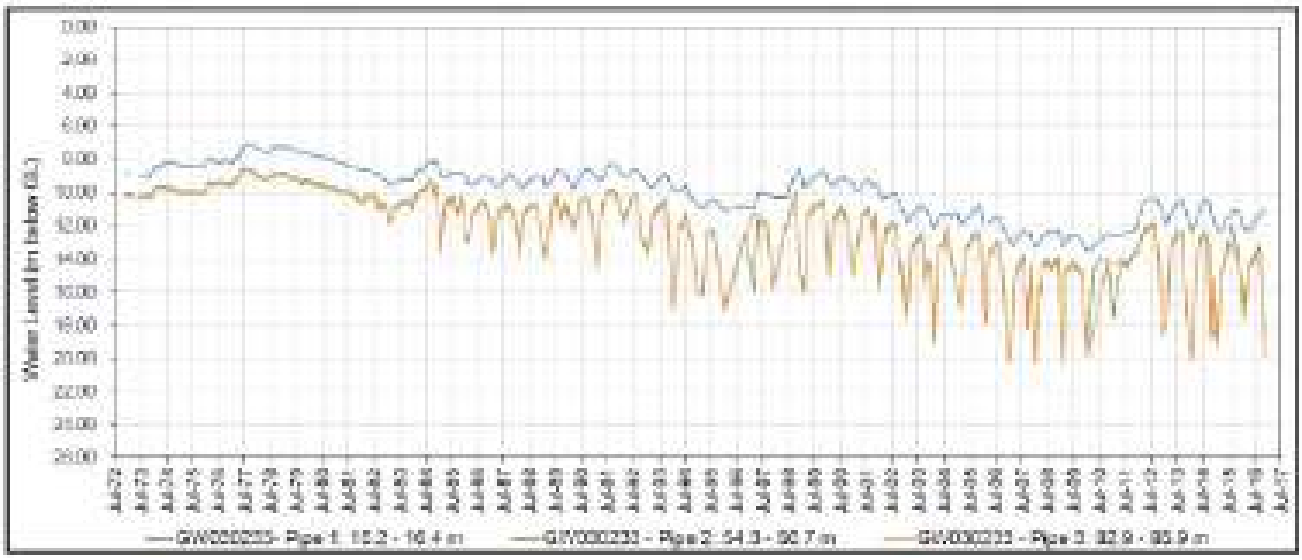


Figure 5-10: Upper Namoi Alluvium long term groundwater data monitored at three depth intervals at bore site GW030233 located south-east of Narrabri (DPI, 2017b)

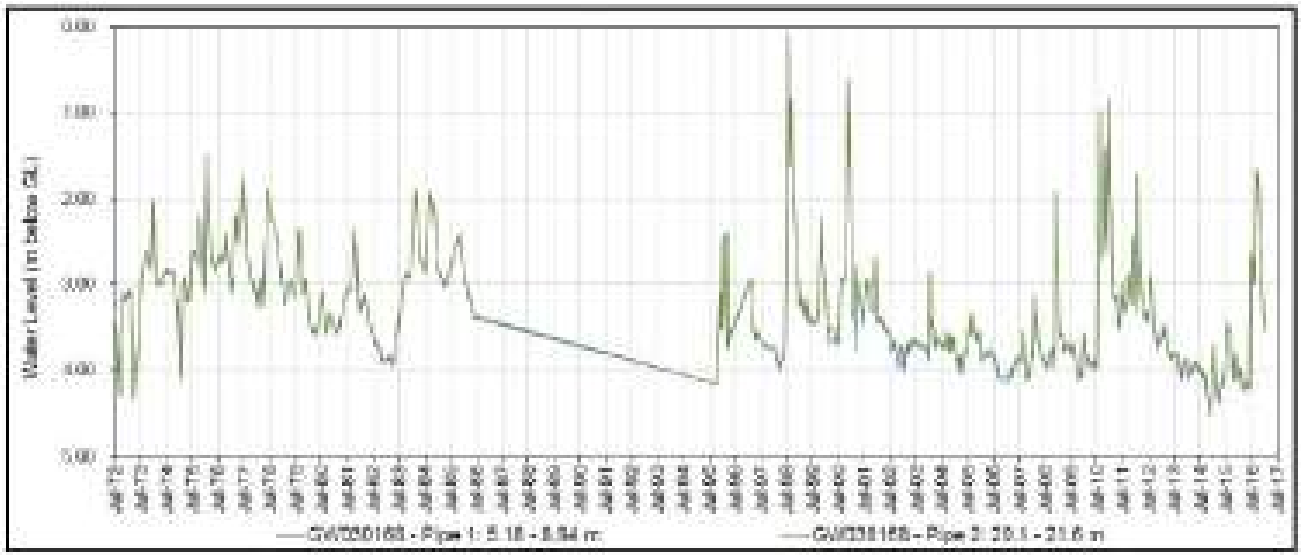


Figure 5-11: Peel Valley Alluvium long term groundwater data monitored at two depth intervals at bore site GW030168 located south-east of Tamworth (DPI, 2017b)

5.4.4 Murray-Darling Basin Fractured and Porous Rock Alluviums

The Murray-Darling Basin Fractured Rock Alluvium and Porous Rock Alluviums capture most of the groundwater sources not included within other water sharing plans within NSW.

Fractured Rock Alluvium

The Murray-Darling Basin Fractured Rock Alluvium is a disparate collection of ten groundwater sources across NSW, capturing all fractured rock groundwater sources that are not included in other water sharing/resource plans and miscellaneous, unmapped alluvial sediments that overlay outcropping fractured rock groundwater sources as well as porous rock sediments that occur within groundwater sources that are predominantly fractured rock. The Namoi JO area falls within the New England Fold Belt Murray Darling Basin Groundwater Source within the Alluvium. The New England Fold Belt covers some 2.8 million hectares. It includes Newcastle

along to the central Queensland coast and evolved during more than 200 million years ago from Silurian to Triassic times between approximately 430 Ma to 200 Ma.

Fractured rock aquifers are typically found within rock formations such as granite, basalt, meta-sediments and limestone, occurring mainly within the fractures and joints as well as in solution channels in limestone. The New England Fold Belt MDB consists of phyllite, chert, jasper, greywacke, mudstone, sandstone, limestone, conglomerate and tuff with interbedded rhyolite (DPI, 2017c). The volume of deposits and average yields are typically below those of deep aquifers and river-associated aquifers. Low yielding stock and domestic supplies of fresh to brackish salinity are typically obtained from these rocks.

Table 5-11 summarises the entitlements and known usage volumes associated with the New England Fold belt. The total usage is relatively low in comparison to the allowable sustainable diversion level, reflecting the variability, uncertainty and cost associated with accessing fractured rock sources.

Table 5-11: Average annual entitlement and use metrics for the New England Fold Belt (DPI, 2017c)

	New England Fold Belt
Local Water Utility Access Licence (ML)	667
Aquifer Access Entitlement (ML or Shares)	9,671
Basic Landholder Right (estimate) (ML/year)	14,520
Sustainable Diversion Level (ML/year)	55,100
Average Annual Usage (ML/year)	122

Porous Rock Alluvium

Groundwater in the porous rocks has both primary and secondary porosity: groundwater is contained both within, and moves through, the pore spaces between the sedimentary grains arranged at the original deposition of the material, as well as through fractures and joints which have occurred over geological time due to the forces and stresses of tectonic movements (DPI, 2017d). Within the Porous Rock Alluvium there are four major sources within NSW:

- Gunnedah-Oxley Basin (GS17)
- Oaklands Basin (GS38)
- Sydney Basin (GS41)
- Western Porous Rock (GS50).

Of these, the Gunnedah-Oxley Basin is the major source within the Namoi JO area, covering an outcrop area of 1,128,000 hectares and a subcrop (buried) area of 2,860,000 hectares. Within the Namoi JO, the Gunnedah Oxley Basin covers much of the land area not covered by either an Alluvial groundwater source or fractured rock. It includes the Permian and Triassic rocks associated with the Gunnedah Basin, and the overlying younger Jurassic and Cretaceous rocks associated with the Oxley Basin (DPI, 2017d). In contrast with fractured rock sources, porous rock sources are of sufficient magnitude to support irrigation and production wells beyond livestock and basic landowner rights.

Table 5-12 summarises the entitlements and known usage volumes associated with the Gunnedah Oxley Basin. However, it is noted that this data extends beyond the Namoi JO area, capturing groundwater use as far west as Dubbo. As with the fracture rock component, it can be seen that total usage is relatively low in comparison

to the allowable sustainable diversion level. However, both the SDL and total average usage are significantly greater in magnitude, reflecting the greater reliability associated with porous rock sources. It is a key groundwater source for irrigated crops within the Liverpool Plains and Gunnedah LGAs. The recharge process associated with porous rock sources is variable and depending on depth: sources close to groundwater (like many within the Liverpool Plains) recharge from rainfall through alluvium, while deeper sources may recharge through porous rock substrate (e.g. sandstone).

Table 5-12: Average annual entitlement and use metrics for the Gunnedah Oxley Basin (DPI, 2017d)

	New England Fold Belt
Local Water Utility Access Licence (ML)	480
Aquifer Access Entitlement (ML or Shares)	23,589
Sustainable Diversion Level (ML/year)	205,640
Average Annual Usage (ML/year)	6,100

5.4.5 Great Artesian Basin

The Great Artesian Basin (GAB) is Australia's major groundwater resource, comprised of three main geological basins: the Eromanga, Surat and Carpentaria basins. It has an estimated water storage capacity of some 67,900 million ML and is over 3,000m deep in some locations. The Surat Basin covers 300,000 km^2 in south-eastern Queensland and north-eastern New South Wales, crossing over into the northern portion of the Gwydir LGA, and extending south to just north of Bingara (Australian Government, 2018). The area of the GAB within the Gwydir LGA is primarily an aquifer recharge area, with rainfall and river water (predominantly from the Macintyre and Gwydir Rivers) percolating to the GAB. As such, groundwater levels are typically closely associated with rainfall. It is managed as the Eastern Recharge Groundwater Source within the Water Sharing Plan for the New South Wales Great Artesian Basin Groundwater Sources 2008. The NSW GAB water sources have been assessed as high risk particularly in relation to:

- The decline in artesian pressures due to over extraction and free-flowing discharge of the groundwater
- stress to groundwater dependent ecosystems due to high levels of extraction
- Threats to grazing industries in the catchment due to a reduction in access for both domestic and stock users and licensed users.

More than 80% of the NSW portion of the GAB has witnessed pressure losses (NSW DWE, 2009), as a result of free-flowing discharges and increased extraction. Falling groundwater pressure results in lower bore flow rates, which can cause the bore to cease to flow. **Table 5-13** summarises the entitlements and known usage volumes associated with the Eastern Recharge Groundwater Source, most of which is within the Namoi JO area.

Table 5-13: Average annual entitlement and use metrics for the Eastern Recharge Groundwater Source (DPI, 2014)

	New England Fold Belt
Aquifer Access Entitlement (ML or Shares)	35,006
Long-term annual average extraction limits (ML/year)	13,300
Average Annual Usage (ML/year)	12,750

While the Great Artesian Basin is a major groundwater resource within the Murray-Darling Basin, its management is not included in the Basin Plan, as the *Commonwealth Water Act 2007* excludes groundwater of the Great Artesian Basin from the definition of Basin water resources. However, Eastern Recharge Groundwater Source, is overlain by groundwater contained within the unconsolidated alluvial deposits (to a maximum depth of 60m). These are considered as the Great Artesian Basin Shallow groundwater resource, and represents a source captured within the Basin Plan and association Great Artesian Basin (Shallow) Water Resource Plan, extending from east of North Star to west of the Paroo River. The eastern portion of this corresponds to the Great Artesian Basin Surat Shallow portion.

These alluvial deposits are mainly floodplain and marshy environment deposits with occasional interlayers of fluvial deposits. Typically, the deposits contain brackish to saline groundwater and occasionally yield potable water from bores drilled near creeks or rivers (DPI, 2017e). The majority of the groundwater used from the NSW GAB Shallow is for stock and domestic purposes, with small volumes utilised to support irrigation activities. **Table 5-14** summarises the entitlement associated with the Great Artesian Basin Surat Shallow groundwater source.

Table 5-14: Average annual entitlement and use metrics for the Great Artesian Basin Surat Shallow (NSW Office of Water, 2011)

	Great Artesian Basin Surat Shallow
Aquifer Access Entitlement (ML or Shares)	5,068
Basic Landholder Rights (ML/year)	978
Local Water Utility Access Licence (ML/year)	0
Long-term annual average extraction limits (ML/year)	143,335

5.4.6 Groundwater Entitlement

Groundwater license data was provided for use in this study on 22 March 2019 by Water NSW in a spatial format, similar to the surface water licenses. A representation of this data is provided in **Figure 5-12**, which shows the total entitlement within a 2.5km radius of the points on the map.

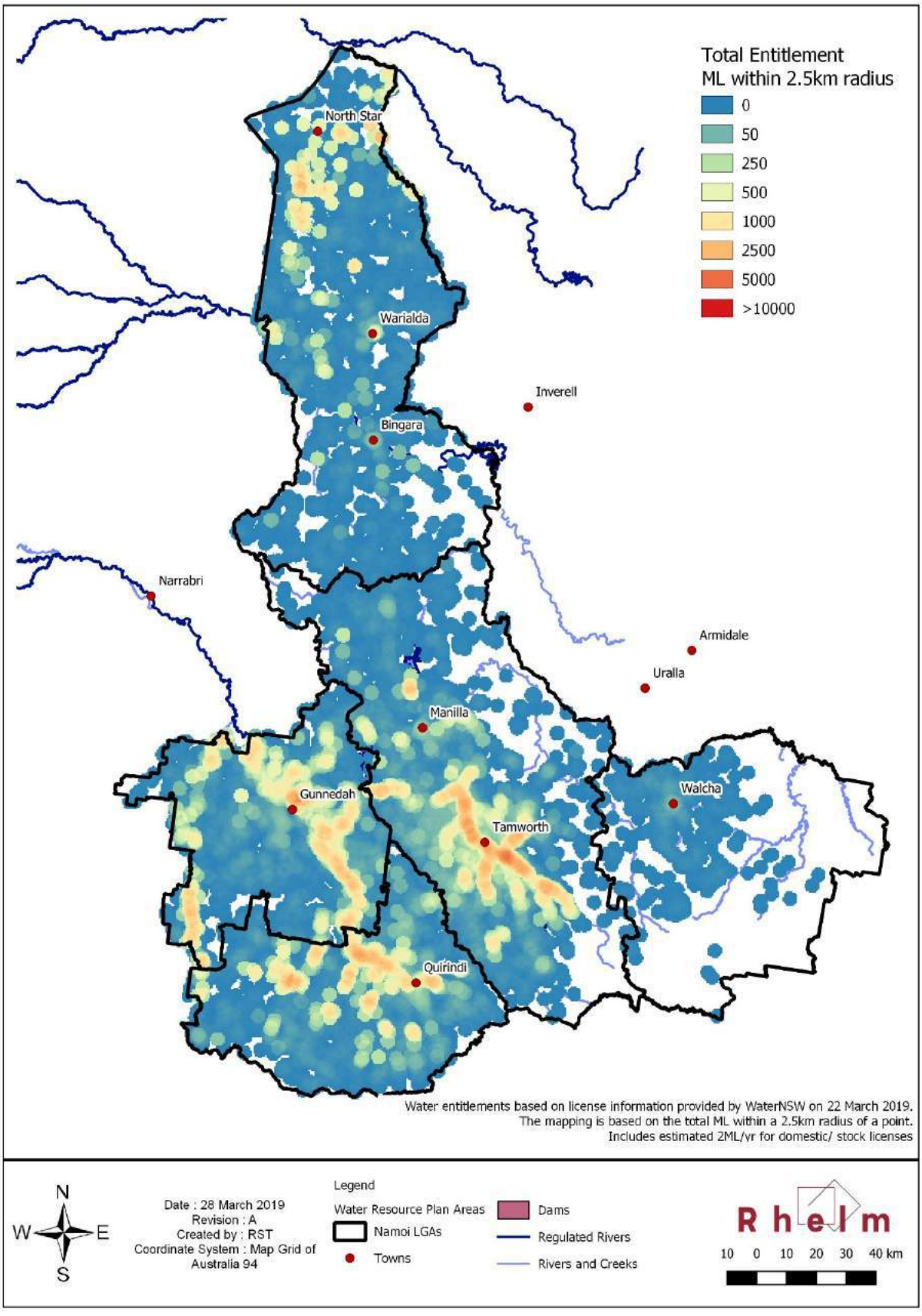


Figure 5-12. Groundwater Entitlement

5.5 Major Water Infrastructure

A number of significant pieces of water infrastructure to support both urban and rural water access have been developed, within or immediately adjacent to the Namoi JO (**Figure 5-1**).

In addition to major water infrastructure, there are numerous minor water storage and processing infrastructure works present within the Namoi JO (e.g. Walcha Council maintains two 100 ML off-river (Macdonald River) storages which it utilises for town supply).

5.5.1 Copeton Dam

Copeton Dam is located upstream of Bingara along the Gwydir River. It is one of the largest inland dams within NSW, capable of holding 1,364,000 ML. The rock wall is 1,484m long and 113m high. It is controlled by nine radial gates and a concrete chute, with a fuse plug spillway to ensure it remains safe in an extreme flood event.

A dam on the Gwydir River was originally proposed in the 1930s to improve both town water supplies and boost agricultural production in the Gwydir Valley (no cotton was grown within the region at the time). However, World War II and subsequent shortage of funds halted further investigations. Construction began at the current site in 1968 with a particular view to support the cotton industry as well as lucerne, cereals, oilseed, pecans, wheat and vegetables. The dam provides water for Inverell and other town supplies, industry and domestic requirements, flood mitigation and recreation. A 21 megawatt hydroelectric power station draws upon discharges for summer irrigation, environmental flows and flood mitigation[27].

5.5.2 Keepit Dam

Keepit Dam is located on the Namoi River upstream of Gunnedah. It is a medium size dam (about one third the size of Copeton Dam) with a storage capacity of 425,000 ML. The rock wall is 553m long and 55m high. It is controlled by six radial gates, two spillways and three saddle dams. Works are currently underway to strengthen the main wall.

A dam on the Namoi River was originally proposed in the 1800s to improve agricultural production within the Namoi Valley. Prior to the dam, the unregulated river was utilised in conjunction with groundwater sources to provide irrigation water. Continued drawdown of groundwater sources and variability in surface water flows led to a push for a dam to be built to improve irrigation and crop reliability. Construction began at the current site in 1939 with a particular view to support the livestock industry, lucerne, cereals, oilseed, wheat and other vegetables grown in the valley. The need for dam, was largely driven out of concern of dwindling groundwater reserves. It opened in 1960. The subsequent growth of the agricultural production (in particular, cotton) was a key driver of downstream towns: Gunnedah, Narrabri, Wee Waa and Walgett, some of which now rely upon the river for water supply[28].

5.5.3 Split Rock Dam

Split Rock Dam is located on the Manilla River upstream of Manilla and its junction within the Namoi River. It is a medium size dam (of similar size to Keepit Dam) with a storage capacity of 397,300 ML. The rock wall is 456m long and 68m high.

Following the construction of Keepit Dam in 1960 a substantial shift in agricultural production from cattle and sheep towards cotton occurred, increasing the demand of additional water supplies and regulation to support irrigation industries. A dam on the Manilla River was identified as a way to supplement supplies from Keepit

[27] https://www.waternsw.com.au/supply/visit/copeton-dam
[28] https://www.waternsw.com.au/supply/visit/keepit-dam

Dam. The dam commenced construction in 1984 and opened in 1987. In addition to supporting the irrigation needs of both Manilla and Namoi Valley farmers, the towns of Walgett and Barraba utilise it as a source of town water supply[29].

5.5.4 Dungowan Dam

Dungowan Dam is located on Dungowan Creek the Peel River upstream of Tamworth and its junction within the Namoi River. It is a small dam with a storage capacity of 6,300ML.

The dam was constructed to supply town water to the growing city of Tamworth in 1958; up until this point Tamworth had been predominantly reliant on groundwater drift wells adjacent to the peel river. The dam is owned and operated by Tamworth Regional Council.

5.5.5 Chaffey Dam

Chaffey Dam is located on the Peel River upstream of Tamworth and its junction within the Namoi River. It is a relatively small dam (approximately one quarter the size of Keepit Dam) with a storage capacity of 100,500 ML. The rock wall is 443m long and 62m high.

The potential to dam the Peel River at the Chaffey Dam location was first identified in 1914. However, construction was not commenced until 1976 and completed in 1979. The driver for the dam was the continued growth of Tamworth (Dungowan Dam's supplies were considered insecure) and to support irrigation and stock watering purposes along the Peel River. It is now Tamworth's major town water source, with town water accounting for approximately one third of extractive use from the dam discharges. The dam wall was upgraded in 2016 to increase its storage capacity from 62,000 ML to its current 100,500 ML.

5.5.6 Quipolly Dam

Quipolly Dam is located on Quipolly Creek, an upper reach tributary to the Mooki River, approximately 15km north of Quirindi. It is a small dam, with a capacity of 8,000 ML (upgraded from 5,200 ML in 2016).

The dam was originally constructed in 1955 by Liverpool Plains Shire Council (then Peel Shire Council) to supply town drinking water to Werris Creek. Upgrades to the dam in 2016 were intended to provide sufficient capacity to allow drinking water supply from the dam to be extended to Quirindi and Willow Tree.

5.5.7 Dam Storage

Across this large dam infrastructure, Keepit Dam, Split Rock Dam and Copeton Dam are less than 50% full in any one year. **Figure 5-13** shows the percentage of level exceedance (over a 30 year period) relative to the percentage capacity of the different dams in the region, based on available data from WaterNSW[30]. For example, Split Rock Dam is seen to be at approximately 30% capacity or less for 60% of the time.

[29] https://www.waternsw.com.au/supply/visit/split-rock-dam
[30] Does not include Dungowan, which is not a WaterNSW dam.

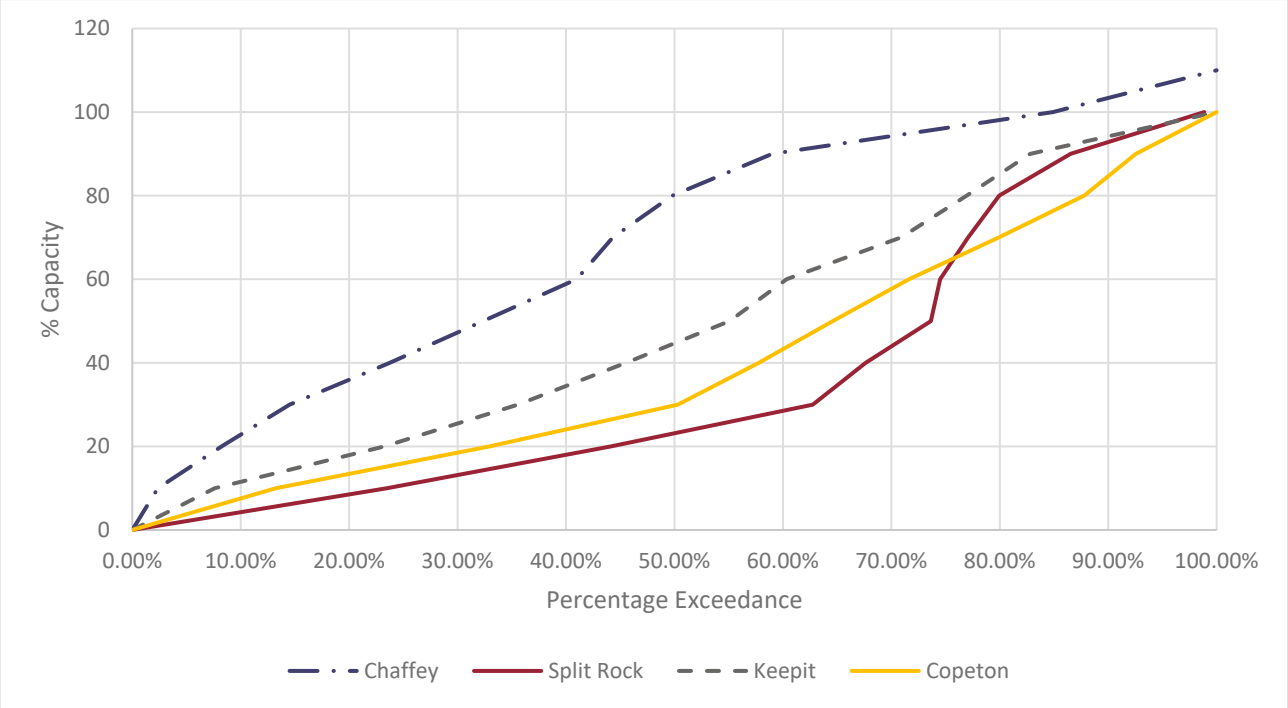


Figure 5-13. Probability of Exceedance for Dam Infrastructure with the Namoi JO[31]

5.5.8 Recycling and Re-use

A number of councils provide small scale secondary re-use and recycling of water extracted from surface water or groundwater, supporting irrigation and watering of public areas (e.g. gardens) and, in some cases, irrigation of private farmlands and water supply for agribusinesses. No major recycling facilities or reticulation are present across the Namoi JO.

5.6 Water Availability

The culmination of groundwater, surface water and rainwater volumes and entitlement lead to an overall picture of water availability throughout the Namoi JO. Based on the licence data and rainfall data, three separate indices were created:

- Groundwater Index – a value of 0 to 1, based on the total entitlement within a 2.5km radius. A value of 1 represents an entitlement of 1200ML or more.
- Surface Water Index – a value of 0 to 1, based on the total entitlement within a 2.5km radius. As with the groundwater index, a value of 1 represents a total entitlement of 1200ML or more.
- Rainfall Index – this has a value of 0 to 1, representing a range of 600mm to 900mm of annual rainfall.

A summary of these index values is provided in **Figure 5-14**. Using these three indices, a composite "Water Availability" index was established, as also shown in **Figure 5-14**.

[31] Based on data acquired from Water NSW (https://realtimedata.waternsw.com.au/water.stm). Recorded periods were Keepit (Feb 1976 – Jan 2019), Split Rock (Jan 1990 – Jan 2019), Chaffey (Aug 1979 – Jan 2019), Copeton (Jun 1976 – Jan 2019). Periods of no record were removed from the data set in undertaking this analysis. Note that the upgrade of Chaffey Dam, which occurred during the period of analysis (in 2016), would alter the outcomes of this assessment. This assessment would be more representative of Chaffey Dam prior to the upgrade.

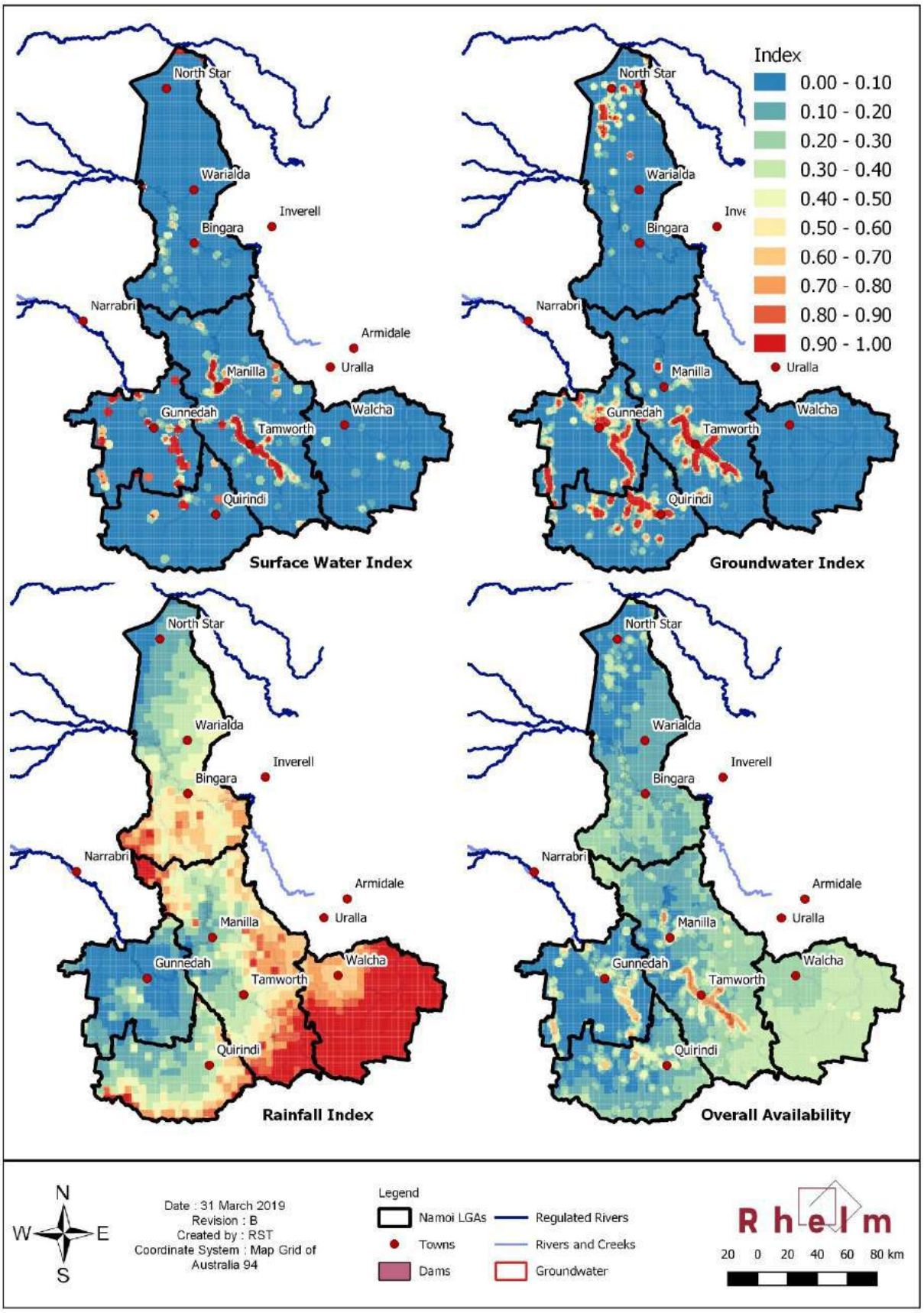


Figure 5-14. Water Availability Index

6 Current Land-Use and Water-Use

Land-use and water-use are inter-related issues with both aspects informing the usage choices and requirements of the other. The range of land-uses adopted within the Namoi JO typically require application/use of water (either for production or consumption) as part of operations, and the availability of water has shaped the adopted land-use across the region.

This chapter provides an overview of the varying land-use practices currently employed across the region and summarises the associated water utilisation and water sources used in facilitating these land-uses. Due to both the nature of land-use and activities undertaken, and the typical water access and governance arrangements, for the purpose of this report, the land and water use within the region has been divided into Urban Areas and Rural Areas. This allows comparison of how the different parts of the economy demand and utilise water and demonstrates the distribution of water resources across the region.

6.1 Regional Development History

The Namoi JO area was first inhabited by people of the Kamilaroi nation, extending from the upper Hunter Valley to South West Queensland. Aboriginal land-use, predominantly hunter/gatherer activities, required minimal disturbance to extant native vegetation and ecosystems, with water-use typically limited to individual consumptions requirements (drinking, washing, cleaning). These practices were maintained over thousands of years and continue today.

European colonisation occurred in the early 1800s, with John Oxley's expedition in 1818 passing through much of the Namoi JO region. Through the Australian Agricultural Company (AAC) early phase rural development of the region was advanced, with numerous settlements and farmsteads springing up across the region. The AAC focussed on facilitating land development for sheep farming (in particular, improving flocks of merino sheep for fine wool production) along with tobacco, flax and other crops for export. As the value of land within the Namoi Region became better understood, the focus shifted more towards cattle farming. 1833 the AAC was granted land parcels in two new areas on the Liverpool Plains: the Warrah Estate of 249,600 acres (1,010 km2), west of Murrurundi, NSW, and the Goonoo Goonoo Estate of 313,298 acres (1,268 km2) along the left bank of the Peel River, to the south of present-day Tamworth. As agricultural activities increased, larger settlements formed and became recognised over time:

- Tamworth –1830s
- Bingara – 1840s
- Warialda – 1840s
- Quirindi – 1850's
- Gunnedah – 1860s
- Walcha – 1870s.

Water use intensity associated with these activities and settlements was typically low, limited mostly to stock watering and limited crop irrigation.

From the 1850's the potential Mining (gold and diamond) and exploration fostered growth in the northern parts of the region and to the south of Tamworth, while livestock and some cropping dominated industries to the south and west. The growth of coal mining and cereal cropping led to the establishment of strong downstream industries within the major urban areas by the turn of the century (e.g. milling and brewing within Tamworth, colliery within Gunnedah). The increased industrial and agricultural activity increased the

associated water demand, with the majority met through use of groundwater bores and unregulated river extraction.

