Socioeconomic implications of the Guide to the proposed Basin Plan – methods and results overview

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Preface

The *Water Act (2007)* requires the Murray–Darling Basin Authority to prepare and implement a Basin Plan for the integrated and sustainable management of water resources in the Basin. The October 2010 release of the Guide to the proposed Basin Plan was a first step in this process and a major milestone for water management in Australia.

Within the Guide, the MDBA described scenarios that could meet the environmental water requirements for the Basin. The scenarios describe long-term average sustainable diversion limits for the Basin designed to return additional water to the environment.

Prior to the release of the Guide, the South Australian Government, through the Goyder Institute for Water Research, commissioned a science review of the Guide proposals in order to provide a South Australian perspective on the environmental and socioeconomic implications of the proposed sustainable diversion limits.

The Goyder Institute for Water Research has been formed to enhance the South Australian Government's capacity to develop and deliver science-based policy solutions in water management, and contribute to water reform in Australia. The science review was undertaken by CSIRO as a member of the Goyder Institute.

This report is one of several prepared as a part of the science review. Key findings from this and other related reports have been synthesized and released in 'A science review of the implications for South Australia of the Guide to the proposed Basin Plan: synthesis' (CSIRO, 2011).

Terms and abbreviations

ABS	Australian Bureau of Statistics
CDL	current diversion limit
cease-to-flow	‘zero’ flow, i.e. no water is coming down the river from upstream
CGE	computable general equilibrium
CLLMM	The Coorong, Lower Lakes, and Murray Mouth – a key environmental asset
EC	electrical conductivity; a measure of salinity – the more salt the higher the EC. EC is usually expressed in microSiemens per cm at 25°C (µS/cm)
GDP	gross domestic product
GL/year, GL/y	gigalitres per year (10^9 litres per year)
GVIAP	gross value of irrigated agricultural production
kL/year, kL/y	kilolitres per year (10^3 litres per year)
MDBA	Murray–Darling Basin Authority
ML/year, ML/y	megalitres per year (10^6 litres per year)
SA	South Australia
SAMRIC	South Australia Murray-Darling Basin Resource Information Centre
SDL	sustainable diversion limit
the southern portion of the Basin	Part of the Murray-Darling Basin, consisting of the following regions: • Wagga – Central Murrumbidgee • Lower Murrumbidgee • Albury – Upper Murray • Central Murray • Murray-Darling • Mildura – West Mallee • East Mallee • Bendigo – North Loddon • South Loddon • Shepparton – North Goulburn • South/South West Goulburn • Ovens–Murray • Murray Lands
the Basin	the Murray-Darling Basin
the border	the River Murray at the South Australian border
the Guide	the Guide to the proposed Basin Plan
the Plan	the Basin Plan
tonnes/year, tonnes/y	tonnes per year
WTP	willingness to pay

Scenarios and EWR optimised flows

Baseline	the flow that comes across the border under the current water sharing plans in all regions in the Basin. In the Guide it represents an average annual flow of 6783 GL at the border.
Without development	the baseline scenario with storages, urban and domestic usage and all river management rules removed. Since unregulated inflows are not adjusted for upstream usage or change in landuse in this scenario, it is not the same as a pre-development (or ‘natural’) flow sequence. In the Guide it represents an average annual flow of 13,592 GL at the border.
3000	the current sharing plans adjusted for 3000 GL/year of water being returned to the environment, spread across the regions of the Basin. In the Guide it represents an average annual flow of 8661 GL at the border.
3500	the current sharing plans adjusted for 3500 GL/year of water being returned to the environment, spread across the regions of the Basin. In the Guide it represents an average annual flow of 8966 GL at the border.
4000	the current sharing plans adjusted for 4000 GL/year of water being returned to the environment, spread across the regions of the Basin. In the Guide it represents an average annual flow of 9290 GL at the border.

Models and data

BigMod daily model	The MDBA’s MSM-BigMod model and its results. A configuration of the model was provided for each scenario, together with daily flow and diversions data. These data were aggregated to annual volumes for comparison with Guide annual volumes.

