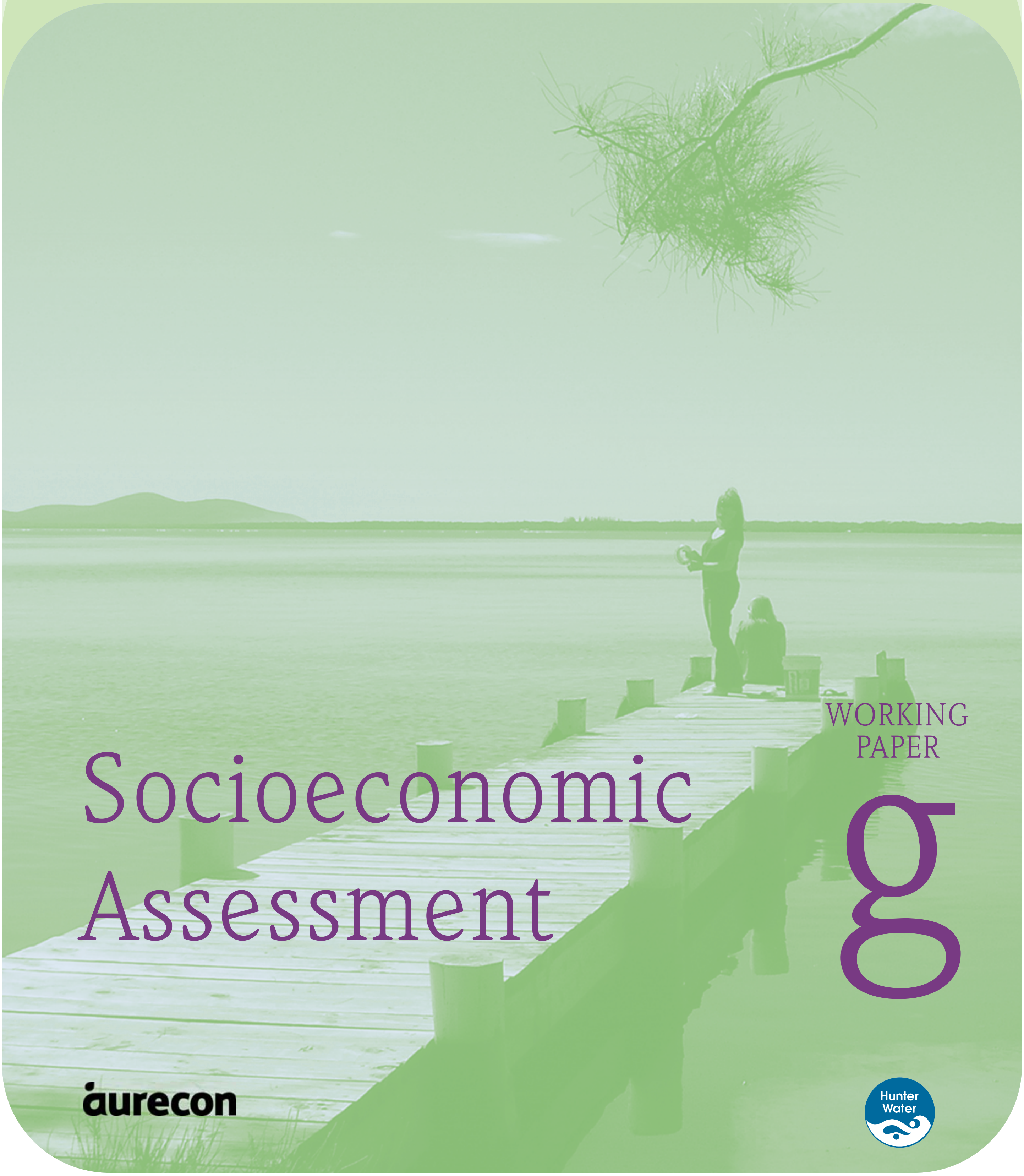
Tillegra Dam

Planning and Environmental Assessment



Socioeconomic Assessment

WORKING PAPER

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aurecon

Hunter Water

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Contents

Report prepared by aurecon

Executive Summary

Hunter Water Corporation (HWC) is proposing to construct the Tillegra Dam and related infrastructure at an estimated capital cost of $377 million (present value). The proposed dam would have a capacity of 450 gigalitres that would effectively double the existing storage capacity of the Lower Hunter region. The current proposal to build Tillegra Dam has resulted from:

- the need to improve drought security for existing customers in the lower Hunter region
- significant growth in the Hunter and Central Coast regions predicted by the most recent regional strategies
- long term climate change implications and the current drought being experienced across the country.

The Lower Hunter region is the sixth largest urban area in Australia and a major centre of economic activity in New South Wales (NSW). The region is the second most heavily populated region in NSW with a population estimated at almost 500,000. The overall growth rate is about 0.9 per cent per year. The regional population is forecast to increase to 730,000 persons in 2026. The region supports a diverse economic base including manufacturing, mining, agriculture, commercial and tourism activities. The range of economic activities would continue to expand with the forecast population growth and other significant prospective commercial and industrial activities that would be attracted to the region.

The socioeconomic assessment of the Tillegra Dam project has been undertaken through:

- a cost effectiveness analysis (CEA) compliant with the requirements of NSW Treasury to confirm that of the seven different water supply schemes considered, Tillegra Dam would be the least cost option to augment HWC's water supply system
- computable general equilibrium (CGE) modelling to assess direct and indirect socioeconomic impacts of the dam's construction at regional, State and national levels.

The CEA has shown that of the water supply options modelled, the Tillegra Dam option produces the lowest levelised cost of $1,661 per megalitre from a present value (ie discounted) total cost of $377 million. From an economic perspective, Tillegra Dam is the best option to meet future expected water demand in the Hunter Region over the next 50 years.

The assessment also shows that at the local (Shire) level, the positive economic impacts of the construction phase would be significant. Some of the more prominent social and economic benefits of the proposal generated through the injection of $380 million in capital investment over a three year period from 2010 to 2013 include:

- direct employment opportunities in the construction of the dam and later in the operational phase
- increased demand and expenditure in Dungog Shire for materials, equipment, goods and services
- direct opportunities for Dungog Shire to attract workers with families that can positively impact on the age profile of the Shire and economic dependency ratio by increasing the level of household income
- strengthening and expanding Dungog Shire by diversifying the range of economic opportunities available for business, these including opportunities to increase the wholesale and retail trade sectors as well as expand construction, tourism, accommodation and food service industries; this would also generate long term flow on benefits to other existing local businesses and promote their ongoing viability
- a positive boost to local tourism resulting from recreational use of Tillegra Dam; increased tourism opportunities within the Shire are expected to generate private investment into retail and accommodation services to service visitor demand
- carbon sequestration, biodiversity and land management benefits delivered through the establishment of riparian habitat around the dam, the planting of trees to offset carbon emissions generated during construction and ongoing general management of land owned by HWC in the vicinity of the project area.

Construction of Tillegra Dam would result in approximately 2,100 hectares of agricultural land being subsumed into the reservoir area, reducing the amount of agricultural land under production in the Dungog Shire by 1.7 per cent. Agriculture in the Shire currently occurs on about 122,000 hectares of land and produces wholesale revenue of $38.4 million per year. Although there are four productive dairies in the reservoir area which are of high value, a reduction in 1.7 per cent of the productive agricultural land in Dungog Shire (approximately 0.1 per cent in the Lower Hunter region) would not have a significant impact on the regional economy.

In fact, construction of Tillegra Dam is expected to bring a significant boost to both the local and regional economies. In particular, the building services sector should be a significant beneficiary with a full range of building subcontracting work required during the construction period. Similarly, accommodation, retail and other commercial service sectors would have the opportunity to expand during the construction period.

The results of the CGE modelling highlight a number of benefits from the Project over the period 2009 to 2030. These arise from the capital and recurrent expenditure required for the Project. The modelled benefits include:

- a discounted national welfare benefit of around $2.3 billion as measured by deviations in real household consumption for the Hunter region, the rest of NSW and the rest of Australia; this occurs firstly through additional investment in the construction period that stimulates short-run employment
- increased real GRP (gross regional product) of approximately $1.18 billion in the Hunter region; this benefit is realised over the longer term as the significant economic gains derived from increased water security are only realised when growth is allowed to increase within the additional capacity of the revised total system yield.

- increased aggregate employment in the Lower Hunter through the construction and operation periods, generating an additional 1,849 jobs; a rise in capital stocks as the increased supply of water as a consequence of the Project makes the Hunter region more conducive to investment with an increase in aggregate investment over 25 years of $588 million (undiscounted).

The CGE modelling results are considered conservative since the modelling period only extends for 25 years to 2031. The effective asset life of Tillegra Dam is generally assumed to be well in excess of 50 years and may in fact be several hundred years. Growth in water demand is also catered for until at least post 2050. There would therefore be trailing economic benefits to the region well into the latter half of the 21st century.

Report prepared by aurecon

1. Introduction and Scope

The environmental assessment requirements (EARs) for the proposed Tillegra Dam project were issued by the Department of Planning on 8 January 2008 under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The EARs specify that the environmental assessment shall 'undertake an assessment of the socioeconomic impacts, whether direct or indirect, associated with the Tillegra Dam project and that due consideration should be given to:

- existing and future land uses and natural resources (both surrounding and within the inundation area), including agriculture (and details on the class of agricultural land within the inundation area), mineral resources and forestry and measures to mitigate and manage any impacts
- potential changes to the local and regional economy and measures to mitigate and manage any impacts
- potential impacts upon social infrastructure (housing, medical, etc.) both in terms of availability and capability to accommodate construction personnel
- proposed recreational uses of the dam
- potential public utilisation rates of the dam and its associated flow-on effects on the surrounding area, including nearby towns, parks and reserves, and its infrastructure (roads, electricity etc.)
- relocation of services, particularly the Fire Station, to ensure it meets the needs of the Rural Fire Service.'

This report is intended to address the first two bullet points above. The third bullet point is addressed in the EA Report while the remaining matters are considered both in the EA Report and in Working Paper N *Draft Integrated Land Use Plan*.

The EARs also state that a cost effectiveness analysis of the Project relative to alternatives be undertaken as part of the EA process in relation to strategic planning and project justification.

The following approach has been adopted to address these requirements:

- provision of a description of the socioeconomic environment impacted by the Project (Section 2)
- assessment of the potential socioeconomic impacts of construction and operation through a cost effectiveness analysis and computable general equilibrium modelling

2. Project Case

Hunter Water Corporation (HWC) provides water services to approximately 500,000 people in five local government areas (LGA) namely Newcastle, Lake Macquarie, Maitland, Cessnock and Port Stephens, that comprise the Lower Hunter. There are over 200,000 properties connected to the HWC water grid. Most of the groundwater and surface water comes from Grahamstown and Chichester Dams, and Tomago Sandbeds.

The region's water supply is extremely variable as water resources deplete and replenish quickly depending on weather conditions. Despite significant population growth over the last 25 years, the total amount of water supplied has remained constant between 70 and 80 gigalitres per annum. This has been due to demand management associated with reductions in industry usage and in per capita residential consumption.

The current proposal to build Tillegra Dam has come about as a result of:

- the need to improve drought security for existing customers in the lower Hunter region
- significant growth in the Hunter and Central Coast regions predicted by the most recent regional planning strategies
- long term climate change implications and the current drought being experienced across the country.

To accommodate the population and economic growth in the region and to balance the long term projected demand with supply, HWC is proposing to construct Tillegra Dam and related project infrastructure at an estimated capital cost of $300 million. The proposed dam would have a water storage capacity of 450 gigalitres that would effectively double the existing storage capacity of the Lower Hunter region.

The Project would comprise the following:

- dam wall and spillway
- a multi-level offtake tower
- provision for a mini hydroelectric power (HEP) plant
- a pipeline and pump station connecting Tillegra Dam to the Chichester Trunk Gravity Main (CTGM)
- relocation and reconstruction of Salisbury Road and provision of alternative access currently provided from Quart Pot Creek Road

- electrical and telecommunication installations
- relocation of affected utilities and public infrastructure (approximately 20 kilometres of telecommunication and electrical supply, and Bendolba Rural Fire Service Station)
- heritage conservation works (relocation of the Quart Pot Cemetery and conservation of Munni House)
- carbon offset initiatives (eg tree planting and riparian revegetation)
- ancillary works (eg viewing areas, boat ramp, walking tracks, information centre, caretaker's residence, HWC office building and storage sheds, and a streamflow station).

The construction of the Project is scheduled to start in 2009 and be completed by 2014.

HWC is not alone in taking a proactive approach to secure future water supplies for the Hunter region. The state of Australia's water supplies has become a significant concern to a number of prominent regions and cities as a result of environmental factors including drought and climate change, forecast population growth and related economic expansion.

All levels of government in Australia have been responding to water supply concerns in a number of ways including:

- planning and delivery of Wyaralong Dam by the Queensland Government in south east Queensland including 400 kilometres of interconnecting pipelines
- construction of desalination plants in Kwinana (Western Australia) and Tugun (Queensland)
- investment in the Western Corridor Recycled Water project located in south eastern Queensland
- planning proactively for sustainable water use, as shown by the Commonwealth and States National Water Initiative which reforms the way society has traditionally dealt with water management issues, including the manner in which the community plans, prices and trades water for the future.

3. Existing Socioeconomic Environment

3.1 Overview of the Project area

While the main components of the proposed dam would directly affect some 2,100 hectares of land during construction and operation, the economic consequences of the Project are much wider ranging. Consequently, the socioeconomic assessment encompasses all of the lower Hunter region and adjacent areas. Specifically, the Project study area comprises the local government areas (LGA) of Newcastle, Lake Macquarie, Port Stephens, Maitland, Cessnock and Dungog. All these LGAs have their water provided by HWC. Meeting the long term demand for water and increasing drought security will directly benefit the communities within these six council areas.

The location of the Hunter Region and the Dungog LGA is broadly depicted in Figure 1.

3.2 Lower Hunter Region

3.2.1 Population

The Lower Hunter region is the sixth largest urban area in Australia and a major centre of economic activity in NSW. It is located 160 kilometres north of Sydney and covers an area of some 4,300 square kilometres. The area is the second most heavily populated region in NSW with a regional population estimated at almost 500,000. The overall growth rate is about 0.9 per cent per year.

The Lower Hunter region covers the LGAs of Lake Macquarie, Newcastle, Port Stephens, Maitland and Cessnock. The major population centre includes NSW's second largest regional city of Newcastle with the largest port in bulk terms and the largest coal exporting port. Other regional centres are Charlestown, Glendale, Morisset and Raymond Terrace.

Cessnock has the largest area in the Lower Hunter region with the lowest density with a population of only approximately 46,000 people. Lake Macquarie has the highest population with 183,139 persons, followed by Newcastle with a population of 141,752 persons. Maitland and Port Stephens have the highest population growth at just over 18 per cent and almost 23 per cent respectively. Over the last 10 years the Lower Hunter region has experienced a growth in population of just over nine percent.

[1] NSW Department of Planning (2006) *Lower Hunter Regional Strategy*, page3.

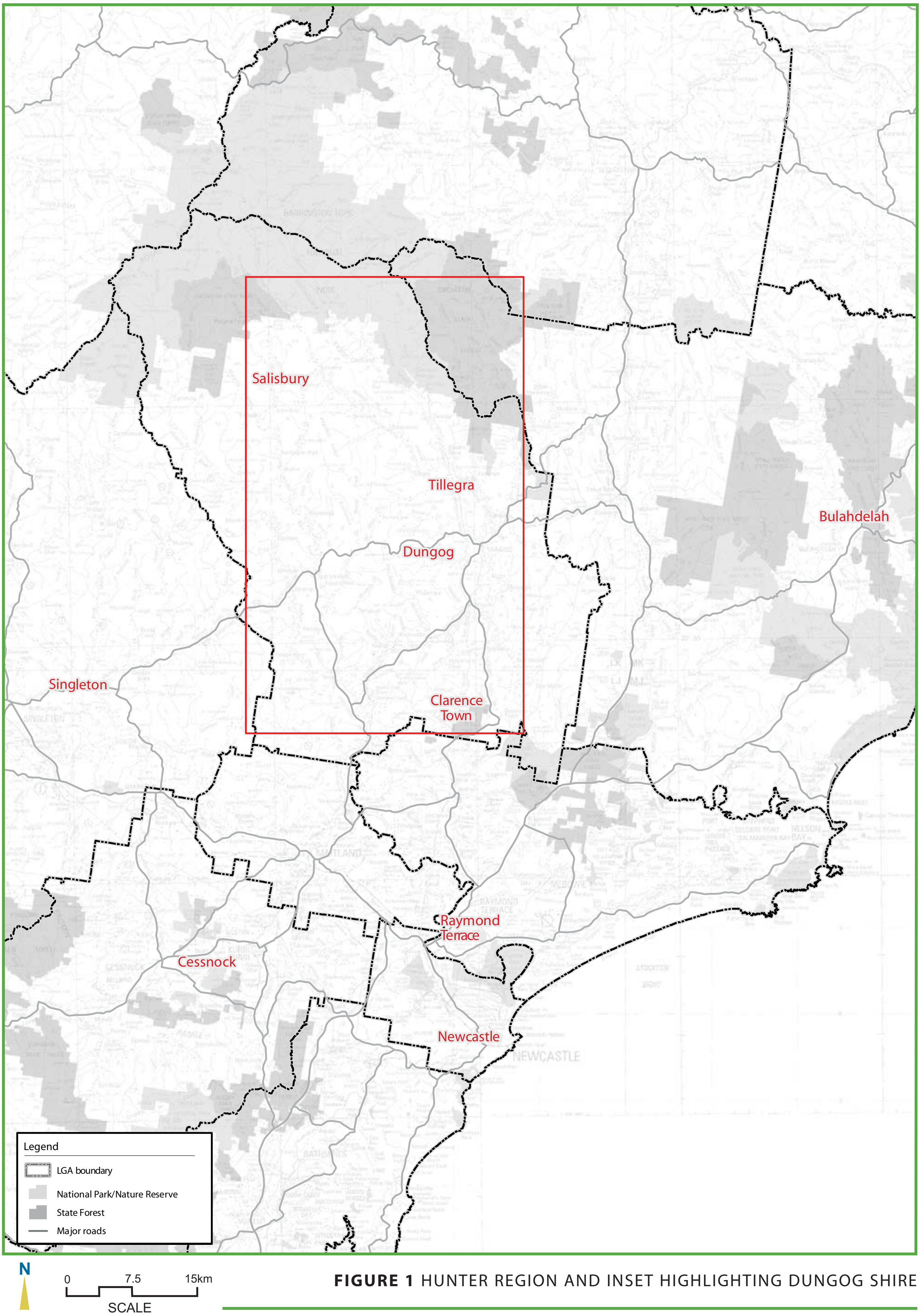


FIGURE 1 HUNTER REGION AND INSET HIGHLIGHTING DUNGOG SHIRE

TABLE 1 LOWER HUNTER POPULATION AND CENTRES

AREA	POPULATION			10 YEARS GROWTH	AREA (KM²)
	1996	2001	2006		
Lake Macquarie	172,725	180,315	183,139	6.02 %	752.9
Newcastle	133,589	136,621	141,752	6.11 %	214.5
Port Stephens	51,146	56,771	60,484	18.26 %	979.5
Maitland	50,324	54,390	61,881	22.97 %	391.7
Cessnock	44,735	45,377	46,206	3.29 %	1,966.4
Total	**452,519**	**473,474**	**493,462**	**9.05 %**	**4,305.0**

Source: Australian Bureau of Statistics. 1996, 2001 and 2006 Census of Population and Housing.

The community profiles for the five LGAs are diverse and the more rural area of Cessnock stands out with a lower income compared to the other LGAs. Key data for the community profiles are shown in Table 2.

TABLE 2 COMMUNITY PROFILE: LOWER HUNTER CENTRES

AREA	LAKE MACQUARIE	NEWCASTLE	PORT STEPHENS	MAITLAND	CESSNOCK
Median age of persons	40	37	40	35	37
Median individual income ($/weekly)	394	409	388	428	358
Median family income ($/weekly)	1,102	1,132	1,030	1,159	1,015
Median household income ($/weekly)	922	885	830	1,025	786
Median housing loan repayment ($/monthly)	1,300	1,300	1,300	1,300	1,148
Median rent ($/weekly)	185	195	180	180	160
Average number of persons per bedroom	1.1	1.1	1.1	1.1	1.1
Average household size	2.6	2.3	2.5	2.7	2.6

Source: ABS 2006 Census Community Profile Series, Table B02 (Data Local Government Area for Lake Macquarie, Newcastle, Port Stephens, Maitland, Cessnock).

3.2.2 Employment and industry

The Lower Hunter region has around 80 per cent rural, semi rural, agricultural and forested landscapes which include key industries such as mining, wine production and tourism. The region has a skilled workforce and nationally significant economic infrastructure. Recent job growth was created mainly in the tertiary sectors, such as health, education, financial and personal services and tourism.

More than one-third of the employed persons in the Lower Hunter region are working in the Health care and social assistance; Retail trade; and Manufacturing sectors, while approximately eight per cent each work in Construction, and Education and training. Analysis of LGA data for Lake Macquarie, Newcastle and Maitland shows a similar distribution. The distribution of employment for the five LGAs by sector is illustrated in Figure 2.

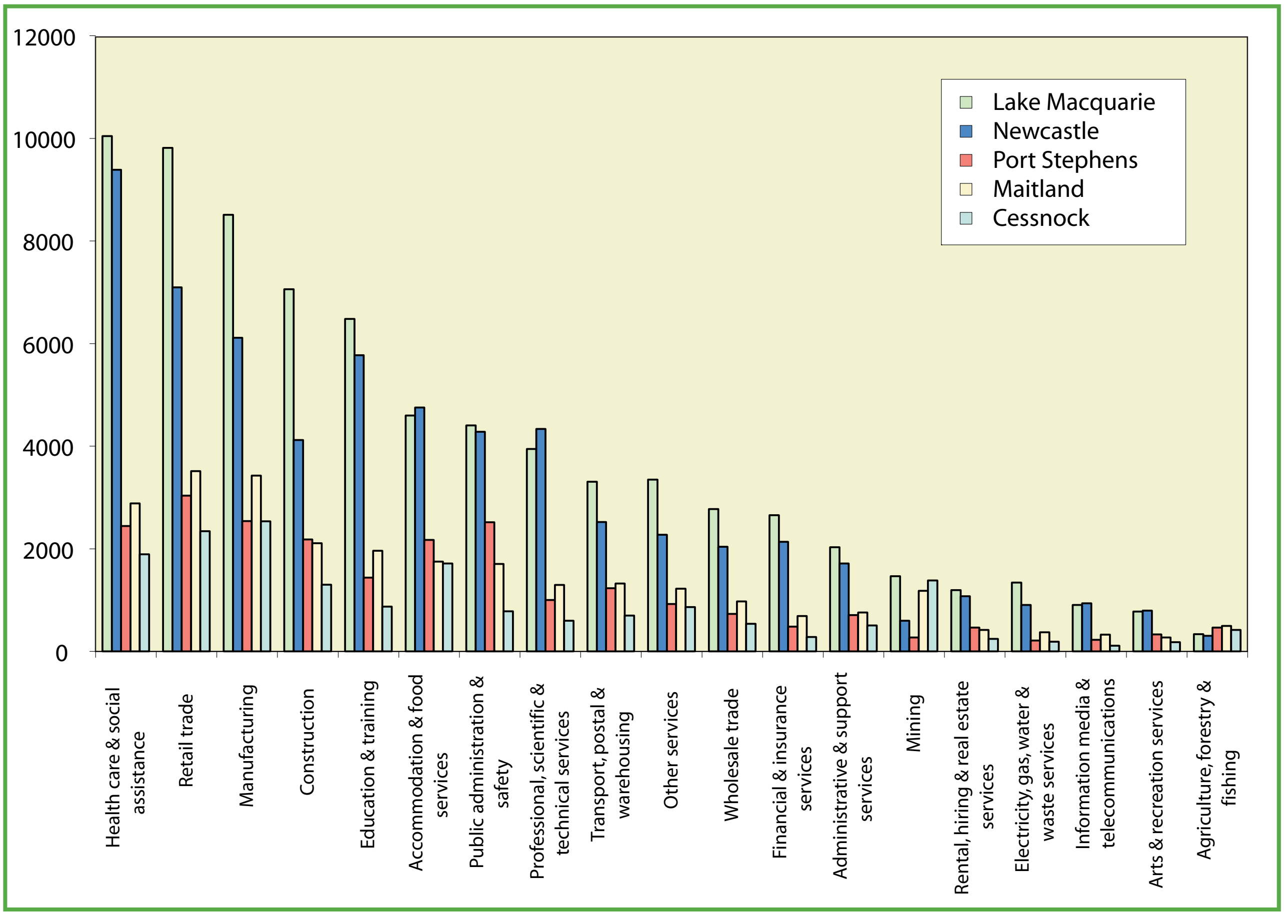


FIGURE 2 EMPLOYMENT BY INDUSTRY SECTOR IN LOWER HUNTER CENTRES IN PER CENT OF TOTAL PERSONS, 2006

Table 3 presents a breakdown by industry sector as follows.

TABLE 3 EMPLOYMENT BY INDUSTRY SECTOR IN LOWER HUNTER CENTRES

	LAKE MACQUARIE	NEWCASTLE	PORT STEPHENS	MAITLAND	CESSNOCK	LOWER HUNTER
Agriculture, forestry and fishing	333	302	466	494	419	2,014
Mining	1,466	599	269	1,180	1,382	4,896
Manufacturing	8,512	6,111	2,539	3,424	2,535	23,121
Electricity, gas, water and waste services	1,343	907	210	370	190	3,020
Construction	7,059	4,121	2,182	2,110	1,301	16,773
Wholesale trade	2,776	2,039	729	973	538	7,055
Retail trade	9,813	7,093	3,037	3,515	2,343	25,801
Accommodation and food services	4,599	4,752	2,171	1,751	1,713	14,986
Transport, postal and warehousing	3,305	2,519	1,233	1,322	699	9,078
Information media and telecommunications	906	939	227	328	110	2,510
Financial and insurance services	2,653	2,137	482	689	278	6,239

	LAKE MACQUARIE	NEWCASTLE	PORT STEPHENS	MAITLAND	CESSNOCK	LOWER HUNTER
Rental, hiring and real estate services	1,193	1,074	465	419	245	3,396
Professional, scientific and technical services	3,946	4,336	1,001	1,296	596	11,175
Administrative and support services	2,030	1,715	707	759	504	5,715
Public administration and safety	4,404	4,279	2,518	1,703	781	13,685
Education and training	6,480	5,771	1,437	1,960	872	16,520
Health care and social assistance	10,045	9,386	2,441	2,882	1,890	26,644
Arts and recreation services	778	795	332	272	179	2,356
Other services	3,350	2,271	925	1,220	864	8,630
Inadequately described/Not stated	1,746	1,280	514	596	536	4,672
Total	**76,737**	**62,426**	**23,885**	**27,263**	**17,975**	**208,286**

Source: ABS 2006 Census Community Profile Series, Table B42C Industry of Employment by Age by Sex, excerpt. (Data Local Government Area for Lake Macquarie, Newcastle, Port Stephens, Maitland, Cessnock).

A total of 208,288 people are employed in the Lower Hunter region, 126,305 persons full time and 68,048 persons part time. Table 4 provides a detailed breakdown by employment status across the five Lower Hunter LGAs.

TABLE 4 LABOUR FORCE STATUS: LOWER HUNTER CENTRES

	LAKE MACQUARIE	NEWCASTLE	PORT STEPHENS	MAITLAND	CESSNOCK	LOWER HUNTER
Employed:						
Full time	46,199	37,990	14,137	17,031	10,948	126,305
Part time	25,330	20,373	8,118	8,494	5,733	68,048
Employed, away from work	3,020	2,609	971	994	672	8,266
Hours worked not stated	2,188	1,455	658	745	623	5,669
Total	76,737	62,427	23,884	27,264	17,976	208,288
Unemployed, looking for work:						
Full time work	3,613	3,084	1,215	1,193	1,201	10,306
Part time work	1,878	1,806	613	716	489	5,502
Total	5,491	4,890	1,828	1,909	1,690	15,808
Total labour force	82,228	67,317	25,712	29,173	19,666	224,096
Not in the labour force	58,513	43,001	19,468	16,248	14,762	151,992
Labour force status not stated	6,522	7,114	2,718	2,253	1,733	20,340
Total	**147,263**	**117,432**	**47,898**	**47,674**	**36,161**	**396,428**

Source: ABS 2006 Census Community Profile Series, Table B41B Labour force status by age by sex, excerpt. (Data Local Government Area for Lake Macquarie, Newcastle, Port Stephens, Maitland, Cessnock).

In summary, the Hunter region supports a diverse economic base including manufacturing, mining, agriculture, commercial and tourism activities. It has an increasing population and economic platform that is significant to NSW. Key socioeconomic aggregates include:

- a regional population of 493,462 persons in 2006
- the regional population has increased by nine percent over the decade at an average annual growth rate of 0.9 per cent
- the total number of persons employed in the Hunter region was 208,288 in December 2007
- regional employment growth over the past decade was 16.9 per cent with an average annual growth rate of 1.6 per cent, almost double the population growth rate
- unemployment in the Hunter region was 5.2 per cent (compared to 4.6 per cent in NSW) in December 2007 compared to historic levels of 7-11 per cent over the past decade
- over the past 25 years the Hunter region has been subject to significant economic structural change with a shift from primary industry and secondary industry to tertiary industry
- service provision or tertiary industry employs almost 84 per cent of workers now compared to almost 70 per cent in 1981
- the manufacturing or secondary industry has declined from 21 per cent in 1981 to 10 per cent in 2006 while the primary industry (predominantly agriculture) has declined from 9.2 per cent to 5.8 per cent over the same period.

3.2.3 Lower Hunter Regional Strategy 2006-2031

The NSW Government has prepared the *Lower Hunter Regional Strategy* to guide social and economic planning for the region over the next 25 years. Ongoing strong population growth is driver of the Strategy.

The Strategy establishes a hierarchy and network of urban centres for the Lower Hunter which includes the City of Newcastle as a major regional centre with national and international importance. In the Strategy, the following economic measures were outlined[3]:

- ensure that sufficient employment lands are available to cater for 66,000 new jobs
- plan for an additional 160,000 residents and 115,000 new dwellings
- reinforce the role of the Newcastle City Centre as the Regional City.

In addition to further develop the regional centres; the Strategy has identified five renewal corridors situated along strategic transport routes linking strategic centres. These corridors present opportunities for economic renewal and/or housing renewal and intensification. The Strategy does not explicitly mention the development of the Tillegra Dam project however, it expects that there would be sufficient water for the anticipated population growth since supply in the past 25 years has been steady between 70 80 gigalitres per year[4]. The Strategy promotes water-sensitive urban design in residential development and local environmental plans to protect drinking water catchments.

The Strategy implies that sufficient water would be available for the expected population growth if demand for water in the non-residential sector does not exceed expectations and there is no significant unpredicted change in climate conditions. These outcomes secure sustainable limits of water sources if water sensitive urban design in residential development is being promoted and local environmental plans are enacted to protect drinking water catchments.

The Strategy does not, however, take into account that under adverse conditions water storages can plummet from 100 per cent to 40 per cent capacity in under 18 months leaving the regions water

[3] NSW Government Department of Planning (2006) *Lower Hunter Regional Strategy*, page 1.

[4] NSW Government Department of Planning (2006) *Lower Hunter Regional Strategy*, page 40.

supply vulnerable to depletion. A revised assessment of the current sustainable yield of the region's water supply also shows that demand already exceeds supply and the extent of this problem would be compounded by additional growth.

3.2.4 Population – Dungog LGA

The Dungog area was called 'Tungog' or 'Tunkok' by the Kooris meaning 'the place of thinly wooded hills' in the Awabakal dialect. Dungog Shire was occupied by Koori people up to about 40,000 years before European settlement in relatively large numbers in the valleys of the Paterson and Williams Rivers.

European settlement in Dungog Shire was based on the movement of settlers inland from the coast and the availability of land for agriculture. Continuing settlement resulted in the principal Shire towns being established along the Williams and Paterson Rivers in the early 1800s. However, it was not until 1825 that an effective land grant scheme opened the area up to agricultural development.

The Dungog Shire had a population of 8,062 persons that was recorded by the ABS Census in 2006. Over the decade 1996-2006, Dungog Shire's population has increased from 7,720 to the current number just in excess of 8,000 persons representing a total growth of six per cent. The average annual population growth over the period was approximately 0.5 per cent.

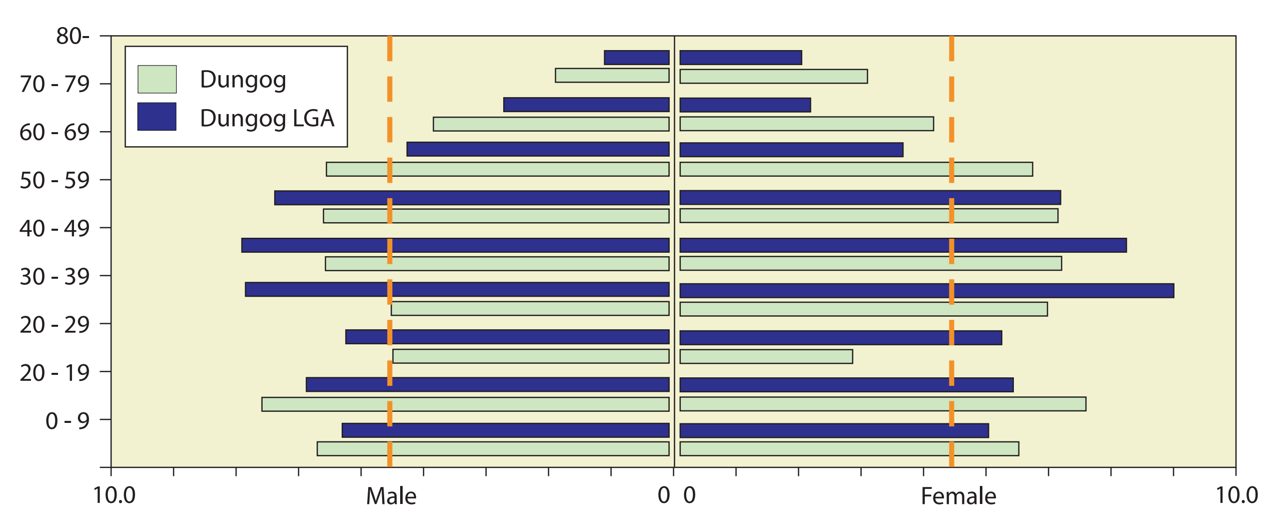
The major population centres within the Shire are:

- Dungog – located approximately 13 kilometres south east of the proposed dam and is the largest population centre in the Shire with an estimated population of 2,116
- Gresford/East Gresford – located approximately 18 kilometres west-southwest of the proposed dam with an estimated population of 289
- Paterson – located approximately 32 kilometres south-southeast of the proposed dam. It is on a major road and train line and the Paterson River. Paterson has an estimated population of 340
- Vacy – located approximately 27 kilometres southwest of the proposed dam on the Paterson River
- Martins Creek – located approximately 27 kilometres south-southwest of the proposed dam
- Clarence Town – located approximately 30 kilometres south-southeast of the proposed dam on the Williams River.

The predominant age group in Dungog Shire is the 30-39 grouping followed by the 40-49 and 50-59 groupings. The 10-19 grouping is the largest in the actual township of Dungog.

The predominantly rural district of Dungog, like many similar rural shires in New South Wales, is experiencing major changes to its demographic profile as a result of the process of ageing. The *Strategic Connections: Economic Flows and Industrial Development in Dungog Shire* (Dungog Shire Council 2005) stated that on existing population projections, and assuming no major interventions (eg the development of a major new urban area), Dungog Shire would experience a significant increase in the proportion of its elderly population over the next two decades and a significant decline in the younger age brackets.

