



Appendix U2

Economic assessment (macroeconomic analysis)

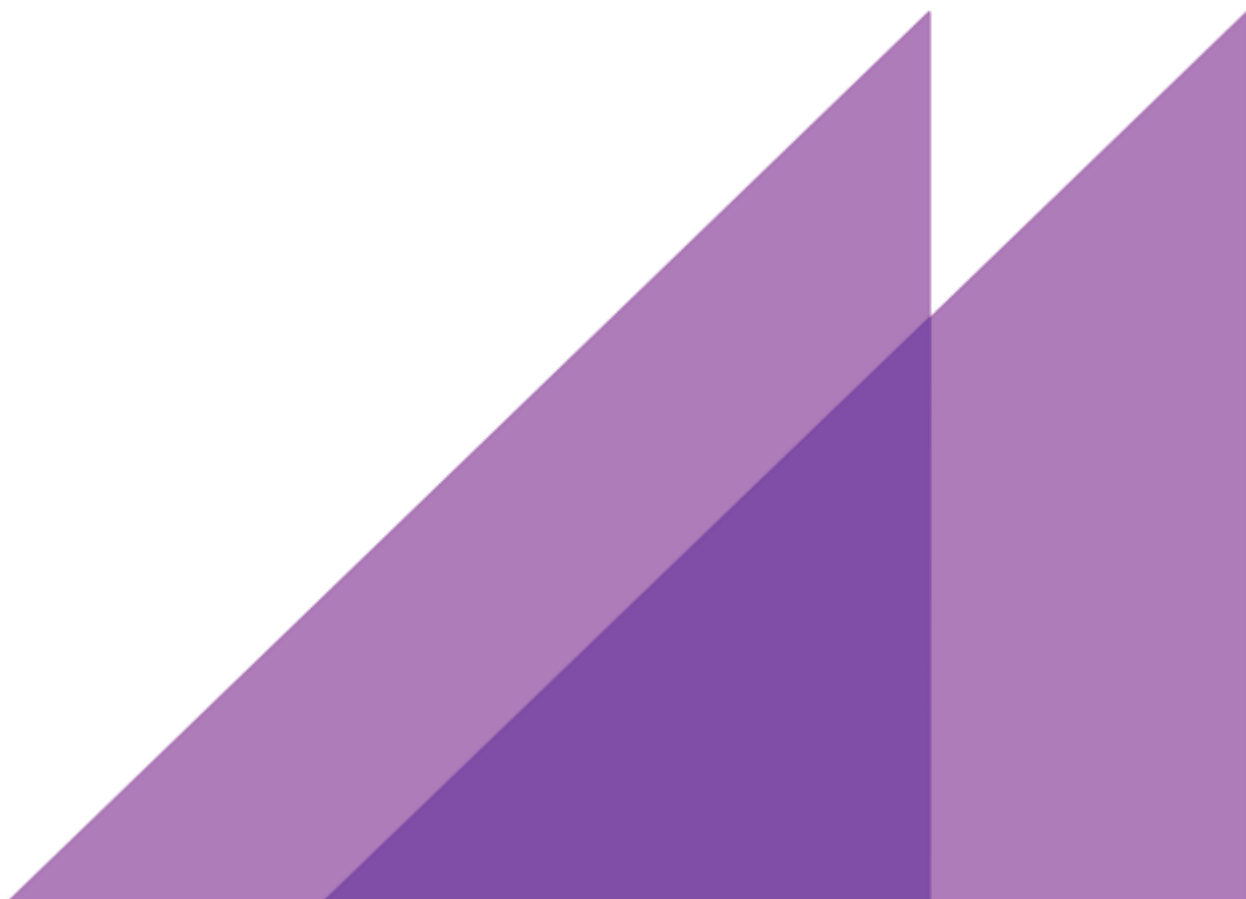
REPORT TO
SANTOS NSW (EASTERN)

AUGUST 2016

NARRABRI GAS PROJECT



Appendix U2
ECONOMIC IMPACT REPORT





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1 Introduction

1.1 Study purpose

The Proponent is proposing to develop natural gas to be made available to the NSW gas market. The project is located south west of the town of Narrabri in the Gunnedah Basin in New South Wales (NSW) (refer to Figure 1). It will include production and appraisal wells, gas and water gathering systems and supporting infrastructure. Natural gas will be treated at a central gas processing facility at Leewood, a rural property owned by Santos near Narrabri.

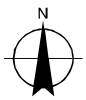
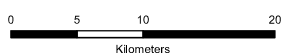
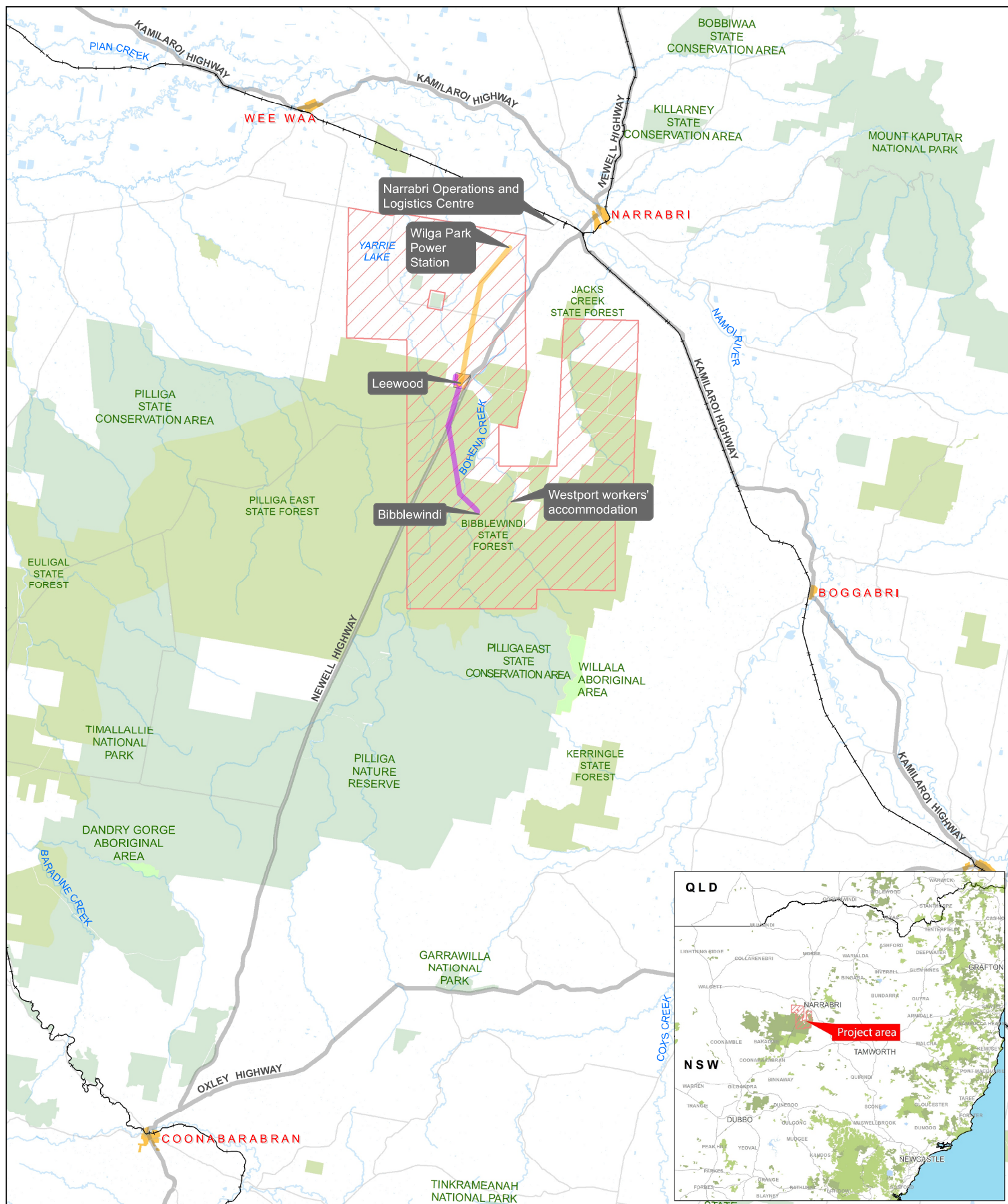
The central gas processing facility will remove water mixed with the gas and further compresses the gas, for subsequent transportation. Leewood will include a central water treatment facility which will manage water produced from previous operations in addition to servicing the proposed project.

Gas will be transported via a high-pressure gas transmission pipeline to market. The gas transmission pipeline is part of a separate approvals process and is not part of the proposed development.

The project is estimated to cost \$3.0 billion (in real terms; around \$3.6 billion in nominal terms) for construction and site rehabilitation, spread over a 25-year timeframe. Around 1,300 jobs will be created at the peak of construction while an estimated 200 jobs will be required during the approximate twenty year operational phase. The operations jobs will be sourced predominantly from Narrabri and surrounding regions.

The project is located within Petroleum Exploration Licence (PEL) 238, Petroleum Assessment Lease (PAL) 2 and Petroleum Production Lease (PPL) 3, to the south and west of Narrabri (refer to Figure 1). PEL 238 covers an area of approximately 7,915 square kilometres in the Narrabri Local Government Area.

This report investigates the economic impact of the project on the Narrabri Shire and the surrounding region as well as on New South Wales. With the potential to supply 50 per cent of NSW's current gas requirements, this project will bring important economic benefits to the State and the regions in which it is located.



Narrabri Gas Project
EIS Technical Appendix

Regional context
and location of key infrastructure

Job Number 21-22463
Revision A
Date 12 Mar 2015

Figure 1

1.2 Approach

1.2.1 Key development parameters

The key parameters for the Narrabri Gas development are:

— Peak construction workforce	1,300
— Operation workforce	200
— Capital expenditure	\$3.0 billion (2016 dollars in real terms)
— Expected operation commencement	2020
— Operation life	23 years
— Expected peak production plateau	200 TJ/day 74 PJ/yr.

1.2.2 Definitions of regions

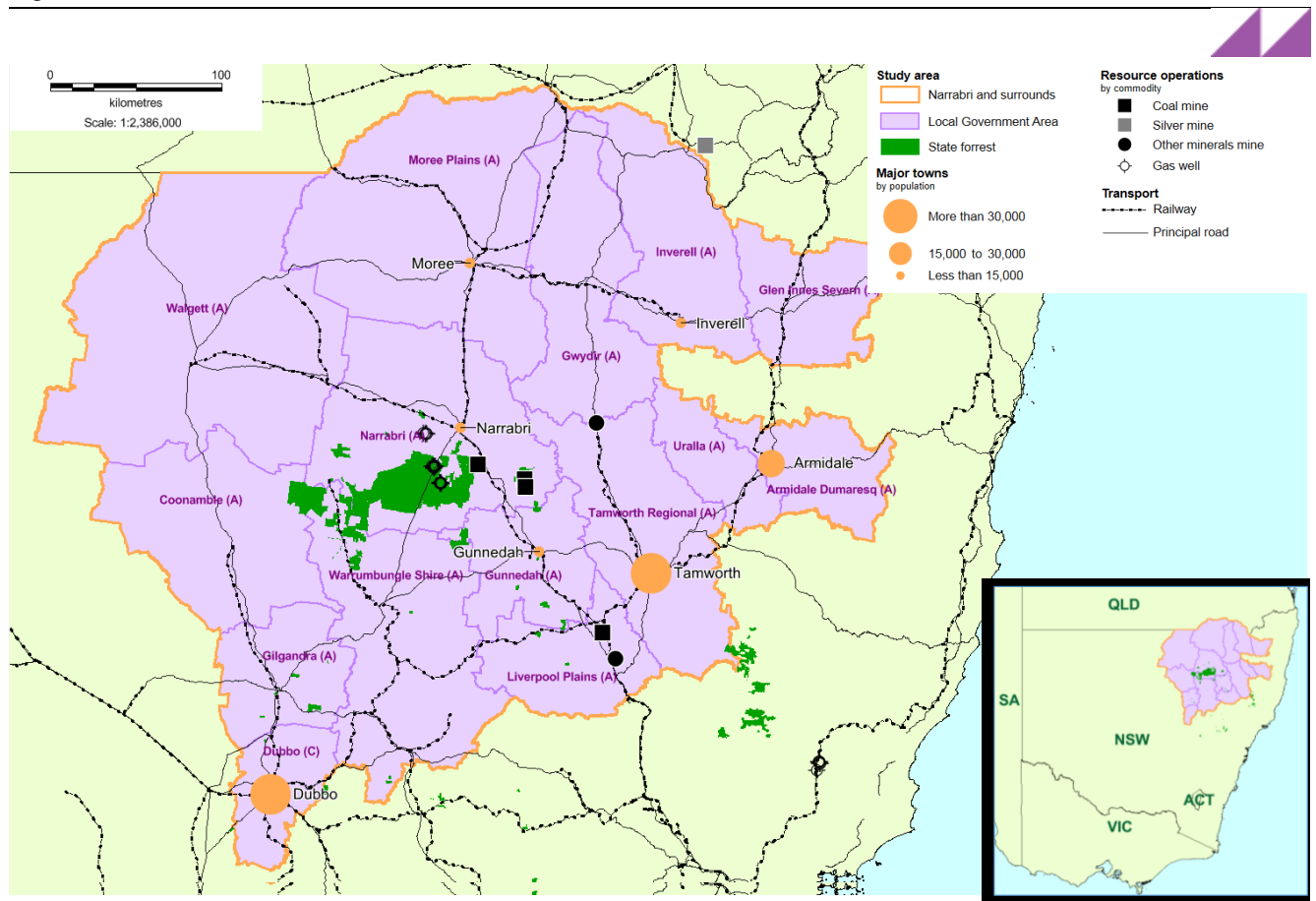
ACIL Allen has examined the impact of the proposed development on the Narrabri Shire as defined by the Narrabri Local Government Area and Narrabri and surrounds.

For the purposes of this report Narrabri and surrounds has been defined to include the Local Government Areas of:

- Narrabri
- Armidale Dumaresq
- Coonamble
- Dubbo
- Gilgandra
- Glen Innes Severn
- Gunnedah
- Gwydir
- Inverell
- Liverpool Plains
- Moree Plains
- Tamworth Regional
- Uralla
- Walgett
- Warrumbungle.

The Narrabri Shire and the Narrabri and surrounds regions, along with the location of major transport routes, primary population centres and current operating resources developments, is presented in Figure 2.

Figure 2 Narrabri Shire and Narrabri and surrounds location



Source: ACIL Allen Consulting

1.2.3 Data sources

Data for this report has primarily been sourced from the Australian Bureau of Statistics and the Department of Employment and referenced accordingly. All other data has been sourced from publicly available documents and referenced as appropriate.

2 Economic and social profile

Narrabri is located in the north west of New South Wales in the Namoi Valley. It is situated at the junction of the Newell and Kamilaroi Highways (equidistant from Sydney and Brisbane) and acts as a service centre for the surrounding towns of Boggabri, Bellata, Wee Waa, Pilliga and Gwabegar. It is home to significant cotton and wheat research centres and the CSIRO Australia Telescope compact array of radio telescopes.

The region is well serviced by transport including road, rail and air. An extensive sealed highway system links the region's major towns, and there are extensive rail links for passenger and freight. There are good air links to Sydney and the Narrabri Airport has recently been granted funds for its upgrade.

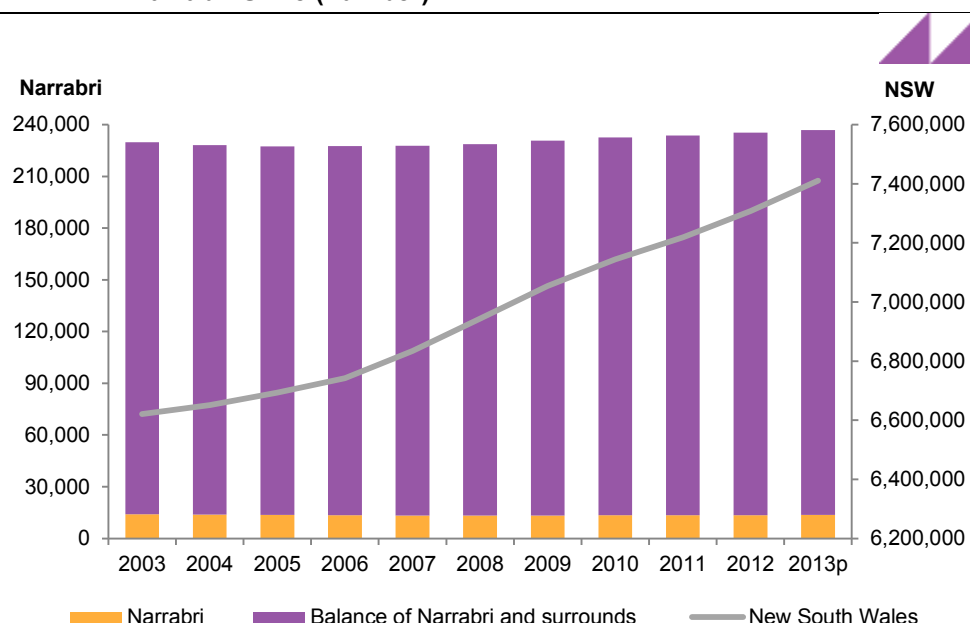
2.1 Population

According to ABS estimates (as at June 2013), the Narrabri Shire has a resident population of 13,685 people. This is equivalent to 2.6 per cent of the population of the Narrabri and surrounds area which comprises 236,890 people or 3.2 per cent of the population of NSW (7.41 million as at June 2013). Approximately 57 per cent of the Narrabri Shire population lives in and around the main centre of Narrabri, with most other residents living in the towns of Wee Waa and Boggabri.

