Economic Analysis
for the
Blue Infrastructure Initiative

A report to

The Nature Conservancy, Primary Industries and Regions South Australia and Department of Environment, Water and Natural Resources

Prepared by

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29 February 2016

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CONTENTS

TABLES

ABBREVIATIONS

ABS	Australian Bureau of Statistics
DEWNR	Department of Environment, Water and Natural Resources
fte	full-time equivalent
GRP	Gross Regional Product
GSP	Gross State Product
I-O	input-output
PIRSA	Primary Industries and Regions SA
SA	South Australia
TNC	The Nature Conservancy
TRA	Tourism Research Australia
WTP	willingness to pay

DOCUMENT HISTORY AND STATUS

Doc Ver	Doc Status	Issued To	Qty elec	Qty hard	Date	Reviewed	Approved
1	Draft	Heidi Alleway, Chris Gillies	1 Word 1 PDF	-	22/2/16	JBM	JBM
2	Final	Heidi Alleway, Chris Gillies	1 Word 1 PDF	-	29/2/16	JBM	JBM

Printed:	29/02/2016 5:40:00 PM
Last Saved:	29/02/2016 5:40:00 PM
File Name:	S:\1_Projects\Current\1562_Reef Restoration\Reports\Reef restoration_Final_160229.docx
Project Manager:	Julian Morison
Authors:	Heather Bailey, Julian Morison
Name of Client:	The Nature Conservancy, Primary Industries and Regions SA and Department of Environment, Water and Natural Resources
Name of Project:	Economic Analysis for the Blue Infrastructure Initiative
Document Version:	2
Job Number:	1562

EXECUTIVE SUMMARY

Background

Native oyster reefs have been lost across more than 1,500km of the South Australian coastline. The current poor status of shellfish reefs worldwide has recently been realised, along with the significant contribution that this habitat makes to the health and productivity of coastal environments. Australia has just launched its approach to shellfish reef restoration, through the interest of state governments, industries and communities, with the leadership and support of the international non-profit organization, The Nature Conservancy (TNC), through their Great Southern Seascapes program.

Under this framework, Primary Industries and Regions SA (PIRSA) and the Department of Environment, Water and Natural Resources (DEWNR) are developing the Blue Infrastructure Initiative in South Australia. The Blue Infrastructure Initiative intends to restore historically damaged reefs in state waters. Two proposals are being considered. One proposal aims to fund the restoration of 100 ha of reef in total, 20 ha each in the following areas: Kangaroo Island, near Port Willunga, Ardrossan, near Port Lincoln and Ceduna. The second proposal aims to fund the restoration of 50 ha of reef in total limited to the Gulf St Vincent sites (i.e. Kangaroo Island (20 ha), near Port Willunga (10 ha) and Ardrossan (20 ha)).

TNC, PIRSA and DEWNR commissioned EconSearch to assess the economic impact of the proposed Blue Infrastructure Initiative and to quantify the economic value of the ecosystem services generated by the restoration of these reefs through the Initiative.

Method of Analysis

The regional economic impacts are estimated using an extension of the conventional I-O method. Over the past decade EconSearch has developed an extended I-O model known as the RISE model (Regional Industry Structure & Employment). The RISE model provides a comprehensive economic framework that is extremely useful in the resource planning process, particularly for regional economic impact applications. The indicators used in impact analysis typically include employment, contribution to household income and contribution to gross regional and gross state product (GRP, GSP) which are used in this report.

Estimation of the economic value of ecosystem services was based on 'benefit transfer'. A calculated benefit derived from an existing study was used, with appropriate manipulations, to estimate a value to South Australian community of the ecosystem services provided by restored reefs.

Estimated number of restoration jobs created

The estimates of economic impact (jobs) of the Blue Infrastructure Initiative expenditure are provided in Table 3-1 ES-1 (100 ha of reef restored) and Table ES-2 (50 ha of reef restored).

Table ES-1 Estimated number of jobs created by Blue Infrastructure Initiative expenditure, 100 ha[a]

	Employment (fte jobs) [a]				
	2016-17	2017-18	2018-19	2019-20	Average
Kangaroo Island					
Direct	7	7	4	2	5
Flow-on	1	1	1	0	1
Total [b]	**7**	**8**	**4**	**3**	**6**
Southern Adelaide					
Direct	5	6	2	1	3
Flow-on	3	5	2	0	3
Total [b]	**8**	**11**	**4**	**1**	**6**
Yorke Peninsula					
Direct	6	7	3	2	4
Flow-on	3	4	2	1	2
Total [b]	**9**	**11**	**5**	**2**	**7**
Eyre & Western					
Direct	15	16	8	6	11
Flow-on	8	10	6	3	7
Total [b]	**23**	**27**	**14**	**9**	**18**
Rest of SA					
Direct	3	3	3	2	3
Flow-on	16	20	12	6	13
Total [b]	**19**	**24**	**15**	**8**	**17**
South Australia					
Direct	36	40	20	13	27
Flow-on	31	40	22	10	26
Total [b]	**67**	**80**	**42**	**23**	**53**

[a] Full-time equivalent.

[b] Totals may not sum due to rounding.

Source: EconSearch analysis.

For the 100 ha option, a total investment of $24.7 million over 4 years generates an estimated total of 212 fte jobs in South Australia over the same period (i.e. an average of 53 fte per year, Table ES-1), 109 direct fte jobs and 103 fte jobs in flow-on activity (Table ES-1). For each of the regions, the following jobs impacts are estimated:

- For a total expenditure of $4.5 million within the region over 4 years, 20 direct fte jobs, 3 flow-on fte jobs and 23 fte jobs in total (i.e. an average of 6 fte per year, Table ES-1) are estimated to be created within the Kangaroo Island regional economy
- For a total expenditure of $3.5 million within the region over 4 years, 14 direct fte jobs, 11 flow-on fte jobs and 25 fte jobs in total (i.e. an average of 6 fte per year, Table ES-1) are estimated to be created within the Southern Adelaide regional economy

- For a total expenditure of $4.0 million within the region over 4 years, 18 direct fte jobs, 9 flow-on fte jobs and 27 fte jobs in total (i.e. an average of 7 fte per year, Table ES-1) are estimated to be created within the Yorke Peninsula regional economy
- For a total expenditure of $10.1 million within the region over 4 years, 45 direct fte jobs, 27 flow-on fte jobs and 72 fte jobs in total (i.e. an average of 18 fte per year, Table ES-1) are estimated to be created within the Eyre and Western regional economy.

Table ES-2 Estimated number of jobs created by Blue Infrastructure Initiative expenditure, 50 ha[a]

	Employment (fte jobs) [a]				
	2016-17	2017-18	2018-19	2019-20	Average
Kangaroo Island					
Direct	5	6	3	2	4
Flow-on	1	1	1	0	1
Total [b]	**6**	**7**	**4**	**2**	**5**
Southern Adelaide					
Direct	3	3	2	1	2
Flow-on	2	3	2	1	2
Total [b]	**5**	**6**	**3**	**2**	**4**
Yorke Peninsula					
Direct	5	6	3	2	4
Flow-on	3	4	2	1	2
Total [b]	**7**	**9**	**5**	**3**	**6**
Eyre & Western					
Direct	1	1	1	0	1
Flow-on	1	1	1	0	0
Total [b]	**1**	**1**	**1**	**0**	**1**
Rest of SA					
Direct	3	3	3	3	3
Flow-on	9	12	7	3	8
Total [b]	**11**	**14**	**10**	**6**	**10**
South Australia					
Direct	17	19	11	8	14
Flow-on	14	19	12	5	13
Total [b]	**31**	**38**	**23**	**13**	**26**

[a] Full-time equivalent.

[b] Totals may not sum due to rounding.

Source: EconSearch analysis.

For the 50 ha option, a total investment of $12.3 million over 4 years generates an estimated total of 105 fte jobs in SA over the same period (i.e. an average of 26 fte per year, Table ES-2), 55 direct fte jobs and 51 fte jobs in flow-on activity. For each of the regions, the following jobs impacts are estimated:

- For a total expenditure of $4.0 million within the region over 4 years, 17 direct fte jobs, 2 flow-on fte jobs and 19 fte jobs in total (i.e. an average of 5 fte per year, Table ES-2) are estimated to be created within the Kangaroo Island regional economy
- For a total expenditure of $2.1 million within the region over 4 years, 14 direct fte jobs, 11 flow-on fte jobs and 25 fte jobs in total (i.e. an average of 4 fte per year, Table ES-2) are estimated to be created within the Southern Adelaide regional economy
- For a total expenditure of $3.7 million within the region over 4 years, 15 direct fte jobs, 9 flow-on fte jobs and 24 fte jobs in total (i.e. an average of 6 fte per year, Table ES-2)are estimated to be created within the Yorke Peninsula regional economy
- For a total expenditure of $0.5 million within the region over 4 years, 2 direct fte jobs, 2 flow-on fte jobs and 4 fte jobs in total (i.e. an average of 1 fte per year, Table ES-2) are estimated to be created within the Eyre and Western regional economy.

A comparison of job creation on the South Australian economy per $1 million invested for various industries is provided in Table ES-3. Whilst the estimates presented in Table ES-3 are indicative only, as they are based on individual projects only, they do suggest that reef restoration is a labour intensive activity and generates relatively high numbers of jobs during the construction phase compared to other development/construction activities.

Table ES-3 Comparison of job creation per $1 million invested for various industries, South Australia [a]

Investment activity	Direct	Flow-on	Total
Reef restoration - 100 ha	4.4	4.2	8.6
Reef restoration - 50 ha	4.5	4.1	8.5
Horticulture expansion	2.4	2.4	4.8
Sporting complex development	1.8	3.1	4.9
Building retrofits	3.1	1.7	4.7
Regional airport upgrade	1.2	0.2	1.4
Mine development	1.7	0.8	2.5
Major road upgrade	2.8	3.1	5.9

[a] Full-time equivalent employment generated by the construction phase of these investment activities.

Source: EconSearch analysis.