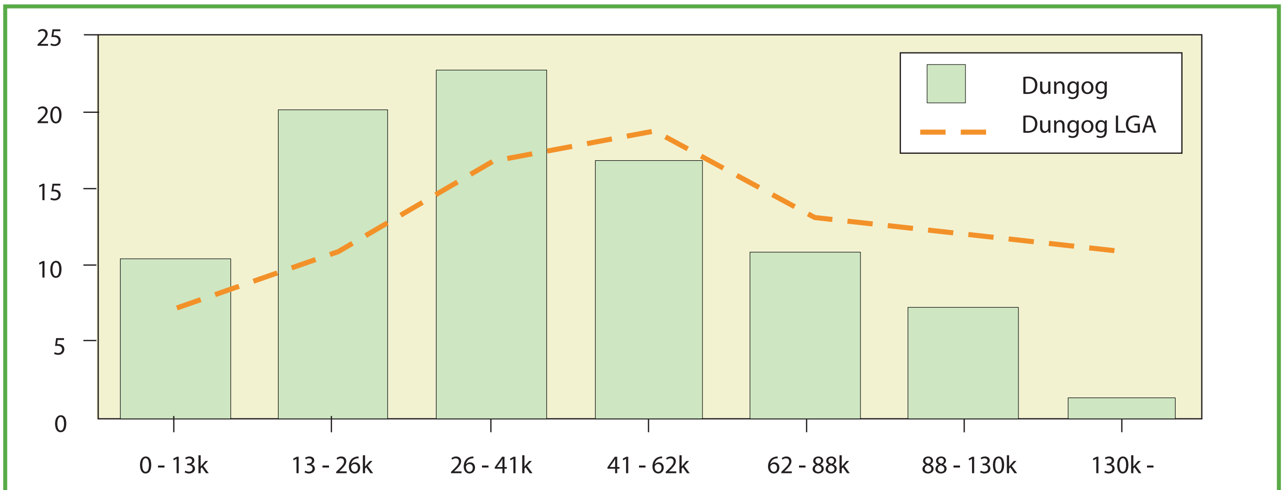
The census data shown in Figure 3 supports Dungog Shire Council's analysis of the town's future demographics which indicated a continued outflow of young adults. As young people leave the town, there would be consequent reduction in families with children. Without these younger age groups or new families arriving, the proportion of households with children in the town would fall dramatically over the coming decade. The economic implications of this trend would be to adversely impact on the Shire's economic dependency ratio, namely the proportion of a population in receipt of earned income.



Source: ABS Census 2006 Data.

FIGURE 3 AGE-SEX RATIO (2006)

Currently, household income in Dungog is diverse with around 60 per cent of households earning between $13,000 and $62,000 per annum. The predominant household income grouping is the $26,000 to $ $41,000 range with around 23 per cent of households falling within this range. For Dungog Shire, the predominant household income grouping is the $41,000 to $62,000 range reflecting the impact of the non-town economic activities. Beyond this grouping, Figure 4 indicates that households in town have a lower household income than those living on farms and/or properties elsewhere in Dungog Shire.



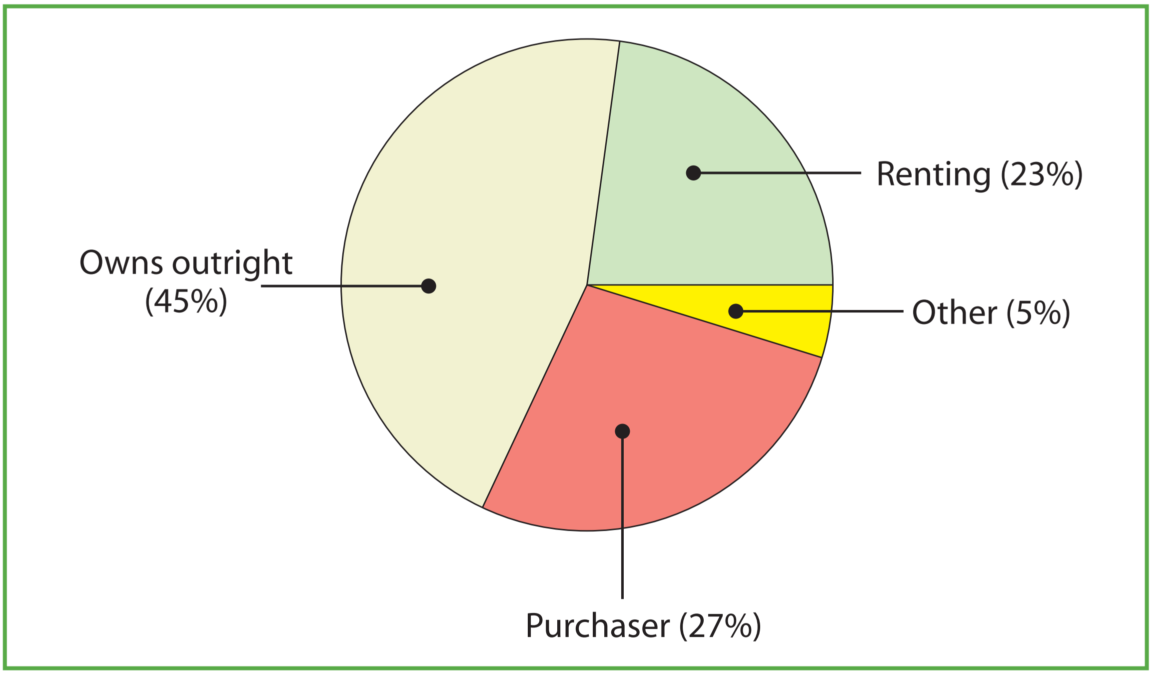
Source: ABS Census 2006 Data.

FIGURE 4 HOUSEHOLD INCOME (%)

In terms of addressing both the Shire's decreasing economic dependency ratio and improving the Shire's household income spread particularly with regard to town residents, the construction of Tillegra Dam, its ongoing operations and related recreational and tourism impacts would provide an economic stimulus within the Shire. The Project would assist in addressing the disparity in earning capacity by providing additional opportunities for employment in the non-agricultural sectors of the local economy. There is also potential for the Project to provide young people in the Shire with expanded employment opportunities and thereby reducing the need for some of the youth segment to leave in the pursuit of work. This in turn would positively impact on the economic dependency ratio as the workforce numbers increase in the Shire.

3.2.5 Housing – Dungog LGA

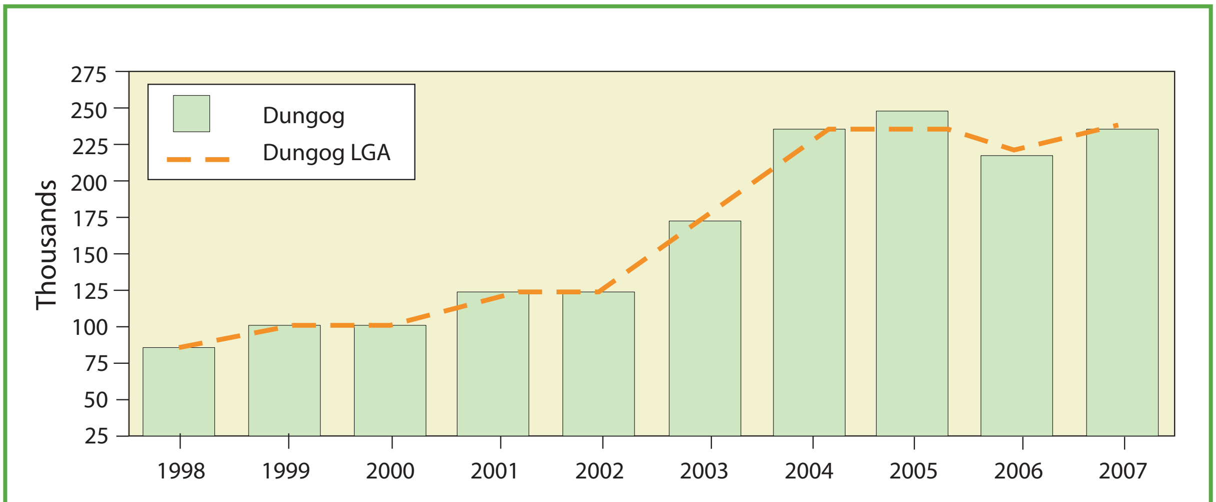
Household occupancy in Dungog highlights that the owner outright category accounts for 45 per cent while purchasers account for 27 per cent and renters 23 per cent. Total owner occupied households was estimated at 73 per cent in 2006. RP Data, a leading Australian property information services provider, notes that purchasing households are likely to be paying between $800 to $1,000 per month on home mortgage repayments.



Source: MyRPData – Dungog Local Government Area.

FIGURE 5 HOUSEHOLD OCCUPANCY (2006)

The median price of houses in Dungog in the first quarter of 2008 was around $235,000 while in 2007 it was around $220,000. House prices have been trending up since 2002 at which time the median price of a house in Dungog was around $120,000. Figure 6 highlights the trend in the median price of houses in Dungog and across the Shire over the past decade.



Source: MyRPData – Dungog Local Government Area.

FIGURE 6 MEDIAN HOUSE PRICES 1998 2007

3.2.6 Economic activity – Dungog LGA

There are 477 businesses in Dungog Shire, mostly small to medium size. Over 40 per cent are in the Agriculture Forestry and Fishing sector. The next largest sectors are Construction (approximately 12 per cent) and Property and Business Services (approximately 10 per cent). Communication Services, Wholesale Trade, Cultural and Recreational Services, and Education are represented with less than 10 businesses each. Aside from the agriculture-related economic activities, the industrial and commercial sectors are characterised by small-sized enterprises with a high level of local market dependence.

With regard to tourism, Dungog Shire largely attracts visitors on short breaks and day trip basis particularly on weekends. Visitors comprise older travellers and families seeking to experience the rural lifestyle and enjoy the scenery of the Barrington Tops and Lake Chichester. Tourism businesses in the area are generally small operations which seek to provide visitors with a personal and authentic experience. These businesses provide accommodation (eg motels, bed and breakfast, and farm stays), wineries, local produce, outdoor recreation activities (eg horse riding, canoeing), farm experiences, and local arts and crafts.

Figure 7 shows the number of businesses in Dungog Shire by industry division as at June 2006. This also indicates the significant role agriculture plays in the local economy. Figure 8 shows the annual turnover of businesses within Dungog Shire which reveals that most business activity occurs within small to medium sized enterprises.

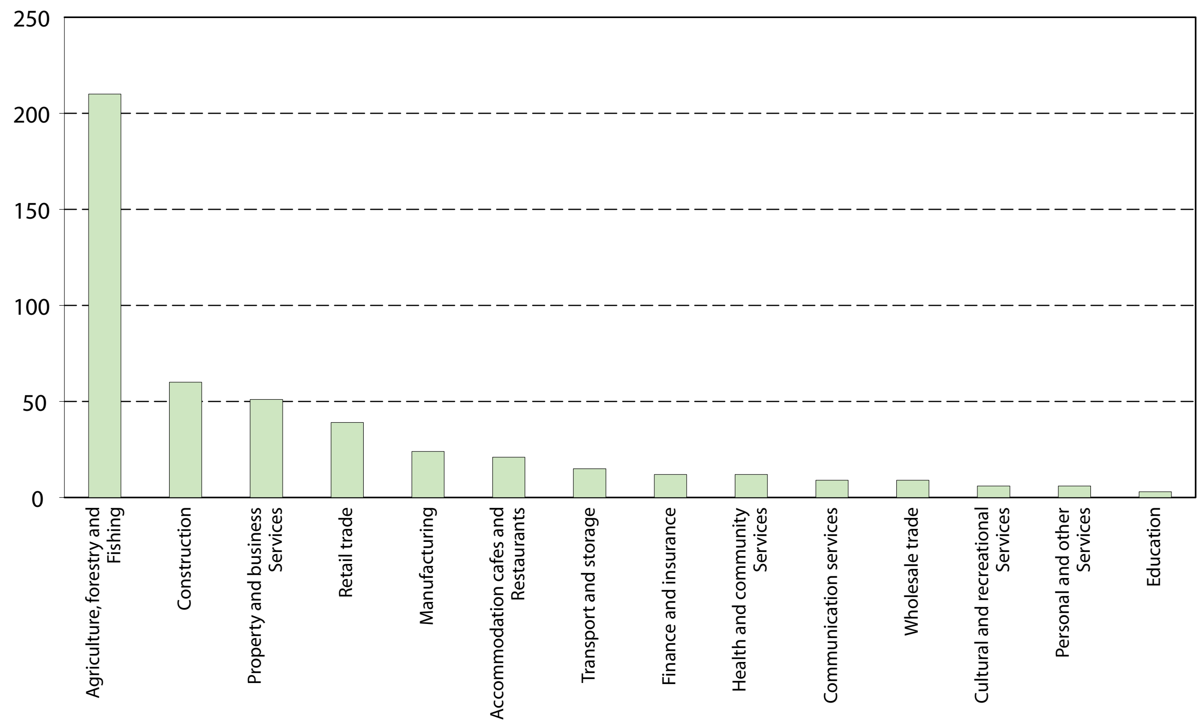


FIGURE 7 BUSINESSES BY INDUSTRY SECTOR IN DUNGOG SHIRE

Source: Australian Bureau of Statistics, 8165.0 Jun 2003 to Jun 2006 Counts of Australian Businesses, including Entries and Exits, Table 3.1 Businesses by Postcode by Industry Division, by Annual Turnover Ranges: June 2006. Postcode 2420.

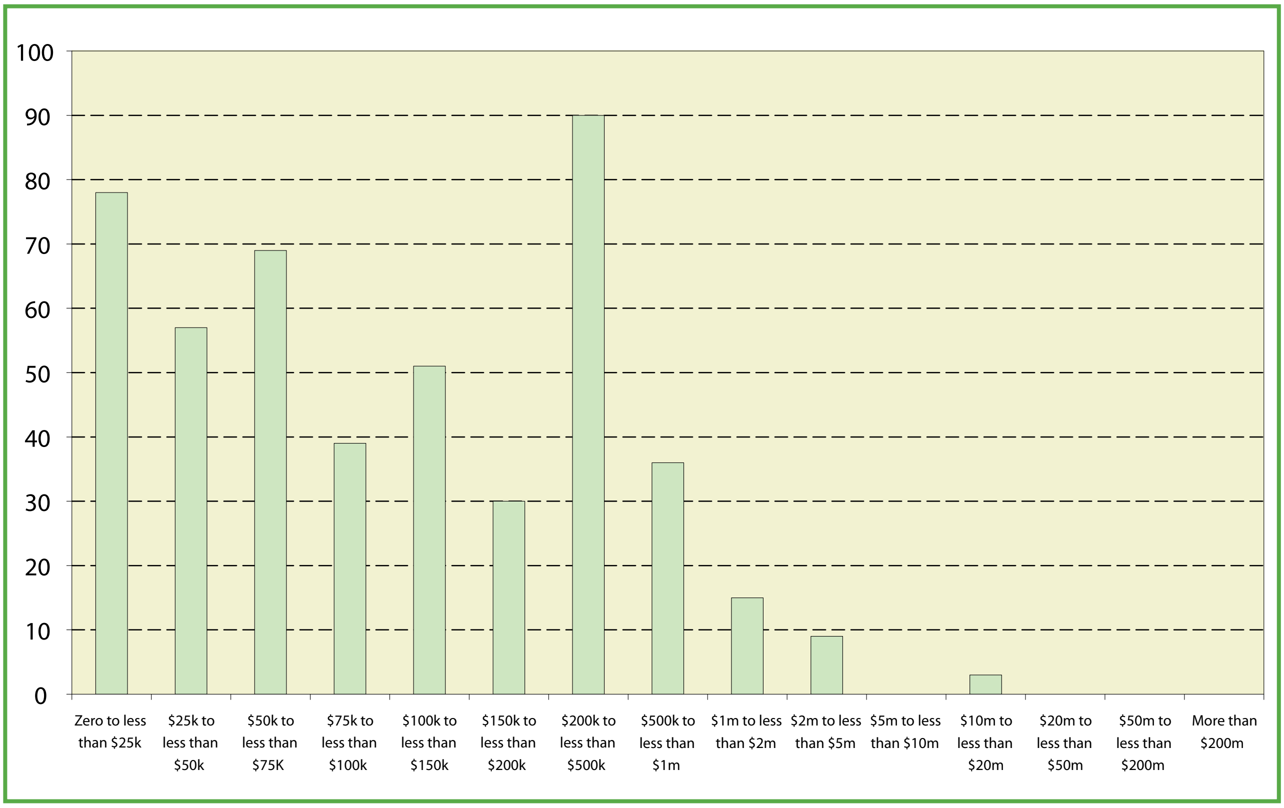


FIGURE 8 ANNUAL BUSINESS TURNOVER IN DUNGOG SHIRE

Source: Australian Bureau of Statistics, 8165.0 Jun 2003 to Jun 2006 Counts of Australian Businesses, including Entries and Exits, Table 3.2 Businesses by Postcode by Industry Division, by Annual Turnover Ranges: June 2006. Postcode 2420.

The ABS statistics show that 50 percent of the businesses in Dungog Shire have an annual turnover of less than $100,000. A further 18 per cent have a turnover between $200,000 and $500,000. At the other end of the scale, three retail trade businesses trading from Dungog have a turnover of between $10 million and $20 million.

The report *Strategic Connections: Economic Flows and Industrial Development in the Dungog Shire* (University of Newcastle 2005) indicates the economic turnover in Dungog Shire is driven by household spending and government services provision. An estimated 55-60 per cent of household spending by Dungog Shire households occurs outside of the Shire.

This high level of expenditure outside of the Shire can been attributed to the dominant retail sector in the Lower Hunter in Maitland, Raymond Terrace and Newcastle. Dungog is classed as a lower order urban centre by the ABS. It has only a limited range of goods and services that can be provided to local residents and to residents in adjoining rural areas, towns and villages.

3.2.7 Employment status by industry – Dungog LGA

The University of Newcastle report also identified that the Shire has experienced major economic and labour force changes over the last two decades associated with falls in industrial employment in agricultural processing sectors. (Dungog Shire Council 2005).

While these trade and industrial employment opportunities traditionally sought by men have been decreasing over time, there has been a shifting employment pattern in the Shire with rising participation rates in the workforce by women in health, education and other services and also residents engaged management and professional occupational categories.

The above report highlights other relevant and distinctive labour market attributes in Dungog Shire namely the high proportion of local jobs captured by local residents with an estimated 50 per cent of Shire workers having employment within the Shire and over 75 per cent of Dungog jobs held by local residents.

Table 5 illustrates the strong level of employment within Dungog Shire.

TABLE 5 DUNGOG LGA LABOUR FORCE STATUS

CATEGORY	TOTAL PERSONS
Employed:	
Full time	2,086
Part time	1,136
Employed, away from work	120
Hours worked not stated	120
Total	3,462
Unemployed, looking for work:	
Full time work	122
Part time work	53
Total	175
Total labour force	3,637
Not in the labour force	2,348
Labour force status not stated	378
Total	**6,363**

Source: ABS 2006 Census of Population and Housing, Table B41B Labour force status by age by sex.

The ABS 2006 Census revealed there were 3,462 persons employed in Dungog Shire with about two thirds working full time. Unemployment is very low with only 175 persons looking for either full time or part time work. The level of local part time employment was slightly higher than the national average of around 29 per cent[5]. However, the local participation rate was 64.5 per cent which was essentially comparable with the rest of Australia.

Approximately 13 per cent of employed people work in Agriculture, Forestry and Fishing sector followed by Health Care and Social Assistance, Construction, Manufacturing and Retail Trade sectors with approximately 10 per cent each. More men work in the Agriculture, Construction, Manufacturing and Transport sectors whereas women are employed mostly in Health care, Retail, Education and Accommodation sectors.

[5] ABS (2007) Labour Force, Australia, Detailed – Electronic Delivery (6291.0.55.001).

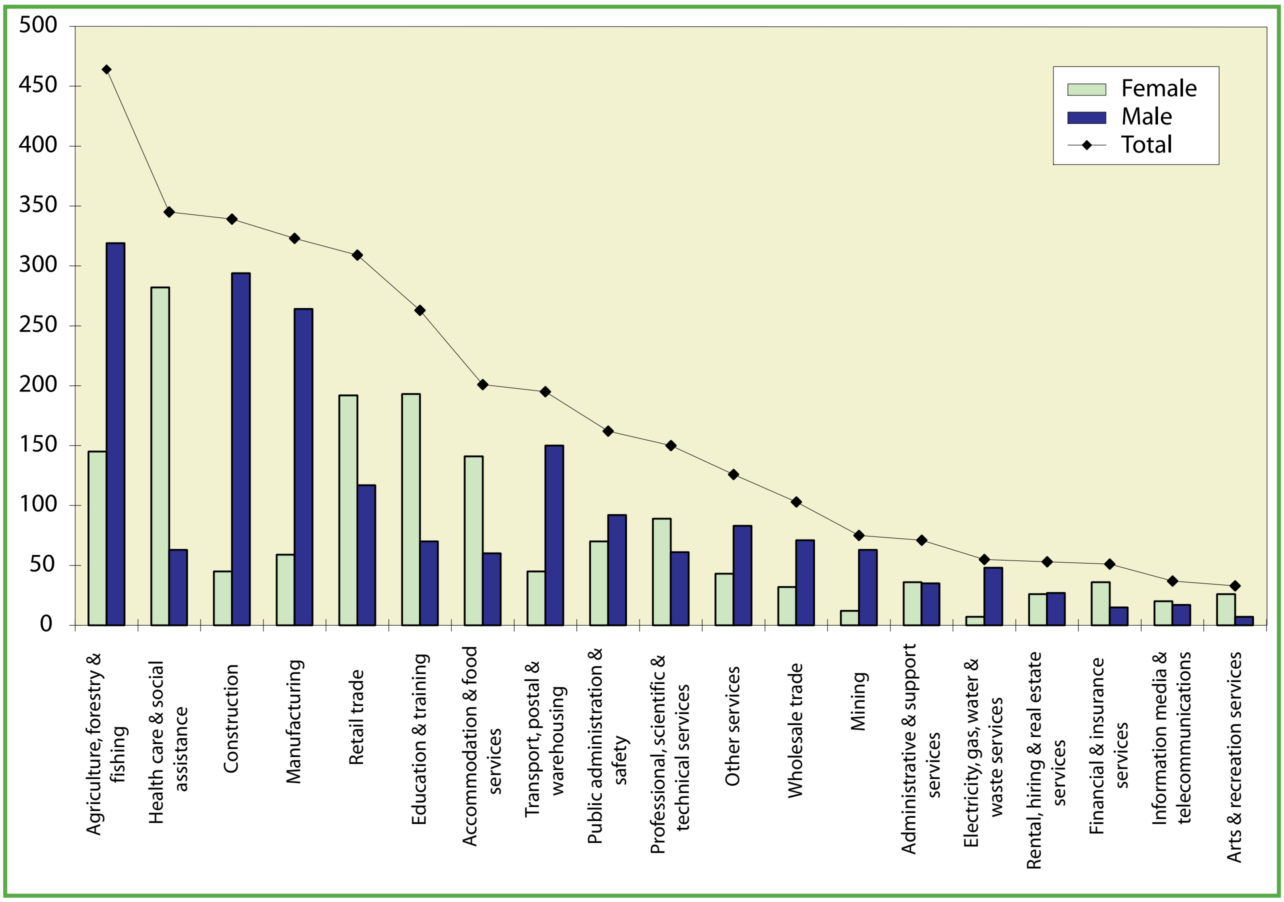


FIGURE 9 EMPLOYMENT BY INDUSTRY SECTOR IN DUNGOG (PERCENTAGE OF TOTAL PERSONS 2006)

Source: ABS 2006 Census Community Profile Series, Table B42 Industry of Employment by Age by Sex, excerpt.

4. Cost Effectiveness Analysis

4.1 Objective

HWC's overall objective is to balance the long term demand and supply of water to the community. A key question to be considered during the process of meeting this objective is that after accounting for demand management initiatives, what is the least cost combination of supply options that will satisfy increasing demand.

Economic valuation techniques can be applied to identify the preferred solution on financial grounds. The two most commonly used techniques in this regard are either a CEA (cost effectiveness analysis) or a CBA (cost benefit analysis). Both evaluation measures comply with the recommendations within the NSW Treasury's *Project Evaluation Guidelines* (2007).

A CEA has been selected as the appropriate technique to apply for the economic analysis of the Tillegra Dam proposal.

4.2 Rationale

CEA was implemented for this assessment in accordance with the EARs. The CEA allows for the comparison of competing project scenarios to determine whether construction of Tillegra Dam represents a least cost option for meeting the region's yield objective. Implicit in data provided by HWC is a long term planning horizon to ensure that water infrastructure projects meet the incremental yield estimated as being required for at least the next 50 years.

CBA has inherent difficulties in monetising benefits where no markets exist. These include issues such as biodiversity protection and resource depletion as well as social, cultural and other intangible impacts where stakeholder values may not align with the views and values of a project's proponent.

The inclusion of environmental and social effects in a CBA such as for a major dam project requires the monetisation of environmental and social goods. Since no market for environmental and social goods generally exists, it is difficult to observe market prices that appropriately reflect marginal costs and benefits.

Although alternative valuation methods may produce monetised CBA benefit and cost streams, there is likely to be incomplete knowledge and high levels of uncertainty in the valuation of environmental and social impacts. These factors may lead to distortions in the monetised benefits which in turn may impact on the robustness of the assessment including reporting of the Benefit Cost Ratio (NPV) and Net Present Values (NPV) relevant to the various project scenarios.

The basic premise of a CEA is to establish what the least cost method, process or option is to meet a predefined objective. For the Project, the objective is to balance the long term supply and demand of potable water in the Hunter Region. Seven alternative water supply options that could meet this objective have been identified and therefore require analysis.

Given that one of the primary benefits expected from the Project is a specific level of increased water security (and this is also difficult to monetise in an economic analysis), the CEA should not be considered in isolation from other elements reported upon in the EA Report. Other non-financial factors have been subject to qualitative analysis which is complemented by CGE (computable general equilibrium) modelling of the impacts on the region.

4.3 Methodology

The methodology adopted for the CEA assesses the least cost impact of providing greater water security to the Dungog LGA and the broader Hunter region. This comprised the following steps:

- **Problem definition** – establishing the water supply schedule and gap using demand growth projections and other forecasts from HWC.
- **Identifying potential measures** – specifically augmentation options that would close the supply schedule gap and meet the yield objective including consideration of the following infrastructure developments: an expanded Chichester Dam; an expanded Lostock Dam; construction of Upper Johnson's Creek Dam; an expanded Grahamstown Dam; indirect potable reuse and a desalinisation plant.
- **Collecting information on costs and effectiveness of each measure** – identifying: capital costs, operating costs and supply volumes of potential augmentation measures; Project sequencing and timing of measures; environmental and social impacts of the measures and their implications on the costs (eg road relocation costs, services relocation costs, environmental offsets, etc); and costs to include any tangible environmental and social impact mitigation that would form the capital and operating costs for the measures.
- **Model development** – comprising a cash flow of capital development costs for each measure over a 40 to 60 year period; and a schedule of operating and maintenance costs (eg labour costs, energy costs, pumping costs and other maintenance costs) for each measure for the same period. The model does not take into account water transport and treatment costs within the existing HWC water distribution network.
- **Evaluation method** – the application of a Project discount rate to reflect a weighted average cost of capital (WACC) for water businesses. This enables the development of a quantitative investment criterion of *Present Value* (PV) of costs and the derivation of a levelised cost.
- **Comparing individual measures and combination of measures** – use of the levelised cost to identify the most effective augmentation option. The most effective option is that which achieves the predefined objective at the lowest cost.

A Cost Effectiveness Model has been developed so that the cost inputs and discount rate can be readily adjusted using Excel macros to test changes within the potential augmentation measures and different combinations of these measures. All CEA modelling sheets are provided as Appendix A.

Separate to this CEA, the EA provides a qualitative assessment of both the positive and negative direct and indirect impacts of the Project. For example, there are significant avoided environmental costs if there is less reliance on desalination plants. Desalination has high energy costs and hence carbon emissions in addition to impacts associated with the disposal of brine residue.

4.4 CEA data and assumptions

The key assumptions adopted for the CEA are listed in Table 6. These are based on information and data provided by HWC. Definitions of terms used are provided in Section 8 *Glossary*.

TABLE 6 KEY ASSUMPTIONS FOR CEA

PARAMETER	ASSUMPTION
Construction	All dam options commence design and/or construction at 2008 and to deliver first water by 2013. Construction of indirect potable reuse or desalinisation plants commence in 2011 and deliver first water in 2013.
Capital costs	Capital costs for each option are distributed over the construction period to ensure parity between each option. Distributions for dam options begin in 2008. Distributions for indirect potable reuse and desalinisation plants commence in 2011 and are also distributed equally.
Operational cost	Operational costs commence in 2013. Dam supply operational costs are weighted to reflect yield such that full operational costs are allocated by 2018 once the option is supplying full yield. For desalination and potable reuse supply options, full operational costs are incurred in 2013.
Yield	Yield for all options commences in 2013. Dam options require 5 years to supply full yield while desalination and indirect potable reuse options supply full yield in year 1.
Demand forecasts	Modelling assumes demand starts at 72.8 GL in 2006, 89.7 GL in 2030 and 109.9 GL in 2050.
Reliable system yield	Reliable system yield at 2006 is assumed to be 67.5 GL/yr.
Discount rate	Real discount rate for the assessment is set at 7% by NSW Treasury.
Project staging	It is not practicable to stagger the development of individual supply options.
Project life	Dam options are likely to have a project life in excess of 100 years. Desalinisation and indirect potable reuse have a project life of 50 years.

4.4.1 Existing demand

The level of demand for water in the Hunter Valley in 2006 was recorded as 72.8 gigalitres. The residential sector accounted for 40.6 gigalitres, non-residential for 23.8 gigalitres, and 8.4 gigalitres was non-metered. Sources of demand are shown in the following table.

TABLE 7 HUNTER VALLEY TOTAL WATER DEMAND (2006)

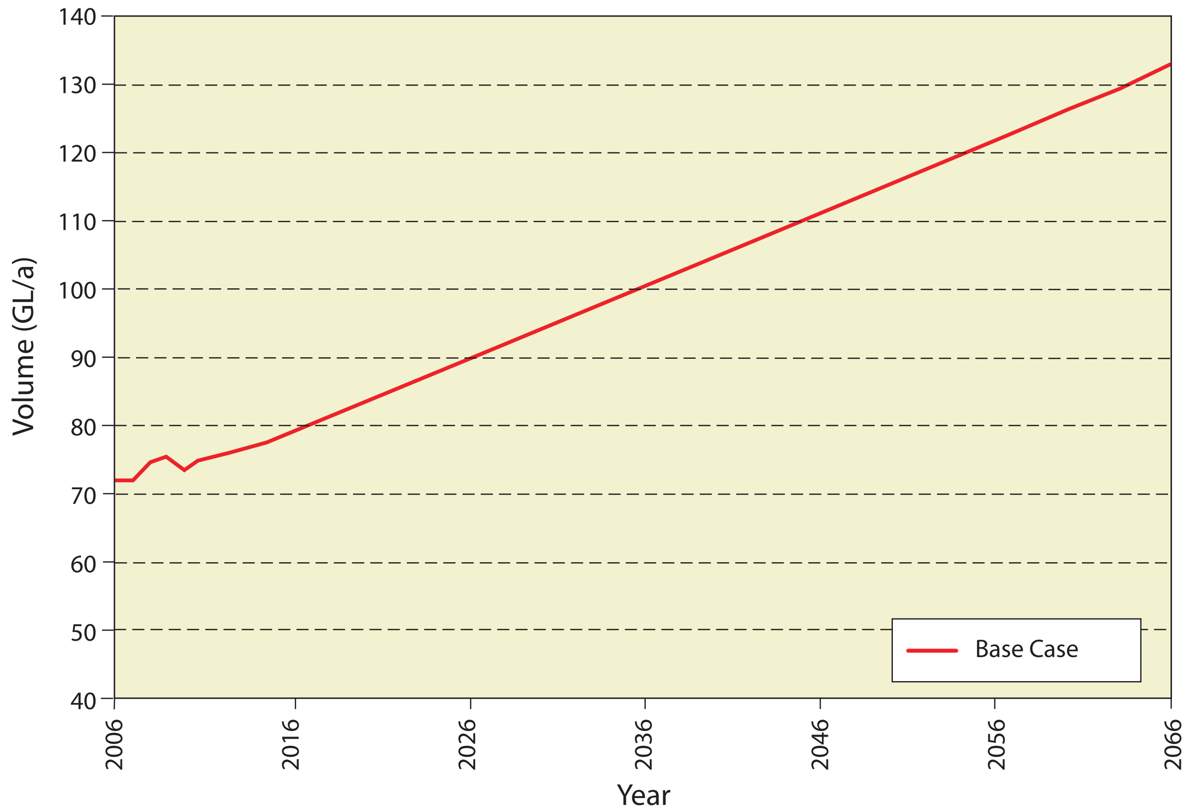
DEMAND SOURCE	VOLUME (GL)
Residential	
Detached	36.2
Units/Flats	4.4
Residential Total	**40.6**
Non-residential	Non-residential
Large Users	20.6
Small Users	3.2
Non-residential Total	**23.8**
Non-metered	8.4
Total Demand	**72.8**

Source: HWC 2007.

4.4.2 Forecast demand

Both population and industry growth are the key drivers of future demand. Demand forecasts allow for savings from recycling initiatives such as the Kooragang Island Scheme but do not make allowance for major new water users.

Given these assumptions, HWC anticipates that future water demand would rise at 1.6 per cent per annum in the period 2006 to 2031 and at one per cent after 2031. This would take the existing level in 2006 from 72.8 gigalitres to 89.7 gigalitres by 2030 and 109 gigalitres by 2050 as shown in Figure 10.



Source: Hunter Water Corporation (2007).

FIGURE 10 FORECAST DEMAND FOR WATER (GL)

4.4.3 Demand management initiatives

Since the early 1980s, HWC has implemented demand management. The initial focus was on pricing but was subsequently extended to include a range of other initiatives. The current focus encompasses the following:

- Pricing – this is based on a two-part water tariff structure comprising a fixed service component and water usage charge. Pricing has been gradually increased to reflect the scarcity of water. This has become the most significant demand management tool and will remain so.
- Recycling – recycling of wastewater currently sits at around 7.5 per cent providing approximately four gigalitres per year with approximately half of this substituting for potable water. The introduction of dual reticulation for major new residential subdivisions is expected to increase the volume of recycled wastewater to 10 per cent. The Kooragang water recycling plant announced as

part of the $342 million dollar water package that included Tillegra Dam would save a further three gigalitres of water per year.

- Loss minimisation – active leak surveillance and replacement of major of water mains has saved approximately one gigalitre of potable water. A full survey of the entire network is planned for completion by 2012. Further work on loss minimisation is expected to double annual savings to approximately two gigalitres.
- Community awareness – water efficiency campaigns are run annually and are aimed at increasing community awareness of potential savings generated from more efficient water use.
- Community programs – a number of programs are underway aimed at promoting more efficient use of water in households through use of water efficient appliances, rainwater tanks and education programs. Examples include the REFIT program and TogetherTODAY which are complemented by activities by other organisations such as Newcastle City Council, Energy Australia, Macquarie Generation, NBN Television, CSIRO, Department of Education and the University of Melbourne.
- Other programs – there are a number of State and national water efficiency programs including the Water Efficiency and Standards Scheme, Smart Approved Water Mark, the Australian Water Fund and the National Australian Built Environment System. In NSW, the Building and Sustainability Index (BASIX) aims to reduce water consumption in new homes through the use of recycled water for outdoor use and toilets. In the lower Hunter, BASIX is expected to save 350 megalitres per year.
- Indoor/outdoor metering program – this program collects data from a sample of residential consumers to characterise water usage behaviour. The information collected will assist in demand forecasting and the design of water efficiency programs.
- Additional water recycling – a major strategy study undertaken recently by HWC has found that by bringing on a number of recycling schemes (eg Kooragang/Mayfield scheme, 'third pipe' schemes, etc) around 10 per cent recycling would be achieved.
- Rainwater tanks – while actively encouraged through the use of rebates, rainwater tanks alone cannot substitute for a major water supply source option, particularly during drought periods. If the worst drought on record in the lower Hunter was repeated, rain water tanks (5,000 litre capacity for 100,000 households) would have delayed implementing water restrictions by only one month.

Further information on these various initiatives is provided in *Why Tillegra Now?* (HWC 2007).

4.4.4 Supply options

HWC has considered a number of possible supply options. These include:

- Williams River schemes, including new dams at Chichester and Tillegra
- further upgrades of Grahamstown Dam
- Karuah Scheme (Mammy Johnsons Dam)
- Paterson River Scheme (Lostock Dam)
- desalination
- indirect potable reuse.

Initial total project costs for the various supply options were first estimated in 2006/07 and reported in *Why Tillegra Now?* (Hunter Water Corporation 2007). Since this time, HWC has refined its understanding of the actual cost of Tillegra Dam as well as undertaking additional work to refine capital costs and yields for the other options. This work has been undertaken to ensure that the results of the CEA are based on the most up to date and accurate data available.