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1 Introduction

This report is companion to 'A science review of the Guide to the proposed Basin Plan: synthesis' (CSIRO, 2011) and provides an overview of the methods employed in the socioeconomic assessment of the Guide to the proposed Basin Plan and results.

The socioeconomic assessment addresses the terms of reference to:

- gather and interpret socioeconomic studies relevant to South Australia (SA) including recent analysis of the impacts of drought on River Murray and Lower Lakes communities
- interpret the socioeconomic modelling, analysis and regional reports undertaken by the Murray–Darling Basin Authority (MDBA) to support the development of the Guide to the proposed Basin Plan sustainable diversion limits (SDLs)
- use the above information to interpret the socioeconomic implications (impacts and benefits) of the new SDLs for SA communities (main focus) disaggregated to a sub-regional scale.

This assessment was to include consideration of: a) the sub-regional implications (Riverland, Mid-Murray and Lower Lakes and non-River Murray areas) and the implications for different sectors and user groups (irrigated agriculture, municipal and industrial water, other water users and the broader community); b) the implications of mitigation actions (the Commonwealth environmental water buyback, on-farm/off-farm irrigation infrastructure rehabilitation and water trade); c) changes to regional economic and social indicators; and d) the implications for stranded assets and structural adjustment.

The objectives of the study were addressed through three main steps: 1) a review of the socioeconomic impact assessment underpinning the Guide; 2) a review of the most pertinent economics studies; and 3) new economics assessment work to estimate potential costs and benefits of the Guide in comparison to current water allocation arrangements.

New economic assessment and analyses were undertaken to address the terms of reference requirement: a), the estimation of sub-regional impacts by key sectors. The benefits and costs evaluated in the original work are outlined in Table 1. These analyses were based on MDBA supplied 114-year modelling of daily flow and water allocations available for diversion under current development and system operating rules for the baseline and three Guide (3000, 3500 and 4000) scenarios. Terms of reference objectives b) – d) were addressed through review and inference from the most pertinent socioeconomic studies.

Table 1. Estimated potential benefits and costs of the Guide to major water users

Benefits	Costs
Irrigation	
Reduced salinity damage	Foregone production
	Purchase of water
Municipal and industrial water	
Reduced salinity damage	Consumer cost of water restrictions
	Purchase of water
	Operating cost of a desalination plant in Adelaide
Other (avoided)	
Infrastructure damage and repair	
Environmental remediation	
Replacement supply and water quality protection infrastructure	
Tourism loss	

An important caveat to this study is to note that, while a range of economic benefits and costs have been quantified, including several categories that were not considered quantitatively in the Guide, the study does not provide the basis for full assessment net benefits. A number of potentially important benefits have not been expressed in dollar terms and costs and benefits incurred outside of South Australia are not included; without this additional information an overall assessment of net benefits is precluded. It should also be noted that the detail of variation in flow and allocations available for diversion was a 114-year time series provided by the MDBA to CSIRO. This dataset, which was received by the project team on 22 January 2011, differs from that posted by the MDBA on their website in April 2011. Analysis based on these new data would generate different results.

A final consideration is that the estimated costs associated with SDLs reported here should be interpreted as an upper bound estimate. The reduced diversions available for SA considered in this analysis do not include any offsetting positive regional economic benefits of water buyback or infrastructure investment. The Commonwealth Government has committed to recovering all the water that is required under a Basin Plan by purchasing water from willing sellers or investing in water efficiency measures under the Water for the Future program. Through this program, the Commonwealth has already recovered a significant portion of the water that is likely to be required under a Basin Plan, thus reducing potential impacts on water entitlement holders. Should the Commonwealth achieve the aim of recovering all the water required through purchase from willing sellers or efficiency investments, there may be little residual impact on water entitlement holders: first, because the sale of entitlements to the Commonwealth will take place in all states, and second, if water purchases or efficiency investments do take place in SA, they are likely to generate regional economic activity which will offset at least some of the lost economic activity from reduced irrigation in the SA portion of the Murray-Darling Basin.