The Narrabri Shire supports a large Aboriginal population of some 1,388 people or 11 per cent of the population of the Shire. This share is high when compared with NSW where Aboriginal people comprise 2.5 per cent of the population. It is, however, not unusual in Narrabri and surrounds where just over 13 per cent of the population is Aboriginal.

Population in the Shire has declined slightly over the past decade but has begun to recover in recent years as a result of economic growth created primarily by the resources sector, and is currently supporting population growth of around 1.2 per cent over the previous year as illustrated in Figure 3. Population growth for the period from 2008 to 2013 has averaged 0.6 per cent per annum in the Shire representing a total population increase of 382 people over the five years. Furthermore, the rate of growth is very low when compared to NSW which has an annual average growth rate for the same period of 1.3 per cent. Narrabri and surrounds also supports a slightly higher growth rate of 0.7 per cent per annum. This growth has been led by the Local Government Areas of Tamworth, Dubbo, Armidale Dumaresq, Gunnedah and Inverell which between them account for 96 per cent of the population growth in the Narrabri and surrounds area over the five years from 2008 to 2013.

Figure 3 **Estimated resident population: NSW, Narrabri and surrounds, Narrabri Shire (number)**



Source: Australian Bureau of Statistics Catalogue 3218.0

There are a number of larger population centres in the area surrounding Narrabri which are presented in Table 1. Together they account for 53 per cent of the population of the area comprising Narrabri and surrounds. The largest population centre is the town of Tamworth which supports a population of 36,131 people (2011) followed by Dubbo with a population of 32,327 (2011).

Table 1 **Population: selected major population centres: Narrabri and surrounds (2011)**

Town	Population	Share of Narrabri and surrounds
Narrabri	5,890	2.6%
Moree	7,720	3.5%
Gunnedah	7,888	3.5%
Inverell	9,347	4.2%
Armidale	19,818	8.9%
Dubbo	32,327	14%
Tamworth	36,131	16%

Source: 2011 Australian Bureau of Statistics Census place of usual residence data and urban centre locality

The NSW Department of Planning and Infrastructure has forecast that population growth in the Narrabri Shire will fall slowly over time (Planning and Infrastructure, 2013). The Narrabri Gas Project could therefore provide an important population boost for the Shire with 200 workers required for the operational phase of the project. It is anticipated that some of these workers will be sourced from the Narrabri Shire, or would move to the Narrabri Shire. This will assist in maintaining or raising the population in the area.

Table 2 shows forecast population for the Shire compared to the surrounding region and NSW for selected periods until 2031. It shows that government projections expect population to fall in Narrabri by around 0.4 per cent per annum. In contrast, population is expected to show a slight increase in the Narrabri and surrounds area of around 0.4 per cent per annum which is just below five-year historic annual population growth for the area. In absolute terms, population growth is expected to result in an additional 19,700 people

living in the area by 2031. This growth will largely be led by the Local Government Areas of Tamworth (an increase of 10,500 people), Armidale Dumaresq (6,200), Dubbo (4,900) and Inverell (3,000). The NSW population is expected to increase at around 1.2 per cent per annum to reach 9.2 million by 2031.

Table 2 Total projected population: NSW, Narrabri and surrounds, Narrabri Shire

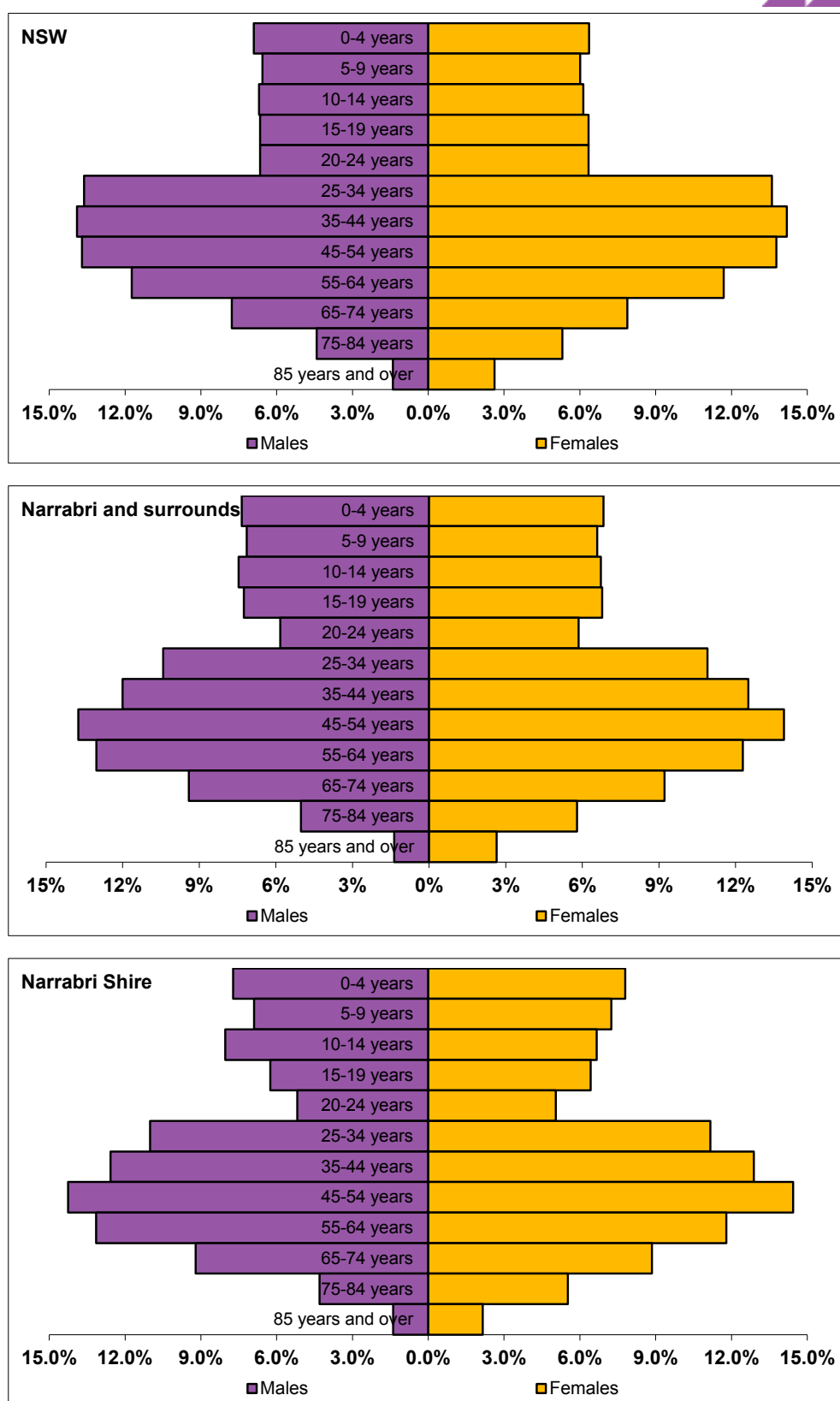
	2011	2016	2021	2026	2031	Total Change	Total % Change	Annual % Change
NSW	7,211,500	7,701,000	8,223,900	8,716,400	9,193,900	1,982,400	27.5%	1.2%
Narrabri Shire	13,500	13,100	12,900	12,700	12,400	-1,000	-8.1%	-0.4%
Narrabri and surrounds	234,800	240,200	245,400	250,400	254,500	234,800	8%	0.4%

Source: Department of Planning and Infrastructure. Note Narrabri and surrounds calculated by ACIL Allen

2.2 Age and gender profile

Figure 4 shows the age and gender profile of the Narrabri Shire compared to the surrounding region and NSW. This profile is typical of regional areas and shows a lack of young people in the 15 to 25 age groups which is a result of younger people leaving the area for education purposes and to seek greater employment diversity. Narrabri and surrounds also supports a similar age and gender profile although it is far less pronounced than for the Narrabri Shire and is a result of the inclusion of Tamworth and Dubbo as a major population centres in the area which have a higher level of social and economic services and infrastructure that can support a more normalised population profile.

Figure 4 **Age and gender profile (2011): NSW, Narrabri region, Narrabri Shire (age as a % of resident population)**



Source: 2011 Australian Bureau of Statistics Census place of usual residence data

2.3 Economic profile

The Narrabri Shire (the Shire) supports a diversified and strong economy. The economy is dominated by the agriculture industry and the associated processing, transport and service industries. This includes the location of a number of cotton and wheat research centres in the Shire (see Section 2.4 for more details). In addition, there are a number of other important industries located in the Shire including coal and gas with one of the largest coal reserves in NSW located in the Shire as well as extensive natural gas deposits. The Australia Telescope Compact Array operated by CSIRO Astronomy and Space Science division is located in the Shire.

As a result of the existence of these industries, the town of Narrabri supports a high level of social infrastructure. This includes the Narrabri District Hospital which has 38 beds and provides a full range of services including surgery, obstetrics, accident/emergency, pathology and radiography. There are also private medical practices and a full range of allied health providers as well as a Community Health Centre and Aged Care facility.

Narrabri has a full range of educational facilities including pre-school kindergartens, two Primary Schools (K -Yr 6), a State High School (Yr 7 -12) and a Catholic School (K-Yr 6); as well as a range of child care options.

Vocational education and training is available at the Community College Narrabri and the New England Institute of TAFE Narrabri Campus (1,000 students) which currently offers courses in a number of areas including aged care, building and construction, business and financial services, children's services, information and communication technology, metal fabrication and visual arts. There is a campus of the University of New England located at nearby Armidale in the Armidale Dumaresq Shire to the south east of Narrabri.

There is an affordable local housing market in the Narrabri Shire with a median housing price well below that for NSW, and a median rental price per week for a separate house similar to that of the NSW average. By way of example, Table 3 shows the median purchase and rental prices for Narrabri (defined by post code 2390) and NSW.

Housing stock varies across the Shire from heritage style cottages to larger more modern homes. There is a good supply of land in Narrabri where there are three residential developments such as the Rocky Creek Estate which is located on the outskirts of the town and includes 47 blocks.

Table 3 Median property prices: NSW and Narrabri Shire (2013)

	NSW	Narrabri
Median House Price	\$484,000	\$299,000
Median house rental price per week	\$386	\$393

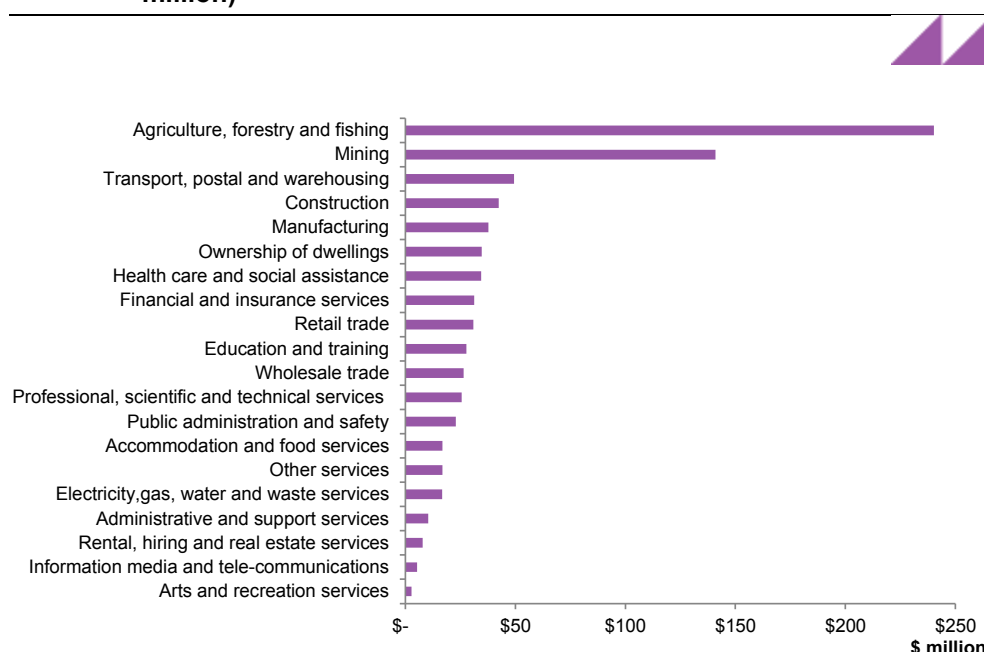
Source: NSW = (NSW Department of Family and Community Services, 2014) and Narrabri = (REA Group Ltd, n.d.).

2.3.1 Gross regional product: Narrabri Shire

Based on estimates of Narrabri's economy in 2010-11, the agriculture, forestry and fishing industry contributed around \$240 million to the Gross Regional Product of the Shire. This is equivalent to 29 per cent of the \$821 million in economic value generated in the Shire in 2010-11. The next most valuable contribution is from the mining industry which contributed \$141 million or 17 per cent of Gross Regional Product. Manufacturing which is primarily related to the processing of agricultural products but includes some non-agricultural manufacturing, is the fifth largest industry in the Shire in terms of value contributing \$38

million to the Gross Regional Product of the Shire as illustrated in Figure 5 which shows the contribution by industry to the Gross Regional Product of the Narrabri Shire.

Figure 5 Contributions to Gross Regional Product: Narrabri Shire 2010-11 (\$ million)



Source: ACIL Allen Consulting. Note: Gross Regional Product at factor cost

Despite the dominance of the agricultural and agricultural processing sector, the Narrabri Shire hosts significant deposits of coal and gas (both conventional natural gas and natural gas from coal seams) located in a geological province known as the Gunnedah Basin. The area has been labelled the “New Coal Frontier” in New South Wales and the Narrabri Shire has been identified as the most “promising” gas field in NSW (Narrabri Shire, June 2007, p. 4).

The area comprising the Narrabri Shire, Gunnedah and Liverpool Plains is estimated to contain around 12 per cent of NSW’s available coal reserves (Narrabri Shire, June 2007, p. 4). There are currently four coal mines located in the Shire which currently supply the export market as illustrated in Table 4. Whitehaven Coal is currently operating a significant coal development at Maules Creek with sales of around 13 million tonnes per annum expected by 2017. This development will more than double the current production of just over 10.2 million tonnes per annum in the Shire. As well as coal, development of the gas industry is underway with gas wells and a gas fired power generation plant located in the Shire.

While Gunnedah appears to be emerging as the service centre for coal mining in the Gunnedah Basin, opportunities will also emerge for the Narrabri Shire particularly for the towns of Narrabri and Boggabri (the closest town to the majority of the existing and proposed coal mines). For example, there are already a large number (n= 180 as of 2011 Census) of residents of the Shire employed in the coal industry.

In addition, there are opportunities to benefit from the development of the gas sector, particularly if the availability of natural gas promotes industrial development.

Table 4 Minerals and energy projects: Narrabri and surrounds and Narrabri Shire

Mine name	Ownership	Estimated production (volume pa)	Estimated employment	Product	Location
Boggabri	Boggabri Coal	1.55 Mt	150	Coal (open cut)	Narrabri
Narrabri North	Whitehaven Coal	5.5 Mt	na	Coal	Narrabri
Tarrowonga	Whitehaven Coal	2.0 Mt	na	Coal	Narrabri
Rocglen	Whitehaven Coal	1.2 Mt	na	Coal	Narrabri/Gunnedah*
Maules Creek	Whitehaven Coal	13 Mt	470	Coal	Narrabri
Werris Creek	Whitehaven Coal	2.5 Mt	70	Coal (open cut)	Narrabri and surrounds
Hill Grove	Bracken Resources	250,000 t	140	Gold and stibnite	Narrabri and surrounds
Barraba	Australian Diatomite Mining	na	na	Diatomite	Narrabri and surrounds
Narrabri Coal Seam Gas	Santos	na	200	Gas	Narrabri

Source: various company profiles.