Long-term[1] impacts from increased fishing tourism

The expected long-term annual economic impact of restoring 20 ha of reef off Kangaroo Island on the Kangaroo Island regional economy is:

- Contribution to GRP ranging from $1.7 million to $5.0 million, 0.62 to 1.85 per cent of GRP

[1] In approximately 10 years' time.

- Contribution to regional employment ranging from 12 to 37 fte jobs, 0.56 to 1.67 per cent of regional employment.

The expected long-term annual economic impact of restoring 20 ha of reef off Port Willunga (100 ha option) on the Southern Adelaide regional economy is:

- Contribution to GRP ranging from $0.5 million to $1.5 million, 0.004 to 0.013 per cent of GRP
- Contribution to regional employment ranging from 4 to 11 fte jobs, 0.004 to 0.013 per cent of regional employment.

The expected long-term annual economic impact of restoring 10 ha of reef off Port Willunga (50 ha option) on the Southern Adelaide regional economy is:

- Contribution to GRP ranging from $0.3 million to $1.0 million, 0.003 to 0.008 per cent of GRP
- Contribution to regional employment ranging from 3 to 8 fte jobs, 0.003 to 0.009 per cent of regional employment.

The expected long-term annual economic impact of restoring 20 ha of reef off Ardrossan on the Yorke Peninsula regional economy is:

- Contribution to GRP ranging from $0.7 million to $2.0 million, 0.13 to 0.38 per cent of GRP
- Contribution to regional employment ranging from 6 to 17 fte jobs, 0.14 to 0.41 per cent of regional employment.

The expected long-term annual economic impact of restoring 20 ha of reef off Port Lincoln and 20 ha of reef off Ceduna on the Eyre and Western regional economy is:

- Contribution to GRP ranging from $1.9 million to $5.7 million, 0.05 to 0.14 per cent of GRP
- Contribution to regional employment ranging from 13 to 40 fte jobs, 0.05 to 0.16 per cent of regional employment.

The expected long-term annual economic impact of restoring 100 ha of reef on the SA economy is:

- Contribution to GSP ranging from $6.2 million to $18.7 million, 0.01 to 0.02 per cent of GSP
- Contribution to employment ranging from 43 to 129 fte jobs, 0.01 to 0.02 per cent of employment.

The expected long-term annual economic impact of restoring 50 ha of reef on the SA economy is:

- Contribution to GSP ranging from $3.9 million to $11.6 million, 0.004 to 0.012 per cent of GSP

- Contribution to employment ranging from 25 to 76 fte jobs, 0.004 to 0.011 per cent of employment.

Ecosystem services provided by Oyster Reefs

The following ecosystem services can be expected to be provided by the restored oyster reefs:

- Water filtration and concentration of biodeposits
- Provision of habitat for sea-floor dwelling fishes and other marine animals
- Augmentation of fish production
- Stabilisation of benthic (i.e. sea-floor) habitat
- Production of food
- Sequestration of carbon
- Contribution to seascape diversity.

Quantified environmental benefits

Present values of $50.0 million for the 100 ha option and $24.5 million for the 50 ha option were estimated using benefit transfer from an existing study. These estimates are indicative of the total value South Australians place in having healthy, restored reefs. Included in these estimates are a number of values held by South Australians. For example, they include use values (e.g. value to recreational fishing and other recreational activities both commercial and non-commercial), indirect use values derived from the ecosystem services provided (e.g. from the amenity of clearer water) and non-use values (e.g. values for preserving habitats, biodiversity and heritage arising from bequest, altruistic, stewardship and self-seeking motives).

1. INTRODUCTION

1.1 Background

Marine habitats underpin the productivity of coastal environments and industries. South Australia's commercial and recreational fisheries and aquaculture industry, as well as coastal tourism and associated services, rely on clean, healthy and intact environments. 'Blue infrastructure' is natural marine infrastructure, such as seagrasses, reefs, mangrove forests and beaches.

Native oyster reefs have been lost across more than 1,500km of the South Australian coastline (Alleway and Connell 2015). This loss likely contributed to declines in associated fisheries species and marine biodiversity that historically would have been abundant in this habitat.

The current poor status of shellfish reefs worldwide has recently been realised, along with the significant contribution that this habitat makes to the health and productivity of coastal environments. Shellfish reefs, including those formed by the native flat oyster, *Ostrea angasi*, are more than just a delicacy, oysters are nature's water filter – improving water quality as they filter algae and other nutrients. When growing as part of the reef, the oyster shells themselves provide a habitat for a range of other animals, such as small crabs, sea squirts, snails and sponges. The habitat and fisheries species associated with this formation mean that oyster reefs can be one of the most diverse and productive marine habitats, becoming, in effect, fish factories.

Australia has just launched its approach to shellfish reef restoration, through the interest of state governments, industries and communities, with the leadership and support of the international non-profit organization, The Nature Conservancy (TNC), through their Great Southern Seascapes program (Fitzsimmons et al. 2015).

Under this framework, Primary Industries and Regions SA (PIRSA) and the Department of Environment, Water and Natural Resources (DEWNR) are developing the Blue Infrastructure Initiative in South Australia. The Blue Infrastructure Initiative intends to restore historically damaged reefs in state waters. Two proposals are being considered. One proposal aims to fund the restoration of 100 ha of reef in total, 20 ha each in the following areas: Kangaroo Island, near Port Willunga, Ardrossan, near Port Lincoln and Ceduna. The second proposal aims to fund the restoration of 50 ha of reef in total limited to the Gulf St Vincent sites (i.e. Kangaroo Island (20 ha), near Port Willunga (10 ha) and Ardrossan (20 ha)).

1.2 Purpose and Scope of the Study

TNC, PIRSA and DEWNR commissioned EconSearch to assess the economic impact of the proposed Blue Infrastructure Initiative and to quantify the economic value of the ecosystem services generated by the restoration of these reefs through the Initiative.

The brief for the work required an assessment of economic impact on the state and on the regions in terms of the following indicators:

Construction phase (reef restoration)

- Number of jobs (impact on employment)

Operation phase (i.e. the long-term economic impact of restored reefs)

- Number of jobs (impact on employment)
- Contribution to households (impact on household income)
- Contribution to the economy (impact on gross state product (GSP)).

1.3 Report Structure

An outline of the methods and data employed in this study is provided in Section 2 of the report. The results of the economic impact analysis are detailed in Section 3. A discussion of the ecosystem services provided by oyster reefs and an initial estimates of the value to the South Australian community of these benefits is discussed in Section 4.

2. METHODS AND DATA

2.1 Economic Impact Analysis

The estimates of economic impact presented are based on the use of an extension of the conventional input-output method. Over the past decade EconSearch has developed an extended input-output model known as the RISE model (Regional Industry Structure & Employment). The RISE model provides a comprehensive economic framework that is extremely useful in the resource planning process, particularly for regional economic impact applications. The RISE I-O models of the South Australian and regional economies, constructed by EconSearch, are widely used by the South Australian (SA) Government (EconSearch 2015). RISE models for the State economy and Kangaroo Island, Southern Adelaide, Yorke Peninsula and Eyre and Western regional economies have been used in this assessment.

2.1.1 Economic activity

Economic activity indicators: the focus of the impact analysis is the generation/loss of economic activity resulting from the proposed Blue Infrastructure Initiative. The key economic activity indicators considered in the analysis are employment, contribution to gross regional/state product (GRP/GSP) and contribution to household income.

Economic impact: changes in economic activity are referred to as economic impacts. Generally, changes in *economic activity indicators* result from some stimulus or external shock imposed. In this analysis the concept of economic impact includes the likely increase in economic contribution from the construction and operation of the Blue Infrastructure Initiative. This *economic impact* is measured in terms of the *economic activity indicators* referred to above.

2.1.2 Indicators of economic activity defined

Employment units: Employment numbers are usually reported in either full time equivalent (fte) units or total job units defined as follows:

- *FTE*: is a way to measure a worker's involvement in a project or industry activity. An FTE of 1.0 means that the person is equivalent to a full-time worker, while an FTE of 0.5 signals that the worker is only half-time. Typically, different scales are used to calibrate this number, depending on the type of industry and scope of the analysis but the basic calculation is the total hours worked divided by average annual hours worked in full-time jobs.
- *Jobs*: is used to refer to the number of workers employed in an industry or on a project at any point in time. It typically refers to either:
    - the *maximum* number of workers required at any point over the analytical period or the duration of the project; or
    - the *average* number of workers required over the analytical period/duration of the project. This can be calculated on a daily, weekly, monthly or annual basis.

In this report employment has been reported in terms of FTE units on a per annum basis.

GRP/GSP: is a measure of the contribution of an activity to the economy. Contribution to GRP/GSP is measured as value of gross output (business revenue) less the cost of goods and services (including imports) used in producing the output. In other words, it can be measured as the sum of household income, gross operating surplus and gross mixed income net of payments to owner managers and taxes less subsidies on products and production. It represents payments to the primary inputs of production (labour, capital and land). Using contribution to GRP/GSP as a measure of economic impact avoids the problem of double counting that may arise from using value of output for this purpose.

Household income: is a component of GRP and is a measure of wages and salaries paid in cash and in kind, drawings by owner operators and other payments to labour including overtime payments, employer's superannuation contributions and income tax, but excluding payroll tax.

2.1.3 Categories of economic activity

Estimates of economic impact are presented in terms of:

- direct impacts
- flow-on impacts (comprised of production-induced and consumption-induced impacts)
- total impacts.

Direct (or initial) impacts are an estimate of the change in final demand or level of economic activity that is the stimulus for the total impacts.

Flow-on impacts are the sum of production-induced impacts, consumption-induced impacts and offsetting consumption effects.

Production-induced impacts are the sum of first-round impacts (i.e. estimates of the requirement for or purchases of goods and services from other sectors in the economy generated by the initial economic activity) and industrial support impacts (i.e. output and employment resulting from second, third and subsequent rounds of spending by firms). Production-induced impacts are sometimes referred to as 'indirect effects'.