The industrialisation and fertilisation expansion of the early 20th century led to a significant intensification in agricultural practices and increased demand for water and security of water supply and the associated expansion of irrigation within the flatter portions of the Namoi, Gwydir and Macintyre River catchments. The steeper areas to the east remained dominated by sheep and cattle production. The planning and construction of major dams (e.g. Keepit Dam and Copeton Dam) from the 1930s – 1960's also coincided with the introduction of new agricultural technologies, particularly around cotton faming (largely imported from California, United States of America). Cotton production in the 1950's within Australia was minimal and limited predominantly to Queensland. However, this grew rapidly in the 1960's through adoption of a federal subsidy ("Cotton Bounty") and the creation of state-sponsored irrigation schemes. Cotton growing within the Namoi Region accelerated during the 1960's, taking advantage of the abundant water availability provided by Keepit Dam and establishment of irrigation networks (mostly developed privately rather than by the State). Keepit Dam's purpose became associated at this point with the regulation of flow for the Namoi River for private diversion irrigation downstream (Keys, 2002). The success of cotton growth with the Namoi Valley, and through associated NSW Government research projects, led to significant government support for the industry and rapid growth. The cotton industry became the largest user of water resources within the Namoi JO area.

The strong growth of the cotton industry also supported the continued growth of the urban centres, associated industries and general regional agricultural production. Due to the reliance of cotton production upon water, only a relatively small portion of the total Namoi JO area was able to switch to cotton production. Livestock (particularly around Walcha, Tamworth and southern Gwydir) continued to be the dominant land use, with extensive grain and cereal cropping adopted in the northern Gwydir region and high-value sorghum cropping developing within the Liverpool Plains.

6.2 Urban Areas

6.2.1 Population and Industry

Table 6-1 summarises the major urban centres within the Namoi JO area, their current population and major commercial industries and social services and contribution to the regional economy. This is contrasted against the non-urban / agricultural production and population levels. **Figure 6-1** provides a breakdown of employment via industry. Unsurprisingly, the proportion of employment and associated valued added from urban centres generally increases with population size, although due to the availability of data for smaller regional urban centres it is not possible to ascribe too much weight to individual statistics (i.e. not all urban centres are captured and some urban centres include elements of agricultural production). However, some key general trends are observable:

- Tamworth is the largest economy in the Namoi JO. Tamworth LGA has approximately five times the population of the next largest LGA (Gunnedah) and provides five times as many jobs, with value added and total output scaling in similar proportions.
- Health Care & Assistance services are prevalent throughout the urban centres of the region. The Health Care industry and associated services represents a key employer and economic player within all LGAs.
- Retail and trade industries are larger in urban areas of high population and employment.
- Agriculture and Forestry is the dominant industry across the Namoi JO, although not within the top three within Tamworth. However, although proportionately not the major industry within

Tamworth, due to the size of Tamworth's economy, employment associated with Agriculture exceeds employment levels observed within the other LGAs, highlighting its importance across the region (**Figure 6-1**).

- Gwydir and Walcha have relatively higher economic dependencies upon agriculture with limited urban development (**Figure 6-2**).
- Even through Agriculture and Forestry is the major economic driver within the Namoi JO, in none of the LGAs was it seen to represent more than either 50% of employment, value added or output. Even within the rural dominated LGAs of Walcha and Gwydir there are a range of urban industries and services that play a significant role in the local and regional economy.

Table 6-1: Urban centre population, employment and economic indicators[32]

Town	Population*	Major Industry Employers	Estimated No. of Jobs	Value Added ($M)^	Output ($M)#
Tamworth Local Government Area					
Tamworth	33,885	Health Care & Assistance (17%) Retail Trade (12%) Education and Training (9%)	21,050	2,009.4	
Manilla	2,106	Health Care & Assistance (16%) Agriculture, Forestry and Fishing (16%) Education and Training (14%)	665	62.08	
Barraba	1,126	Health Care & Assistance (23%) Education and Training (17%) Retail Trade (12%)	332	28.45	
LGA Total	**59,663**	**Health Care & Assistance (17%)** **Retail Trade (12%)** **Education and Training (9%)**	**25,955**	**3,664**	**7,922**
Estimated Urban Proportion**	62%		85%	93%	93%
Liverpool Plains Local Government Area					
Quirindi	2,680	Health Care & Assistance (15%) Education and Training (11%) Transport, Postal and Warehouse (11%)	1141	157.04	
Werris Creek	1,572		750	216.67	
Willow Tree	308				
Premer	85				
Caroona	202				
LGA Total (incl. Agriculture)	**7,687**	**Agriculture, Forestry and Fishing (29%)**	**2,678**	**405.03**	**865**

[32] Source data: Regional Development Australia: Northern Inland NSW – REMPLAN (https://www.communityprofile.com.au/northerninland

Town	Population*	Major Industry Employers	Estimated No. of Jobs	Value Added ($M)^	Output ($M)#
		Health Care & Assistance (10%) **Education and Training (8%)**			
Estimated Urban Proportion	63%		70%	92%	73%
Gunnedah Local Government Area					
Gunnedah	7,984	Health Care & Assistance (17%) Retail Trade (12%) Education and Training (9%)	4,096	637.14	
Curlewis	597		170	36.52	
Mullaley	154				
Tambar Springs	187				
LGA Total (incl. Agriculture)	**12,215**	**Agriculture, Forestry and Fishing (16%)** **Health Care & Assistance (10%)** **Education and Training (9%)**	**5,077**	**771.77**	**1,704**
Estimated Urban Proportion	73%		85%	87%	85%
Gwydir Local Government Area					
Warialda	1,186	Health Care & Assistance (19%) Public Administration & Safety (16%) Education and Training (14%)	385	53.77	
Bingara	1,074		625	97.36	
Gravesend	321				
North Star	230				
LGA Total (incl. Agriculture)	**5,258**	**Agriculture, Forestry and Fishing (46%)** **Health Care & Assistance (10%)** **Public Administration & Safety (9%)**	**1,881**	**245.22**	**519**
Estimated Urban Proportion	53%		54%	61%	52%
Walcha Local Government Area					
Walcha	1451	Health Care & Assistance (14%) Education and Training (12%) Transport, Postal and Warehouse (11%)	702	106.3	
LGA Total (incl. Agriculture)	**3,092**	**Agriculture, Forestry and Fishing (44%)** **Health Care & Assistance (8%)** **Education and Training (7%)**	**1,418**	**192.65**	**419**
Estimated Urban Proportion	46%		50%	55%	55%

* ABS 2016 Census data - http://quickstats.censusdata.abs.gov.au/

^ Value Added represents the marginal economic value that is added by each industry sector in a defined region. Value-Added can be calculated by subtracting local expenditure and expenditure on regional imports from the output generated by an industry sector. It is measure that captures an estimate of efficiency of production

Output data represents the gross revenue generated by businesses/organisations in each of the industry sectors in a defined region. Gross revenue is also referred to as total sales or total income. It does not take into account the cost of production

** It was assumed that any population/employment/production outside of the quantified town centres would be considered to be "agricultural"

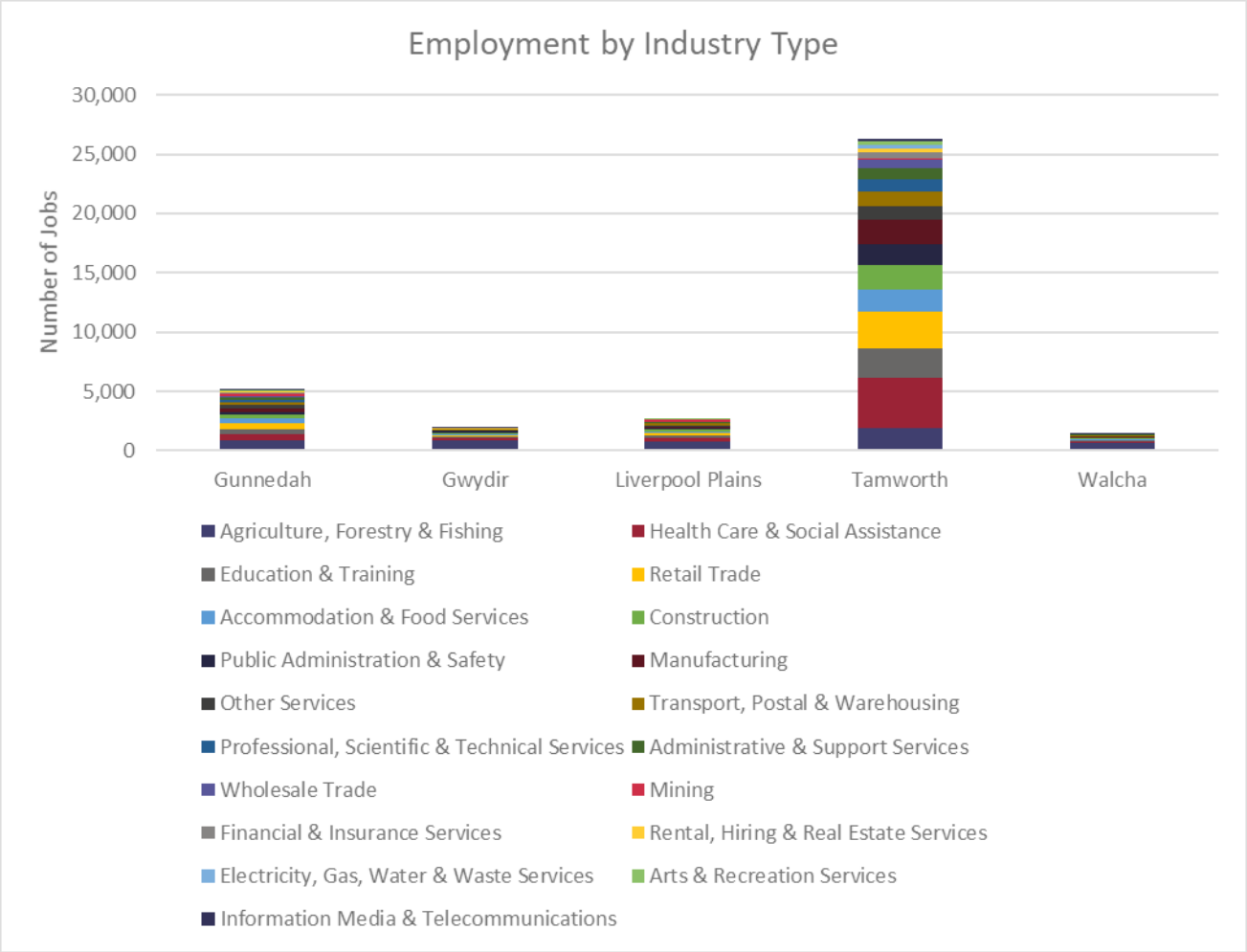


Figure 6-1: Employment by industry (2016-17)[33]

[33] Source data: Regional Development Australia: Northern Inland NSW – REMPLAN (https://www.communityprofile.com.au/northerninland

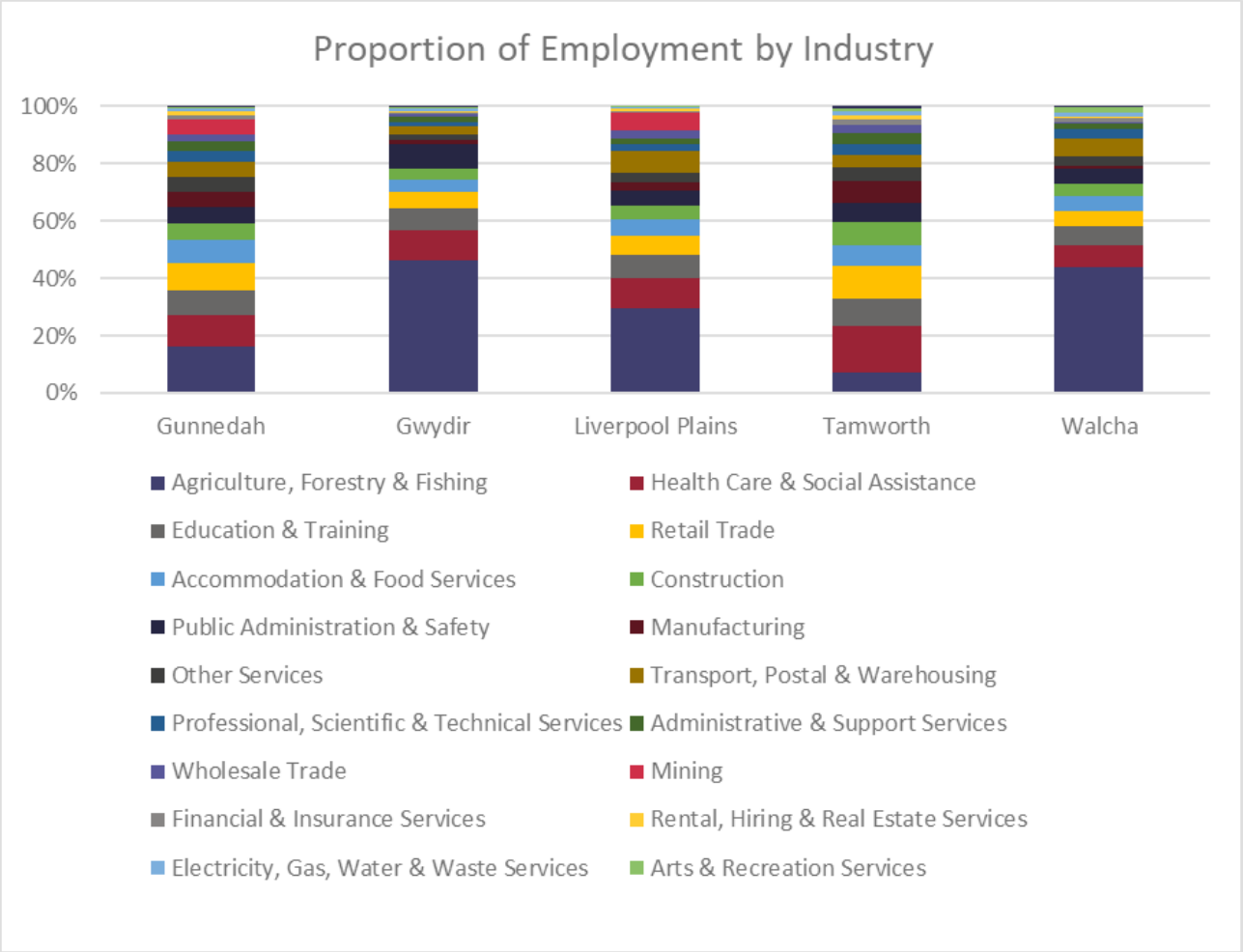


Figure 6-2: Proportion of Employment by industry (2016-17)[34]

The significant contribution of non-agricultural industries to regional economic activity is important when consideration water use and allocation. There is significant variation in the water usage intensity of many non-agricultural industries. However, the majority of industries have a lower average daily water demand than in comparison to agricultural production. **Figure 6-3** shows the 2015-16 physical water use by type across NSW (including Sydney and other major urban centres, excluding environmental flows), highlighting the relatively low usage of water within non-agricultural activities.

[34] Source data: Regional Development Australia: Northern Inland NSW – REMPLAN (https://www.communityprofile.com.au/northerninland

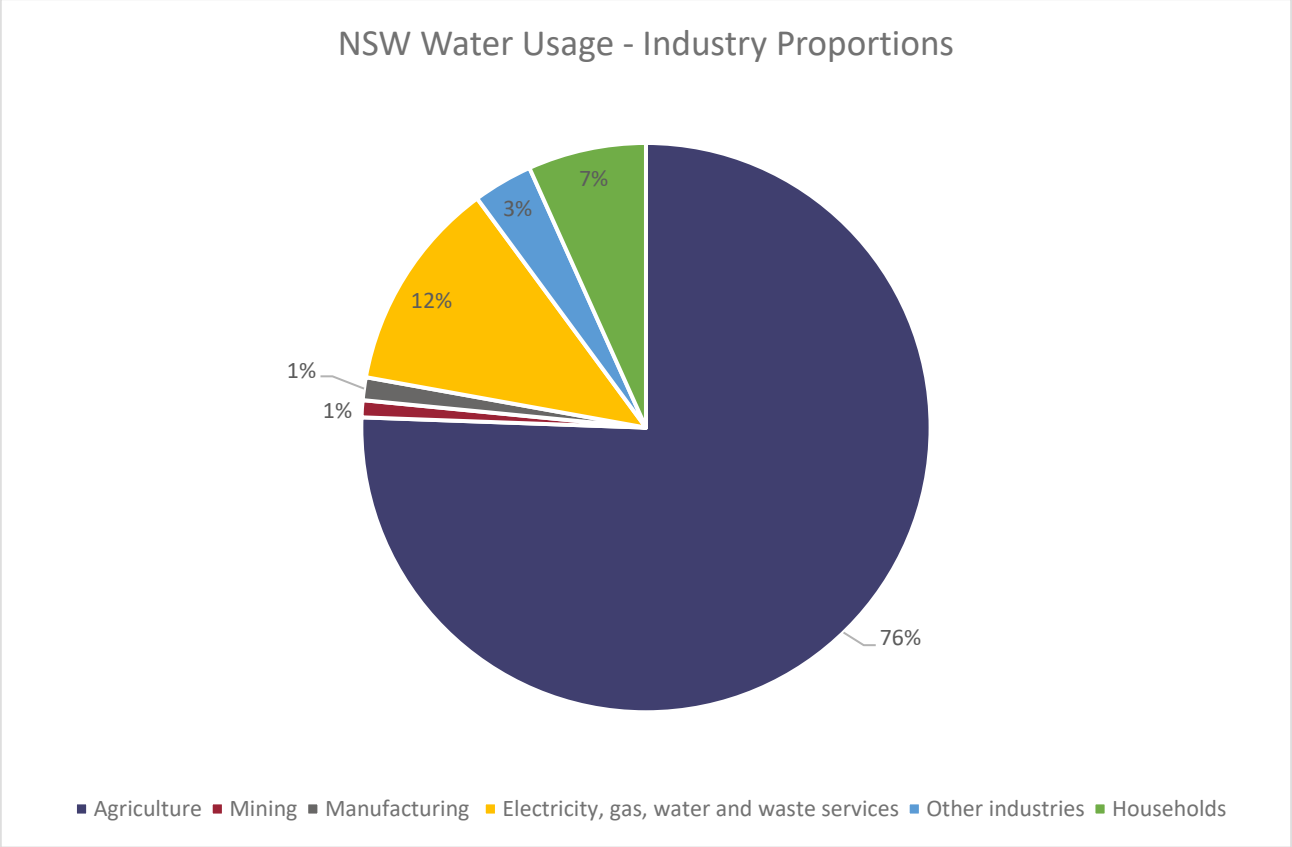


Figure 6-3: NSW Water usage by industry (2015-16)[35]

6.2.2 Water Supply and Entitlement

Water supply within urban areas of the Namoi JO is primarily managed through each of the respective councils. Each council maintains a water services arm which acts as a local water utility and provides water to local residential, commercial, industrial and other businesses and organisations. To provide the service Council maintains reticulated distribution and treatment systems, ensuring quality and quantity of supply. In order to sustainably operate and maintain these services, Council's apply a usage and fee structures.

The councils have WAL entitlements for various water sources to supply water for town water use, typically these entitlements scale with population growth under the current water sharing plans of relevance to each LGA (**Figure 6-4**). Individual businesses and residences may maintain their own WALs from regulated or unregulated sources (providing they have access to a share entitlement or are able to trade), while a large number of properties can also utilise water tanks to supplement council reticulation supply (e.g. Gwydir is estimated to have 1,500 residential rainwater tanks). The water supply arms within each council also work collaboratively within the Namoi JO as the Namoi Water Alliance, for the purpose of sharing efficiencies and knowledge in water management across the region.

[35] Data source: ABS 4610.0 – Water Account

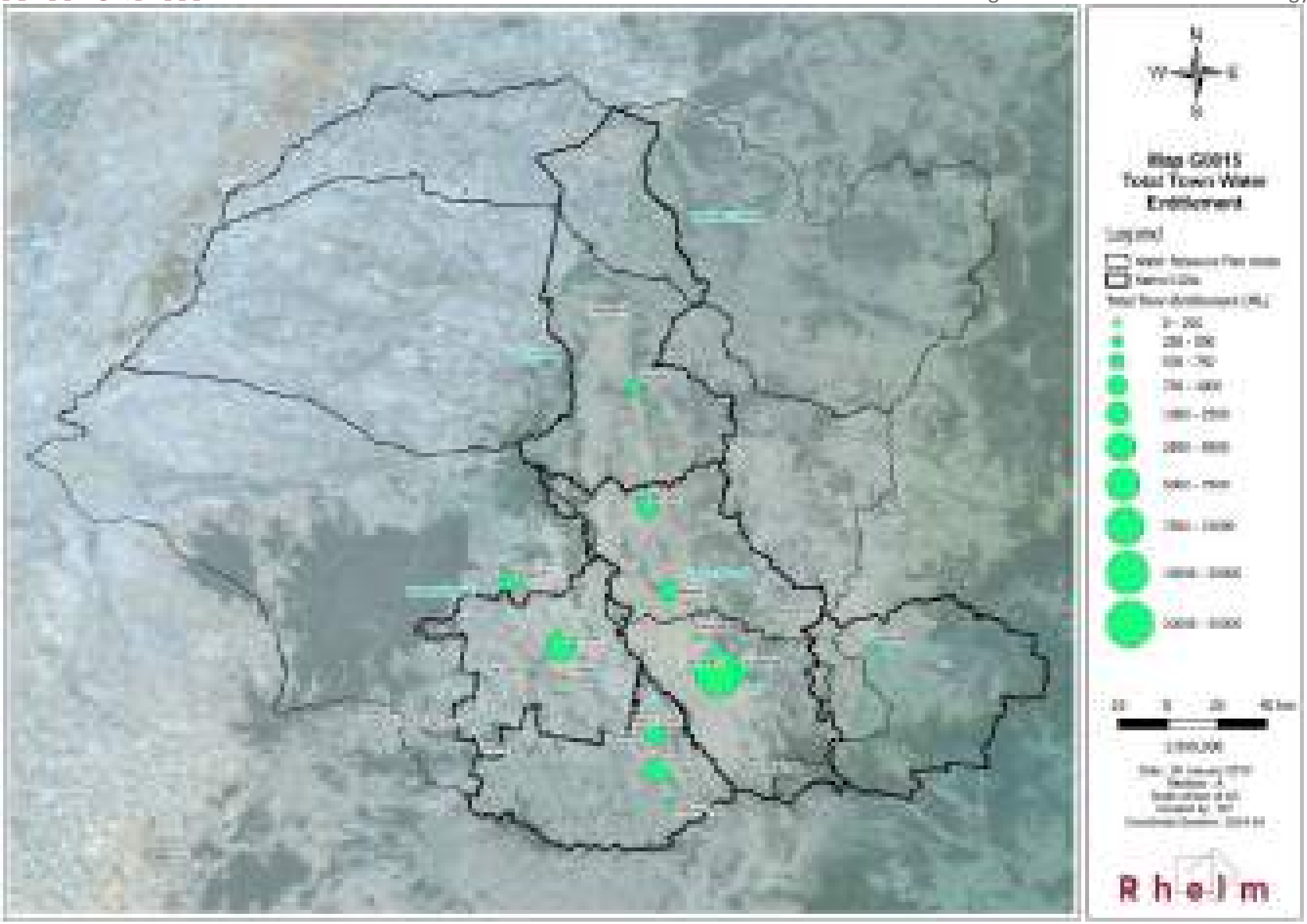


Figure 6-4: Water Entitlement by Town

Table 6-2 summarises the various town water supplies managed by each of the respective councils as a local water utility and their associated water sources, and entitlements. It is also noted that there are a number of urban communities in which no water supply is provided by a council (e.g. Breeza, Gunnedah Shire). Such communities depend upon private WAL and basic landowner rights to water. It is also noted that many of the councils also maintain additional water entitlements not in their role as a water utility but separately as a landowner. Water entitlements that are accessed by Council but not as local water utility is not considered Town Supply and does not receive priority over other WAL types. Some of the groundwater licences are available for use as emergency sources of water only.

Table 6-2: Town Water Sources and Entitlement

Town	Water Source		Entitlement (ML/yr)
	Type	Source	
Tamworth			
Tamworth	Regulated	Peel Regulated River – Chaffey Dam	16,400
	Unregulated	Dungowan Creek Management Zone - Dungowan Dam	5,600
	Groundwater	Peel Regulated River Alluvium Management Zone - Drift Wells	10
Manilla	Regulated	Upper Namoi Regulated River - Manilla River	150
	Unregulated	Namoi Unregulated and Alluvial	540
	Groundwater	Namoi Unregulated and Alluvial – Manilla Alluvial Groundwater Source	60
Barraba	Regulated	Upper Namoi Regulated River - Split Rock Dam	365
	Unregulated	Namoi Unregulated and Alluvial – Upper Manilla	421
	Groundwater	NSW Murray Darling Basin Fractured Rock Groundwater sources	180
Moobi/Kootingal	Groundwater	Peel Valley Alluvium – Cockburn River Alluvium	530
Attunga	Groundwater	Peel Regulated River Alluvium Management Zone	120
Bendemeer	Unregulated	Namoi Unregulated and Alluvial – Mid Macdonald River	10
	Groundwater	NSW Murray Darling Basin Fractured Rock Groundwater sources – New England Fold Belt	84
Nundle	Groundwater	Peel Valley Alluvium – Peel Fractured Rock Source	100
Gunnedah			
Gunnedah	Groundwater	Upper Namoi Zone 4 Namoi Valley (Keepit Dam To Gin'S Leap) Groundwater Source	3,900
Mullaley	Groundwater	Upper Namoi Zone 2 Cox'S Creek (Mullaley To Boggabri) Groundwater Source	59

Town	Water Source		Entitlement (ML/yr)
	Type	**Source**	
Tambar Springs	Groundwater	Upper Namoi Zone 9 Cox'S Creek (Up-Stream Mullaley) Groundwater Source	42
Curlewis	Groundwater	Upper Namoi Zone 3 Mooki Valley (Breeza To Gunnedah) Groundwater Source	198
Liverpool Plains			
Quirindi	Groundwater	Upper Namoi Zone 1 Borambil Creek Groundwater Source	1,150
	Unregulated	Water supply upgrades are currently in development to link Quirindi to the Quipolly Dam water supply	
Werris Creek	Unregulated	Werris Creek – Quipolly Dam	1,000
Caroona	Groundwater	Upper Namoi Zone 8 Mooki Valley (Quirindi - Pine Ridge Road To Breeza) Groundwater Source	50
Willow Tree	Groundwater	Upper Namoi Zone 1 Borambil Creek Groundwater Source	66
	Unregulated	Willow Tree shares the Werris Creek unregulated supply	
Premer	Groundwater	Upper Namoi Zone 9 Coxs Creek (Up-Stream Mullaley) Groundwater Source	55
Blackville	Groundwater	Gunnedah - Oxley Basin Mdb (Other)	25
Wallabaddah	Groundwater	NSW Murray Darling Basin Fractured Rock Groundwater sources - New England Fold Belt	60
Spring Ridge	Groundwater	Gunnedah - Oxley Basin Mdb (Spring Ridge) Management Zone	60
Gwydir			
Warialda	Groundwater	Great Artesian Basin - Eastern Recharge Groundwater Source	400
Bingara	Regulated	Gwydir Regulated River Water Source	660
North Star	Groundwater	Great Artesian Basin - Eastern Recharge Groundwater Source	23
Gravesend	Regulated	Gwydir Regulated River Water Source	85
	Groundwater	Upper Gwydir Alluvial Groundwater Source	60
Walcha			
Walcha	Unregulated	Namoi Unregulated and Alluvial Water Sources – Macdonald River	379
	Unregulated	Apsley River Water Source	10
	Groundwater	New England Fold Belt Coast Groundwater Source	10
TOTALS	**Regulated**		**17,660**
	Unregulated		**8,034**

Town	Water Source		Entitlement (ML/yr)
	Type	Source	
	Groundwater		**7,168**
	TOTAL		**32,862**

With the exception of Tamworth, Bingara and Barraba, the majority of towns within the Namoi JO area do not depend on regulated river water sources. Two-thirds of the towns supplied by local water utilities draw upon groundwater as their primary water source, spread across a range of groundwater sources including:

- Great Artesian Basin
- NSW Murray Darling Basin Fractured Rock - New England Fold Belt
- Upper Namoi Alluvium
- Peel Valley Alluvium.

Gunnedah is the only LGA which does not have access to entitlement from more than one water source type (**Figure 6-5**), drawing exclusively from zones within the Upper Namoi Alluvium. Walcha is seen to be unique in its dependency upon an unregulated water source (the Macdonald River). Water security issues associated with dependency of a town or LGA upon single or multiple water sources are discussed further in **Section 8**. The city of Tamworth represents the urban centre with greatest entitlement, with both its regulated and unregulated surface water components exceeding the total LGA requirements for each of the other member LGAs.

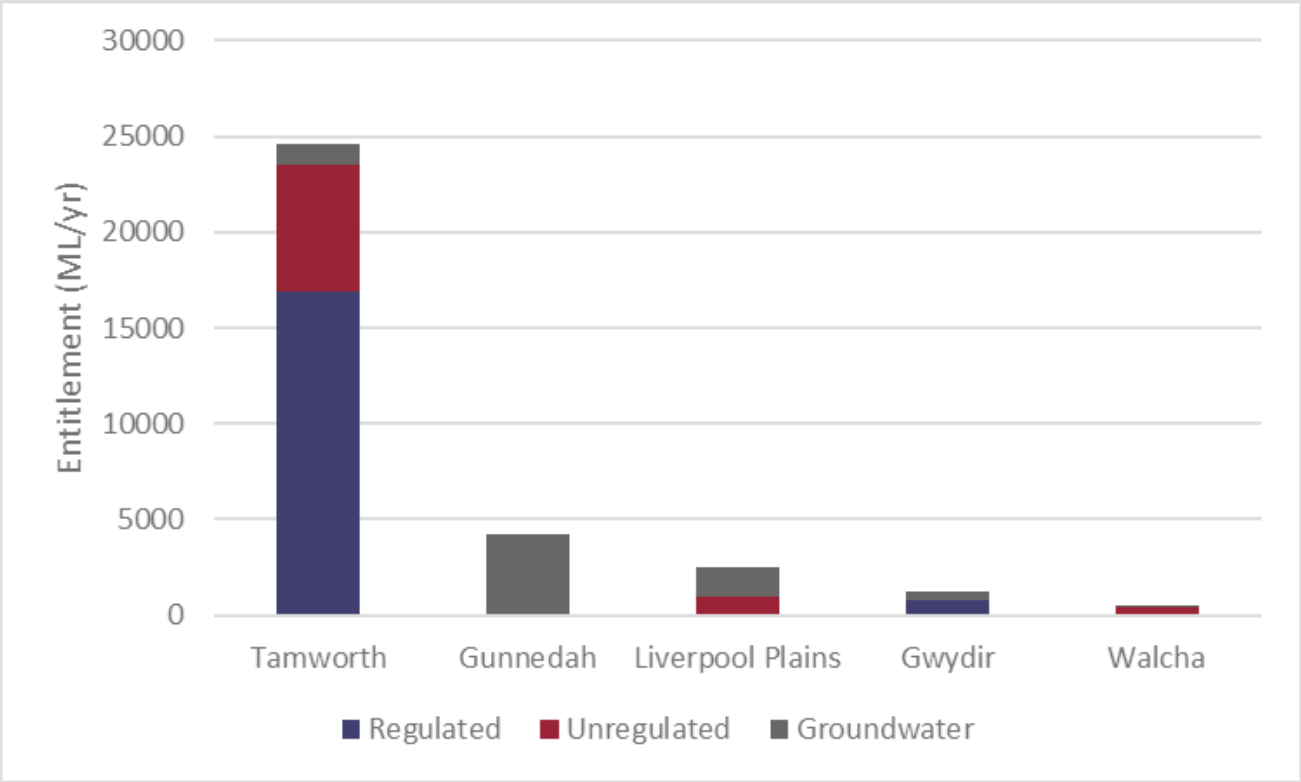


Figure 6-5: Water Entitlement by LGA

Water entitlement figures do not capture any stormwater capture, water re-use and recycling undertaken by Councils within their urban areas. The extent of stormwater harvesting across the Namoi JO is minimal. Both

Tamworth, Gunnedah and Gwydir operate effluent re-use schemes, providing an alternate water source for irrigation to a limited number of land-owners.

6.2.3 Water Use

Water usage is typically lower than the entitlement values within each of the town as the agreed entitlement values were originally set to facilitate growth and ensure security of supply under their relevant water sharing plans. Estimated water use volumes within each LGA are shown in **Table 6-3**. It can be seen that total entitlement significantly exceeds local utilisation. The proportion of use to entitlement remains relatively constant between the LGAs, between 50% and 60% for most LGAs, and less than 40% for Tamworth Regional Council.

Table 6-3: Local water utility supply volumes (2018)

	Total Water Usage (ML)					
Local Government Area	**2017/18**	**2016/17**	**2015/16**	**2014/15**	**Average**	**Entitlement (ML/year)**
Gunnedah	2,412	2,547	2,419	2,645	2,506	4,199
Gwydir	781	646	581	646	666	1,228
Liverpool Plains	1,168	1,031	1,062	982	982	2,466
Tamworth	10,624	8,542	8,940	7,158	8,816	24,570
Walcha	221	196	193	189	199	399
TOTAL	**14,038**	**11,931**	**12,133**	**11,620**	**13,169**	**32,862**

The major usage groups of this water consist of:

- Residential Use
- Commercial, Industrial and Bulk Sales
- Council and other institutions.