Note: * note this mine is located on the Narrabri/Gunnedah LGA border.

In the future, it is likely that the economy of the Narrabri Shire will be driven by the agricultural sector but will diversify towards the resources sector particularly the emerging energy sector which will provide opportunities in the development of the mine related service sector. Opportunities could present themselves for heavy engineering businesses, equipment repairs, and specialty mine services such as blasting.

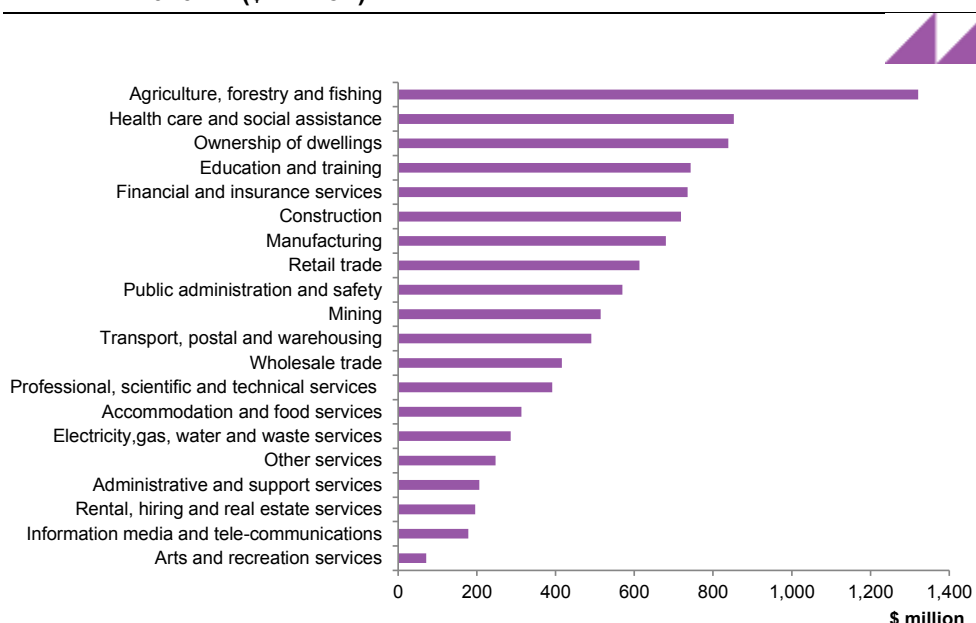
Tourism will remain important with attractions including the local wine and olive oil industries, the CSIRO Australia Telescope Compact Array, and the Mount Kaputar National Park. There is also the potential to attract business travellers from the agricultural, resources and related industries.

2.3.2 Gross regional product: Narrabri and surrounds

ACIL Allen estimates the Gross Regional Product of the Narrabri and surrounds area in 2010-11 to be \$10.4 billion. The agriculture, forestry and fishing industry is the largest contributor to this value with an estimated \$1.32 billion or 12.7 per cent of the total Gross Regional Product. The next largest contribution comes from the health care and social assistance industry (\$853 million or 8.2 per cent of the total Gross Regional Product) and ownership of dwellings industry (\$839 million; 8.1%) as illustrated in Figure 6. Mining contributes \$514 million with the Narrabri Shire contributing around one third of this value.

Agriculture is expected to play a key role in the economic future of the area however the resources sector is expected to play an increasingly important role in the economy if plans for the development of the sector proceed. There are a number of resource developments being considered in the area, primarily in the coal industry. These include the Watermark open-cut coal mine near Gunnedah, and the Caroon Coal underground coal mine near Gunnedah and Tamworth.

Figure 6 **Contributions to Gross Regional Product: Narrabri and surrounds 2010-11 (\$ million)**



Source: ACIL Allen Consulting. Note: Gross Regional Product at factor cost

2.4 Agriculture

The Namoi Valley is a rich agricultural region that produces a range of crops including cotton, wheat, barley, oilseeds, grapes and peanuts. There is also a strong livestock sector including the production of wool, fat lambs, beef and pork. The history of the Narrabri Shire is in the agricultural and agricultural processing sectors and they remain the Shire's most important industry.

Cotton is the major agricultural industry in the Narrabri Shire with the majority of production located on irrigable land around Wee Waa. Irrigation is supplied from the Namoi River and the extraction of bore water. Wheat is the next most valuable commodity and is produced on broadacre properties North of Narrabri in the Bellata and Edgeroi areas. Latest production figures were not available for this report however production estimates for 2005-06 report that cotton production was 916,000 tonnes and wheat production was 256,000 tonnes (AEC Group for the Narrabri Shire Council, July 2011, p. 11).

The strength of the agricultural sector has led to the development of major storage, transport (including the containerised transport of agricultural goods), service and secondary processing industries in the Shire. These include the Cargill Oilseeds plant and the Canz Pulse Processors plant both located at Narrabri. There are also seed grading, mixing and packaging operations located in the Shire.

There are a number of agricultural research institutes in Narrabri including Sydney University's I.A Watson Grains Research Centre which is the main field testing site for crops being developed by the University. The Australian Cotton Research Institute (ACRI) is the NSW Department of Primary Industries' Centre of Excellence for cotton, pulses and oilseed improvements and is located between Narrabri and Wee Waa. These facilities are shared with the Cotton Catchment Communities Cooperative Research Centre (Cotton CRC) and the CSIRO Divisions of Plant Industry and Ecosystem Services (Cotton Research Unit).

The Cotton Research and Development Corporation is also located in Narrabri. The Corporation is a partnership between the Australian Government and the Australian cotton

industry that invests in and manages a portfolio of research, development and extension projects relating to cotton.

The State Forests of The Pilliga are located in the Shire of Narrabri. Also known as the Pilliga Scrub, it is around 500,000 ha of semi-arid woodland made up of the Pilliga Nature Reserve, Timallallie National Park, and Pilliga West and East State Conservation Areas. Nearly half the Pilliga forest is managed by the National Parks and Wildlife Service under the National Parks and Wildlife Act 1974. Some of the forest is currently commercially logged. No production estimates were available for this report. It is understood that regenerated white cypress is harvested for use in the construction and residential construction industries as well as in the production of furniture.

2.5 Water availability

Narrabri Shire is located in the Namoi Irrigation District with water from the Namoi River and groundwater sources (subject to licences) providing water for irrigation purposes. Water supplies for towns in the Narrabri Shire including Narrabri, Wee Waa, Boggabri, Bellata, Pilliga and Gwabegar are sourced from bores and managed by the Narrabri Shire.

The Namoi River catchment covers an area of approximately 42,000 km² from Woolbrook in the east to Walgett in the west. The catchment is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south and the Nandewar Ranges and Mount Kaputar to the north. Major tributaries of the Namoi River include Coxs Creek and the Mooki, Peel, Cockburn, Manilla and Macdonald Rivers, all of which join the Namoi River upstream of Boggabri. A range of land and water management issues affect the Namoi Catchment including water quality decline, soil and land degradation, increasing dryland salinity, and loss of native vegetation and decline in biodiversity (Namoi Catchment Management Authority, 2013).

Many of the agricultural industries in Narrabri Shire rely heavily on irrigation to support their production. The primary irrigated crop is cotton, but cereal crops, fodder crops, fruit and vegetables are also grown under irrigation in different parts of the Namoi catchment.

The availability of water has been identified as the major constraint for irrigated agriculture in the Namoi catchment. In a report investigating future water availability in the catchment, it was concluded that Narrabri would suffer an economic shock if the level of irrigated agriculture was reduced because of its reliance on the agricultural sector for employment and revenue. However the impact would be larger on other towns in the Shire such as Wee Waa (Murray Darling Basin Authority, 2011, p. 941 and 951).

The report concludes the following for communities in the Namoi catchment:

- For a 20 per cent reduction in long-term cap equivalent (LTCE) water entitlements, there will be significant loss of economic activity in water dependent communities
- For a 40 per cent reduction there would be major loss of economic activity in water dependent communities and significant loss of activity in more diverse centres
- For a 60 per cent reduction, a catastrophic loss of economic activity in water dependent communities and major loss of activity in more diverse centres would result (Murray Darling Basin Authority, 2011, p. 961).

Water dependent communities in Narrabri and surrounds include Moree, Gunnedah, Narrabri, Walgett, Warren and Wee Waa, which are likely to be affected by the move to sustainable diversion limits as well as the smaller towns of Boggabri (Narrabri Shire) and Burren Junction (Walgett Shire) (Murray Darling Basin Authority, 2011, pp. 835, 958, 1073).

The production of water from the proposed Narrabri Gas Project to a suitable standard for irrigation and/or town use could therefore be an important boost to future water supplies in the Shire.

2.6 Workforce

There is currently an annual workforce of 7,700¹ people (as of 2013) in the Narrabri Shire. Just under 392 of these people are unemployed which represents an unemployment rate of 5.1 per cent. In comparison, the area of Narrabri and surrounds supports a workforce of 123,750 most of whom are located in the Local Government Areas of Tamworth (workforce of 30,900), Dubbo (22,200), Armidale Dumaresq (12,500), Inverell (8,200) and Moree Plains (8,000). Together they account for 66 per cent of the workforce of Narrabri and surrounds.

Unemployment in the Narrabri Shire has remained fairly static since 2008-09 as illustrated in Figure 7. However, after experiencing a slight decline to reach 4.7 per cent in the March quarter of 2012, it has begun to rise again reaching current levels of 5.5 per cent in the 2013 December quarter. Despite this rise, the unemployment rate for the Shire is below that for NSW which recorded unemployment of 5.8 per cent in the December 2013 quarter².

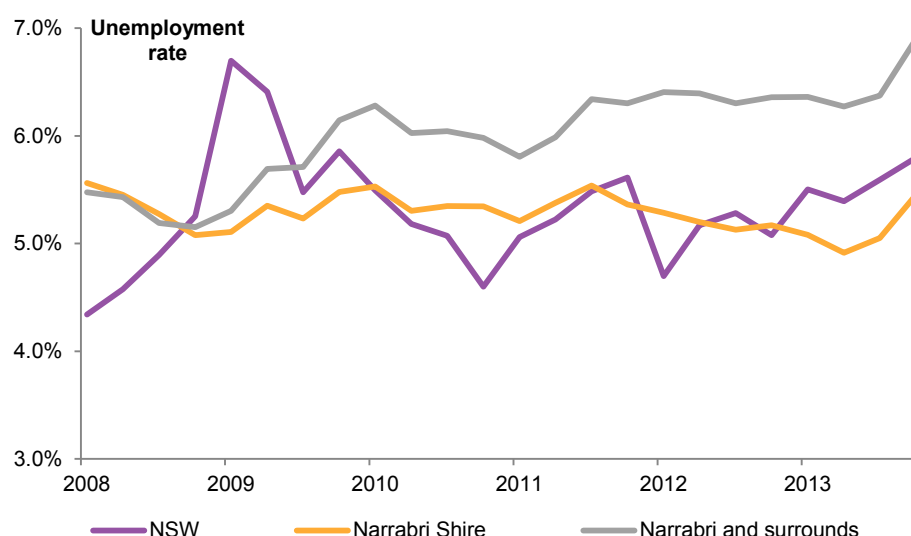
Unemployment in the Shire is also currently lower than for Narrabri and surrounds where there are comparatively high levels of unemployment that have remained above the State average since 2009/10. There are currently 8,000 people seeking work in Narrabri and surrounds indicating an unemployment rate of 6.5 per cent. Almost 5,150 of job seekers in Narrabri and surrounds are located in the Local Government Areas of Tamworth (1,950 unemployed), Dubbo (1,080), Armidale Dumaresq (785), Inverell (690) and Moree Plains (630). Combined, these areas represent 64 per cent of all job seekers in the area³.

¹ Department of Employment, Small Area Labour Markets reports for ,December Quarter 2013

² Ibid

³ Ibid

Figure 7 Unemployment rate: NSW, Narrabri and surrounds, Narrabri Shire (% of total workforce)



Source: Local Government Area sourced from Department of Employment Small Area Labour Markets and NSW data sourced from Australian Bureau of Statistics Catalogue 6202.0

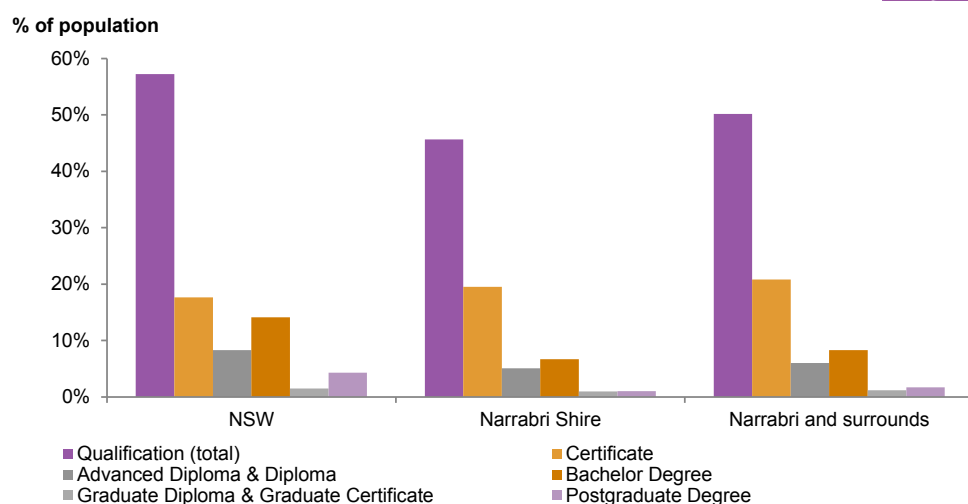
2.7 Level of skills

There is a very high level of skills amongst residents of the Narrabri Shire and Narrabri and surrounds. This is because of the high number of agricultural research institutions and large businesses in and around the area. In total there are 102 people with postgraduate degrees, 98 with graduate diploma and graduate certificates and 671 with bachelor degrees in Narrabri Shire. Together they make up 19 per cent of residents of the Shire who hold a qualification. This high level of qualifications is shown in Figure 8 which shows the level of non-school education attainment amongst residents.

It shows that 46 per cent of all residents aged 15 and over in the Narrabri Shire hold a qualification of some sort compared to 50 per cent of the residents of Narrabri and surrounds and 57 per cent of all residents of NSW.

The most commonly held qualification in Narrabri Shire is a Certificate (20% of residents aged 15 and over) followed by a Bachelor Degree (7%), and an Advanced Diploma and Diploma (5%).

Figure 8 **Non-school level of education: NSW, Narrabri and surrounds, Narrabri Shire (% of persons aged 15 and over)**



Source: Australian Bureau of Statistics 2011 Census

The existence of a large number of highly skilled people living in the Shire suggests a level of social infrastructure including housing, health and education services, and recreation facilities that is adequate to attract a skilled workforce.

2.8 Employment by industry

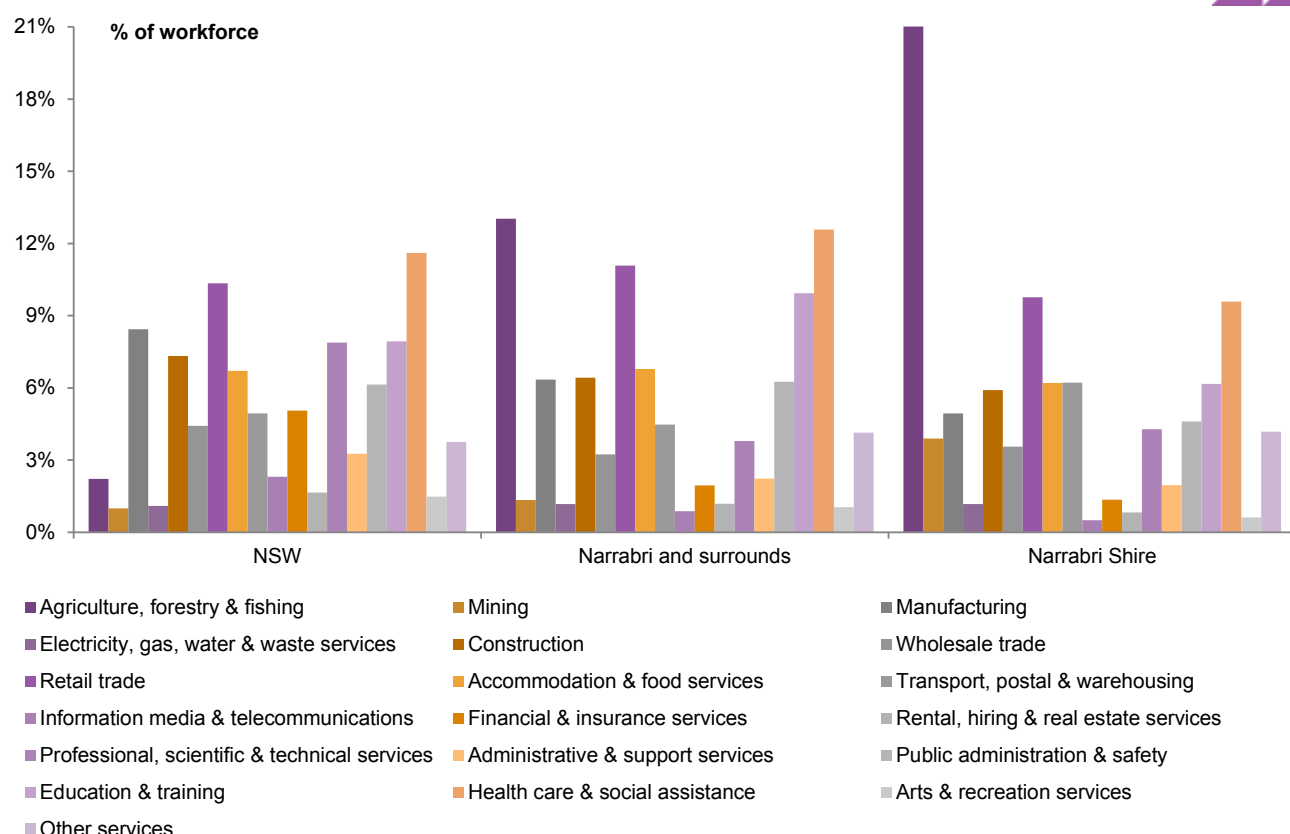
The employment profile of the Narrabri Shire is typical of a regional service centre and is reflective of its role in supporting the local agricultural industry and the resident population.