A summary of the key economic aspects of each scheme is presented in Table 9. Both the original 2006/07 estimates (from *Why Tillegra Now?*) and more recent estimates for 2008/09 are detailed to show progressive development of option estimates. Supply and demand graphs for the refined 2008/09 estimates are shown in Figures 11a-11g. Analysis of the Paterson River Scheme has been completed as part of the CEA. However, as it fails to meet the demand projection, it is not an option which can be realistically pursued.

Budgets for major infrastructure projects can be reported against in either real or nominal dollars. A budget in nominal dollars expresses the budget in the dollars in which the capital is spent. A budget quoted in real dollars is the cost in the dollars of the base year.

The 2006/07 project estimates produced by HWC were in real dollars; accounting for the cost of the projects should any of the options have been pursued in that particular year. Conversion of 2006/07 estimates into 2008/09 dollars requires the application of the general consumer price index (CPI) and understanding of cost escalations of specific relevance to the construction industry.

To allow conversion and reporting in 2008/09 dollars, HWC commissioned BIS Shrapnel to investigate construction cost escalations over recent years and likely trends into the future, taking into account the specific mix of materials and activities relevant to Hunter Water's program of capital works. Using data sourced from the Australian Bureau of Statistics, BIS Shrapnel determined that annual percentage increases in construction costs are significantly higher than the consumer price index. Inflation is currently running at between 2.4 per cent and 3.2 per cent annually. Over the same period however, with consideration of a significant correction in 2006, construction costs have increased at almost twice the rate. A comparison of the consumer price index and construction inflation rates is provided in the following table.

TABLE 8 CONSUMER AND CONSTRUCTION PRICE INDEXES

	2003/04	2004/05	2005/06	2006/07	2007/08
CPI	2.4%	2.4%	3.2%	2.9%	3.2%
Construction cost	3.1%	5.3%	5.7%	10.8%	4.5%

BIS Shrapnel forecast ongoing escalation of construction costs in the order of 4.8 per cent per annum for at least the next five years. This escalation is driven by the high demand for construction services in the short to medium term, especially in the mining and infrastructure areas. As reflected by the index, demand exceeds supply. Global prices for key inputs are also rising strongly particularly for steel, fuel and other oil-related products such as bitumen.

As part of this assessment, this work has been revised to consider shifts in construction costs. Since September 2006 when the initial estimates were made, annual increases of eight per cent , 4.5 per cent and 4.8 per cent[6] have been applied to the original cost estimates to account for movements in contractor margins and overheads.

HWC also amended a number of its budget estimates to reflect increased knowledge of individual options. For example, initial estimates related to indirect potable reuse indicated that the scheme would supply 32.5 gigalitres of potable water per annum. Additional refinement of the estimate showed that at the reported cost of $400 million (2006/07 real) such a scheme would in fact only deliver 26.28 gigalitres of water per year.

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6 Only the 2nd, 3rd and 4th quarters (8%) of the BIS Shrapnel cost escalation index of 10.8% in 2006/07 was applied to the estimates as original estimates were considered to be current as of the first quarter of 2006/07.

Additional work in 2007 by GHD also assisted HWC to refine estimates for desalinisation. Originally HWC estimated that a desalinisation plant could be constructed in the vicinity of Newcastle at a capital cost of $500 million (2006/07 dollars) and that such a plant would supply 32.5 gigalitres of water per annum. Additional work indicated that in 2006/07 dollars, such a plant would actually cost $688 million although yield would also commensurately increase to 46.2 gigalitres per year. This means however that after the application of the BIS Shrapnel index for construction costs and adjusting for other inflationary pressures, while the relativity is the same, such a plant would cost $989 million in today's terms.

Further design work has also been undertaken for the Project. The original budget estimate for Tillegra Dam assumed the construction of a 11.17 kilometre long road from Dusodie to the northern end of the storage, reconnecting to Salisbury Road at Underbank. This connecting road was first proposed in 1985. Since this time, design standards for roads have progressed. Due to the steep grades, road geometry and safety implications associated with the route, it is no longer considered to meet the necessary public road standard.

An alternative 16.9 kilometre long road is now proposed to replace the section of Salisbury Road within the inundation area. The design of the new road addresses current standards with appropriate grades and geometry to allow a signposted speed of 80 km/hr for the majority of its length. The design also includes several bridges beyond those originally proposed. The increased length of road, its higher design standard and additional waterway crossings would mean that HWC would incur additional costs beyond the original estimate.

Additional hydrological modelling has also been undertaken since the original budget estimates were made in 2006/07. Evaporation rates and runoff co-efficients used to calculate total system yield have been refined. These refinements indicate that Tillegra Dam would increase the total sustainable system yield by an additional 3.5 gigalitres (56 gigalitres gross, attributable to the dam).

With the conversion of the 2006/07 estimate to take into account inflation, construction cost escalation, land acquisition and design adjustment's, the estimated cost is now $396.92 million in 2008-09 dollars.

Refinement of all project scenarios has been undertaken. Original estimates were made solely focusing on engineering design and construction costs. All estimates now include environmental Part 3A pre-construction costs as well as, for parity, an allowance to establish 1.5 million trees pursuant to the NSW Government's announcement of the Tillegra Dam project.

Finally, all of the dam scenarios have made refinements to land acquisition costs and road construction estimates, based on recent real life experience gained from further design work undertaken for the Project. Together with the application of the BIS Shrapnel construction cost index across all of the 2006/07 estimates, this has resulted in the upward revision of all final supply option estimates.

4.4.5 Individual supply options refined and developed to 2008-09

Option 1: Tillegra Dam

This option has a storage capacity of 450 gigalitres and an annual yield of 56 gigalitres increasing the reliable system yield beyond 120 gigalitres per year. The proposed dam's location in an alternate subcatchment (to Chichester Dam) in the Upper Williams River provides supply diversity, double redundancy and drought security advantages.

Establishment and operational costs are similar to a new dam at Chichester and less than all other options as Tillegra Dam has the ability to gravity feed into the water network either through Grahamstown Dam or via the Chichester Trunk Gravity Main.

The total cost of the project in real 2008-09 dollars is $396.92 million accounting for refined design, inflation and construction cost escalation.

Option 2: New Chichester Dam

A new Chichester Dam immediately downstream of the existing Chichester Dam would have a storage capacity of 400 gigalitres and an annual yield of 48.5 gigalitres increasing the reliable system yield to approximately 116 gigalitres per year.

In addition to providing drought security, the ability to connect to existing infrastructure provides significant advantages. However, the drawback of this option is that it would require emptying the existing Chichester Dam and using it as a coffer dam for at least a two year construction period.

This would create significant operational difficulties in maintaining supply north of Seaham resulting in a supply risk during this period. The inundation of 270 hectares of Barrington Tops National Park of which 80 hectares is World Heritage listed is a further issue of concern.

The total cost of the scheme in real 2008-09 dollars is $585.58 million accounting for refined design, inflation and construction cost escalation.

Option 3: Grahamstown Dam Upgrade

The Grahamstown Dam upgrade would provide an annual yield of 30 gigalitres and increase the total system yield to around 97.5 gigalitres. This option would improve the drought security of the existing system, however this would not similarly contribute to the advantages inherent in source diversity.

The reliance on pumping from the Williams River as well as the shallowness and larger surface area of the dam makes this option more susceptible to climate change due to evaporation.

The total cost of the scheme in real 2008-09 dollars is $655.8 million accounting for refined design, inflation and construction cost escalation.

Option 4: Paterson River Scheme (Lostock Dam)

Lostock Dam would provide an annual yield of 9.5 gigalitres raising the reliable system yield to around 77 gigalitres per year.

The advantage of this option is its ability to connect to existing infrastructure at the dam site. However, inter-basin transfers would result in high operation costs over the life of the scheme derived from the operation of substantial pump stations.

The total cost of the scheme in real 2008-09 dollars is $425 million accounting for refined design, inflation and construction cost escalation.

Option 5: Karuah River Scheme (Mammy Johnsons Dam)

The Karuah River Scheme would involve the construction of a 330 gigalitre dam on Mammy Johnsons River, a weir on the Karuah River one kilometre downstream of Booral and a pump station/transfer scheme to Black Camp Creek on the Williams River. This option would have an annual yield of 27.5 gigalitres and would increase the reliable system yield to 95 gigalitres per year.

Potential issues associated with this option are environmental impacts related to the damming of an unregulated river at two locations and impacts derived from inter-basin transfers to the Williams Valley.

The total cost of the scheme in real 2008-09 dollars is $565.2 million accounting for refined design, inflation and construction cost escalation.

Option 6: Desalination

A desalination option would provide an annual yield of 46.2 gigalitres increasing the reliable system yield to 113.7 gigalitres per year.

The principal advantages of this option are that it would provide a climate-independent source and improve system diversity. The disadvantages are its much higher operational costs relative to dams and environmental impacts including high energy use and brine disposal. Operational costs are estimated at $26.6 million per year.

The total cost of the scheme in real 2008-09 dollars is $989.76 million accounting for refined design, normal inflation and construction cost escalation.

Option 7: Indirect potable reuse

This option would involve the construction of a large scale collection, reticulation and advanced recycled water treatment network to supplement potable water supply via Grahamstown Dam. This option would feed water sourced from Kurri Kurri, Farley, Morpeth, Raymond Terrace, Shortland, Edgeworth and Toronto WWTW. It would provide around 26.28 gigalitres per year of highly treated recycled water increasing the reliable system yield to 93.8 gigalitres per annum.

The discharge of this water to the northern embayment of Grahamstown Dam would provide the opportunity to blend and store recycled water prior to further potable water treatment.

Brine disposal is a major consideration for this option. The outfall at the Burwood Beach WWTW could be used for this purpose as brine concentration is likely to have little impact on the treatment process if passed through the WWTW. A 29 kilometre long brine return line from Raymond Terrace WWTW would be required.

Like desalinisation, operational costs are significant, these being estimated at $21.19 million per year. The total cost of the scheme in real 2008-09 dollars is $523.14 million accounting for refined design, inflation and construction cost escalation.

TABLE 9 KEY ELEMENTS OF WATER INFRASTRUCTURE PROJECT OPTIONS

		TILLEGRA DAM	NEW CHICHESTER DAM	GRAHAMSTOWN DAM UPGRADE	PATERSON RIVER SCHEME (LOSTOCK DAM)	KARUAH RIVER SCHEME (MAMMY JOHNSONS DAM)	DESALINATION	INDIRECT POTABLE REUSE
2006/07 ESTIMATE	Yield (GL/yr 2006/07)	52.5	48.5	30	9.5	27.5	32.5	32.5
	Capex ($M 2006/07)	300	$330	$410	$389	$260	$500	$400
	Opex ($M 2008-09)	$0.60	$0.60	$0.40	$0.75	$0.80	$25.00	$22.00
	Levelised cost ($/kL)	$1.26	$1.39	$1.91	$2.94	$1.66	$3.15	$2.62
2008/09 REVISED ESTIMATE	Yield (GL/yr)	56.0	48.5	30.0	9.5	27.5	46.2	26.3
	Capex ($M 2008-09)	396.92	585.59	655.80	425.00	565.22	989.76	523.14
	Opex ($M 2008-09)	0.64	0.64	0.43	0.80	0.85	26.63	21.19
	Satisfies demand up to and including:	2058	2051	2034	–	2031	2049	2030
	Satisfies demand for (years)	45	38	21	–	18	36	17
	Present value of total capital costs ($M)	$371.07	$547.45	$613.09	$397.32	$528.41	$809.17	$427.69
	Present value of total ongoing costs ($M)	$6.58	$6.58	$4.39	$8.23	$8.78	$274.41	$218.35
	Present value of total costs ($M)	$377.65	$554.03	$617.48	$405.55	$537.19	$1,083.58	$646.04
	Levelised cost ($/ML)	$1,661	$2,450	$3,038	$4,760	$2,733	$4,803	$3,291
	Levelised cost ($/kL)	$1.66	$2.45	$3.04	$4.76	$2.73	$4.80	$3.29

Source: Hunter Water Corporation.

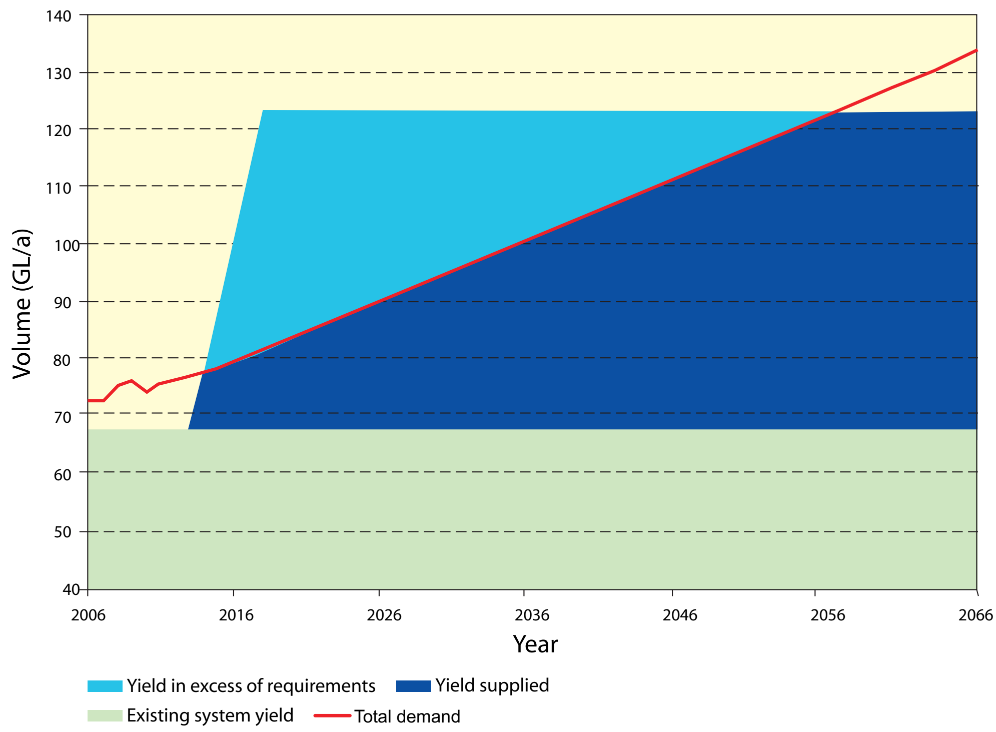


FIGURE 11A TILLEGRA DAM

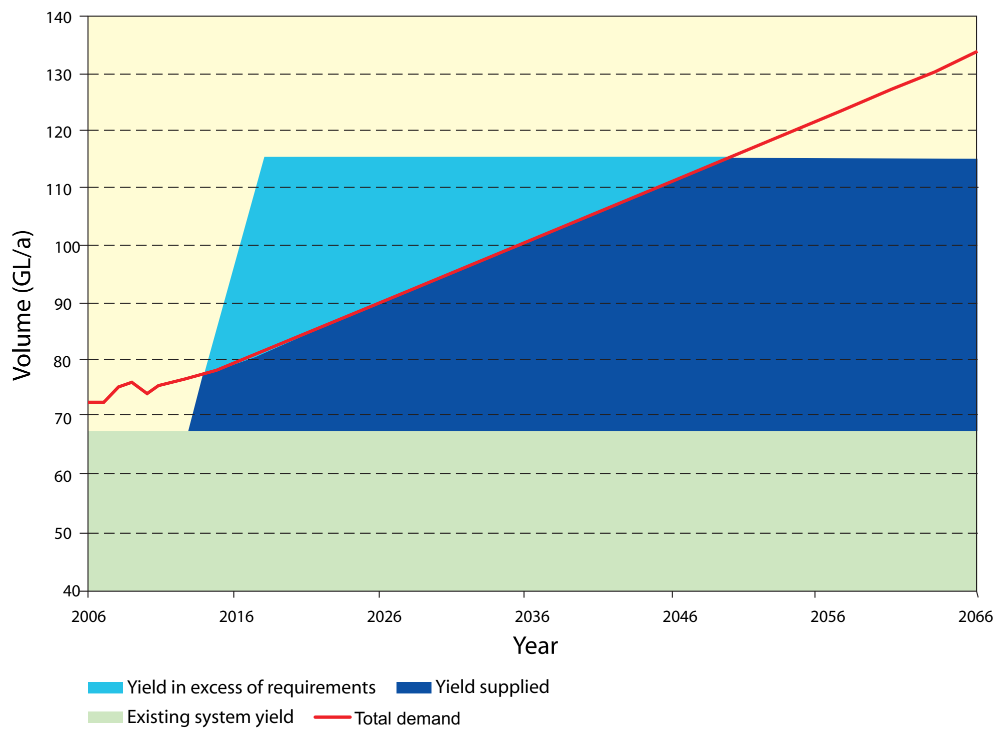


FIGURE 11B NEW CHICHESTER DAM

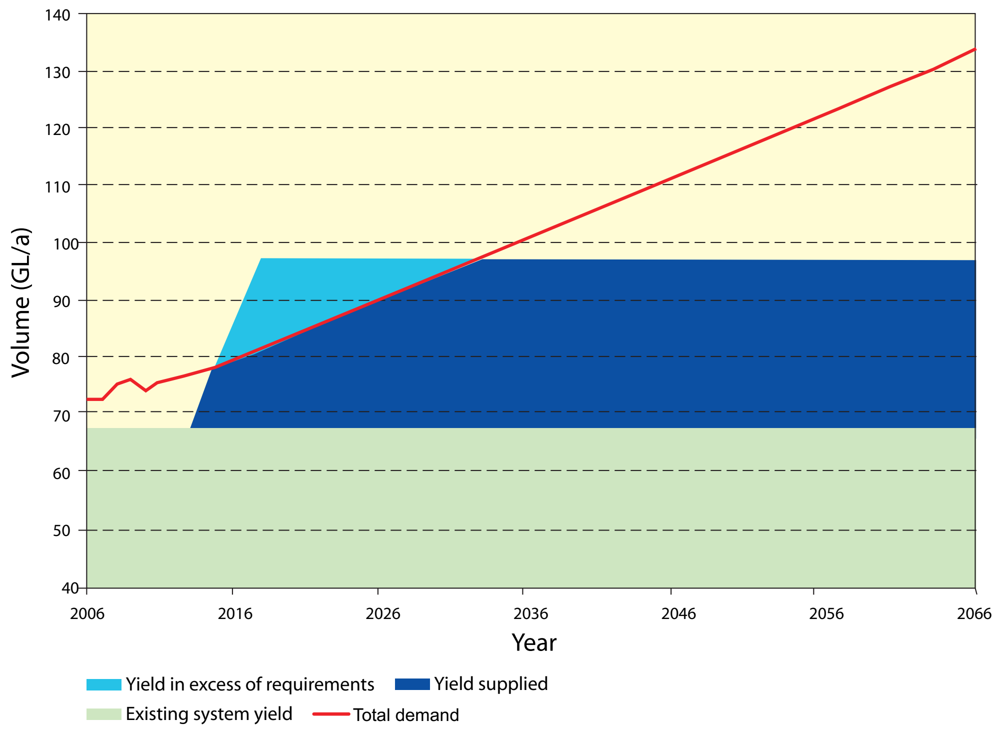


FIGURE 11C GRAHAMSTOWN DAM UPGRADE

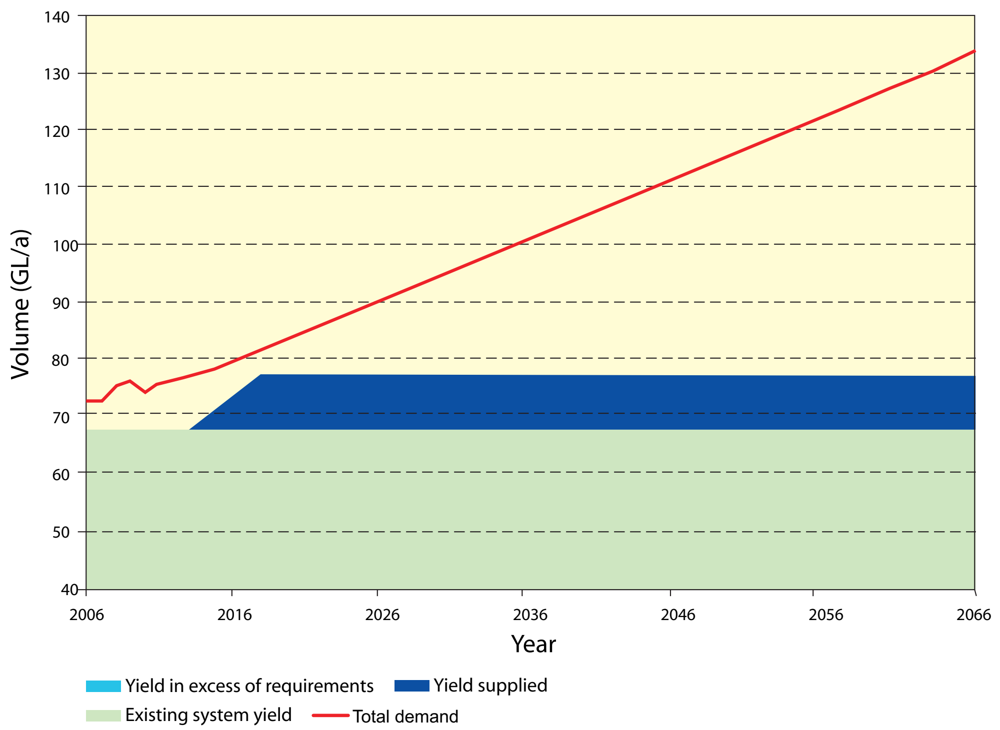


FIGURE 11D PATERSON RIVER SCHEME (LOSTOCK DAM)

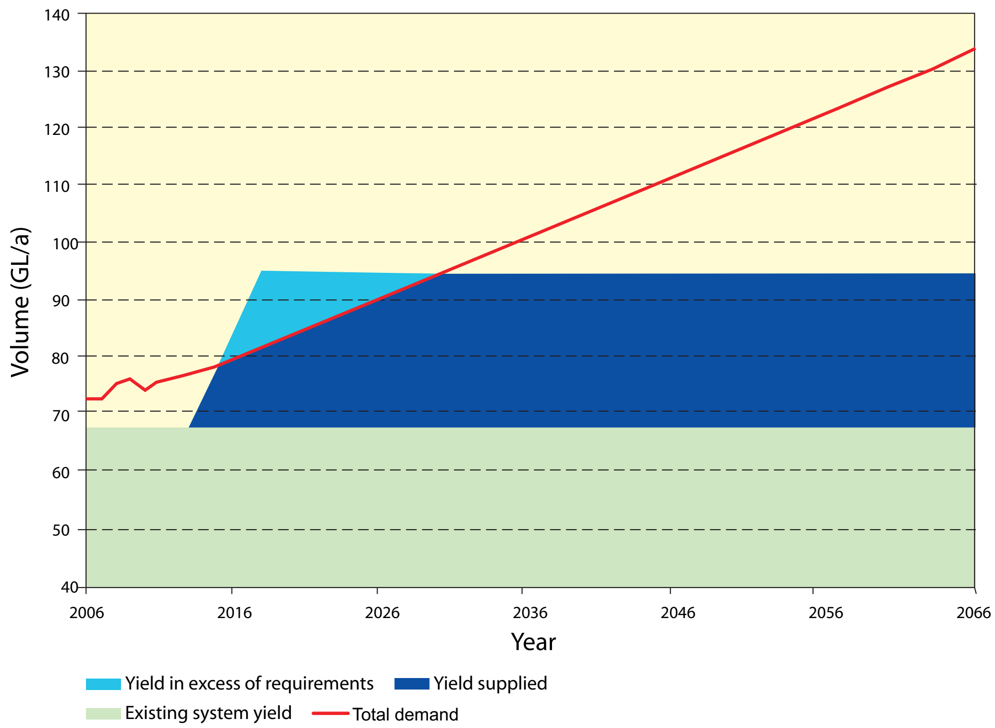


FIGURE 11E KARUAH RIVER SCHEME (MAMMY JOHNSONS DAM)

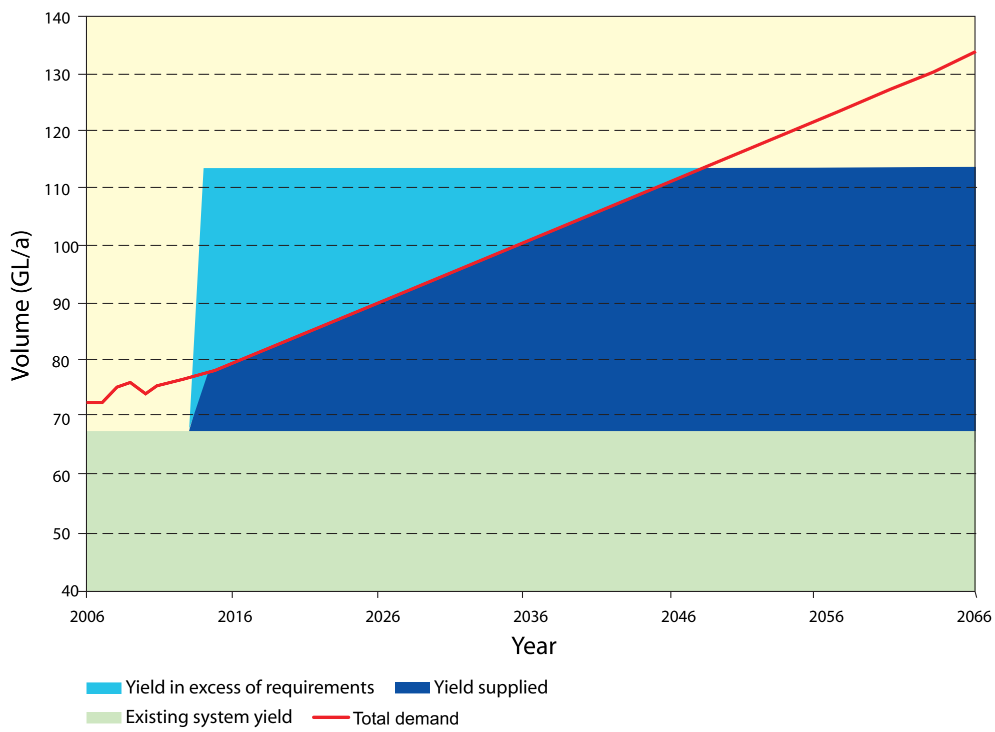


FIGURE 11F DESALINATION

FIGURE 11G INDIRECT POTABLE REUSE

4.4.6 Levelised costs for individual supply options

The preliminary results of the CEA modelling conducted in 2006/07 allowed the levelised costs for each supply option to be determined. The results of the analysis are presented in Figure 12.

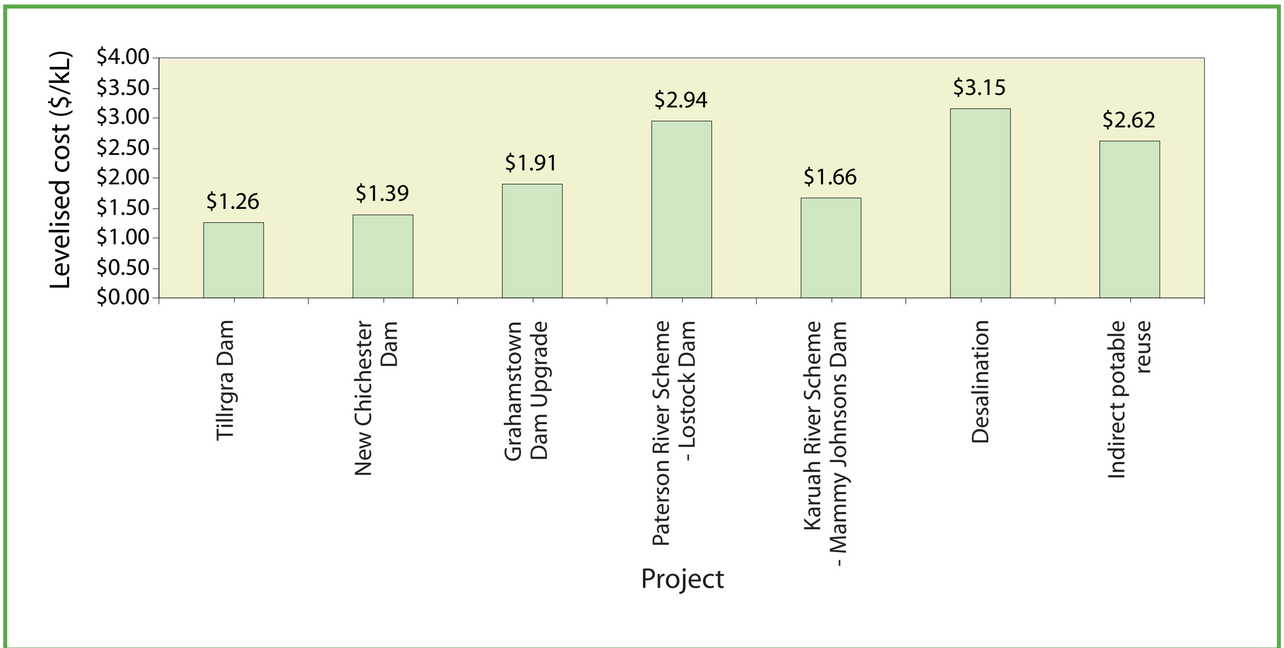


FIGURE 12 PRELIMINARY ANALYSIS, LEVELISED COST COMPARISON FOR ESTIMATES MADE FOR THE 2006/07 FINANCIAL YEAR

Based on the preliminary analysis conducted in 2006/07, Tillegra Dam was identified as the most cost effective option because at $1.26 per kilolitre, it had the lowest levelised cost of any of the proposed supply options (refer Table 9). It also had the second lowest present value of total cost ($250 million).

While inflationary and cost escalation changes to the capital and operating costs of all options between 2006/07 and 2008/09 are relative, it was considered prudent to reassess the levelised cost to consider how design refinements might affect the options. Levelised costs for the different water supply schemes based on net present values derived from the 2008/09 (real) estimate are presented in Figure 13.

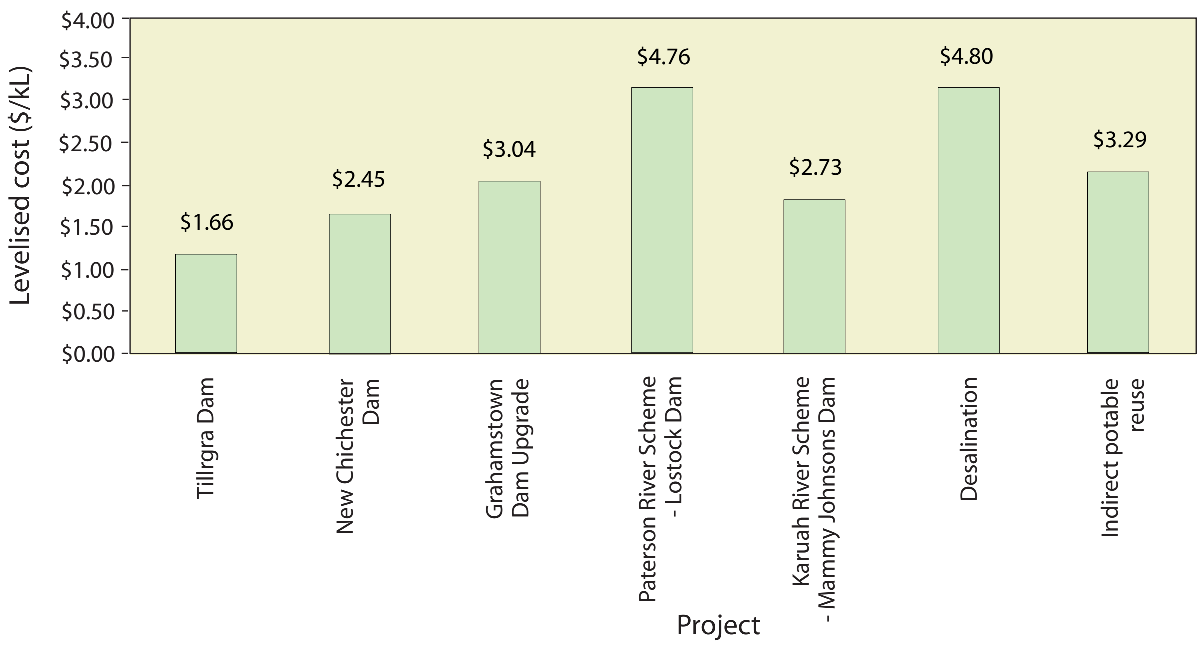


FIGURE 13 LEVELISED COST COMPARISON FOR WATER SUPPLY OPTIONS BASED ON 2008/09 FINANCIAL YEAR.

The estimated costs and yields for each option provide relativity for comparison in the CEA in both cases. The final levelised cost figures for the CEA are based on the best information to hand in 2008/09. The costs include both capital construction costs and basic operation costs converted to 2008/09 dollars.

Basic operational costs of each project measure are used within the CEA. However, water treatment plant and subsequent transportation costs within the wider water distribution network have not been included in the CEA as they are considered to be equally applicable across all options for the purpose of the assessment.

Based on an undiscounted total capital cost of $396.92 million (2008/09 real) and a yield of 56 gigalitres, the levelised cost for Tillegra is $1.66 per kilolitre. Changes to the yield estimate by 3.5 gigalitres only marginally affects the analysis (moving the costs $0.05).

Based on this analysis, it can still be seen that even with refined budget estimates and with or without refinements in system yield, Tillegra Dam provides the lowest levelised cost and is the most effective option to pursue on economic terms. The next closest option is the New Chichester Dam option which when assessed on 2008/09 terms, returns a levelised cost of $2.45 per kilolitre.

Based on refined project estimates and accounting for inflation and construction cost escalation, ranking for all other options remained static with the exception of the Paterson River Scheme (Lostock Dam) option. This supply option has the lowest present value of total cost ($219 million), however as it can only supply 9.5 gigalitres of water annually, it cannot satisfy even short term demand (refer Figure 11).

The levelised cost for the Paterson River Scheme (Lostock Dam) option therefore changed significantly as the limited yield gained from the proposal renders it sensitive to cost escalations. As it fails in the first instance to meet the overall objective of meeting the supply/demand imbalance, it was not considered further.

Tillegra Dam has the next lowest present value, the lowest overall levelised cost and it also provides the greatest yield of any of the schemes allowing demand to be satisfied for approximately 45 years (refer Figure 11).

The desalination option is the least attractive with a levelised cost of $4.80 per kilolitres. This option could be delivered in stages which conceivably could reduce the levelised cost. However, the reduction would not be significant and the ultimate cost would likely be similar to the figure identified in the CEA.

4.5 Sensitivity analysis

Data on capital costs and operating costs was highly aggregated. In addition, data on forecast demand was also highly aggregated. In order to assess the impact of these variables on the cost effectiveness analysis, a detailed sensitivity analysis was undertaken.

The cost effectiveness of the seven options was assessed in terms of:

- a discount rate of four per cent (real)
- a discount rate of 10 per cent (real)
- a 50 per cent increase in capital costs – the extent to which capital costs are grossly underestimated
- a 50 per cent increase in operating costs – the extent to which operating costs are grossly underestimated
- HWC's low demand forecast – the extent to which planned excess capacity is taken up later than expected
- HWC's high demand forecast – the extent to which planned excess capacity is taken up earlier than expected.

TABLE 10 SENSITIVITY ANALYSIS-LEVELISED COST ($/ML)

	TILLEGRA DAM	NEW CHICHESTER DAM
Base	$1,661	$2,450
Low demand	$2,137	$3,135
High demand	$1,220	$1,832
4% discount rate	$876	$1,292
10% discount rate	$2,816	$4,155
+50% capex	$2,477	$3,660
+50% opex	$1,676	$2,464

Tillegra Dam remained the preferred option with New Chichester Dam the next best option for all sensitivity scenarios. Table 10 summarises the results of the sensitivity analysis of changes to capital and operating costs (capex and opex respectively).

Given the long-lived nature of the assets and relatively low operating costs, it is not surprising that significant changes in capital expenditure affect the cost. The impact of a substantial increase in operating expenditures is less significant. A 50 per cent increase raises the levelised cost by just one per cent for Tillegra Dam with similar results for the other scenarios.