The proportionate consumption of water between these groups varies between towns in accordance with the extent of development and land-use. **Figure 6-6** shows a breakdown of relative water uses based on 2015/16 data across the five LGAs. Residential use is the major component in all LGAs. Interestingly, Tamworth and Walcha have similar proportionate use profiles, despite being significantly different in magnitude. Gwydir has the lower proportion of commercial/industrial water use.

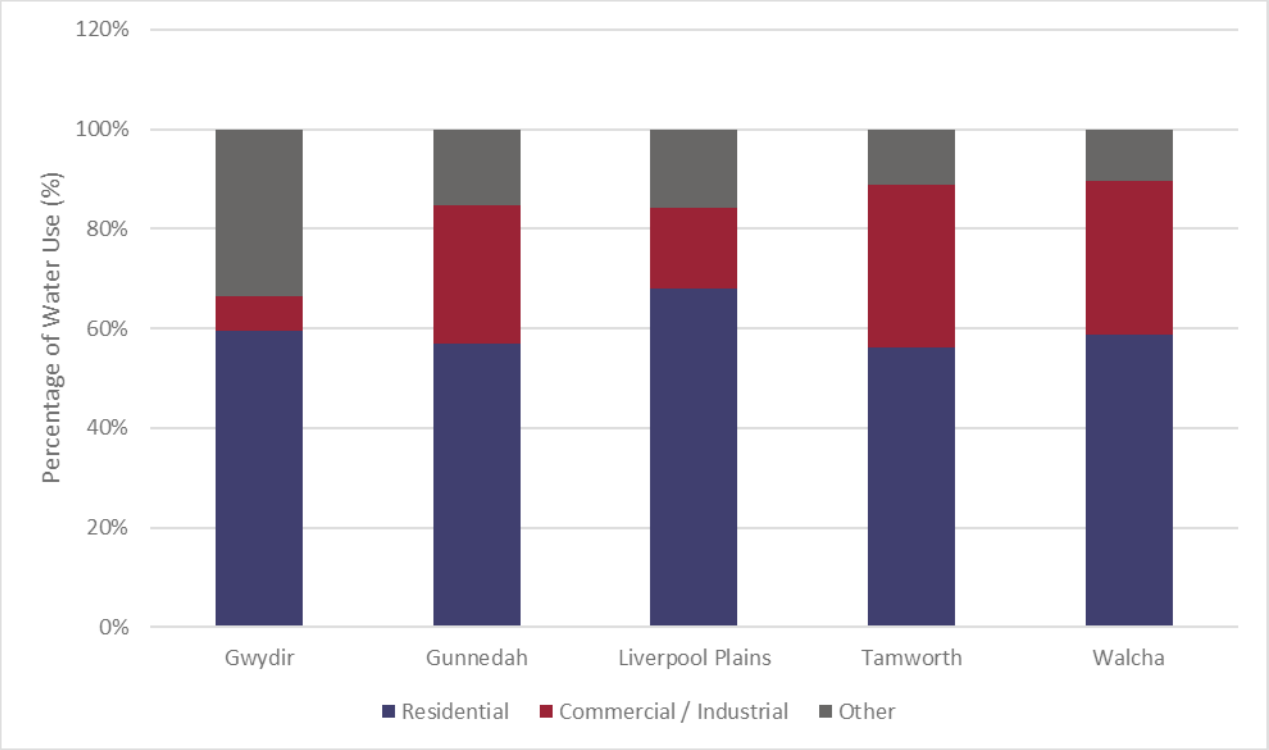


Figure 6-6: Components of urban water use[36]

Residential Use

Residential use of water captures a range of activities associated with household management and operation. The majority of household water use tends to be on garden watering (**Figure 6-7**), representing approximately 50% of total consumption, followed by bathroom, laundry and kitchen use.

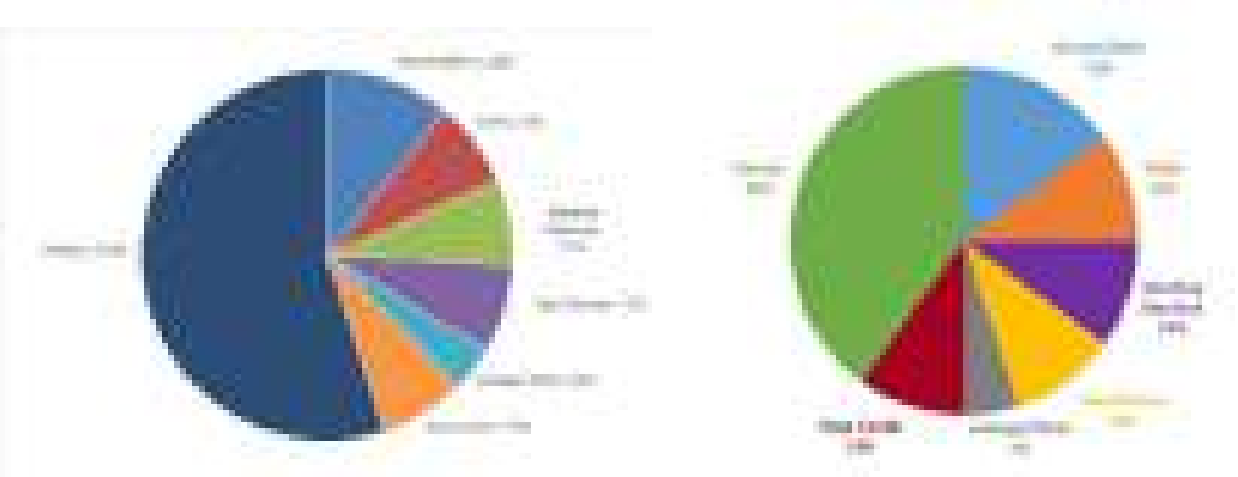


Figure 6-7: Estimated household water use for Gunnedah, 2017 (Left)[37] **and Tamworth, 2012 (right)**[38]

[36] Source Data: NSW Water Supply and Sewerage Benchmarking Report 2015-16 (DPI Water)
[37] Gunnedah Shire Council Water Conservation and Demand management Plan (Hunter H20, 2017)
[38] Tamworth 2016 Demand Management Plan (H2O Hunter, 2016)

The total consumption per household is seen to vary with location and availability of water. Typically, higher density urban households have lower overall consumption than lower-density / peri-urban households. This is primarily due to block / house size and garden size. Similarly, areas with abundant / reliable water supplies often demonstrate higher residential use in comparison to communities in which water availability is scarce. Standard planning assumptions assume a minimum essential supply requirement of 100 L per person per day. DPI (2016) indicates a weighted median of 248 kL/householder per year for inland areas. The five LGAs within the Namoi JO vary significantly around this mark (**Figure 6-8**). Both Gunnedah (400kL/property/year) and Gwydir exceed the state average usage per property, potentially reflecting the size of residential properties and relatively cheap price of water from groundwater resources.

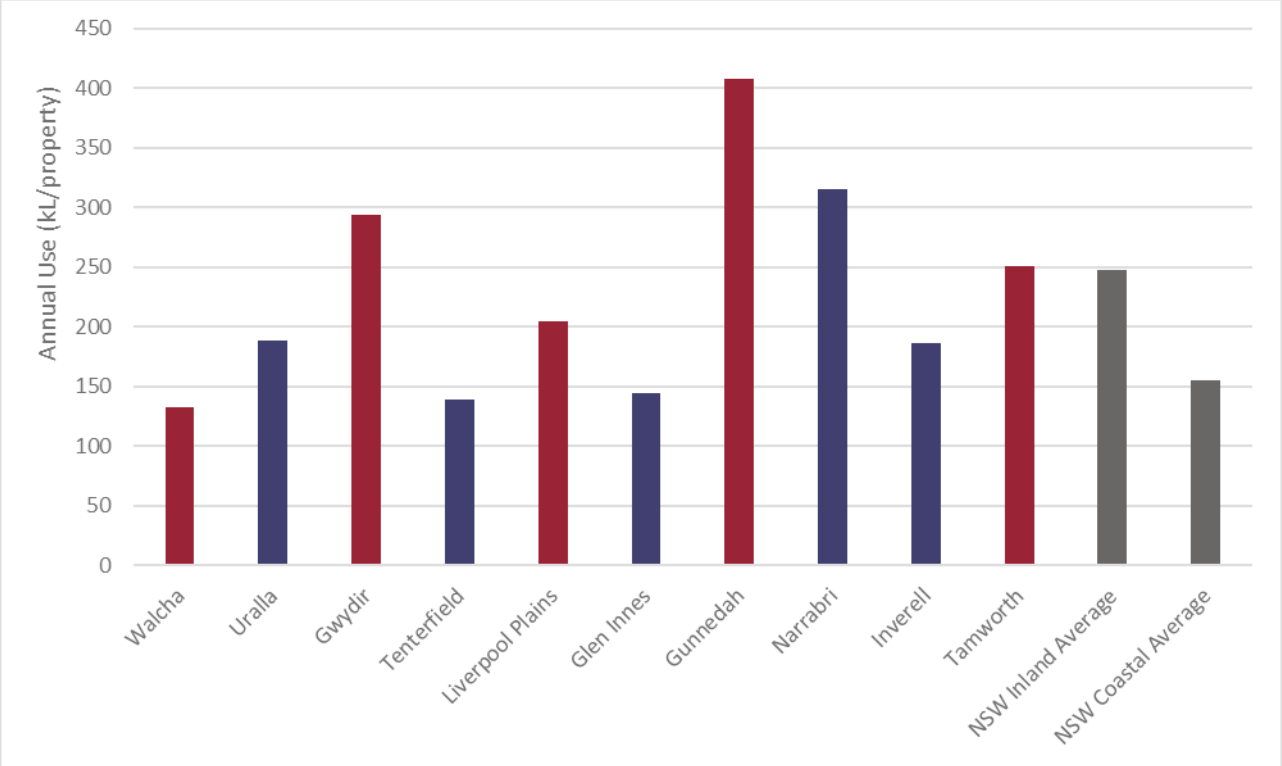


Figure 6-8: Residential water use per property (DPI, 2016) (red = LGAs within the Namoi JO, grey = state averages)

Data recorded by Tamworth Regional Council indicates that since the application of water restrictions as part of the Millenium Drought, water use per household has significantly stabilised at a reduced level (i.e. following the drought water usage did not significantly increase). This suggests an increased community awareness regarding water use and the value of water.

Commercial, Industrial Other Use

While the commercial and industrial water use is less than 30% for each LGA it is noted that the per connection use associated with commercial and, in particular, industrial operations greatly exceeds the average residential annual usage (e.g. 248 kL per household per year). Tamworth has an average industrial consumption per connection of 12,790 kL per year, over 86 industrial connections (in comparison to 16,017 residential connections (Hunter H20, 2016)). The magnitude of industrial requirements can lead to lumpy demand growth for water within urban areas and challenges in securing adequate future supply to support development.

Water use requirements differ significantly pending on the scale and nature of the facility proposed, for example:

- Reported water usage between abattoirs varies substantially, ranging from 3.8 to 17.9 kL per tonne of carcase weight produced (MLA, 2008). An abattoir processing in the order of 30,000 tonnes per annum would use in the order of 300ML.
- Hospitals require approximately 271 L/bed/day[39]. Tamworth hospital maintains 265 bed and generates a water demand requirement in the order of 26 ML per year
- The land area of parks and reserves managed by Council vary significantly, requiring irrigation. Gunnedah utilised 151 ML on park and garden irrigation in 2015/16 in comparison to 80 ML for Liverpool Plains.
- Retail facilities typically have a water usage than residential properties (1000 – 2000 kL per year per connection). However, it varies significantly with property type (e.g. coffee shop vs. bookstore).

6.3 Rural Areas

6.3.1 Agricultural Activity

The types of agriculture vary across the Namoi JO. A summary of the agricultural production by some of the key sectors is provided in **Figure 6-9**. **Figure 6-10** to **Figure 6-12** provide a further breakdown livestock, cereal and non-cereal production. Both Tamworth and Walcha are dominated by livestock and livestock products (e.g. eggs, milk etc). In the case of Walcha, the dominant agricultural production, while Tamworth also produces some cereals and broadacre crops, although these represent just over 10% of production in dollar terms.

Gunnedah, Liverpool Plains and Gwydir all have much higher proportions of broadacre cropping, with more than 60% of total production in dollar terms. Livestock represents a much lower portion, between around 25 and 40%. Of the broadacre cropping, roughly half are cereal crops and the other half are non-cereal crops.

Across the region, cattle is the dominant livestock production. However, Tamworth has nearly half of its livestock production from poultry, which is driven by the proximity to the Baiada processing facilities in Tamworth itself.

Cotton is the dominant non-cereal broadacre crop in the Namoi JO, although in Gwydir chickpeas dominate this category. It is understood that around 38% of NSW chickpeas are produced in the Gwydir Valley as a whole[40]. These represent an important winter crop for this area.

Of the cereal broadacre crops, there is a mix of wheat, oats, barley and sorghum in Liverpool Plains, Gunnedah and Gwydir.

39 https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq2/~edisp/dd_046262.pdf

40 https://www.gvia.org.au/the-gwydir-valley/industry-profiles/broadacre-croppping/

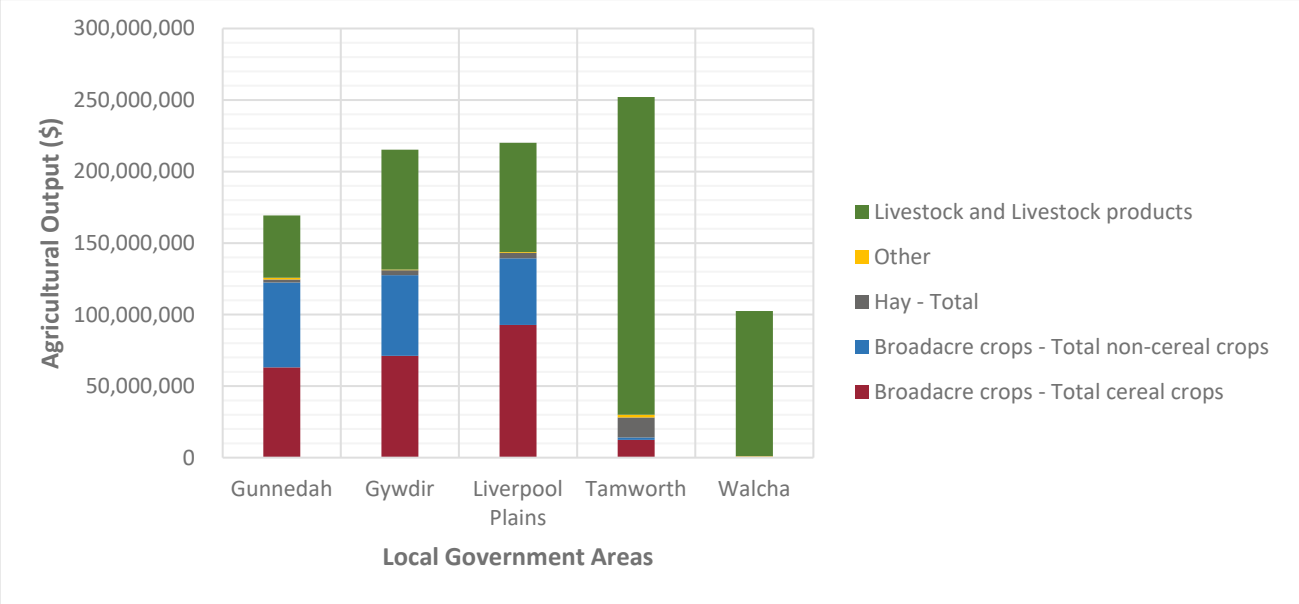


Figure 6-9. Agricultural Production (2015/2016)[41]

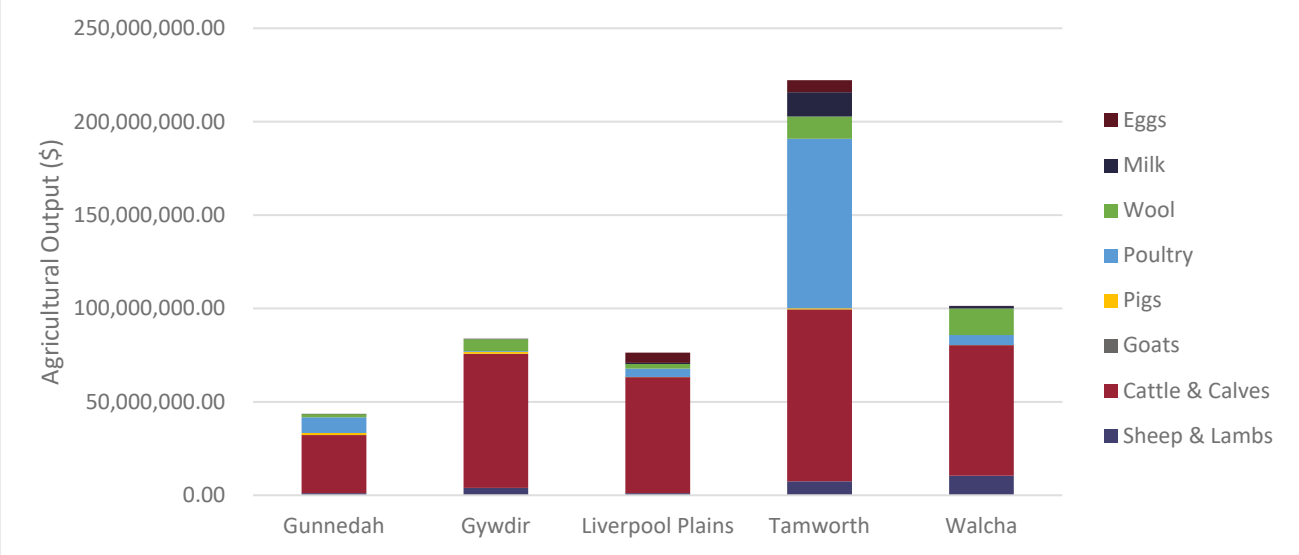


Figure 6-10. Livestock and Livestock Production (2015/2016)[42]

[41] Data derived from Australian Bureau of Statistics *7503.0 - Value of Agricultural Commodities Produced*, Australia, 2015-16. Livestock and livestock products includes livestock slaughtered and livestock products (e.g. eggs, milk etc).

[42] Data derived from Australian Bureau of Statistics *7503.0 - Value of Agricultural Commodities Produced*, Australia, 2015-16.

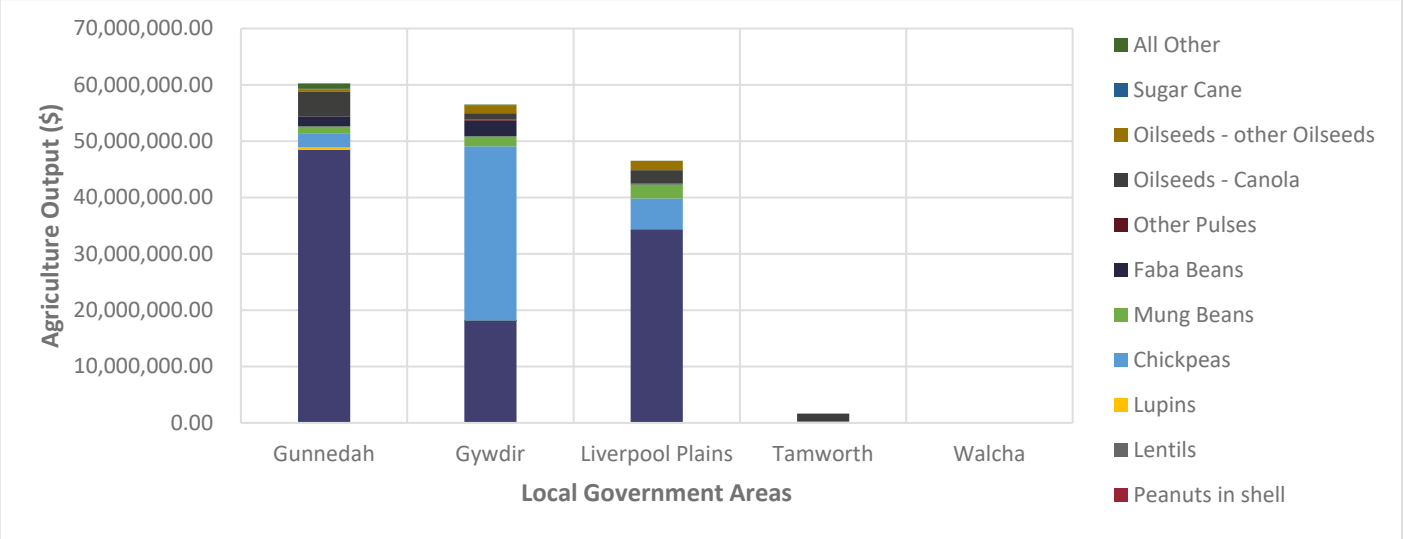


Figure 6-11. Non-Cereal Broadacre Crops (2015/2016) Production[43]

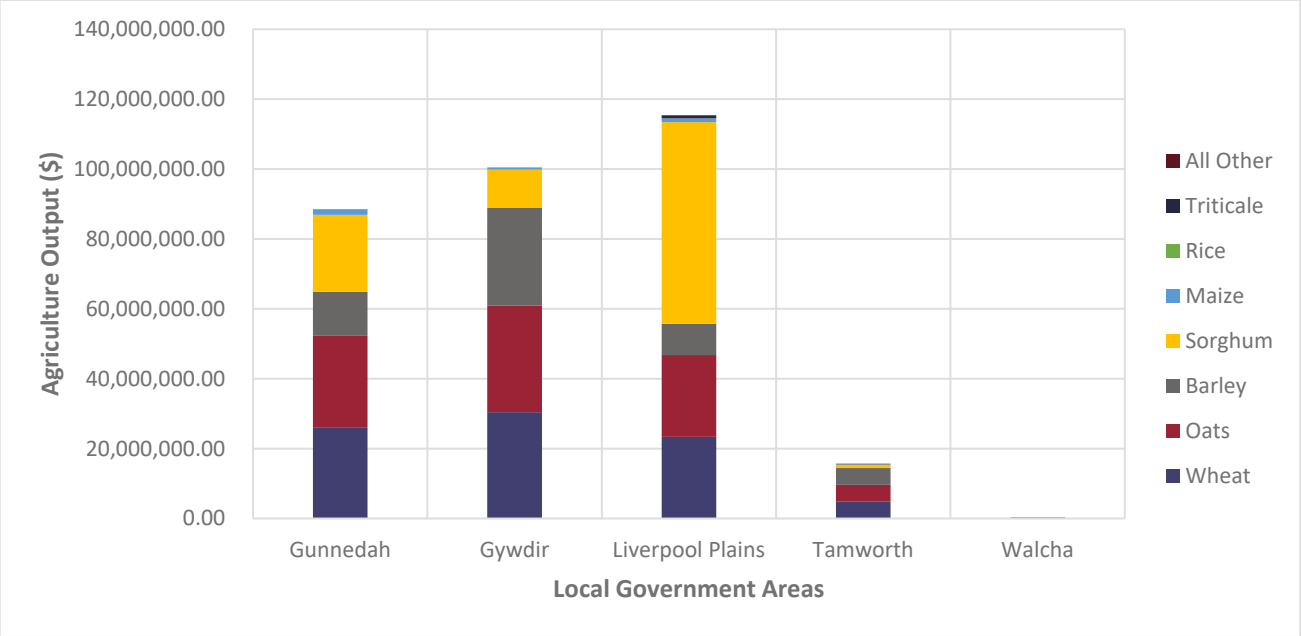


Figure 6-12. Cereal Broadacre Crops (2015/2016) Production[44]

Figure 6-13 and **Figure 6-14** shows the agricultural land use map for the Namoi JO. This provides an overview of the general spread and concentration of different types of agricultural land use. A key point to note is that the irrigated agricultural areas are focused around the groundwater resource area of Liverpool Plains and Gunnedah, with the remainder focused around the regulated rivers where water supply is more reliable.

[43] Data derived from Australian Bureau of Statistics *7503.0 - Value of Agricultural Commodities Produced*, Australia, 2015-16.

[44] Data derived from Australian Bureau of Statistics *7503.0 - Value of Agricultural Commodities Produced*, Australia, 2015-16.

As would be expected and consistent with the terrain as discussed in **Section 3.1**, cropping (irrigated and dryland) is generally focused on the flatter areas of Gunnedah, Liverpool Plains and Gwydir, while livestock grazing is in the remainder of areas where there are steeper slopes and higher elevations.

Understanding the distribution and intensity of agricultural output throughout the Namoi JO is useful, particularly in understanding the water availability. In order to understand the general intensity (in terms of $/ha) output from different areas in the Namoi JO, the landuse mapping was used in conjunction with ABS data to estimate an approximate spatial representation of agricultural output per hectare. This was converted to an index value, which is shown in **Figure 6-16**.

This index shows the higher productivity occurs around the areas of irrigating cropping, and that this is relatively concentrated in some key areas throughout the LGAs.

In addition to the above, there are a number of intensive agricultural activities in the Namoi JO. An overview of the key areas is provided in **Figure 6-15**. Following a review of the available information and consultation with key stakeholders, the key existing intensive agriculture areas are:

- Poultry – poultry has grown significantly centred around Tamworth, with the Baiada processing facility a key factor for this growth. The processing facility is located in Tamworth (near the airport), and this has driven the growth of poultry farms radiating out from Tamworth. Distance from the abattoir is a key driver for the development of poultry.
- Feedlots – there are a number of feedlots (predominantly beef cattle) in the LGA. Some of the major ones include Myola in Gwydir Shire in the north, and Killara Feedlot near Liverpool Plains. There are several smaller ones throughout the Namoi JO.