Agriculture, forestry and fishing is the largest source of employment for people living in the Narrabri Shire providing jobs for 21 per cent of the resident workforce. Retail trade is the next largest employer providing jobs for 10 per cent of the working population and health care and social assistance which also employs 10 per cent of the resident workforce.

The two main sectors of employment are the agricultural sector and the government and associated services sector. The combined industries of health care and social assistance (10% of working residents), education and training (6%) and public administration and safety (5%) provide 21 per cent of all employment for people living in Narrabri. If it is assumed that much of transport, postal and warehousing (employing 6% of working residents), manufacturing (5%) and professional, scientific and technical services (4%) are dependent on agriculture then the agricultural sector employs as many as 32 per cent of working residents.

Mining which includes petroleum extraction accounts for 3.9 per cent of employment and is one of the smallest employers in the Shire.

Figure 9 **Employment by industry NSW, Narrabri and surrounds, Narrabri Shire (% of total workforce)**



Source: 2011 Australian Bureau of Statistics Census place of usual residence data

In contrast, Narrabri and surrounds has less reliance on the agricultural sector as an employer of local people despite the industry being the largest contributor to Gross Regional Product. In comparison, there is more of a reliance on the government sector as a source of employment reflecting the health care and social assistance industry as the second largest contributor to Gross Regional Product.

The three main sources of employment for residents of Narrabri and surrounds are agriculture, forestry and fishing (13% of working residents), health care and social assistance (13%) and retail trade (11%). mining employs just 1.3 per cent of working residents in the area. The government and associated services sector which includes the industries of health care and social assistance, education and training (10%) and public administration and safety (6%) provides 29 per cent of all employment for people living and working in Narrabri and surrounds. This sector provides a greater share of employment in Narrabri and surrounds because of the location of towns such as Tamworth, Dubbo and Moree in the area which are home to large populations and the associated social infrastructure and services required to support these.

2.8.1 Employment by industry further defined

Table 5 and Table 6 show employment in the key industries of agriculture and mining located in the Shire in greater detail. For agriculture, forestry and fishing the table shows that 1,261 people working in the Narrabri Shire are employed in this industry. The majority (83% of the people working in the industry in the Shire) are employed in agriculture and 192 people (15%) in agriculture support services. There are also small amounts of people employed in forestry and logging (5 people) and aquaculture (4 people).

In total the number of people employed in this industry comprises 10 per cent of the 12,714 people employed in the agriculture, forestry and fishing industry in Narrabri and surrounds.

Table 5 Employment by industry: Agriculture, Forestry and Fishing: Narrabri Shire and Narrabri and surrounds (2011)

	Narrabri Shire		Narrabri and surrounds	
	Number	Share	Number	Share
Agriculture	1,041	83%	11,653	92%
Aquaculture	4	0.3%	11	0.1%
Forestry and Logging	5	0.4%	39	0.3%
Fishing, Hunting and Trapping	0	0.0%	21	0.2%
Agriculture, Forestry and Fishing Support Services	192	15%	881	7%
Agriculture, Forestry and Fishing not further defined	19	2%	109	1%
Total Agriculture, Forestry and Fishing	1,261	100%	12,714	100%

Source: 2011 Australian Bureau of Statistics Census place of work data

The 2011 census shows a total of 233 people working in the Narrabri Shire are employed in the mining industry. This includes 180 people employed in coal mining and 18 in oil and gas extraction. A further 31 are employed in mining support services and the exploration industry.

In total the number of people employed in this industry comprises 18 per cent of the 1,289 people employed in the industry in Narrabri and surrounds. There are also large numbers of people employed in mining, particularly coal mining in the Gunnedah, Tamworth and Dubbo Local Government Areas which are all located in the southern half of the study area. Despite being a large employer for residents of the Tamworth and Dubbo Local Government Areas, there are no operating coal mines currently located within their boundaries, suggesting that the workers employed in these areas may actually be involved in exploration and/or administration.

Table 6 Employment by industry: Mining: Narrabri Shire and Narrabri and surrounds (2011)

	Narrabri Shire		Narrabri and surrounds	
	Number	Share	Number	Share
Coal Mining	180	77%	763	59%
Oil and Gas Extraction	18	8%	35	3%
Metal Ore Mining	0	0%	115	9%
Non-Metallic Mineral Mining and Quarrying	0	0%	147	9%
Exploration and Other Mining Support Services	31	13%	172	11%
Mining not further defined	4	2%	57	4%
Total Mining	233	100%	1,289	100%

Source: 2011 Australian Bureau of Statistics Census place of work data

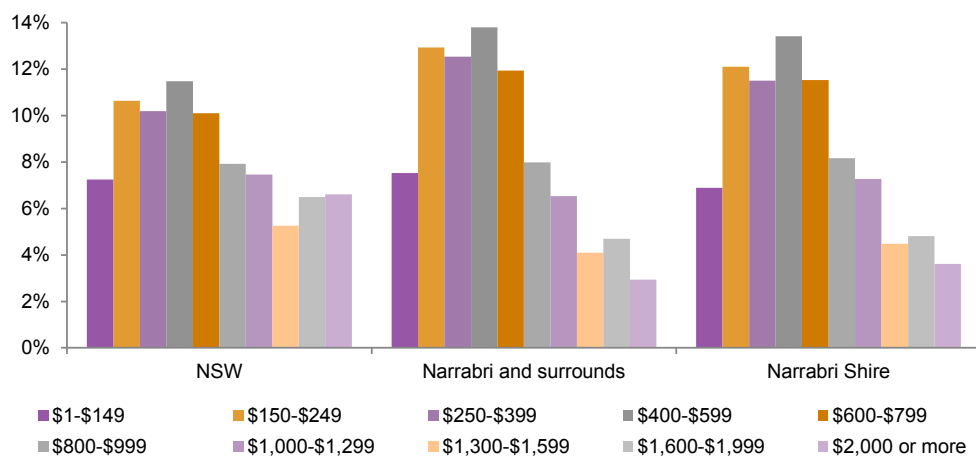
Note that in addition to employment directly in these industries, there are also people employed in industries that are reliant on or directly related to agriculture and mining such as manufacturing (food products, pulp and paper, wood, petroleum and coal etc.), warehousing and storage, professional, scientific and technical services, road transport and so on.

2.9 Average weekly earnings

Average weekly incomes in the Narrabri Shire are low when compared to NSW. In NSW, 26 per cent of the population aged 15 and over earn more than \$1,000 per week compared to

20 per cent for the Narrabri Shire. However, wages are higher when compared to Narrabri and surrounds where 18 per cent of the population earn more than \$1,000 per week. These comparatively higher earnings are most likely due to the location of several agricultural research institutes in the Shire as well as significant agricultural processing, transport and service industries which support occupations that earn a higher average wage.

Figure 10 **Average weekly income: NSW, Narrabri region, Narrabri Shire (% of total population aged 15 and over)**



Source: 2011 Australian Bureau of Statistics Census place of usual residence data

3 Economic impact analysis

3.1 Methodology

The macroeconomic impacts of a policy, project or other activity can be estimated using a variety of economic analysis tools. The most common methods utilised are input-output multiplier analysis and computable general equilibrium (CGE) modelling. The selection of the right tool is critical to the accuracy of the estimated impacts and depends upon the characteristics of the project/industry. Sometimes a range of tools are required. Appendix A contains a brief discussion of input-output multipliers and CGE models.

By their nature, input-output multipliers and CGE models focus on “market impacts” across the economy (i.e. impacts on activities with observed market prices). Analysis of various “non-market impacts”, such as property right infringements, potential loss of biodiversity, changes in air quality, social justice implications, etc., may also be relevant in assessing the full implications of a project or policy.

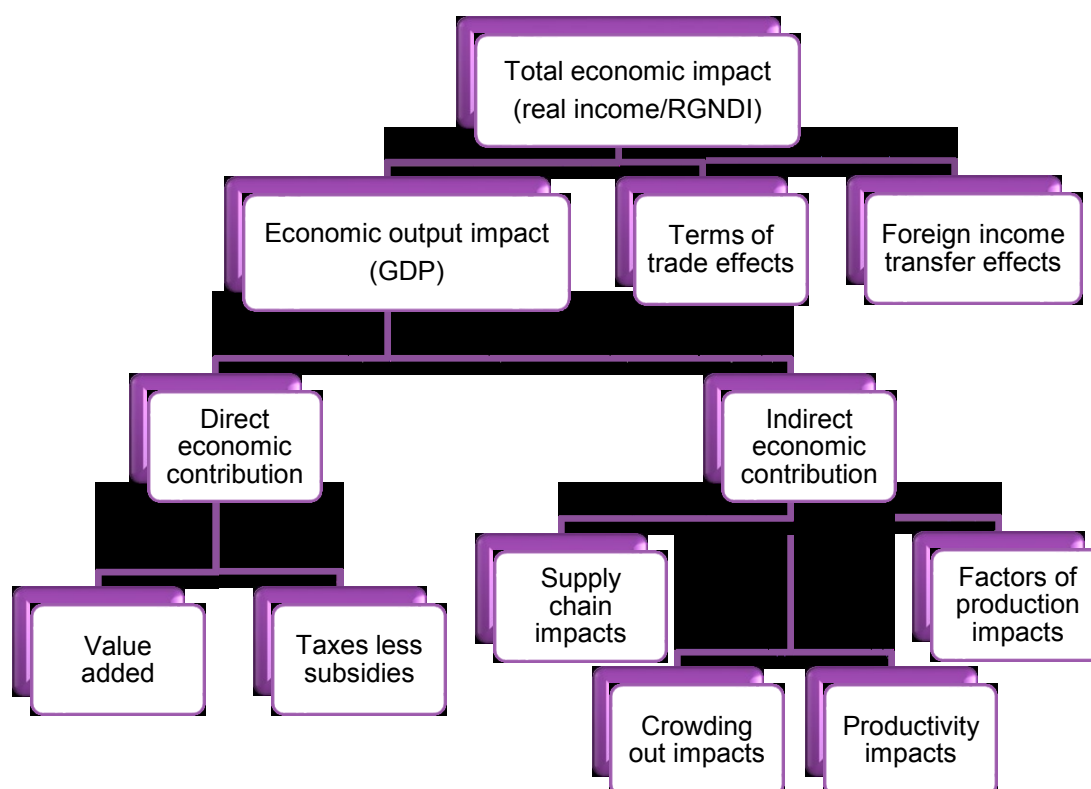
Fundamentally, although various aspects of a policy or project – such as the number of jobs or the size of the investment expenditure – are of relevance to certain stakeholders, the key aggregate measure of the macroeconomic impact of a project is the extent to which the total income of the economy has changed as a result of the policy or project. Typically, this is measured by real gross national disposable income (RGNDI), although real gross domestic product (GDP) and consumer surplus (among others) can also be important aggregate measures depending on the nature of the policy or project being analysed.

The main factors that need to be considered when analysing the macroeconomic impacts of a project or policy include:

- the direct and indirect contribution to the economy as a result of the activities associated with the project
- crowding out implications as resources are potentially diverted from other productive activities to undertake the project being analysed
- productivity effects generated as a direct result of the policy or project activities – particularly any enduring productivity changes or productivity impacts on other activities not directly associated with the project or policy
- changes to the factors of production in the economy
- implications associated with changes in terms of trade or foreign income transfers
- whether there is a dynamic element to the size of the above effects (due to different phases of the project for example).

Figure 11 shows these components graphically. Some of these effects may be negligible while others may be very significant and an understanding of the effects helps determine the most appropriate tool(s) for the analysis.

Figure 11 Estimating the macroeconomic impact of a project or policy



Source: ACIL Allen

For many projects, static estimates of the direct economic contribution and supply chain implications can be obtained through the use of I-O multipliers. Estimating the size of other components using multiplier techniques is either not possible or very complex, as is estimating the economic impacts through time. In contrast, most CGE models are able to estimate all of the components shown in Figure 11 with dynamic CGE models able to estimate the impacts through time.

A project the size of the Narrabri Gas Project will have the potential for some crowding out implications as well as terms of trade and foreign income transfers effects. Therefore, CGE modelling has been chosen as the appropriate tool to undertake the economic impacts assessment in this report.

For this analysis, ACIL Allen's CGE model, *Tasman Global*, was used to estimate the impacts of the construction and operation activities associated with the Narrabri Gas Project.

3.2 The *Tasman Global* CGE model

Tasman Global is a large scale, dynamic, CGE model of the world economy that has been developed in-house by ACIL Allen. *Tasman Global* is a powerful and effective tool for undertaking economic analysis at the regional, state, national and global levels.

CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, starting with individual markets, producers and consumers and building up the system via demands and production from each component. When an economic shock or disturbance is applied to a model, each of the markets adjusts according to the set of

behavioural parameters which are underpinned by economic theory. The generalised nature of CGE models enable a much broader range of analysis to be undertaken (generally in a more robust manner) compared to I-O multiplier techniques, which are also often applied in economic impact assessments

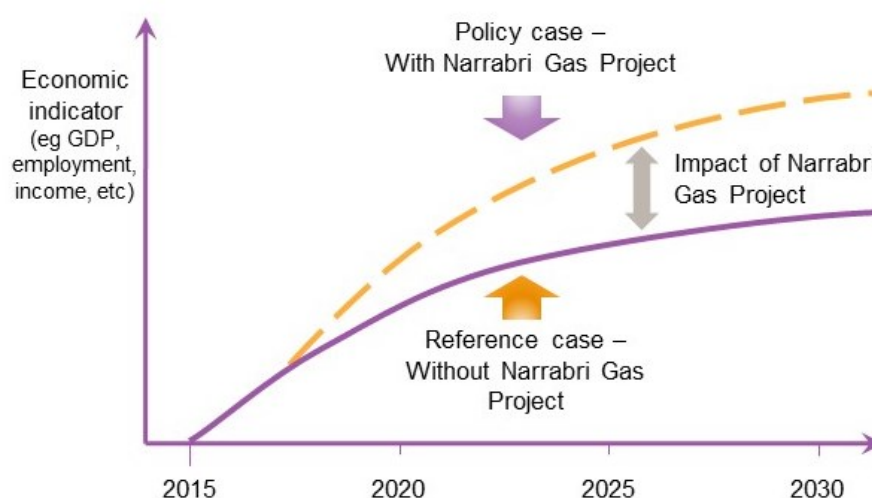
More detail of the *Tasman Global* model is provided in Appendix A of this report.

A dynamic model

Tasman Global is a model that estimates relationships between variables at different points in time. This is in contrast to comparative static models, which compare two equilibriums (one before a policy change and one following). A dynamic model such as *Tasman Global* is beneficial when analysing issues where both the timing of and the adjustment path that economies follow are relevant in the analysis.

In applications of the *Tasman Global* model, a Reference Case simulation forms a 'business-as-usual' basis with which to compare the results of various simulations. The Reference Case provides projections of growth in the absence of the Narrabri Gas Project (such as GDP, population, labour supply, industry output, etc.) and provides projections of endogenous variables such as productivity changes and consumer tastes. The Policy Case assumes all productivity improvements, tax rates and consumer preferences change as per the Reference Case projections but also includes the proposed Narrabri Gas Project. The two scenarios give two projections of the economy and the net impact of the Narrabri Gas Project is then calculated as deviations from the Reference Case (see Figure 12).