Consumption-induced impacts are additional output and employment resulting from re-spending by households that receive income from employment in direct and indirect activities. Consumption-induced effects are sometimes referred to as 'induced effects'.

Offsetting consumption effects are 'lost' consumption expenditure by the local unemployed before taking a job or 'new' consumption expenditure of those losing a job as they shift to welfare payments.

Total impacts are the sum of direct and flow-on impacts.

2.1.4 Economic impact models

RISE models for the State economy and Kangaroo Island, Southern Adelaide, Yorke Peninsula and Eyre and Western regional economies were used for this assessment. The economic impact models are specified in terms of 78 intermediate sectors/industries. Sector specification in terms of the national input-output sectors is detailed in Appendix 1. An overview of economic impact analysis methodology is provided in Appendix 2.

In addition to the assumptions embodied in the input-output model itself (see Appendix 2), it was necessary to make a number of other general assumptions in estimating the economic impacts:

- The impacts were measured using a model that represent the structure of the regional economy for the year in which the most recent data are available (2013/14). However, over time there are likely to be improvements in primary factor productivity in this economy. To allow for the improvements an across-the-board (all sectors) labour productivity improvement rate of 1 per cent per annum have been incorporated into the modelling.
- When new jobs are created, it should be determined where the people come from to fill those jobs. In some cases the jobs will be taken by previously unemployed locals or by someone who is currently employed locally but whose own job is taken by a previously unemployed local. In both cases the impact of the newly created job and associated income is partially offset by the fact that someone who was previously receiving unemployment benefits is no longer doing so. To calculate this effect requires estimates of the parameter *rho* (see Appendix 2), the proportion of new jobs that are likely to be filled by previously unemployed locals. A r*ho* value of 0.90 for the regions and 0.95 for South Australia was used.

2.1.5 Data used in the economic impact analysis

Construction Phase

PIRSA provided data on the Blue Infrastructure Initiative costs, which are detailed in Table 2-1 and Table 2-2.

Table 2-1 Blue Infrastructure Initiative costs, 100 ha [a]

Program component	2016-17	2017-18	2018-19	2019-2020	Total
Program Management					
Salaries	349,320	349,320	349,320	237,390	1,285,350
Employee overhead	27,000	27,000	27,000	18,000	99,000
Corporate overhead	634,500	817,400	366,500	139,300	1,957,700
Industry Capacity Building & Extension	440,000	440,000	440,000	440,000	1,760,000
Reef design	103,000	0	0	0	103,000
Substrate					
Pacific oyster shell	84,941	84,941	0	0	169,882
Limestone	1,720,059	1,720,059	0	0	3,440,118
Concrete reef balls	1,416,000	1,416,000	0	0	2,832,000
Shellfish seeding	625,000	625,000	625,000	625,000	2,500,000
Deployment	1,289,000	3,221,000	1,933,000	0	6,443,000
Reef monitoring	1,107,000	1,107,000	1,107,000	768,000	4,089,000
Total	**7,795,820**	**9,807,720**	**4,847,820**	**2,227,690**	**24,679,050**

[a] In 2016 dollars.

Source: H. Alleway, PIRSA, pers. comm.

Table 2-2 Blue Infrastructure Initiative costs, 50 ha [a]

Program component	2016-17	2017-18	2018-19	2019-2020	Total
Program Management					
Salaries	125,460	125,460	125,460	125,460	501,840
Employee overhead	9,000	9,000	9,000	9,000	36,000
Corporate overhead	289,600	381,100	206,300	76,800	953,800
Industry Capacity Building & Extension	330,000	330,000	330,000	330,000	1,320,000
Reef design	51,000	0	0	0	51,000
Substrate					
Pacific oyster shell	33,082	33,082	0	0	66,165
Limestone	669,918	669,918	0	0	1,339,835
Concrete reef balls	509,000	509,000	0	0	1,018,000
Shellfish seeding	250,000	250,000	250,000	0	750,000
Deployment	645,000	1,611,000	1,075,000	0	3,331,000
Reef monitoring	738,000	738,000	738,000	768,000	2,982,000
Total	**3,650,060**	**4,656,560**	**2,733,760**	**1,309,260**	**12,349,640**

[a] In 2016 dollars.

Source: H. Alleway, PIRSA, pers. comm.

It is intended that the goods and services procured for project management, design, construction and monitoring of the reef restorations will be engaged from the local region where possible (H. Alleway, pers. comm.). The following assumptions have been made in this regard:

- Project management and associated costs: 100 ha option - 1 fte based in Adelaide, remaining engaged from the regions in which the projects occur; 50 ha option – 1 fte based in Adelaide.

- Industry capacity building and extension: 100 ha option – 1 fte each in Kangaroo Island, Yorke Peninsula, Port Lincoln and Ceduna; 50 ha option – 1 fte each in Kangaroo Island, Willunga and Yorke Peninsula.
- Reef design: completed by an existing contract with an inter-state design engineering company.
- Limestone: procured locally.
- Pacific oyster shell: Kangaroo Island (sourced locally), Port Willunga (sourced from the Eyre Peninsula), Yorke Peninsula (50 per cent sourced locally, 50 per cent sourced from the Eyre Peninsula), Port Lincoln and Ceduna (sourced locally).
- Concrete reef balls: manufactured locally.
- Shellfish seeding: Two oyster hatcheries on the Eyre Peninsula and a grower on Kangaroo Island contracted.
- Deployment: local construction engineering companies, or equivalent, contracted.
- Reef monitoring: South Australian university based researchers assisted by local dive teams.

These assumptions were used to generate expenditure profiles (Table 2-3 and Table 2-4) that were used to estimate the economic impact of the construction phase using the RISE models described earlier.

Table 2-3 Blue Infrastructure Initiative expenditures by region, 100 ha

	Expenditure ($) [a]				
	2016-17	2017-18	2018-19	2019-20	Total
South Australia					
Kangaroo Island	1,424,776	1,847,756	855,776	373,712	4,502,020
Southern Adelaide	1,172,788	1,595,768	620,776	138,712	3,528,044
Yorke Peninsula	1,291,282	1,714,262	730,776	248,712	3,985,032
Eyre & Western	3,125,034	3,970,994	1,961,552	997,424	10,055,005
Rest of SA	678,940	678,940	678,940	469,130	2,505,950
Sub-total	7,692,820	9,807,720	4,847,820	2,227,690	24,576,050
Rest of Australia	103,000	0	0	0	103,000
Total	**7,795,820**	**9,807,720**	**4,847,820**	**2,227,690**	**24,679,050**

[a] In 2016 dollars.

Source: H. Alleway, PIRSA, pers. comm.

Table 2-4 Blue Infrastructure Initiative expenditures by region, 50 ha

	Expenditure ($) [a]				
	2016-17	2017-18	2018-19	2019-20	Total
South Australia					
Kangaroo Island	1,216,240	1,639,240	870,120	294,320	4,019,920
Southern Adelaide	606,504	818,004	440,060	202,160	2,066,727
Yorke Peninsula	1,109,624	1,532,624	770,120	294,320	3,706,687
Eyre & Western	163,233	163,233	150,000	0	476,466
Rest of SA	503,460	503,460	503,460	518,460	2,028,840
Sub-total	3,599,060	4,656,560	2,733,760	1,309,260	12,298,640
Rest of Australia	51,000	0	0	0	51,000
Total	**3,650,060**	**4,656,560**	**2,733,760**	**1,309,260**	**12,349,640**

[a] In 2016 dollars.

Source: H. Alleway, PIRSA, pers. comm.

In addition, a comparison of the number of jobs (in terms of fte) created per $1 million invested in other industries was undertaken. This analysis was based on actual/proposed projects in South Australia. Expenditures (i.e. investments) and expected jobs (direct, flow-on and total fte) were analysed over the full period of each investment. Expenditures were updated to current (2016) dollars using the CPI index for Adelaide (ABS 2016). All jobs impacts were analysed for the SA economy using RISE.

Operation Phase

The estimation of the long-term economic impact of restored reefs was based on a lift in visitor numbers and visitor expenditures arising from the increased attraction for recreational fishing and other activity associated with the restored reefs.

The following method and data sources were used to estimate a profile of tourism expenditure (or sales to final demand) for the regional economies.

- Base data were sourced from Tourism Research Australia (TRA) (www.tra.australia.com). These data were supplemented with information obtained directly from TRA.
    - The key data were total tourism expenditure by tourism region and average expenditure profiles, by region, across a range of goods and services (e.g. food and drink, fuel, shopping, etc.).
    - Estimates were available for domestic day, domestic overnight and international visitor expenditure.
- The first significant adjustment to the base data was the application of a more detailed expenditure breakdown from the ABS Australian National Accounts: Tourism Satellite Account for both domestic and international visitor expenditure.
- The second significant adjustment to the base data was the conversion of tourism expenditure estimates from purchasers' to basic prices (i.e. reallocation of net taxes (taxes minus subsidies) and marketing and transport margins) to make the data

consistent with accounting conventions used in both the national and regional transactions (I-O) tables. Purchasers' to basic price ratios were derived from the ABS.

- The final adjustment to the base data was the allocation of the tourism expenditure data in basic prices to the relevant input-output sectors (78 intermediate sectors, other value added or imports) in which the expenditure occurred, thus compiling a profile of sales to final demand. This process was undertaken for each type of tourism expenditure (domestic day, domestic overnight and international visitor) and the results aggregated to form a single tourism demand profile.

The process outlined above gave an estimate of total visitor expenditure in each of the regional economies. The next step was to estimate how much of that expenditure could be attributed to recreational fishing and it would be likely to increase under the reef restoration program.