One point to note is where there is lower than expected increase in demand, the range of potential costs increases relative to the baseline. For example, for Tillegra Dam the cost per megalitre demanded lies in a $476 per megalitre range around $1,661. There are two consequences to consider:

- the water charge for a higher cost project is likely to be more sensitive to a deviation from the expected quantity of water demanded
- greater uncertainty in the demand for water will increase the likelihood of excess capacity in the system from inefficient staging in the water infrastructure development.

4.6 Final levelised costs of the Project and IPART

The final cost charged to the consumer from an augmented water supply wouldnot be based on the levelised cost calculated by this cost effectiveness analysis if the Tillegra Dam project is approved. Costs and charges are fixed by the Independent Pricing and Regulatory Tribunal (IPART). IPART is an independent body that oversees regulation of the water, gas, electricity and public transport industries in NSW. Established by the NSW Government in 1992, IPART's primary purpose is to regulate the maximum prices charged by these industries and in general consider industry structure, service provision and competition.

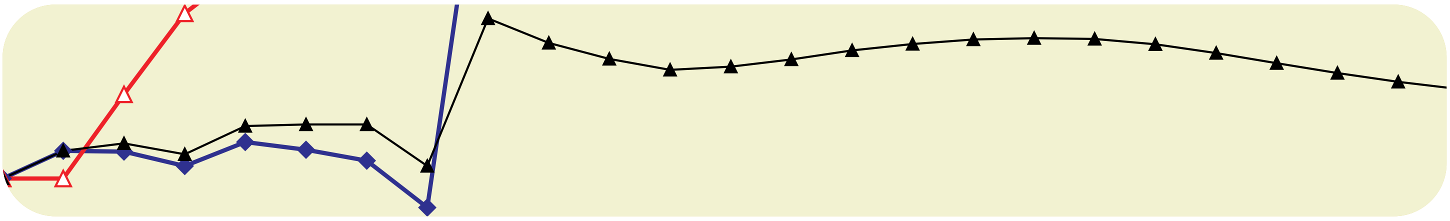
HWC's submission to IPART, which is pending at the time of preparation of this report, will include the revised 2008/09 budget estimate of $396.92 million for Tillegra Dam. This is the most up to date and refined information currently available.

This analysis will not form part of the IPART submission. The CEA modelling undertaken allows only the most effective economic option to augment the existing water supply to be identified. It requires the estimation of the size and timing of all expenditure related to the projects. These future cash flows are then discounted to determine their net present value to reflect the true cost of capital. In simple terms, the subsequent levelised costs are a function of the present value of the demand supplied divided by the present value of the costs to supply.

None of the options examined in the CEA consider treatment and subsequent transportation costs within the water distribution network. These costs are inconsequential to the CEA analysis as they are fixed and relative to all options. Consequently, these costs would need to be considered separately by IPART.

Further, IPART is likely to calculate and set permissible fees and charges on the basis of the long run marginal cost of meeting incremental demand. Costs may also be ascribed between consumer and developer charges. This will therefore affect the fee set by IPART for the majority of existing consumers and ultimately, any fee or charge set by IPART would not relate specifically to the analysis in this working paper.

Report prepared by aurecon



5. Computable General Equilibrium Analysis

Monash University's Centre for Policy Studies (COPS) used TERM, a 'bottom-up' CGE (computable general equilibrium) model of the Australian economy to analyse the impact of the dam, treating each region as a separate sub-economy. The key feature of TERM, in comparison to predecessors such as the Monash Multi-regional Forecasting Model (MMRF), is its ability to handle a greater number of regions or sectors.

The TERM master database distinguishes 169 sectors and 59 regions (the Australian Statistical Divisions). The high degree of regional detail makes TERM a useful tool for examining the regional impacts of shocks that may be region-specific. TERM has a particularly detailed treatment of transport costs and is naturally suited to simulating the effects of improving infrastructure and consequent service provision from that infrastructure. The COPS report is provided as Appendix B.

5.1 Methodology

The key aspects of the methodology adopted in the CGE analysis using TERM are:

- development of a baseline forecast which models a 'without dam' scenario using a set of recognised macroeconomic forecasts and certain assumptions about water scarcity at the regional, State and national levels
- development of a policy scenario ('with dam'), which introduces a shock to the model through the 'Water and Drains' industry sector, based on the proposed capital expenditure and continuing operation of the proposed Tillegra Dam
- comparison of relative changes in gross domestic product, investment, and household consumption as assess the impact of the dam on the regional, state and national economies.

Even though COPS considers TERM computationally efficient, it would be slow to solve if the full 169 sector, 59 region database was used. In practice, sectors or regions are aggregated to manageable dimensions. The TERM database programs facilitate this aggregation. The choice of sectors or regions to aggregate is application-specific, avoiding unnecessary disaggregation. For example, aggregated regions can be designed which followed the boundaries of climatic zones or watersheds, or which highlighted the distinction between metropolitan and rural regions. Similarly, the sectoral aggregation would be tailored to a particular simulation.

For this analysis, the Hunter region was disaggregated to exclude statistical divisions outside the watershed for the Tillegra Dam. It was also aggregated to produce the following aggregated outputs: Hunter region (as defined), rest of NSW, and rest of Australia.

5.2 Data and assumptions

Key data and assumptions used in the CGE model are described in terms of baseline forecast assumptions and the policy (Project) scenario as follows:

5.2.1 Key baseline forecast assumptions

The following assumptions were used by COPS in projecting the dynamic regional model, TERM, baseline from 2006 to 2031:

- based on various studies undertaken by COPS, there are ongoing productivity improvements in most sectors, with growth more rapid in primary and secondary industries than in most services
- State macro forecasts provided by Access Economics were used
- since water remains scarce, water users are assumed to increase water efficiency by one per cent per annum. Critically, throughout Australia, water scarcity is assumed to worsen over time, ie population and economic growth over time results in growing demand for water that is only partly offset by growing water supplies.

The baseline is important because it assumes that there is a fixed water resource that would not grow as rapidly as the economy. Therefore, with economic growth water scarcity would worsen. The Tillegra Dam provides benefits relative to the baseline by alleviating the ever-worsening scarcity of water in the Lower Hunter as the economy grows.

5.2.2 Policy scenario

In the policy scenario the following assumptions were used by COPS:

- $300 million is spent constructing Tillegra Dam between 2008 and 2014
- direct costs of the Project ascribed to the CGE model were based initially on the HWC report *Why Tillegra Now?* (Hunter Water Corporation 2007)
- the dam becomes fully operational in 2015, raising minimum annual yields in the Lower Hunter from around 67 gigalitres to 125 gigalitres
- the model shock is introduced in the 'Water and Drains' sector, which comprises both water provision and water services components. The water services component accounts for 90 per cent of the 'Water and Drains' labour, while all capital is ascribed to the water provision component. Capital is 67 per cent of the total factor value in the sector. Based on this, the 72 per cent increase in water volume is scaled down to a 50 per cent sectoral output increase: ([0.1*[1-0.67] +1.0*0.67]*72 %=50 %).

In the model, finance is borrowed from a global market to fund construction. This implies that national debt may rise in the future at the same as additional production capacity rises due to the Project. Therefore, some of the additional income generated by the Project must be paid in interest internationally.

5.3 Results

A key finding from the results is that the dam brings an additional benefit each year to the Hunter region because baseline water scarcity is worsening year by year. Each year brings a marginal benefit from the dam as baseline water scarcity from a fixed resource worsens with economic growth.

This is the reason the labour market in the Hunter continues to strengthen relative to baseline. This is a crucial point and one which the slow adjustment relative to forecast illustrates. Were the benefit is a one-off gain, the equilibrium would be reached more quickly.

A more detailed discussion of key regional and national results follows.

5.3.1 Key regional Results

Key results for the Hunter region are shown in Figures 24 and 25 as percentage deviations from the baseline forecast for the region. Given the capital expenditure and the scale of alleviation of water scarcity relative to the regional economy, the regional level impacts are considered significant.

As Figure 14 shows, an increase in capital stock relative to the baseline forecast, peaks at 0.51 per cent of baseline forecast Gross Domestic Product (GDP) in 2023. Employment and real regional GDP achieve small positive results over the forecast period, increasing noticeably once operation of the dam commences.

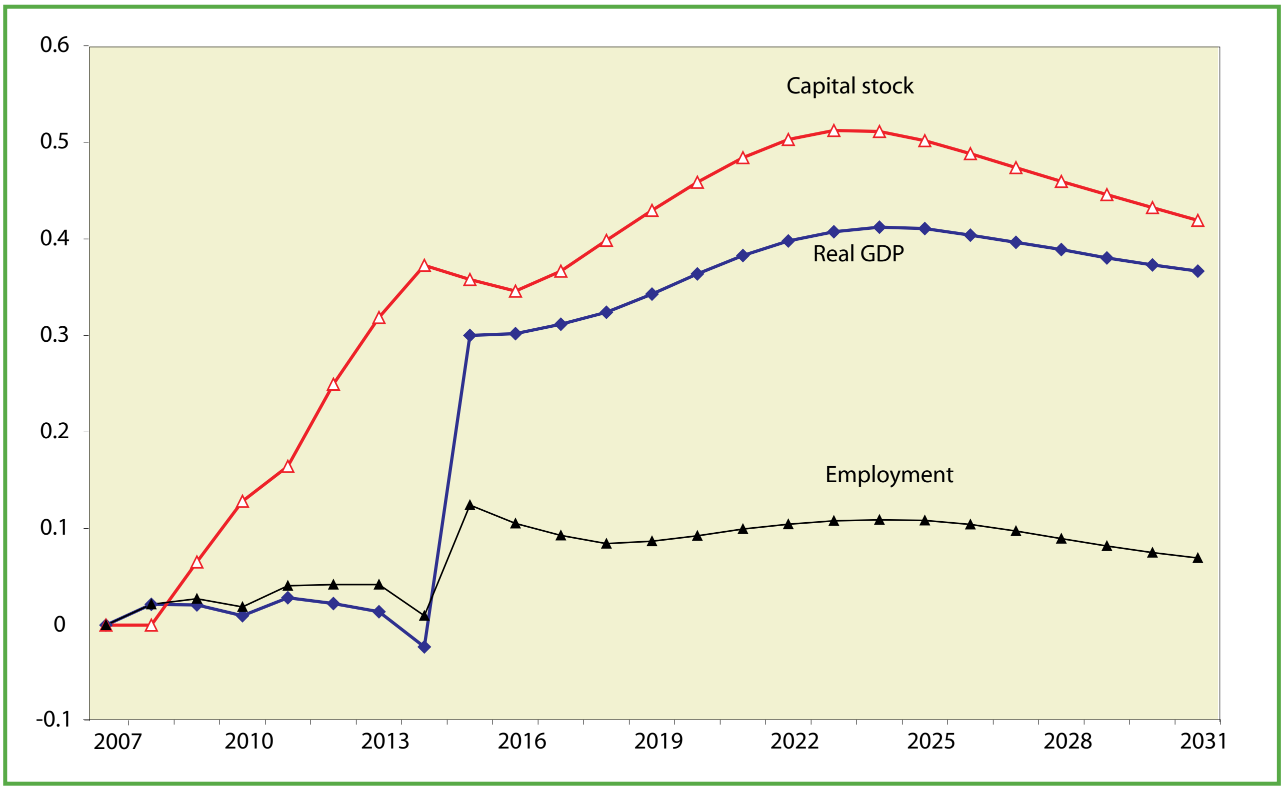


FIGURE 14 KEY RESULTS FOR HUNTER REGION – GDP, CAPITAL AND EMPLOYMENT

Employment and real regional GDP are more affected by the alleviation of ongoing water scarcity, which is why after 2014 GDP initially rises sharply and then slowly increases, while labour maintains an increased level over the baseline forecast. The impact of construction is significant at the regional level. Capital stock increases faster, earlier, reflecting the construction costs of the Tillegra Dam and runs at a faster rate than GDP relative to the baseline forecast.

The investment phase strengthens the Lower Hunter Valley labour market, with rising employment impacted off by rising real wages from 2014. The technological improvement arising from the dam becoming operational in 2015 strengthens the labour market further. The regional labour demand and supply are assumed to be constrained so convergence of demand and supply occurs over time.

The impacts of aggregate consumption and investment at the regional level are larger relative to the baseline forecasts of the Australian economy than the impacts on capital stock, real regional GDP and employment. As Figure 15 shows, the increase in aggregate investment peaks at 1.07 per cent of baseline forecast in 2012, reflecting the significant regional impact of the Tillegra Dam's construction costs.

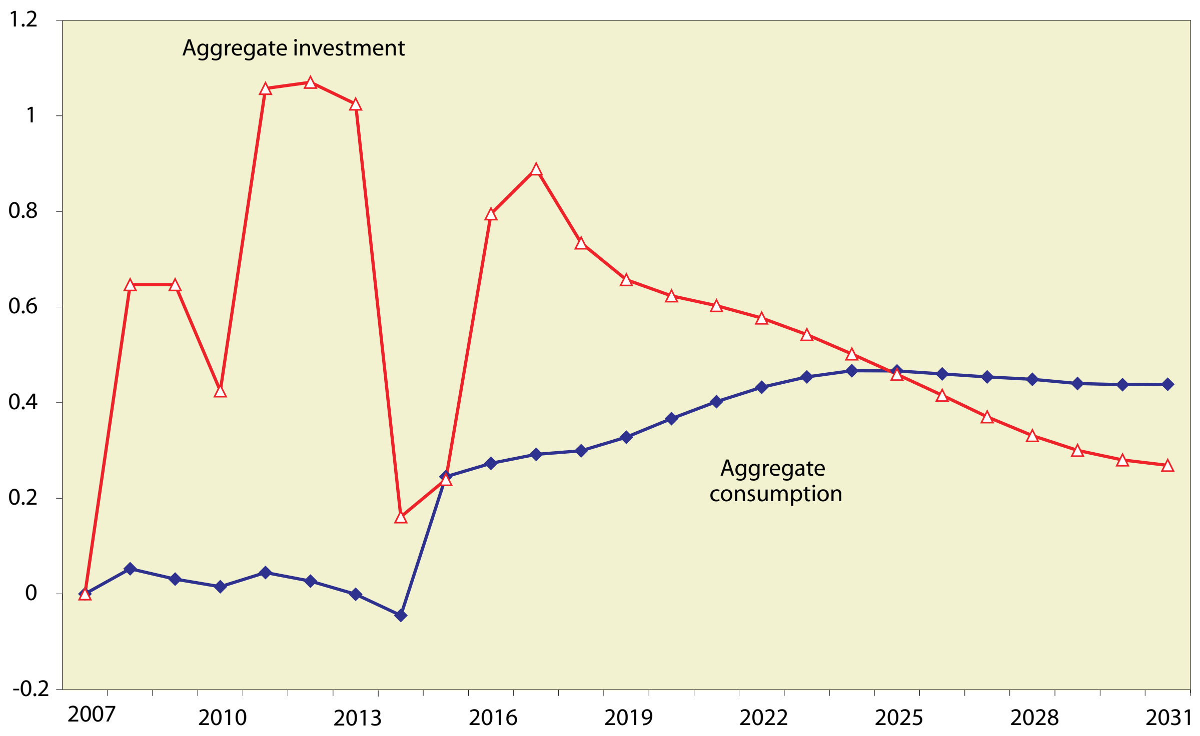


FIGURE 15 KEY RESULTS FOR HUNTER REGION – AGGREGATE CONSUMPTION AND AGGREGATE INVESTMENT

The subsequent dip in aggregate investment reflects the declining pattern of dam construction costs before aggregate investment is stimulated by water availability once the dam becomes fully operational.

The ongoing availability of additional water underpins a higher level of economic activity, allowing a higher level of household consumption relative to the baseline forecast for the region.

5.3.2 Key national results

Key national results are shown in Figures 16 and 17 as percentage deviations from the baseline forecast. Given the capital expenditure and the scale of alleviation of water scarcity relative to the national economy, it is not surprising that the national level impacts are not very significant.

As Figure 16 shows, even the largest impact, an increase in real GDP relative to the baseline forecast, peaks at 0.0379 per cent of baseline forecast GDP in 2025. Employment and capital achieve small positive results over the forecast period.

Employment and real GDP are more affected by the alleviation of ongoing water scarcity, which is why after 2014 GDP initially rises sharply and then slowly increases, while labour maintains an

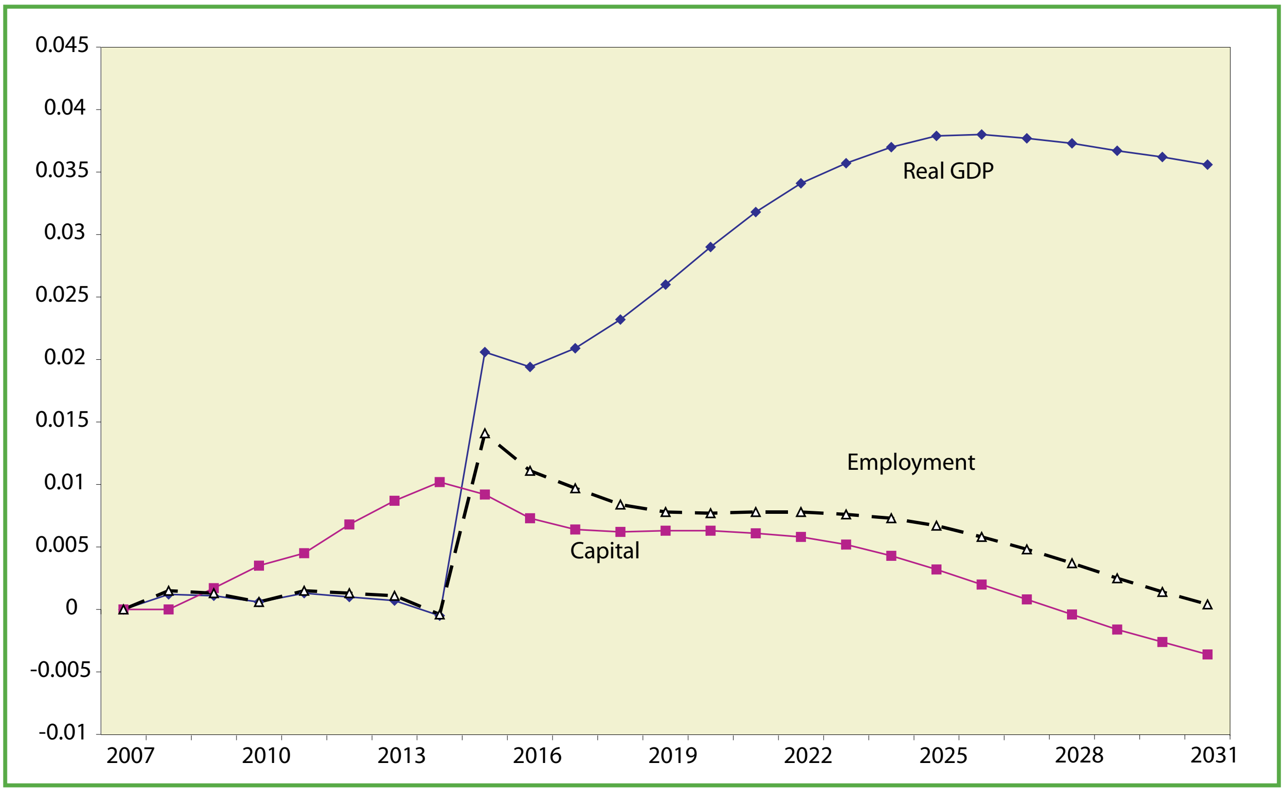


FIGURE 16 KEY NATIONAL RESULTS – GDP, CAPITAL AND EMPLOYMENT

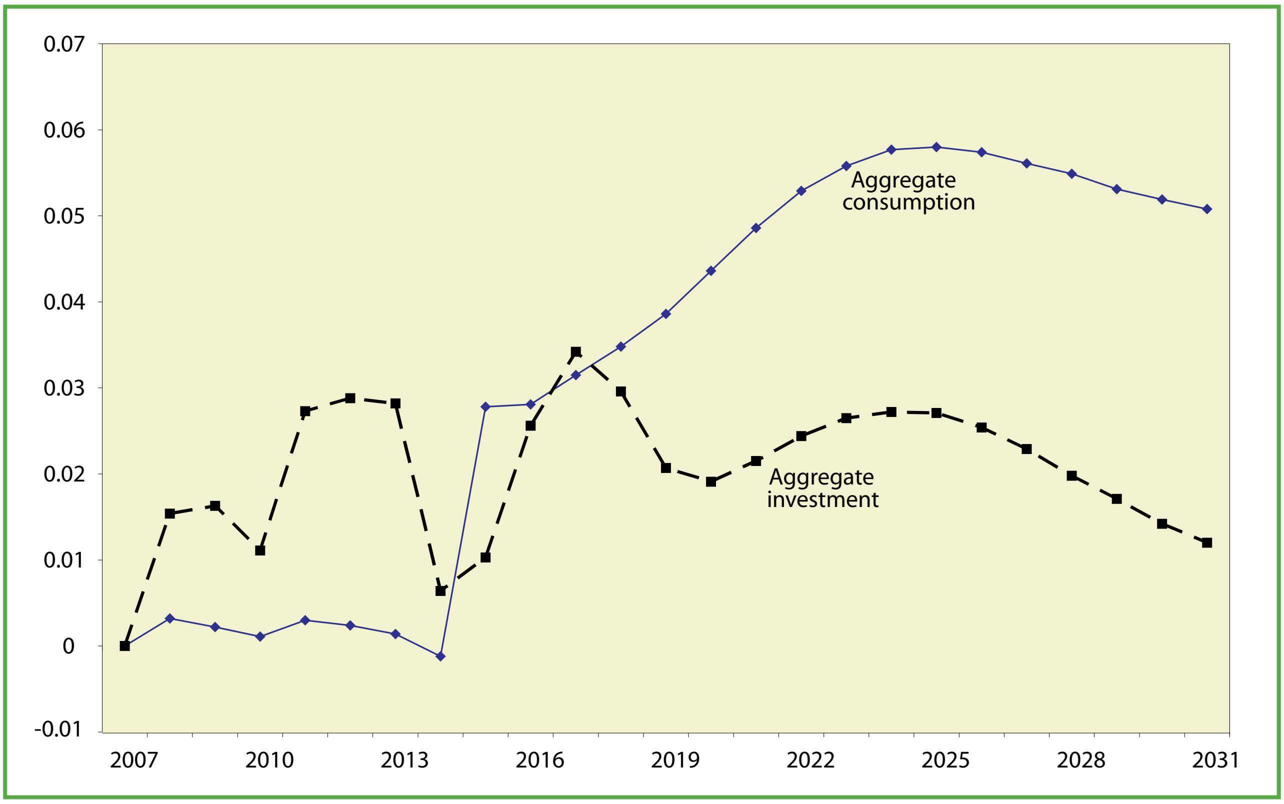


FIGURE 17 KEY NATIONAL RESULTS – AGGREGATE CONSUMPTION AND AGGREGATE INVESTMENT

increased level over the baseline forecast. The impact of construction is nominal on real GDP and employment at the national level. In contrast, capital expenditure increases faster and earlier, reflecting the construction costs of the Tillegra Dam.

National level impacts of aggregate consumption and investment are slightly larger but still small relative to the baseline forecasts of the Australian economy. Figure 17 shows that the increase in aggregate consumption peaks at 0.06 per cent of baseline forecast aggregate consumption in 2025.

5.4 Analysis of welfare impacts

A more detailed analysis of household consumption highlights some key welfare impacts from the Tillegra Dam project. The welfare gain is calculated as the year-by-year increase in national household spending due to the Project, relative to business-as-usual household spending. The calculation of year-by-year household spending is based on disposable income after accounting for interest payments on net debt.

The net present value (the discounted sum of future year-by-year household spending gains) of the welfare gain arising from the Project is $2.3 billion at a national level. This assumes that water scarcity rises in the future (that is, additional supplies in the future are smaller than additional demands).

The following figures summarise the expected paths of household income and provide an insight into the benefits that might be achieved at the Hunter region, rest of NSW and rest of Australia levels. These household income benefits were discounted using a real discount rate of seven per cent.

5.4.1 Hunter region

Figure 18 shows there is a clear difference in impact between the construction and operation phases of the Project. There is a short period where household income is negative around 2013-14. During this time construction has largely been completed however the dam has not achieved full operation.

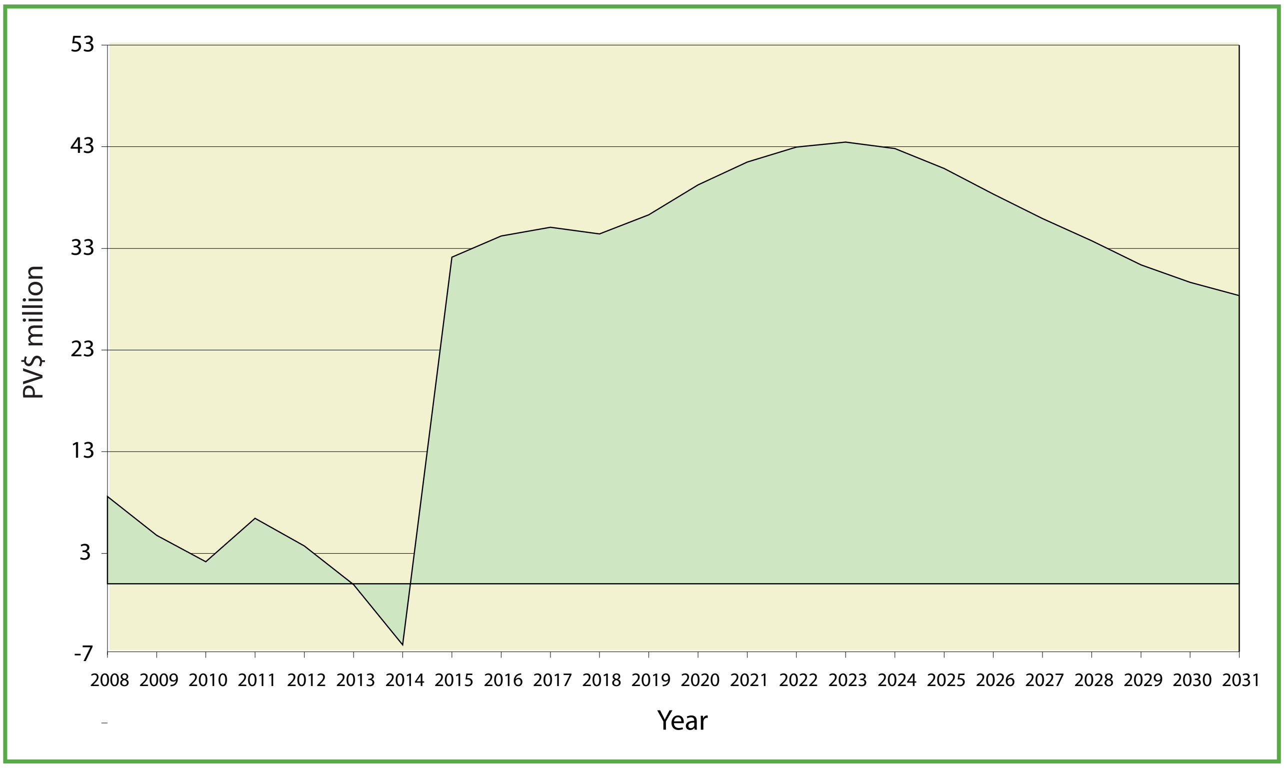


FIGURE 18 HOUSEHOLD INCOME – HUNTER NSW

That is, the service potential from additional water is not there because the dam is filling.

During operation of the dam, average annual household income in the Hunter region is $35.6 million better in present value terms than the do nothing case, within a range of $28.4 million to $43.5 million.

Consequently, over the construction and operation periods, the household income in the Hunter region is $640 million more in present value terms than the do nothing case.

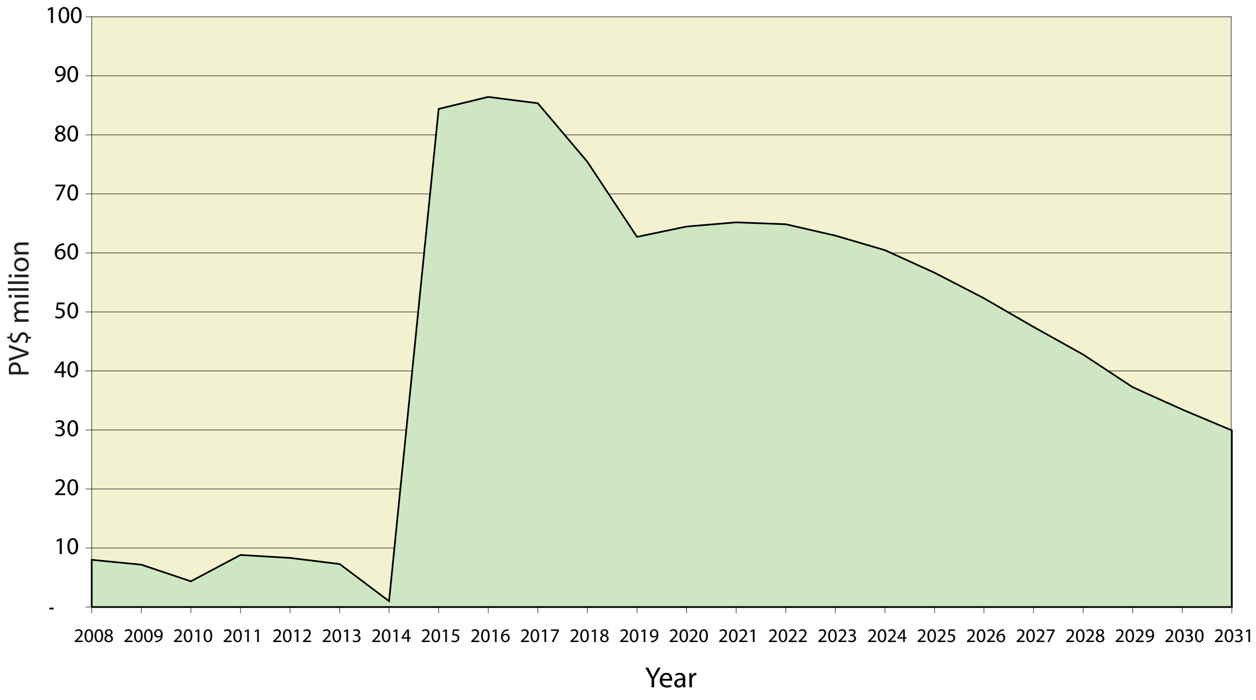


FIGURE 19 HOUSEHOLD INCOME – REST OF NSW

5.4.2 Rest of NSW

Figure 19 shows that the rest of NSW benefits to a small degree from the construction phase of the Project. Household income in the rest of NSW increases slightly during the construction period, reflecting the spill over of some construction benefits into the rest of the State.

During operation of the dam, average annual household income in the rest of NSW is $59.5 million better in present value terms than the do nothing case, within a range of to $29.9 million to $86.4 million.

Consequently, over the construction and operation periods, the household income in the rest of NSW is $1,057 million more in present value terms than the do nothing case.

5.4.3 Rest of Australia

The rest of Australia does not benefit as much during the construction phase as the Hunter region or the rest of NSW (refer Figure 20).

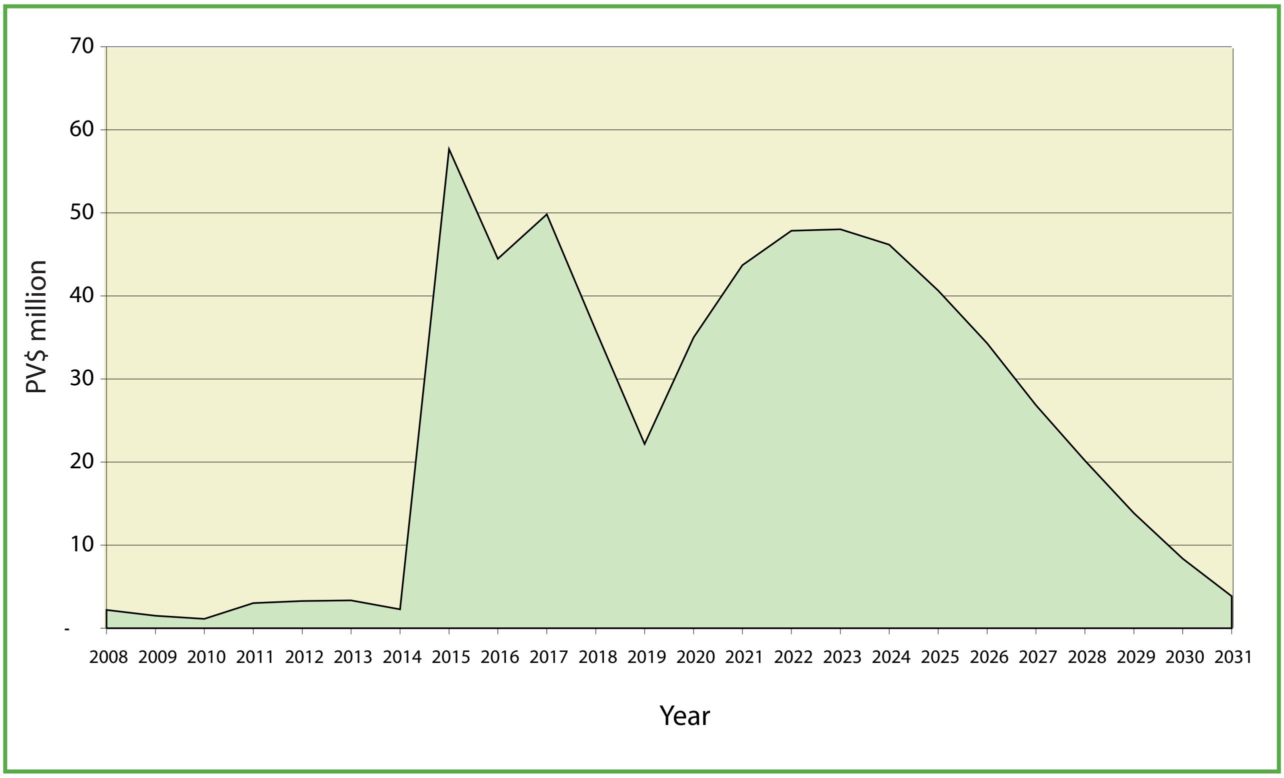


FIGURE 20 HOUSEHOLD INCOME – REST OF AUSTRALIA

During operation of the dam, average annual household income in the rest of Australia is $34 million better in present value terms than the do nothing case with a range of $3.9 million to $57.7 million.

Consequently, over the construction and operation periods of the Project, the household income in the rest of Australia is $595.5 million more in present value terms than the do nothing case.

5.4.4 Overall

In order to see how a national welfare figure was estimated, Figure 21 shows the aggregation of the Hunter region, the rest of NSW and the rest of Australia household consumption. The present value of the area under the discounted curve over 25 years comes to $2.3 billion.

Another way to consider this is that approximately $300 million in capital expenditure on the dam is expected to release a present value benefit of $2.3 billion at the national level in additional household expenditure over a 25 year period. At a regional level, the project is expected to stimulate an additional present value $640 million in regional household expenditure over the period.

5.4.5 Alternative assumption of no water scarcity in the rest of Australia

An alternative and less realistic assumption about baseline water supply is that in regions of Australia other than the Lower Hunter, water availability grows in line with economic growth. That is, water supply supplementation is sufficient to meet additional effective demands over time. Consequently, water scarcity does not worsen with economic growth. At the same time, the assumption of one percent savings in water requirements by all users is maintained.