Figure 12 Illustrative scenario analysis using *Tasman Global*



Source: ACIL Allen

3.2.2 Database aggregation

The database which underpins the model contains a wealth of sectoral detail. The foundation of this information is the set of input-output tables that underpin the database. Industries and regions in the model can be aggregated or disaggregated as required for a specific project. For this project the model has been aggregated to:

- Five economies, namely the Narrabri Shire, the Shires with Narrabri surrounds (which for the purposes of this report has been defined to include the Local Government Areas of Armidale Dumaresq, Coonamble, Dubbo, Gilgandra, Glen Innes Severn, Gunnedah,

Gwydir, Inverell, Liverpool Plains, Moree Plains, Tamworth Regional, Uralla, Walgett and Warrumbungle), the Rest of NSW, the Rest of Australia and the Rest of the World.

— Thirty four industries/commodities as presented in Table 7.

The aggregation was chosen to provide the maximum detail possible for the key industries in the New South Wales economy.

Table 7 Industry/Commodity aggregation used in *Tasman Global* modelling

Industry/Commodity		Industry/Commodity	
1	Crops	18	Fabricated metal products
2	Livestock	19	Motor vehicle and parts
3	Fishing	20	Electronic equipment
4	Forestry	21	Other machinery and equipment
5	Processed food	22	Other manufacturing
6	Coal	23	Water
7	Oil	24	Construction
8	Gas	25	Trade services (includes all retail and wholesale trade, hotels and restaurants)
9	Electricity	26	Road, rail, pipeline and other transport
10	Petroleum & coal products	27	Water and air transport services
11	Iron & steel	28	Communications services
12	Other mining	29	Other financial services
13	Nonferrous metals	30	Insurance services
14	Non-metallic minerals (including cement, plaster, lime, gravel)	31	Other business services (including financial, insurance, real estate services)
15	Chemicals, rubber, plastics	32	Recreational and other services
16	Textiles, clothing and footwear	33	Government services (including public administration and defence)
17	Wood and paper products; publishing and printing (excluding furniture)	34	Dwellings

Note: Excludes micro-industries developed specifically for this analysis

Data source: ACIL Allen aggregation

3.2.3 Micro industry approach

To accurately assess the economic impacts or economic contribution of a major project, such as the Narrabri Gas Project, it must be accurately represented in the model's database. An accurate representation can be guaranteed by establishing the proposed project as a new 'micro' industry in the database.

The micro industry approach is so called because it involves the creation of one or more new, initially very small, industries in the *Tasman Global* database. The specifications of each of the micro industry's costs and sales structures are directly derived from the financial data for the project to be analysed. At the outset, before construction and/or production commences, the new industry is necessarily very small so that its existence in the *Tasman Global* database does not affect the database balance or the "business-as-usual" Reference Case outcomes. Once, construction and production commence, the new industry is expanded so that its true economic significance can be determined.

Besides having a separate cost structure for the project of interest, a further challenge is to faithfully represent the time profile of the individual cost items. This is particularly important for the investment phase where there are typically large changes in demands for machinery, labour and imported components year on year. This challenge is met in *Tasman Global* through incorporating detailed year on year, input specific shocks by source.

Using the micro industry approach for project evaluations is the most accurate way to capture the detailed economic linkages between the project and the other industries in the economy. This approach has been developed by ACIL Allen because each project is unique relative to the more aggregated industries in the *Tasman Global* database.

Consequently, in addition to the 34 industries identified in Table 7, the database also identified the construction and operation phases of the Narrabri Gas Project as separate industries with their own input cost structure, sales and employment based on information provided to ACIL Allen by Santos and based on assumptions made by ACIL Allen.

Another important aspect in the CGE modelling approach used for this analysis is to have separate identification of the capital stock created as part of the project's investment phase and isolating it until the capital is available for use, thereby preventing the economy gaining false benefits from, say, half a bridge. In the past, some CGE models potentially overstated the impact of an investment, because investment in one period was automatically added to capital stock in the next period and was made available to the rest of the economy, thereby spuriously increasing GDP.

As mentioned in Section A.2, the model has the ability to explicitly account for the repatriation of profits (for example through foreign ownership of capital or through the use of fly-in, fly-out or drive-in, drive-out workers).

3.2.4 Assumptions

In order to undertake Impact analysis using CGE modelling it is always necessary to make a certain number of assumptions to overcome data limitations. To the greatest extent possible the expectations of project proponents are used to underpin assumptions regarding the project to be analysed; however, depending upon the stage of project definition the modellers will be required to make more or less assumptions of their own. Key data assumptions used in the modelling are presented in Table 8.

Certain modelling assumptions are unrelated to a specific project and are dependent upon the economic environment. Key in this regard are assumptions about the labour market. For this analysis it has been assumed that the overall labour supply in Australia is unaffected by the project. Under this assumption international migration rates and labour market participation rates are unaffected by the labour demand stimulus presented by the project. However, the modelling assumes that labour is mobile between states and regions in response to changes to real wage differentials. It has been assumed that labour is highly responsive to changes in real wage differentials and moves to virtually eliminate these changes.

3.2.5 Applications of CGE modelling

CGE models, such as *Tasman Global*, are the preeminent tool used in Australia for analysis requiring estimates of the potential economic impacts of a project on the wider economy. The economic impacts of major projects around Australia are frequently analysed using these models, particularly when there are likely to be significant crowding out, terms of trade or structural adjustment effects. For example, virtually all of the LNG projects undertaken in Australia have been analysed with CGE models – frequently more than once. The first of these projects, the North West Shelf Gas Project, was analysed using the *Orani* model in 1992 (Higgs and Powell, 1992).

CGE models are also used extensively in policy analysis in Australia. Applications include:

- Tax policy changes, such as the Henry review (Australia's Future Tax System Review) (KPMG Econtech, 2010).

- Climate change impacts (Garnaut, 2008; Australian Government, 2008; Treasury, 2011).
- Immigration effects.
- Free trade agreements.

CGE models continue to evolve and develop to meet the needs of researchers and policy makers. However, the application of these models to economic impact analysis, such as in this report, remains their major use outside of academia.

Table 8 Key data assumptions used in *Tasman Global* modelling

	Assumption		Source
1	Australian ownership of Santos	87%	Santos
2	Employment at peak construction	1,300	Santos
3	Current “operational” employment	50	Santos
4	Employment at full production (includes the current 50 jobs)	200	Santos
5	Source of construction labour (region of residence)*:		
	Narrabri Shire	10%	ACIL Allen
	Narrabri’s surrounding shires	20%	ACIL Allen
	Rest of NSW	65%	ACIL Allen
	Rest of Australia	5%	ACIL Allen
6	Source of operations labour (region of residence), not including existing Santos employees in Narrabri:		
	Narrabri Shire	50%	Santos/ACIL Allen
	Narrabri’s surrounding shires	10%	Santos/ACIL Allen
	Rest of NSW	20%	Santos/ACIL Allen
	Rest of Australia	20%	Santos/ACIL Allen
7	Gas sales will be into the NSW domestic market		Santos

Note:* Not including drilling workers who are assumed to be sourced from Rest of Australia..

4 Projected economic impacts

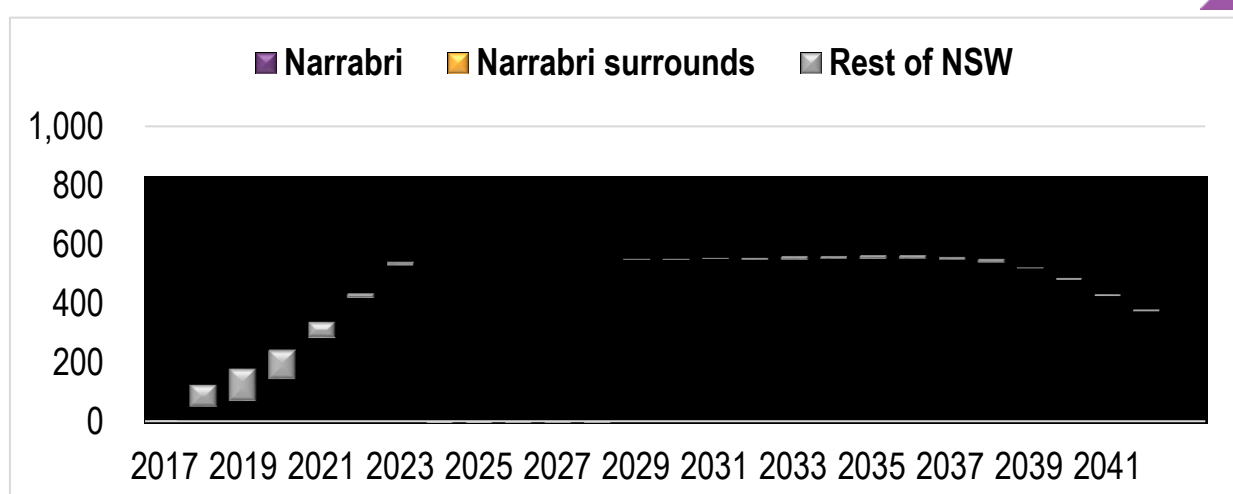
4.1 Real GDP and GNP

The projected macroeconomic impacts for each region associated with the Narrabri Gas Project are presented in Figure 13, Figure 14 and Table 9. In comparison to the operations phase (which begins in 2020) the projected changes in real economic output and real income as a result of the initial investment phase are relatively small. This is because the largest changes in real economic output and real income are projected to occur broadly in line with the value of production. More specifically, it is the operations phase where the key benefits of the project are expected to be realised – namely, through the monetisation of otherwise unutilised resources and additional factors of production. In contrast, the construction phase is largely increasing demand for scarce factors of production and so has a smaller effect on economic output compared to the size of the investment. Another way to view this is to note that investment is an alternative form of consumption. All else equal, it does not add to the productive capacity of the economy. Only when the operations phase begins is the productive potential of the economy increased.

However, the additional construction activity associated with the project in 2018 and 2019 has a noticeable effect on the real income of residents in New South Wales as there is increased demand for labour and goods and services and this boosts local incomes relative to the baseline.

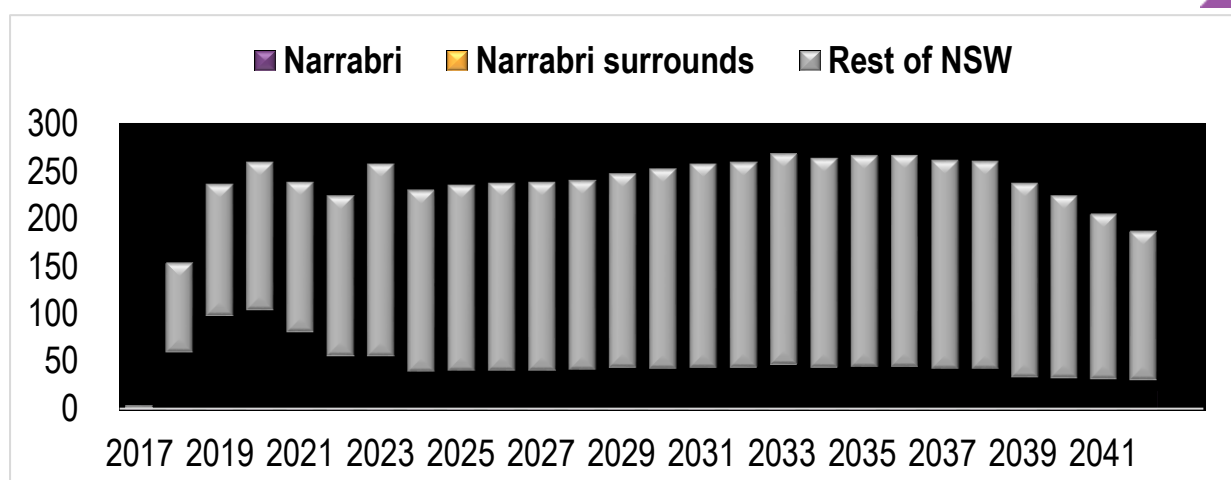
Figure 13 and Figure 14 show the change in real economic output and real income in each region for each year of the projection period (2017 to 2042) under the Policy Case (with the Narrabri Gas Project) compared to the Base Case (without the project). A summary of the projected impacts for all regions are presented in Table 9.

Figure 13 Real economic output (A\$m 2016)



Source: ACIL Allen

Figure 14 Real GNP/Real income (A\$m 2016)



Source: ACIL Allen

Table 9 Projected cumulative change in real economic output and real income in each region as a result of the Narrabri Gas Project relative to the Base Case (in 2016 terms)

	Real economic output			Real income		
	Total (2017 to 2042)	Net present value*		Total (2017 to 2042)	Net present value*	
		4%	7%		4%	7%
	2016 A\$m	2016 A\$m	2016 A\$m	2016 A\$m	2016 A\$m	2016 A\$m
Narrabri	10,970	6,380	4,456	526	332	250
Narrabri surrounds	572	420	348	690	488	396
Rest of NSW	384	325	295	4,777	2,901	2,111
Total NSW	11,926	7,125	5,100	5,993	3,722	2,757

Source: ACIL Allen

Note: * the use of the 4 per cent and 7 per cent are consistent with NSW Government (2012)

4.1.1 Real economic output

Over the period 2017 to 2042, the Narrabri Gas Project is projected to increase the real economic output of:

- the Narrabri region by a cumulative total of \$11.0 billion relative to the Base Case (with a net present value of \$4.5 billion, using a 7 per cent real discount rate).
- the areas surrounding Narrabri (Narrabri surrounds as defined earlier in this report) by a cumulative total of \$572 million (with a net present value of \$348 million, using a 7 per cent real discount rate)
- New South Wales as a whole (i.e. real GSP) by a cumulative total of \$11.9 billion relative to the Base Case (with a net present value of \$5.1 billion, using a 7 per cent real discount rate).

To place these projected changes in economic output estimates in perspective, the discounted present values (using a 7 per cent discount rate) are equivalent to around 1.0 per cent of New South Wales' current GSP.

4.1.2 Real income

Real income is a measure of the ability to purchase goods and services, adjusted for inflation. A rise in real income indicates a rise in the capacity for current consumption, but also an increased ability to accumulate wealth in the form of financial and other assets. The change in real income from a development is a measure of the change in welfare of an economy.

The extent to which the local residents will benefit from the additional economic output depends on the level of ownership of the capital (including the natural resources) utilised in the business as well as wealth transfers undertaken by Australian governments as a result of the taxation revenues generated by the Narrabri Gas Project.

Given the low population currently living in the local region, the assumed proportion of the potential employees for the project will live in the local area will provide a significant boost to the local incomes. However, as only a small portion of the project is assumed to be owned by local residents, a significant portion of the wealth generated by the economic activity is transferred outside of the Narrabri region (primarily to Australian shareholders which have been assumed to be evenly disbursed across Australia). Although, as will be discussed shortly, this wealth transfer will be somewhat reversed by the creation of a Community Benefit Fund.

The New South Wales Government will receive additional royalties (estimated to be \$1.2 billion in nominal terms) and taxes from the project. The NSW Government has committed that for every two dollars paid by a gas producer into an authorised Gas Community Benefit Fund, the company is entitled to claim a one dollar rebate on its gas royalties, up to a maximum of 10 per cent of the royalty due in each year. (The total value of the Community Benefit Fund is anticipated to be around \$120 million in nominal terms.) It is assumed for this modelling that the remainder of the royalty revenue will be spent proportionately to the population in each region of New South Wales. Similarly, taxes paid to the Australian Government have been assumed to be spent in each Australian region proportionate to their population.

Consequently, most of the real income benefit associated with the project, in absolute terms rather than in per capita terms, is projected to accrue to residents outside of the local region.

More specifically, over the period 2017 to 2042, the Narrabri Gas Project is projected to increase the real income of:

- the Narrabri region by a cumulative total of \$526 million, relative to the Reference Case (with a net present value of \$250 million, using a 7 per cent real discount rate)
- the areas surrounding Narrabri (Narrabri surrounds as defined earlier in this report) by a cumulative total of \$690 million, relative to the Reference Case (with a net present value of \$396 million, using a 7 per cent real discount rate)
- New South Wales as a whole by a cumulative total of \$6.0 billion, relative to the Reference Case (with a net present value of \$2.8 billion, using a 7 per cent real discount rate).