This required two key pieces of information:

1. Proportion of all visitors to the region who participate in recreational fishing: SATC data for the broad regions involved indicate a range from as low as 8 per cent in the Fleurieu Peninsula/Southern Adelaide to over 40 per cent on Yorke Peninsula. These are annual average figures.
2. The increase in the proportion of recreational fishers who would visit the region (or stay longer) if the proposed reef restoration program was implemented and resulted in the expected improvement in fish stocks, access and catchability. Although this is difficult to quantify, discussions with recreational fishing industry representatives suggest it could be in the range of 10 to 30 per cent depending on the location and current levels of visitation to the impacted region. Because of this uncertainty, a range of values for the increase in recreational fisher visitation was used for estimating the economic impacts in each region, namely high (30 per cent increase), medium (20 per cent) and low (10 per cent) scenarios.

The regional economic impact of increased visitation (and therefore increased expenditure) by recreational fishers was estimated on the basis of a combination of these factors described above.

2.2 Environmental Benefits

A literature review was undertaken to identify the expected ecosystem services generated by restored oyster reefs and to identify suitable studies with benefit values suitable for transfer to this project.

A suitable study was found which estimated the value households in the Greater Adelaide area placed on restoring rocky reefs in the Gulf St Vincent (Hatton MacDonald et al 2014). A detailed description of the assumptions in undertaking the 'benefit transfer' together with the estimated benefits are provided in Section 4.2.

3. ECONOMIC IMPACT ANALYSIS RESULTS

The results of an assessment of economic impact on the state and on the regions are provided in sections 3.1 (construction phase) and 3.2 (operation phase) in terms of the following indicators:

Construction phase (reef restoration)

- Number of jobs (impact on employment)

Operation phase (i.e. the long-term economic impact of restored reefs)

- Number of jobs (impact on employment)
- Contribution to households (impact on household income)
- Contribution to the economy (impact on gross regional/state product).

These analyses are based on the data and assumptions provided in section 2.1.5.

3.1 Estimated number of restoration jobs created

The estimates of economic impact (jobs) of the Blue Infrastructure Initiative expenditure are provided in Table 3-1 (100 ha of reef restored) and Table 3-2 (50 ha of reef restored).

For the 100 ha option, a total investment of $24.7 million over 4 years (Table 2-3) generates an estimated total of 212 fte jobs in South Australia over the same period (i.e. an average of 53 fte per year, Table 3-1), 109 direct fte jobs and 103 fte jobs in flow-on activity. For each of the regions, the following jobs impacts are estimated:

- For a total expenditure of $4.5 million within the region over 4 years (Table 2-3), 20 direct fte jobs, 3 flow-on fte jobs and 23 fte jobs in total (i.e. an average of 6 fte per year, Table 3-1) are estimated to be created within the Kangaroo Island regional economy
- For a total expenditure of $3.5 million within the region over 4 years (Table 2-3), 14 direct fte jobs, 11 flow-on fte jobs and 25 fte jobs in total (i.e. an average of 6 fte per year, Table 3-1)are estimated to be created within the Southern Adelaide regional economy
- For a total expenditure of $4.0 million within the region (Table 2-3), 18 direct fte jobs, 9 flow-on fte jobs and 27 fte jobs in total (i.e. an average of 7 fte per year, Table 3-1) are estimated to be created within the Yorke Peninsula regional economy
- For a total expenditure of $10.1 million within the region (Table 2-3), 45 direct fte jobs, 27 flow-on fte jobs and 72 fte jobs in total (i.e. an average of 18 fte per year, Table 3-1) are estimated to be created within the Eyre and Western regional economy.

Table 3-1 Estimated number of jobs created by Blue Infrastructure Initiative expenditure, 100 ha[a]

	Employment (fte jobs) [a]				
	2016-17	2017-18	2018-19	2019-20	Average
Kangaroo Island					
Direct	7	7	4	2	5
Flow-on	1	1	1	0	1
Total [b]	**7**	**8**	**4**	**3**	**6**
Southern Adelaide					
Direct	5	6	2	1	3
Flow-on	3	5	2	0	3
Total [b]	**8**	**11**	**4**	**1**	**6**
Yorke Peninsula					
Direct	6	7	3	2	4
Flow-on	3	4	2	1	2
Total [b]	**9**	**11**	**5**	**2**	**7**
Eyre & Western					
Direct	15	16	8	6	11
Flow-on	8	10	6	3	7
Total [b]	**23**	**27**	**14**	**9**	**18**
Rest of SA					
Direct	3	3	3	2	3
Flow-on	16	20	12	6	13
Total [b]	**19**	**24**	**15**	**8**	**17**
South Australia					
Direct	36	40	20	13	27
Flow-on	31	40	22	10	26
Total [b]	**67**	**80**	**42**	**23**	**53**

[a] Full-time equivalent.

[b] Totals may not sum due to rounding.

Source: EconSearch analysis.

For the 50 ha option, a total investment of $12.3 million over 4 years (Table 2-4) generates an estimated total of 105 fte jobs in SA over the same period (i.e. an average of 26 fte per year, Table 3-2), 55 direct fte jobs and 51 fte jobs in flow-on activity. For each of the regions, the following jobs impacts are estimated:

- For a total expenditure of $4.0 million within the region over 4 years (Table 2-4), 17 direct fte jobs, 2 flow-on fte jobs and 19 fte jobs in total (i.e. an average of 5 fte per year, Table 3-2) are estimated to be created within the Kangaroo Island regional economy
- For a total expenditure of $2.1 million within the region over 4 years (Table 2-4), 14 direct fte jobs, 11 flow-on fte jobs and 25 fte jobs in total (i.e. an average of 4 fte per year, Table 3-2) are estimated to be created within the Southern Adelaide regional economy

- For a total expenditure of $3.7 million within the region over 4 years (Table 2-4), 15 direct fte jobs, 9 flow-on fte jobs and 24 fte jobs in total (i.e. an average of 6 fte per year, Table 3-2)are estimated to be created within the Yorke Peninsula regional economy
- For a total expenditure of $0.5 million within the region over 4 years (Table 2-4), 2 direct fte jobs, 2 flow-on fte jobs and 4 fte jobs in total (i.e. an average of 1 fte per year, Table 3-2) are estimated to be created within the Eyre and Western regional economy.

Table 3-2 Estimated number of jobs created by Blue Infrastructure Initiative expenditure, 50 ha[a]

	Employment (fte jobs) [a]				
	2016-17	2017-18	2018-19	2019-20	Average
Kangaroo Island					
Direct	5	6	3	2	4
Flow-on	1	1	1	0	1
Total [b]	**6**	**7**	**4**	**2**	**5**
Southern Adelaide					
Direct	3	3	2	1	2
Flow-on	2	3	2	1	2
Total [b]	**5**	**6**	**3**	**2**	**4**
Yorke Peninsula					
Direct	5	6	3	2	4
Flow-on	3	4	2	1	2
Total [b]	**7**	**9**	**5**	**3**	**6**
Eyre & Western					
Direct	1	1	1	0	1
Flow-on	1	1	1	0	0
Total [b]	**1**	**1**	**1**	**0**	**1**
Rest of SA					
Direct	3	3	3	3	3
Flow-on	9	12	7	3	8
Total [b]	**11**	**14**	**10**	**6**	**10**
South Australia					
Direct	17	19	11	8	14
Flow-on	14	19	12	5	13
Total [b]	**31**	**38**	**23**	**13**	**26**

[a] Full-time equivalent.

[b] Totals may not sum due to rounding.

Source: EconSearch analysis.

A comparison of job creation on the South Australian economy per $1 million invested for various industries is provided in Table 3-3. Whilst the estimates presented in Table 3-3 are indicative only, as they are based on individual projects only, they do suggest that reef restoration is a labour intensive activity and generates relatively high numbers of jobs during the construction phase compared to other development/construction activities.

Table 3-3 Comparison of job creation per $1 million invested for various industries, South Australia [a]

Investment activity	Direct	Flow-on	Total
Reef restoration - 100 ha	4.4	4.2	8.6
Reef restoration - 50 ha	4.5	4.1	8.5
Horticulture expansion	2.4	2.4	4.8
Sporting complex development	1.8	3.1	4.9
Building retrofits	3.1	1.7	4.7
Regional airport upgrade	1.2	0.2	1.4
Mine development	1.7	0.8	2.5
Major road upgrade	2.8	3.1	5.9

[a] Full-time equivalent employment generated by the construction phase of these investment activities.

Source: EconSearch analysis.

3.2 Long-term[2] Impacts from Increased Fishing Tourism

The estimates of annual economic impact of restoring the reefs in terms of increased fishing tourism are provided in Table 3-4 to Table 3-8 for the regions and Table 3-9 (100 ha) and Table 3-10 (50 ha) for the State.

The expected long-term annual economic impact of restoring 20 ha of reef off Kangaroo Island on the Kangaroo Island regional economy is (Table 3-4):

- Contribution to GRP ranging from $1.7 million to $5.0 million, 0.62 to 1.85 per cent of GRP
- Contribution to regional employment ranging from 12 to 37 fte jobs, 0.56 to 1.67 per cent of regional employment
- Contribution to regional household income ranging from $0.9 million t0 $2.7 million, 0.62 to 1.85 per cent of regional household income.

[2] In approximately 10 years' time.

Table 3-4 Annual economic impact of reef restoration from fishing tourism, Kangaroo Island[a]

	Contribution to GRP ($m)	Employment [b] (fte jobs)	Household Income ($m)
High (30 per cent increase)			
Direct	2.8	30	2.3
Flow-on	2.1	6	0.4
Total	**5.0**	**37**	**2.7**
Medium (20 per cent increase)			
Direct	2.7	20	1.6
Flow-on	0.6	4	0.3
Total	**3.3**	**24**	**1.8**
Low (10 per cent increase)			
Direct	1.4	10	0.8
Flow-on	0.3	2	0.1
Total	**1.7**	**12**	**0.9**

[a] Estimates in 2016 dollars. Totals may not sum due to rounding.

[b] Full-time equivalent.

Source: EconSearch analysis.

The expected long-term annual economic impact of restoring 20 ha of reef off Port Willunga on the Southern Adelaide regional economy is (Table 3-5):

- Contribution to GRP ranging from $0.5 million to $1.5 million, 0.004 to 0.013 per cent of GRP
- Contribution to regional employment ranging from 4 to 11 fte jobs, 0.004 to 0.013 per cent of regional employment
- Contribution to regional household income ranging from $0.3 million t0 $0.8 million, 0.004 to 0.011 per cent of regional household income.