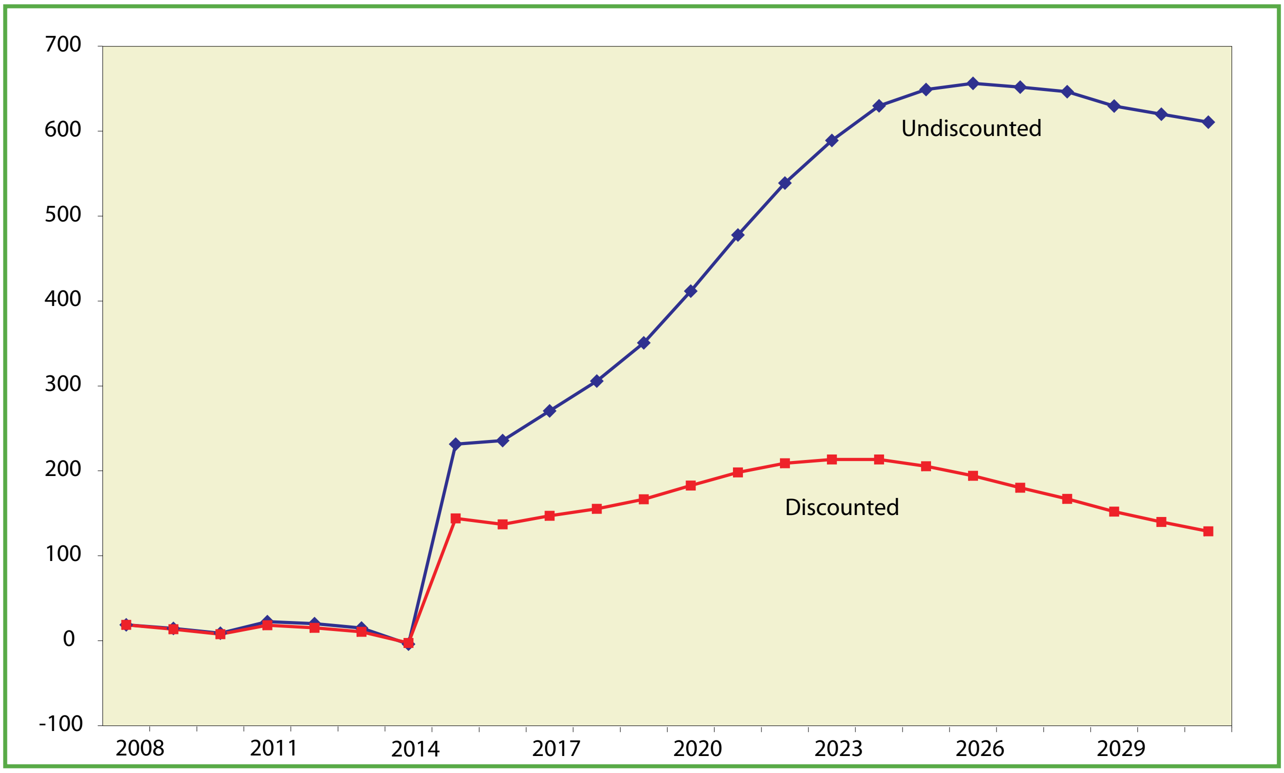


FIGURE 21 ADDITIONAL HOUSEHOLD INCOME, DISCOUNTED AND UNDISCOUNTED – AUSTRALIA 2006-2031 ($ MILLION)

If there are no significant water constraints in the rest of Australia, the economic benefit of Tillegra Dam would be much smaller at around $500 million. That is, the Project can still be justified on economic grounds if the Lower Hunter is the only region in Australia to suffer worsening water scarcity in the future.

5.5 Summary

Table 11 summarises the key results from the CGE modelling undertaken for the Hunter region for the 25 year period to 2030.

TABLE 11 HUNTER REGION CHANGE FROM BASELINE

AGGREGATE	HUNTER REGION
Real GRP ($ million)	$1,180
Employment (no.)	1,849
Household consumption ($ million)	$640
Aggregate investment ($ million)	$321

Note Figures are in present value terms at a 7% real discount rate (2007 base year) over a 25 year period.

Table 11 shows that over a 25 year period, real GDP is estimated to increase by $1.18 billion in the region. The dam is expected to stimulate employment and create 1,849 jobs over that time. As a result of the dam, aggregate investment is expected to increase by $321 million (or $588 million in undiscounted terms).

The CGE modelling results may be considered conservative because benefits are likely to continue beyond the 25 year period of analysis in the model. This is because the effective asset life of Tillegra Dam is generally assumed to be in excess of 50 years. However, the present value results need to be carefully interpreted as they do not represent a precise point estimate of future economic benefits given the large number of CGE modelling assumptions required to estimate economic impacts. Instead, they indicate that the direction of the economic impact is positive. Further, as the order of magnitude of the impact is in billions of dollars, it can be considered significant and material in terms of the national, NSW and regional economies.

6. Conclusion

Improvements in water scarcity through provision of additional yield from the proposed Tillegra Dam are partly a function of existing and forecast increases in water scarcity relative to the baseline economic growth expected.

The Tillegra Dam project would generate predominantly positive short and long term economic impacts while lesser negative economic impacts would be localised in the proposed inundation area. The positive impacts are significant and would accrue at the Dungog Shire, Lower Hunter region and NSW levels. At the Lower Hunter region level, the provision of water storage capacity of 450 gigalitres would effectively double the existing storage capacity of the region. This increase in capacity in the water supply network and enhanced water supply security through provision of additional yield would be pivotal in underpinning and supporting continued population and economic growth in the region.

Population in the Lower Hunter region is forecast to increase from the current 500,000 persons to about 730,000 in 2026. Economic activity in the Hunter Valley region is forecast to continue to expand with this population growth and other major commercial and industrial development likely to be attracted to the region.

CGE Modelling undertaken by Monash University in 2008 indicated a number of benefits from the Project over the period 2009 to 2030. These arise from the capital and recurrent expenditure required for the Project. The modelled benefits include:

- a discounted national welfare benefit of around $2.3 billion, as measured by deviations in real household consumption for the Hunter region, rest of NSW and rest of Australia (this occurs firstly through additional investment in the construction period that stimulates short-run employment)
- increased real Gross Regional Product (GRP) of approximately $1.18 billion in the Hunter region; impacts during construction are relatively modest because the significant gains expected from increased water security are only realised as yield increases
- increased aggregate employment in the Lower Hunter region through the construction and operation periods generating an additional 1,849 jobs; a rise in capital stocks as the increased supply of water as a consequence of the Project makes the Hunter region more conducive to investment, with an increase in aggregate investment over 25 years of $588 million (undiscounted).

The CGE economic modelling results are considered conservative since the modelling period extends for 25 years to 2030. There will be trailing economic benefits to the region beyond 2030 since the asset life of the Tillegra Dam will extend beyond 50 years.

Most significantly, the CEA modelling supports the Tillegra Dam water supply option when compared to other competing project scenarios to meet the region's yield objective. The Tillegra Dam option produces a levelised cost of $1,661 per megalitre from a present value (ie discounted) of total costs of $377 million. This represents the lowest cost option to meet future expected water demand over the next 50 years.

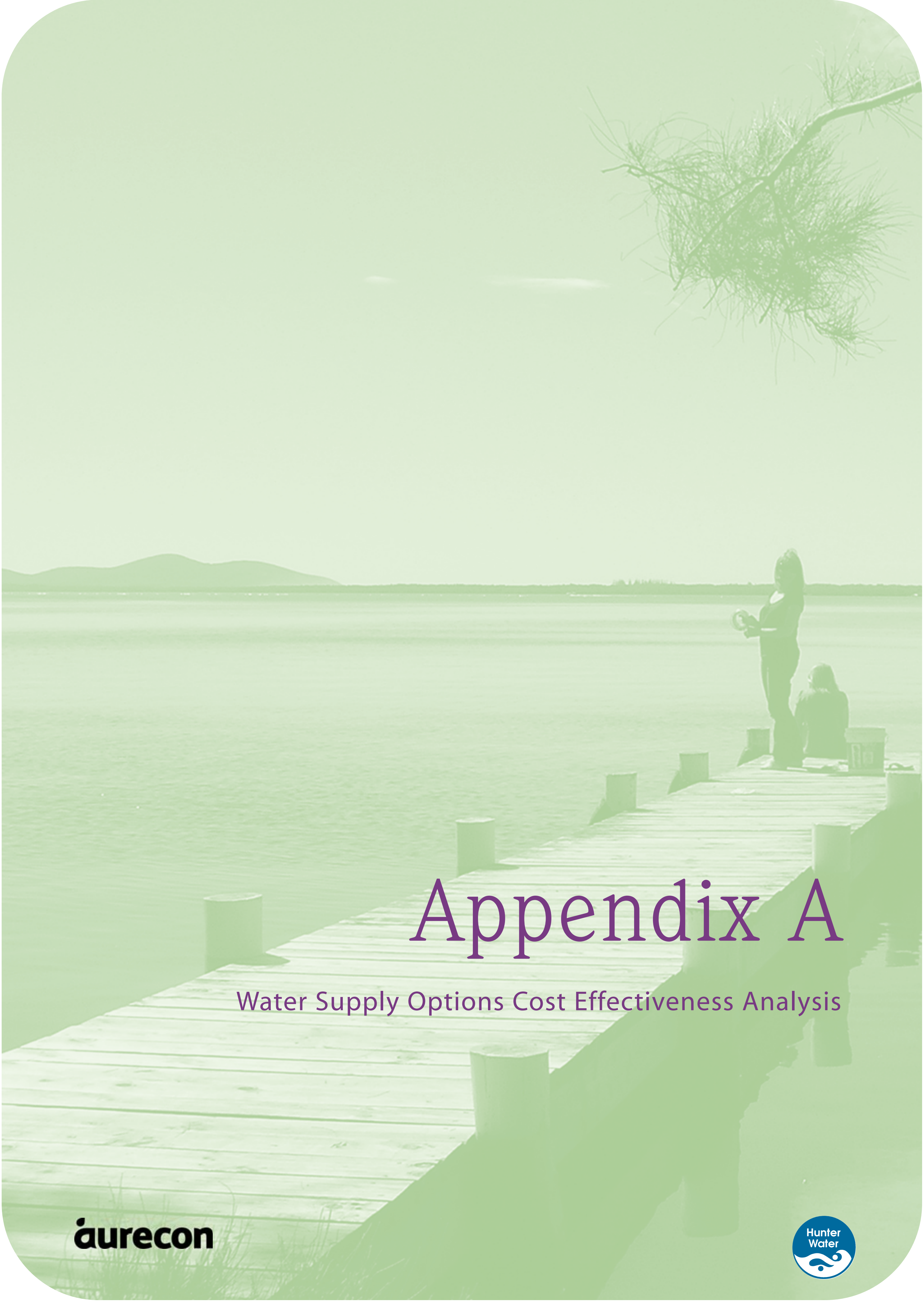
7. Glossary

Annualised cost	The combined annual capital and operating costs of the project case. It is used to identify and assign future costs by spreading the initial costs over the project assessment period (usually the economic life of the asset) while accounting for the time value of money using a predetermined discount rate.
Average-time job	This represents about 34 hours work a week (an average of part-time and full-time hours).
Consumption	Expenditure by households on goods and services.
Deviation from the baseline	The percentage/dollar/job deviation from the baseline forecast result for that variable which comes about as a result of the construction and operation of the dam. The baseline forecast assumes the dam is not built.
Discount rate	The discount rate reflects the time value of the money for use in developing public infrastructure. The value of money is not constant over time. Costs and benefits that are expected to increase in the future have a lower worth (assuming the impact of inflation) when compared to the value of costs and benefits that are realised in today's terms. The application of the discount rate brings the stream of future cost and benefits back to current monetary values so that the future can be readily compared to the existing situation.
Gross State Product (GSP)	The value of final goods and services produced annually in a state (valued at market prices)
Gross Domestic Product (GDP)	The value of final goods and services produced annually (valued at market prices). It is one measure of the economic vitality of a country
Gross Regional Product (GRP)	The value of final goods and services produced annually at a regional level (valued at market prices)
Household Income	Income accruing to members of a household from wages and salaries, receipts of regular interest payments and dividends, and recurring government transfer payments
Investment	Formation of capital (ie the production of physical assets such as infrastructure, plant, machinery and equipment)

Levelised cost	The present value of the total cost of building and operating the dam and plant over its economic life, converted to equal annualised costs or payments, divided by the present value of the stream of water demand reduced or supplied over the same period. Costs are levelised in real dollars (ie adjusted to remove the impact of inflation)
Present value (PV)	The value of the future costs over the assessment period discounted back to current monetary values using a predetermined discount rate
Net Present Value (NPV)	The difference between the present value of benefits and the present value of costs of the project case over the assessment period
Real values	Economic aggregates that have been appropriately deflated for changes in price levels
Value Added (of an industry)	This is equal to the value of the primary factors employed by the industry. That is, value added is the difference between an industry's total output and its bought-in inputs (materials and services)
Yield	The average annual volume of water that can be drawn from supply sources to meet a specified demand at a specified level of service.

8. References

University of Newcastle (2005) *Strategic Connections: Economic Flows and Industrial Development in the Dungog Shire*, Centre for Urban and Regional Studies, 28 January 2005.



Appendix A

Water Supply Options Cost Effectiveness Analysis

aurecon

Hunter Water

CEA - Summary of key inputs and outputs

Key inputs (variables)

Supply scenario		
Option 1	1	Tillegra Dam
Option 2	9	Do Nothing

Economic indicators	
Discount rate	7%
Valuation final year	2056

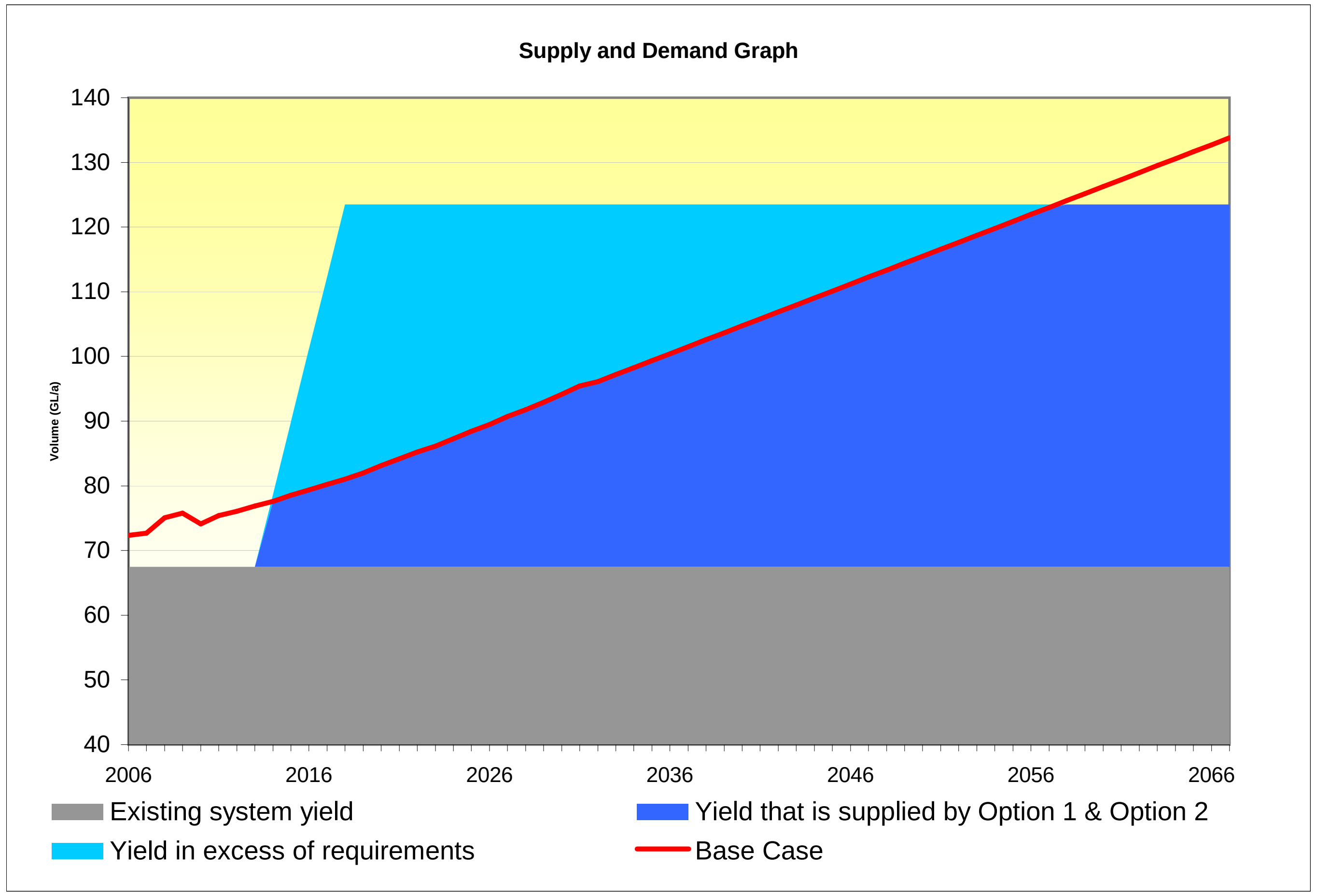
Demand scenario	
Demand scenario	Base Case

Sensitivity variables	(+/-)
Supply	0%
Capex	0%
Opex	0%

Key outputs

	1. Tillegra Dam	2. Do Nothing
Yield (GL/yr)	56	0
Capex ($M)	396.92	0
Opex ($M/yr)	0.6390144	0
Construction commences	2008	2055
Construction complete	2013	2055
Construction duration	6	1
Time to fill	5	1
Project life	100	0
End of project life	2113	2055
Present value capital costs ($M)	371.1	0.0
Present value operational costs ($M)	6.6	0.0
Present value total costs ($M)	377.7	0.0
Levelised cost ($/ML)	$1,661.1	$0.0
Levelised cost ($/kL)	$1.66	$0.00

Combined Supply Scenario - Options 1 & 2: Tillegra Dam and Do Nothing	
Yield (GL/yr)	56
Capex ($M)	396.92
Opex ($M/yr)	0.6390144
Satisfies demand up to and including	2058
Satisfies demand for (years)	45
Present value of total capital costs ($M)	$371.07
Present value of total ongoing costs ($M)	$6.58
Present value of total costs ($M)	$377.65
Levelised cost ($/ML)	$1,661.1
Levelised cost ($/kL)	$1.66



Cost effectivness analysis model

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Financial Yr ending		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Year Number			-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Discount Factors			1.145	1.070	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508	0.475	0.444	0.415	0.388	0.362	0.339	0.317	0.296	0.277	0.258	0.242	0.226	0.211	0.197	0.184	0.172	0.161	0.150	0.141	0.131	0.123	0.115	0.107	0.100	0.094	0.088	0.082	0.076	0.071	0.067	0.062	0.058	0.055	0.051	0.048	0.044	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.026	0.024	0.023	0.021	0.020

Demand projections

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Base Case	GL/yr	**72.36**	73	75	76	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97	98	99	100	101	103	104	105	106	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	123	124	125	126	127	128	129	131	132	133	134

Supply calculations

Supply Option 1 - Tillegra Dam — 1

Summary	8	
Incremental yield	GL/yr	**56.0**
Construction commences	Year	2008
Construction completed	Year	2013
End of project life	Year	2113
Construction period	Yrs	6
Time to fill	Yrs	5
Satisfies demand up to and including	Year	2058
or for (years)	Yrs	45

Supply Option 1 - Tillegra Dam - yield supplied calculations		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Existing system yield	GL/yr	**67.5**	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	GL/yr								56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Fill assumption										0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	GL/yr									11	22	34	45	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
System yield including incl supply option 1	GL/yr	67.5	68	68	68	68	68	68	68	79	90	101	112	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124
Components of incremental yield																																																															
Yield that is supplied by Option 1	GL/yr									10	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	43	44	45	46	47	48	49	50	51	52	53	54	56	56	56	56	56	56	56	56	56	56	56
Yield in excess of requirements	GL/yr									1	11	22	32	42	42	40	39	38	37	36	35	34	33	32	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	14	13	12	11	10	9	8	7	6	5	4	3	2	0										

Supply Option 2 - Do Nothing

Summary		
Incremental yield	GL/yr	**0.0**
Construction commences	Year	2055
Construction completed	Year	2055
End of project life	Year	2055
Construction period	Yrs	1
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2007
or for (years)	Yrs	0

Supply Option 2 - Do Nothing - yield supplied calculations		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Incr. yield timing workings for supply Option 2	GL/yr																																																														
Fill assumption																																																				1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 2	GL/yr																																																														
System yield surplus (shortfall)	GL/yr		-5	-8	-8	-7	-8	-9	-9	1	11	22	32	42	42	40	39	38	37	36	35	34	33	32	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	14	13	12	11	10	9	8	7	6	5	4	3	2	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
Yield that is supplied by Option 2	GL/yr																																																														
Yield in excess of requirements	GL/yr																																																														

Combined Supply (Option 1 & Option 2)

Summary		
Satisfies demand up to and including	Year	2058
or for (years)	Yrs	45

Combined Supply (Option 1 & Option 2) - yield supplied calculations		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Total yield available from supply options 1 & 2	GL/yr									11	22	34	45	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Total yield in system	GL/yr	67.5	68	68	68	68	68	68	68	79	90	101	112	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124
Yield that is supplied by Option 1 & Option 2	GL/yr									10	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	43	44	45	46	47	48	49	50	51	52	53	54	56	56	56	56	56	56	56	56	56	56	56
Yield in excess of requirements	GL/yr									1	11	22	32	42	42	40	39	38	37	36	35	34	33	32	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	14	13	12	11	10	9	8	7	6	5	4	3	2	0										

Levelised cost calculations

Supply Option 1 - Tillegra Dam

			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by option 1	GL	**227.3**								7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	5	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1
Capital costs																																																															
Capex	$m	396.92		111.1	29.1	79.4	84.7	79.4	13.2																																																					
PV of capital costs of option 1		**371.1**		118.9	29.1	74.2	74.0	64.8	10.1																																																				
Operating costs																																																															
Opex	$m/yr	0.63901								0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
PV of operating costs of option 1	$m	**6.6**								0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Results Summary - Levelised cost of Supply Option 1		
Present value of total costs @ 7%	$M 2007	377.7
Present value of demand supplied @ 7%	GL	227.3
Levelised cost	$/ML	1661.14
Levelised cost	$/kL	1.66

Supply Option 2 - Do Nothing

PV of demand supplied by option 1	GL	**0.0**
Capital costs		
Capex	$m	0
PV of capital costs of option 2		**0.0**
Operating costs		
Opex	$m/yr	0
PV of operating costs of option 2	$m	**0.0**

Results Summary - Levelised cost of Supply Option 2		
Present value of total costs @ 7%	$M 2007	0.0
Present value of demand supplied @ 7%	GL	0.0
Levelised cost	$/ML	0
Levelised cost	$/kL	0.00

Combined Supply (Option 1 & Option 2)

			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by options 1 & 2	GL	**227.3**								7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	5	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1
Capital costs																																																															
Capex	$m	**397**		111.1	29.1	79.4	84.7	79.4	13.2																																																				
PV of capital costs of options 1 & 2	$m	**371.1**		118.9	29.1	74.2	74.0	64.8	10.1																																																				
Operating costs																																																															
Opex	$m/yr	**1**								0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
PV of operating costs of options 1 & 2	$m	**6.6**								0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Results Summary - Levelised cost of combined supply options		
Satisfies demand up to and including	Yr	2058
Satisfies demand for	Years	45
Present value of total costs @ 7%	$M 2007	377.7
Present value of demand supplied @ 7%	GL	227.3
Levelised cost	$/ML	1,661
Levelised cost	$/kL	1.66

Data assumptions

Supply options summary

Option No.	Source	Yield (GL/yr)	Total Capex ($M)	O&M ($M/yr)	Construction Start	Construction Finish	Years	Years to Fill	Project Life
1	Tillegra Dam	56.0	397	0.64	2008	2013	6	5	100
2	New Chichester Dam	48.5	586	0.64	2008	2013	6	5	100
3	Grahamstown Dam Upgrade	30.0	656	0.43	2008	2013	6	5	100
4	Paterson River Scheme - Lostock Dam	9.5	425	0.80	2008	2013	6	5	100
5	Karuah River Scheme - Mammy Johnsons Dam	27.5	565	0.85	2008	2013	6	5	100
6	Desalination	46.2	990	26.63	2011	2013	3	1	100
7	Indirect potable reuse	26.3	523	21.19	2011	2013	3	1	100
8	Revised Tillegra Dam	55.5	333	0.60	2008	2013	6	5	100
9	Do Nothing	0.0	0	0.00	0	0	1	1	0

Source: Hunter Water Corporation (2007) "Why Tillegra Now?" p.33

Supply options capital costs

Option No.	Source	Total Capex ($M)	Sensitivity	Total ($M)
1	Tillegra Dam	396.92	0	397
2	New Chichester Dam	585.59	0	586
3	Grahamstown Dam Upgrade	655.80	0	656
4	Paterson River Scheme - Lostock Dam	425.00	0	425
5	Karuah River Scheme - Mammy Johnsons Dam	565.22	0	565
6	Desalination	989.76	0	990
7	Indirect potable reuse	523.14	0	523
8	Revised Tillegra Dam	332.5	0	333

Source: Hunter Water Corporation (2007) "Why Tillegra Now?" p.33

Supply options operating costs

Option No.	Source	O&M ($M/yr)	Sensitivity	Total ($M/yr)
1	Tillegra Dam	0.64	0	0.64
2	New Chichester Dam	0.64	0	0.64
3	Grahamstown Dam Upgrade	0.43	0	0.43
4	Paterson River Scheme - Lostock Dam	0.80	0	0.80
5	Karuah River Scheme - Mammy Johnsons Dam	0.85	0	0.85
6	Desalination	26.63	0	26.63
7	Indirect potable reuse	21.19	0	21.19
8	Revised Tillegra Dam	0.60	0	0.60

Source: Hunter Water Corporation (2007) "Why Tillegra Now?" p.33

Supply options yields

Option No.	Source	Yield (GL/yr)	Sensitivity	Total Yield (GL/yr)
1	Tillegra Dam	56	0	56.0
2	New Chichester Dam	48.5	0	48.5
3	Grahamstown Dam Upgrade	30	0	30.0
4	Paterson River Scheme - Lostock Dam	9.5	0	9.5
5	Karuah River Scheme - Mammy Johnsons Dam	27.5	0	27.5
6	Desalination	46.2	0	46.2
7	Indirect potable reuse	26.28	0	26.3
8	Revised Tillegra Dam	55.5	0	55.5

Source: Hunter Water Corporation (2007) "Why Tillegra Now?" p.33

Supply options capex spend profiles

Option No.	Source	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
1	Tillegra Dam		28.0%	7.3%	20.0%	21.3%	20.0%	3.3%
2	New Chichester Dam		28.0%	7.3%	20.0%	21.3%	20.0%	3.3%
3	Grahamstown Dam Upgrade		28.0%	7.3%	20.0%	21.3%	20.0%	3.3%
4	Paterson River Scheme - Lostock Dam		28.0%	7.3%	20.0%	21.3%	20.0%	3.3%
5	Karuah River Scheme - Mammy Johnsons Dam		28.0%	7.3%	20.0%	21.3%	20.0%	3.3%
6	Desalination					33.3%	33.3%	33.3%
7	Indirect potable reuse					33.3%	33.3%	33.3%
8	Revised Tillegra Dam		28.0%	7.3%	20.0%	21.3%	20.0%	3.3%
9	Do Nothing							100.0%

Source: Roland Bow (Source: Hunter Water) via email (05/12/07)

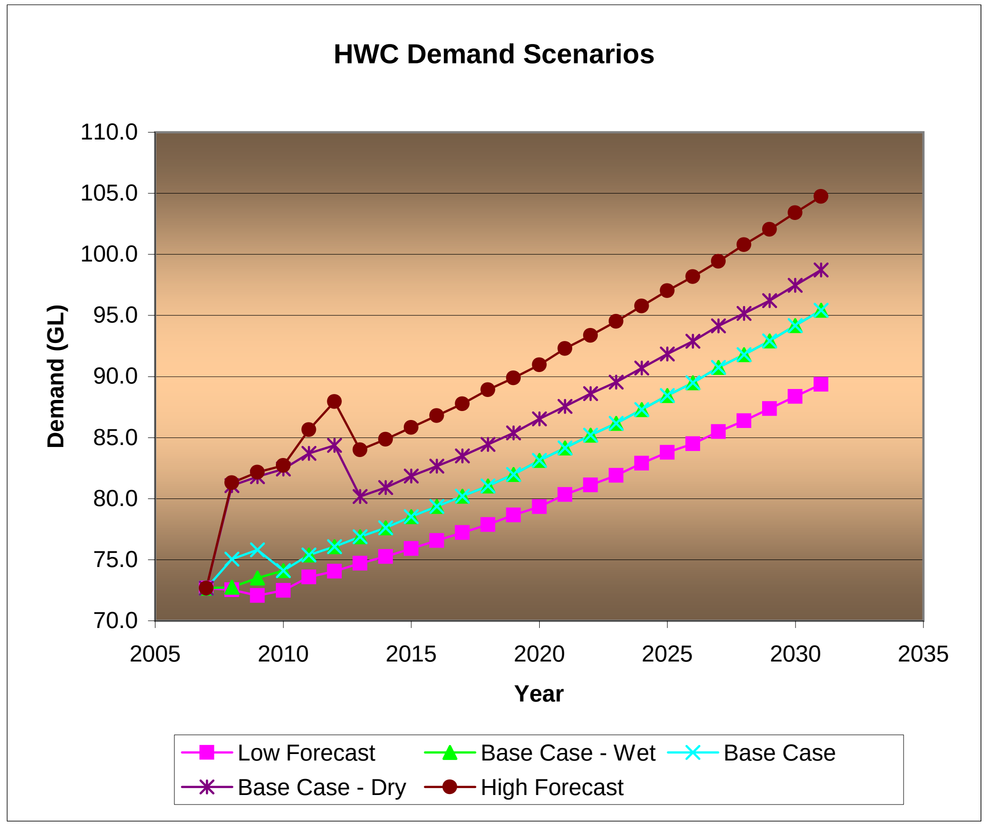
Demand scenario data summary

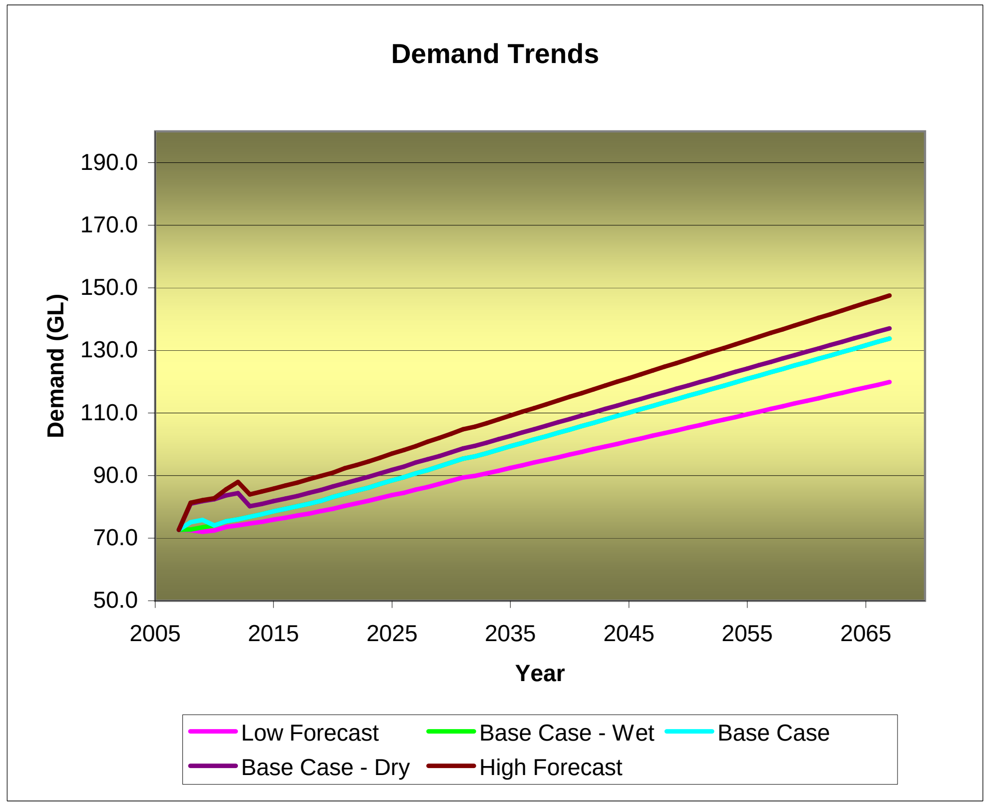
Demand scenario data summary (Hunter Water Corporation)

	Historical	Low Forecast	Base Case - Wet	Base Case	Base Case - Dry	High Forecast
2001	73.3	73.3	73.3	73.3	73.3	73.3
2002	73.6	73.6	73.6	73.6	73.6	73.6
2003	77.5	77.5	77.5	77.5	77.5	77.5
2004	72.8	72.8	72.8	72.8	72.8	72.8
2005	71.9	71.9	71.9	71.9	71.9	71.9
2006	72.4	72.4	72.4	72.4	72.4	72.4
2007	72.5	72.7	72.7	72.7	72.7	72.7
2008		72.5	72.8	75.1	81.1	81.3
2009		72.1	73.5	75.8	81.8	82.2
2010		72.5	74.1	74.1	82.4	82.7
2011		73.6	75.4	75.4	83.7	85.6
2012		74.1	76.1	76.1	84.4	88.0
2013		74.7	76.9	76.9	80.2	84.0
2014		75.2	77.6	77.6	80.9	84.9
2015		75.9	78.5	78.5	81.8	85.8
2016		76.6	79.4	79.4	82.7	86.8
2017		77.2	80.2	80.2	83.5	87.8
2018		77.9	81.0	81.0	84.4	88.9
2019		78.6	82.0	82.0	85.4	89.9
2020		79.3	83.1	83.1	86.5	90.9
2021		80.3	84.2	84.2	87.6	92.3
2022		81.1	85.2	85.2	88.6	93.4
2023		81.9	86.2	86.2	89.6	94.5
2024		82.9	87.3	87.3	90.7	95.8
2025		83.8	88.4	88.4	91.8	97.0
2026		84.5	89.5	89.5	92.9	98.2
2027		85.5	90.7	90.7	94.1	99.4
2028		86.4	91.8	91.8	95.2	100.8
2029		87.4	92.9	92.9	96.2	102.0
2030		88.4	94.2	94.2	97.5	103.4
2031		89.4	95.4	95.4	98.7	104.8

Demand scenario data summary (trended data)

	Low Forecast	Base Case - Wet	Base Case	Base Case - Dry	High Forecast
2032	89.9	96.1	96.1	99.5	105.6
2033	90.7	97.2	97.2	100.5	106.8
2034	91.6	98.3	98.3	101.6	108.0
2035	92.4	99.3	99.3	102.7	109.2
2036	93.3	100.4	100.4	103.8	110.4
2037	94.1	101.5	101.5	104.8	111.6
2038	95.0	102.6	102.6	105.9	112.8
2039	95.9	103.7	103.7	107.0	114.0
2040	96.7	104.7	104.7	108.1	115.2
2041	97.6	105.8	105.8	109.1	116.4
2042	98.4	106.9	106.9	110.2	117.6
2043	99.3	108.0	108.0	111.3	118.8
2044	100.1	109.0	109.0	112.4	120.0
2045	101.0	110.1	110.1	113.4	121.2
2046	101.9	111.2	111.2	114.5	122.4
2047	102.7	112.3	112.3	115.6	123.6
2048	103.6	113.3	113.3	116.7	124.8
2049	104.4	114.4	114.4	117.7	126.0
2050	105.3	115.5	115.5	118.8	127.2
2051	106.2	116.6	116.6	119.9	128.4
2052	107.0	117.6	117.6	121.0	129.6
2053	107.9	118.7	118.7	122.0	130.8
2054	108.7	119.8	119.8	123.1	132.0
2055	109.6	120.9	120.9	124.2	133.2
2056	110.4	121.9	121.9	125.3	134.4
2057	111.3	123.0	123.0	126.3	135.6
2058	112.2	124.1	124.1	127.4	136.8
2059	113.0	125.2	125.2	128.5	138.0
2060	113.9	126.3	126.3	129.6	139.2
2061	114.7	127.3	127.3	130.6	140.4
2062	115.6	128.4	128.4	131.7	141.6
2063	116.4	129.5	129.5	132.8	142.8
2064	117.3	130.6	130.6	133.9	144.0
2065	118.2	131.6	131.6	134.9	145.2
2066	119.0	132.7	132.7	136.0	146.4
2067	119.9	133.8	133.8	137.1	147.6





CEA - Summary of key inputs and outputs

Key inputs (variables)