4.2 Employment

As well as creating medium term employment in the New South Wales economy, monetising the resources from the Narrabri Gas Project will generate a significant number of short-term jobs related to the construction phase of the project. In addition to the direct jobs generated on-site, the construction and operation phases will require other New South Wales sourced goods and services including engineering and management services, transportation, OH&S

and various business services. Supply of these inputs will further increase the demand for labour across the New South Wales economy.

A key issue when estimating the impact of a project is determining how the labour market will clear.⁴ For this analysis it has been assumed that the overall supply of labour in Australia is unaffected by the project. Under this assumption international migration rates and labour market participation rates are unaffected by the labour demand stimulus presented by the project. However, the modelling assumes that labour is mobile between states and regions in response to changes to real wage differentials. It has been assumed that labour is highly responsive to changes in real wage differentials and moves to virtually eliminate these differences.

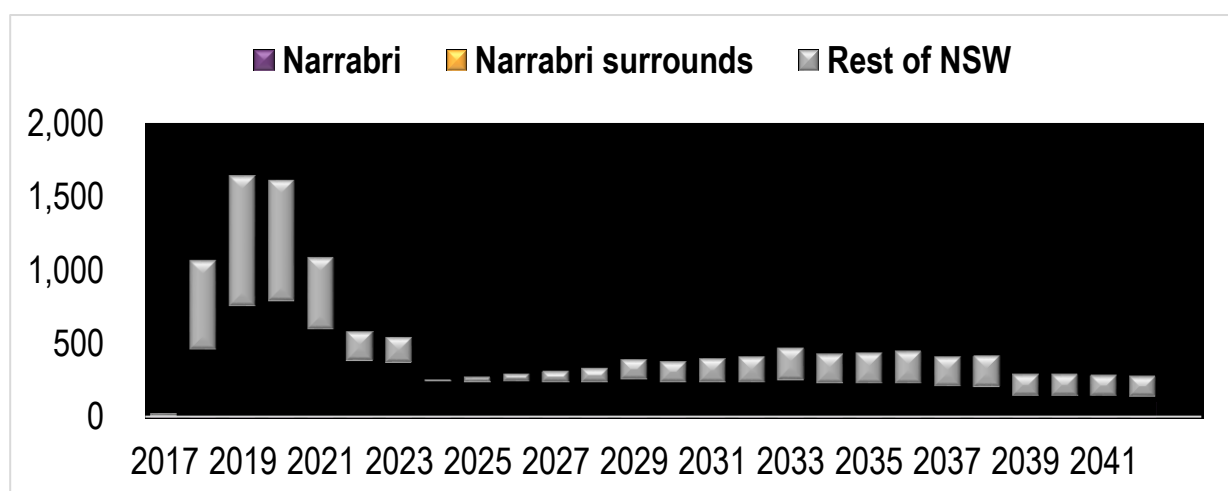
4.2.1 Employment creation

Over the life of the Narrabri Gas Project it is projected that an average of 540 full time equivalent direct and indirect jobs will be created in New South Wales. More specifically, over the period 2017 to 2042 it is projected that the Narrabri Gas Project will increase employment (by place of residence) in:

- the Narrabri region by an average of 127 FTE jobs
- the Narrabri surrounds region by an average of 161 FTE jobs
- New South Wales as a whole by an average of 512 FTE.

As illustrated in Figure 15, the employment impacts are variable year-to-year as a result of capital expenditure fluctuations over the life of the project.

Figure 15 **Projected change in total employment by region as a result of the Narrabri Gas Project, relative to the Base Case (full time equivalent jobs)**



Source: ACIL Allen

⁴ As with other CGE models, the standard assumption within *Tasman Global* is that all markets clear (i.e. demand equals supply) at the start and end of each time period, including the labour market. CGE models place explicit limits on the availability of factors and the nature of the constraints can greatly change the magnitude and nature of the results. In contrast, most other tools used to assess economic impacts, including I-O multiplier analysis, do not place constraints on the availability of factors. Consequently, non-CGE methods tend to overestimate the impacts of a project or policy.

4.3 Government revenues

Government revenues will rise significantly as a result of the Narrabri Gas Project. It is likely that some of the additional revenue will be returned to private households through slightly lower effective tax rates compared to the reference case, while the rest will be used to provide public goods and services.

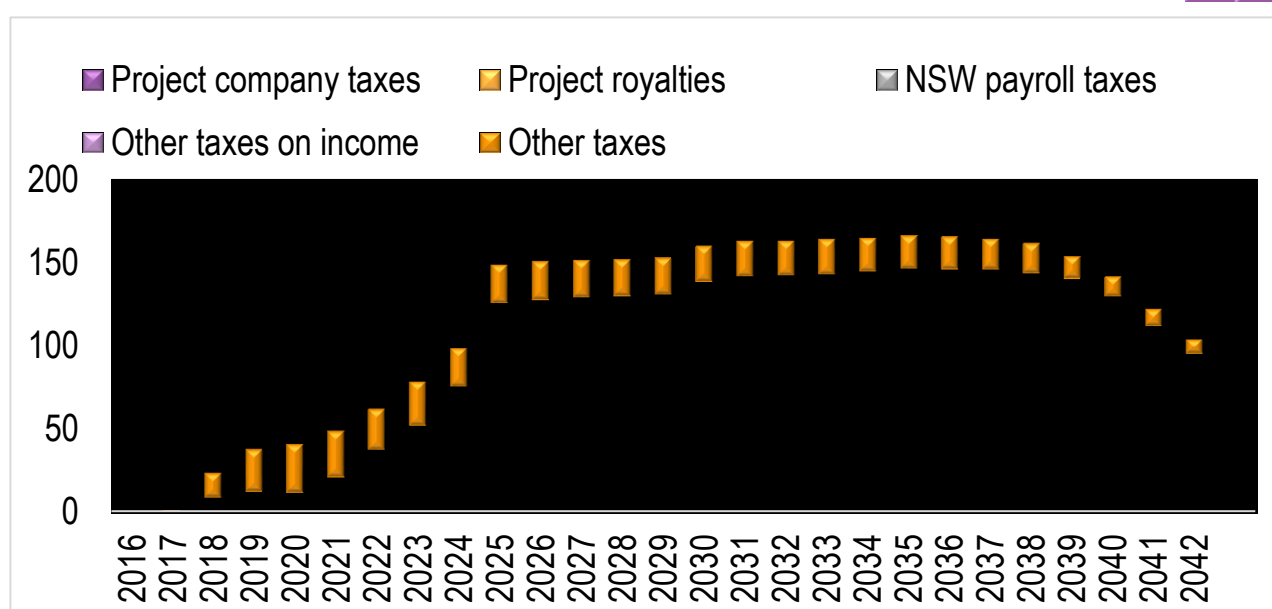
Table 10 provides a summary of the anticipated total additional tax revenues projected to be generated as a result of the project, while Figure 16 shows the changes in different revenue streams through time.

Table 10 **Cumulative projected change in real government tax revenues, relative to the Reference Case**

	Total (2017 to 2042)	Net present value	
		4%	7%
	2016 A\$m	2016 A\$m	2016 A\$m
Project company taxes	1,386	745	456
Project royalties	821	462	293
NSW payroll taxes	129	83	60
Other taxes on income	294	178	120
Other taxes	503	330	237
TOTAL	3,133	1,799	1,165

Source: ACIL Allen and Santos NSW (Eastern) Pty Ltd

Figure 16 **Projected changes in annual real government revenues, relative to the Reference Case (in 2016 terms)**



Nationally, tax revenues rise significantly, with nearly 70 percent due directly to projected project company taxes and royalties.

4.4 Industry and regional effects

4.4.1 Industry impacts

There are several key factors to consider when anticipating the impact that a major project, such as the Narrabri Gas Project, will have on other domestic industries:

- Competition for resources, particularly labour and land
- Impact on costs
- Impact on the exchange rate
- Increased demand from the project, both directly and from increased levels of income.

The Narrabri Gas Project will provide job opportunities in both the construction and operations phases. In construction, direct employment is anticipated to peak at over 1,300 (see Section 1.2.1) while operations is expected to add 150 jobs (in addition to the 50 Santos employees currently working in Narrabri) (see Table 8).

Competition for labour, particularly for skilled labour, can have a negative effect on other local industries. However, while the project will provide job opportunities for local and regional workers, the source of labour for the Narrabri Gas Project is expected to be widely dispersed.

As Table 8 shows, around 10 per cent of construction labour is anticipated to be resident in the Narrabri Shire, with an additional 20 per cent resident in the area designated as Narrabri surrounds. While much of this labour may be currently local, some will move into these areas, even if only on a temporary basis, for the duration of their involvement on the project. The remainder of the construction workforce is assumed to be sourced from the rest of NSW.

The peak levels of construction labour demand will be short lived: two to three years. The much longer operations phase represents a relatively minor drain on the local labour supply. Section 2.6 shows that in 2013 the Narrabri Shire's workforce stood at 7,700 (with an unemployment rate of 5.5 per cent). When Narrabri and Narrabri surrounds are added together this rose to 123,750 jobs (with an unemployment rate of 6.5 per cent). The job opportunities created by the proposed Narrabri Gas Project will be highly skilled and well paid, but they are not of a magnitude, particularly in the long lasting operations phase, that will cause a significant drain on local businesses access to skilled labour.

To develop the Narrabri Gas Project will require a certain amount of land disturbance. The total amount of land cleared is projected to be 980 hectares. After rehabilitation this disturbed area will be reduced to an anticipated 453 hectares. All of this land use will be within the Narrabri Shire which has a total area of 1,301,410 hectares; therefore, the total area of disturbance prior to rehabilitation equates to 0.08 per cent of the area of the shire (0.035 per cent after rehabilitation). However, the impact of the land use associated with the project depends on its current alternative use. The land areas disturbed will include some currently productive agricultural land (including land used for forestry). In 2005-06 the Narrabri Shire had 223,455 hectares under crop and 420,090 hectares of grazing land (ABS, 2008). A total area of 643,545 hectares. Therefore, the total area of disturbance represents at most 0.2 per cent of total agricultural land within Narrabri Shire (0.07 per cent after rehabilitation). In reality the level of disturbance (on a percentage basis) will be much less as most of the land disturbed is currently not economically productive.

Changes to land access for primary producers has been incorporated into the modelling by allowing for reduced land availability.

Agricultural land holders whose land is disturbed by the Narrabri Gas Project are subject to a compensation package from Santos to ensure that loss of production associated with the project is not detrimental to their farming operations. This offsetting compensation package has not been included in the modelling.

Modelling suggests that the impact of the Narrabri Gas Project on costs within Narrabri and Narrabri surrounds will be small. At its peak the construction phase of the project is estimated to increase the Narrabri consumer price index (CPI) by 0.9 per cent and the CPI of Narrabri surrounds by 0.2 per cent over baseline. In the longer term operations phase, the modelling shows that price levels remain only slightly higher (0.4 per cent and 0.1 per cent higher respectively) than they would have been without the project. Such small increases in costs are not major impediments to local industry.

Large export orientated resource development projects are associated with appreciations of the exchange rate. As exchange rate appreciations make Australian exports relatively more expensive than their international competitors, this has a negative impact on export orientated industries. This is known in Australia as the “Gregory effect” (Gregory, 1976). The impact of the Narrabri Gas Project on the Australian exchange rate is negligible. As the project is supplying the domestic market, and is replacing gas from other domestic (Australian) sources rather than imports, this small impact on the exchange rate is to be expected. With the exchange rate effectively unaltered by the project, the “Gregory effect” on other industries is negligible.

The effects described above have focussed on the potentially negative impacts a project can have on other industries, with a particular focus on local and regional industries. But there are also substantial positive impacts available from a project such as the Narrabri Gas Project. The Narrabri Gas Project, in both the construction and operations phases, will be a purchaser of goods and services from Narrabri, Narrabri surrounds and the wider NSW economies. This increased demand for NSW production will provide a stimulus to businesses throughout the state.

In addition to the direct demand effects of the project there will be significant income effects throughout NSW, with special emphasis on the local region. The proposed Narrabri Gas Project will create value from a presently underutilised natural resource in the region. In creating value from this resource, Santos will generate income and profits that will see them paying significant taxes and royalties. In addition to the standard State Government royalty, an additional amount equivalent to 5 per cent of the royalty payment will be provided by Santos to the Narrabri region in the form of a Community Benefit Fund. The NSW Government has committed that for every two dollars paid by a gas producer into an authorised Gas Community Benefit Fund, the company is entitled to claim a one dollar rebate on its gas royalties, up to a maximum of 10 per cent of the royalty due in each year. This additional income will stimulate local, regional and state level demand to the benefit of NSW businesses.

A further demand stimulus will be generated by the new jobs created by the project and the higher wages that many of these higher skilled jobs will command.

Table 11 shows the average impacts over the life of the Narrabri Gas Project on industry employment and output at the local, regional and state levels. The impacts shown do not include the Narrabri Gas Project within the mining industry; therefore, the industry effects shown relate only to the pre-existing mining industry. The results show employment and output change relative to baseline, i.e. relative to where they would be without the project.

Table 11 Industry employment and output impacts over the project life – per cent deviation from the baseline

	Employment			Output		
	Narrabri	Narrabri surrounds	NSW	Narrabri	Narrabri surrounds	NSW
Agriculture and forestry	-0.29	-0.06	-0.03	-0.21	-0.04	-0.02
Mining	-0.56	-0.3	-0.04	-0.80	-0.68	-0.04
Manufacturing	-0.32	0.01	-0.04	-0.64	-0.02	-0.05
Utilities	1.19	0.11	0.01	0.34	0.01	0.00
Construction	1.45	0.39	0.02	1.08	0.34	0.02
Trade	1.12	0.14	0.02	0.67	0.08	0.01
Transport	0.63	0.30	0.01	0.63	0.27	0.00
Services	0.91	0.10	0.01	0.36	0.04	0.00
TOTAL	0.49	0.09	0.01	0.19	0.05	-0.01

Source: ACIL Allen

The results in Table 11 demonstrate that on both an employment and output level the impacts of the Narrabri Gas Project are positive on most of the sectors shown. The negative impacts shown to agriculture and forestry, mining and manufacturing are small and are likely mainly due to the competition for labour and small increases in local costs. The positive benefits seen for the construction industry will be mainly a result of demand from the project while trade will benefit not only from project demand but from the increased levels of income at the local, regional and state levels.

Due to its domestic sales orientation, modest direct employment demand and relatively low land requirements, the Narrabri Gas Project has relatively little potential to have detrimental effects on NSW industries at the local, regional and state level. The positive demand and income effects are offsetting of the potential negative effects.

The anticipated reduction in mining output relative to the baseline projection is the largest of all industries shown in Table 11. Workers in the existing mining industry possess skills that match the needs of the Narrabri Gas Project. The existing Mining industry will therefore face strong competition for labour from the project. The mining industry also has a strong export orientation and so the changes in domestic costs and the exchange rate, though relatively small, will also have a negative effect on the pre-existing industry (relative to the baseline).

At the state level, the negative impact on mining in NSW is sufficient to generate a small negative output effect on NSW as a whole: -0.01 per cent relative to baseline. This effect is completely reversed by including the output of the Narrabri Gas Project into the output estimation. The impact on NSW output is then a positive 0.03 per cent.

4.4.2 Regional impacts

In sections 4.1 and 4.2 the impacts of the Narrabri Gas Project on NSW at the local, regional and state level were discussed. The regional level, Narrabri surrounds, is an aggregation of the following shires:

- Armidale Dumaresq
- Coonamble
- Dubbo
- Gilgandra
- Glen Innes Severn
- Gunnedah

- Gwydir
- Inverell
- Liverpool Plains
- Moree Plains
- Tamworth Regional
- Uralla
- Walgett
- Warrumbungle.

These shires were selected for inclusion in the analysis based on their perceived ability to interact/contribute to the project. The assessment of this potential interaction was based on the size of their regional centres and their driving distances/times from the project.

The larger regional centres of Tamworth and Dubbo (within their respective shires) have a greater capacity to supply the project with goods and services than the smaller Coonamble and Moree, even though these latter towns are both closer to the project. Gunnedah, with a population somewhat in between and good proximity to the project has potential to benefit from the development. Gunnedah has been an emerging service centre for coal mining in the region and is well placed to also service the emerging gas industry.

Precise identification of the degree that each shire will benefit from the Narrabri Gas Project is not possible. However, the larger centres, with larger workforces, greater access to infrastructure and more diverse economic bases, are best positioned to take advantage of their proximity to the project.

4.5 Gaps in the data used in the modelling and their implications

When performing an economic impact analysis, the aim is to incorporate as much relevant data as is available. In undertaking this analysis there has been extensive interaction with Santos representatives to maximise data acquisition and use. However, at some point the analysis must be completed with some issues still unresolved. While that is the case with this project, fortunately the issues involved are not major and are likely to mean that the impacts estimated in the modelling are conservative.