Table 3-5 Annual economic impact of reef restoration from fishing tourism, Southern Adelaide, 100 ha option [a]

	Contribution to GRP ($m)	Employment [b] (fte jobs)	Household Income ($m)
High (30 per cent increase)			
Direct	1.0	8	0.5
Flow-on	0.5	3	0.2
Total	**1.5**	**11**	**0.8**
Medium (20 per cent increase)			
Direct	0.7	6	0.4
Flow-on	0.3	2	0.2
Total	**1.0**	**8**	**0.5**
Low (10 per cent increase)			
Direct	0.3	3	0.2
Flow-on	0.2	1	0.1
Total	**0.5**	**4**	**0.3**

[a] Estimates in 2016 dollars. Totals may not sum due to rounding.

[b] Full-time equivalent.

Source: EconSearch analysis.

The expected long-term annual economic impact of restoring 10 ha of reef off Port Willunga on the Southern Adelaide regional economy is (Table 3-6):

- Contribution to GRP ranging from $0.3 million to $1.0 million, 0.003 to 0.008 per cent of GRP
- Contribution to regional employment ranging from 3 to 8 fte jobs, 0.003 to 0.009 per cent of regional employment
- Contribution to regional household income ranging from $0.2 million t0 $0.5 million, 0.002 to 0.007 per cent of regional household income.

Table 3-6 Annual economic impact of reef restoration from fishing tourism, Southern Adelaide, 50 ha option [a]

	Contribution to GRP ($m)	Employment [b] (fte jobs)	Household Income ($m)
High (30 per cent increase)			
Direct	0.7	6	0.4
Flow-on	0.3	2	0.2
Total	**1.0**	**8**	**0.5**
Medium (20 per cent increase)			
Direct	0.5	4	0.2
Flow-on	0.2	1	0.1
Total	**0.7**	**5**	**0.3**
Low (10 per cent increase)			
Direct	0.2	2	0.1
Flow-on	0.1	1	0.1
Total	**0.3**	**3**	**0.2**

[a] Estimates in 2016 dollars. Totals may not sum due to rounding.

[b] Full-time equivalent.

Source: EconSearch analysis.

The expected long-term annual economic impact of restoring 20 ha of reef off Ardrossan on the Yorke Peninsula regional economy is (Table 3-7):

- Contribution to GRP ranging from $0.7 million to $2.0 million, 0.13 to 0.38 per cent of GRP
- Contribution to regional employment ranging from 6 to 17 fte jobs, 0.14 to 0.41 per cent of regional employment
- Contribution to regional household income ranging from $0.3 million t0 $1.0 million, 0.13 to 0.40 per cent of regional household income.

Table 3-7 Annual economic impact of reef restoration from fishing tourism, Yorke Peninsula[a]

	Contribution to GRP ($m)	Employment [b] (fte jobs)	Household Income ($m)
High (30 per cent increase)			
Direct	1.4	13	0.8
Flow-on	0.6	4	0.3
Total	**2.0**	**17**	**1.0**
Medium (20 per cent increase)			
Direct	1.0	9	0.5
Flow-on	0.2	3	0.2
Total	**1.2**	**11**	**0.7**
Low (10 per cent increase)			
Direct	0.5	4	0.3
Flow-on	0.2	1	0.1
Total	**0.7**	**6**	**0.3**

[a] Estimates in 2016 dollars. Totals may not sum due to rounding.

[b] Full-time equivalent.

Source: EconSearch analysis.

The expected long-term annual economic impact of restoring 20 ha of reef off Port Lincoln and 20 ha of reef off Ceduna on the Eyre and Western regional economy is (Table 3-8):

- Contribution to GRP ranging from $1.9 million to $5.7 million, 0.05 to 0.14 per cent of GRP
- Contribution to regional employment ranging from 13 to 40 fte jobs, 0.05 to 0.16 per cent of regional employment
- Contribution to regional household income ranging from $0.9 million t0 $2.8 million, 0.05 to 0.14 per cent of regional household income.

Table 3-8 Annual economic impact of reef restoration from fishing tourism, Eyre and Western[a]

	Contribution to GRP ($m)	Employment [b] (fte jobs)	Household Income ($m)
High (30 per cent increase)			
Direct	4.1	30	2.0
Flow-on	1.6	10	0.8
Total	**5.7**	**40**	**2.8**
Medium (20 per cent increase)			
Direct	2.7	20	1.3
Flow-on	1.1	7	0.5
Total	**3.8**	**27**	**1.9**
Low (10 per cent increase)			
Direct	1.4	10	0.7
Flow-on	0.5	3	0.3
Total	**1.9**	**13**	**0.9**

[a] Estimates in 2016 dollars. Totals may not sum due to rounding.

[b] Full-time equivalent.

Source: EconSearch analysis.

The expected long-term annual economic impact of restoring 100 ha of reef on the SA economy is (Table 3-9):

- Contribution to GSP ranging from $6.2 million to $18.7 million, 0.01 to 0.02 per cent of GSP
- Contribution to employment ranging from 43 to 129 fte jobs, 0.01 to 0.02 per cent of employment
- Contribution to household income ranging from $3.2 million t0 $9.5 million, 0.01 to 0.02 per cent of household income.

Table 3-9 Long-term economic impact of reef restoration, SA, 100 ha [a]

	Contribution to GRP ($m)	Employment [b] (fte jobs)	Household Income ($m)
High (30 per cent increase)			
Direct	10.0	76	5.3
Flow-on	8.7	53	4.2
Total	**18.6**	**129**	**9.5**
Medium (20 per cent increase)			
Direct	6.6	51	3.6
Flow-on	5.8	35	2.8
Total	**12.4**	**86**	**6.3**
Low (10 per cent increase)			
Direct	3.3	25	1.8
Flow-on	2.9	18	1.4
Total	**6.2**	**43**	**3.2**

[a] Estimates in 2016 dollars. Totals may not sum due to rounding.

[b] Full-time equivalent.

Source: EconSearch analysis.

The expected long-term annual economic impact of restoring 50 ha of reef on the SA economy is (Table 3-10):

- Contribution to GSP ranging from $3.9 million to $11.6 million, 0.004 to 0.012 per cent of GSP
- Contribution to employment ranging from 25 to 76 fte jobs, 0.004 to 0.011 per cent of employment
- Contribution to household income ranging from $1.9 million t0 $5.8 million, 0.003 to 0.010 per cent of household income.

Table 3-10 Long-term economic impact of reef restoration, SA, 50 ha [a]

	Contribution to GRP ($m)	Employment [b] (fte jobs)	Household Income ($m)
High (30 per cent increase)			
Direct	6.2	43	3.2
Flow-on	5.4	33	2.6
Total	**11.6**	**76**	**5.8**
Medium (20 per cent increase)			
Direct	4.1	29	2.1
Flow-on	3.6	22	1.8
Total	**7.7**	**51**	**3.9**
Low (10 per cent increase)			
Direct	2.1	14	1.1
Flow-on	1.8	11	0.9
Total	**3.9**	**25**	**1.9**

[a] Estimates in 2016 dollars. Totals may not sum due to rounding.

[b] Full-time equivalent.

Source: EconSearch analysis.

4. ENVIRONMENTAL BENEFITS OF REEF RESTORATION

4.1 Ecosystem Services Provided by Oyster Reefs

There is a growing body of evidence (e.g. Grabowski and Petersen 2007, Petersen et al. 2003, Coen et al. 2007) that oyster reefs provide a number of important ecosystem services and the value of restoring lost and depleted native oyster beds is starting to be appreciated (Gillies et al. 2015).

Grabowski and Petersen (2007) have identified seven categories of ecosystem services provided by native oyster reefs.

- *Water filtration and concentration of biodeposits*: oysters are filter feeders and intact oyster reefs play an important role in the ecosystem by removing suspended solids, phytoplankton and microbes from the water column. This reduces turbidity and reduces nitrites in the water. These filtered materials are converted by oysters to biosolids which become available to submerged aquatic vegetation (e.g. seagrass and macroalgae), thus encouraging, through better light penetration and appropriate nutrition, healthier seagrass and other submerged aquatic vegetation habitats.
- *Provision of habitat for sea-floor dwelling fishes and other marine animals*: the vertically upright structure formed by vertically upright aggregations of oysters creates habitat for dense assemblages of other mollusks, polychaetes (worms), crustaceans and other invertebrates. Juvenile fish and mobile crustaceans also use oyster reefs as refuge and foraging grounds.
- *Augmentation of fish production*: through the above-mentioned processes (i.e. filtering out microorganisims and detritus out of the water column and encouraging the resultant energy/nutrients up the food chain), oyster reefs augment fish production
- *Stabilisation of benthic (i.e. sea-floor) habitat*: oyster reefs directly attenuate wave energy and also promote sedimentation which benefits the establishment of submerged aquatic vegetation which in turn stabilise seafloors.
- *Production of food*: native oysters are food to many animals and they are also a delicacy to humans with a fledging aquaculture industry underway in Australia. Oysters are important to coastal aboriginal communities, having in the past formed an important component of their diet and customs (Gillies et al. 2015).
- *Sequestration of carbon*: oyster shells are made from calcium carbonate. In growing their shells, oysters remove carbon from the water column and sequester it in their relatively hardwearing, long-lived shells.

- *Contribution to seascape diversity*: oyster reefs are an important component of the marine landscape. The location of an oyster reef could influence landscape-scale processes, such as providing a corridor between shelter and foraging grounds.

4.2 Environmental Benefits

As described in Section 2.2, a literature review was undertaken to find suitable studies with benefit values appropriate for transfer to this project. A suitable study was found which estimated the value households in the Greater Adelaide area placed on restoring rocky reefs in the Gulf St Vincent (Hatton MacDonald et al. 2014).