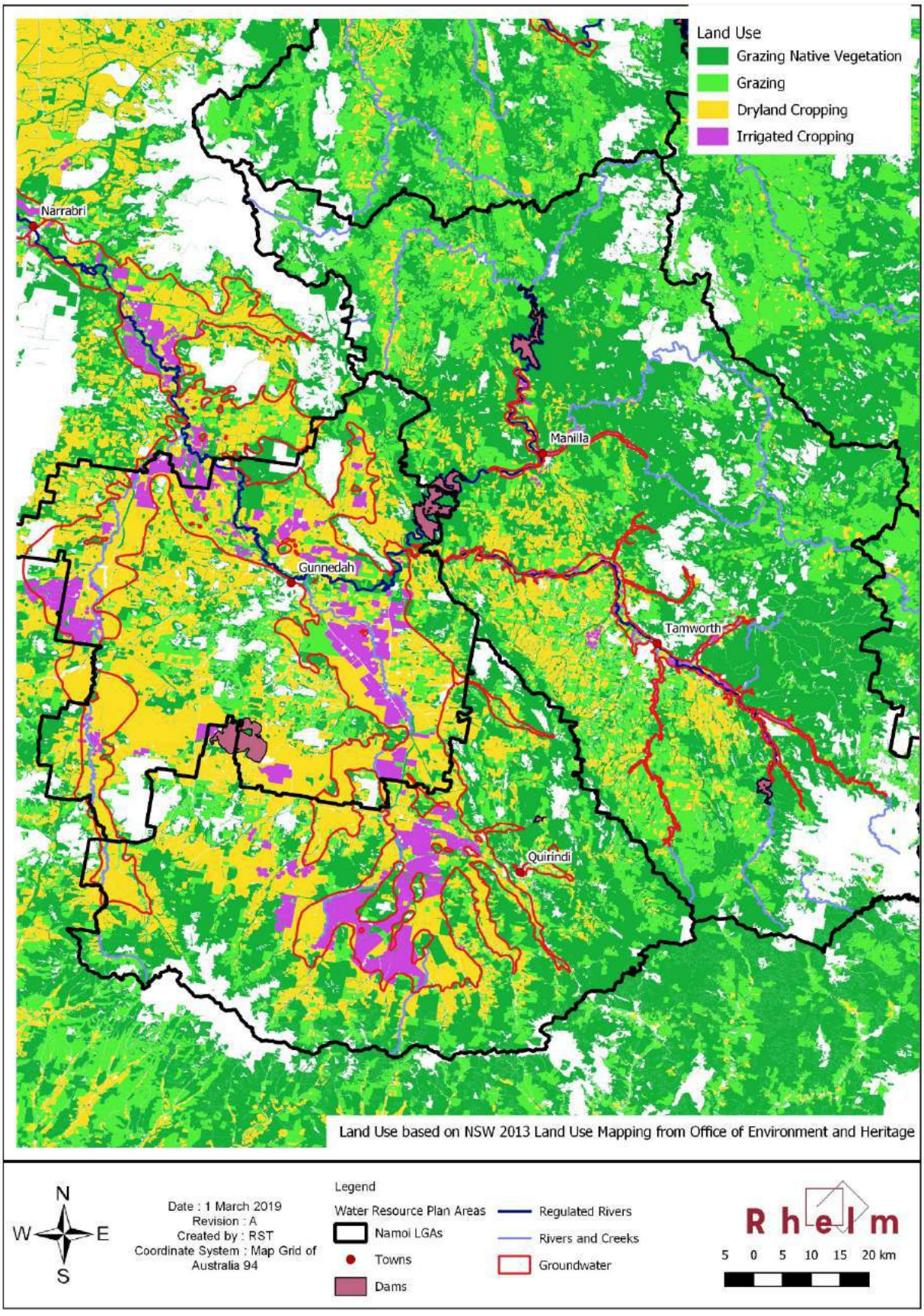


Figure 6-13. Agricultural Land Use and Water Sources – Part 1

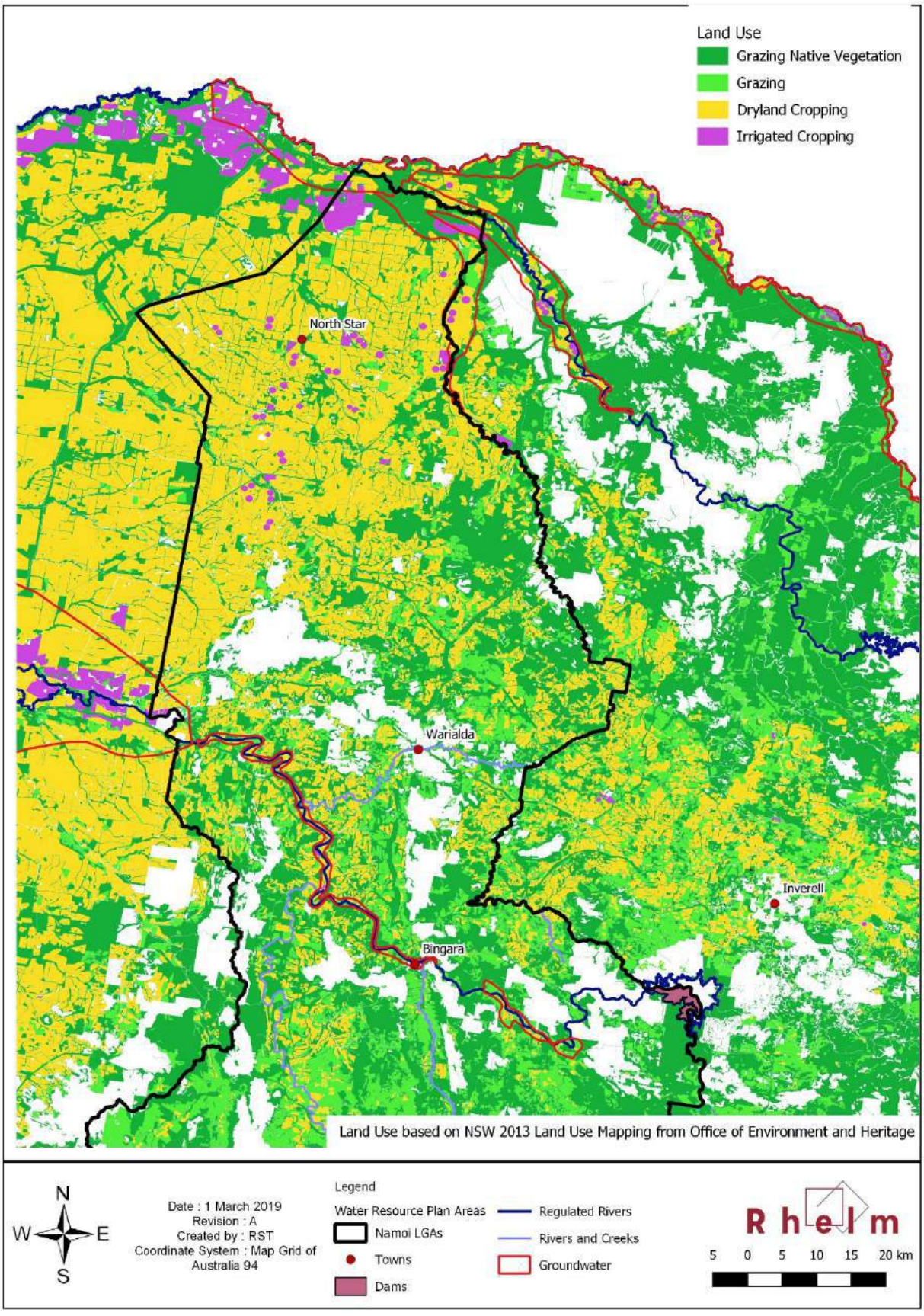


Figure 6-14. Agricultural Land Use and Water Sources – Part 2

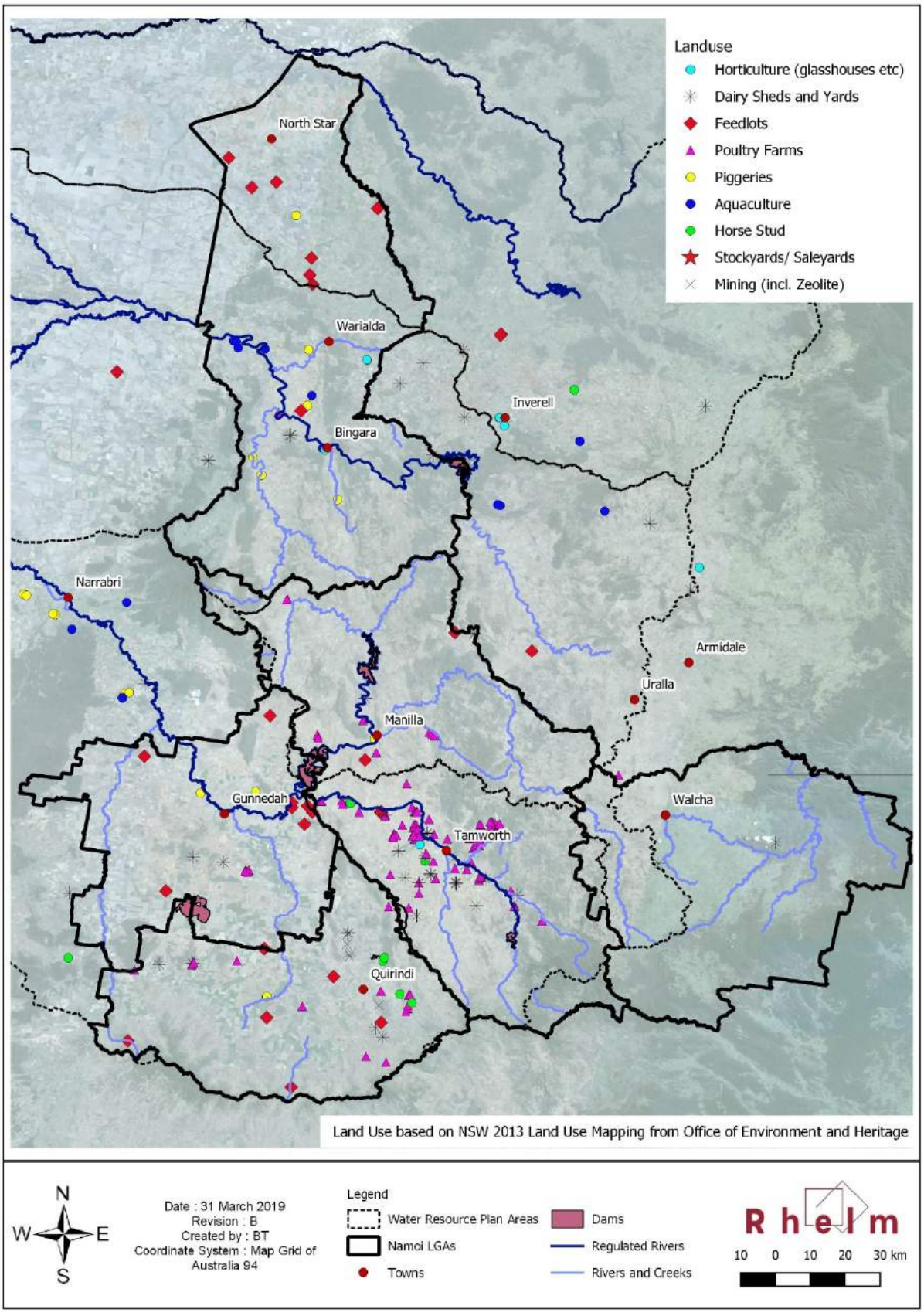


Figure 6-15. Intensive Agriculture

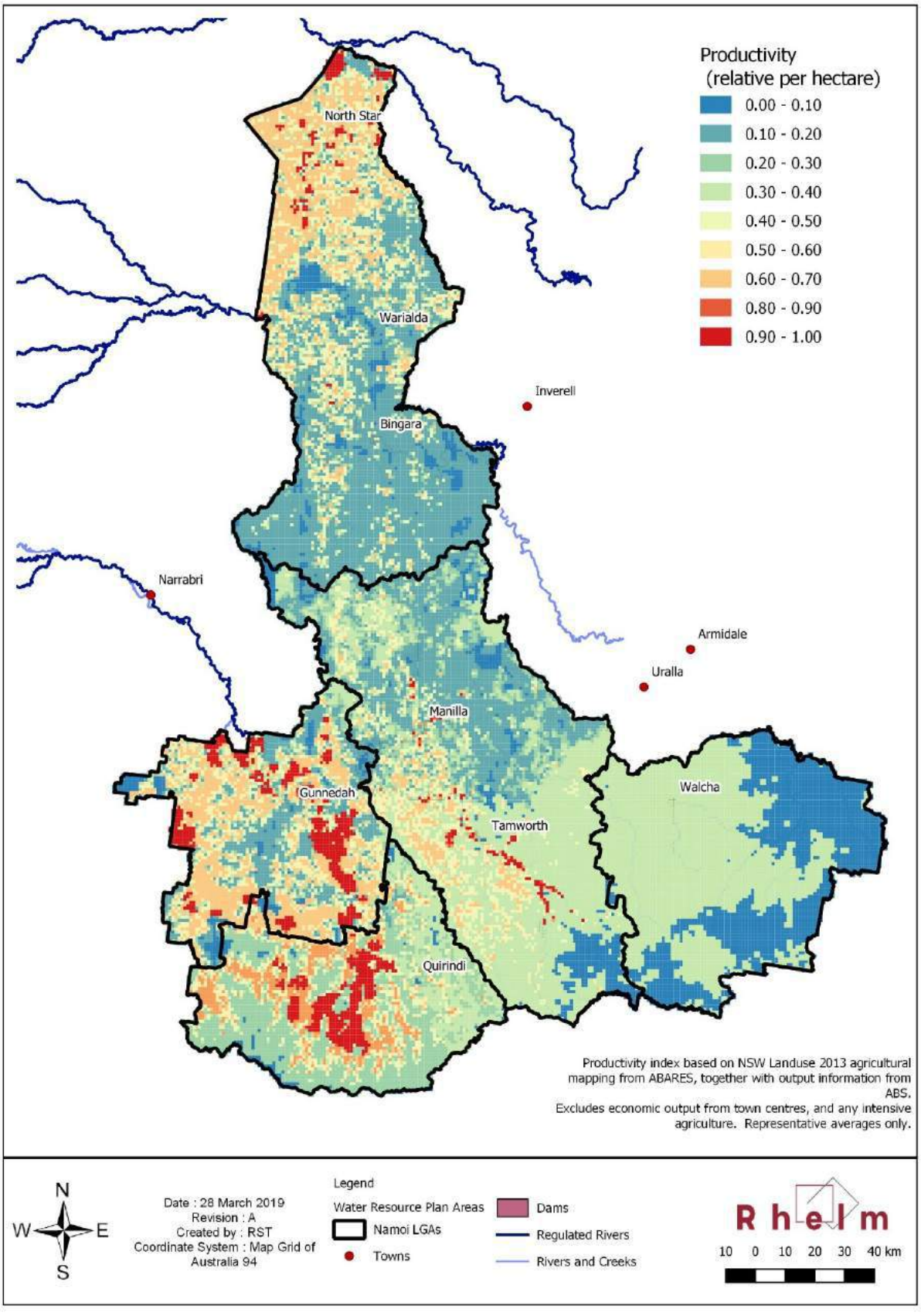


Figure 6-16. Productivity Index

6.3.2 Water Use

The total water usage for agriculture varies across the LGAs within the Namoi JO. An overview of water usage for each of the LGAs and the different agricultural commodities is provided in **Figure 6-17** for 2015/2016. Gunnedah has the highest water usage for all LGAs within the Namoi JO (at around 37,000 ML over the year), with a large portion of this made up of the water usage for cotton. Liverpool Plains LGA (at around 30,000ML) is the second highest user of water for agriculture, with a large proportion for cotton and for grain. By comparison, Tamworth LGA's water usage is dominated by pastures (hay etc.). Walcha has the lowest water usage of all LGAs, with under 5,000ML/year.

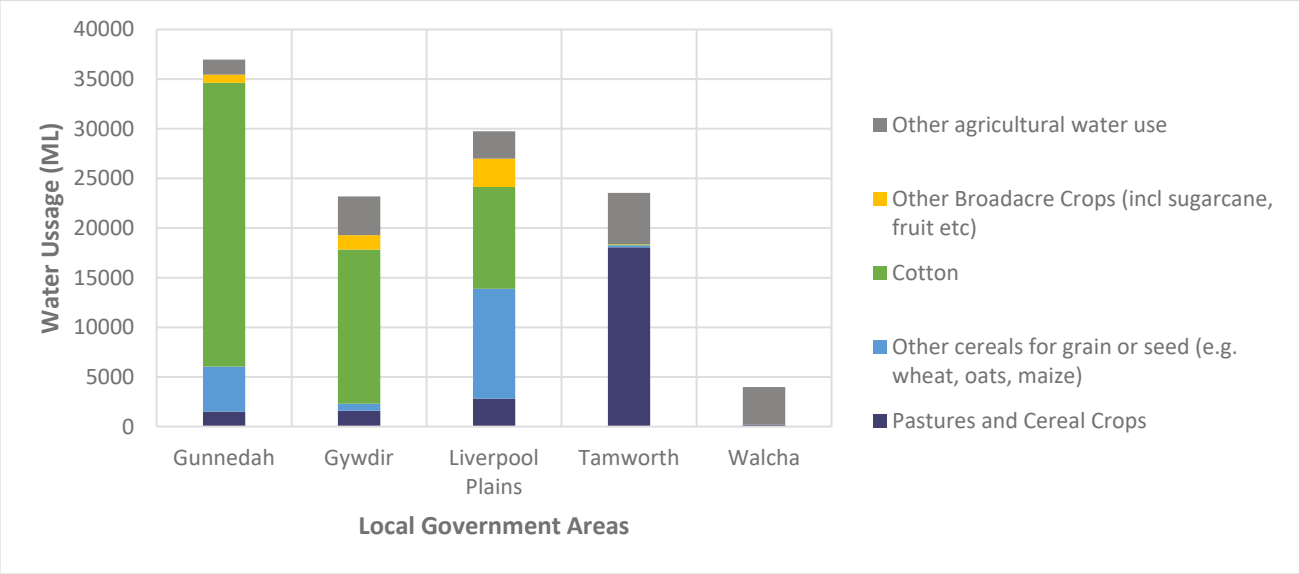


Figure 6-17. Water Usage by Agricultural Commodity (2015/2016)[45]

An overview of the water use by agricultural commodity across the entire Namoi JO is provided in **Figure 6-18**. Overall, cotton (47%) and pastures (hay etc) and cereal crops (together 35%) represent the dominant water users across the study area. Livestock production (which is assumed to be primary user under "other agricultural water use") has a relatively low water use (at 15%).

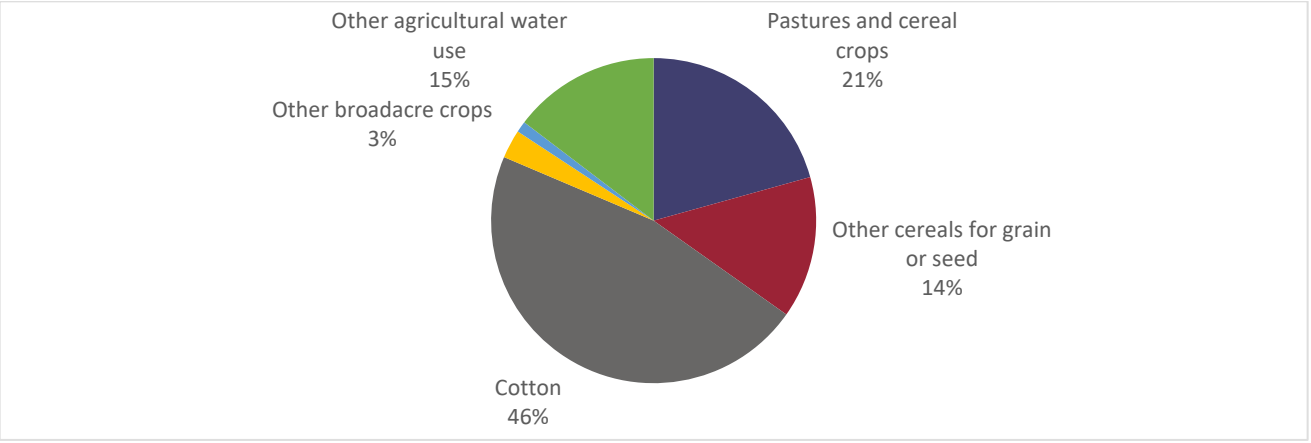


Figure 6-18. Water Usage by Agricultural Commodity (total Namoi JO) (2015/2016)[46]

[45] Data derived from Australian Bureau of Statistics *4618.0 - Water Use on Australian Farms,* 2015-16
[46] Data derived from Australian Bureau of Statistics *4618.0 - Water Use on Australian Farms,* 2015-16

Agriculture within the Namoi JO uses a variety of water sources. An overview of the proportion of different water sources that are used for agriculture is summarised in **Figure 6-19**. Both Liverpool Plains and Gunnedah have a large dependency on groundwater, with over 90% of agricultural water coming from this source. This is expected given the larger groundwater resource in those LGAs (refer **Section 5.3.5**). It is noted that since the generation of the data displayed (2016) additional recycling / re-use activities have been adopted within several of the LGAs (e.g. Gunnedah), supporting a limited number of agribusinesses.

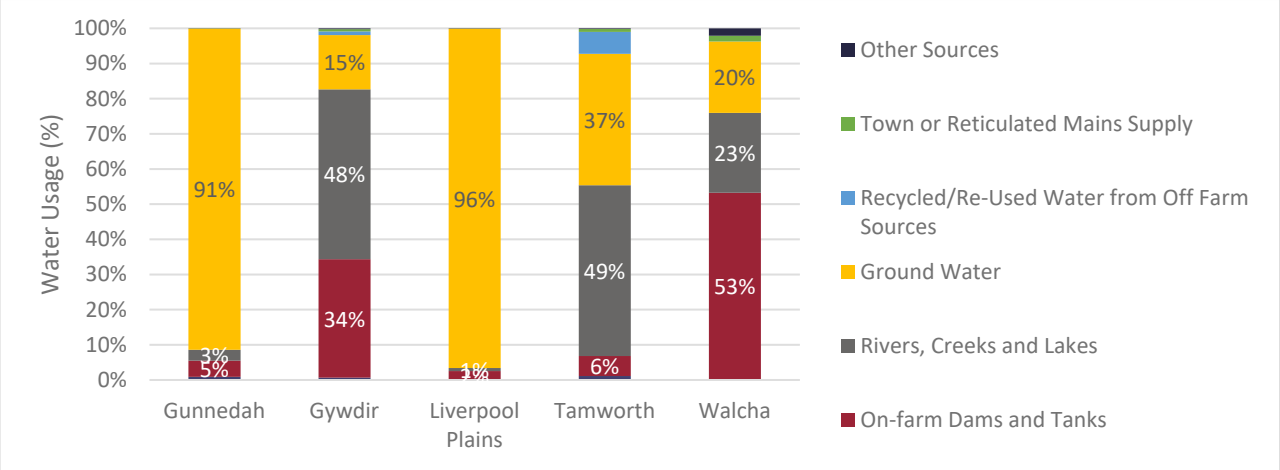


Figure 6-19. Water Sources and Water Use in Agriculture (2015/2016)[47]

Tamworth, Gwydir and Walcha have a larger variety of water sources that are used, with a mixture of groundwater, river use and on-farm storage/ capture.

Another useful measure is to understand the amount of water that is used per hectare. This provides an indication of the intensity of the water demand for different types of agriculture. An estimate of this has been prepared for the different agricultural types and is summarised in **Figure 6-20**. Note that this is for irrigated areas only, showing the water that is applied to the land (rather than rainfall). **Figure 6-21** is provided showing the intensity of water use relative to overall agricultural land.

[47] Data derived from Australian Bureau of Statistics *4618.0 - Water Use on Australian Farms,* 2015-16

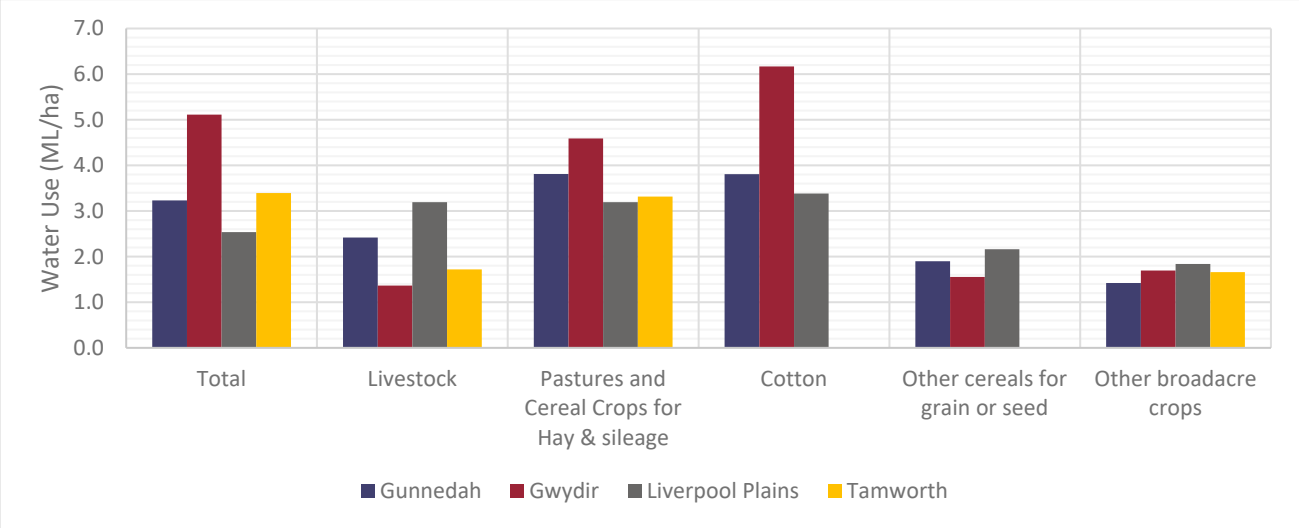


Figure 6-20. Water Applied per Hectare (2015/2016)[48]

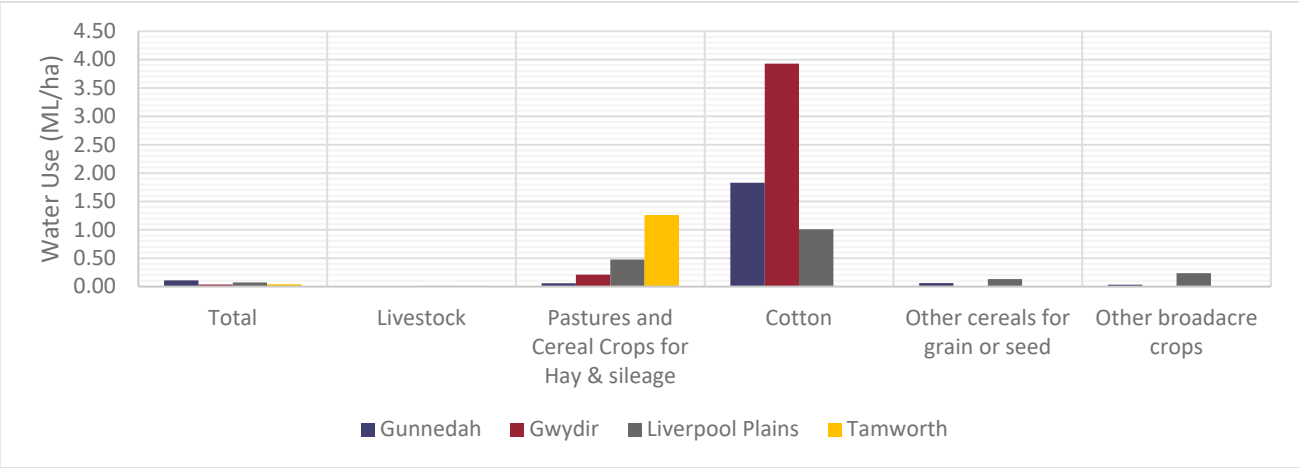


Figure 6-21. Water Applied per hectare – Weighted average on Dry and Irrigated Land (2015/2016)

Figure 6-22 provides the trend over time of the water usage for crops for the portions of the Border Rivers/Gwydir and Namoi catchments that lie within the Namoi JO. It demonstrates the general higher usage per hectare in Gwydir is a long term trend. It also shows that the water usage varies responding to rainfall and other conditions, as would be expected.

[48] Data derived from Australian Bureau of Statistics *4618.0 - Water Use on Australian Farms,* 2015-16. Livestock includes water used to irrigate pasture for stock, as well as other agricultural water such as livestock drinking water.

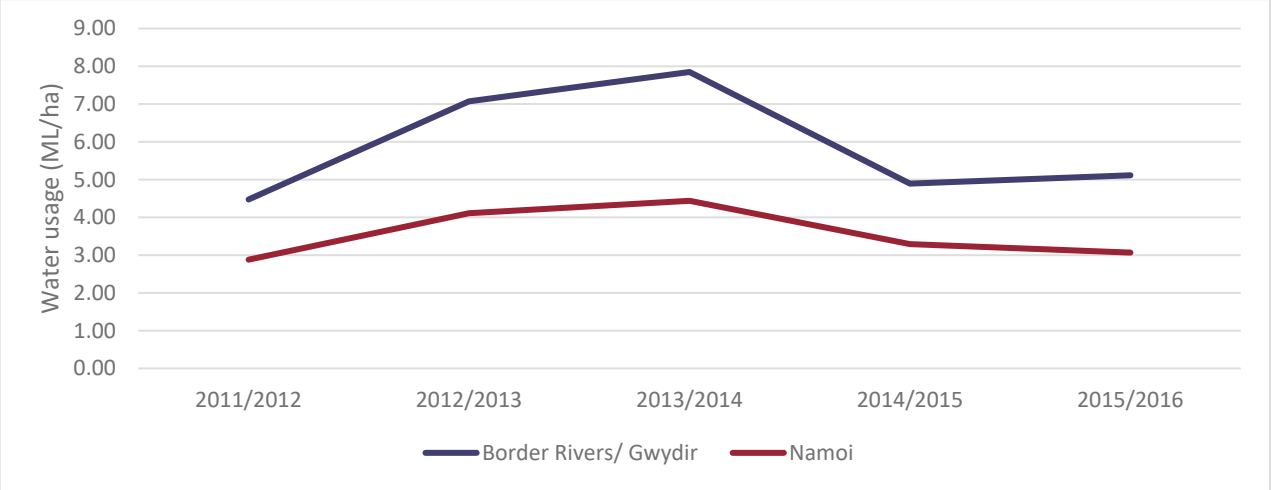


Figure 6-22. Irrigation Water Usage per Hectare - Crops[49]

6.3.3 Water Use and Agricultural Output

From a water usage perspective, agricultural land use can be categorised into grazing lands, dryland cropping and irrigated cropping. Using land use information from Office of Environment and Heritage, an overview of these key categories of agricultural land use are provided in **Figure 6-13** and **Figure 6-14**.

A summary of the water usage relative to agricultural output is provided in **Figure 6-23** for each of the LGAs. This graph also shows the productivity of the agricultural land in each LGA, measured in dollars per hectare. This provides a general understanding of the relative dependence of the different agricultural economies in the Namoi JO to water use. Further discussion on this is also provided in **Section 10**.

Both Gunnedah and Liverpool Plains have the highest water use per dollar of agricultural output, which is reflective of the high degree of cropping, and particularly irrigated cropping, in these two LGAs. Conversely, this higher water use results in a higher yield, with much higher $/ha output from these two LGAs. Tamworth and Gwydir both have similar water usage rates per dollar of output. While there is more cropping in the northern part of Gwydir, it is expected that this is offset and averages out with the higher proportion of livestock in the southern half of Gwydir (south of Bingara). Walcha has the lowest water use per dollar output of all the LGAs, with very limited cropping and no formal irrigation schemes in this area.

It is important to note that in this case, water use is only one part of a much larger consideration in terms of agricultural output. While Gunnedah has higher water use per dollar output, this is reflective of relatively higher abundance of water and good productive land availability for crops. There are also other considerations in production, such as the productivity of the land, transport access and supply chain considerations that all influence the types and intensity of production. These are beyond the consideration of this project.

[49] Derived based on the Australian Bureau of Statistics data for water usage on farms. Scaled to the portions of the catchments that are within the Namoi JO.

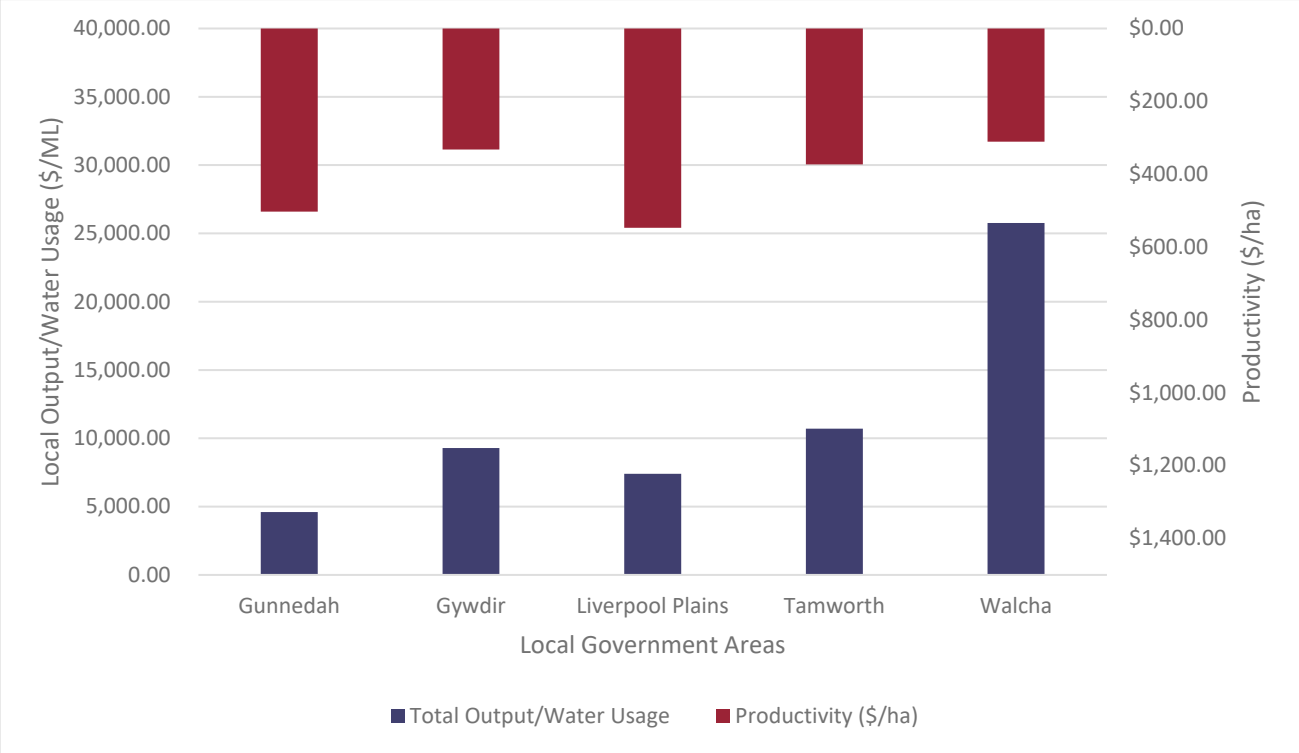


Figure 6-23. LGA Agricultural Production with Water Use (ML/$1000) (2015/2016)[50]

6.4 Mining

In addition to the agricultural and urban activities and water use detailed in the previous sections, there is strong history of natural resource extraction within the Namoi JO area, with a significant number of currently active mines and planned mines, including:

- Maules Creek Coal Mine
- Boggabri Coal Mine
- Tarrawonga Coal Mine
- Rocglen Coal Mine
- Vickey Coal Mine and Extension (in development)
- Shenhua Coal Mine (in development).

Mining operations are typically relatively moderately water intensive in comparison to other industries in terms of use volumes (e.g. similar to a larger irrigated cropping farm). However, it is argued that the economic output of mining per litre of water used, greatly exceeds returns generated from other industries. Water is required through the mining process for:

- Minerals exploration
- Ore extraction and processing
- Dust suppression
- Irrigation of surrounding lands and rehabilitated areas.

[50] Data derived from Australian Bureau of Statistics *7503.0 - Value of Agricultural Commodities Produced*, Australia, 2015-16 and Australian Bureau of Statistics *4618.0 - Water Use on Australian Farms,* 2015-16

In particular, extraction and excavation works have the potential to intersect with groundwater sources, requiring extraction and removal from the system. For example, the proposed Shenhua Mine site is estimating an average annual groundwater seepage rate of 180 ML/year, peaking at 756 ML/year. This seepage has the potential to affect the groundwater level in other groundwater compartments. All seepage and water extraction arising as a result of mine operations have to be permitted under appropriate WALs consistent with the relevant WSP. While this process theoretically ensures sustainable use of water for mining operations within the context of other land uses it is also noted that:

- Due to the financial size of mining operations, there is potential for mining operations to distort the trading market for water
- The uncertainty of groundwater impacts given the complexity of systems is high
- Mining operations generate hazardous wastes and common concerns relate to potential contamination of connected groundwater and surface water bodies
- Mining operations often vaporise aqueous waste, removing water entirely from the catchment system preventing any re-use value being extracted.

6.5 Environmental Water

A key element of water management is accounting for both natural systems and environmental assets and users. An environmental asset is considered to be a water dependent ecosystem satisfying criteria established within the Murray Darling Basin Plan, considering native vegetation, waterbirds, native fish and ecosystem functions. The catchments within the Namoi JO area support a variety of important water dependent ecosystems, including instream aquatic habitats, riparian forests, and floodplain woodlands and wetlands. These features are spread throughout the catchment and each has their own water requirements depending on the plants and animal species they support, and ecosystem functions they perform.

Goran Lake is the most highly recognised water dependent environmental asset within the Namoi JO. It is a nationally recognised wetland[51], of high ecological importance and of high conservation value, providing habitat for numerous threatened species. However, numerous other water courses and floodplains within the area fall within the category of an environmental asset, requiring provision and management as part of water provisioning (e.g. Warrabah National Park). The Namoi River sustains five threatened native aquatic fish species and numerous other threatened species are found within the rivers and riparian corridors within the Namoi JO area. **Figure 6-24** outlines key Environmental Assets identified as part of development of the Murray Darling Basin Plan for the Namoi, Gwydir and Border Rivers catchments. It is understood that NSW Office of Environment and Heritage is currently undertaking a comprehensive stocktake of water dependent environmental assets and ecosystem functions to contribute to long-term water management.

To manage the environmental and ecological assets, the flow and inundation regime of associated water sources is considered. For a river, its flow regime represents the totality of flow events or flow patterns, made up of flows of different magnitudes, which shape river channels and provide cues for key biological processes such as breeding or migration, support dispersal of plants and animals and shape how a river links with its floodplain. An Environmental Water Requirement (EWR) is the flow or inundation regime that a species, or group of species needs to ensure its survival and persistence. It can also be the flow regime needed to meet the water requirements of a range of species in a defined geographic area.

[51] Listed in the national Directory of Important Wetlands of Australia

Based on the identified assets and estimated EWRs, overall catchment flow requirements can be captured, identifying recommended managed flow timings, duration and frequency based on the suite of plants, animals and functions it supports. A similar approach is considered in the management of unregulated and groundwater systems, in which Sustainable Diversion Limits are identified, considering the presence of dependant ecosystems, and overall resource availability.

Within the regulated water system, environmental flows are currently managed under either:

- Held Environmental Water (HEW) - an entitlement held by a licence-holder that is used for environmental watering purposes. Although a water sharing plan facilitates the HEW, the use and volumes of HEW are generally not defined by the plan. HEW is generally held by the Commonwealth Environmental Water Holder or NSW Office of Environment and Heritage. It is released either in accordance with EWR levels or where additional environmental support is seen as necessary.
- Planned Environmental Water (PEW) – A provision for flow volumes established within a water sharing plan. Typically, the WSP will specify a PEW based on a minimum daily flow to be maintained and any intra/inter annual variation to this flow level. The plan may detail flows at specific times and volumes that consider both the rainfall in preceding periods and seasonal patterns. The state issued water allocations to other licence holders made each year are developed secondarily to provisioning for PEW requirements. However, there may be times in which the PEW requirements is unable to be met to support provision of town supplies or similar. Conversely, the WSP may also consider PEW requirements when catchment flows are above specified flood levels and there is an excess of water (i.e. following large rainfall events). The WSP will limit total extractions by supplementary water holders in the catchment as the periodic inundation associated with high flow events can be a significant aspect of determined EWRs.