Supply scenario		
Option 1	2	New Chichester Dam
Option 2	9	Do Nothing

Economic indicators	
Discount rate	7%
Valuation final year	2056

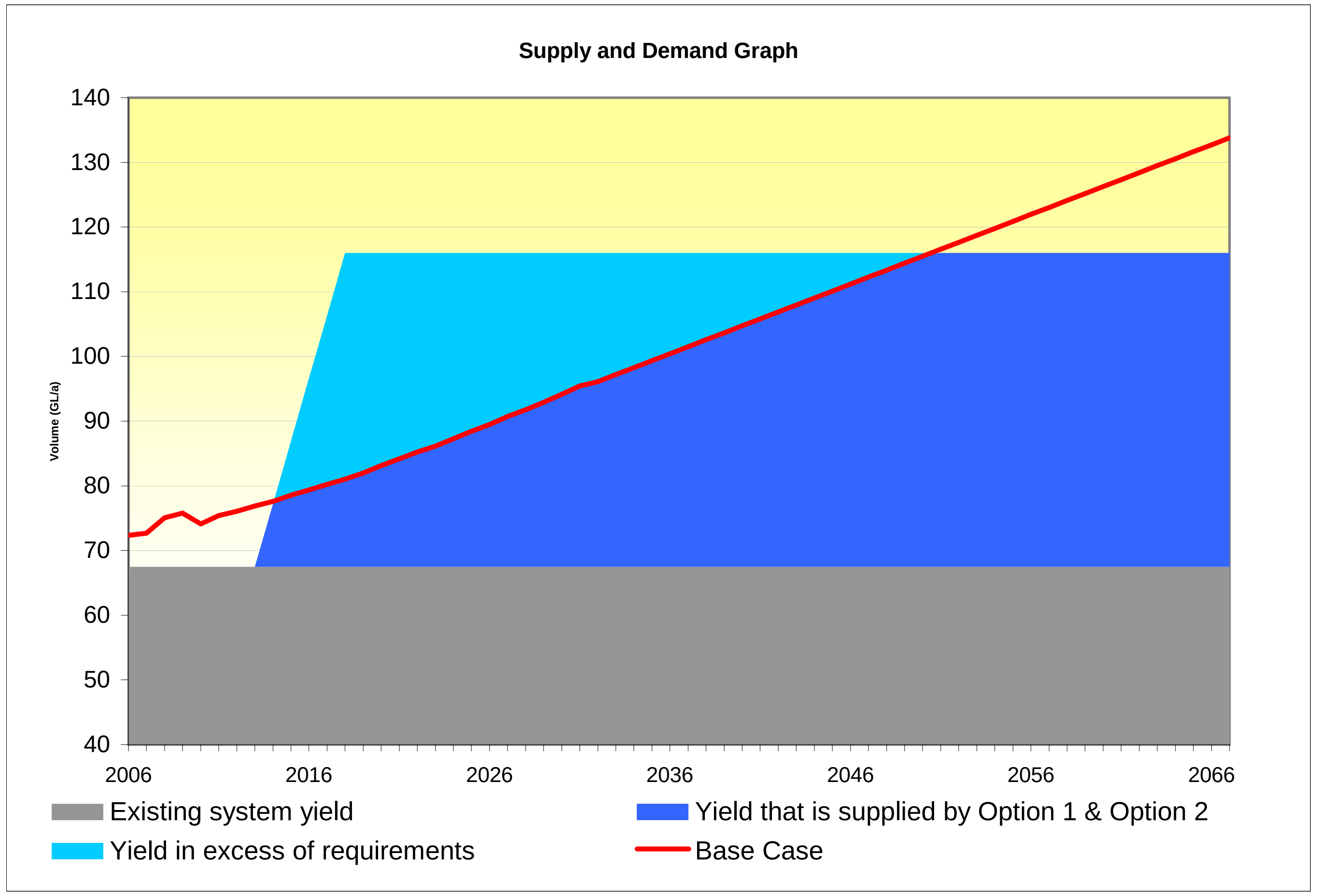
Demand scenario	
Demand scenario	Base Case

Sensitivity variables	(+/-)
Supply	0%
Capex	0%
Opex	0%

Key outputs

	1. New Chichester Dam	2. Do Nothing
Yield (GL/yr)	48.5	0
Capex ($M)	585.587526	0
Opex ($M/yr)	0.6390144	0
Construction commences	2008	2048
Construction complete	2013	2048
Construction duration	6	1
Time to fill	5	1
Project life	100	0
End of project life	2113	2048
Present value capital costs ($M)	547.4	0.0
Present value operational costs ($M)	6.6	0.0
Present value total costs ($M)	554.0	0.0
Levelised cost ($/ML)	$2,449.8	$0.0
Levelised cost ($/kL)	$2.45	$0.00

Combined Supply Scenario - Options 1 & 2: New Chichester Dam and Do Nothing	
Yield (GL/yr)	48.5
Capex ($M)	585.587526
Opex ($M/yr)	0.6390144
Satisfies demand up to and including	2051
Satisfies demand for (years)	38
Present value of total capital costs ($M)	$547.45
Present value of total ongoing costs ($M)	$6.58
Present value of total costs ($M)	$554.03
Levelised cost ($/ML)	$2,449.8
Levelised cost ($/kL)	$2.45



Financial Yr ending		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Year Number			-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Discount Factors			1.145	1.070	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508	0.475	0.444	0.415	0.388	0.362	0.339	0.317	0.296	0.277	0.258	0.242	0.226	0.211	0.197	0.184	0.172	0.161	0.150	0.141	0.131	0.123	0.115	0.107	0.100	0.094	0.088	0.082	0.076	0.071	0.067	0.062	0.058	0.055	0.051	0.048	0.044	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.026	0.024	0.023	0.021	0.020

Demand projections

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Base Case	GL/yr	**72.36**	73	75	76	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97	98	99	100	101	103	104	105	106	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	123	124	125	126	127	128	129	131	132	133	134

Supply calculations

Supply Option 1 - New Chichester Dam 1

Summary	2	
Incremental yield	GL/yr	**48.5**
Construction commences	Year	2008
Construction completed	Year	2013
End of project life	Year	2113
Construction period	Yrs	6
Time to fill	Yrs	5
Satisfies demand up to and including	Year	2051
or for (years)	Yrs	38

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Existing system yield	GL/yr	**67.5**	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	GL/yr								49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
Fill assumption										0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	GL/yr									10	19	29	39	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
System yield including incl supply option 1	GL/yr	67.5	68	68	68	68	68	68	68	77	87	97	106	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116
Components of incremental yield		
Yield that is supplied by Option 1	GL/yr									10	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	43	44	45	46	47	48	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
Yield in excess of requirements	GL/yr										8	17	26	35	34	33	32	31	30	29	28	27	25	24	23	22	21	20	19	18	17	16	15	13	12	11	10	9	8	7	6	5	4	3	2	1

Supply Option 2 - Do Nothing

Summary		
Incremental yield	GL/yr	**0.0**
Construction commences	Year	2048
Construction completed	Year	2048
End of project life	Year	2048
Construction period	Yrs	1
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2007
or for (years)	Yrs	0

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Incr. yield timing workings for supply Option 2	GL/yr	
Fill assumption																																													1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 2	GL/yr	
System yield surplus (shortfall)	GL/yr		-5	-8	-8	-7	-8	-9	-9	0	8	17	26	35	34	33	32	31	30	29	28	27	25	24	23	22	21	20	19	18	17	16	15	13	12	11	10	9	8	7	6	5	4	3	2	1	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-15	-16	-17	-18
Yield that is supplied by Option 2	GL/yr	
Yield in excess of requirements	GL/yr	

Combined Supply (Option 1 & Option 2)

Summary		
Satisfies demand up to and including	Year	2051
or for (years)	Yrs	38

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Total yield available from supply options 1 & 2	GL/yr									10	19	29	39	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
Total yield in system	GL/yr	67.5	68	68	68	68	68	68	68	77	87	97	106	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116
Yield that is supplied by Option 1 & Option 2	GL/yr									10	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	43	44	45	46	47	48	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
Yield in excess of requirements	GL/yr										8	17	26	35	34	33	32	31	30	29	28	27	25	24	23	22	21	20	19	18	17	16	15	13	12	11	10	9	8	7	6	5	4	3	2	1

Levelised cost calculations

Supply Option 1 - New Chichester Dam

			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by option 1	GL	**226.2**								7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	5	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Capex	$m	585.588		164.0	42.9	117.1	124.9	117.1	19.5
PV of capital costs of option 1		**547.4**		175.4	42.9	109.5	109.1	95.6	14.9
Opex	$m/yr	0.63901								0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
PV of operating costs of option 1	$m	**6.6**								0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Present value of total costs @ 7%	$M 2007	554.0
Present value of demand supplied @ 7%	GL	226.2
Levelised cost	$/ML	2449.84
Levelised cost	$/kL	2.45

Supply Option 2 - Do Nothing

PV of demand supplied by option 1	GL	**0.0**
Capex	$m	0
PV of capital costs of option 2		**0.0**
Opex	$m/yr	0
PV of operating costs of option 2	$m	**0.0**

Present value of total costs @ 7%	$M 2007	0.0
Present value of demand supplied @ 7%	GL	0.0
Levelised cost	$/ML	0
Levelised cost	$/kL	0.00

Combined Supply (Option 1 & Option 2)

			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by options 1 & 2	GL	**226.2**								7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	5	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Capex	$m	**586**		164.0	42.9	117.1	124.9	117.1	19.5
PV of capital costs of options 1 & 2		**547.4**		175.4	42.9	109.5	109.1	95.6	14.9
Opex	$m/yr	**1**								0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
PV of operating costs of options 1 & 2	$m	**6.6**								0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Satisfies demand up to and including	Yr	2051
Satisfies demand for	Years	38
Present value of total costs @ 7%	$M 2007	554.0
Present value of demand supplied @ 7%	GL	226.2
Levelised cost	$/ML	2,450
Levelised cost	$/kL	2.45

CEA - Summary of key inputs and outputs

Key inputs (variables)

Supply scenario		
Option 1	3	Grahamstown Dam Upgrade
Option 2	9	Do Nothing

Economic indicators	
Discount rate	7%
Valuation final year	2056

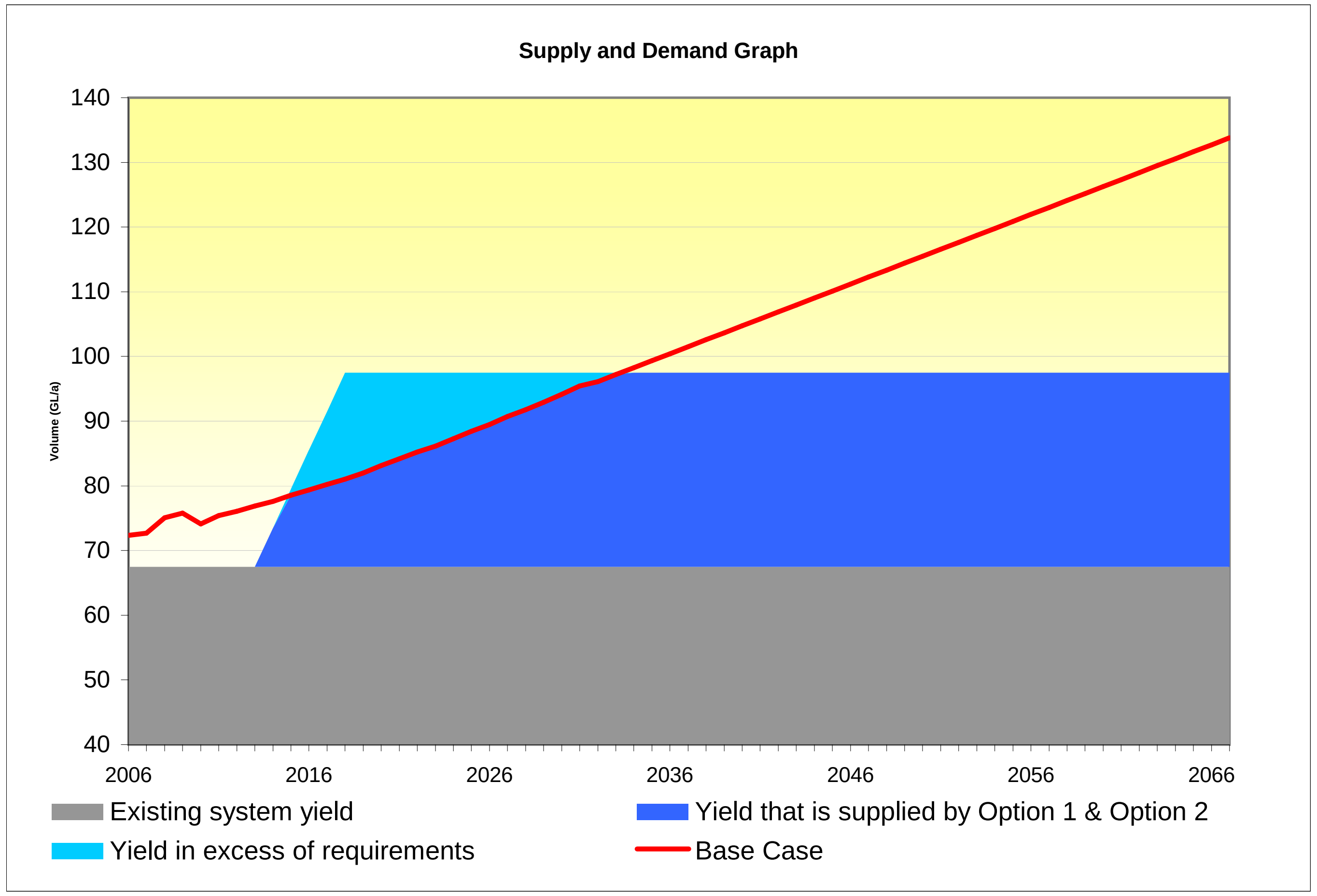
Demand scenario	
Demand scenario	Base Case

Sensitivity variables	(+/-)
Supply	0%
Capex	0%
Opex	0%

Key outputs

	1. Grahamstown Dam	2. Do Nothing
Yield (GL/yr)	30	0
Capex ($M)	655.797445	0
Opex ($M/yr)	0.4260096	0
Construction commences	2008	2031
Construction complete	2013	2031
Construction duration	6	1
Time to fill	5	1
Project life	100	0
End of project life	2113	2031
Present value capital costs ($M)	613.1	0.0
Present value operational costs ($M)	4.4	0.0
Present value total costs ($M)	617.5	0.0
Levelised cost ($/ML)	$3,038.1	$0.0
Levelised cost ($/kL)	$3.04	$0.00

Combined Supply Scenario - Options 1 & 2: Grahamstown Dam Upgrade and Do Nothing	
Yield (GL/yr)	30
Capex ($M)	655.797445
Opex ($M/yr)	0.4260096
Satisfies demand up to and including	2034
Satisfies demand for (years)	21
Present value of total capital costs ($M)	$613.09
Present value of total ongoing costs ($M)	$4.39
Present value of total costs ($M)	$617.48
Levelised cost ($/ML)	$3,038.1
Levelised cost ($/kL)	$3.04



Financial Yr ending		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Year Number			-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Discount Factors			1.145	1.070	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508	0.475	0.444	0.415	0.388	0.362	0.339	0.317	0.296	0.277	0.258	0.242	0.226	0.211	0.197	0.184	0.172	0.161	0.150	0.141	0.131	0.123	0.115	0.107	0.100	0.094	0.088	0.082	0.076	0.071	0.067	0.062	0.058	0.055	0.051	0.048	0.044	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.026	0.024	0.023	0.021	0.020
Demand projections																																																															
Base Case	GL/yr	72.36	73	75	76	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97	98	99	100	101	103	104	105	106	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	123	124	125	126	127	128	129	131	132	133	134

Supply calculations

Supply Option 1 - Grahamstown Dam Upgrade 1

Summary	3	
Incremental yield	GL/yr	30.0
Construction commences	Year	2008
Construction completed	Year	2013
End of project life	Year	2113
Construction period	Yrs	6
Time to fill	Yrs	5
Satisfies demand up to and including	Year	2034
or for (years)	Yrs	21

Existing system yield	GL/yr	67.5	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	GL/yr								30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Fill assumption										0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	GL/yr									6	12	18	24	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
System yield including incl supply option 1	GL/yr	67.5	68	68	68	68	68	68	68	74	80	86	92	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Components of incremental yield																																																															
Yield that is supplied by Option 1	GL/yr									6	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	27	28	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Yield in excess of requirements	GL/yr										1	6	11	16	16	14	13	12	11	10	9	8	7	6	5	3	2	1	0																																					

Supply Option 2 - Do Nothing

Summary		
Incremental yield	GL/yr	0.0
Construction commences	Year	2031
Construction completed	Year	2031
End of project life	Year	2031
Construction period	Yrs	1
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2007
or for (years)	Yrs	0

Incr. yield timing workings for supply Option 2	GL/yr																																																														
Fill assumption																												1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 2	GL/yr																																																														
System yield surplus (shortfall)	GL/yr		-5	-8	-8	-7	-8	-9	-9	-4	1	6	11	16	16	14	13	12	11	10	9	8	7	6	5	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-12	-13	-14	-15	-16	-17	-18	-19	-20	-21	-22	-23	-24	-26	-27	-28	-29	-30	-31	-32	-33	-34	-35	-36
Yield that is supplied by Option 2	GL/yr																																																														
Yield in excess of requirements	GL/yr																																																														

Combined Supply (Option 1 & Option 2)

Summary		
Satisfies demand up to and including	Year	2034
or for (years)	Yrs	21

Total yield available from supply options 1 & 2	GL/yr									6	12	18	24	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Total yield in system	GL/yr	67.5	68	68	68	68	68	68	68	74	80	86	92	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Yield that is supplied by Option 1 & Option 2	GL/yr									6	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	27	28	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Yield in excess of requirements	GL/yr										1	6	11	16	16	14	13	12	11	10	9	8	7	6	5	3	2	1	0																																					

Levelised cost calculations

Supply Option 1 - Grahamstown Dam Upgrade

PV of demand supplied by option 1	GL	**203.2**								4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	5	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Capex	$m	655.797		183.6	48.1	131.2	139.9	131.2	21.9																																																						
PV of capital costs of option 1		**613.1**		196.5	48.1	122.6	122.2	107.1	16.7																																																					
Opex	$m/yr	0.42601								0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
PV of operating costs of option 1	$m	**4.4**								0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Present value of total costs @ 7%	$M 2007	617.5
Present value of demand supplied @ 7%	GL	203.2
Levelised cost	$/ML	3038.06
Levelised cost	$/kL	3.04

Supply Option 2 - Do Nothing

PV of demand supplied by option 1	GL	**0.0**
Capex	$m	0
PV of capital costs of option 2		**0.0**
Opex	$m/yr	0
PV of operating costs of option 2	$m	**0.0**

Present value of total costs @ 7%	$M 2007	0.0
Present value of demand supplied @ 7%	GL	0.0
Levelised cost	$/ML	0
Levelised cost	$/kL	0.00

Combined Supply (Option 1 & Option 2)

PV of demand supplied by options 1 & 2	GL	**203.2**								4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	5	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Capex	$m	**656**		183.6	48.1	131.2	139.9	131.2	21.9																																																						
PV of capital costs of options 1 & 2		**613.1**		196.5	48.1	122.6	122.2	107.1	16.7																																																					
Opex	$m/yr	**0**								0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
PV of operating costs of options 1 & 2	$m	**4.4**								0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Satisfies demand up to and including	Yr	2034
Satisfies demand for	Years	21
Present value of total costs @ 7%	$M 2007	617.5
Present value of demand supplied @ 7%	GL	203.2
Levelised cost	$/ML	3,038
Levelised cost	$/kL	3.04

CEA - Summary of key inputs and outputs

Key inputs (variables)

Supply scenario		
Option 1	4	Paterson River Scheme - Lostock Dam
Option 2	9	Do Nothing

Economic indicators	
Discount rate	7%
Valuation final year	2056

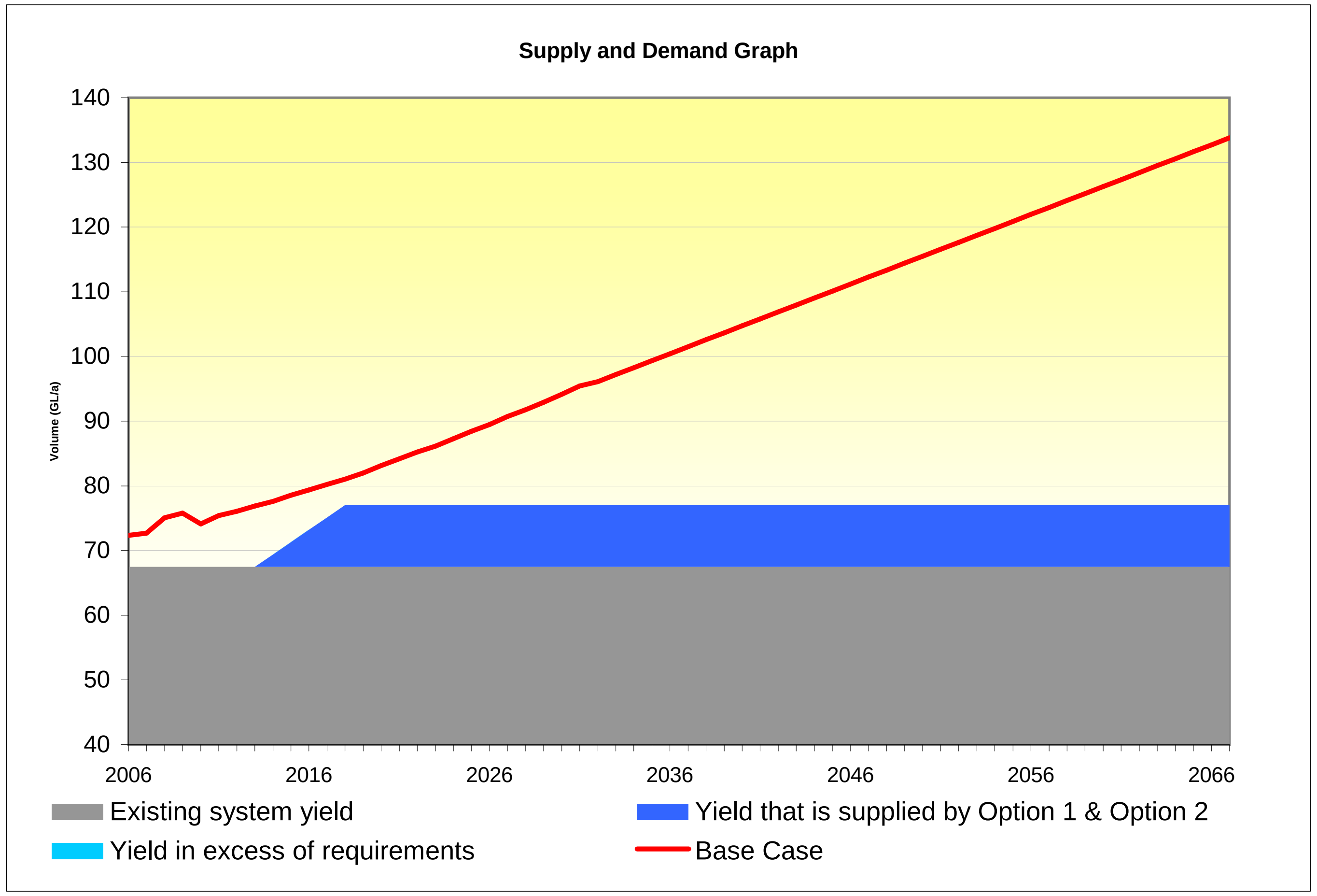
Demand scenario	
Demand scenario	Base Case

Sensitivity variables	(+/-)
Supply	0%
Capex	0%
Opex	0%

Key outputs

	1. Paterson River Scheme -	2. Do Nothing
Yield (GL/yr)	9.5	0
Capex ($M)	425.003454	0
Opex ($M/yr)	0.798768	0
Construction commences	2008	2015
Construction complete	2013	2015
Construction duration	6	1
Time to fill	5	1
Project life	100	0
End of project life	2113	2015
Present value capital costs ($M)	397.3	0.0
Present value operational costs ($M)	8.2	0.0
Present value total costs ($M)	405.6	0.0
Levelised cost ($/ML)	$4,759.9	$0.0
Levelised cost ($/kL)	$4.76	$0.00

Combined Supply Scenario - Options 1 & 2: Paterson River Scheme - Lostock Dam and Do Nothing	
Yield (GL/yr)	9.5
Capex ($M)	425.003454
Opex ($M/yr)	0.798768
Satisfies demand up to and including	2018
Satisfies demand for (years)	5
Present value of total capital costs ($M)	$397.32
Present value of total ongoing costs ($M)	$8.23
Present value of total costs ($M)	$405.55
Levelised cost ($/ML)	$4,759.9
Levelised cost ($/kL)	$4.76



Financial Yr ending		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Year Number			-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Discount Factors			1.145	1.070	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508	0.475	0.444	0.415	0.388	0.362	0.339	0.317	0.296	0.277	0.258	0.242	0.226	0.211	0.197	0.184	0.172	0.161	0.150	0.141	0.131	0.123	0.115	0.107	0.100	0.094	0.088	0.082	0.076	0.071	0.067	0.062	0.058	0.055	0.051	0.048	0.044	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.026	0.024	0.023	0.021	0.020

Demand projections

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Base Case	GL/yr	**72.36**	73	75	76	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97	98	99	100	101	103	104	105	106	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	123	124	125	126	127	128	129	131	132	133	134

Supply calculations

Supply Option 1 - Paterson River Scheme - Lo 1

Summary		4
Incremental yield	GL/yr	**9.5**
Construction commences	Year	2008
Construction completed	Year	2013
End of project life	Year	2113
Construction period	Yrs	6
Time to fill	Yrs	5
Satisfies demand up to and including	Year	2018
or for (years)	Yrs	5

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Existing system yield	GL/yr	**67.5**	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	GL/yr								10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Fill assumption										0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	GL/yr									2	4	6	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
System yield including incl supply option 1	GL/yr	67.5	68	68	68	68	68	68	68	69	71	73	75	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Components of incremental yield																																																															
Yield that is supplied by Option 1	GL/yr									2	4	6	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Yield in excess of requirements	GL/yr																																																														

Supply Option 2 - Do Nothing

Summary		
Incremental yield	GL/yr	**0.0**
Construction commences	Year	2015
Construction completed	Year	2015
End of project life	Year	2015
Construction period	Yrs	1
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2007
or for (years)	Yrs	0

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Incr. yield timing workings for supply Option 2	GL/yr																																																														
Fill assumption												1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 2	GL/yr																																																														
System yield surplus (shortfall)	GL/yr		-5	-8	-8	-7	-8	-9	-9	-8	-7	-6	-5	-4	-5	-6	-7	-8	-9	-10	-11	-12	-14	-15	-16	-17	-18	-19	-20	-21	-22	-23	-24	-26	-27	-28	-29	-30	-31	-32	-33	-34	-35	-36	-37	-38	-40	-41	-42	-43	-44	-45	-46	-47	-48	-49	-50	-51	-52	-54	-55	-56	-57
Yield that is supplied by Option 2	GL/yr																																																														
Yield in excess of requirements	GL/yr																																																														

Combined Supply (Option 1 & Option 2)

Summary		
Satisfies demand up to and including	Year	2018
or for (years)	Yrs	5

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Total yield available from supply options 1 & 2	GL/yr									2	4	6	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Total yield in system	GL/yr	67.5	68	68	68	68	68	68	68	69	71	73	75	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Yield that is supplied by Option 1 & Option 2	GL/yr									2	4	6	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Yield in excess of requirements	GL/yr																																																														

Levelised cost calculations

Supply Option 1 - Paterson River Scheme - Lostock Dam

			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by option 1	GL	**85.2**								1	3	4	4	5	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capex	$m	425.003		119.0	31.2	85.0	90.7	85.0	14.2																																																						
PV of capital costs of option 1		**397.3**		127.3	31.2	79.4	79.2	69.4	10.8																																																						
Opex	$m/yr	0.79877								0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
PV of operating costs of option 1	$m	**8.2**								0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Present value of total costs @ 7%	$M 2007	405.6
Present value of demand supplied @ 7%	GL	85.2
Levelised cost	$/ML	4759.88
Levelised cost	$/kL	4.76

Supply Option 2 - Do Nothing

PV of demand supplied by option 1	GL	**0.0**
Capex	$m	0
PV of capital costs of option 2		**0.0**
Opex	$m/yr	0
PV of operating costs of option 2	$m	**0.0**

Present value of total costs @ 7%	$M 2007	0.0
Present value of demand supplied @ 7%	GL	0.0
Levelised cost	$/ML	0
Levelised cost	$/kL	0.00

Combined Supply (Option 1 & Option 2)

			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by options 1 & 2	GL	**85.2**								1	3	4	4	5	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capex	$m	**425**		119.0	31.2	85.0	90.7	85.0	14.2																																																					
PV of capital costs of options 1 & 2		**397.3**		127.3	31.2	79.4	79.2	69.4	10.8																																																						
Opex	$m/yr	**1**								0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
PV of operating costs of options 1 & 2	$m	**8.2**								0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Satisfies demand up to and including	Yr	2018
Satisfies demand for	Years	5
Present value of total costs @ 7%	$M 2007	405.6
Present value of demand supplied @ 7%	GL	85.2
Levelised cost	$/ML	4,760
Levelised cost	$/kL	4.76

CEA - Summary of key inputs and outputs

Key inputs (variables)

Supply scenario		
Option 1	5	Karuah River Scheme - Mammy Johnsons Dam
Option 2	9	Do Nothing

Economic indicators	
Discount rate	7%
Valuation final year	2056

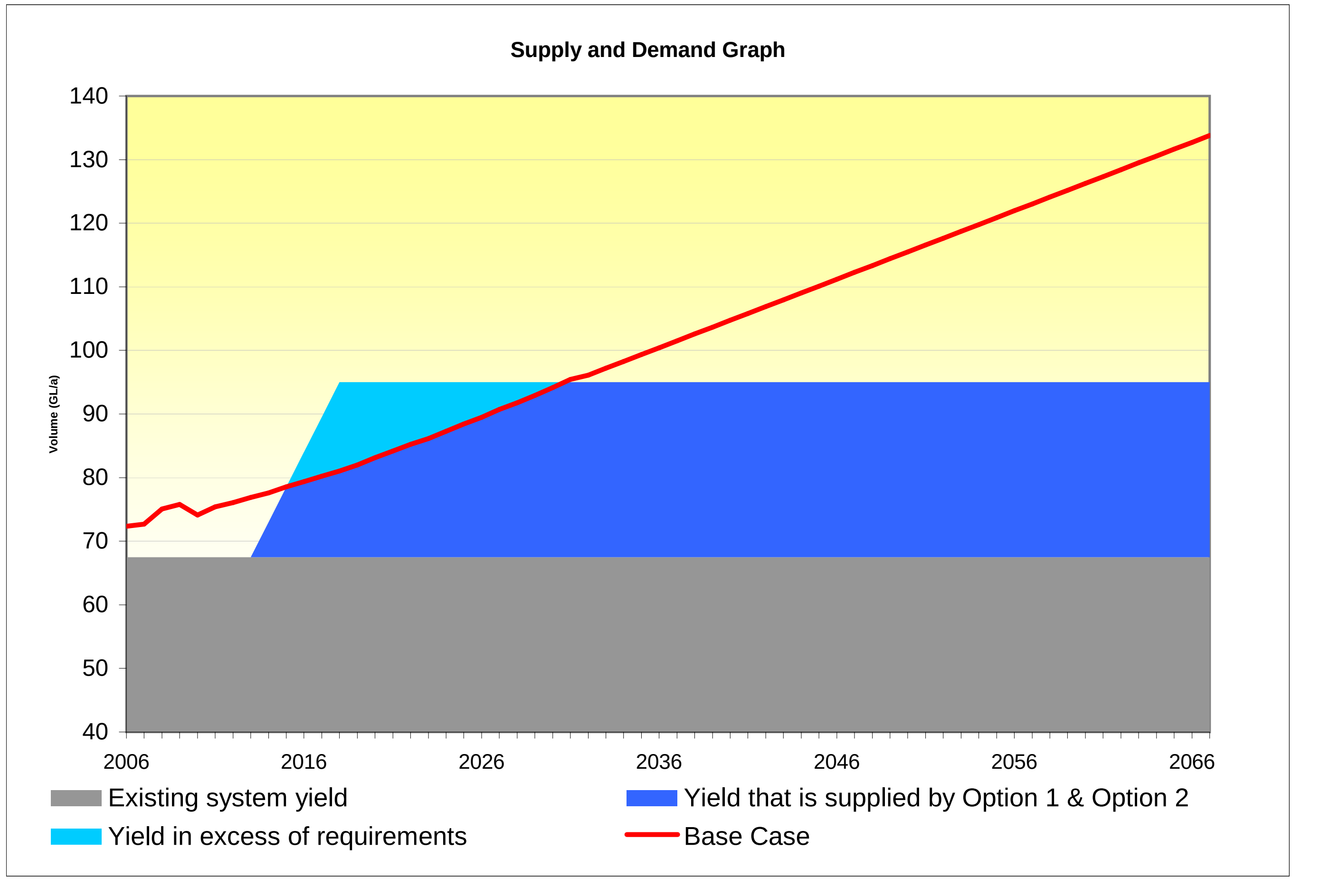
Demand scenario	
Demand scenario	Base Case

Sensitivity variables	(+/-)
Supply	0%
Capex	0%
Opex	0%

Key outputs

	1. Karuah River Scheme -	2. Do Nothing
Yield (GL/yr)	27.5	0
Capex ($M)	565.219894	0
Opex ($M/yr)	0.8520192	0
Construction commences	2008	2028
Construction complete	2013	2028
Construction duration	6	1
Time to fill	5	1
Project life	100	0
End of project life	2113	2028
Present value capital costs ($M)	528.4	0.0
Present value operational costs ($M)	8.8	0.0
Present value total costs ($M)	537.2	0.0
Levelised cost ($/ML)	$2,733.1	$0.0
Levelised cost ($/kL)	$2.73	$0.00

Combined Supply Scenario - Options 1 & 2: Karuah River Scheme - Mammy Johnsons Dam and Do Nothing	
Yield (GL/yr)	27.5
Capex ($M)	565.219894
Opex ($M/yr)	0.8520192
Satisfies demand up to and including	2031
Satisfies demand for (years)	18
Present value of total capital costs ($M)	$528.41
Present value of total ongoing costs ($M)	$8.78
Present value of total costs ($M)	$537.19
Levelised cost ($/ML)	$2,733.1
Levelised cost ($/kL)	$2.73



		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Financial Yr ending		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Year Number			-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Discount Factors			1.145	1.070	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508	0.475	0.444	0.415	0.388	0.362	0.339	0.317	0.296	0.277	0.258	0.242	0.226	0.211	0.197	0.184	0.172	0.161	0.150	0.141	0.131	0.123	0.115	0.107	0.100	0.094	0.088	0.082	0.076	0.071	0.067	0.062	0.058	0.055	0.051	0.048	0.044	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.026	0.024	0.023	0.021	0.020

Demand projections

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Base Case	GL/yr	**72.36**	73	75	76	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97	98	99	100	101	103	104	105	106	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	123	124	125	126	127	128	129	131	132	133	134

Supply calculations

Supply Option 1 - Karuah River Scheme - Mam 1

Summary	5	
Incremental yield	GL/yr	**27.5**
Construction commences	Year	2008
Construction completed	Year	2013
End of project life	Year	2113
Construction period	Yrs	6
Time to fill	Yrs	5
Satisfies demand up to and including	Year	2031
or for (years)	Yrs	18

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Existing system yield	GL/yr	**67.5**	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	GL/yr								28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Fill assumption										0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	GL/yr									6	11	17	22	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
System yield including incl supply option 1	GL/yr	67.5	68	68	68	68	68	68	68	73	79	84	90	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95
Components of incremental yield																																																															
Yield that is supplied by Option 1	GL/yr									6	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Yield in excess of requirements	GL/yr											5	9	14	13	12	11	10	9	8	7	6	4	3	2	1																																					

Supply Option 2 - Do Nothing

Summary		
Incremental yield	GL/yr	**0.0**
Construction commences	Year	2028
Construction completed	Year	2028
End of project life	Year	2028
Construction period	Yrs	1
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2007
or for (years)	Yrs	0

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Incr. yield timing workings for supply Option 2	GL/yr																																																														
Fill assumption																								1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 2	GL/yr																																																														
System yield surplus (shortfall)	GL/yr		-5	-8	-8	-7	-8	-9	-9	-5	0	5	9	14	13	12	11	10	9	8	7	6	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-8	-9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20	-22	-23	-24	-25	-26	-27	-28	-29	-30	-31	-32	-33	-34	-36	-37	-38	-39
Yield that is supplied by Option 2	GL/yr																																																														
Yield in excess of requirements	GL/yr																																																														

Combined Supply (Option 1 & Option 2)