The Hatton MacDonald et al. (2014) study undertook a choice experiment to elicit households' willingness to pay (WTP) for water quality management actions which would achieve improved environmental quality of coastal waters, namely improved water clarity, increased areas of seagrass and increased areas of healthy reef. The water quality management actions were not specified to participants of the choice experiment, but the context of the study was stormwater and treated wastewater management. However, it is reasonable to assume that restoring oyster reefs would contribute to similar outcomes. Whilst it might be expected that large-scale restoration of oyster reefs would contribute to healthier seagrass beds and clearer water, there are likely to be other, significant contributing factors associated with these outcomes and therefore only the healthy reef WTP value was used.

The study estimated a WTP of $7.38 per household per year per reef restored (Hatton MacDonald et al. 2014). This estimate was updated to current dollars using the consumer price index for Adelaide (ABS 2016). The payment vehicle in the study was a levy paid over five years. This WTP value ($7.51) was aggregated and discounted (using a discount rate of 7 per cent as per the original study) to give a total present value of $32.93 per household per reef restored.

The following assumptions were made concerning the number of reefs restored:

- For the 100 ha option, it was assumed that the equivalent of five reefs would be restored
- For the 50 ha option, it was assumed that the equivalent of three reefs would be restored.

These are conservative assumptions because reef size is much larger under the Blue Infrastructure Initiative in comparison with the original study, i.e. the rocky reefs referenced in the original study are smaller than the constructed oyster reefs.

The 100 ha option is a state-wide project addressing a state-wide issue and therefore it was assumed that the population was all households in South Australia[3]. The 50 ha option is more

[3] 702,381 households. Based on a population of 1,685,714 persons (ABS 2015) and an average household size of 2.4 persons (ABS 2011b).

limited in its scope and was limited to households in the Yorke Peninsula, Greater Adelaide, Fleurieu and Kangaroo Island regions[4].

The household WTP value was estimated to be relevant to 43.2 per cent of households in the population (Hatton MacDonald et al. 2014), and the population estimates were adjusted accordingly.

To calculate the aggregate benefit, the WTP per household value was multiplied by the population relevant to the analysis, giving an estimated present value of $50.0 million for the 100 ha option and $24.5 million for the 50 ha option.

These estimates are indicative of the total value South Australians place in having healthy, restored reefs. Included in these estimates are a number of values held by South Australians. For example, they include use values (e.g. value to recreational fishing and other recreational activities both commercial and non-commercial), indirect use values derived from the ecosystem services provided (e.g. from the amenity of clearer water) and non-use values (e.g. values for preserving habitats, biodiversity and heritage arising from bequest, altruistic, stewardship and self-seeking motives (Morrison and Hatton MacDonald 2010)).

[4] 574,558 households. Based on a population of 1,378,940 persons (ABS 2015) and an average household size of 2.4 persons (ABS 2011b).

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APPENDIX 1 INTERMEDIATE SECTOR SPECIFICATION

Appendix Table 1-1 Intermediate sector specifications for the input-output model

	National I-O 111 Sectors		**South Australia & Regions, 2013/14, 78 Sectors**
101	Sheep, Grains, Beef and Dairy Cattle	1	Sheep
		2	Grains
		3	Beef Cattle
		4	Dairy Cattle
102	Poultry and Other Livestock	5	Poultry
		6	Pigs
		7	Other Livestock
103	Other Agriculture	8	Winegrapes
		9	Vegetables
		10	Fruit and Nuts
		11	Other Agriculture
201	Aquaculture	12	Aquaculture
301	Forestry and Logging	13	Forestry and Logging
401	Fishing, hunting and trapping	14	Fishing, Hunting and Trapping
501	Agriculture, Forestry and Fishing Support Services	15	Agriculture, Forestry and Fishing Support Services
601	Coal mining	16	Coal Mining
701	Oil and gas extraction	17	Oil and Gas Extraction
801	Iron Ore Mining	18	Iron & Non-ferrous Ore Mining
802	Non Ferrous Metal Ore Mining		
901	Non Metallic Mineral Mining	19	Non Metallic Mineral Mining
1001	Exploration and Mining Support Services	20	Exploration and Mining Support Services
1101	Meat and Meat product Manufacturing	21	Meat and Meat Product Manufacturing
1102	Processed Seafood Manufacturing	22	Processed Seafood Manufacturing
1103	Dairy Product Manufacturing	23	Dairy Product Manufacturing
1104	Fruit and Vegetable Product Manufacturing	24	Fruit and Vegetable Product Manufacturing
1105	Oils and Fats Manufacturing	25	Oils and Fats Manufacturing

	National I-O 111 Sectors		South Australia & Regions, 2013/14, 78 Sectors
1106	Grain Mill and Cereal Product Manufacturing	26	Grain Mill and Cereal Product Manufacturing
1107	Bakery Product Manufacturing	27	Other Food Product Manufacturing
1108	Sugar and Confectionary Manufacturing		
1109	Other Food Product Manufacturing		
1201	Soft Drinks, Cordials and Syrup Manufacturing	28	Other Beverages
1202	Beer Manufacturing	29	Beer Manufacturing
1205	Wine, Spirits and Tobacco	30	Wine, Spirits and Tobacco Manufacturing
1301	Textile Manufacturing	31	Textiles, Clothing and Footwear Manufacturing
1302	Tanned Leather, Dressed Fur and Leather Product Manufacturing		
1303	Textile Product Manufacturing		
1304	Knitted Product Manufacturing		
1305	Clothing Manufacturing		
1306	Footwear Manufacturing		
1401	Sawmill Product Manufacturing	32	Sawmill Product Manufacturing
1402	Other Wood Product Manufacturing	33	Other Wood Product Manufacturing
1501	Pulp, Paper and Paperboard Manufacturing	34	Pulp, Paper and Paperboard Manufacturing
1502	Paper Stationery and Other Converted Paper Product Manufacturing	35	Paper Stationery and Other Converted Paper Product Manufacturing
1601	Printing (including the reproduction of recorded media	36	Printing (including the reproduction of recorded media)
1701	Petroleum and Coal Product Manufacturing	37	Petroleum and Coal Product Manufacturing
1801	Human Pharmaceutical and Medicinal Product Manufacturing	38	Pharmaceutical & Other Chemical Product Manufacturing
1802	Veterinary Pharmaceutical and Medicinal Product Manufacturing		
1803	Basic Chemical Manufacturing		
1804	Cleaning Compounds and Toiletry Preparation Manufacturing		
1901	Polymer Product Manufacturing		
1902	Natural Rubber Product Manufacturing		

	National I-O 111 Sectors		South Australia & Regions, 2013/14, 78 Sectors
2001	Glass and Glass Product Manufacturing	39	Non-metallic Mineral Product Manufacturing
2002	Ceramic Product Manufacturing		
2003	Cement, Lime and Ready-Mixed Concrete Manufacturing		
2004	Plaster and Concrete Product Manufacturing		
2005	Other Non-Metallic Mineral Product Manufacturing		
2101	Iron and Steel Manufacturing	40	Iron and Steel Manufacturing
2102	Basic Non-Ferrous Metal Manufacturing	41	Basic Non-Ferrous Metal Manufacturing
2201	Forged Iron and Steel Product Manufacturing	42	Metal Product Manufacturing
2202	Structural Metal Product Manufacturing		
2203	Metal Containers and Other Sheet Metal Product manufacturing		
2204	Other Fabricated Metal Product manufacturing		
2301	Motor Vehicles and Parts; Other Transport Equipment manufacturing	43	Motor Vehicles and Parts; Other Transport Equipment Manufacturing
2302	Ships and Boat Manufacturing	44	Other Machinery & Equipment Manufacturing
2303	Railway Rolling Stock Manufacturing		
2304	Aircraft Manufacturing		
2401	Professional, Scientific, Computer and Electronic Equipment Manufacturing		
2403	Electrical Equipment Manufacturing		
2404	Domestic Appliance Manufacturing		
2405	Specialised and other Machinery and Equipment Manufacturing		
2501	Furniture Manufacturing	45	Furniture Manufacturing
2502	Other Manufactured Products	46	Other Manufactured Products
2601	Electricity Generation	47	Electricity Generation
2605	Electricity Transmission, Distribution, On Selling and Electricity Market Operation	48	Electricity Supply

	National I-O 111 Sectors		South Australia & Regions, 2013/14, 78 Sectors
2701	Gas Supply	49	Gas Supply
2801	Water Supply, Sewerage and Drainage Services	50	Water Supply, Sewerage and Drainage Services
2901	Waste Collection, Treatment and Disposal Services	51	Waste Collection, Treatment and Disposal Services
3001	Residential Building Construction	52	Residential Building Construction
3002	Non-Residential Building Construction	53	Other Construction
3101	Heavy and Civil Engineering Construction		
3201	Construction Services	54	Construction Services
3301	Wholesale Trade	55	Wholesale Trade
3901	Retail Trade	56	Retail Trade
4401	Accommodation	57	Accommodation
4501	Food and Beverage Services	58	Food and Beverage Services
4601	Road Transport	59	Road Transport
4701	Rail Transport	60	Rail Transport
4801	Water, Pipeline and Other Transport	61	Water, Pipeline and Other Transport
4901	Air and Space Transport	62	Air and Space Transport
5101	Postal and Courier Pick-up and Delivery Service	63	Transport Support Services and Storage
5201	Transport Support services and storage		
5401	Publishing (except Internet and Music Publishing)	64	Publishing (except Internet and Music Publishing)
5501	Motion Picture and Sound Recording	65	Communication Services
5601	Broadcasting (except Internet)		
5701	Internet Publishing and Broadcasting and Services Providers, Websearch Portals and Data Processing Services		
5801	Telecommunication Services	65	Communication Services (cont.)
6001	Library and Other Information Services		
6201	Finance	66	Finance
6301	Insurance and Superannuation Funds	67	Insurance & Other Financial Services
6401	Auxiliary Finance and Insurance Services		

	National I-O 111 Sectors		South Australia & Regions, 2013/14, 78 Sectors
6601	Rental and Hiring Services (except Real Estate)	68	Rental, Hiring and Real Estate Services
6701	Ownership of Dwellings	69	Ownership of Dwellings
6702	Non-Residential Property Operators and Real Estate Services	68	Rental, Hiring and Real Estate Services (cont.)
6901	Professional, Scientific and Technical Services	70	Professional, Scientific and Technical Services
7001	Computer Systems Design and Related Services		
7201	Building Cleaning, Pest Control, Administrative and Other Support Services	71	Administrative and Support Services
7501	Public Administration and Regulatory Services	72	Public Administration and Regulatory Services
7601	Defence	73	Defence
7701	Public Order and Safety	74	Public Order and Safety
8001	Education and Training	75	Education and Training
8401	Health Care Services	76	Health & Community Services
8601	Residential Care and Social Assistance Services		
8901	Heritage, Creative and Performing Arts	77	Cultural & Recreational Services
9101	Sports and Recreation		
9201	Gambling		
9401	Automotive Repair and Maintenance	78	Personal & Other Services
9402	Other Repair and Maintenance		
9501	Personal Services		
9502	Other Services		

Source: EconSearch analysis.