Table 6-4 summarises the current PEW and HEW provisions within the Namoi, Gwydir and Border Rivers Catchments. It can be seen that the volume and use of HEW has currently been low in comparison to other water users. The need for agencies to release held water is typically dependent upon regional drought and rainfall patterns. The PEW volume is difficult to quantify as the measure varies between catchments and the realised environmental portion will vary along the length of a water source. However, it is recognised that typically at least 60% of the average annual source flows are not extracted for use at any one point. This is consistent with the Murray Darling Basin Authority objective to maintain base flows within the regulated (and unregulated) sources above 60% of their natural flow levels[52] The adequacy of adopted Long Term Average Annual Extraction Limits and Sustainable Diversion Limits is typically determined by the State Government in consideration of the Murray Darling Basin Authority.

Table 6-4: Planned and Held Environmental Water (ML/year) (2016-17)

Regulated Resource Area	Planned Environmental Water*	Held Environmental Water	Estimated HEW Use**
Upper Namoi	632,000	105	79
Lower Namoi		13,548	10,202
Peel[#]	238,530	1,257	263

[52] MDBA (2014) Basin Wide Environmental Watering Strategy

Gwydir	753,060	135,965	25,847
Border River#	854,765	4,000	<200

*Assumes that all annual flows not extracted (i.e. the difference between total flow and the long-term average extraction limits) will be preserved and contribute to maintenance of basic ecosystem health. It is noted that these flows may be extracted beyond the Resource Area limits. Data taken from relevant DPI 2016-17 General Purpose Water Accounting Reports

**based on Long Term Average Annual Yield of HEW and General Purpose Water Accounting Reports

Based on river balance data from General Purpose Water Accounting Reports.

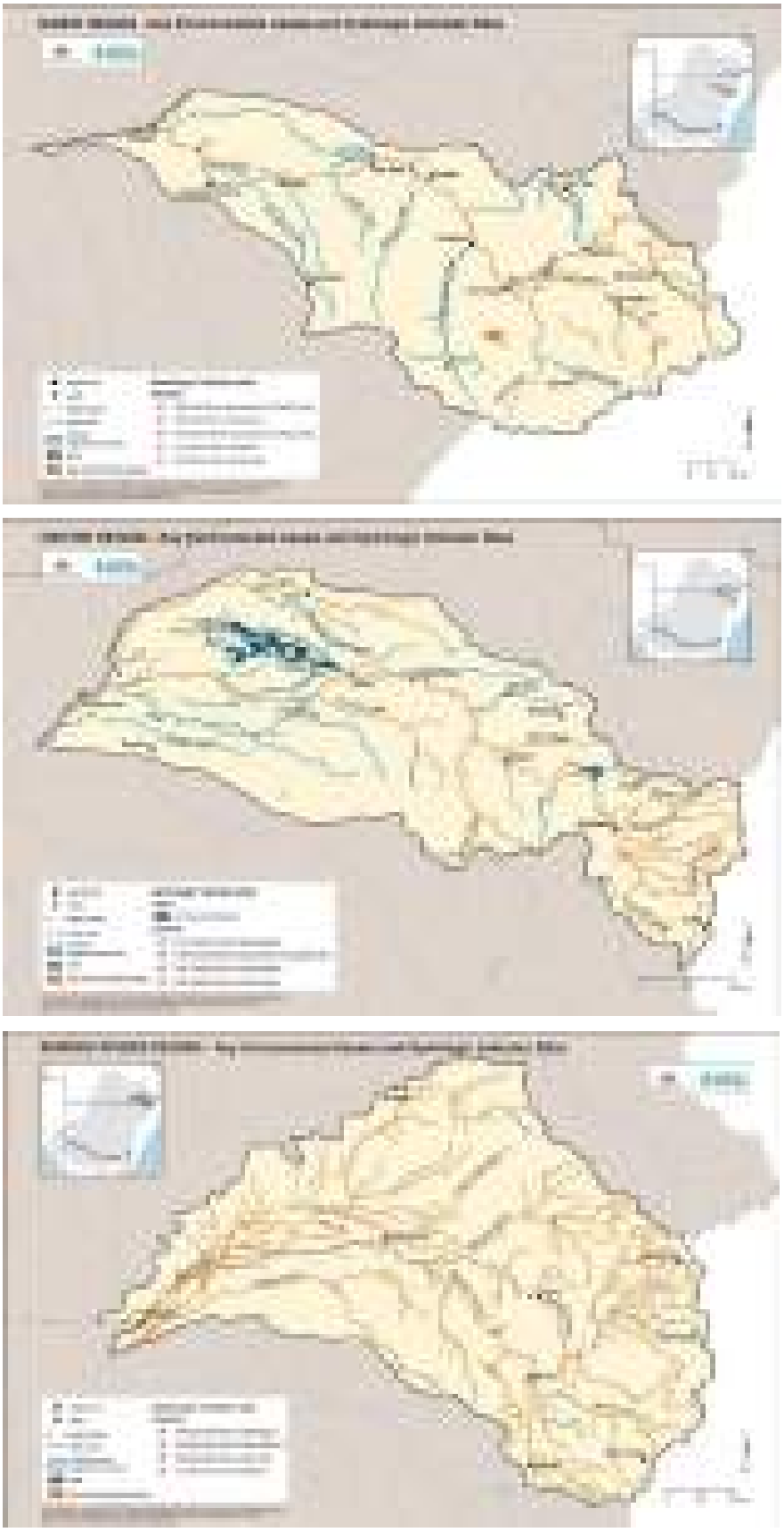


Figure 6-24: Key Environmental Assets (MDBA, 2010)

6.6 Aboriginal Water Use

Indigenous people have diverse and interrelated interests in water and have adopted numerous ways to address water management issues within their customary estates. It is recognised that reduced inflows and over-allocation of water within catchments has placed environmental stresses on ecosystems and increased competition for resources, making it harder for Indigenous people to compete in accessing water (for both consumptive and non-consumptive uses (Jackson et al. 2010). Indigenous water requirements have not been holistically quantified within current Water Resource Plans currently in development. However, it is recognised that Aboriginal communities utilise water in a number of ways:

- Waterholes/soaks/billabongs – Specific waterholes provide refuge for iconic species for Aboriginal people. Waterholes have a customary value, traditional use, and often represent a connection between groundwater and surface water. Uses include gathering resources that have an economic value for Aboriginal peoples.
- Wetlands – Wetlands are frequently associated with traditional, customary and spiritual values.
- Lagoons/Wetlands bowls – Areas often utilised for annual traditional resource gathering, often dependent upon groundwater for maintenance and use.
- Transit stops – ephemeral flows – Periodic use of ephemeral water sources is well documented as part of contemporary knowledge sharing and incorporated within traditional songlines.
- Occupation sites and camp grounds – A number of occupation sites and camp grounds existing within the Namoi JO area, relying on both surface water and ground water.
- Spiritual sites – The is often a spiritual connection to water across the regional landscape.

In comparison with many urban and agricultural water extraction demands, Aboriginal uses are low intensity in terms of water use. Typically, environmental water management has been seen to aid in conservation of these uses. However, common concerns raised[53] as part of this approach include the need to:

- Identify opportunities to better address the needs and aspirations of Aboriginal communities in terms of equitable access to water for social, cultural, spiritual and economic purposes.
- Ensure that Aboriginal communities' issues and concerns have been carefully considered with appropriate provisions that ensure the long-term sustainability of their cultural values and uses.
- Support the removal of barriers that constrain and limit equitable access to water for Aboriginal communities, by reviewing policy gaps and legislation.
- Ensure Aboriginal communities are appropriately consulted and informed of issues affecting their ability to participate in the decision-making process. This includes building partnerships and trust regarding the use and storage of culturally sensitive information.
- Identify and address water quality issues that are impacting on the Aboriginal values and uses across the WRP area. These impacts include the cultural connections to iconic species (fish, vegetation and birds), as well as the instream use of water for swimming, drinking and maternal use.
- Address and identify the impacts on the spiritually significant cultural values from water extraction.

[53] NSW DPI (2017) Namoi Alluvium Water Resource Plan: Groundwater – Status & Issues Paper

6.7 Losses and Evaporation

Environmental losses represent a significant issue in water management, particularly for surface water sources. Losses arise primarily as a result of evaporation from the surface of the water body as well as losses to the environment and groundwater during transmission. While losses to groundwater facilitate the recharge of aquifers and groundwater sources, it does shift water availability away from surface water WAL holders towards those with groundwater WALs.

Within the Namoi Regulated River Water Source storage losses (predominantly due to evaporation) accounted for some 45.9 GL, representing 13% of total storage, while delivery losses represented a further 52.4 GL (14%) in 2018. Similarly, Chaffey Dam operates with losses representing approximately 17% of total storage as of March 2019.

These volumes of losses are substantial and introduce inefficiencies into the water management system. Anecdotal accounts were received of losses requiring water releases to exceed twice the order volume (i.e. 100% losses) within the Peel River system. Liverpool Plains Shire Council recently developed a pipeline access for Quipolly Dam water source access to help manage losses.

6.8 Comparison of Urban and Rural Economies and Water Use

Figure 6-25 and **Figure 6-26** show the difference in estimated water usage and known water entitlement between urban (Local Water Utilities) and non-urban (agricultural land-use) areas within each LGA. With the exception of Walcha, agricultural water use varies between 20,000 and 40,000 ML per annum across the represented LGAs, with Gunnedah generating the greatest use volumes. When urban usage is considered, the significant demand associated with Tamworth, increases its regional water consumption relative to the other LGAs. A somewhat similar trend is observed in terms of entitlement. However:

- The available entitlement to landowners/councils far exceeds the average annual use. Due to limited usage data and complexity of AWDs over time it is not possible to fully compare efficiency of entitlement use between LGAs
- Tamworth LGA has the largest overall entitlement reflecting its diversity of catchment and water sources.

Across all of the council areas, the proportion of water-use and entitlement dedicated towards agricultural production greatly outweighs total urban use and entitlement. However, individual farms may utilise similar volumes to individual commercial operations. The average entitlement of surface water sources for agricultural commercial users is approximately 175 ML per year, and 123 ML per year for groundwater water sources[54].

The local water utility suppliers represent the largest individual water licensees within the region. With the exception of Walcha, the local councils all maintain entitlements in excess of 1,200 ML per year. For comparison, only 24 individual agricultural surface water and one individual groundwater entitlement exceeding these volumes. The local water utilities represent players with significant weight in the water market. However, it is noted that an individual irrigator may hold multiple individual entitlements or trade licences to access greater water supplies.

[54] Excluding licence entitlements of less than 10 ML per year, based NSW Water 2018 water supply and use approvals

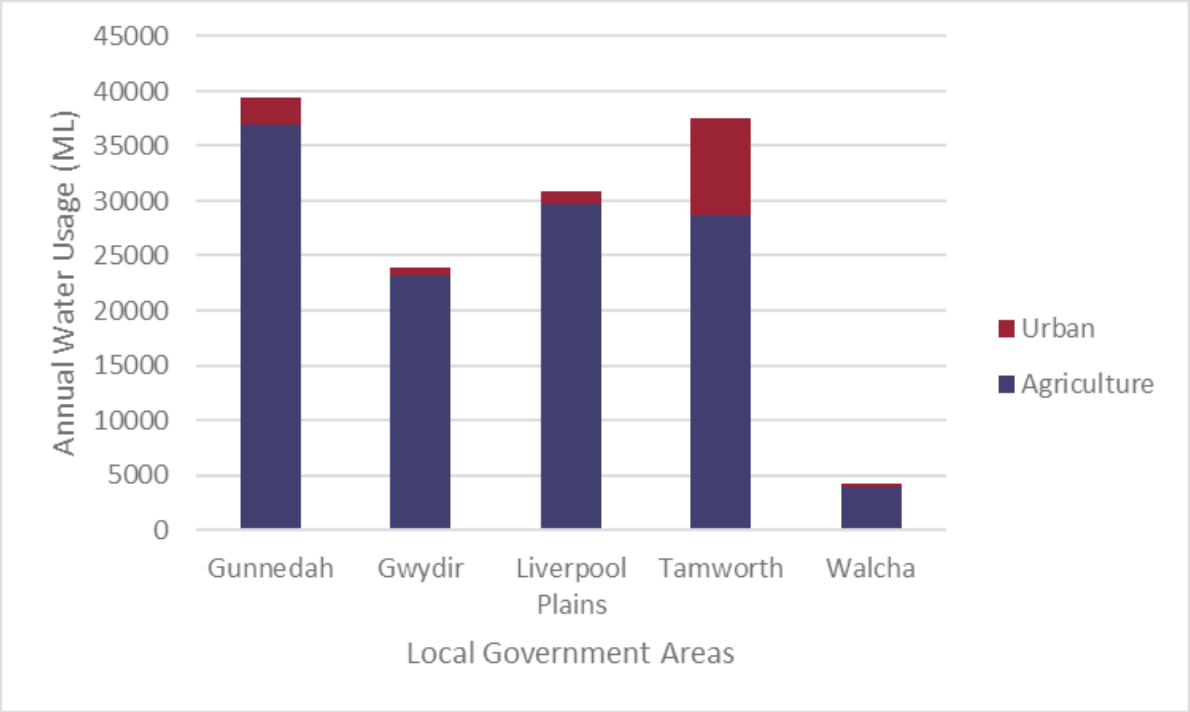


Figure 6-25: Comparison of urbans[55] and agricultural[56] water use

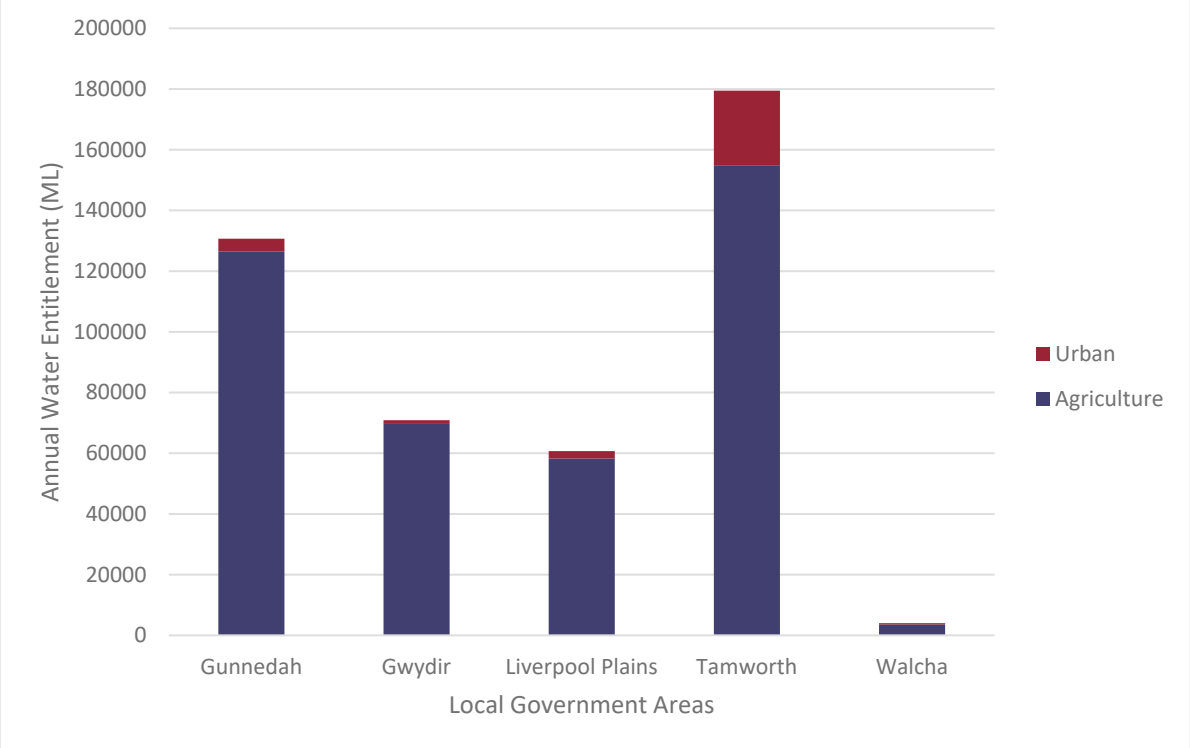


Figure 6-26: Comparison of urbans and agricultural water entitlement[57]

[55] Data derived from individual Council usage records
[56] Data derived from Australian Bureau of Statistics *4618.0 - Water Use on Australian Farms,* 2015-16
[57] NSW DPI Water Access Licence Data (2019)

The comparison of economic metrics associated with agricultural and urban activity is not readily comparable as the inputs and industry that drive the urban area activities are heavily based upon the raw products developed within the surrounding agricultural areas. The dependency of urban areas upon agricultural production and water is discussed further in **Section 10**. However, for the purposes of comparison, and demonstrate the relative water use in deriving the associated economic output estimates for agriculture and non-agricultural sectors within each LGA (**Figure 6-27**). The economic output data represents the gross annual revenue generated by businesses/organisations in each of the industry sectors within each LGA divided by estimated water use (ML) in generating this output. Gross revenue is also referred to as total sales or total income. It does not take into account the cost of production. Similarly, the water usage does not take into account the embedded water with products sold (e.g. the figures do not capture the cost of production or water use associated with the sale of a cotton shirt in a clothes store). As would be expected, it clearly demonstrates that average urban activities are far less water intensive industries than agricultural water. Water security is discussed further in **Section 8**, while the industry water dependencies and other constraints are discussed further in **Section 9**.

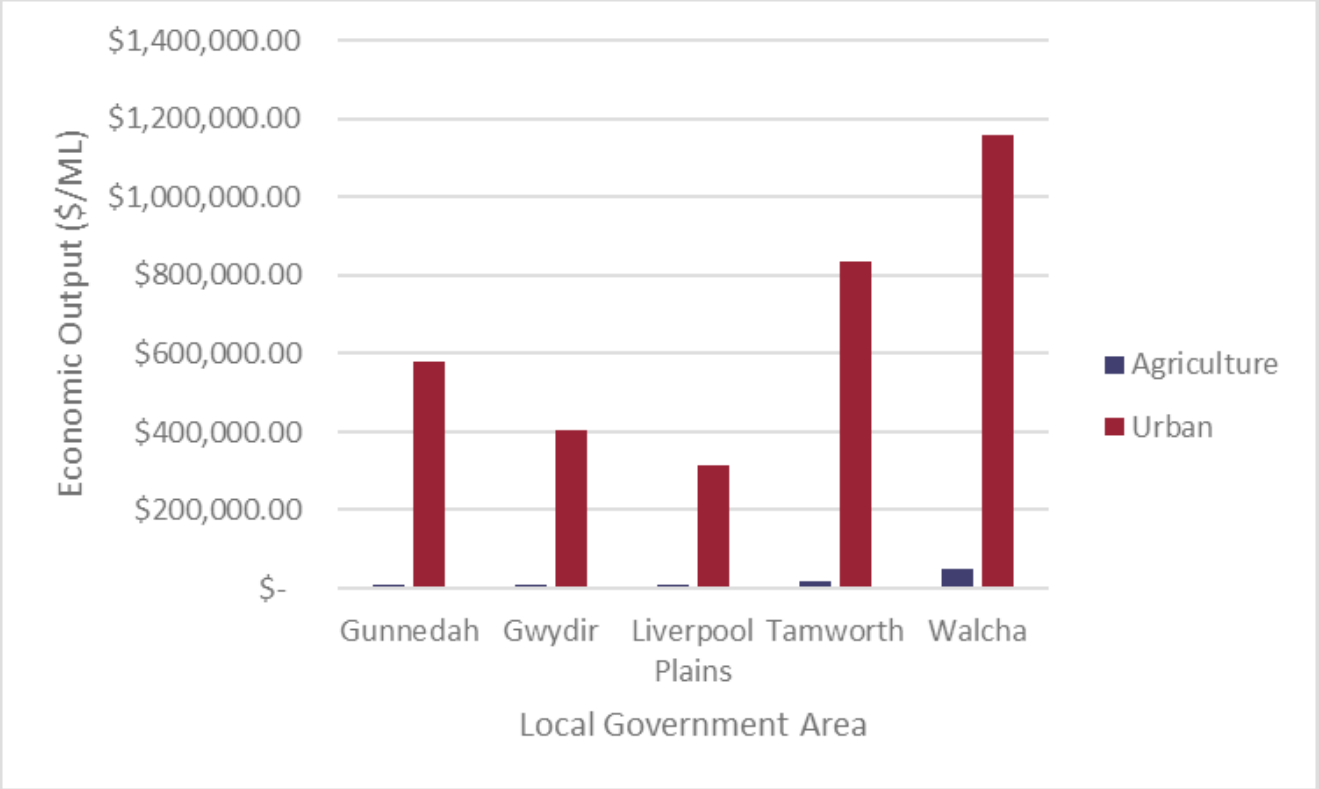


Figure 6-27: Water usage per economic output by LGA[58]

[58] Agriculture water data derived from Australian Bureau of Statistics *4618.0 - Water Use on Australian Farms,* 2015-16. Urban water data represents current 5 year average of water use. Agricultural and Urban output values derived from Regional Development Australia: Northern Inland NSW 2016-17 data.

7 Future Development and Growth

7.1 Population & Economic Growth

Historical population and growth regional product for the Namoi JO have changed over time. A summary of historical growth rates are provided in **Table 7-1**, with the time series provided in **Figure 7-1**. Overall population growth has been around 0.8% in the 10 years from 2008 to 2017, while GRP has grown roughly 2.8% over the period. However, GRP is more susceptible to various changes in the economy, as indicated in **Figure 7-1**.

Forecasts of potential growth are available for some of the LGAs within the JO. DPC[2] (2018) Regional Economic Development Strategy (REDS) for the Lower North West (Tamworth, Gunnedah and Liverpool Plains) identified a population growth of 12.8% across the three member LGAs by 2036 (representing a growth rate of 0.7% pa), with the largest growth for Tamworth LGA of 15.5% (a growth rate of 0.8%pa). The REDS for Southern New England (DPC[4], 2018) and Upper North West (DPC[6], 2018) did not provide details on the expected population growth. However, as the three three LGAs within the Lower North West represent around 85% of the population total population within the Namoi JO, it is unlikely that higher growth rates within the Walcha or Gwydir LGAs will significantly alter the overall Namoi JO growth rate. Application of a 0.7% pa growth rate across the JO would represent approximately 12,400 people within the Namoi JO by 2036.

Table 7-1. Historical Economic and Population Growth Rates[59]

	Overall	Gunnedah	Gwydir	Liverpool Plains	Tamworth Regional	Uralla	Walcha
GRP (2017) (billions)	$5.98	$0.84	$0.27	$0.44	$3.99	$0.22	$0.21
GRP growth rate pa (2008 to 2017)	2.8%	3.4%	1.7%	0.7%	2.9%	0.9%	1.4%
Population (2017)	96,657	12,628	5,316	7,887	61,554	6,115	3,157
Population Growth Rate pa (2008 to 2017)	0.8%	0.6%	0.2%	0.2%	1.0%	0.2%	-0.1%

[59] Based on data from Regional Development Australia Northern Inland NSW (https://www.economyprofile.com.au/northerninland/trends/population, accessed 30 August 2018). Walcha, and overall growth of GRP, estimated for period 2010 to 2017 based on data only being available for Walcha from 2010 onwards

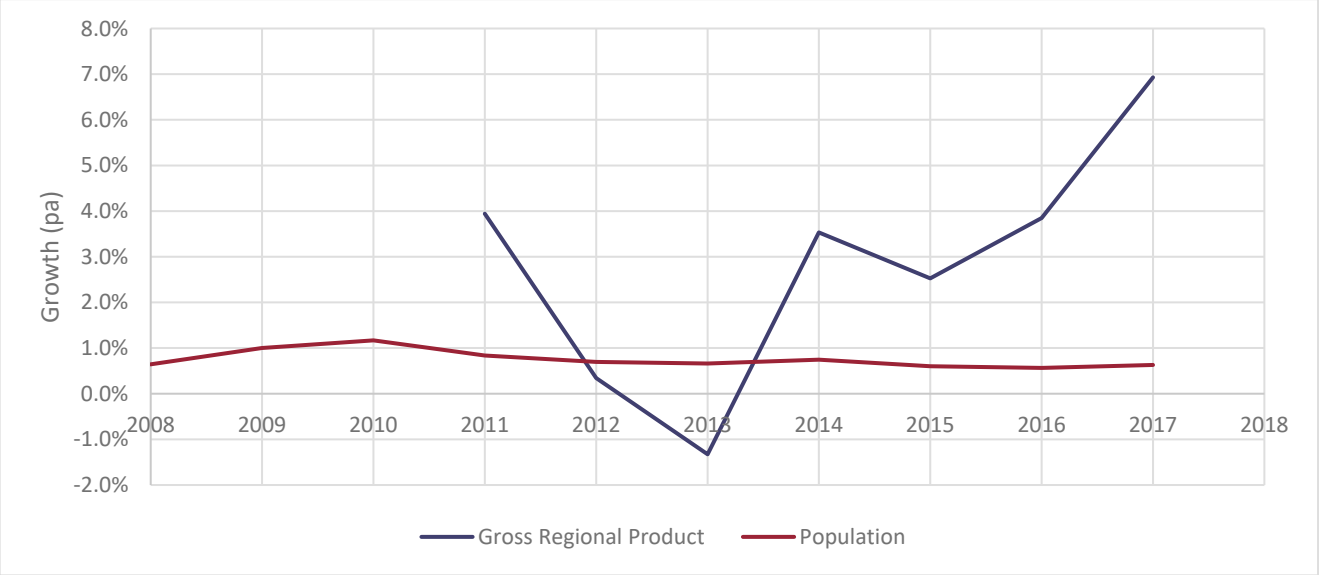


Figure 7-1. Economic and Population Growth Rates for Namoi JO

7.1.1 Tamworth 100K

In discussions with Tamworth Council, it was identified that strategic planning was underway to achieve a growth in the Tamworth Regional Local Government Area to 100,000 by 2041. With a population of 62,156 people in 2018 (ABS ERP), this represents a growth rate of approximately 2.1%pa, which is a significantly larger growth than is forecast for the wider Namoi JO.

With this level of growth in Tamworth, it is likely that surrounding regional centres, such as Gunnedah and Manilla, for example, would be influenced and may grow at higher rates than were forecast in the REDS. However, it is not clear what this growth rate might be.

7.1.2 Potential impact on demand for water

Tamworth

The largest growth is expected to occur in Tamworth urban area, where there is expected to be approximately 2.1% pa growth as identified above. Hunter H20 undertook assessments in 2015 and 2016 on the water demand within Tamworth under a range of growth scenarios, with the maximum growth rate of 1.25%pa.

A preliminary calculation was undertaken using the Hunter H2O (2016) estimates for high growth but incorporating 2.1% pa growth for residential properties. It is noted that this is likely to be a low bound estimate, given that there would be an associated increase in growth for commercial and industrial water users. However, it provides an indication of the general increase in water demand. This is compared with the medium growth water demand estimates from Hunter H2O (2016) (1% pa, or similar to the current rate of growth). This is summarised in **Figure 7-2**.

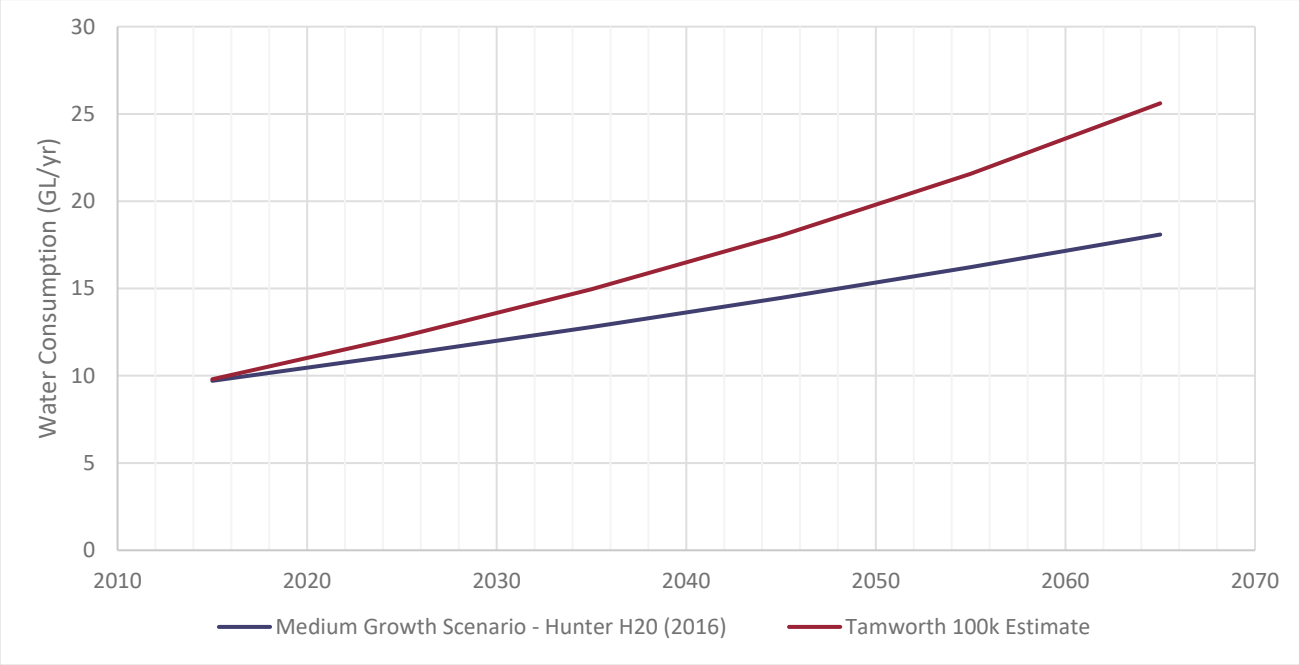


Figure 7-2. Water Consumption in Tamworth Urban Area[60]

Other Urban Areas

A yield study like the one undertaken for Tamworth has not been undertaken for the other urban centres within the Namoi JO. Instead, water usage estimates were available for the different council areas, as identified in Section 6.2. Some Councils have undertaken growth and forecast water use estimates as part of their Integrated Water Cycle Management strategies and Demand Management Plans. However, the majority of these studies are currently out of date and may not align with current growth forecasts. **Table 7-2** provides a summary of available water demand forecasts.

Table 7-2. Town Project Bulk Water Demands[61]

	Project Town Demand (ML/Yr)							
	2010	**2017**	**2020**	**2027**	**2030**	**2037**	**2040**	**2047**
Gunnedah		2,300		2,500		2,700		2,900
Curlewis		113		119		125		131
Mullaley		18		18		18		18
Tambar Springs		15		15		15		15
Tamworth	8,950		10,700		12,300		14,400	
Attunga	55.0		55.6		56.1		56.7	
Nundle	44.3		47.0		49.9		53.0	
Barraba	231		236		240		245	
Manilla	350		364		379		395	
Bendemeer	45.8		46.2		46.7		47.1	

[60] Derived based on data contained within Hunter H20 (2015, 2016). Secure yields shown are those under different climate change projections.

[61] Based on Hunter H20 (2017) Gunnedah Water Conservation and Demand management Plan and Hunter H20 (2012) IWCM Evaluation Study and does not consider Tamworth 100K forecasts

Estimating future water use is difficult, as it can depend not only on population growth but also on key industrial growth in the different areas. A new abattoir in Gunnedah, for example, would create a significant change in water demand.

To provide some indication of potential growth in water use, a rough estimate of water demand increase was undertaken assuming a direct correlation with population growth of around 1%pa. This analysis is shown in **Figure 7-3**, against existing water entitlement. In the absence of large industrial or commercial growth beyond this 1% pa growth, this preliminary analysis suggests that there may be sufficient entitlement for the next 40 years. However, the key issue is the reliability of this entitlement. A yield study would be required to understand more fully the reliable yield that can be drawn and to more accurately estimate the water demand for the different areas. For example, Hunter H2O (2015) estimated that Tamworth's secure yield would be around 18GL/a (with no climate change impacts), compared with the overall entitlement of around 22GL (roughly 80% of entitlement).