This report is structured as follows. The economic impact of the Guide depends on the baseline water available for diversions and how this water availability is affected under the Guide scenarios. As such, section 2 describes the allocation and flow sequences over which Guide scenarios were evaluated. Section 3 offers an overview of the irrigation sector model, its calibration to observed data and water allocation calculations. Section 4 provides detail of how economic impacts to municipal and industrial water users supplied by SA Water were estimated. Section 5 discusses the methods developed to quantify ecosystem service loss resulting from changes in flows. Section 6 is a brief review of literature pertaining to regional economic impacts of SDLs. The report concludes with a discussion of structural adjustment implications.

2 Water available for diversions assumed in economic analysis

The economic impact of the Guide depends on the baseline water available for diversions and how this water availability is affected under the Guide scenarios.

The baseline against which costs and benefits were measured was supplied by the MDBA (the BigMod daily model) and consists of 114 years of historical flow and water allocations data. Water allocations as total diversions to irrigation in SA were modelled in MSM-Bigmod by the MDBA under conditions specific to the baseline (current development and operating rules with historical inflows) and for each of the Guide scenarios. Figure 1 shows the average amount of water allocations available for all uses in SA by decade under the baseline and Guide scenarios. The figure shows bars representing the ten-year sequence average allocations available for diversion, expressed in GL, that irrigators would have been allocated historically (with baseline inflows and operating rules) and under each of the Guide scenarios. From the left to the right of the figure, decades are ranked from lowest to highest allocations under the 3500 scenario. The black lines represent the standard error of variation from the average. Figure 2 shows the average annual allocation of water available for irrigation under the baseline and Guide scenarios.

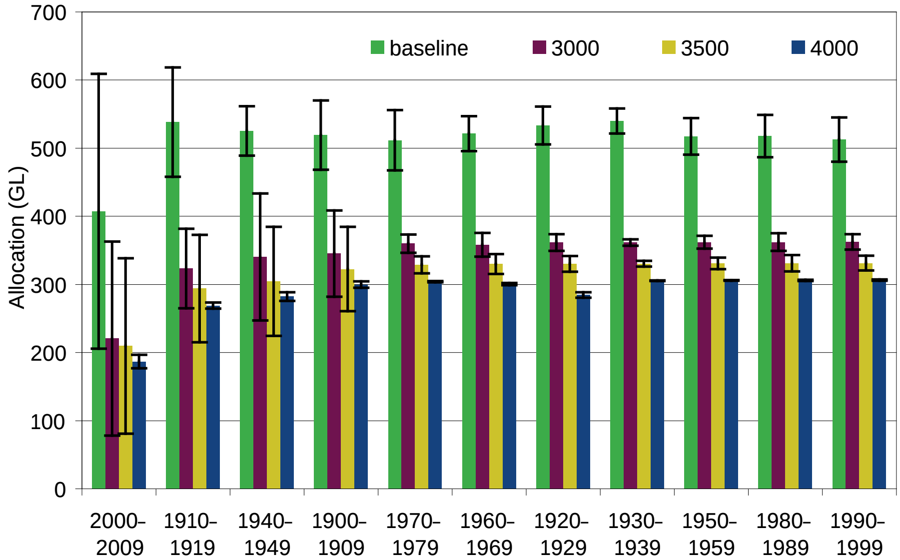

Figure 1. Average allocations (as total diversions) to South Australia per decade, showing standard error, and ranked by allocations under the 3500 scenario, under the baseline and Guide scenarios