APPENDIX 2 AN OVERVIEW OF ECONOMIC IMPACT ANALYSIS USING THE INPUT-OUTPUT METHOD

Input-output (I-O) analysis provides a comprehensive economic framework that is extremely useful in the resource planning process. Broadly, there are two ways in which the I-O method can be used.

First, the I-O model provides a numerical picture of the size and shape of an economy and its essential features. The I-O transactions model (or table) can be used to describe some of the important features of an economy, the interrelationships between sectors and the relative importance of the individual sectors.

Second, I-O analysis provides a standard approach for the estimation of the economic impact of a particular activity. The I-O model is used to calculate industry multipliers that can then be applied to various development or change scenarios.

The input-output transactions table

Input-output analysis, as an accounting system of inter-industry transactions, is based on the notion that no industry exists in isolation. This assumes, within any economy, each firm depends on the existence of other firms to purchase inputs from, or sell products to, for further processing. The firms also depend on final consumers of the product and labour inputs to production. An I-O transactions table is a convenient way to illustrate the purchases and sales of goods and services taking place in an economy at a given point in time.

As noted above, input-output models provide a numerical picture of the size and shape of the economy. Products produced in the economy are aggregated into a number of groups of industries and the transactions between them recorded in the transactions table. The rows and columns of the I-O table can be interpreted in the following way:

- The rows of the I-O table illustrate sales for intermediate usage (i.e. to other firms in the region) and for final demand (e.g. household consumption, exports or capital formation).
- The columns of the I-O table illustrate purchases of intermediate inputs (i.e. from other firms in the region), imported goods and services and purchases of primary inputs (i.e. labour, land and capital).
- Each item is shown as a purchase by one sector and a sale by another, thus constructing two sides of a double accounting schedule.

In summary, the I-O transactions table can be used to describe some of the important features of a state or regional economy, the interrelationships between sectors and the relative

importance of the individual sectors. The model is also used for the calculation of sector multipliers and the estimation of economic impacts arising from some change in the economy.

Using input-output analysis for estimation of regional economic impacts

The standard approach for the estimation of the regional economic impact of a particular activity, such as wine grape production, for example, is to employ I-O analysis. The I-O model conceives the economy of the region as being divided up into a number of sectors and this allows the analyst to trace expenditure flows.

To illustrate this, consider the example of a vineyard that, in the course of its operation, purchases goods and services from other sectors. These goods and services would include fertiliser, chemicals, transport services, and, of course, labour. The direct employment created by the vineyard is regarded in the model as an expenditure flow into the household sector, which is one of several non-industrial sectors recognised in the I-O model.

Upon receiving expenditure by the vineyard, the other sectors in the regional economy engage in their own expenditures. For example, as a consequence of winning a contract for work with vineyard, a spraying contractor buys materials from its suppliers and labour from its own employees. Suppliers and employees in turn engage in further expenditure, and so on. These indirect and induced (or flow-on) effects, as they are called, are part of the impact of the vineyard on the regional economy. They must be added to the direct effects (which are expenditures made in immediate support of the vineyard itself) in order to arrive at a measure of the total impact of the vineyard.

It may be thought that these flow-on effects (or impacts) go on indefinitely and that their amount adds up without limit. The presence of leakages, however, prevents this from occurring. In the context of the impact on a regional economy, an important leakage is expenditure on imports, that is, products or services that originate from outside the region, state or country (e.g. machinery).

Thus, some of the expenditure by the vineyard (i.e. expenditure on imports to the region) is lost to the regional economy. Consequently, the flow-on effects get smaller and smaller in successive expenditure rounds due to this and other leakages. Hence the total expenditure created in the regional economy is limited in amount, and so (in principle) it can be measured.

Using I-O analysis for estimation of regional economic impacts requires a great deal of information. The analyst needs to know the magnitude of various expenditures and where they occur. Also needed is information on how the sectors receiving this expenditure share their expenditures among the various sectors from whom they buy, and so on, for the further expenditure rounds.

In applying the I-O model to economic impact analysis, the standard procedure is to determine the direct or first-round expenditures only. No attempt is made to pursue such inquiries on expenditure in subsequent rounds, not even, for example, to trace the effects in the regional economy on household expenditures by vineyard employees on food, clothing, entertainment,

and so on, as it is impracticable to measure these effects for an individual case, here the vineyard.

The I-O model is instead based on a set of assumptions about constant and uniform proportions of expenditure. If households in general in the regional economy spend, for example, 13.3 per cent of their income on food and non-alcoholic beverages, it is assumed that those working in vineyards do likewise. Indeed, the effects of all expenditure rounds after the first are calculated by using such standard proportions (i.e. multiplier calculations). Once a transactions table has been compiled, simple mathematical procedures can be applied to derive multipliers for each sector in the economy.

Input-output multipliers

Input-output multipliers are an indication of the strength of the linkages between a particular sector and the rest of the state or regional economy. As well, they can be used to estimate the impact of a change in that particular sector on the rest of the economy.

Detailed explanations on calculating I-O multipliers, including the underlying assumptions, are provided in any regional economics or I-O analysis textbook (see, for example, Jensen and West (1986)). They are calculated through a routine set of mathematical operations based on coefficients derived from the I-O transactions model, as outlined below.

The transactions table may be represented by a series of equations thus:

$$X_1 = X_{11} + X_{12} + \ldots\ldots\ldots\ldots\ldots + X_{1n} + Y_1$$
$$X_2 = X_{21} + X_{22} + \ldots\ldots\ldots\ldots\ldots + X_{2n} + Y_2$$
$$X_n = X_{n1} + X_{n2} + \ldots\ldots\ldots\ldots\ldots + X_{nn} + Y_n$$

where X_i = total output of intermediate sector *i* (row totals);

X_{ij} = output of sector *i* purchased by sector *j* (elements of the intermediate quadrant); and

Y_j = total final demand for the output of sector *i*.

It is possible, by dividing the elements of the columns of the transactions table by the respective column totals to derive coefficients, which represent more clearly the purchasing pattern of each sector. These coefficients, termed 'direct' or 'I-O' coefficients, are normally denoted as a_{ij}, and represent the direct or first round requirements from the output of each sector following an increase in output of any sector.

In equation terms the model becomes:

$$X_1 = a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots\ldots\ldots + a_{1n}X_n + Y_1$$
$$X_2 = a_{21}X_1 + a_{22}X_2 + \ldots\ldots\ldots\ldots\ldots + a_{2n}X_n + Y_2$$
$$X_n = a_{n1}X_{11} + a_{n2}X_2 + \ldots\ldots\ldots\ldots\ldots + a_{nn}X_n + Y_n$$

where a_{ij} (the direct coefficient) = X_{ij}/X_j. This may be represented in matrix terms:

$X = AX + Y$

where A = $[a_{ij}]$, the matrix of direct coefficients.

The previous equation can be extended to:

$(I\text{-}A)X = Y$

where $(I\text{-}A)$ is termed the Leontief matrix,

or $X = (I\text{-}A)^{-1}Y$

where $(I\text{-}A)^{-1}$ is termed the 'general solution', the 'Leontief inverse' or simply the inverse of the open model.

The general solution is often represented by:

$Z = (I\text{-}A)^{-1} = [z_{ij}]$

The I-O table can be 'closed' with respect to certain elements of the table. Closure involves the transfer of items from the exogenous portions of the table (final demand and primary input quadrants) to the endogenous section of the table (intermediate quadrant). This implies that the analyst considers that the transferred item is related more to the level of local activity than to external influences. Closure of I-O tables with respect to households is common and has been adopted in this project.

The 'closed' direct coefficients matrix may be referred to as A^*. The inverse of the Leontief matrix formed from A^* is given by:

$Z^* = (I\text{-}A^*)^{-1} = [z^*_{ij}]$

Z^* is referred to as the 'closed inverse' matrix.

A multiplier is essentially a measurement of the impact of an economic stimulus. In the case of I-O multipliers the stimulus is normally assumed to be an increase of one dollar in sales to final demand by a sector. The impact in terms of output, contribution to gross regional product, household income and employment can be identified in the categories discussed below.

(i) The initial impact: refers to the assumed dollar increase in sales. It is the stimulus or the cause of the impacts. It is the unity base of the output multiplier and provides the identity matrix of the Leontief matrix. Associated directly with this dollar increase in output is an own-sector increase in household income (wages and salaries, drawings by owner operators etc.) used in the production of that dollar. This is the household income coefficient h_j. Household income, together with other value added (OVA), provide the total contribution to gross regional product from the production of that dollar of output. The contribution to gross regional product coefficient is denoted v_j. Associated also will be an own-sector increase in employment, represented by the size of the employment coefficient. This employment coefficient e_j represents an employment/output ratio and is usually calculated as 'employment per million dollars of output'.