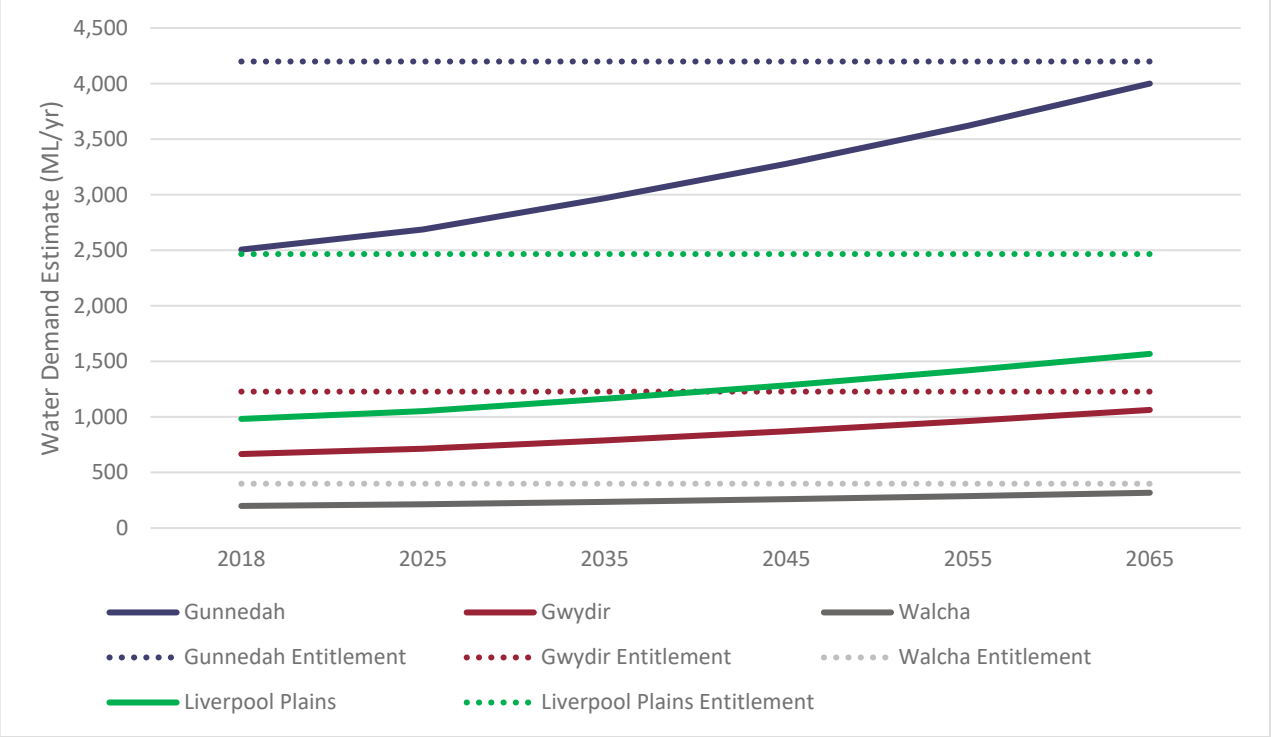


Figure 7-3. Potential Future Water Demand - Preliminary Estimate[62]

7.2 Planned and Potential Major Developments

There are a number of large planned and potential major developments within the Namoi JO. The key ones, in terms of size and potential influence on water demand, are identified in **Table 7-3**. The information in this table has been prepared primarily based on the stakeholder engagement (**Section 2**).

[62] Assumes a growth in water demand of 1% pa.

Table 7-3. Planned and Potential Major Developments

Future Developments	Description	Potential change to Water Demand	Water Supply
Tamworth Intermodal Freight Terminal & associated Glen Artney Industrial Area	This large development, located on the north west side of Tamworth, will utilise the rail spur in this location and establish an intermodal terminal. It is understood that this is likely to come online by 2021.	This will increase overall industrial processing in the vicinity of the intermodal. Water demand changes will be highly dependent on the industrial uses that are implemented in that area.	Tamworth Urban
Baiada Silverweir Development	Baiada is looking to expand its poultry abattoir in Tamworth. It is understood to process roughly 700,000 chickens per week, and now looking to expand to roughly 3 million chickens per week.	Existing water use is roughly 1.8ML/day (15-16L per chicken, total of 0.5GL/yr). This would increase to 8ML/day from the existing 1.8ML/day, roughly 2.5GL/yr. This represents roughly 25% of Tamworth's existing water demand. Options are currently being investigated for water reuse to bring water demand back to closer to existing levels.	Tamworth Urban
Manilla Poultry Development	A large scale poultry development is proposed (Baiada Chickens) near Manilla, related to the increase in abattoir in Tamworth.	Water use has been considered as a part of the DA and environmental approvals for this development.	Namoi Unregulated
Werris Creek Intermodal	A DA has recently been approved in Werris Creek, adjacent to the rail line, for an intermodal facility. It is understood that this will process timber (from Piliga and Nundle), cotton (Tamworth, Gunnedah and Narrabri) and potentially meat from Tamworth.	At this stage, it is unclear on the industries beyond the timber that will grow around this intermodal.	Liverpool Plains Urban
Shenhua Coal Mine	The Shenhua Mine will be located in the vicinity of Breeza. This is a large scale mine development. The timeframe for this is unclear.	While mining is generally not a significant user of water, it can have the potential to influence pricing of water trading as identified in Section 6.4.	Liverpool Plains/ Gunnedah Groundwater

7.3 Agricultural Developments

A detailed discussion on the general trends in the agricultural industry is provided in **Section 9**. This section focuses on major developments and changes in the agriculture in the Namoi JO, which are a step change outside of the background growth of different sectors.

The key one for the Namoi JO is the growth of poultry surrounding Tamworth. With the potential expansion of the Baiada processing plant (**Section 7.2**), there plant will have capacity for up to 3 million birds per week compared with the existing 700,000 birds. This is a dramatic increase in capacity that will drive further development of poultry farming in the surrounding area. An example of this increase is a recently approved large scale poultry farm near Manilla (as identified in **Section 7.2**).

Gwydir Shire Council has adopted a Circular Economy initiative designed to retain resources used/generated within shire, as far as possible, and circulate through the local economy. This process ensures that the costs of economic activity are minimised and optimises the use of available resources. The initiative is based on a regional scale agri-industrial system, incorporating a vertically integrated poultry sector, a biogas plant and a large-scale glasshouse system for the production of organic food. By integrating numerous industry types (power, crop production, chicken production, waste management), the local economy effectively becomes inter-dependent and the growth and efficiencies of one flow through to the growth and efficiency of others.

7.4 Special Activation Precincts

Special Activation Precincts are dedicated areas in regional NSW that have been identified by the NSW Government as places where businesses in many sectors will thrive. These precincts will create jobs, attract businesses and investors, and fuel economic development in regional NSW to ensure regions are well placed to grow and meet future economic needs. All Special Activation Precincts (SAPs) will be delivered as part of the $4.2 billion Snowy Hydro Legacy Fund[63].

At the time of preparation of this report, the Department of Premier and Cabinet (DPC) were undertaking investigations into the potential for a Special Activation Precinct centred around Tamworth. This would focus around the beef, lamb and poultry industries.

Based on discussions and presentations with DPC, it is understood that the scope of the precinct would not be limited Tamworth itself, but would attempt to also include a "catchment area" of farming in the surrounding areas. This catchment area would support higher intensity agriculture such as poultry sheds and feedlots. Namoi Unlimited recognises that the potential "activation" of Tamworth would provide acceleration opportunities for all five members councils of the JO.

It is understood that the aims of the Special Activation Precinct includes:

- Provide a planning structure against which future development of industry can work within, and to improve the approval processes for associated industry for the precinct such as intensive agriculture. For example, regional environmental studies might be undertaken to provide a more efficient pathway for approval of individual intensive agriculture development;
- Identify key infrastructure constraints, and upgrade as appropriate to improve overall efficiency (this may include transport, power, water etc).

While the work on the SAPs is wide ranging, and the above provides only a brief context, the key implications in regard to water are:

[63] https://www.nsw.gov.au/improving-nsw/regional-nsw/activation-precincts/

- Potential acceleration of intensive agriculture (poultry and feedlots for beef and lamb) in the region, particularly around Tamworth, Liverpool Plains and Gunnedah. This may see further acceleration in the growth of poultry (**Section 7.3**).
- Growth of associated industry, including abattoirs. For poultry, this is likely to be focused around the new Baiada abattoir identified above, as well as associated industries. For the beef industry, this may result in expansion of processing in Tamworth or potentially a new abattoir in Gunnedah. Both of these will increase water demand within the urban areas of Gunnedah and Tamworth.
- Growth in agricultural supply chains, particularly in the expansion of grain production in Gwydir to support larger feedlot and abattoir activities. Similarly, provision of additional feedlot locations will lower the cost of livestock production (both sheep and cattle) and encourage additional production. Expansion of both crop and livestock supply chains will increase overall water demand.

8 Water Security

8.1 Defining water security

Water security can be defined as the level of confidence that an individual may have in being able to access enough water to satisfy their water demand. This can apply to both current and future water demand levels. The level of water security may be affected both through:

- **Availability** and **Reliability** – there may not physically be enough water present within the water source to meet the requirement at the time at which it is demanded
- **Accessibility** and **Cost** – there are barriers (administrative, financial, physical, economic) that prevent the user from accessing a sufficient water source.

Within the Namoi JO there is a complex nexus of these four factors. The fundamental availability and reliability are based on the natural and evolving characteristics of the water sources within the region. However, this is moderated (both positively and negatively) through:

- Competing land use
- Competing water usage and demand
- Management by numerous authorities
- Application of variable Water Sharing Plans and Water Resource Plans and associated entitlements/allocations/extraction levels
- Use of a water market mechanism and associated imperfect market restrictions.

Both the actual and perceived level of water security have the potential to alter the concerns and investment decisions of individuals (e.g. crop choice, land-use choice). However, given the multifaceted nature of water security, it can be difficult to quantify security in a way that is common across all stakeholders. In particular, the accessibility and costs elements associated within water security are often highly location specific. As such the majority of water security assessments focus on availability and reliability as these are primarily characteristics of the water source as opposed to that of the governance structures, economic systems or individual water users. Similarly, this strategy focuses upon the availability and reliability of water resources within the region. For example, the NSW Office of Water (2013) recommended adoption of the "5/10/10 rule" as the basis of defining water security for NSW local water utilities when evaluating whether their available water sources are adequate.

The 5/10/10 design rule requires urban water storages to be sized so as to ensure that full unrestricted urban water demands can be supplied in wet, average and shorter dry periods but that moderate duration, frequency and severity of water restrictions will be required in extended drought periods. Under this design rule, the total time spent in drought restrictions should be no more that 5% of the time, restrictions should not need to be applied in more than 10% of years and when they are applied the water supply system should be able to provide 90% of the unrestricted dry year water demand (i.e. 10% average reduction in consumption due to water restrictions) through simulation of the worst drought on record, starting with storage at the restriction volume at which restrictions should be applied to satisfy the above 5% and 10% conditions. In essence this means that a resident can be highly confident that in all but the very driest conditions, at worst 90% of demand. Satisfaction of this criteria (for a given demand) indicates that the water source/supply for the urban area is said to provide a secure yield.

In contrast, no such criteria exist for individual agricultural landowners who manage their own water needs and do not necessarily have periods of restrictions forced upon them. Water security for individual landowners is typically associated with availability and reliability from sources as rainfall conditions vary. Typically, during periods of high rainfall, agricultural landowners have a lower reliance upon regulated or unregulated water sources and decrease their usage[64], while under periods of low rainfall agricultural landowners will seek to increase their extraction from catchment and groundwater sources to make up for the lack of rain. However, as the various identified water sources (**Section 5**) are dependent, to a greater/lesser degree, on catchment rainfall, it is often the case that in periods of high-water demand (e.g. drought) there is little water available within the available water sources. Consequently, rather than evaluate secure yield levels, landowners typically consider the frequency in which their full entitlement is available to them as a measure of water security. A water source from which they are able to extract their full entitlement (i.e. allocation is 100%) in every year would be considered a secure supply/ source.

8.2 Urban Water Security

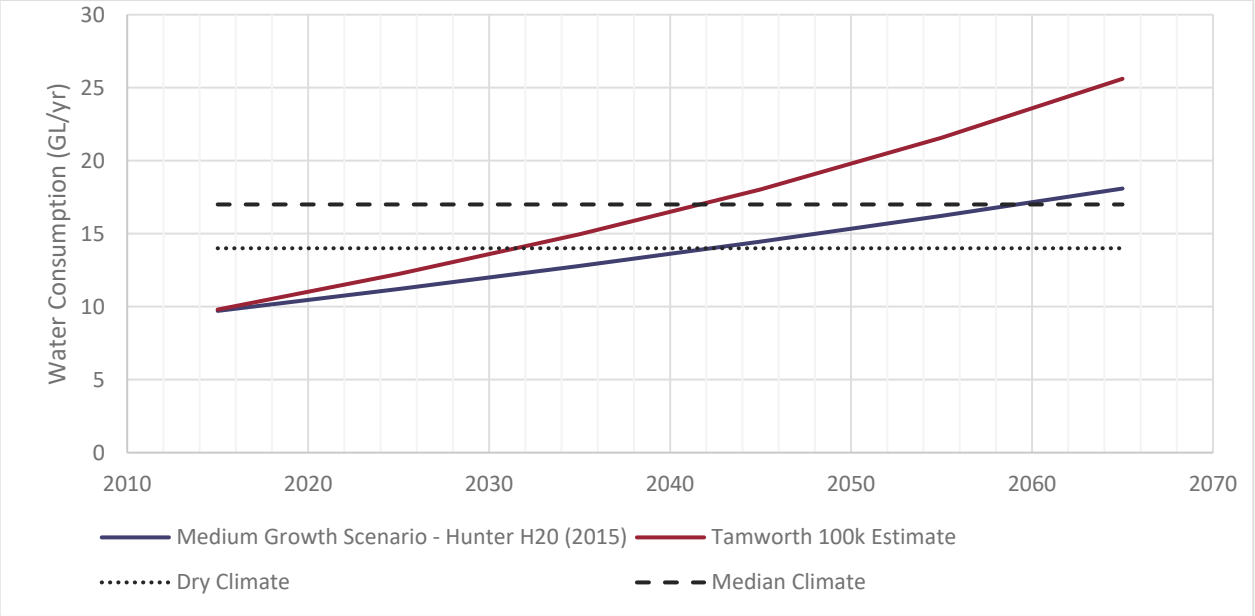
To date the only a small number of towns have undertaken Secure Yield Supplies in regard to their water security at satisfaction of the 5/10/10 rule:

- Tamworth (2012)
- Walcha (2015 & 2017).

As noted in **Section 7**, Tamworth has not currently revised its secure yield study to take account for its current forecast 100K growth strategy (although its 2012 yield study did incorporate the future Chaffey Dam upgrade). **Figure 8-1** shows the forecast water demand growth plotted against the forecast levels of secure yield that would be available under a dry and median climate change scenario. This suggests that, while the town may have sufficient security at the current time, the original growth rate estimates would see Tamworth exceeding the dry climate yield rate after 2040, and the median climate yield after 2060. By comparison, by considering just residential growth, the Tamworth 100k would result in meeting the dry climate yield by 2031 and the median climate yield by around 2041. While this is a very preliminary analysis, it highlights the need to update and review the yield analysis and the need to investigate options for Tamworth moving forward.

[64] Though it is noted that large irrigators will often maximise their extraction during high rainfall events and store water themselves for future use.

Figure 8-1: Tamworth forecast water demand against secure yield scenarios



Walcha undertook a secure yield study of potential additional storage options for the town based on the Apsley River McDonald River in 2015[65]. Under current climatic conditions the current unregulated McDonald River supply provides a secure yield of 108 ML/year, decreasing to 100 ML/year under likely adopted climate change scenarios. This is significantly below the average historic usage of 200 ML/year for Walcha (**Table 6-3**), indicating Walcha currently has poor water security.

In regard to other towns within the Namoi JO there is limited data regarding the formal definition of water security. As shown in **Figure 7-3**, the other LGAs maintain sufficient entitlement volumes relative to current and forecast demand to be able to supply requested increase in demand from an accessibility point of view. However, the availability and reliability of the relevant water supplies for individual towns is uncertain.

Figure 8-2 demonstrates the observed frequency in which Level 2 (or greater) urban water restrictions were applied/changed over a ten-year period by the local water utility. Gunnedah has no record of restrictions over this period, suggesting that its groundwater sources have both sufficient volume and reliability to meet current forecast demand. Within the other LGAs there is significant variation in the reliability and availability of the water supply between towns. This directly reflects the nature of the primary water source supplying the town (**Figure 8-3**). Towns relying on unregulated water sources (**Table 6-2**) typically have a much lower water security than those relying on regulated sources or groundwater.

[65] NSW Urban Water Sources (2015) Walcha Water Supply: Yield Study Report

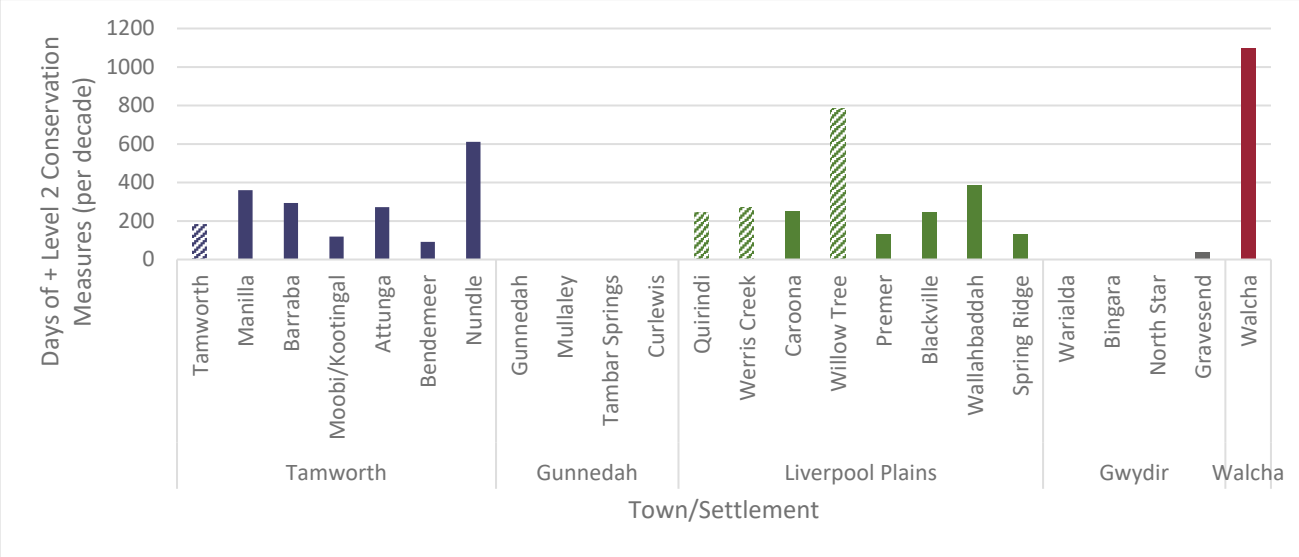


Figure 8-2: Frequency of water conservation measures within the Namoi JO[66]

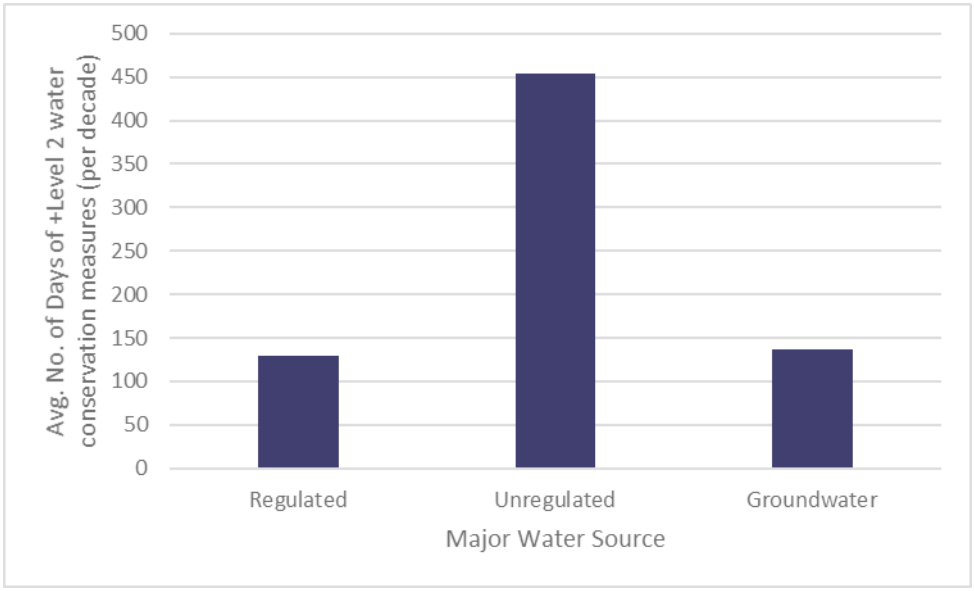


Figure 8-3: Occurrence of restrictions by water source

Although the groundwater supply within Gunnedah demonstrates historical security for urban supply, the complexity of groundwater systems and long-term cycles/recharge patterns may mean that undertaking a secure yield study against the forecast future water availabilities is recommended.

8.3 Agricultural Water Security

Water security for individual land owners is likely to reflect the observed reliability/availability patterns observed for the various water source types (**Figure 8-3**). Land-users with access to more than one water source are able to partial hedge security risk. However, as the three water sources are inter-related the periods in which there is a lack of availability of unregulated waters sources is often associated with increased

[66] Data provided by each Local Government as of March 2019. Hatched data indicates that recent upgrade works have been undertaken that may alter the frequency of water conservation measures being applied

groundwater dependency, drawdown and reduced accessibility (e.g. additional costs of groundwater pumping from greater depths, higher prices to purchase water), reducing overall security. Although it varies between activities, in general the volumes of rainfall in any one year is the primary factor in the need for extraction / use from any water source. This is particularly the case for lower intensity water users (e.g. livestock) in which under wet conditions there is limited need for extraction to occur.

Security for agricultural land users is ultimately represented by having enough water in any year to satisfy they demand (e.g. 100% secure water supply would mean that drought conditions would not alter their ability to utilise water to satisfy their demand). Currently, the accessibility of water to individual landowners is moderated by their water access licence (WAL) conditions and associated entitlements. In effect, the WAL entitlement represents an upper bound on the volumes of water potentially able to be accessed by an individual. The determination of WAL entitlements is a complex issue and stakeholder engagement activities undertaken as part of the project identified significant concern regarding the allocation of entitlements under the current various WSP and WRP across the Namoi JO. In particular, within the Gunnedah and Liverpool Plain regions, reductions in entitlements over the past 20 years are seen to be a key limitation to agricultural activity within the region. This concern reflects the fact that entitlement level needs to be sufficiently high to meet demand with dry and drought conditions, which will be typically substantially higher than the average annual usage volumes.

For example, **Figure 8-4** demonstrates the difference between entitlement and usage within the Upper Namoi groundwater resources. Groundwater use within the Peel Valley Alluvium is significantly lower than in the Upper Namoi Alluvium reflecting both the difference in reliability of those availability and accessibility of those resources, as well as the opportunity for landowners to access alternate water sources (e.g. the Regulated Peel River).

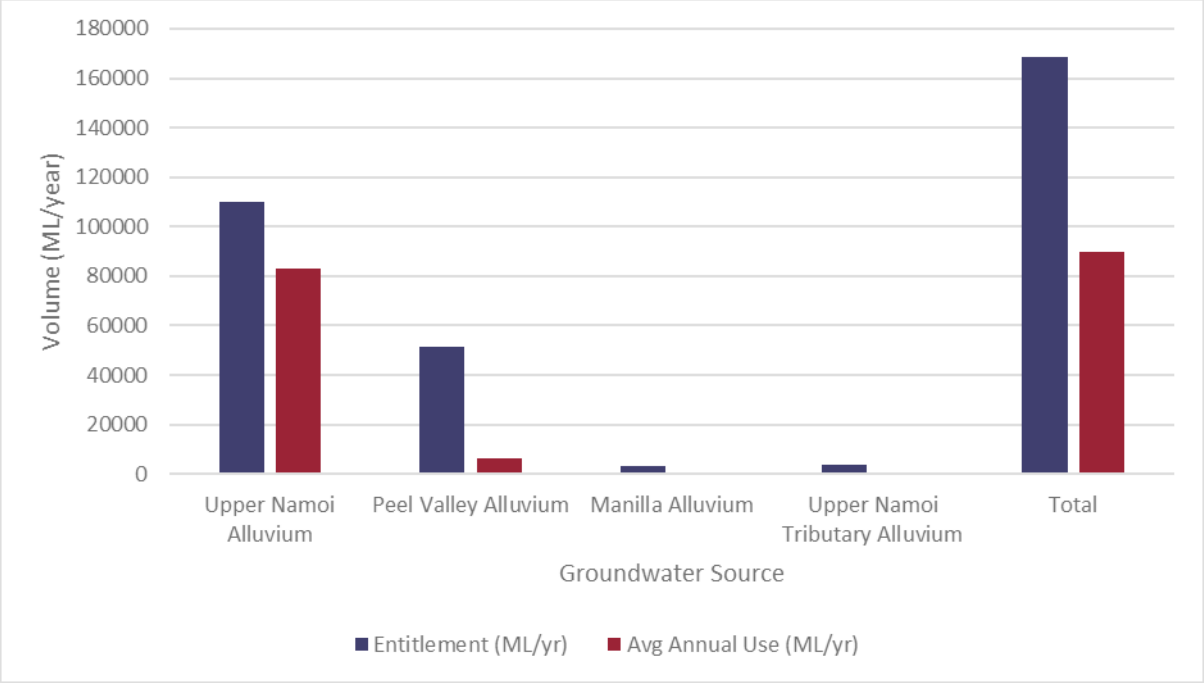


Figure 8-4: Upper Namoi Alluvium water sources

The entitlement value may even exceed the overall available or permissible extraction volumes. For example, within the Regulated Peel River, under the current Water Sharing Plan, total extractions from the regulated

water source must be limited to a Long-Term Average Annual Extraction amount of 15,100 ML per year. Accounting for historical average town water uses (which gets priority in terms of supply) of around 9,000 ML per year, this leaves 6,100 ML per year for remaining water users. The entitlement volumes of general security water users within the Regulated Peel River is 30,500 ML/year (**Table 5-3**). If total extraction volume is representative of a practicable water demand in drought periods (i.e. taking into account the cost of access), then any such over-subscription represents a reduction in the security of water supply to individuals.

The over subscription of entitlement in comparison to permissible extraction limits / sustainable diversion limits is a result of the process undertaken in establishing the WSP and WRP and is primarily a function of using historic average use volumes to determine extraction limits, while acknowledging the variable demand and land-owner usage rights in determining entitlements. An outcome of this is that individual landowners utilise their entitlements as a way of protecting security (i.e. storing up carryover volumes, not participating in trading) to ensure water supply in drier periods. This is somewhat in conflict with management procedures adopted by Water NSW in its management and allocation of regulated water sources which is designed to moderate flows such that water users can be confident that in any one year they will be able to access at least their average water usage volumes.

Stakeholder engagement activities undertaken with agricultural water users as part of the study identified that the confidence which individual landowners place in the security of water supplies is often associated with the measure of how frequently 100% of their WAL entitlement is made available within the various groundwater and surface water resources[67]. **Table 8-1** details the proportion of years in which a full allocation for general security water users is made available within each of the major regulated water sources[68].

Table 8-1 Water source allocation reliability

Water Source	General Security Water Entitlement (ML/yr) (2016)	General Security Water Usage (ML/yr) (2016)	Applicable Total Extraction Limit / Sustainable Diversion Limit (ML/yr)	Likelihood of 100% Allocation (avg over last 6-10 years)
Peel River	30,500	4,894	15,100	64%
Upper Namoi	9,886	3,678	238,000	88%
Lower Namoi	246,127	103,515		84%
Gwydir	509,665	169,538	392,000	63%
Border Rivers (Macintyre)	241,211	78,939	N/A	85%

It is seen that there is substantial variation between the water sources in terms of receiving full allocation. However, it is noted that the data source deriving these statistics vary between the water sources and may be affected by changes in management and infrastructure installed over this period. In particular, it is noted that

[67] WaterNSW will issue Available Water Determinations on annual basis determining what proportion of an individuals entitlement (its allocation) would be available for extraction based on water resource levels at the start of the allocation period and forecast inflows/extractions.

[68] It is noted that the waters sources extend beyond the Namoi JO boundary. Based on 2016/17 General Purpose Water Accounting reports for each water source prepared by DPI: Water Avaliability (AWD + Carryover)

the allocation statistics were based on end of year allocations (i.e. was the total allocation amount made available to users by the end of the allocation year). For a land-owner there is a significant difference in reliability of water supply if it is known that the full allocation is available at the start of the year as opposed to the end of the year. These limitations notwithstanding, an individual landowner will typically have between 60%-90% confidence that they will be able to access at least their historic average water use. There is no criteria currently applied determining whether this is a satisfactory level of security. Consultation with landowners would indicate that significant improvements in water security are required to support the region's agricultural activity.

The non-regulated resources available to landowners typically have greater accessibility as they are cheaper and require less management/administration costs but are more variable in availability.

It is also recognised that the land-use activity adopted, and its water intensity will affect the realised water security of an individual. For example, livestock production is typically a low water intensity activity (most access licences limited to stock watering). However, it is also the industry which may most often feel the first effects of the drought as it is proportionately more dependent upon rainfall to support feed production. The location of livestock production activities is such that they generally do not have good access to reliable water supplies (e.g. regulated rivers, high quality groundwater) as it is economically preferable to have higher water intensity activities undertaken in areas of high security.

8.4 Water Reliability Index

Based on the available water restriction information between the various water sources, an indicative reliability index was created based on:

- The individual WAL held, type and entitlement
- The water source to which the WAL applies
- The number of days in a 10 year period in which Level 2 water conservation measures occurred for the relevant water source within an LGA.

This does not take into account the severity or duration of the overall restrictions, not the degree of allocation reliability, but provides some general broad indication on reliability of water supplies. The results of this analysis are shown in **Figure 8-5**. It is considered that this represents a major element of water security.

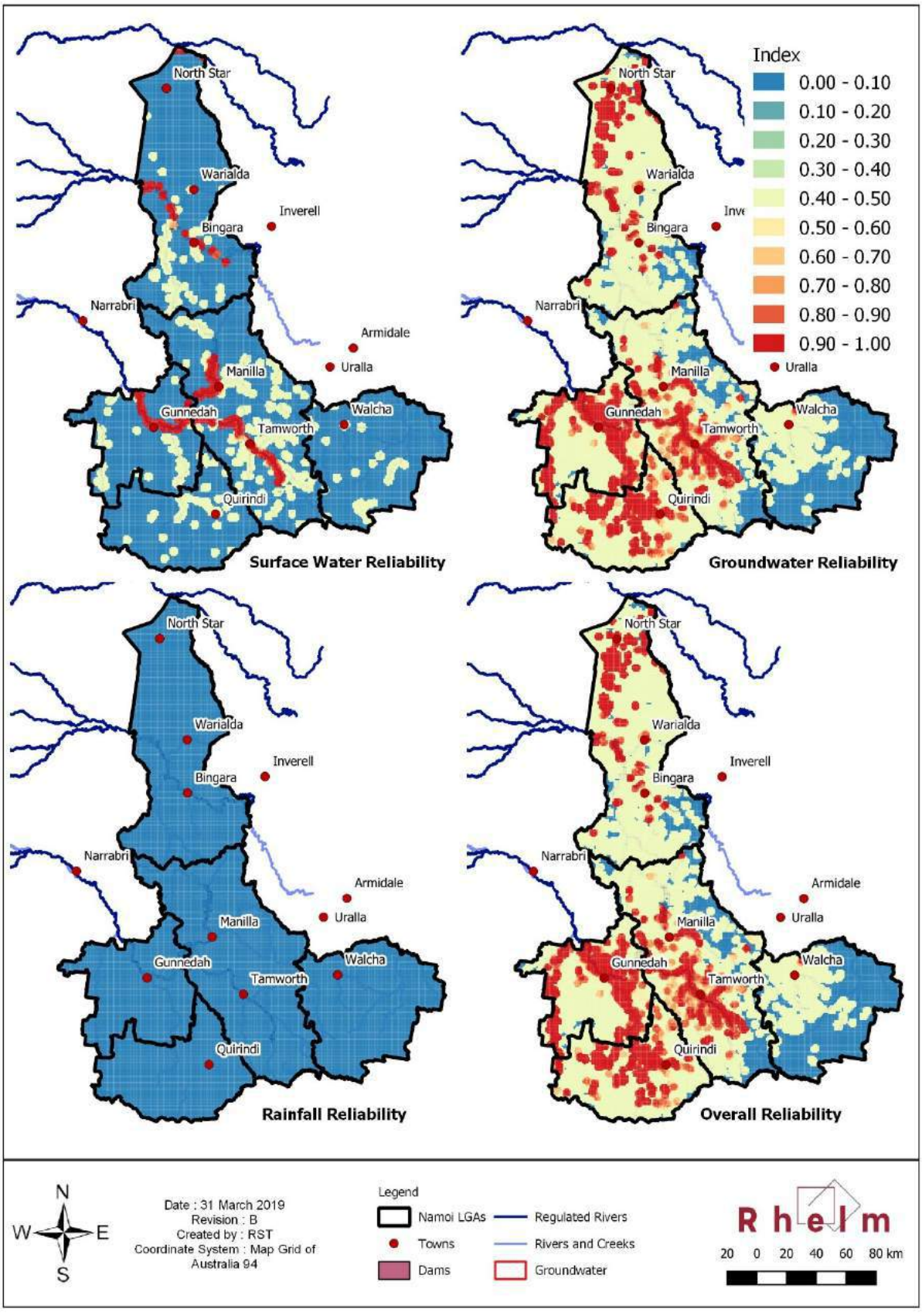


Figure 8-5. Water Reliability Index

8.5 Water Sharing and Regulation: Issues and Concerns

Stakeholder engagement activities undertaken as part of the project identified that the issue of Water Security was of high concern to the majority of agricultural landholders and a concern for some specific towns. Key issues identified are summarised in **Table 8-2**.