The following issues still require resolution:

- Electricity supply to the project. In the modelling it has been assumed that the electricity supply needs of the project will be met by the installation of new transmission capacity. Electricity supply has therefore been modelled as a purchased input. However, it is possible that the project will install its own gas fired power station. It is not anticipated that such a change would have a substantial impact on the modelling outcomes.
- Increased regional water resource. In the process of extracting the gas, a significant amount of underground water will be released. After treatment some of this water may be available for agricultural use with associated positive impacts on agricultural production within the Narrabri Shire. At this time there is not sufficient information available on water treatment and use for this potential benefit to be included in the CGE analysis.

5 Comparison with previous analysis

In December 2011, the Allen Consulting Group (ACG) produced the report: *The economic impacts of developing coal seam gas operations in Northwest NSW*. It is appropriate to consider the economic impacts presented in that report and compare these with the impacts presented in Section 4 of this report.

Before proceeding with a comparison of the results, it is useful to consider the modelling approach and scope of the ACG analysis, and compare it with the approach taken in this report. ACG made use of the *Monash Multi-Regional Forecasting* (MMRF) model which was run in comparative static mode as opposed to the dynamic simulations undertaken for this report using the *Tasman Global* model. Comparative static analysis compares two states of the economy: one with the project and one without the project. In the specific analysis performed by ACG, there were two comparative static analyses performed: with the construction phase of the project compared to without, and with the operations phase of the project compared to without. For this approach, ACG analysed an average year of construction and an average year of full production. Therefore, the ACG report could not present results through time as has been done in Section 4 of this report.

The ACG report considered a larger project than the Narrabri Gas Project. The Narrabri Gas Project's peak production is anticipated to be 74 PJ per annum, whereas the ACG analysis was based on 210 PJ per annum. Therefore, the analysis in this report represents a production level of 35 per cent of the previous analysis.

Due to the larger gas reserve being developed, capital costs in the project were considerably larger in the project covered by the ACG report. ACG stated that around \$16.6 billion will be spent on the project. However, only \$4.3 billion of that is spent during the seven year construction period they analysed: 2011 to 2017: an average of \$614 million per construction year. The capital spend for the Narrabri Gas Project analysed in this report is much smaller (\$3.0 billion in real terms). The amount spent in the construction only period of 2017 to 2019 is projected to be \$261 million per year.

The regions of analysis for the two reports are also quite different. In this report the regions are based on shires, with Narrabri representing the Narrabri Shire and Narrabri surrounds representing 14 surrounding shires. The ACG report analysis used four statistical sub-divisions – North Central Plain, Central Macquarie, Northern Slopes and Hunter SD Balance.

Comparison of the results from the two reports is further complicated by the dynamic nature of the *Tasman Global* simulations used in this report. It is customary in dynamic simulations of projects to report year on year results that include the impacts of construction and operation where they are occurring in both years. For all but the first three years of the Narrabri Gas Project construction and operation are coexisting. To aid comparison between the two sets of modelling, the results presented in Table 12 we have attempted to isolate the construction and operation phases in the Narrabri Gas Project. Consequently, the construction phase results only refer to years 2017 to 2019, before production commences, while the production phase results refer to the year 2039 when construction spend was absent and production remained close to its peak. The results of the two reports have been normalised to simplify comparison, with the construction phase results based on \$100 million per annum of capital spend while the operations phase results are based on 10 PJ per annum of production.

One further point to consider is that the ACG report presents dollar impacts in 2011 dollars, whereas in this report the base year for the reporting is 2016. To aid comparison the ACG dollar value results presented below have been inflated to 2016 dollars (ABS, 2014 and an assumed inflation rate of 2.5 per cent).

Due to the significant difference in regional breakdown between the two reports, the comparisons have been limited to the impacts at the New South Wales level. The normalised comparisons of the projected impact on gross state product (GSP) and employment are presented in Table 12.

Table 12 Comparison with Allen Consulting Group report – NSW results

	Construction (\$100m capex)		Operations (10 PJ per annum)	
	Narrabri Gas Project	Northwest NSW Gas Project	Narrabri Gas Project	Northwest NSW Gas Project
Gross State Product (2016 A\$m)	39	47	73	45
Employment (FTE jobs)	350	138	41	138

Source: ACIL Allen and Allen Consulting Group

The comparison of results in Table 12 is quite mixed. Consider the construction phase first. The impacts of construction on GSP (per \$100m capex) were quite similar between the two reports: \$39 million compared to \$47 million; however, the employment numbers differ considerably, with this report estimating over two and a half times the employment impact of the ACG report (350 FTE jobs compared to 138 FTE jobs).

The data available for project analysis in this report has had the benefit of three years of scope development by Santos. This report has been able to incorporate the additional data that was not available to the previous analysts. For example, the peak employment specified in the ACG report was 1,800 jobs with an average construction spend of \$614 million (although the corresponding peak construction spend is unknown). The data provided by Santos for this report has peak construction labour at 1,300 (see Section 1.2.1) with an average construction spend of just \$261 million. This suggests that direct labour intensity has risen from an index of 3.0 to 5.0 peak jobs per million dollars, representing a 70 per cent increase in direct labour intensity. Additionally, Santos provided a breakdown of construction spend at a level of detail not available for the previous analysis. It is these factors that are likely to account for the variation in employment outcomes in the construction phase.

The operations phase presents an interesting dichotomy: the GSP predicted by this report is 60 per cent larger (per 10 PJ) as that predicted by the ACG report, while the employment impact is less than one third the size. The GSP effect is easily understood. The GSP impact of a given project is significantly influenced by the value of the project's output, and the value of the output is of course a function of the quantity produced as well as the price. The comparisons of operations phases in Table 12 standardise the quantity of gas (in PJ) produced and sold for ease of comparison; however, they are not standardised for gas price.

The previous analysis undertaken by ACG used the MMRF model. In the MMRF model, as in *Tasman Global*, there is an existing representation of the gas industry. In the absence of additional project specific data, the existing MMRF gas industry was used to represent the project. Inherent in this approach is the model's pre-existing gas price assumptions, which are reflective of legacy gas contract prices rather than new entrant prices. In contrast, the analysis in this report has used projected new entrant prices. These prices will be significantly higher than the legacy prices in MMRF (even given recent declines in energy prices). The difference in pricing accounts for the majority of the GSP difference between

the two reports. It would therefore be correct to say that the ACG report took a conservative approach regarding gas prices and that this is reflected in the conservative GSP projections for the operations phase of the project.

How then to explain the opposite effect being seen in the employment numbers? Here again the effect of using the existing MMRF gas industry explains at least part of the difference. The MMRF database is based on a representation of the Australian economy in the 2005-06 financial year, therefore the gas industry was based on the basic underlying technology of 2005-06. The modelling for this report, being dynamic, has projected the economy forward to 2042, and this projection incorporates labour productivity growth, and, more importantly, the modelling in this report uses the latest Santos data which was unavailable to the previous modellers.

In summary, the GSP impacts in construction are similar between the two reports, while the differences in GSP impacts in the operations phase are easily explained by the differences in assumed gas market prices between the two analyses. The differences in employment results between the two analyses are likely due to the additional project data available for this analysis. By having detailed project specific data and by incorporating that data into the analysis through the “micro industry” approach described in Section 3.2.3, this report has been able to incorporate the additional project detail that was unavailable for the previous analysis.

6 Summary

This report has investigated the economic impact of the Narrabri Gas Project on NSW at the local, regional and state levels. The Narrabri Gas Project will create economic value from an underutilised natural resource, located south west of the town of Narrabri in the Gunnedah Basin. The natural gas liberated by the project will be used to supply the east coast market, in particular the NSW gas market. First gas is anticipated to reach market in 2020 with the project's life extending out to 2042. Once production reaches capacity the Narrabri Gas Project will supply 200 TJ per day of gas.

For the purpose of analysis, the Narrabri Shire, which contains the project, has been analysed as the local region. Shires surrounding the project which, by virtue of their size and proximity are believed capable of contributing to the project, have been included in the region designated as Narrabri surrounds. Narrabri surrounds has been defined to include the Local Government Areas of Armidale Dumaresq, Coonamble, Dubbo, Gilgandra, Glen Innes Severn, Gunnedah, Gwydir, Inverell, Liverpool Plains, Moree Plains, Tamworth Regional, Uralla, Walgett and Warrumbungle. The report has also considered the impacts of the project on the NSW economy as a whole.

In 2013 the Narrabri region had a population of 13,685 and a workforce of 7,700. When Narrabri and Narrabri Sounds (Narrabri and surrounds) are combined the population increases to 236,890 with a workforce of 123,750. The sizes of each economy are similarly proportioned. In 2010-11 the gross product of Narrabri was estimated to be \$240 million, while the gross product of Narrabri and surrounds was estimated to be \$10.4 billion.

The economic impact of the Narrabri Gas Project has been analysed using the CGE model *Tasman Global*. The results of the analysis show that the project will, over its productive life:

- Increase the real economic output of:
 - Narrabri by \$11.0 billion
 - Narrabri surrounds by \$572 million
 - NSW by \$11.9 billion
- Increase real income in:
 - Narrabri by \$526 million
 - Narrabri surrounds by \$690 million
 - NSW by \$6.0 billion
- Increase average employment by:
 - 127 FTE jobs in Narrabri
 - 161 FTE jobs in Narrabri surrounds
 - 512 FTE jobs in NSW.

The Narrabri Gas Project, with an estimated real capital cost of \$3.0 billion and a steady state production of 200 TJ per day will provide a boost to the NSW economy and deliver benefits at the state, regional and local levels.

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Appendix A Modelling appendix

A.1 Overview of input-output multipliers and general equilibrium models

Input-output (I-O) tables are at the heart of both multiplier analysis and CGE models. Input-output tables provide a comprehensive picture of the supply and consumption of all commodities within the economy, including detailed information on factor incomes, taxes and the source (domestic or foreign) of every commodity. They are essentially the bottom-up accounting framework that underlies the calculation of aggregate GDP. Unlike the GDP accounts, however, I-O tables retain all intermediate consumption and therefore provide a detailed picture of the structure and interrelationships of industries. An important feature of I-O tables is that they are fully balanced matrices. For example, production costs (including returns to factors of production) equals sales revenue.

I-O multipliers are summary measures generated from input-output tables that can be used for predicting the total impact on all industries in the economy of changes in demand for the output of an industry. The tables and multipliers can also be used to measure the relative importance of the product chain linkages to different parts of the economy. In most circumstances, the results of I-O multiplier analysis should be treated as upper level impacts.

CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, starting with individual markets, producers and consumers and building up the system via demands and production from each component. When an economic shock or disturbance is applied to a model, each of the markets adjusts according to the set of behavioural parameters which are underpinned by economic theory. The generalised nature of CGE models enable a much broader range of analysis to be undertaken (generally in a more robust manner) compared to I-O multiplier techniques.

Limitations of I-O Analysis

The limitations of the I-O analysis relate to four key simplifying assumptions underpinning the model:

- Each industry in the I-O table is assumed to produce a single output
- There can be no substitution between the goods or services of different industry sectors (or their source)
- There are constant returns to scale in production such that the inputs to production of all industry sectors are in fixed proportion to the level of output from that industry
- The total effect of production in several sectors is equal to the sum of the separate effects.

Therefore, particular care should be used when interpreting multiplier impacts, as they represent a linear response from the increase in final demand under implicit assumptions that an economy or industry has no spare capacity and that the productivity of that industry is constant.

The I-O approach ignores the opportunity costs associated with diverting resources from other productive activities as the model has no mechanism whereby the prices of factors (land, labour and capital) adjust in response to changes in demand. As such, I-O analysis

does not consider the efficiency of an investment and the wider social implications. I-O analyses are not well suited to the analysis of social or population changes that might arise over the life of a project.

Weaknesses of CGE modelling

One complaint sometimes levelled at CGE modelling is that the models are “black boxes”. In part this complaint arises because of the computing used to drive the model and the thousands of simultaneous equations which are solved to reach a modelled equilibrium. However, it must be stressed that the equations which underpin the credible models used in Australia are based on rigorous economic theory.

This theory and the use of the models are generally well understood and respected by Australian Government decision makers. CGE models can be a powerful tool for understanding the implications of a project to a region and the State as it recognises not only the direct and second round impacts but the third and fourth round etc. impacts of a project in a region.

A weakness of CGE models is that they can only model market impacts on economic variables such as regional gross product, consumption, production and population etc. CGE models generally do not have the capacity to model wider social or environmental impacts although various modern models have attempted to capture some of these aspects (such as greenhouse gas emissions which are widely modelled using CGE models or incorporating the value of leisure time into the household decision making functions).

A.2 The *Tasman Global* model

ACIL Allen’s computable general equilibrium model *Tasman Global* is a powerful tool for undertaking economic impact analysis at the regional, state, national and global level.

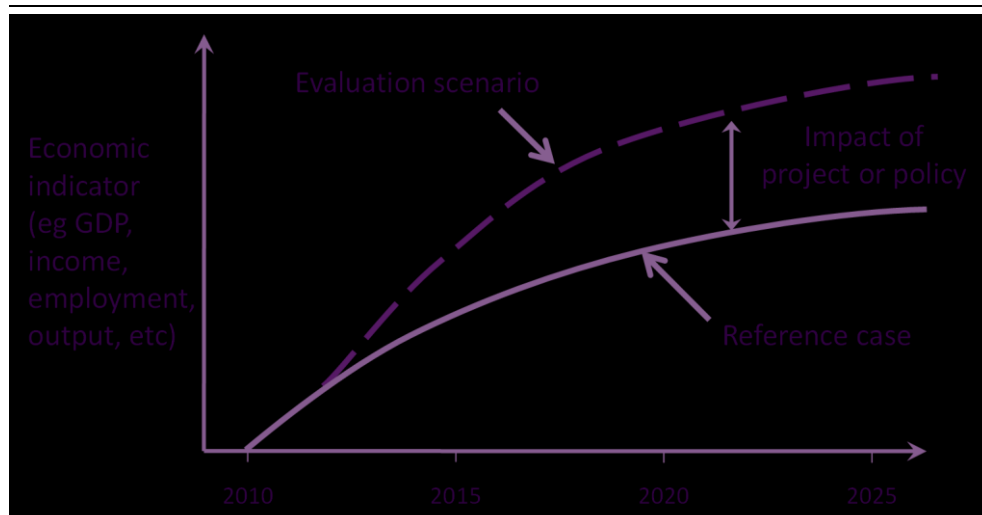
There are various types of economic models and modelling techniques. Many of these are based on partial equilibrium analysis that usually considers a single market. However, in economic analysis, linkages between markets and how these linkages develop and change over time can be critical. *Tasman Global* has been developed to meet this need.

Tasman Global is a large-scale computable general equilibrium model which is designed to account for all sectors within an economy and all economies across the world. ACIL Allen uses this modelling platform to undertake industry, project, scenario and policy analyses. The model is able to analyse issues at the industry, global, national, state and regional levels and to determine the impacts of various economic changes on production, consumption and trade at the macroeconomic and industry levels.

A dynamic model

Tasman Global is a model that estimates relationships between variables at different points in time. This is in contrast to comparative static models, which compare two equilibriums (one before a policy change and one following). A dynamic model such as *Tasman Global* is beneficial when analysing issues where both the timing of and the adjustment path that economies follow are relevant in the analysis.

In applications of the *Tasman Global* model, a Reference Case simulation forms a ‘business-as-usual’ basis with which to compare the results of various simulations. The Reference Case provides projections of growth in the absence of the changes to be examined. The impact of the change to be examined is then simulated and the results interpreted as deviations from the Reference Case (see Figure A1).

Figure A1 Illustrative scenario analysis using *Tasman Global*

Source: ACIL Allen

The database

A key advantage of *Tasman Global* is the level of detail in the database underpinning the model. The database is derived from the latest Global Trade Analysis Project (GTAP) database (version 8.1). This database is a fully documented, publicly available global data base which contains complete bilateral trade information, transport and protection linkages among regions for all GTAP commodities.

The GTAP model was constructed at the Centre for Global Trade Analysis at Purdue University in the United States. It is the most up-to-date, detailed database of its type in the world.

Tasman Global builds on the GTAP model's equation structure and database by adding the following important features:

- dynamics (including detailed population and labour market dynamics)
- detailed technology representation within key industries (such as electricity generation and iron and steel production)
- disaggregation of a range of major commodities including iron ore, bauxite, alumina, primary aluminium, brown coal, black coal and LNG
- the ability to repatriate labour and capital income
- a detailed emissions accounting abatement framework
- explicit representation of the states and territories of Australia
- the capacity to explicitly represent multiple regions within states and territories of Australia.