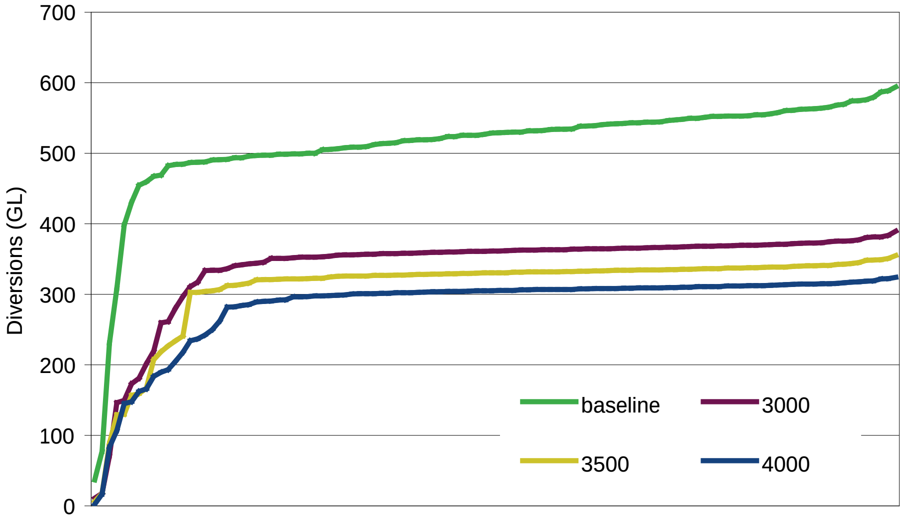

Figure 2. Average annual allocation of water available to South Australia for irrigation over the 114-year modelling period, ranked in ascending order, under the baseline and Guide scenarios

Since it is expected that the potential economic impacts of SDLs will differ in dry, average inflow and wet periods, impacts were evaluated over three decade-long allocation and flow sequences:

- years 2000 to 2009 – the Millennium Drought, which is the driest decade on record
- years 1910 to 1919 – continuation of the Federation Drought, the decade with the second lowest allocation levels available for diversion in SA under the Guide scenarios
- years 1970 to 1979 – representing the median flow and allocation decade. This decade is treated as representative of the 94 years outside of the two decades described above. In these 94 years, allocations to SA in the BigMod modelled data were relatively constant under the Guide scenarios.

Within these decades there is considerable annual variation in allocations of water available for irrigation. This range of allocations is represented in the BigMod model. For each of these decades, we consider four water availability 'states of nature': state1 is the driest year in the decade; state 2 is the second and third driest years in the decade; state 3 is the fourth and fifth driest years in the decade; and state 4 is the five wettest years in the decade (Table 2).

It is important to note that these are modelled scenarios only and do not necessarily reflect actual water availability observed historically. There are a range of factors which impact on water availability for allocation which are not necessarily fully reflected in these modelled results. For example, irrigators received 18% allocations in 2008/09 which reflected the lowest period of water availability in South Australia on record – this is higher than the 7% water availability modelled for the driest year in the 2000s decade under the baseline scenario.

Table 2. Allocations of water available for irrigation for the three selected decades and 'states' of water availability within those decades, under the baseline and Guide scenarios

	Baseline		3000		3500		4000	
State of water availability within decade	Average for State	Allocation	Average for State	Allocation	Average for State	Allocation	Average for State	Allocation
	GL	fraction	GL	fraction	GL	fraction	GL	fraction
2000s decade								
driest year	36.63	0.07	10.87	0.02	6.35	0.01	2.46	0.00
2nd and 3rd driest years	154.13	0.29	44.31	0.08	53.04	0.10	50.15	0.09
4th and 5th driest years	504.88	0.95	200.23	0.38	213.07	0.40	176.03	0.33
5 wettest years	544.31	1.03	341.11	0.65	312.01	0.59	282.50	0.53
1910s decade								
driest year	467.22	0.88	146.43	0.28	129.30	0.24	106.90	0.20
2nd and 3rd driest years	519.44	0.98	245.11	0.46	231.04	0.44	205.17	0.39
4th and 5th driest years	527.53	1.00	360.62	0.68	329.49	0.62	304.69	0.58
5 wettest years	564.39	1.07	374.81	0.71	338.33	0.64	312.68	0.59
1970s decade								
driest year	430.27	0.81	334.24	0.63	305.06	0.58	282.31	0.53
2nd and 3rd driest years	471.83	0.89	348.06	0.66	317.41	0.60	293.94	0.56
4th and 5th driest years	510.49	0.97	360.43	0.68	329.09	0.62	304.48	0.58
5 wettest years	544.48	1.03	369.86	0.70	338.14	0.64	312.55	0.59