Table 8-2 Water Securities Issues and Concerns

Issue	Concern	Summary
Water Supply	Groundwater decline	Groundwater sources are recognised as the major source for agricultural activities within the Namoi JO, and the primary water supply source for the majority of towns within the Namoi JO. Stakeholder consultation identified high concerns regarding deteriorating groundwater supplies as a result of both increased dependency under drought conditions and the presence of new operations increasing groundwater usage (e.g. mining activities, proposed abattoirs). As detailed in **Section 4.3**, an observable declining trend in a number of the major groundwater sources and the current drought period has identified significant drawdown. There is a general assumption that groundwater levels are the responsibility of the State and there is a reliance upon their management. No sustainable yield studies have been undertaken for groundwater sources and limited evaluation as to whether the depth and number of bores currently in operation has been undertaken.
Water Supply	Timing of Water Use and Storage	The timing of water use requirements varies both with season and the use/crop/product. While AWDs may be issued by DPI Water meeting the definition of 100% of allocation being made available over the course of the year, it is often the case the landowner water investment decisions required certainty and availability of water supply at other points throughout the year. In particular, not all land-users have the potential to store water, meaning that even when flows released to provide a requested amount, their ability to practically use the water is limited.
Water Supply	Inadequate Entitlement	The State and Federal Governments implementation of The Basin plan was associated with significant buy back and redistribution of entitlements. In particular, landowners within Gunnedah and Liverpool Plains noted that the limitation on groundwater entitlements within the region diminished their water security.

Issue	Concern	Summary
Water Supply	Inadequate Sustainable Diversion Limits / Long-Term Average Annual Extraction Limits	While the entitlements to landowners may be high, the adopted Sustainable Diversion Limit / Annual Average Extraction Limits, ultimately play a larger role in determining water availability. Stakeholder engagements identified a strong opinion that the applicable limits were too low, limiting the development of water intensive industries.
	Water Market Distortions:	
Demand Management	Sleeper licences	The implementation of a water trading system has the potential to improve water security for individuals (or groups), allowing them to source water when and as required. However, a significant portion of water licences are not used or traded on an annual basis. This limits liquidity in the market and potentially increases trading costs. Non-trading of licences is often associated with: • Highly risk averse owners seeking better protection for the future • Individuals utilising water entitlement as a long-term investment • Lack of awareness of trading opportunities / mechanisms • Small / Lifestyle farming activities in which the magnitude of trade and associated transaction costs are high. Similarly, where a farm might have a small amount of "left over" water to trade, but the transaction costs are too high. It is understood that this is a particular problem for groundwater. With a market system, poor liquidity diminishes the availability and security of water
Demand Management	Market dominance	The implementation of a water trading system has the potential to improve water security for individuals (or groups), allowing them to source water when and as required. However, due to the structure of water trading there is potential for larger water buyers to significantly influence the market for a particular water resource. In particular, the presence of mining companies is anecdotally reported to drive up prices within a particular groundwater zones through market dominance (and their ability to pay significantly higher prices). Water price inflation may lead to smaller buyers being unable to access water when required for their production, decreasing reliability. Market dominance is also identified on the Peel River, where Tamworth is a significant entitlement holder, and can limit the overall amount of water available to trade in the much smaller Peel River catchment.

Issue	Concern	Summary
Demand Management	Valuation of Water	The various water sources provide different values of water. Unregulated surface water represents the cheapest but most unreliable water sources. Groundwater is moderately cheap in comparison to regulated water sources but also the most reliable. Within the Namoi JO, farmers and water users undertaking the same activity may pay substantially different prices to do so. High Price water represents an accessibility cost, decreasing the security of water.
Planning	Trade of between environment, town and country water use	The majority of non-local water utility water usage is undertaken as part of General Security Water access licences. General Security water access allocations are determined secondarily after consideration of environmental, town and high security water uses. Where there is a finite extraction limit applied (e.g. a sustainable diversion limit), any increase in environmental or town water supply will necessarily, ceteris paribus, lead to a reduction in the volume of water available for extraction to General Security users; increasing the security of one user at the expense of another.

9 Agricultural Trends and Water Resource Issues

9.1 State and National Agriculture Trends

Australian agriculture has changed substantially in recent decades and continues to change. The sector has demonstrated strong productivity growth leading to a major increase in agricultural output over time. While agricultural production has grown, the sector's share of the economy has declined due to growth of the services sector, falling from around 15.5% in 1960 to 2.7% in 2017 (PC 2005, World Bank 2019).

Within this overall trend Australian agriculture is characterised by substantial volatility in production over time due to Australia's variable climate. Australian agriculture also experiences considerable variation in the growth or decline in profitability between industries within the sector due to a variety of domestic and international factors. Key factors influencing the agricultural sector in recent decades have been:

- Productivity growth supported by new technologies and innovation
- Ongoing decline in the sector's terms of trade (the ratio of prices received to prices paid)
- Movements in consumer demand
- Changes in government policies, such as deregulation of some industries and other reforms
- Emerging consumer concerns about environmental and animal welfare management.

Australia's comparative advantages in agriculture include its large area of arable land, enviable biosecurity status, ease in doing business, technological advancement and innovative culture, high education levels, close proximity to export markets and low trade barriers (which are being further reduced under new free trade agreements) (Deloitte 2019). This includes Australia's reputation as a "clean and green" producer of food and agricultural products. Australia's key comparative disadvantages are generally; low and variable rainfall, water availability and water reliability issues, low soil fertility, an aged workforce, high labour costs and the cost implications of stringent regulatory requirements.

9.1.1 Declining Terms of Trade

There has been an ongoing decline in the agriculture sector's terms of trade (that is, the ratio of prices received for farm products to prices paid for farm inputs) - a trend which is also termed a "cost-price squeeze". The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) Australian farmers' terms of trade index fell by almost 2% a year over the past four decades to 2004 (Roberts et al. 2004). This trend has continued with a decline of 2.8% between 2013-14 and 2018-19.

9.1.2 Growth in Productivity and Production

Farm businesses (in aggregate) have been able to maintain profitability, despite declining terms of trade, by being able to lower per unit costs of production through increasing productivity. For example, Total Factor Productivity[69] growth in agriculture averaged almost 3% a year over the period 1974-75 to 2003-04 (or 2.3% in trend terms) which was considerably stronger than that achieved in Australia's market sector (1% in trend terms) (RIRDC 2007). Total Factor Productivity growth has been much higher on larger farms than smaller

[69] Total Factor Productivity (TFP), also known as Multifactor Productivity (MFP) is a measure of all outputs (such as crops, livestock, wool and dairy products) compared to all inputs (labour, capital, land, materials and services) used in production. TFP is a better indicator of productivity because it has a more comprehensive coverage of inputs than other productivity measures.

farms and there has been variation between industries in productivity growth, for example long-term productivity growth has been higher in the dairy than the sheep industries.

Key sources of productivity growth in agriculture have been the generation and adoption of new knowledge or technologies, such as:

- Development of better farm machinery and equipment
- Development of more effective herbicides, fertilisers and other chemicals
- Better breeding and more direct genetic modification of living organisms, which has improved plant and animal productivity - for example improving disease resistance
- Advances in the way that farmers have been able to bring available technologies and management practices together.

9.1.3 Structural Adjustment

In Australia, and globally, there has been an ongoing trend of fewer and larger farms. As noted above for productivity growth, this is linked to declining terms of trade which has created ongoing pressure on farm businesses to expand in order to capture the economies of scale available to larger enterprises. This has typically occurred as small farmers sell up to large-scale farming operations (ABS 2012). As a result, the number of farms in Australia declined by 106,200 (40%) over the 30 years to 2011 (ABS 2012).

There has been an associated concentration of production, with a dual nature emerging in the sector whereby a small minority of large commercial farms are responsible for the majority of production while many small farms account for a small share of output. In 2005, the Productivity Commission estimated that the largest 10% of Australian farm businesses produced over 50% of output while the smallest 50% of farms accounted for just 10% of gross farm output (PC 2005).

The last twenty years have also seen a shift towards more intensive farming and greater integration of farm production into the agri-food chain. This trend is reflected in both more intensive production systems (such as chicken meat, wine grapes, cotton and nurseries) and the adoption of more intensive production techniques (such as increased use of feed, chemicals and irrigation).

9.1.4 Growth in Exports

Australian agriculture is a significant exporter. This is despite it being a relatively small agricultural producer globally and representing a small proportion of the Australian economy. While the sector only directly generated 2.7% of gross domestic product and employed 2.5% of the workforce, it accounted for around 14% of total goods and service exports in 2016-17 (ABARES 2018).

The growth in agricultural production noted earlier has translated into growth in exports, with industries generally becoming more export-oriented. Over the last 20 years the value (in real terms, adjusted for inflation) of Australian agricultural, fisheries and forestry production has increased by 34% and the value of exports has increased by 37%. Around two-thirds of the total value of agriculture, fisheries and forestry production is now exported (ABARES 2018). As part of this trend the mixture of exports has become more diverse and there has been less reliance on traditional exports such as wool and wheat and growth in processed products such as wine and cheese.

9.1.5 Foreign Investment

Currently 4% of NSW land (by area) and 12% of Australian land is owned by foreign persons. Foreign ownership grew 2.6% in NSW and 4% in Australia in the two years to 2017-18. Livestock industries account for the large majority of foreign agricultural land ownership, at just over 85% of total foreign-owned land (ATO 2018).

Foreign investment represents another source of funding to the sector to potentially improve productivity and to enable some existing farmers to transition out of agriculture.

National wide data indicates the two largest foreign country owners of Australian land are the United Kingdom (10,239,000ha) and China (9,169,000ha). Combined, these two countries represent over 50% of all foreign land ownership within Australia.

9.1.6 Changes in Government Policy

There has been substantial regulatory reform in Australian agriculture over the last three decades in the following three key areas:

- Removal of tariffs and border protection measures for agricultural imports and farm inputs, including reforms to quarantine to balance pest and disease risk against trade benefits. A number of free trade agreements (FTAs) have been negotiated and executed, including the China-Australia FTA (2015), ASEAN – Australia – New Zealand FTA (2012) and Singapore-Australia FTA (2003).
- Dismantling of a wide range of producer support, price stabilisation and control schemes, protection measures and statutory marketing arrangements. This has included: removal of monopoly control by bulk grain handling organisations, removal of the single desk monopoly for wheat exports, removal of the wool reserve price scheme, deregulation of the dairy industry and reforming industry marketing and research and development organisations to become industry owned.
- Structural adjustment measures have included introducing incentives for agricultural producers to be more self-reliant, such as the introduction of Farm Management Deposits which assist farmers to save for bad years and reduce fluctuations in taxable income (ADA 2015).
- Implementation and subsequent renegotiation of the Murray Darling Basin Plan and buy-back of water entitlements from private and public WAL holders.

It is recognised that the Namoi Region agricultural sector has demonstrated significant adaptability and resilience to the implementation of these various changes in government policy.

9.1.7 Changes in Farmer Demographics and Agricultural Workforce

Key features of the Australian agricultural workforce are: a high proportion of self-employed, family and casual workers; long job tenure; and a relatively old workforce with comparatively low education levels and employee wages (PC 2005). However, there is a trend of an increasing ratio of employees to owner-operator/family staff and an improvement in educational attainment of workers.

There has been growth in the prevalence of small farms reliant on sources of off-farm income to maintain family farm incomes. For example, from 1990 to 2007 the proportion of farm families deriving income from off-farm wages and salaries increased from 30 to 45%, with average earnings more than doubling (PC 2005). Meanwhile the average age of farmers has increased significantly over the last two decades — from 44 in 1981 to 56 in 2017 (ABS 2016). This has been due to: 1) fewer young people entering farming, with reduced interest of the next generation to take over the farm; and 2) existing farmers working until they are older, with the first factor contributing to the second. The beef and sheep industries have the oldest and the horticulture and dairy industries the youngest farmer age profiles.

9.1.8 Changes in Consumer Demand and Environmental Concerns

There has been a general trend of growing consumer concerns about the performance of agriculture in the areas of environmental and animal welfare management. This has translated into growth in organic

production, which is perceived to be more environmentally friendly, and growth in free-range livestock production which is perceived to be more animal welfare friendly.

Growth in Organics

Organic certification relies on products being free from artificial chemicals, pesticides and fertilisers, and genetically modified organisms. Key products from the organic farming industry are beef, fruit, vegetables and poultry. Organic products generally receive higher prices but with higher costs. A typical premium to cost ratio of 1.6 to 2.1 has been reported in industry surveys (Australian Organic 2018).

The industry has grown considerably in recent years, with retail revenue rising from $1.3 billion in 2012 to $2.4 billion in 2017. Meanwhile, the number of organic certified operations in Australia grew between 2002 and 2017 in the following categories: primary producers (20%), processors (260%), handlers and other businesses (200%) (Australian Organic 2018).

Growth in the farm-gate value of production increased from $301m in 2012 to $1,583m in 2017. During 2014 to 2017 the organic sector's share of total farm gate value grew from 1% to 3%, with growth highest in fruit, vegetables, nuts, eggs and poultry meat (Australian Organic 2018). Meanwhile the value of exports (including processes products) grew from $126m to (10% exported) to $1,677m (30% exported).

Growth in Free Range Livestock Production

Research suggests that public values and attitudes towards animals are changing with increased public concern and emotional engagement about the treatment of animals (Cornish 2017). For example, in one survey 71% of Australians agreed that farm animal welfare matters to them when purchasing animal products (Coleman, Hay & Toukhsati 2005 in Cornish 2017). However, a gap has been observed between consumers' attitudes toward animal welfare and their purchasing behaviour, known as the 'attitude-behaviour gap' (Cornish 2017). Some of the reasons for the gap include inconvenience, lack of knowledge and information, and the abundance of confusing claims and labels on food packaging. However, despite this there has been growth in demand for production perceived as animal welfare friendly. For example, free-range eggs sales are up from 5% of egg sales in 2009 to 40% in 2016 (AECL 2016). Similar demand factors have also seen around 65–70% of Australia's meat chickens now coming from farms that are accredited under the RSPCA Approved Farming Scheme which sets standards above current legal requirements for animal welfare (ACMF 2019). However, as noted by DPI (2015) management has the greatest influence on animal welfare rather than production system.

9.1.9 Water Resource Trends

9.1.9.1 Water Use Efficiency

An increase in the value of water has provided incentives for improvements in water use efficiency. These improvements have occurred through better irrigation infrastructure such as the conversion of open channels to pipelines to reduce seepage and evaporation losses, and on-farm improvements such as installing automatic gates or outlets, water metering and automated irrigation systems. New opportunities to improve water use efficiency are emerging through use of remote sensing techniques and wireless communication systems and more versatile sensors to improve water use efficiency (Koech and Langat 2018).

9.2 Climate Change and Agriculture

9.2.1 Overview

Climate variability has always been a key challenge for Australian agriculture, although this varies between regions. Australia has less, and more variable, rainfall than most other nations. As a result, Australian agriculture is subject to more revenue volatility than almost any other country (ABARES 2019b). In the context

of this existing variability the emergence of climate change is presenting new challenges. Climate modelling predicts large changes in future rainfall including lower rainfall in southern Australia and more severe droughts and floods (ABARES 2019b). The last two decades of recorded data indicates substantial changes in the Australian climate with reductions in average winter rainfall in southern Australia and general increases in temperature.

Further discussion on the specific potential impact of Climate Change on the Namoi JO area is provided in **Section 3.4**. Stokes and Howden (2011) advise that many on-farm climate adaptation options are in-line with existing 'best practice' and do not require farmers to make sweeping changes to their operations in the short-term.

9.2.2 Grazing Industries

For the grazing industries, while research has shown that a rise in carbon dioxide tends to promote pasture growth, this could be counteracted by reduced rainfall which is particularly important for dryland grazing industries (DPI 2019). However, the interaction between carbon dioxide and the main drivers of plant growth (i.e. temperature, water and fertiliser) makes it difficult to determine the exact impact of climate change on the nutritional quality of pasture. Increased temperature and humidity would also impact directly on the productive capacity of grazing animals, particularly cattle. There is also potential for changing patterns of parasite risk to animals. For example, cattle ticks are the most serious external cattle parasite in the country and there is potential for the 'tick line' (the cattle tick boundary) to move further south (DPI 2019). This would change the requirements for animal health treatments. This is particularly relevant to the Namoi Region as the "tick line" is currently near the NSW/Queensland border, although infestations regularly occur in north-east NSW.

Adaptation to climate change is likely to require more flexibility and improved management of seasonal risk. An example of a risk management strategy for the extensive livestock industries is the maintenance of a higher proportion of animals in the flock/herd that can be readily sold in response to seasonal changes, while adaptation to increased heat stress could involve cross-breeding (DPI 2019).

9.2.3 Dryland Cropping

Climate change may exacerbate the impact of weeds, pests and diseases, through increased occurrence and changes in geographic distribution. There is potential for increased incidence of rust disease in crops and pasture species; however, a drier climate may reduce the impact of cereal diseases (DPI 2019). Higher levels of carbon dioxide are likely to increase plant growth, but the protein content of those plants is expected to be lower (CSIRO 2006).

A simulation study by Kokic et al (2005, in RIRDC 2017) found that marginal cropping and grazing areas, with few alternate production opportunities, may experience the largest productivity and land value changes. In many of these regions, the decline in wheat yields under the worst simulated scenario is expected to be greater than any likely increase in economic productivity from the adoption of new techniques and technology. CSIRO (2011) have identified some possible adaptations for cropping including changing to crop varieties that are more tolerant of heat and drought and changing planting times and practices for crops.

9.2.4 Cotton

CSIRO (2006) predicted a reduced number of cold days with climate change which would be beneficial to cotton production, however, the prediction of more days above 35°C may be detrimental (DPI 2019). Fibre quality of both irrigated and dryland cotton is significantly affected by both temperature and water availability

– world markets are increasingly focused on fibre quality. Because of this, managing fibre quality is likely to become a greater challenge to Australian cotton growers as the climate changes (DPI 2019).

As discussed in **Section 3.4**, climate change is likely to constrain water supply, reduce future water allocations for farmers and increase competition for water among water users (and therefore increase water prices). This is also likely to be increased pressure for irrigated cotton operations to become more efficient and responsive.

9.2.5 Intensive Livestock

An increase in temperatures could also require intensive livestock operations to redesign facilities or encourage them to relocate to a more favourable climate - this would require substantial investment and would impact on local communities (DPI 2019).

The other consideration for the livestock industries is finding opportunities to reduce Greenhouse Gas (GHG) emissions. In the pork industry GHG emissions are mainly associated with emissions from effluent ponds. The industry has identified the potential to reduce these emissions by up to 80% through emissions capture, destruction or use (biogas). The industry has a target to reduce emissions to 1kg carbon dioxide-equivalent per kilogram of pork produced (Australian Pork 2019). In the cattle feedlot industry, there may be opportunities to reduce emission by using methane-reducing feed additives and supplements.

There are several key feedlots within the Namoi JO (as identified in **Section 6.3**). It is expected that these feedlots will continue to grow, particularly with the potential for a SAP as identified in **Section 7.4**.

9.2.6 Horticulture and Viticulture

Higher temperatures would lead to inadequate winter chilling for some fruit trees, which may reduce fruit yield and quality. This is also expected for wine grapes – warmer temperatures may increase productivity but reduce quality, e.g. by 16 to 52% in the NSW Riverina for example (Webb, 2006). It could also compress the growing season for all grape growing areas.

9.3 Agricultural Industry Changes

This section outlines keys changes in each major agricultural industry relevant to the Namoi region. This is in the context of a sustained and ongoing growth in the local agricultural sector, largely due to growth in the value of broadacre (grains and hay) and extensive livestock production (primarily cattle, including cattle finishing in feedlots) (RMCG 2018).

9.3.1 Cotton

The Namoi region is a substantial cotton producer. Cotton can be grown as part of mixed farming operations with other crops such as wheat, chickpeas and sorghum and/or sheep and cattle. The average Australian cotton farm has around 500 hectares of cotton and employs six to seven people (Cotton Australia 2016).

Australia is the fifth largest cotton exporter, despite producing only 3% of world cotton - 99% of Australia's raw cotton is exported to key markets in Asia. Over the last decade Australian cotton production has been variable with the peak in production nine times larger than the trough, due to variations in irrigation water availability and growing conditions. Australian cotton yields are high by international standards, more than three times the world average (Cotton Australia 2016).

The cotton industry has been able to greatly reduce insecticide use through a combination of biotechnology and Integrated Pest Management Practices with a 92% reduction in average pesticide use between 1998-2003 and 2010-2015 (Cotton Australia 2017). The industry also reported a 40% increase in water productivity between 2003 and 2014 (CRDC 2012, NFF 2017).

Virtually the entire Australian cotton crop is made up of varieties with biotech traits. The development of new more cold-tolerant genetic strains has enabled cotton growing to be undertaken further south in NSW along the Murrumbidgee River and associated irrigation areas. For example, the town of Hay in the western Riverina, NSW has experienced a major economic boost with a large new area of cotton production and a new local cotton gin (processing facility) (Weekly Times 2014). A pre-requisite for the success of a local cotton industry is proximity to a cotton gin due to transport costs. The development of cotton to the south may affect the competitiveness of the Namoi Region, although cold summers still pose a key risk for southern NSW production areas.

9.3.2 Grains

The Namoi region is part of the Northern (mid and northern NSW and Queensland) grains production region which has diverse production. Key local grain crops are sorghum and cereals. In addition to grains lucerne fodder crops are also grown locally.

The broader Australian grains industry (total grains, oilseeds and pulses) has roughly doubled in value between 2004-05 and 2016-17. While wheat still dominates Australian grains production, pulses, particularly chickpeas has been a major source of industry growth.

Areas for productivity in the grains industry relate to biotechnology and plant breeding to develop new crop cultivars, development of agricultural chemicals, adoption of new cropping equipment, better fertiliser, and improved weed, pest and disease management practices (ABARE 2009, GrainGrowers 2015). One key potential area for productivity growth in the grains industry is Precision Agriculture. This refers to spatially-aware technologies supported by the use of global positioning systems (GPS). Most commonly this includes: the use of vehicle guidance to reduce overlap in application of agricultural chemicals, reduced traffic associated with tramlining to reduce compaction and operator fatigue, shielded spraying of pesticides in row crops, yield monitoring, variable rate technology (VRT) for application of agricultural chemicals and fertiliser, and within-paddock zone management for agricultural operations (Robertson, Carberry and Brennan 2007). While Precision Agriculture provides substantial scope for productivity gains, it requires substantial capital investment, and adoption in the industry is still ongoing.

9.3.3 Beef

Australia is a major exporter, exporting around 60% of its production. A major strength of the Australian beef industry is its disease free, 'clean and green' image, supported by the quality assurance and traceability provided by the National Livestock Identification System. The Australian beef industry has grown over time with enhanced export market access and many wool producers shifting to beef production.

Deloitte (2019) have forecast a long-term positive outlook for beef exporters due to the ongoing high demand for protein through growth in household incomes in Asia – and Australia's strong reputation for quality red meat products. Deloitte note that this may be somewhat offset by other industry issues such as dietary concerns over high red meat consumption and animal welfare concerns.

Ongoing opportunities for productivity improvement in the beef industry include pasture productivity and increased use of genomics to support better animal breeding.

9.3.3.1 Cattle Feedlots

There are 400 accredited feedlots in Australia, of which around one-third are in NSW, with an average size of 2,793 head – this represents 2-3% of Australian cattle. Cattle spend an average of 95 days in a feedlot or around 10-15% of average animal life span (ALFA 2015). There has been an ongoing trend of more cattle being

finished on grain in feedlots: with approximately 40% of all beef sold, and 80% of all beef sold in Australian supermarkets, now finished in a feedlot (RMCG 2018).

Key factors that could encourage the expansion of the feedlot industry are: diminishing available land resources for grazing, pressures to reduce greenhouse gas emissions and pressure to improve the general environmental performance of the Australian beef industry (MLA 2009).

In the sector, opportunities have been identified to improve efficiency in production, particularly regarding energy usage and waste stream resource recovery (MLA 2009). There has been a trend for greater integration in the sector with 22% of feedlot capacity now owned by meat processors. Unlike the pig and poultry industry, feedlots more commonly prepare feed rations on-farm.

Prerequisites for feed lotting are a supply of good quality, reliable water, access to grain supplies, a well-drained feedlot site, access to a reliable workforce and a temperate climate (RMCG 2018). Odour is less of an issue in feedlots, and less of a barrier to new developments, than broilers (chicken meat). However, there are still important environmental considerations for the approval of new major feedlot developments such as water runoff (RMCG 2018).

MLA (2009) estimate that the construction and operation of new 5,000, 15,000 and 30,000 standard cattle unit capacity feedlots will typically create jobs locally (nationally) of: 12 (35), 33 (97) and 60 (187) respectively, after flow-on effects are considered.

9.3.4 Sheepmeat

Australia's lamb consumption has remained steady and remains as one of the largest per capita consumers of sheepmeat in the world. Meanwhile Australia is a key lamb exporter, exporting nearly half of its production. The industry has shown a trend of increasing carcass weight and a steady increase in lamb production and exports over the last 20 years with saleyard and retail lamb prices also increasing over this time (MLA 2017). During this period the productivity gains among small and medium producers have been limited whereas larger producers have achieved productivity gains of around 0.9% (Boult and Chancellor 2019).

9.3.5 Wool

Australia is the largest wool-producing country in the world and dominates world wool production below 20 microns (fine and superfine wool) with NSW being Australia's largest producing state (DPI 2015). The industry has recovered from previous poor profitability, and a 20-year decline in production, but the outlook is for maintenance in industry size. Deloitte (2018) advise that wool's long-term growth prospects as a sector are looking far more positive than they have in previous years. One factor limiting a growth in wool production will be competition for land to produce food e.g. for cropping and lamb production (DPI 2015).

9.3.6 Intensive Poultry Production

9.3.6.1 Chicken Meat

The NSW chicken meat industry has been growing steadily in response to growing consumer demand. A key growth factor has been the relatively low cost of chicken meat compared to beef, lamb and pork as gains in farm production efficiency have contained retail chicken prices (DPI 2017). Efficiency gains have included improved breeding, which has increased average weights and reduced growing times, while the intensification and industrialisation of production has enabled higher slaughterings (DPI 2017).

There is a general migration of the industry away from the Sydney basin, due to issues with interacting with urban areas. Regions such as the Namoi region are attractive for chicken meat production because of low population density, proximity to grain supplies and not being too far from major population centres (RMCG

2018). The existing Baiada processing facility at Tamworth is a key factor that could facilitate future growth in the local industry, with the planned expansion of the abattoir facilities by approximately three-fold likely to see significant increase in poultry farming in the surrounding area. Potential strategic planning around the SAP (**Section 7.4**) would likely see further growth.

9.3.6.2 Eggs

The Australian egg industry has been growing in line with higher consumer demand, with declining demand from cage eggs offset by increasing demand for free range eggs. However, there has been no growth in the local industry. Other areas of NSW have attracted new egg operations due to having lower population densities and greater distance from other poultry producers to reduce biosecurity risk (biosecurity is a greater concern for egg farms than chicken meat farms). The egg industry is not constrained by the location of a processing plant (unlike chicken meat) with the sorting and packaging of eggs typically undertaken at the farm site.

9.3.6.3 Pigs

Pork is the second most consumed meat in Australia after chicken, having overtaken beef earlier this decade. Australians now consume around double the amount of pork as they did in 1975 (ABS 2015). The pork industry in Australia is one of the smallest livestock industries but is the only one competing with imported product (DPI 2015). It is generally based on intensive production systems. This includes vertically integrated operations in southern NSW. However, there has been a growth in the small outdoor production system sector, but higher biosecurity risk applies to outdoor production due to the populations of feral pigs in Australia - the outdoor sector still represents a very small proportion of the industry.

Local factors have seen a decline in the Namoi pig industry due to a lack of a local commercially attractive abattoir (RMCG 2018). This decline has included the closure of pig sale yards and decommissioning of the Gunnedah pig abattoir.

9.3.7 Other industries

While a dairy industry exists in the Namoi region, it is much smaller than the industries discussed in the previous sections. The key issue in recent years in the dairy industry has been low world and local prices making farm profitability challenging. This is in the context of long-term industry achievement in lifting production per cow, increasing herd size and improving farm productivity.

There is some production of fruit and vegetables in the Namoi region, although at a much smaller scale of irrigation than cotton. There is a large glasshouse tomato operation in neighbouring Guyra, outside the study area, operated by the Costa Group. Field grown green and French beans and pumpkins are also grown in the wider area. At a state level the horticulture industry has exhibited healthy growth with the value of production and exports having increased substantially in the last five years. This has been driven by strong local demand while processing improvements are also enhancing the quality, suitability and convenience of vegetable products for export and sale locally.

At a local level New England is NSW's newest wine region area and now represents around 0.1% of the NSW grape crush.

9.3.8 Potential New Industries

As well as the above mainstream industries there is ongoing work to identify new industries. For example, AgriFutures Australia, a statutory corporation established to grow the long-term prosperity of rural industries, has identified the following potential new agricultural industries which may have relevance to the Namoi region: sheep milk, hemp seed, buffalo milk, lavender oil, deer (venison), and taro. There is a myriad of other

potential industries, including intensive production systems such as edible cricket (insects) which are already farmed in NSW and Western Australia (ABC 2017).

10 Water Dependency of the Economy

10.1 Community Vulnerability

Different areas within the Namoi JO have different levels of vulnerability to water availability, security and use. Understanding this potential vulnerability provides some context to the likely areas that will be more resilient and those that may be more susceptible to changes in water supply.

Stenekes *et al* (2012) prepared vulnerability indicators across the Murray-Darling Basin on vulnerability of communities to changes in water availability (due to a range of different potential factors). These vulnerability indicators comprised of two key components:

- Sensitivity – representing how dependent a community is on changes in water availability
- Adaptive Capacity – representing the ability of a community to change and adapt to changes in water availability.

Adaptive capacity was a metric that was derived based on indicators of resources available to a community, through human capital, built capital, natural capital, social capital and financial capital. It was developed based on ABS data and some other regional information to form up an understanding of the potential adaptive capacity. This includes, for example, measures on education within the community, economic diversity etc. The adaptive capacity indicator was based on a score of 0 to 1, scaled across the entire Murray-Darling Basin. This is summarised in **Figure 10-1**. Higher scores represent greater adaptive capacity for an area.

Sensitivity, by comparison, is based on the general sensitivity of the community to water availability. This includes, for example, how dependent an economy might be on irrigation water, based on the amount of irrigation farming. This was formed based on ABS data and other regional sources, and included exposure to agricultural industry through employment, amount of economy in agriculture etc. The sensitivity indicator was based on a score of 0 to 1, scaled across the entire Murray-Darling Basin. This is summarised in **Figure 10-1**. Higher scores represent higher sensitivity to changes in water availability.

The overall vulnerability index was then formed by combining the sensitivity and adaptive capacity indices. This is summarised in **Figure 10-1**. Higher scores represent greater vulnerability to changes in water availability.

It is noted that the Walcha LGA is largely not within the Murray-Darling catchment, and therefore was not included in this mapping.

Generally speaking, areas around the larger centres of Tamworth and Gunnedah have lower vulnerability to lower water availability, due to the combination of their lower reliability on agriculture within the townships and their greater adaptive capacity, through diverse economies, education levels and mobility of the workforce.

Areas outside these larger centres are generally more vulnerable. This includes towns like Bingara, which are more strongly tied to the surrounding agriculture.

However, while this provides a general indicator on overall vulnerability, there remain some limitations in this approach. For example, the large abattoirs in Tamworth (including poultry and beef) are reliant on the agriculture, albeit not specifically counted as agriculture. Reductions in output from surrounding agricultural areas will have a direct impact on output and employment in these areas.

Similarly, agricultural provides an input to many of the industries in Tamworth (whether it be small or large), and reductions in agricultural output can have a knock-on effect to these industries.