Nominally the *Tasman Global* database divides the world economy into 141 regions (133 international regions plus the 8 states and territories of Australia) although in reality the regions are frequently disaggregated further. ACIL Allen regularly models Australian projects or policies at the regional level.

The *Tasman Global* database also contains a wealth of sectoral detail currently identifying up to 70 industries (Table A1). The foundation of this information is the input-output tables that underpin the database. The input-output tables account for the distribution of industry production to satisfy industry and final demands. Industry demands, so-called intermediate usage, are the demands from each industry for inputs.

For example, electricity is an input into the production of communications. In other words, the communications industry uses electricity as an intermediate input. Final demands are those made by households, governments, investors and foreigners (export demand). These final demands, as the name suggests, represent the demand for finished goods and services. To continue the example, electricity is used by households – their consumption of electricity is a final demand.

Table A1 Sectors in the *Tasman Global* database

Sector	Sector
1 Paddy rice	36 Paper products, publishing
2 Wheat	37 Diesel (incl. nonconventional diesel)
3 Cereal grains nec	38 Other petroleum, coal products
4 Vegetables, fruit, nuts	39 Chemical, rubber, plastic products
5 Oil seeds	40 Iron ore
6 Sugar cane, sugar beef	41 Bauxite
7 Plant- based fibres	42 Mineral products nec
8 Crops nec	43 Ferrous metals
9 Bovine cattle, sheep, goats, horses	44 Alumina
10 Animal products nec	45 Primary aluminium
11 Raw milk	46 Metals nec
12 Wool, silk worm cocoons	47 Metal products
13 Forestry	48 Motor vehicle and parts
14 Fishing	49 Transport equipment nec
15 Brown coal	50 Electronic equipment
16 Black coal	51 Machinery and equipment nec
17 Oil	52 Manufactures nec
18 Liquefied natural gas (LNG)	53 Electricity generation
19 Other natural gas	54 Electricity transmission and distribution
20 Minerals nec	55 Gas manufacture, distribution
21 Bovine meat products	56 Water
22 Meat products nec	57 Construction
23 Vegetables oils and fats	58 Trade
24 Dairy products	59 Road transport
25 Processed rice	60 Rail and pipeline transport
26 Sugar	61 Water transport
27 Food products nec	62 Air transport
28 Wine	63 Transport nec
29 Beer	64 Communication
30 Spirits and RTDs	65 Financial services nec
31 Other beverages and tobacco products	66 Insurance
32 Textiles	67 Business services nec
33 Wearing apparel	68 Recreational and other services
34 Leather products	69 Public Administration, Defence, Education, Health
35 Wood products	70 Dwellings

Note: nec = not elsewhere classified

The other key feature of the database is that the cost structure of each industry is also represented in detail. Each industry purchases intermediate inputs (from domestic and imported sources) primary factors (labour, capital, land and natural resources) as well as paying taxes or receiving subsidies.

Factors of production

Capital, land, labour and natural resources are the four primary factors of production. The capital stock in each region (country or group of countries) accumulates through investment (less depreciation) in each period. Land is used only in agriculture industries and is fixed in each region. *Tasman Global* explicitly models natural resource inputs as a sector specific factor of production in resource based sectors (coal mining, oil and gas extraction, other mining, forestry and fishing).

Population growth and labour supply

Population growth is an important determinant of economic growth through the supply of labour and the demand for final goods and services. Population growth for the 112 international regions and for the 8 states and territories of Australia represented in the *Tasman Global* database is projected using ACIL Allen's in-house demographic model. The demographic model projects how the population in each region grows and how age and gender composition changes over time and is an important tool for determining the changes in regional labour supply and total population over the projection period.

For each of the 120 regions in *Tasman Global*, the model projects the changes in age-specific birth, mortality and net migration rates by gender for 101 age cohorts (0-99 and 100+). The demographic model also projects changes in participation rates by gender by age for each region, and, when combined with the age and gender composition of the population, endogenously projects the future supply of labour in each region. Changes in life expectancy are a function of income per person as well as assumed technical progress on lowering mortality rates for a given income (for example, reducing malaria-related mortality through better medicines, education, governance etc.). Participation rates are a function of life expectancy as well as expected changes in higher education rates, fertility rates and changes in the work force as a share of the total population.

Labour supply is derived from the combination of the projected regional population by age by gender and the projected regional participation rates by age by gender. Over the projection period labour supply in most developed economies is projected to grow slower than total population as a result of ageing population effects.

For the Australian states and territories, the projected aggregate labour supply from ACIL Allen's demographics module is used as the base level potential workforce for the detailed Australian labour market module, which is described in the next section.

The Australian labour market

Tasman Global has a detailed representation of the Australian labour market which has been designed to capture:

- different occupations;
- changes to participation rates (or average hours worked) due to changes in real wages;
- changes to unemployment rates due to changes in labour demand;
- limited substitution between occupations by the firms demanding labour and by the individuals supplying labour; and
- limited labour mobility between states and regions within each state in response to changes to real wages.

Tasman Global recognises 97 different occupations within Australia – although the exact number of occupations depends on the aggregation. The firms who hire labour are provided with some limited scope to change between these 97 labour types as the relative real wage

between them changes. Similarly, the individuals supplying labour have a limited ability to change occupations in response to the changing relative real wage between occupations. Finally, as the real wage for a given occupation rises in one state relative to other states, workers are given some ability to respond by shifting their location. The model produces results at the 97 3-digit ANZSCO (Australian New Zealand Standard Classification of Occupations) level which are presented in Table A2.

The labour market structure of *Tasman Global* is thus designed to capture the reality of labour markets in Australia, where supply and demand at the occupational level do adjust, but within limits.

Labour supply in *Tasman Global* is presented as a three stage process:

1. labour makes itself available to the workforce based on movements in the real wage and the unemployment rate;
2. labour chooses between occupations in a state based on relative real wages within the state; and
3. labour of a given occupation chooses in which state to locate based on movements in the relative real wage for that occupation between states.

By default, *Tasman Global*, like all CGE models, assumes that markets clear. Therefore, overall, supply and demand for different occupations will equate (as is the case in other markets in the model).

Table A2 Occupations in the *Tasman Global* database, ANZSCO 3-digit level (Minor Groups)

ANZSCO code, Description	ANZSCO code, Description	ANZSCO code, Description
MANAGERS	3. TECHNICIANS & TRADES WORKERS	5. CLERICAL & ADMINISTRATIVE
111 Chief Executives, General Managers and Legislators	311 Agricultural, Medical and Science Technicians	511 Contract, Program and Project Administrators
121 Farmers and Farm Managers	312 Building and Engineering Technicians	512 Office and Practice Managers
131 Advertising and Sales Managers	313 ICT and Telecommunications Technicians	521 Personal Assistants and Secretaries
132 Business Administration Managers	321 Automotive Electricians and Mechanics	531 General Clerks
133 Construction, Distribution and Production Managers	322 Fabrication Engineering Trades Workers	532 Keyboard Operators
134 Education, Health and Welfare Services Managers	323 Mechanical Engineering Trades Workers	541 Call or Contact Centre Information Clerks
135 ICT Managers	324 Panelbeaters, and Vehicle Body Builders, Trimmers and Painters	542 Receptionists
139 Miscellaneous Specialist Managers	331 Bricklayers, and Carpenters and Joiners	551 Accounting Clerks and Bookkeepers
141 Accommodation and Hospitality Managers	332 Floor Finishers and Painting Trades Workers	552 Financial and Insurance Clerks
142 Retail Managers	333 Glaziers, Plasterers and Tilers	561 Clerical and Office Support Workers
149 Miscellaneous Hospitality, Retail and Service Managers	334 Plumbers	591 Logistics Clerks
	341 Electricians	599 Miscellaneous Clerical and Administrative Workers
PROFESSIONALS	342 Electronics and Telecommunications Trades Workers	
211 Arts Professionals	351 Food Trades Workers	6. SALES WORKERS
212 Media Professionals	361 Animal Attendants and Trainers, and Shearers	611 Insurance Agents and Sales Representatives
221 Accountants, Auditors and Company Secretaries	362 Horticultural Trades Workers	612 Real Estate Sales Agents
222 Financial Brokers and Dealers, and Investment Advisers	391 Hairdressers	621 Sales Assistants and Salespersons
223 Human Resource and Training Professionals	392 Printing Trades Workers	631 Checkout Operators and Office Cashiers
224 Information and Organisation Professionals	393 Textile, Clothing and Footwear Trades Workers	639 Miscellaneous Sales Support Workers
225 Sales, Marketing and Public Relations Professionals	394 Wood Trades Workers	
231 Air and Marine Transport Professionals	399 Miscellaneous Technicians and Trades Workers	7. MACHINERY OPERATORS & DRIVERS
232 Architects, Designers, Planners and Surveyors		711 Machine Operators
233 Engineering Professionals	4. COMMUNITY & PERSONAL SERVICE	712 Stationary Plant Operators
234 Natural and Physical Science Professionals	411 Health and Welfare Support Workers	721 Mobile Plant Operators
241 School Teachers	421 Child Carers	731 Automobile, Bus and Rail Drivers
242 Tertiary Education Teachers	422 Education Aides	732 Delivery Drivers
249 Miscellaneous Education Professionals	423 Personal Carers and Assistants	733 Truck Drivers
251 Health Diagnostic and Promotion Professionals	431 Hospitality Workers	741 Storepersons
252 Health Therapy Professionals	441 Defence Force Members, Fire Fighters and Police	
253 Medical Practitioners	442 Prison and Security Officers	8. LABOURERS
254 Midwifery and Nursing Professionals	451 Personal Service and Travel Workers	811 Cleaners and Laundry Workers
261 Business and Systems Analysts, and Programmers	452 Sports and Fitness Workers	821 Construction and Mining Labourers
262 Database and Systems Administrators, and ICT Security Specialists		831 Food Process Workers
263 ICT Network and Support Professionals		832 Packers and Product Assemblers
271 Legal Professionals		839 Miscellaneous Factory Process Workers
272 Social and Welfare Professionals		841 Farm, Forestry and Garden Workers
		851 Food Preparation Assistants
		891 Freight Handlers and Shelf Fillers
		899 Miscellaneous Labourers

Source: ABS (2009), ANZSCO – Australian and New Zealand Standard Classifications of Occupations, First Edition, Revision 1, ABS Catalogue no. 1220.0.

Greenhouse gas emissions

The model has a detailed greenhouse gas emissions accounting, trading and abatement framework that tracks the status of six anthropogenic greenhouse gases (namely, carbon

dioxide, methane, nitrous oxide, HFCs, PFCs and SF₆). Almost all sources and sectors are represented; emissions from agricultural residues and land-use change and forestry activities are not explicitly modelled.

The greenhouse modelling framework not only allows accounting of changes in greenhouse gas emissions, but also allows various policy responses such as carbon taxes or emissions trading to be employed and assessed within a consistent framework. For example, the model can be used to measure the economic and emission impacts of a fixed emissions penalty in single or multiple regions whether trading is allowed or not. Or, it can be used to model the emissions penalty required to achieve a desired cut in emissions based on various trading and taxation criteria.

A.3 Reference Case economic growth

In the Reference Case scenario, the pattern and rate of real economic growth is a function of assumptions on:

- Changes in population – particularly changes in the number of people of working age (15 years old and over).
- Changes in workforce participation rates – defined here as the average number of hours worked in the labour force by all people of working age. This measure encompasses changes in participation rates by age by gender, the unemployment rate and average hours worked.
- Growth in labour productivity – defined here as the average output per hour worked.

The projection of each of these elements is discussed in the following sections.

Population growth

Population growth is an important determinant of economic growth through the supply of labour and the demand for final goods and services. Population growth for 133 international regions and the 8 states and territories of Australia represented in the *Tasman Global* database has been projected using ACIL Allen's in-house demographic model.⁵ The demographic model projects how the population in each region grows and how age and gender composition changes over time and is an important tool for determining the changes in regional labour supply and total population over the projection period.

For each of the 141 regions, the model projects the changes in age-specific birth, mortality and net migration rates by gender for 101 age cohorts (0-99 and 100+). The demographic model also projects changes in participation rates by gender by age for each region, and, when combined with the age and gender composition of the population, endogenously projects the future supply of labour in each region. Changes in life expectancy are a function of income per person as well as assumed technical progress on lowering mortality rates for a given income (for example, reducing malaria-related mortality through better medicines, education, governance etc). Participation rates are a function of life expectancy as well expected changes in higher education rates, fertility rates and changes in the work force as a share of the total population.

Global population growth

For this analysis, global population is projected to increase over the projection period by 0.83 per cent a year, increasing the global population from around 6.7 billion in 2008 to 7.66 billion in 2023. Most of this growth occurs in the next decade, with the average annual

⁵ For the modelling in this report the population all Australian states and territories other than New South Wales have been aggregated to form the population for the rest of Australia.

growth projected to be 0.95 per cent a year to 2020. The slowing rate of growth is due to continuing declines in fertility rates across developing countries coupled with ageing population effects across developed economies and some developing economies such as China.

Australian population growth

Population growth for the eight Australian states and territories incorporates all the latest ABS information on population levels, as well as on fertility, mortality and migration rates.

Labour supply

Labour supply is derived from the combination of the projected regional population by age by gender and the projected regional participation rates by age by gender. Over the projection period labour supply in most developed economies is projected to grow slower than total population as a result of ageing population effects. Some developing economies, notably China, are also projected to have slower growth in labour supply compared to total population.

Unemployment

In addition to tracking the available workforce through the changes in population demographics and participation rates, *Tasman Global* also tracks unemployment rates. It should be noted that unemployment and participation rates are largely interchangeable in affecting the number of people available for work in the model. Separate identification of the components is undertaken to allow a more representative labour market. In general, when unemployment is high, changes in labour demand can largely be supplied by reducing the unemployment rate but when unemployment is low, changes in labour demand will largely be met by increasing participation rates (and hours worked). Changes in participation rates in *Tasman Global* are driven by changes in the real wages offered by employers.

Labour productivity growth

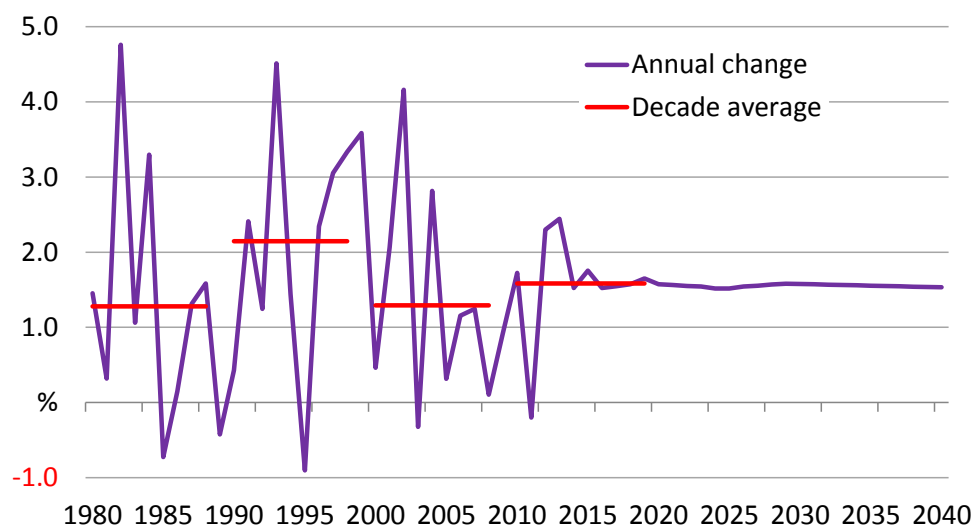
Labour productivity is a measure of the quantity of goods and services per unit of time worked. Growth in labour productivity is highly variable on a year to year basis and is influenced by many developments in the economy, including changes in capital intensity and the composition of the work-force⁶.

Over the past 30 years Australian labour productivity growth has averaged 1.75 per cent a year and 1.8 per cent over the past 40 years⁷. Near term labour productivity growth is determined as a result of the near term projections of labour supply and real GDP. In the reference case, the annual growth in Australian labour productivity is subsequently assumed to gradually slow from around 1.75 to 1.5 per cent a year in the long term as the composition of the Australian economy continues to shift toward services, which has historically have had lower rates of productivity growth compared to the rest of the economy.

⁶ Treasury 2008, *Australia's Low Pollution Future: The economics of climate change mitigation*. Canberra: Commonwealth Government.

⁷ Treasury 2010, *Intergenerational Report 2010: Australia to 2050: future challenges*. Canberra: Commonwealth Government.

Figure A2 **Historical and assumed Australian labour productivity growth, Reference Case (per cent change, year on year)**



Note: All years are financial years ending June 30.

Source: ABS Catalogue number 5206.0 and ACIL Allen projections.

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