Summary		
Satisfies demand up to and including	Year	2031
or for (years)	Yrs	18

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Total yield available from supply options 1 & 2	GL/yr									6	11	17	22	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Total yield in system	GL/yr	67.5	68	68	68	68	68	68	68	73	79	84	90	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95
Yield that is supplied by Option 1 & Option 2	GL/yr									6	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Yield in excess of requirements	GL/yr											5	9	14	13	12	11	10	9	8	7	6	4	3	2	1																																					

Levelised cost calculations

Supply Option 1 - Karuah River Scheme - Mammy Johnsons Dam

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by option 1	GL	**196.5**								4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	5	5	5	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Capex	$m	565.22		158.3	41.4	113.0	120.6	113.0	18.8																																																						
PV of capital costs of option 1		**528.4**		169.3	41.4	105.6	105.3	92.3	14.4																																																						
Opex	$m/yr	0.85202								0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
PV of operating costs of option 1	$m	**8.8**								0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Present value of total costs @ 7%	$M 2007	537.2
Present value of demand supplied @ 7%	GL	196.5
Levelised cost	$/ML	2733.14
Levelised cost	$/kL	2.73

Supply Option 2 - Do Nothing

PV of demand supplied by option 1	GL	**0.0**
Capex	$m	0
PV of capital costs of option 2		**0.0**
Opex	$m/yr	0
PV of operating costs of option 2	$m	**0.0**

Present value of total costs @ 7%	$M 2007	0.0
Present value of demand supplied @ 7%	GL	0.0
Levelised cost	$/ML	0
Levelised cost	$/kL	0.00

Combined Supply (Option 1 & Option 2)

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by options 1 & 2	GL	**196.5**								4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	5	5	5	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Capex	$m	**565**		158.3	41.4	113.0	120.6	113.0	18.8																																																				
PV of capital costs of options 1 & 2	$m	**528.4**		169.3	41.4	105.6	105.3	92.3	14.4																																																					
Opex	$m/yr	**1**								0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
PV of operating costs of options 1 & 2	$m	**8.8**								0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Satisfies demand up to and including	Yr	2031
Satisfies demand for	Years	18
Present value of total costs @ 7%	$M 2007	537.2
Present value of demand supplied @ 7%	GL	196.5
Levelised cost	$/ML	2,733
Levelised cost	$/kL	2.73

CEA - Summary of key inputs and outputs

Key inputs (variables)

Supply scenario		
Option 1	6	Desalination
Option 2	9	Do Nothing

Economic indicators	
Discount rate	7%
Valuation final year	2056

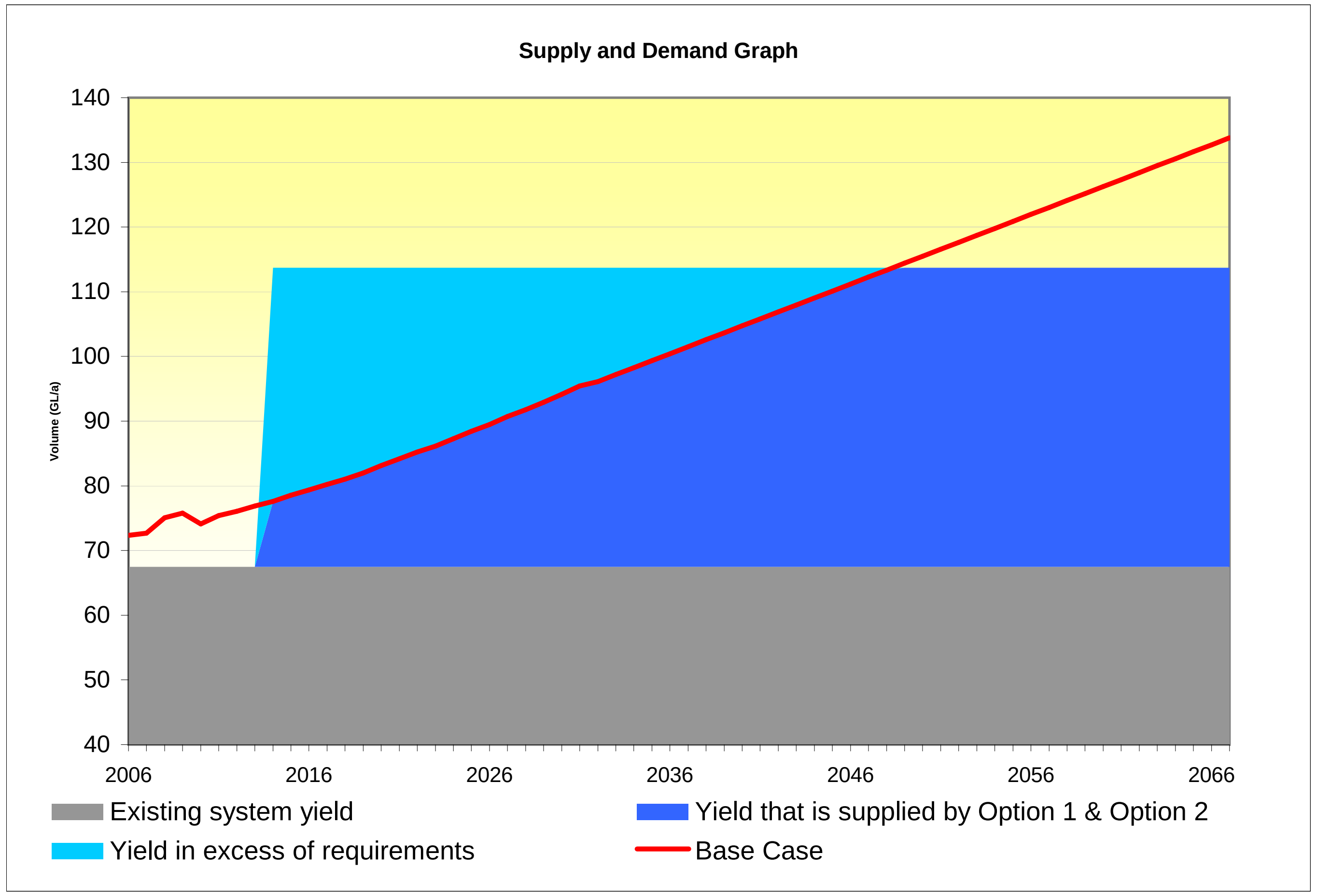
Demand scenario	
Demand scenario	Base Case

Sensitivity variables	(+/-)
Supply	0%
Capex	0%
Opex	0%

Key outputs

	1. Desalination	2. Do Nothing
Yield (GL/yr)	46.2	0
Capex ($M)	989.757	0
Opex ($M/yr)	26.63	0
Construction commences	2011	2046
Construction complete	2013	2046
Construction duration	3	1
Time to fill	1	1
Project life	100	0
End of project life	2113	2046
Present value capital costs ($M)	809.2	0.0
Present value operational costs ($M)	274.4	0.0
Present value total costs ($M)	1083.6	0.0
Levelised cost ($/ML)	$4,803.2	$0.0
Levelised cost ($/kL)	$4.80	$0.00

Combined Supply Scenario - Options 1 & 2: Desalination and Do Nothing	
Yield (GL/yr)	46.2
Capex ($M)	989.757
Opex ($M/yr)	26.63
Satisfies demand up to and including	2049
Satisfies demand for (years)	36
Present value of total capital costs ($M)	$809.17
Present value of total ongoing costs ($M)	$274.41
Present value of total costs ($M)	$1,083.58
Levelised cost ($/ML)	$4,803.2
Levelised cost ($/kL)	$4.80



Financial Yr ending		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Year Number			-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Discount Factors			1.145	1.070	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508	0.475	0.444	0.415	0.388	0.362	0.339	0.317
Demand projections																						
Base Case	GL/yr	72.36	73	75	76	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	88	89

Financial Yr ending	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Year Number	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Discount Factors	0.296	0.277	0.258	0.242	0.226	0.211	0.197	0.184	0.172	0.161	0.150	0.141	0.131	0.123	0.115	0.107	0.100	0.094	0.088	0.082
Base Case	91	92	93	94	95	96	97	98	99	100	101	103	104	105	106	107	108	109	110	111

Financial Yr ending	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Year Number	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Discount Factors	0.076	0.071	0.067	0.062	0.058	0.055	0.051	0.048	0.044	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.026	0.024	0.023	0.021	0.020
Base Case	112	113	114	115	117	118	119	120	121	122	123	124	125	126	127	128	129	131	132	133	134

Supply calculations

Supply Option 1 - Desalination 1

Summary		6
Incremental yield	GL/yr	46.2
Construction commences	Year	2011
Construction completed	Year	2013
End of project life	Year	2113
Construction period	Yrs	3
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2049
or for (years)	Yrs	36

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Existing system yield	GL/yr	67.5	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	GL/yr								46	46	46	46	46	46	46	46	46	46	46	46	46	46
Fill assumption										1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	GL/yr									46	46	46	46	46	46	46	46	46	46	46	46	46
System yield including incl supply option 1	GL/yr	67.5	68	68	68	68	68	68	68	114	114	114	114	114	114	114	114	114	114	114	114	114
Components of incremental yield																						
Yield that is supplied by Option 1	GL/yr									10	11	12	13	14	14	16	17	18	19	20	21	22
Yield in excess of requirements	GL/yr									36	35	34	33	33	32	31	30	28	28	26	25	24

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Existing system yield	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Fill assumption	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
System yield including incl supply option 1	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114
Yield that is supplied by Option 1	23	24	25	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	43	44
Yield in excess of requirements	23	22	21	20	18	18	17	15	14	13	12	11	10	9	8	7	6	5	4	3

	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Existing system yield	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Fill assumption	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
System yield including incl supply option 1	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114
Yield that is supplied by Option 1	45	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Yield in excess of requirements	1	0																			

Supply Option 2 - Do Nothing

Summary		
Incremental yield	GL/yr	0.0
Construction commences	Year	2046
Construction completed	Year	2046
End of project life	Year	2046
Construction period	Yrs	1
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2007
or for (years)	Yrs	0

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Incr. yield timing workings for supply Option 2	GL/yr																				
Fill assumption																					
Incremental yield from Option 2	GL/yr																				
System yield surplus (shortfall)	GL/yr	-5	-8	-8	-7	-8	-9	-9	36	35	34	33	33	32	31	30	28	28	26	25	24
Yield that is supplied by Option 2	GL/yr																				
Yield in excess of requirements	GL/yr																				

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
System yield surplus (shortfall)	23	22	21	20	18	18	17	15	14	13	12	11	10	9	8	7	6	5	4	3

	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Fill assumption	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
System yield surplus (shortfall)	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-13	-14	-15	-16	-17	-18	-19	-20

Combined Supply (Option 1 & Option 2)

Summary		
Satisfies demand up to and including	Year	2049
or for (years)	Yrs	36

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total yield available from supply options 1 & 2	GL/yr									46	46	46	46	46	46	46	46	46	46	46	46	46
Total yield in system	GL/yr	67.5	68	68	68	68	68	68	68	114	114	114	114	114	114	114	114	114	114	114	114	114
Yield that is supplied by Option 1 & Option 2	GL/yr									10	11	12	13	14	14	16	17	18	19	20	21	22
Yield in excess of requirements	GL/yr									36	35	34	33	33	32	31	30	28	28	26	25	24

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Total yield available from supply options 1 & 2	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Total yield in system	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114
Yield that is supplied by Option 1 & Option 2	23	24	25	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	43	44
Yield in excess of requirements	23	22	21	20	18	18	17	15	14	13	12	11	10	9	8	7	6	5	4	3

	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Total yield available from supply options 1 & 2	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Total yield in system	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114	114
Yield that is supplied by Option 1 & Option 2	45	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Yield in excess of requirements	1	0																			

Levelised cost calculations

Supply Option 1 - Desalination

		Total	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
PV of demand supplied by option 1	GL	**225.6**								7	7	7	7	7	7	7	7	7	7	7	7	7
Capex	$m	989.757					329.9	329.9	329.9													
PV of capital costs of option 1		**809.2**					288.2	269.3	251.7													
Opex	$m/yr	26.63								26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
PV of operating costs of option 1	$m	**274.4**								19.0	17.7	16.6	15.5	14.5	13.5	12.7	11.8	11.1	10.3	9.7	9.0	8.4

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
PV of demand supplied by option 1	7	7	7	6	6	6	6	6	5	5	5	5	5	5	4	4	4	4	4	4
Opex	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
PV of operating costs of option 1	7.9	7.4	6.9	6.4	6.0	5.6	5.3	4.9	4.6	4.3	4.0	3.7	3.5	3.3	3.1	2.9	2.7	2.5	2.3	2.2

	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by option 1	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
Opex	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
PV of operating costs of option 1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5

Present value of total costs @ 7%	$M 2007	1,083.6
Present value of demand supplied @ 7%	GL	225.6
Levelised cost	$/ML	4803.15
Levelised cost	$/kL	4.80

Supply Option 2 - Do Nothing

PV of demand supplied by option 1	GL	**0.0**
Capex	$m	0
PV of capital costs of option 2		**0.0**
Opex	$m/yr	0
PV of operating costs of option 2	$m	**0.0**

Present value of total costs @ 7%	$M 2007	0.0
Present value of demand supplied @ 7%	GL	0.0
Levelised cost	$/ML	0
Levelised cost	$/kL	0.00

Combined Supply (Option 1 & Option 2)

		Total	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
PV of demand supplied by options 1 & 2	GL	**225.6**								7	7	7	7	7	7	7	7	7	7	7	7	7
Capex	$m	**990**					329.9	329.9	329.9													
PV of capital costs of options 1 & 2	$m	**809.2**					288.2	269.3	251.7													
Opex	$m/yr	**27**								26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
PV of operating costs of options 1 & 2	$m	**274.4**								19.0	17.7	16.6	15.5	14.5	13.5	12.7	11.8	11.1	10.3	9.7	9.0	8.4

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
PV of demand supplied by options 1 & 2	7	7	7	6	6	6	6	6	5	5	5	5	5	5	4	4	4	4	4	4
Opex	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
PV of operating costs of options 1 & 2	7.9	7.4	6.9	6.4	6.0	5.6	5.3	4.9	4.6	4.3	4.0	3.7	3.5	3.3	3.1	2.9	2.7	2.5	2.3	2.2

	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
PV of demand supplied by options 1 & 2	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
Opex	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
PV of operating costs of options 1 & 2	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5

Satisfies demand up to and including	Yr	2049
Satisfies demand for	Years	36
Present value of total costs @ 7%	$M 2007	######
Present value of demand supplied @ 7%	GL	225.6
Levelised cost	$/ML	4,803
Levelised cost	$/kL	4.80

CEA - Summary of key inputs and outputs

Key inputs (variables)

Supply scenario		
Option 1	7	Indirect potable reuse
Option 2	9	Do Nothing

Economic indicators	
Discount rate	7%
Valuation final year	2056

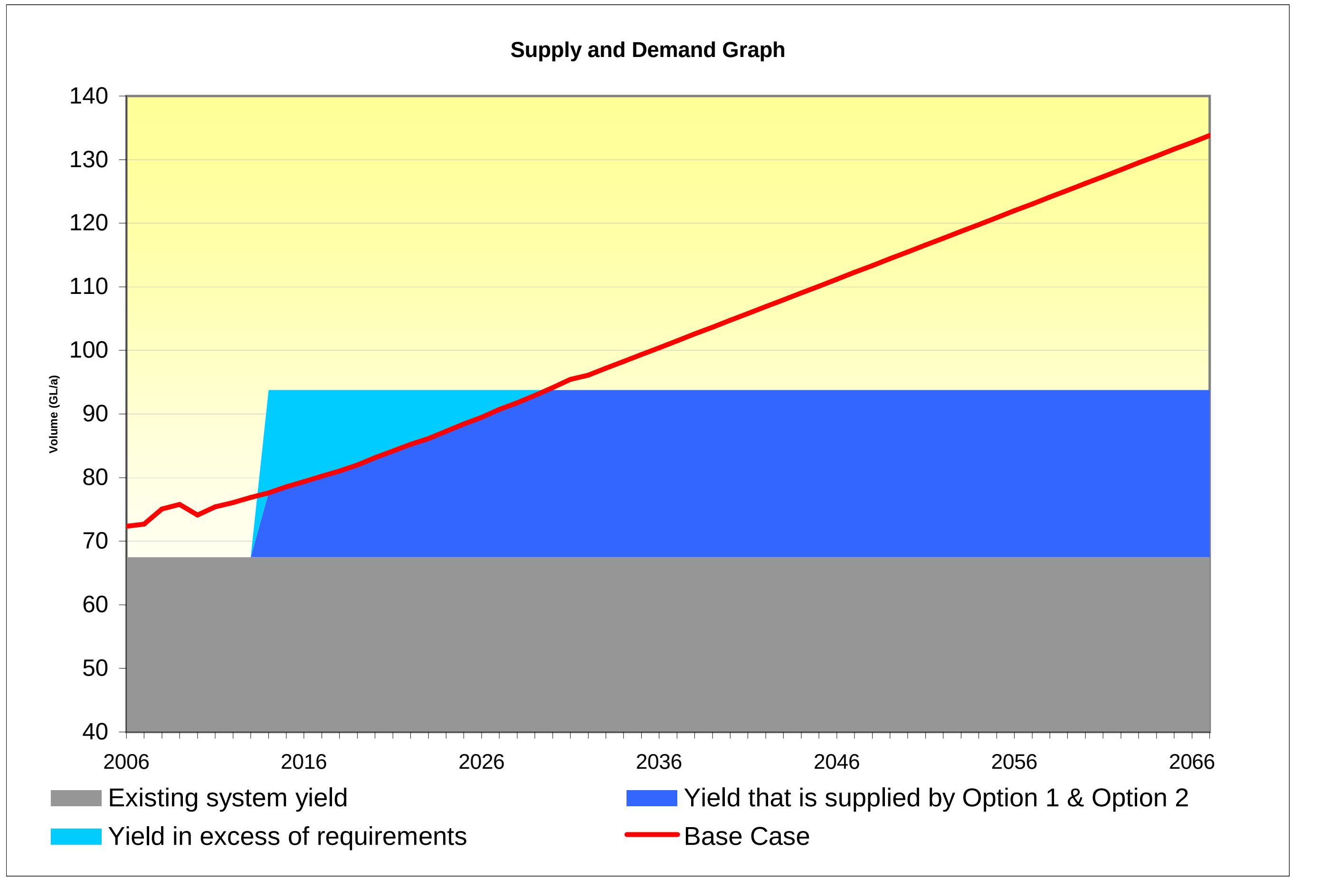
Demand scenario	
Demand scenario	Base Case

Sensitivity variables	(+/-)
Supply	0%
Capex	0%
Opex	0%

Key outputs

	1. Indirect potable reuse	2. Do Nothing
Yield (GL/yr)	26.28	0
Capex ($M)	523.138368	0
Opex ($M/yr)	21.19	0
Construction commences	2011	2027
Construction complete	2013	2027
Construction duration	3	1
Time to fill	1	1
Project life	100	0
End of project life	2113	2027
Present value capital costs ($M)	427.7	0.0
Present value operational costs ($M)	218.4	0.0
Present value total costs ($M)	646.0	0.0
Levelised cost ($/ML)	$3,291.4	$0.0
Levelised cost ($/kL)	$3.29	$0.00

Combined Supply Scenario - Options 1 & 2: Indirect potable reuse and Do Nothing	
Yield (GL/yr)	26.28
Capex ($M)	523.138368
Opex ($M/yr)	21.19
Satisfies demand up to and including	2030
Satisfies demand for (years)	17
Present value of total capital costs ($M)	$427.69
Present value of total ongoing costs ($M)	$218.35
Present value of total costs ($M)	$646.04
Levelised cost ($/ML)	$3,291.4
Levelised cost ($/kL)	$3.29



Financial Yr ending		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
Year Number			-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Discount Factors			1.145	1.070	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508	0.475	0.444	0.415	0.388	0.362	0.339	0.317	0.296	0.277	0.258	0.242	0.226	0.211	0.197	0.184	0.172	0.161	0.150	0.141	0.131	0.123	0.115	0.107	0.100	0.094	0.088	0.082	0.076	0.071	0.067	0.062	0.058	0.055	0.051	0.048	0.044	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.026	0.024	0.023	0.021	0.020

Demand projections

Base Case	GL/yr	**72.36**	73	75	76	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97	98	99	100	101	103	104	105	106	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	123	124	125	126	127	128	129	131	132	133	134

Supply calculations

Supply Option 1 - Indirect potable reuse 1

Summary	7	
Incremental yield	GL/yr	**26.3**
Construction commences	Year	2011
Construction completed	Year	2013
End of project life	Year	2113
Construction period	Yrs	3
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2030
or for (years)	Yrs	17

Existing system yield	GL/yr	**67.5**	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Incr. yield timing workings for supply Option 1	GL/yr								26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Fill assumption										1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 1	GL/yr									26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
System yield including incl supply option 1	GL/yr	67.5	68	68	68	68	68	68	68	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
Components of incremental yield																																																															
Yield that is supplied by Option 1	GL/yr									10	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Yield in excess of requirements	GL/yr									16	15	14	14	13	12	11	10	9	8	6	5	4	3	2	1																																						

Supply Option 2 - Do Nothing

Summary		
Incremental yield	GL/yr	**0.0**
Construction commences	Year	2027
Construction completed	Year	2027
End of project life	Year	2027
Construction period	Yrs	1
Time to fill	Yrs	1
Satisfies demand up to and including	Year	2007
or for (years)	Yrs	0

Incr. yield timing workings for supply Option 2	GL/yr																																																														
Fill assumption																								1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Incremental yield from Option 2	GL/yr																																																														
System yield surplus (shortfall)	GL/yr		-5	-8	-8	-7	-8	-9	-9	16	15	14	14	13	12	11	10	9	8	6	5	4	3	2	1	0	-2	-2	-3	-4	-6	-7	-8	-9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-20	-21	-22	-23	-24	-25	-26	-27	-28	-29	-30	-31	-32	-34	-35	-36	-37	-38	-39	-40
Yield that is supplied by Option 2	GL/yr																																																														
Yield in excess of requirements	GL/yr																																																														

Combined Supply (Option 1 & Option 2)

Summary		
Satisfies demand up to and including	Year	2030
or for (years)	Yrs	17

Total yield available from supply options 1 & 2	GL/yr									26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Total yield in system	GL/yr	67.5	68	68	68	68	68	68	68	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
Yield that is supplied by Option 1 & Option 2	GL/yr									10	11	12	13	14	14	16	17	18	19	20	21	22	23	24	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Yield in excess of requirements	GL/yr									16	15	14	14	13	12	11	10	9	8	6	5	4	3	2	1																																						

Levelised cost calculations

Supply Option 1 - Indirect potable reuse

PV of demand supplied by option 1	GL	**196.3**								7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	5	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Capex	$m	523.138					174.4	174.4	174.4																																																						
PV of capital costs of option 1		**427.7**					152.3	142.3	133.0																																																						
Opex	$m/yr	21.19								21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2
PV of operating costs of option 1	$m	**218.4**								15.1	14.1	13.2	12.3	11.5	10.8	10.1	9.4	8.8	8.2	7.7	7.2	6.7	6.3	5.9	5.5	5.1	4.8	4.5	4.2	3.9	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.3	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4

Present value of total costs @ 7%	$M 2007	646.0
Present value of demand supplied @ 7%	GL	196.3
Levelised cost	$/ML	3291.45
Levelised cost	$/kL	3.29

Supply Option 2 - Do Nothing

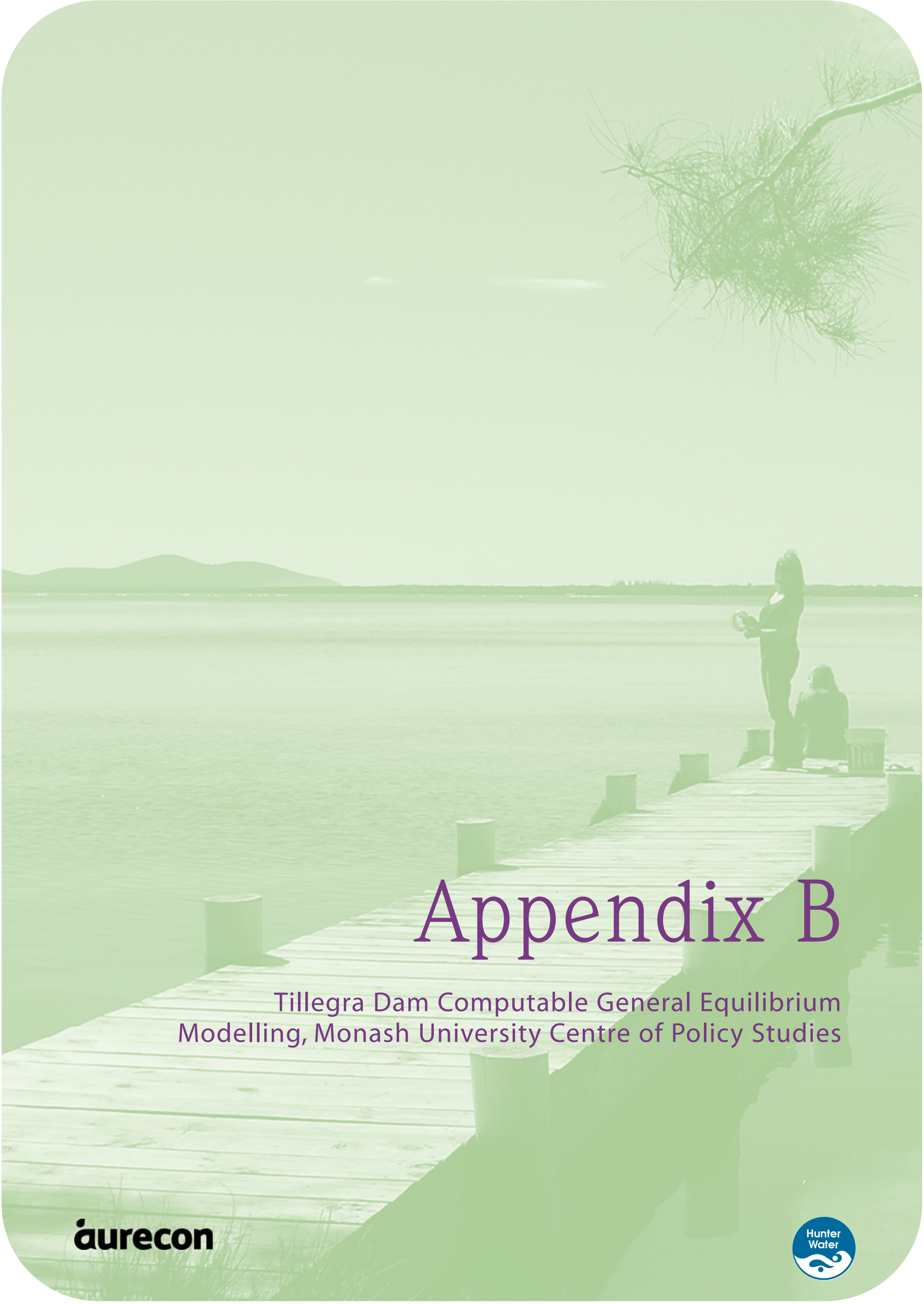
PV of demand supplied by option 1	GL	**0.0**
Capex	$m	0
PV of capital costs of option 2		**0.0**
Opex	$m/yr	0
PV of operating costs of option 2	$m	**0.0**

Present value of total costs @ 7%	$M 2007	0.0
Present value of demand supplied @ 7%	GL	0.0
Levelised cost	$/ML	0
Levelised cost	$/kL	0.00

Combined Supply (Option 1 & Option 2)

PV of demand supplied by options 1 & 2	GL	**196.3**								7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	5	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Capex	$m	**523**					174.4	174.4	174.4																																																						
PV of capital costs of options 1 & 2	$m	**427.7**					152.3	142.3	133.0																																																						
Opex	$m/yr	**21**								21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2
PV of operating costs of options 1 & 2	$m	**218.4**								15.1	14.1	13.2	12.3	11.5	10.8	10.1	9.4	8.8	8.2	7.7	7.2	6.7	6.3	5.9	5.5	5.1	4.8	4.5	4.2	3.9	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.3	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4

Satisfies demand up to and including	Yr	2030
Satisfies demand for	Years	17
Present value of total costs @ 7%	$M 2007	646.0
Present value of demand supplied @ 7%	GL	196.3
Levelised cost	$/ML	3,291
Levelised cost	$/kL	3.29



Appendix B

Tillegra Dam Computable General Equilibrium Modelling, Monash University Centre of Policy Studies

The economic effects of the Tillegra Dam in the Lower Hunter Valley region

Glyn Wittwer
Centre of Policy Studies
March 2008

Report prepared for Connell Wagner, Brisbane office

Executive Summary

This study concerns the construction of Tillegra Dam and the economic impacts of the additional water resource in the Lower Hunter Valley once the dam is operating.

The model used in this study tracks the year-by-year costs and benefits associated with this project. The estimated costs of dam construction are $300 million. Construction of the dam proceeds from 2008 to 2014. Once the dam is operational, it increases the reliable water supply of the lower Hunter region from around 72 gigalitres to 125 gigalitres.

The construction phase of the project creates additional employment in the lower Hunter region – around 100 jobs. In the theory of the model, the local labour market responds through both additional jobs and wages that are slightly higher than otherwise. This implies that real wages are not strictly national strengthening of the local labour market may result in regional wages rising more than national wages.

Once the construction phase has ended, and the dam becomes operational, lower Hunter's labour market remains stronger than in the business-as-usual forecast. This is because increased water availability has pervasive benefits, raising the marginal product of labour in the region and increasing the rate of return on capital across a number of industries. In response, there is, in the early years of the operational phase of the dam, an increase in both investment and employment relative to the baseline forecast as a consequence of the project. There are between 200 and 300 jobs above those of the baseline forecast in the Lower Hunter Valley from 2015 onwards.

By reducing water scarcity in the long term, the dam provides the Lower Hunter Valley with lasting economic benefits. Without the dam, water scarcity worsens each year as baseline effective demand (that is, net of water efficiency gains by users) for water grows more rapidly then effective water supply over time.

Economists often use a single number to evaluate the potential net benefits of a project. This is referred to as the welfare gain. This is calculated as the year-by-year increase in national household spending due to the project, relative to business-as-usual household spending. The calculation of year-by-year household spending is based on disposable income after accounting for interest payments on net foreign debt. We assume in the model that finance is borrowed from foreigners to fund construction. This implies that national debt may rise in the future at the same as additional production capacity rises due to the project. Therefore, some of the additional income generated by the project must be paid in interest to foreigners. We usually calculate the welfare benefit at the national level, as inter-regional migration tends to confound regional calculations of welfare.

The net present value (the discounted sum of future year-by-year household spending gains) of the welfare gain arising from the project is $3,000 million, assuming that water scarcity rises in the future (that is, additional supplies in the future are smaller than additional demands). A section on sensitivity analysis discusses this further.

Introduction

This study uses a dynamic multi-regional CGE model to assess the economic impacts of the construction and operational phases of Tillegra dam. The need for the dam arises from rapid population growth in the Lower Hunter Valley projected over the next few decades, combined with fears that with climate change, droughts may become more frequent.

The direct costs of the project as ascribed to the CGE model were based initially on a report prepared by Hunter Water (2007).

Key baseline forecast assumptions

The following assumptions were used in projected the dynamic regional model, TERM, from 2006 to 2031.

- The population of the Lower Hunter Valley grows by 100,000 in this period.
- Based on various studies undertaken at the Centre of Policy Studies, there are ongoing productivity improvements in most sectors, with growth more rapid in primary and secondary industries than in most services.
- We have used state macro forecasts provided by Access Economics.
- Since water remains scarce, we assume that water users increase water efficiency by 1% per annum. Critically, we assume that throughout Australia, water scarcity worsens over time. That is, population and economic growth over time results in growing demand for water that is only partly offset by growing water supplies.

The policy scenario

In the policy scenario, $300 million is spent constructing Tillegra dam between 2008 and 2014. It becomes fully operational in 2015, raising minimum annual yields in the Lower Hunter Valley from around 72 gigalitres to 125 gigalitres. Recognising that the industry to which we ascribe shocks, Water & drains, is a bundle of services plus water provision, we raise the output of the sector not by 72% (=[125-72]/72) but by a smaller proportion, 50%.[1]

The baseline and why it is important

We are dealing with a fixed water resource, the availability of which will not grow as rapidly as the economy. Therefore, with economic growth, water scarcity will worsen. The Tillegra dam provides economic benefits relative to the baseline by relieving the ever-worsening scarcity of water in the Lower Hunter Valley as the economy grows.

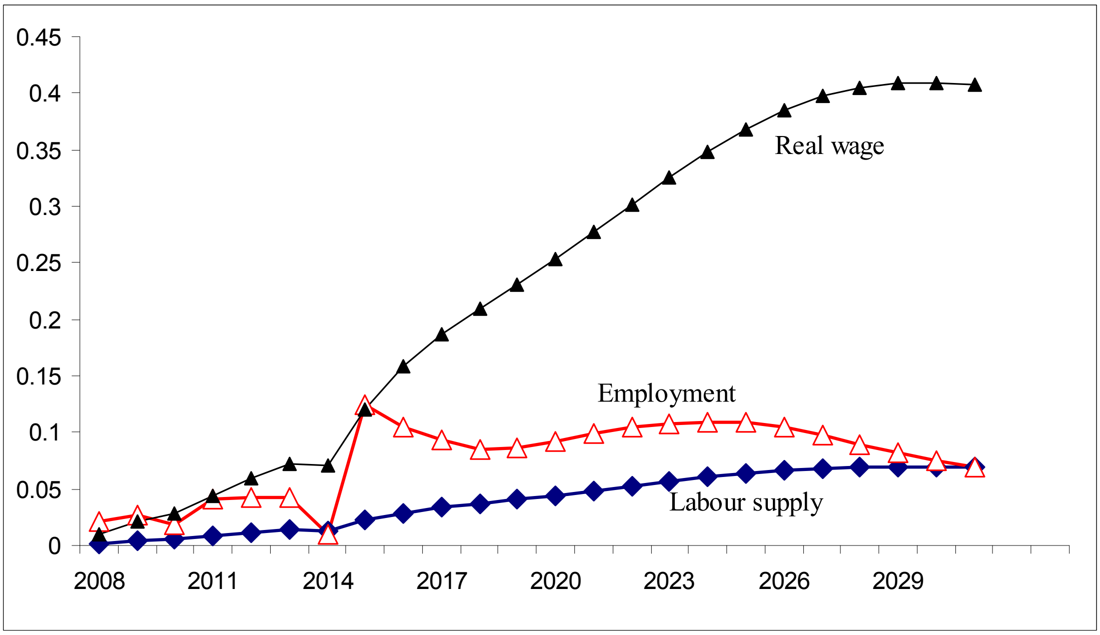
[1] We assumed that 90% of the water & drains labour relates to the services component of the sector, and all the capital to water. Capital is 67% of total factor value in the sector. Based on this, we scale the 72% increase in water volume down to a 50% sectoral output increase:
([0.1*[1-0.67] +1.0*0.67]*72%=50%).

Results

All the results presented in this study refer to the policy scenario relative to a business-as-usual or baseline forecast. An important feature of CGE modelling is that both prices and quantities play a role in response to an economic stimulus. Consider the impacts on the labour market of Lower Hunter Valley (figure 1). The investment phase brings with it both a jump in employment in the region (0.04% relative to forecast, or around 200 jobs in 2012) and a rise in real wages. Some of the regional benefit is choked off by rising prices – particularly since there is an assumed lag before the dam becomes operational. We assume that yield increase arising from the dam only occurs in 2015. This means that capital constructed during the investment phase is idle until then. Within the model, idle capital contributes to a technological deterioration, which reduces both real disposable income and aggregation consumption in the Lower Hunter Valley in 2014 relative to forecast.

The regional boost to employment during the construction phase in this project is smaller than the lasting boost that occurs during the operational phase. This is because increasing the water resource in the Lower Hunter Valley relative to forecast initially raises the productivity of labour and capital in the region. This induces additional inward migration of other labour from other regions, plus additional investment.