2.1 Modelling water available for municipal and industrial diversions

The BigMod daily model assumed how water allocations available to SA would be shared between irrigation and SA Water entitlements (water for municipal and industrial uses in SA). Specifically, the BigMod daily model assumed that municipal and industrial water would be provided with full allocation first and then irrigation allocations would comprise the residual allocation available for diversion in SA. The SA Government, however, has not determined how to share the state allocation as the SDLs are yet to be finalised. To further understand the potential impacts on water users in SA under the Guide scenarios, the SA Government requested an evaluation of both the MDBA allocation scenario and an alternative scenario involving an equal percentage reduction in water available to municipal and industrial water and to irrigation.

Figure 3, Figure 4 and Figure 5 show the baseline and expected water allocations available as irrigation diversions under the 3500 scenario both with and without reductions being shared between irrigated agriculture and municipal and industrial water. Allocation reductions for irrigation are evident across all years and decades although they are most significant in the driest years and even more so in the driest decades.

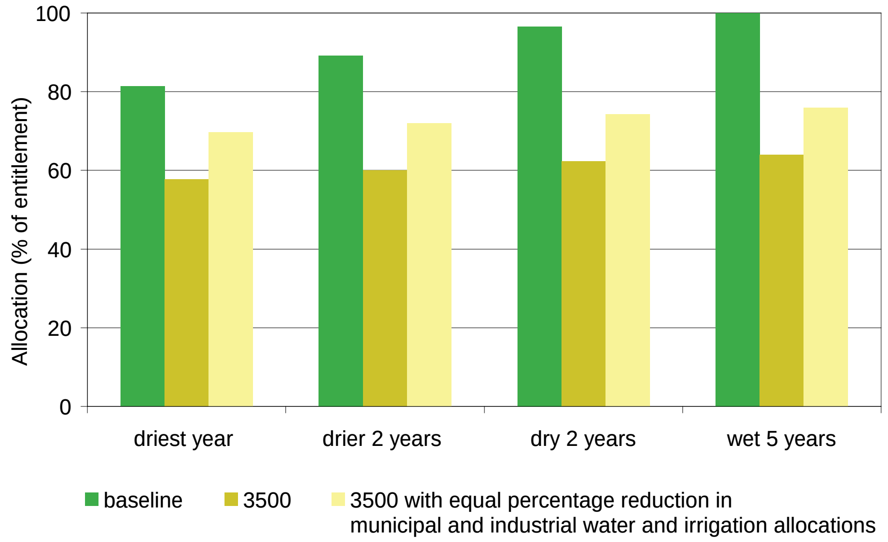

Figure 3. Irrigation allocations as percent of entitlement under the 'normal' 94 years in the 114-year modelling period for the driest year in each decade (driest year), the 2nd and 3rd driest years in each decade (drier 2 years), the fourth and fifth driest years in each decade (dry 2 years) and the five wettest (wet 5 years) under the baseline and 3500 scenarios