(ii) The first round impact: refers to the effect of the first round of purchases by the sector providing the additional dollar of output. In the case of the output multiplier this is shown by the direct coefficients matrix [a_{ij}]. The disaggregated effects are given by individual a_{ij} coefficients and the total first-round effect by Σa_{ij}. First-round household income effects are calculated by multiplying the first-round output effects by the appropriate household income coefficient (h_j). Similarly, the first-round contribution to gross regional product and employment effects are calculated by multiplying the first-round output effects by the appropriate contribution to gross state product (v_j) and employment (e_j) coefficients.

(iii) Industrial-support impacts. This term is applied to 'second and subsequent round' effects as successive waves of output increases occur in the economy to provide industrial support, as a response to the original dollar increase in sales to final demand. The term excludes any increases caused by increased household consumption. Output effects are calculated from the open Z inverse, as a measure of industrial response to the first-round effects. The industrial-support output requirements are calculated as the elements of the columns of the Z inverse, less the initial dollar stimulus and the first-round effects. The industrial support household income, contribution to gross regional product and employment effects are defined as the output effects multiplied by the respective household income, contribution to gross regional product and employment coefficients. The first-round and industrial-support impacts are together termed the production-induced impacts.

(iv) Consumption-induced impacts: are defined as those induced by increased household income associated with the original dollar stimulus in output. The consumption-induced output effects are calculated in disaggregated form as the difference between the corresponding elements in the open and closed inverse (i.e. $z^*_{ij} - z_{ij}$, and in total as $\Sigma(z^*_{ij} - z_{ij})$. The consumption-induced household income, contribution to gross regional product and employment effects are simply the output effects multiplied by the respective household income, contribution to gross regional product and employment coefficients.

(v) Flow-on impacts: are calculated as total impact less the initial impact. This allows for the separation of 'cause and effect' factors in the multipliers. The cause of the impact is given by the initial impact (the original dollar increase in sales to final demand), and the effect is represented by the first-round, industrial-support and consumption-induced effects, which together constitute the flow-on effects.

Each of the five impacts are summarised in Appendix Table 2-1. It should be noted that household income, contribution to gross regional product and employment multipliers are parallel concepts, differing only by their respective coefficients h_j, v_j and e_j.

The output multipliers are calculated on a 'per unit of initial effect' basis (i.e. output responses to a one dollar change in output). Household income, contribution to gross regional product and employment multipliers, as described above, refer to changes in household income per initial change in output, changes in contribution to gross regional product per initial change in output and changes in employment per initial change in output. These multipliers are conventionally converted to ratios, expressing a 'per unit' measurement, and described as Type I and Type II ratios. For example, with respect to employment:

Type I employment ratio = [initial + first round + industrial support]/initial

and

Type II employment ratio = [initial + production induced[5] + consumption induced]/initial

Appendix Table 2-1 The structure of input-output multipliers for sector *i* [a]

Impacts	General formula
Output multipliers ($)	
Initial	1
First-round	$\Sigma_i a_{ij}$
Industrial-support	$\Sigma_i z_{ij}$-1-$\Sigma_i a_{ij}$
Consumption-induced	$\Sigma_i z^*_{ij}$-$\Sigma_i z_{ij}$
Total	$\Sigma_i z^*_{ij}$
Flow-on	$\Sigma_i z^*_{ij}$-1
Household Income multipliers ($)	
Initial	h_j
First-round	$\Sigma_i a_{ij} h_i$
Industrial-support	$\Sigma_i z_{ij} h_i$- h_j-$\Sigma_i a_{ij} h_i$
Consumption-induced	$\Sigma_i z^*_{ij} h_i$-$\Sigma_i z_{ij} h_i$
Total	$\Sigma_i z^*_{ij} h_i$
Flow-on	$\Sigma_i z^*_{ij} h_i$-h_j
Contribution to gross regional product multipliers ($)	
Initial	v_j
First-round	$\Sigma_i a_{ij} v_i$
Industrial-support	$\Sigma_i z_{ij} v_i$- v_j-$\Sigma_i a_{ij} v_i$
Consumption-induced	$\Sigma_i z^*_{ij} v_i$-$\Sigma_i z_{ij} v_i$

[5] Where (first round + industrial support) = production induced.

Total	$\Sigma_i z^*_{ij} v_i$
Flow-on	$\Sigma_i z^*_{ij} v_i - v_j$
Employment multipliers (full time equivalents)	
Initial	e_j
First-round	$\Sigma_i a_{ij} e_i$
Industrial-support	$\Sigma_i z_{ij} e_i - e_j - \Sigma_i a_{ij} e_i$
Consumption-induced	$\Sigma_i z^*_{ij} e_i - \Sigma_i z_{ij} e_i$
Total	$\Sigma_i z^*_{ij} e_i$
Flow-on	$\Sigma_i z^*_{ij} e_i - e_j$

[a] In a DECON model, Z^* (the 'closed inverse' matrix), includes a population and an unemployed row and column.

Input-output model assumptions

There are a number of important assumptions in the I-O model that are relevant in interpreting the analytical results.

- Industries in the model have a linear production function, which implies constant returns to scale and fixed input proportions.
- Another model assumption is that firms within a sector are homogeneous, which implies they produce a fixed set of products that are not produced by any other sector and that the input structure of the firms are the same. Thus it is preferable to have as many sectors as possible specified in the models and the standard models for this study were compiled with 66 sectors.
- The model is a static model that does not take account of the dynamic processes involved in the adjustment to an external change, such as a permanent change in natural resources management.

Population and the Unemployed

Based on work undertaken by Mangan and Phibbs (1989), all of the I-O models developed for this project were extended as demographic-economic (DECON) models. The two key characteristics of the DECON model, when compared with a standard economic model, are as follows.

1. The introduction of a population 'sector' (or row and column in the model) makes it possible to estimate the impact on local population levels of employment growth or decline.
2. The introduction of an unemployed 'sector' makes it possible to account for the consumption-induced impact of the unemployed in response to economic growth or decline.

The population 'sector'

The introduction of a population 'sector' to the traditional I-O model allows for the calculation of population multipliers. These multipliers measure the flow-on population impact resulting

from an initial population change attributable to employment growth or decline in a particular sector of the regional economy.

Calculation of population multipliers is made possible by inclusion of a population row and column in the 'closed' direct coefficients matrix of the I-O model.

Population row: the population coefficient (p_j) for sector *j* of the DECON model is represented as:

$p_j = -rho_j * e_j * family\ size_j$

where rho_j = the proportion of employees in sector *j* who remain in the region after they lose their job (negative employment impact) or the proportion of new jobs in sector *j* filled by previously unemployed locals (positive employment impact);

e_j = the employment coefficient for sector *j*; and

$family\ size_j$ = average family size for sector *j.*

Population column: the population column of the DECON model is designed to account for growth or decline in those sectors of the economy that are primarily population-driven (i.e. influenced by the size of the population) rather than market-driven (i.e. dependent upon monetary transactions). Clearly, many of the services provided by the public sector fit this description and, for the purpose of this analysis, it was assumed that the following intermediate sectors were primarily population-driven:

- government administration;
- defence;
- education;
- health and community services; and
- cultural and recreational services.

Thus, the non-market coefficient for sector *j* of the DECON model is represented as expenditure on that non-market service (by governments) in $million per head of population.

The population multiplier for sector *j* is represented as: z^*_{pj} / p_{pj}

where z^*_{pj} = coefficient of the 'closed inverse' matrix in the population row for sector *j*; and

p_{pj} = coefficient of the direct coefficients matrix in the population row for sector *j.*

Sources of local data for the population sector of the DECON models used in this study included the following.

- rho: little or no published data are available to assist with estimation of this variable, particularly at a regional level. The DECON models have been constructed to enable the

analyst to estimate this variable (for all or individual sectors) on the basis of the availability superior data or assumptions.

- Family size: in order to estimate average family size by industry, relevant data were obtained from the Australian Bureau of Statistics (2011 Census of Population and Housing) via the Table Builder database. These data were modified by the consultants in order to ensure consistency with the specification and conventions of the I-O models.

The unemployed 'sector'

As outlined above, the introduction of an unemployed 'sector' to the standard I-O model makes it possible to account for the consumption-induced impact of the unemployed in response to economic growth or decline.

Through the inclusion of an unemployed row and column in the 'closed' direct coefficients matrix of the standard I-O model it is possible to calculate Type IV multipliers (for output, GSP, household income and employment).

The key point to note is that, in the situation where at least some of the unemployed remain in a region after losing their job (negative employment impact) or some of the new jobs in a region are filled by previously unemployed locals (positive employment impact), Type IV multipliers will be smaller than the more frequently used Type II multipliers.

Unemployed row: the unemployed coefficient (u_j) for sector *j* of the DECON model is represented as:

$u_j = -\text{rho}_j * (1-ess_j) * e_j$

where rho_j = the proportion of employees in sector *j* who remain in the region after they lose their job (negative employment impact) or the proportion of new jobs in sector *j* filled by previously unemployed locals (positive employment impact);

ess_j = the proportion of employed in sector *j* who are not eligible for welfare benefits when they lose their job*; and*

e_j = the employment coefficient for sector *j*.

Unemployed column: the unemployed column of the DECON model is an approximation of total consumption expenditure and the consumption pattern of the unemployed. It is represented as dollars per unemployed person rather than $million for the region as a whole, as is the case for the household expenditure column in a standard I-O model.

Sources of local (i.e. state and regional) data for the unemployed sector of the DECON models used in this study included the following.

- ess: in order to estimate the proportion of employed by industry who are not eligible for welfare benefits when they lose their job, relevant data were obtained from the Australian Bureau of Statistics (2011 Census of Population and Housing) via the Table

Builder database. These data were modified by the consultants in order to ensure consistency with the specification and conventions of the I-O models.

- Unemployed consumption: total consumption expenditure by the unemployed was based on an estimate of the Newstart Allowance whilst the pattern of consumption expenditure was derived from household income quintiles in the 2009/10 Household Expenditure Survey (ABS 2011).