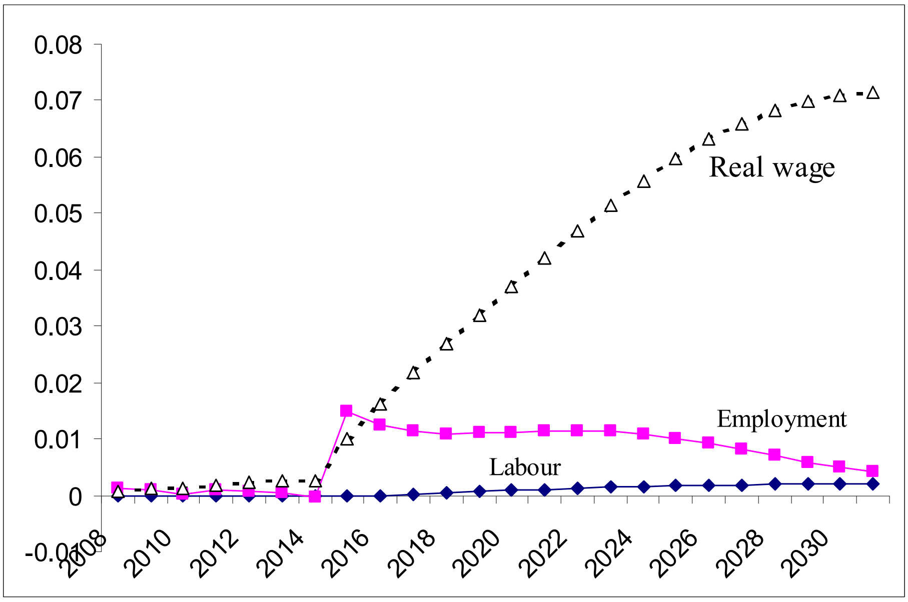
Figure 1: Lower Hunter Valley's labour market
(% change relative to forecast)



The investment phase strengthens Lower Hunter Valley's labour market, with rising employment choked off in 2014 by rising real wages. The technological improvement that arises from the dam becoming operational in 2015 strengthens the labour market further. Since wages are sticky, labour supply and demand (i.e., employment) converge slowly over time. In addition, the regional labour market continues to strengthen relative to forecast. This is because baseline water scarcity is worsening year by year. Each year from 2015 brings a marginal benefit relative to forecast from the dam as water scarcity from a fixed resource worsens with economic growth. Real wages do not stop increasing relative to forecast until 2031, when labour supply and demand are equalised relative to forecast – although in the preceding years, the deviations from forecast are low in percentage terms (figure 1). Between 2015 and 2031, employment in the Lower Hunter Valley is around 0.1% or between 200 and 300 jobs higher than in the baseline forecast.[2]

Figures 2 and 3 shows the respective impacts on the labour markets of the rest of New South Wales and rest of Australia. The dynamic labour market theory within TERM allows national employment to rise temporarily above forecast in the short run. This occurs at the beginning of the construction phase and then in the initial year of the operational phase (2015). Thereafter, rising real wages relative to forecast bring national employment back in line with baseline levels. The project raises the real wages of all regions relative to forecast, but in keeping with the theory of imperfect regional labour market adjustment, has the largest real wages impact in the Lower Hunter Valley.

Figure 2: Rest of New South Wales's labour market
(% change relative to forecast)



[2] If the benefit occurred as a one-off in 2015, labour supply and employment would reach an equilibrium more quickly. The marginal benefit each year of the dam strengthens the regional labour market relative to forecast, delaying the equilibrium.

Figure 3: Rest of Australia's labour market
(% change relative to forecast)

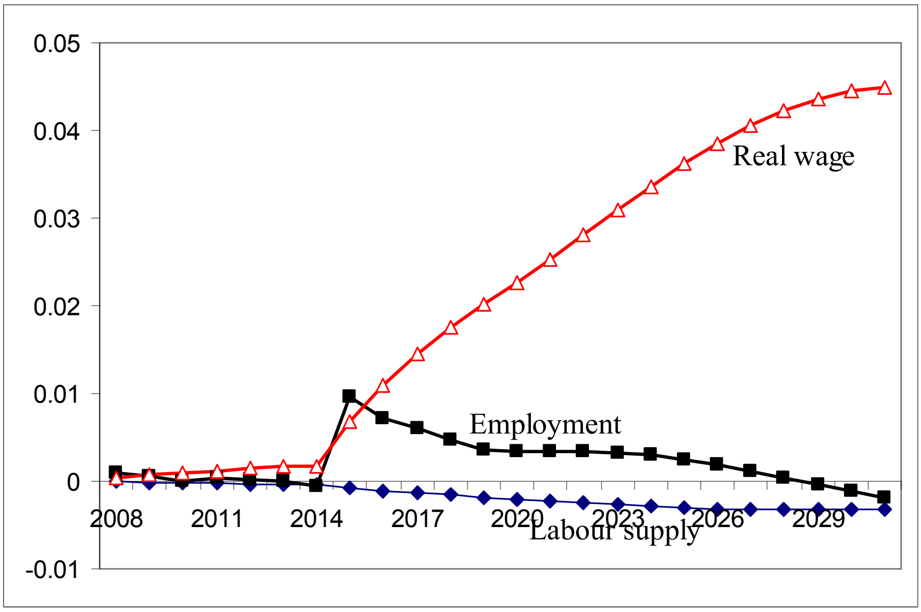
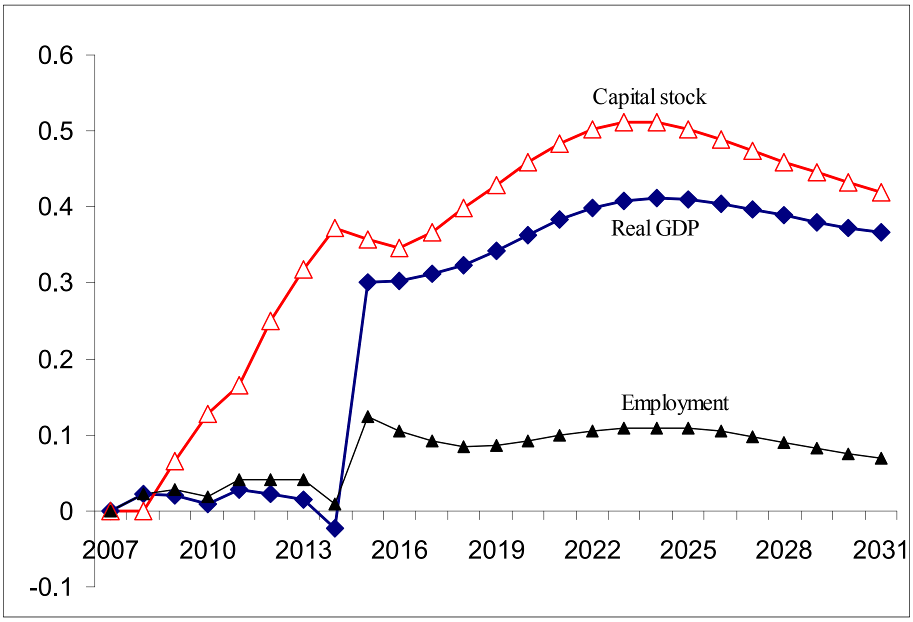


Figure 4: Capital, employment and real GDP in Lower Hunter Valley
(% change relative to forecast)



Next, we examine the deviation in real GDP from forecast in the Lower Hunter Valley. The increase in employment relative to forecast during the construction phase is accompanied by a build-up in capital stocks due to dam construction. However, the additional capital is idle until 2015; before then, there is technological deterioration as more factors are used to produce the same real GDP. The technological improvement implied by the dam becoming operational results in a jump in regional real GDP in 2015. The enhancement in Lower Hunter Valley's competitiveness relative to forecast each year (as the dam alleviates ever-worsening scarcity in the region year by year) results in labour and capital being drawn in the operational phase, raising real GDP further to forecast (figure 4). The national income-side impacts are shown in figure 5.

Figure 5: Capital, employment and real GDP -- national
(% change relative to forecast)

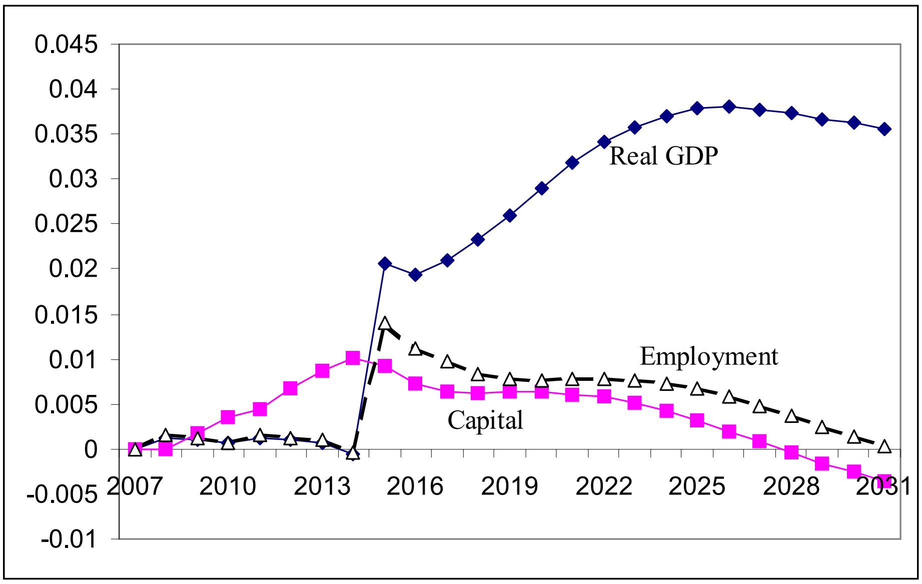
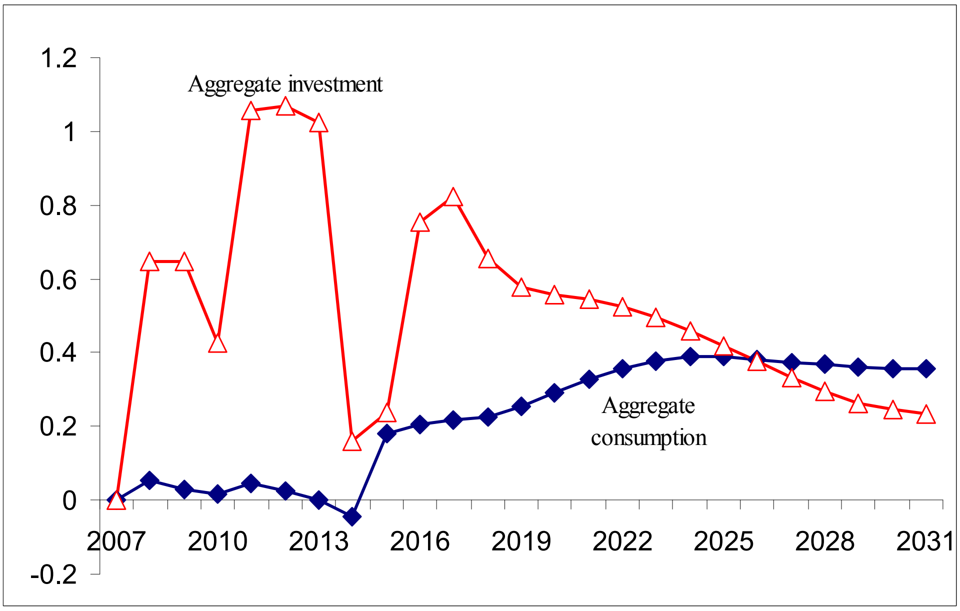


Figure 6: Lower Hunter Valley's aggregate consumption and investment
(% change relative to forecast)



The assumed year-by-year investment in the project dips in 2009 and then jumps again in 2010, as reflected in the macro result for investment for the Lower Hunter Valley (Figure 6). Aggregate consumption in the region follows regional real GDP. In 2015, there is a jump in investment arising from the technological gain of Tillegra dam becoming operational. Thereafter, aggregate investment in Lower Hunter Valley gradually moves back towards forecast levels as the additional capital lowers rates-of-return towards forecast. Figure 7 shows the national impact on consumption and investment. Consumption continues to grow relative to forecast though eventually the marginal benefit of the dam diminishes (around 2025) and consumption moves slightly back towards forecast.

Figure 7: Aggregate consumption and investment -- national
(% change relative to forecast)

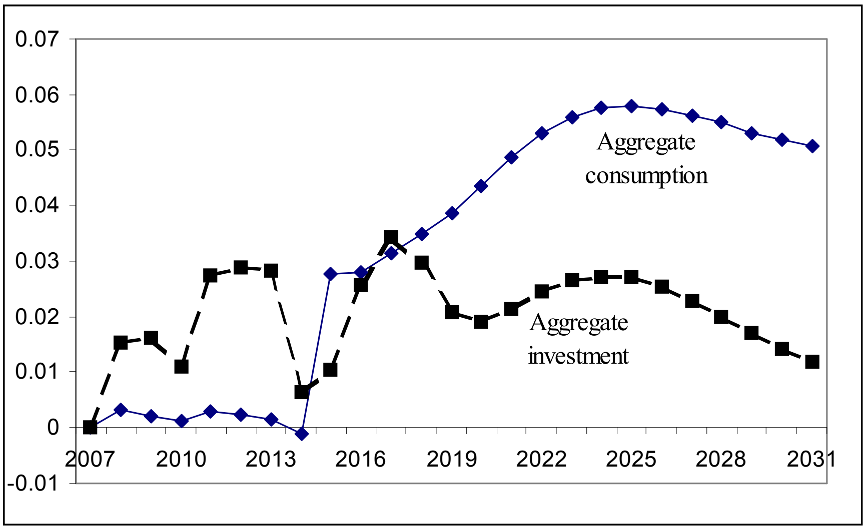
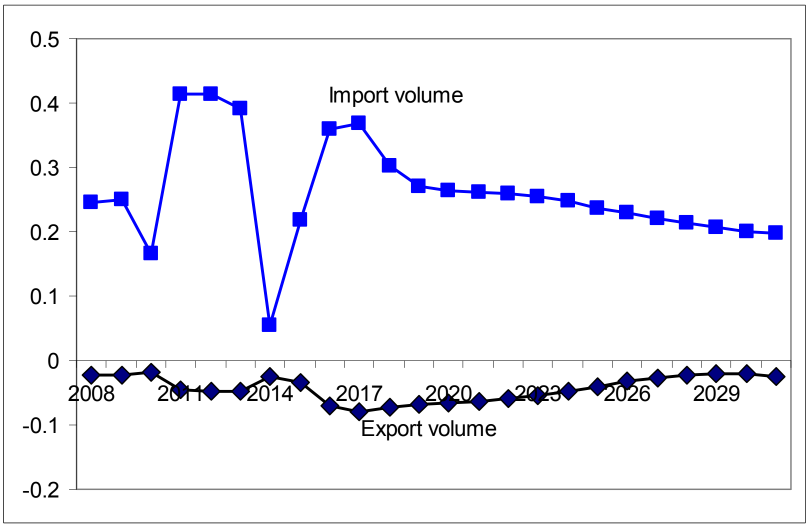
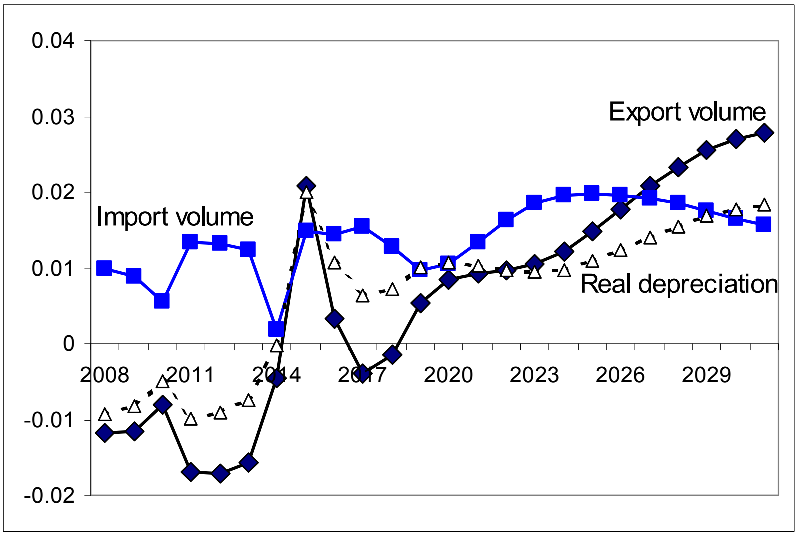


Figure 8: Lower Hunter Valley's international trade volumes
(% change relative to forecast)



The main impact on trade volumes in the Lower Hunter Valley is during the construction phase. Imports of construction materials rise (Figure 8). Less scarce water favours industries in the Hunter other than coal, the main export from the region. The region's coal sector therefore loses competitiveness slightly relatively to other Hunter sectors. But by reducing the national scarcity of water, the dam project enhances Australia's international competitiveness overall reflected in the real depreciation and rising export volumes relative to forecast after 2015 shown in figure 9.

Figure 9: Australia's international trade volumes
(% change relative to forecast)



Industry outputs

The gains arising in the operational phase in the Lower Hunter Valley are spread over many sectors. The sectors that do best in percentage terms relative to forecast are the services sectors with higher income elasticities of demand, arising from the increase in aggregate consumption in the region. Even sectors that do not benefit directly from an increased water resource, either through the direct productivity gain or via the income effect, eventually benefit through the real depreciation. For example, from 2020 onwards at the national level, mining output expands.

Table 2: Industry outputs, Lower Hunter Valley, % change relative to forecast

Hunter NSW	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
AgriForFish	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	-0.02	0.04	0.02	0.02	0.03	0.04	0.06	0.07	0.08	0.09	0.11	0.12	0.13	0.14	0.15	0.15	0.16	0.17
Mining	-0.01	-0.01	-0.01	-0.03	-0.04	-0.06	-0.07	-0.08	-0.10	-0.10	-0.10	-0.10	-0.09	-0.08	-0.07	-0.05	-0.04	-0.03	-0.02	-0.02	-0.02	-0.03	-0.04	-0.05
FoodBeTob	-0.03	-0.03	-0.03	-0.06	-0.06	-0.07	-0.05	0.03	-0.01	-0.01	0.00	0.01	0.02	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.06	0.06
OtherManuf	0.00	0.00	-0.01	0.00	-0.01	-0.01	-0.02	0.08	0.05	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.04	0.03	0.03
Metals	-0.02	-0.02	-0.02	-0.05	-0.05	-0.06	-0.05	-0.04	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
Utilities	-0.01	-0.01	-0.01	-0.03	-0.04	-0.05	-0.05	-0.04	-0.06	-0.06	-0.05	-0.04	-0.02	0.00	0.02	0.05	0.07	0.08	0.09	0.10	0.10	0.09	0.09	0.07
WaterDrains	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Construction	0.17	0.18	0.11	0.31	0.32	0.30	0.02	0.06	0.28	0.45	0.59	0.69	0.78	0.82	0.83	0.80	0.74	0.63	0.52	0.42	0.33	0.28	0.24	0.23
Trade	0.08	0.08	0.05	0.13	0.13	0.12	0.01	0.12	0.15	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.11	0.11	0.10	0.10
HotelsCafes	0.01	0.00	-0.01	-0.01	-0.03	-0.04	-0.05	0.10	0.08	0.08	0.11	0.14	0.18	0.21	0.24	0.26	0.28	0.28	0.28	0.27	0.26	0.24	0.23	0.21
Transport	-0.03	-0.03	-0.02	-0.04	-0.05	-0.05	-0.04	0.01	-0.02	-0.02	-0.01	-0.01	0.00	0.02	0.03	0.04	0.05	0.06	0.07	0.07	0.07	0.07	0.06	0.05
Commnication	-0.01	-0.01	-0.01	-0.03	-0.04	-0.04	-0.04	-0.01	-0.03	-0.02	0.00	0.02	0.05	0.08	0.11	0.14	0.17	0.19	0.19	0.21	0.21	0.20	0.19	0.18
PropBusSrvc	-0.02	-0.02	-0.02	-0.05	-0.05	-0.06	-0.06	0.07	0.04	0.06	0.09	0.14	0.19	0.24	0.28	0.31	0.34	0.35	0.36	0.36	0.36	0.35	0.34	0.33
FinancInsur	-0.02	-0.02	-0.02	-0.05	-0.06	-0.07	-0.07	0.05	0.01	0.03	0.06	0.09	0.13	0.16	0.19	0.21	0.23	0.24	0.25	0.26	0.26	0.26	0.26	0.26
OwnerDwellng	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	0.03	0.07	0.11	0.16	0.21	0.27	0.32	0.36	0.40	0.43	0.45	0.46	0.46	0.47
GovAdminDef	-0.03	-0.03	-0.02	-0.05	-0.05	-0.05	-0.03	-0.01	-0.04	-0.04	-0.04	-0.04	-0.04	-0.05	-0.05	-0.06	-0.06	-0.07	-0.07	-0.08	-0.08	-0.08	-0.08	-0.08
Education	0.00	-0.02	-0.02	-0.04	-0.05	-0.06	-0.05	0.01	-0.03	-0.05	-0.05	-0.06	-0.07	-0.08	-0.09	-0.10	-0.11	-0.12	-0.13	-0.14	-0.15	-0.16	-0.16	-0.16
HealthComSrv	0.01	0.00	-0.01	0.00	-0.01	-0.03	-0.03	0.03	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.01	0.00	0.00	-0.01	-0.01
CultRecSrvc	-0.01	-0.02	-0.02	-0.04	-0.05	-0.06	-0.06	0.07	0.04	0.03	0.03	0.03	0.04	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.04	0.04	0.03	0.03
PersOthSrvc	0.02	0.00	-0.01	-0.01	-0.03	-0.05	-0.07	0.17	0.16	0.15	0.15	0.16	0.17	0.18	0.18	0.18	0.17	0.16	0.15	0.13	0.12	0.11	0.11	0.10

Table 3: Industry outputs, Australia, % change relative to forecast

HunterNSW	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
AgriForFish	-0.002	-0.002	-0.001	-0.002	-0.002	-0.002	-0.001	0.010	0.007	0.007	0.008	0.009	0.011	0.013	0.014	0.015	0.017	0.018	0.019	0.019	0.020	0.020	0.021	0.021
Mining	-0.001	-0.001	-0.002	-0.004	-0.005	-0.006	-0.007	-0.004	-0.007	-0.006	-0.003	-0.001	0.002	0.004	0.007	0.010	0.012	0.015	0.017	0.020	0.021	0.023	0.024	0.025
FoodBeTob	-0.003	-0.003	-0.002	-0.004	-0.004	-0.004	-0.002	0.019	0.012	0.011	0.012	0.016	0.018	0.020	0.021	0.022	0.023	0.024	0.025	0.025	0.025	0.025	0.025	0.025
OtherManuf	-0.002	-0.003	-0.002	-0.004	-0.004	-0.004	-0.002	0.025	0.015	0.012	0.014	0.018	0.021	0.023	0.025	0.026	0.027	0.028	0.029	0.029	0.030	0.030	0.030	0.030
Metals	-0.006	-0.005	-0.004	-0.008	-0.009	-0.009	-0.006	0.009	0.002	0.001	0.003	0.006	0.009	0.011	0.012	0.014	0.015	0.017	0.019	0.020	0.021	0.021	0.022	0.022
Utilities	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.002	0.012	0.009	0.011	0.015	0.019	0.024	0.028	0.031	0.034	0.036	0.037	0.037	0.036	0.035	0.033	0.031	0.029
WaterDrains	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.679	0.678	0.678	0.677	0.676	0.674	0.673	0.672	0.670	0.669	0.667	0.665	0.663	0.662	0.660	0.658	0.656
Construction	0.006	0.008	0.005	0.013	0.014	0.013	0.002	0.003	0.024	0.036	0.045	0.053	0.061	0.068	0.074	0.077	0.077	0.075	0.069	0.062	0.055	0.048	0.042	0.038
Trade	0.003	0.003	0.001	0.004	0.004	0.003	0.000	0.019	0.014	0.013	0.013	0.014	0.016	0.018	0.020	0.022	0.023	0.024	0.024	0.024	0.024	0.023	0.023	0.022
HotelsCafes	0.004	0.003	0.001	0.003	0.002	0.001	-0.002	0.021	0.021	0.023	0.026	0.029	0.033	0.038	0.041	0.042	0.043	0.042	0.041	0.038	0.036	0.034	0.032	0.030
Transport	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	0.012	0.010	0.010	0.012	0.014	0.016	0.017	0.019	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.020	0.020
Commnication	0.001	0.000	0.000	0.000	0.000	0.000	-0.001	0.015	0.012	0.014	0.018	0.022	0.027	0.030	0.033	0.035	0.036	0.037	0.036	0.035	0.034	0.032	0.031	0.029
PropBusSrvc	0.001	0.000	0.000	0.001	0.001	0.000	0.000	0.018	0.019	0.021	0.024	0.026	0.029	0.031	0.033	0.033	0.034	0.034	0.033	0.033	0.032	0.031	0.031	0.030
FinancInsur	0.001	0.001	0.000	0.001	0.001	0.001	-0.001	0.017	0.016	0.018	0.021	0.024	0.028	0.031	0.034	0.035	0.036	0.036	0.035	0.034	0.033	0.032	0.030	0.029
OwnerDwellng	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.003	0.007	0.011	0.016	0.022	0.028	0.034	0.040	0.046	0.051	0.056	0.059	0.062	0.063	0.064
GovAdminDef	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Education	0.000	-0.001	-0.001	-0.002	-0.003	-0.003	-0.002	0.014	0.010	0.009	0.009	0.011	0.013	0.014	0.015	0.015	0.015	0.014	0.014	0.014	0.013	0.013	0.012	0.012
HealthComSrv	0.001	0.001	0.000	0.001	0.000	0.000	-0.001	0.010	0.009	0.009	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.012	0.011	0.010	0.009	0.008	0.008	0.007
CultRecSrvc	0.003	0.002	0.001	0.003	0.002	0.001	-0.001	0.022	0.021	0.024	0.026	0.028	0.032	0.036	0.038	0.040	0.040	0.039	0.037	0.035	0.033	0.031	0.030	0.029
PersOthSrvc	0.003	0.002	0.001	0.002	0.002	0.000	-0.002	0.027	0.025	0.027	0.028	0.030	0.033	0.036	0.038	0.038	0.038	0.036	0.034	0.031	0.029	0.026	0.025	0.023

Welfare impacts and sensitivity analysis

Economists often use a single number to evaluate the potential net benefits of a project. This is referred to as the welfare gain. This is calculated as the year-by-year increase in national household spending due to the project, relative to business-as-usual household spending. The calculation of year-by-year household spending is based on disposable income after accounting for interest payments on net foreign debt. We assume in the model that finance is borrowed from foreigners to fund construction. This implies that national debt may rise in the future at the same as additional production capacity rises due to the project.[3] Therefore, some of the additional income generated by the project must be paid in interest to foreigners. A consumption function links aggregate consumption (on which we base the welfare calculation) to disposable income in each region. We usually calculate the welfare benefit at the national level, as inter-regional migration tends to confound regional calculations of welfare.

In calculating the welfare benefit of the project, the most critical assumption concerns baseline forecast water availability. We assume in the core policy scenario that water savings throughout Australia average 1% per annum for each user. At the same time, we assume that in the rest of Australia (that is, all regions other than Lower Hunter Valley) active measures are being taken to supplement existing water supplies. These measures may include increased recycling, increased urban stormwater catchment, greater use of rainwater tanks, construction of desalination plants and dam construction. We assume that these measures undertaken in the rest of Australia increased water availability by 2% per annum. These assumptions reflect at the very least moderately worsening water scarcity throughout Australia, but an increase in aggregate water usage made possible by supplementation of existing supplies outside the Lower Hunter Valley. That is, sustained population and economic growth result in increased demand for water that is not quite matched by increased supply. In later years of the baseline forecast, economic growth slows so that the gap between water demand and supply closes slightly, reducing the net benefit of Tillegra dam.

The net present value (the discounted sum of future year-by-year household spending gains) of the welfare gain arising from the project is $3,000 million, based on the water resource scenario outlined in the previous paragraph.

The Hunter Water report (2007, p. 13-14) provides some background on how the usefulness of supply supplementation depends critically on rainfall conditions – in the context of constructing a desalination plant. A similar issue applies to building a dam: if there is no prolonged period of drought, the need to increase dam capacity so as to attain a minimum yield is reduced. However, once a dam has been constructed, it will increase the minimum water yield of a catchment within a region for many decades to come, thereby helping deal with the risk of drought far into the future. In this study, we have measured the welfare benefit by assuming that the dam increases the supply of water when the baseline forecast includes worsening scarcity of water. Alternative analysis, that does not fit the CGE modelling framework readily, might be to measure

[3] Dynamic TERM links investment flows and capital stocks year by year, with similar linkages for international trade balances and international debt.

the benefits of the dam in terms of reducing the risk of water deficiencies in the future.

Alternative assumption (water is not scarce in the rest of Australia in the long term)

An alternative and, we believe, less realistic assumption is that in regions of Australia other than the Lower Hunter Valley, water availability grows in line with economic growth. That is, water supply supplementation is sufficient to meet additional effective demands over time, so that the scarcity of water does not worsen with economic growth. At the same time, we assume a 1% saving in water requirement per unit of activity by all users as before. If there are no significant water resource constraints in the rest of Australia, the economic benefit of Tillegra dam would be much smaller than that modelled using our core assumption – around $500 million. That is, the project can still be justified on economic grounds if the Lower Hunter Valley is the only region of Australia likely to suffer worsening water scarcity in the future.

The Hunter Water (2007) report discusses in some detail estimates of future water savings and increase supplies from other sources. Supposing we disregarded such estimates entirely, by devising a scenario in which there is no gradual worsening of water scarcity, or in which droughts disappear from the region so that minimum water yields in the region rise without any further water infrastructure construction. It would be possible in such scenarios to model zero or negative welfare gains from Tillegra dam. These scenarios – at least over several decades – seem implausible.

References

Hunter Water, *Why Tillegra now?* August 2007. Downloaded from *www.hunter.water.au/files/TillegraWhyNowPaper.pdf*

Appendix A: Baseline macro growth assumptions

NSW	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023-2031
Real GDP	4.4	3.8	2.5	2.7	3.6	3.4	2.2	2.1	2.9	2.8	2.6	2.5	2.5	2.5	2.5	2.4
Aggregate consumption	1.0	1.4	2.2	1.9	2.8	2.7	2.1	2.0	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.0
Import Volumes	7.8	4.9	1.8	3.0	2.3	1.4	0.9	1.3	2.9	2.7	4.7	4.6	4.6	4.5	4.5	4.4
Employment	1.8	1.4	0.8	1.1	1.3	1.1	0.5	0.0	0.1	0.3	1.0	1.0	1.0	1.0	0.9	0.9
Govt consumption	3.1	2.6	2.0	2.0	2.5	2.0	1.3	1.4	2.8	3.3	2.3	2.3	2.3	2.2	2.2	2.2
Aggregate investment	10.3	6.0	2.5	2.6	3.1	0.8	-1.6	-0.2	4.4	4.6	2.7	2.7	2.7	2.6	2.6	2.6

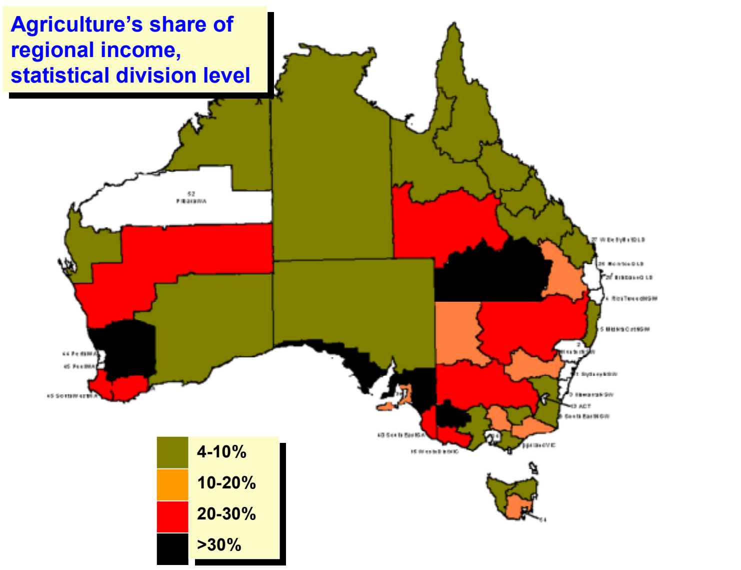
Rest of Australia	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023-2031
Real GDP	4.7	4.0	3.2	3.1	3.8	3.6	2.4	2.5	3.1	2.8	3.3	3.3	3.3	3.2	3.2	3.2
Aggregate consumption	3.5	2.9	3.3	2.9	3.6	3.3	2.7	2.5	2.6	2.4	3.2	3.1	3.1	3.1	3.0	3.0
Import Volumes	13.1	5.6	1.8	3.0	2.4	1.6	1.1	1.5	3.1	2.9	5.0	4.9	4.9	4.8	4.8	4.8
Employment	2.3	1.9	1.5	1.3	1.4	1.2	0.6	0.2	0.2	0.5	1.6	1.6	1.6	1.5	1.5	1.5
Govt consumption	4.0	3.2	1.4	2.0	2.6	2.2	1.4	1.6	3.0	3.5	2.9	2.9	2.8	2.8	2.8	2.7
Aggregate investment	8.9	4.2	-3.0	0.0	1.7	0.3	-1.7	-0.2	4.2	4.4	3.6	3.5	3.5	3.5	3.4	3.4

Appendix B: The TERM Model
(http://monash.edu.au/policy/term.htm)

TERM (**T**he **E**normous **R**egional **M**odel) is a "bottom-up" CGE model of Australia which treats each region as a separate economy. The key feature of TERM, in comparison to predecessors such as MMRF (Monash Multi-regional Forecasting Model), is its ability to handle a greater number of regions or sectors. The TERM master database distinguishes 169 sectors and 59 regions (the Australian Statistical Divisions). The high degree of regional detail makes TERM a useful tool for examining the regional impacts of shocks that may be region-specific. Finally, TERM has a particularly detailed treatment of transport costs and is naturally suited to simulating the effects of improving particular road or rail links.

We have modified the master database in this application of TERM to exclude statistical local areas of the Upper Hunter Valley from the main Hunter region. The Upper Hunter regions are part of a separate water region whose main users are irrigators, not urban.

Figure 1: Example of detail available from the TERM database



Variable aggregation facility

Even though TERM is computationally efficient, it would be slow to solve if a full 169-sector, 59-region database were used. In practice, we must aggregate sectors or regions to manageable dimensions. The TERM database programs facilitate this aggregation. The choice of sectors or regions to aggregate is application-specific. For example, we could design aggregated regions which followed the boundaries of climatic zones or watersheds, or which highlighted the distinction between metropolitan and rural regions. Similarly the sectoral aggregation would be tailored to a particular simulation.

Labour market theory

This section outlines the theory of labour market adjustment which is crucial in the modelled employment impacts of the present study. The regional labour market adjustment mechanism, in levels, is given by:

$$\left(\frac{W_t^r}{Wf_t^r}-1\right)=\left(\frac{W_{t-1}^r}{Wf_{t-1}^r}-1\right)+\alpha\left(\frac{EMP_t^r}{EMPf_t^r}-\frac{LS_t^r}{LSf_t^r}\right) \qquad (1)$$

The interpretation of (1) is that if the deviation shock weakens the labour market in region *r* and period *t* relative to forecast, real wages W_t^r in deviation will fall relative to forecast Wf_t^r. In addition, there will be an initial enlarged gap between labour market demand EMP_t^r and supply LS_t^r, relative to forecast levels $EMPf_t^r$ and LSf_t^r. In successive years, the gap between demand and supply will gradually return to forecast through a further decline in real wages. The speed of labour market adjustment is governed by α, a positive parameter.

The regional labour supply equation is:

$$\frac{LS_t^r}{LSf_t^r}=\frac{\left(W_t^r\right)^\gamma}{\sum_q\left(W_t^q\right)^\gamma S_t^q}\Bigg/\frac{\left(Wf_t^r\right)^\gamma}{\sum_q\left(Wf_t^q\right)^\gamma Sf_t^q} \qquad (2)$$

The deviation in regional labour supply from forecast depends on the deviation in regional relative to national real wages from forecast. In (2), $\sum_q\left(W_t^q\right)^\gamma S_t^q$ is a measure of labour responsiveness to real wages summed across all regions, where γ is a positive parameter and S_t^q is the share of region *q* in national employment. Should the deviation in real wages from forecast fall in a particular region relative to the situation nationally, this equation implies that labour supply in the particular region will fall, while in other regions it will rise. Combining (1) and (2), adjustment in the labour market in a given region will initially occur via a combination of additional unemployment and lower real wages. Unemployment will eventually return to forecast rates, with lower real wages. As real wages fall relative to the base case, the region's labour supply will also fall. Within this theory, long run labour market adjustment occurs as a combination of inter-regional labour migration and changes in regional real-wage differentials.

Applications of TERM

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