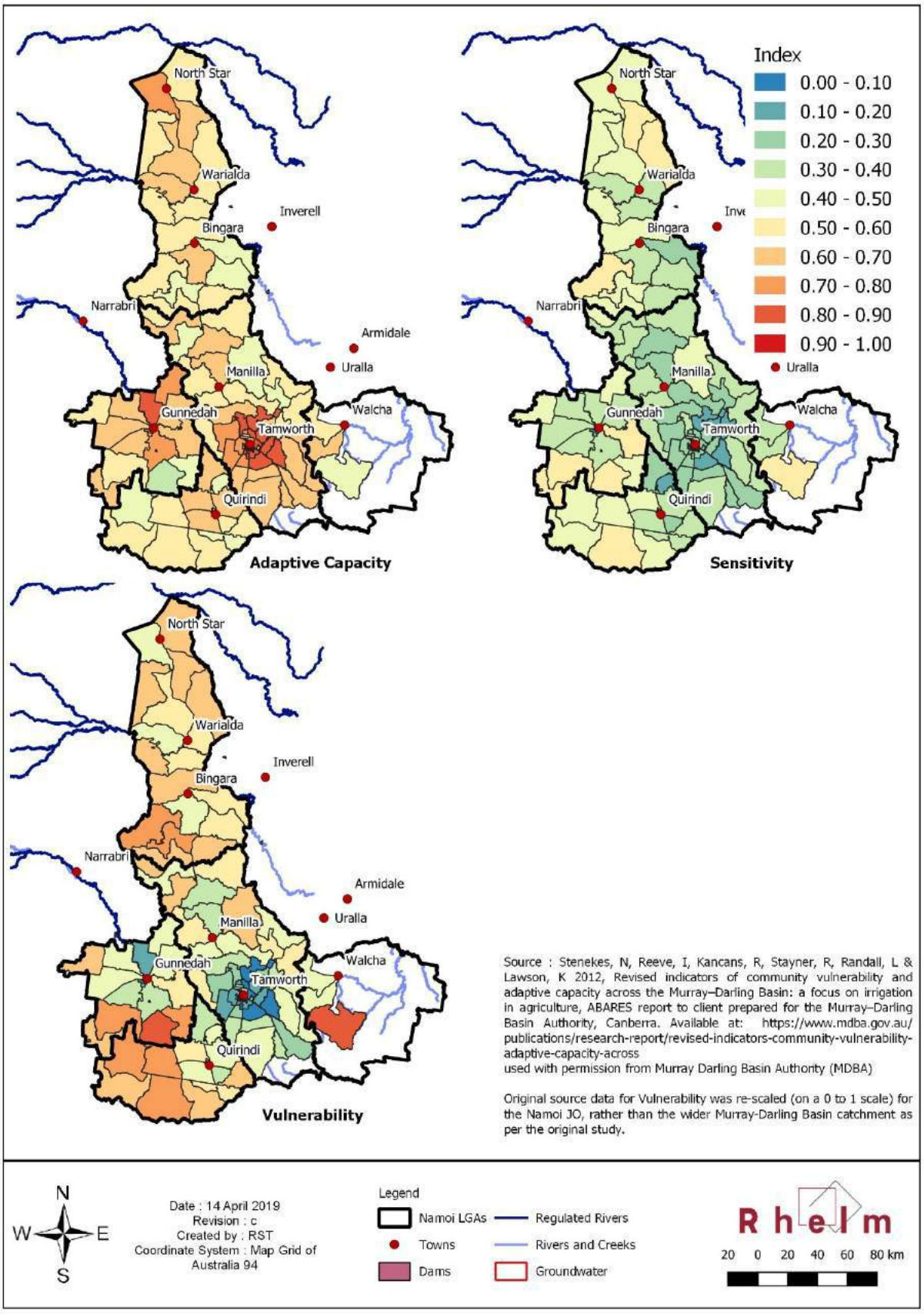


Figure 10-1. Water Vulnerability Index

10.2 Economic Impacts of Water Availability

The above indicators on community vulnerability provide a general indication of susceptibility of different areas within the Namoi JO. Further details on the impact of water availability come from more detailed economic models that can trace the impacts throughout the entire economy on key changes, including reductions in water availabilities.

Deloitte (2012) undertook an assessment of the value of water to the Namoi catchment. This study used a combination of three models:

- Water and landuse model of the Namoi Catchment
- Computable General Equilibrium (CGE) model of the Namoi Catchment
- A community level disaggregation resilience model.

These three models were used to understand potential changes in the economy as a result of water availability through reductions in rainfall and water entitlements, the latter which may be driven by climate change or through policy changes.

Several scenarios were analysed. The key one, and worst case in terms of reductions in water availability that was analysed, is provided in **Table 10-1**. The average rainfall and average water extraction allocation volume are assumed to be the result of climate change, whereas the total water extraction entitlements are a result of potential policy changes within the Murray-Darling Basin.

Table 10-1. Summary of Deloitte (2012) Drier Future Scenario

Parameter	Long Term Average	Projections	
		2019	2030
Average Rainfall (mm)	578	-0.2%	-0.4%
Average water extraction allocation volume	69%	-2.5%	-5.0%
Total water extraction entitlements (ML)	497,000	-8.5%	-8.5%
Overall impacts on extractive water availability		-10.8%	-13.1%

A key challenge with this work is that it is focused on the entirety of the Namoi catchment, which skews its application to the Namoi JO area through the presence of larger irrigators downstream. However, it is still useful to provide broad insights into the changes in the economy as a result of reductions in water availability. Further, some additional granularity is provided in the report for regional performance, which is discussed below.

By 2030, agricultural production was modelled to decline by 2% under this scenario. Overall, the economy (through GRP) was estimated to contract by 0.4% compared with the business as usual case.

The impacts on agriculture are not uniform, with some parts of the agricultural industry being more exposed than others. A summary of these changes is provided in **Figure 10-2**. As expected, industries that are more heavily reliant on irrigation were more heavily impacted, with cotton having the largest impact of over 8% reduction. It is noted that dry-land cropping actually increases, but this was driven by switching from cotton to dry-land cropping. Deloitte (2012) noted that while output from dry land increases, the yield per hectare fell.

Beyond agriculture, the reduced output from the agricultural sector and the associated reductions in incomes etc. results in flow through impacts to other industries. A summary of the results from the modelling are provided in **Figure 10-3**.

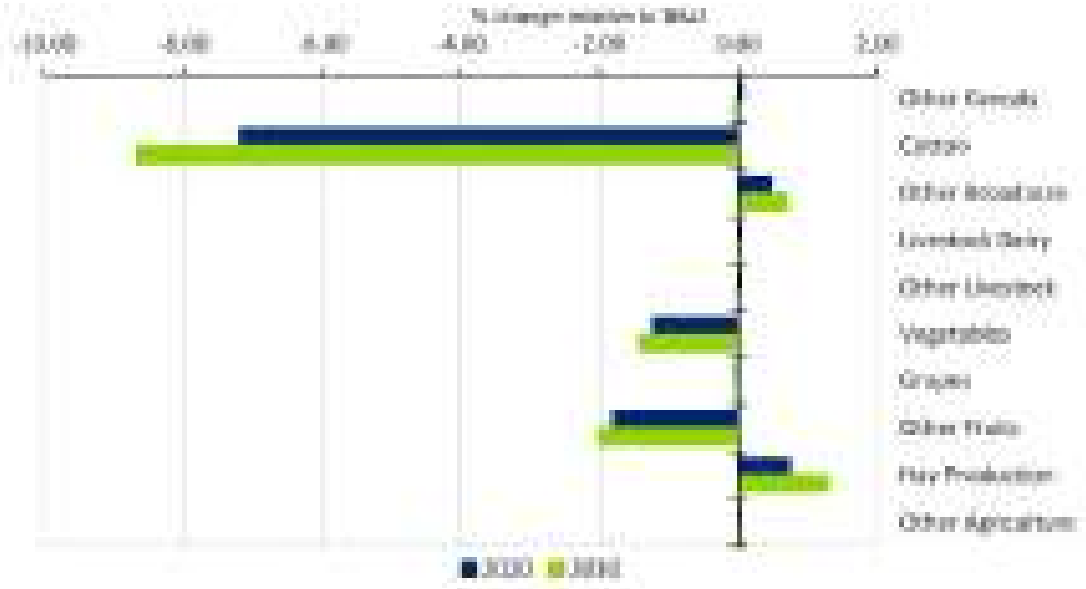


Figure 10-2. Change in Agricultural Output (Deloitte, 2012)

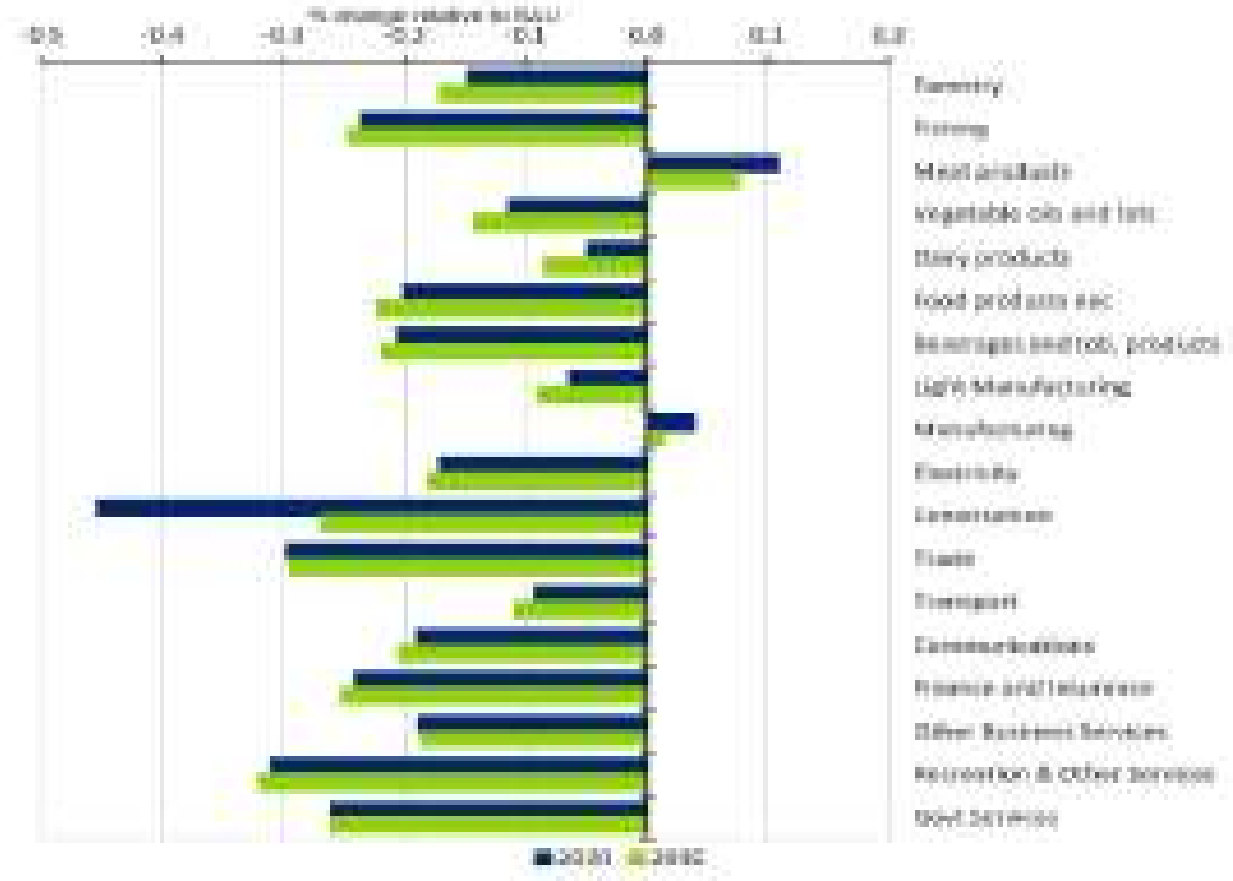


Figure 10-3. Flow on Impacts to Other Industries (Deloitte, 2012)

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Appendix A – Data Register

Category	Document	Publisher	Date	Brief summary	Type	Keywords
Water Sharing Plan	Water Sharing Plan for the Gwydir Unregulated and Alluvial Water Sources 2012: Background document	NSW Department of Primary Industries	Jul-16	Covers 28 unregulated river surface water sources that are grouped into one extraction management unit (EMU) and the Upper Gwydir Alluvial groundwater source	Report	Rivers Groundwater
Water Sharing Plan	Water Sharing Plan for the Gwydir Regulated River Water Source 2016	NSW Department of Primary Industries	Jul-16	Legisaltion of WSP	Legislation	Rivers Groundwater
Water Sharing Plan	NSW Floodplain Harvesting Policy	NSW Department of Primary Industries Office of Water	May-13	Information on Floodplain Harvesting Policy that provides a framework for licensing floodplain harvesting extractions.	Report	Water management Floodplain
Groundwater Status Reports	Upper Namoi Groundwater Source – Status Report 2011	NSW Department of Primary Industries	Nov-12	Describes the status of the groundwater resources of the Upper Namoi Groundwater Source, in terms of quantity, quality and management as observed over the period 2006 to 2010, since the commencement of the Water Sharing Plan	Report	Groundwater
Groundwater Status Reports	Lower Namoi Groundwater Sources Summary Report 2006-2013	NSW Department of Primary Industries	Aug-13	Information on Lower Namoi groundwater sources managed under the water sharing plan	Report	Groundwater Extraction Limits
Groundwater Status Reports	Lower Namoi Groundwater Source Groundwater Status Report – 2008	Department of Water and Energy	Jun-09	Presents the status of the Lower Namoi Groundwater Source, Groundwater Management Area 001, for 2006–2008.	Report	Groundwater Extraction Limits
Groundwater Status Reports	Peel Valley Catchment Groundwater Status Report – 2010	NSW Office of Water	Mar-11	Presents the status of the groundwater resources of the Peel Valley catchment.	Report	Groundwater
Groundwater Status Reports	Lower Gwydir Groundwater Source Summary Report 2006-2015	NSW Department of Primary Industries	May-15	Describes the framework for managing these groundwater sources in Lower Gwydir until the end of June 2017	Report	Grounwater
Water Resource Plan	Gwydir Alluvium Water Resource Plan (GW15): Status and Issues Paper	NSW Department of Primary Industries	Feb-17	This Status and Issues paper summarises the status of water resources and issues that DPI Water will consider when developing the Gwydir Alluvium Water Resource Plan	Report	groundwater
Water Resource Plan	Gwydir Surface Water Resource Plan: Basin Plan Implementation	NSW Government	Oct-18	Explains out how NSW will meet its obligations under the Murray–Darling Basin Plan 2012 (Basin Plan) in the Gwydir Surface Water Resource Plan Area (Gwydir Surface WRPA).	Report	Surface Water Ground Water Water Quality
Water Resource Plan	Namoi Water Resource Plan: Surface Water (SW14) Status and Issues Paper	NSW Department of Primary Industries	Feb-17	Summarises the status of water resources and issues that DPI Water will consider when developing the Namoi WRP (Surface Water).	Report	Surface Water
Water Resource Plan	Namoi Water Resource Plan: Surface Water Resource Descriptio	NSW Department of Primary Industries	Apr-18	Summarises the Namoi Catchment characteristics	Report	Surface Water
Water Resource Plan	Gwydir Water Resource Plan: Surface Water Resource Description	NSW Department of Primary Industries	Apr-18	Summarises the Gwydir Catchment characteristics	Report	Surface Water
Water Resource Plan	Water Resources and Mangement Overview: Border Rivers Catchment	NSW Department of Primary Industries	Apr-12	Summarises the catchment characteristics of the Border Rivers	Report	Surface Water Ground Water
Water Resource Plan	NSW Border Rivers Surface Water Resource Plan: Surface Water Resource Description	NSW Department of Primary Industries	Dec-18	Summarises the status of water resources and issues that DPI Water will consider when developing Border Rivers WRP	Report	Surface Water Ground Water
Water Resource Plan	Namoi Alluvium Water Resource Plan Groundwater (GW 14) Status and Issues paper	NSW Department of Primary Industries	Mar-17	Summarises the status of water resources and issues that DPI Water will consider when developing the Namoi Alluvium WRP.	Report	Goundwater
Long Term Water Plan	Gwydir Long Term Water Plan Part A: Gwydir catchment	Office of Environment and Heritage	Aug-18	Explains water management strategies for maintaining and improving the long-term health of the Gwydir's riverine and floodplain environmental assets and the ecological functions they perform.	Report	Water Management Environmental Water
Long Term Water Plan	Gwydir Long Term Water Plan Part B: Gwydir planning units	Office of Environment and Heritage	Oct-18	Information on how water is managed in Gwydir Zone A and Zone B Planning Units. Includes layouts of the main watercourses, the lateral extent of the managed floodplain and groups of priority assets with similar water requirements.	Report	Water Management Environmental Assets
Operations Plan	Gwydir Operations Plan: August 2018	Water NSW	Aug-18	Water Operations Reports provide updates on water system operations per valley. It includes information on current state (storage volumes, water availability, resource assessment and supplementary events), influences and forecast and planning.	Report	Storage Water availability
Operations Plan	Gwydir Operations Plan: November 2018	Water NSW	Nov-18	as above	Report	Storage Water availability
Operations Plan	Namoi Peel Operations Plan: August 2018	Water NSW	Aug-18	as above	Report	Storage Water availability
Operations Plan	Namoi Peel Operations Plan: November 2018	Water NSW	Nov-18	as above	Report	Storage Water availability
Water Security	Regional Water Availability Report	Water NSW	Dec-18	Summarises information on regional water storage in NSW	Report	System Risks Storage Dam Levels
Water Security	Water Availability in the Namoi A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project	CSIRO	Dec-07	Describes the assessment undertaken for the Namoi region as part of the CSIRO Murray-Darling Basin Sustainable Yields Project	Report	Rainfall-runoff Modelling River System Modelling Surface Water Ground Water
Water Security	Current Water Accounts and Water Quality for the Namoi Subregion	Department of the Environment Bureau of Meteorology CSIRO Geoscience Australia	Feb-16	Northern Inland Catchments Bioregional Assessment for the Namoi subregion (Bioregional Assessment Programme)	Report	Surface Water Ground Water Water Quality
Water Security	Floodplain Inundation Mapping and Modelling in the Northern Regions, the Murray Darling Basin	CSIRO	Sep-16	Provides technical details of the project including data gathering and processing, various methods and tools used for flood mapping and modelling, the results of model calibration and validation and final outputs produced.	Report	Flood Mapping Inundation Modelling
Water Security	Tamworth Bulk Water Supply - Long Term Augmentation Options Review	Hunter H2O	Nov-15	This report encompasses the first step in determining the preferred long term augmentation strategy- a high level assessment of long term agmentation options for Tamworth town water supply.	Report	Water Supply
Water Security	Gunnedah Integrated Water Cycle Management Strategy	Woodlots & Wetlands	2010	Provides information on integrated Water Supply Management for Gunnedah	Report	Council Water Supply
Water Security	Gunnedah Shire Council Drought Management Plan	Hunter H2O	Jul-17	Drought management strategy with some useful information on Council usage of water	Report	Council Water Supply
Water Security	Gunnedah Shire Council Water Conservation & Demand Management Plan	Hunter H2O	Jul-17	Forecast of water demand within Gunnedah LGA	Report	Council Water Supply
Water Security	Liverpool Plains Shire Council Water Asset Management Plan	Liverpool Plains Shire Council	2012	Provides a summary of water infrastrcuture	Report	Council Water Supply
Water Security	Liverpool Plains Shire Council Regional Water Supply Strategy	Liverpool Plains Shire Council	2017	Outline of proposed upgrades fo Quirindi, Werris Creek and Willow Tree	PPT	Council Water Supply
Water Security	Tamworth 2016 Demand Management Plan	Hunter H2O	Jun-16	Update of demand and use forecast from 2012 IWCM	Report	Council Water Supply
Water Security	Tamworth Regional Council Integrated Water Cycle Management (IWCM) Evaluation Study	Hunter Water Australia	2012	IWCM for Tamworth	Report	Council Water Supply
Water Security	Walcha IWCM Evaluation Study (Part 1)	Walcha Council	2010	IWCM for Walcha - forms the first part of an Integrated Water Cycle Management (IWCM) strategy for Walcha Council's water utility services	Report	Council Water Supply
Water Security	Walcha IWCM Simplified Strategy (Part 2)	Walcha Council	2010	Summary of main actions from the IWCM	Report	Council Water Supply
Water Security	Walcha Water Security Options Assessment Report	GHD	2018	Review of options to improve Walcha watersupply and a potential new dam	Report	Council Water Supply
Water Security	Walcha Council Drougt Management Plan	Hunter H2O	Jul-17	Draft version of drought management strategy with some useful information on Council usage of water	Draft	Council Water Supply
Water Security	Assuring Future Urban Water Security: Assessment and adaption guidelines for NSW Local Water Utilities	NSW Department of Primary Industries	2013	Draft - Outlines the process to assess water secutiry and identifies the 5/10/20 rule	Draft	Water Security
Water Security	Centroc Regional Integrated Water Cycle Management Plan	MWH	2013	A regional IWCM capturing a vast number of Councils with recommendations for regional sharing	Report	IWCM
Water Security	20 Year Infrastructure Options Study Rural Valleys (Summary Report)	WaterNSW	2018	Details the state's existing rural bulk water supply systems and provides a strategic level assessment of infrastructure solutions to mitigate or improve long-term level of service issues in the regulated valleys.	Report	Water secutiry
Water Security	Integrated Water Cycle Management Strategy Plan: Liverpool Plains Shire Council	Liverpool Plains Shire Council	2011	Details LPSC IWCM Stategy Plan	Report	IWCM

Water Security	Water and Australia's Future Economic Growth	Roberts, Mitchel & Douglas (Industry, Environment and Defence Division, the Australian Treasury)	N/A	This article examines how water in Australia is currently allocated and used, and explores some of the consequences of current water management arrangements.	Paper	National Water Initiative Water Management
Water Security	Gunnedah 2018 Draft Integrated Water Cycle Management Strategy - Issues Paper	Hunter H2O	2018	Update of Gunnedha IWCM (draft) / includes 30-year water demand and sewage loadings projections and provides a summary of the key water supply and sewerage management issues (IWCM issues) that Coun are facing or are likely to face in the short to medium term.	Report	IWCM
Water Security	Namoi Water Alliance Deed	Namoi ROC	2015	Water Alliance agreement between member councils	Deed	Water Utilities
Water Recovery Plan	Water Recovery under the Basin Plan as at 31 October 2018	Department of Agriculture and Water Resources	Oct-18	Total water recovery figures under the basin plan	Data	Surface Water
Murray-Darling plans	Murray-Darling Basin Plan: Five-year assessment	Productivity Commission	Aug-18	Draft report prepared for further public consultation and input on the Murray-Darling Basin Plan: Five-year assessment	Report	Basin Plan Water Resource Planning
Murray-Darling plans	Murray - Darling Basin Government Storages 28 November 2018	Murray–Darling Basin Authority	2018	Map showing current storage volumes for Northern Basin, Lachlan and Southern Basin	Map	Storage Volumes
Murray-Darling plans	Murray - Darling Basin Government Storages 28 November 2018	Murray–Darling Basin Authority	Dec-18	The information on water in storage in the Murray–Darling Basin as at dec 2018	Data	Storage Volumes
Murray-Darling plans	The Northern Basin Review	Murray–Darling Basin Authority	Nov-16	The economic, social and environmental outcomes from water recovery in the northern basin	Report	Water Recovery Basin Plan
Murray-Darling plans	NSW Groundwater Environmental Monitoring, Evaluation and Reporting Plan *Basin plan implementation/monitoring/ evaluation & reporting* (MER)	NSW Department of Industry	Sep-18	Describes the expected groundwater environmental MER programme for all NSW groundwater WRPs.	Report	MER Groundwater
Murray-Darling plans	Murray-Darling Basin SDL adjustment mechanism Report by the Victorian and NSW Ministers' Independent Expert Panel	Independent Expert Panel	Apr-17	The Independent Expert Panel's review of the Sustainable Diversion Limits adjustment mechanism (SDL adjustment mechanism) and in particular the application of the mechanism, key assumptions, interpretation and environmental outcomes for Murray-Darling Basin	Report	Sustainable Diversion Limit
Murray-Darling plans	The proposed 'environmentally sustainable level of take' for surface water of the Murray–Darling Basin: Method and outcomes	Murray–Darling Basin Authority	Nov-11	Describes the method used by the MDBA to determine the Environmentally Sustainable Level of Take (ESLT) for surface water resources and describes the environmental objectives, ecological targets and environmental outcomes that can be achieved under the proposed ESLT.	Report	Sustainable Diversion Limit Basin Plan
Murray-Darling plans	NSW Healthy Floodplains project: Fact Sheet	NSW Department of Industry	Jun-18	A summary of facts about the NSW Healthy Floodplains project	Fact Sheet	Floodplain Management
Water Trading	Strategic Priorities Basin Plan Water Trading Rules	Murray–Darling Basin Authority	N/A	Assesses the relative importance that each rule under the Basin Plan water trading rules (Chapter 12) has on the achievement of the water market and trading objectives set out in Schedule 3 of the Water Act 2007.	Report	Water Trading Rules Basin Plan
Water Trading	Australian Water Markets Report 2016–17	Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)	N/A	Analysis of data on water trading in Australia	Report	Water Trading Water Market Agriculture Water Supply/ Demand
Water Trading	Water Markets in NSW	AITHER	Mar-17	Analysis of status of key water sources and their trafing history, of high relevance to the study	Report	Water Trading Water Market Agriculture Water Supply/ Demand
Water Trading	Future scenarios for the southern Murray–Darling Basin water market	ABARES	Aug-18	Analysis of what would happen to the water market under a repeat of the Millennium drought, with current water demand, environmental water recovery, trade limits and carryover rules.	Report	Water Market Water Demand
Extreme Events	Policy framework for the management of NSW Murray–Darling Basin water resources during extreme events NSW Extreme Events Policy	NSW Department of Industry	Oct-18	Provides a framework to manage extreme events in the Lower Darling and Barwon-Darling river systems and the Namoi, Gwydir and Macquarie river systems in northern inland NSW	Report	Exterme Events
Extreme Events	NSW approach to managing extreme events Extreme events policy	Michael Wrathall NSW Government	N/A	Overview of NSW government approach to extreme events (droughts)	Presentation	Exterme Events
Water Accounting	General Purpose Water Accounting Report 2014–2015 Namoi Catchment	NSW Department of Primary Industries	Feb-16	Annual summary of the available water resources and the water resource management that occurred during the period of 1 July 2014 to 30 June 2015	Report	Water Accounting
Water Accounting	General Purpose Water Accounting Report 2016–2017 Namoi Catchment	NSW Department of Primary Industries	Apr-18	Annual summary of the available water resources and the water resource management	Report	Water Accounting
Water Accounting	General Purpose Water Accounting Report 2016–2017 Peel Catchment	NSW Department of Primary Industries	Apr-18	Annual summary of the available water resources and the water resource management	Report	Water Accounting
Water Accounting	General Purpose Water Accounting Report 2016–2017 Gwydir	NSW Department of Primary Industries	Jul-18	Annual summary of the available water resources and the water resource management	Report	Water Accounting
Water Accounting	General Purpose Water Accounting Report 2016–2017 Borders River Catchment	NSW Department of Primary Industries	Jul-18	Annual summary of the available water resources and the water resource management	Report	Water Accounting
Catchment Overview	Water Resources and Management Overview - Borders Rivers Catchment	NSW Department of Primary Industries	Apr-12	This report provides supplementary information to other components of the Gwydir Water Resource Plan including the Gwydir Risk Assessment, Water Quality Management Plan, and Salinity Management Plan.	Report	Catchment Overview
Catchment Overview	Water Resources and Management Overview - Gwydir	NSW Department of Primary Industries	Apr-18	This report provides supplementary information to other components of the Gwydir Water Resource Plan including the Gwydir Risk Assessment, Water Quality Management Plan, and Salinity Management Plan.	Report	Catchment Overview
Catchment Overview	Water Resources and Management Overview - Namoi	NSW Department of Primary Industries	Apr-18	This report is intended to provide supplementary information to other water resource reports for the Namoi Water Resource Plan including the Status and Issues Paper (DPI Water 2017a), the Risk Assessment and Water Quality Management Plan (this covers the Peel as well)	Report	Catchment Overview
Legal	Water Sharing Plan for the Gwydir Regulated River Water Source 2016	Parliamentary Counsel's Office	Jun-18	Legislation related to Water Sharing Plan for the Gwydir Regulated River Water Source 2016	Legislation	Water Sharing
Economic Development Strategies	Southern New England High Country Regional Economic Development Strategy 2018–2022	NSW Government	2018	Sets out a long term economic vision and associated strategy for the region that encompasses the Armidale Regional, Uralla Shire and Walcha Local Government Areas	Report	Economic Development
Economic Development Strategies	Southern New England High Country Regional Economic Development Strategy 2018-2022 — Supporting Analysis	NSW Government	2018	Details the Strategy's methodology, evidence and development process of Southern New England High Country REDS	Report	Economic Development
Economic Development Strategies	Lower North West Regional Economic Development Strategy 2018–2022	NSW Government	2018	Sets out a long term economic vision and associated strategy for the functional economic region encompassing Tamworth Regional, Gunnedah Shire and Liverpool Plains Shire Local Government Areas	Report	Economic Development
Economic Development Strategies	Lower North West Economic Development Strategy 2018-2022 — Supporting Analysis	NSW Government	2018	Details the Strategy's methodology, evidence and development process of Lower North West REDS	Report	Economic Development
Economic Development Strategies	Upper North West Regional Economic Development Strategy 2018–2022	NSW Government	2018	Sets out a long term economic vision and associated core strategies for the functional economic region encompassing the Moree Plains Shire, Narrabri Shire, Gwydir Shire and Inverell Shire local government areas.	Report	Economic Development
Economic Development Strategies	Upper North West Economic Development Strategy 2018-2022 — Supporting Analysis	NSW Government	2018	Details the Strategy's methodology, evidence and development process of Upper North West REDS	Report	Economic Development
Economic Development Strategies	Tamworth Regional Infrastructure Strategy	Tamworth Regional Council	2014	Details Tamworth Regional Infrastructure Strategy which seeks to support the delivery of the community vision by collating into a single high level document the range of regionally significant capital works projects that are considered important for respective Tamworth Regional Councils to pursue over the next 20 plus years.	Report	Economic Development
Economic Development Strategies	Liverpool Plains Shire Economic Development Strategy 2017 - 2020	Liverpool Plains Shire Council	2018	The Economic Development Strategy provides the direction and framework to encourage, support and facilitate economic development within Liverpool Plains Shire.	Report	Economic Development
Economic Development Strategies	New England North West Regional Plan 2036	NSW Department of Planning & Environment	2017	Details New England North West Regional Plan 2036 which guides the NSW Government's land use planning priorities and decisions to 2036	Report	Economic Development
Economic Development Strategies	New England North West Regional Plan 2036: Implementation Plan 2017 - 2019	NSW Department of Planning & Environment	2017	Details the priorities and purspose of New England North West Regional Plan 2036	Report	Economic Development
Economic Development Strategies	Gunnedah Economic Development Strategy vol 1	Gunnedah Shire Council	2018	Provides framework and direction for economic development within GSC	Report	Economic Development
Economic Development Strategies	Gunnedah Economic Development Strategy vol 2	Gunnedah Shire Council	2018	Provides framework and direction for economic development within GSC	Report	Economic Development
Economic Growth	Apsley Dam Economic Benefit Study	Regional Development Australia	2017	A regional economic model estimating the impacts of improved water supply on Walcha	Report	Economics
Economic Growth	Kamilaroi Destination Management Plan	N/A	2018	Kamilaroi Corridor tourism growth strategy	Report	Economic gorwth
Economic Growth	Tamwoth City Growth Corridors	Tamworth Rehional Council	2018	Map of development strategy	Map	Growth Corridors

Economic Growth	New England North West Intensive Agribusiness Strategy: Data and Gap Analysis and targeted stakehold consultation	RMCG	2018	Opporuntities for Agri-business within New England	Report	Agribusiness
Socio-Economics	Murray-Darling Basin Authority (MDBA) Community Conditions	Murray–Darling Basin Authority	2016	Summary of socio-economic conditions within local communtiies	Web	Socio Demographics
Socio-Economics	LGA Community Trends - Gunnedah	NSW Department of Planning & Environment	2018	Summary of socio-economic conditions within local communtiies	PPT	Socio Demographics
Socio-Economics	LGA Community Trends - Gwydir	NSW Department of Planning & Environment	2018	Summary of socio-economic conditions within local communtiies	PPT	Socio Demographics
Socio-Economics	LGA Community Trends - LPSC	NSW Department of Planning & Environment	2018	Summary of socio-economic conditions within local communtiies	PPT	Socio Demographics
Socio-Economics	LGA Community Trends - Tamworth	NSW Department of Planning & Environment	2018	Summary of socio-economic conditions within local communtiies	PPT	Socio Demographics
Socio-Economics	LGA Community Trends - Wlacha	NSW Department of Planning & Environment	2018	Summary of socio-economic conditions within local communtiies	PPT	Socio Demographics
Agriculture	Gunnedah Shire Council Intensive Agriculture opportunities	Gunnedah Shire Council	2018	Map of intensive agriculture locations	Map	Agriculture
Agriculture	LPSC Dryland Agriculture Mapping	Liverpool Plains Shire Council	2018	Map of dryland agriculture	Map	Agriculture
Climate Change	New England North West Climate Change Snapshot	Office of Environment and Heritage	2014	Provides an overview of climate change impacts in New England North West	Report	Climate Change
Climate Change	Western Enabling Regional Adaptation - New England North West Region Report	Office of Environment and Heritage	2017	Provides an overview of climate change impacts, industries and people affected and potential adaptation pathways	Report	Climate Change
Water Resources	Namoi Bioregional Asssessments	Australian Government	2016	Assessment of vulnerabilty to coal mining/groundwater impacts	Web	Coal Mining Ground water
Water Resources	The value of water to Namoi Catchment	Deloitte	May-12	Economic impacts of a drier future on the Namoi economy	Report	Rainfall Climate Change Agriculture
Water Resources	Commonwealth Environmental Water Portfolio Management Plan Namoi–River Valley 2018–19	Commonwealth Environmental Water Office	2018	Sets out the plans for managing the Commonwealth environmental water portfolio in the Namoi River Valley for 2018–19	Report	Environmental Water Portfolio Management
Water Resources	Rainfall Runoff Modelling Across the Murray Darling Basin	CSIRO	2008	This is a report to the Australian Government from CSIRO. It is an output of the Murray-Darling Basin Sustainable Yields Project which assessed current and potential future water availability in 18 regions acr the Murray-Darling Basin considering climate change and other risks to water resources.	Report	Water Availability Climate Change Water Resources
Water Vulnerability	Revised indicators of community vulnerability and adaptive capacity across the Murray–Darling Basin	ABARES	2012	This document presents revised measures of community vulnerability, including refined subindicators of sensitivity and adaptive capacity that were previously developed for the MDBA to assess community vulnerability.	Report	Agriculture Irrigation
Tourism	Gunnedah Destination Management Plan	Gunnedah Shire Council	2019	Website with resources showing tourism growth plans for GSC	Website	Destination Management Tourism

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