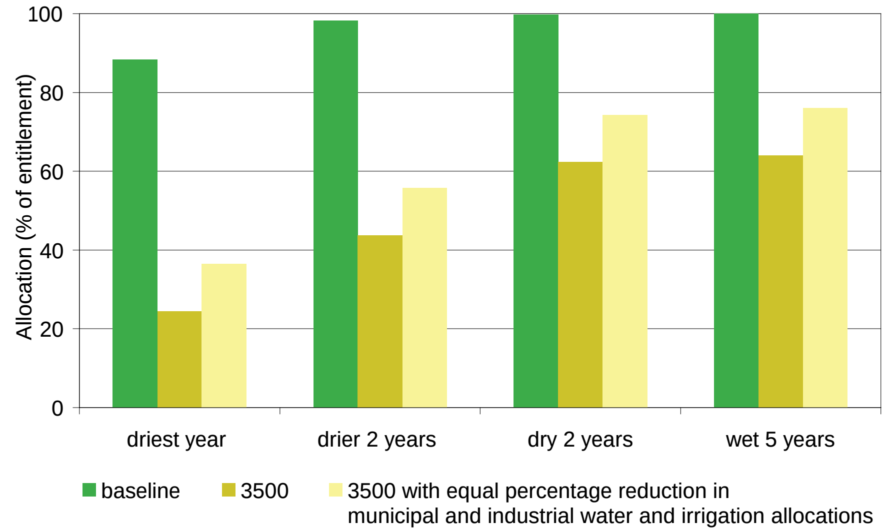

Figure 4. Irrigation allocations as percent of entitlement under one of the driest decades (1910–1919) for the driest year in each decade (driest year), the 2nd and 3rd driest years in each decade (drier 2 years), the fourth and fifth driest years in each decade (dry 2 years) and the five wettest (wet 5 years) under the baseline and 3500 scenarios

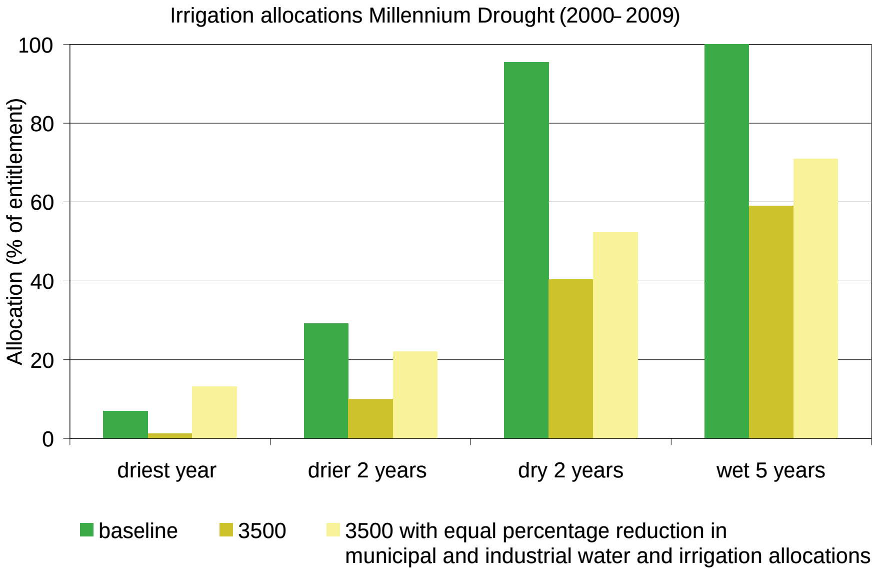

Figure 5. Irrigation allocations as percent of entitlement under the driest decade on record (2000–2009) for the driest year in each decade (driest year), the 2nd and 3rd driest years in each decade (drier 2 years), the fourth and fifth driest years in each decade (dry 2 years) and the five wettest (wet 5 years) under the baseline and 3500 scenarios

3 Irrigation economics model

Reduced water allocations under the Guide scenarios may result in a need for the irrigation sector to adapt, with possible adaptation strategies including: buying additional water on the market, reducing irrigation applications rates, reducing irrigated area, and changing crop mix.

An economic model of the irrigation sector was developed to assess the likely adaptation patterns and costs in response to reduced water allocation available for irrigation under the Guide scenarios. Irrigation sector economic impacts were estimated for three sub-regions (Figure 6):

- the area above Blanchetown (also known as the Riverland)
- the area between Blanchetown and Wellington (also known as the Murray Gorge)
- and the area below Wellington (also referred to as the Lower Lakes).

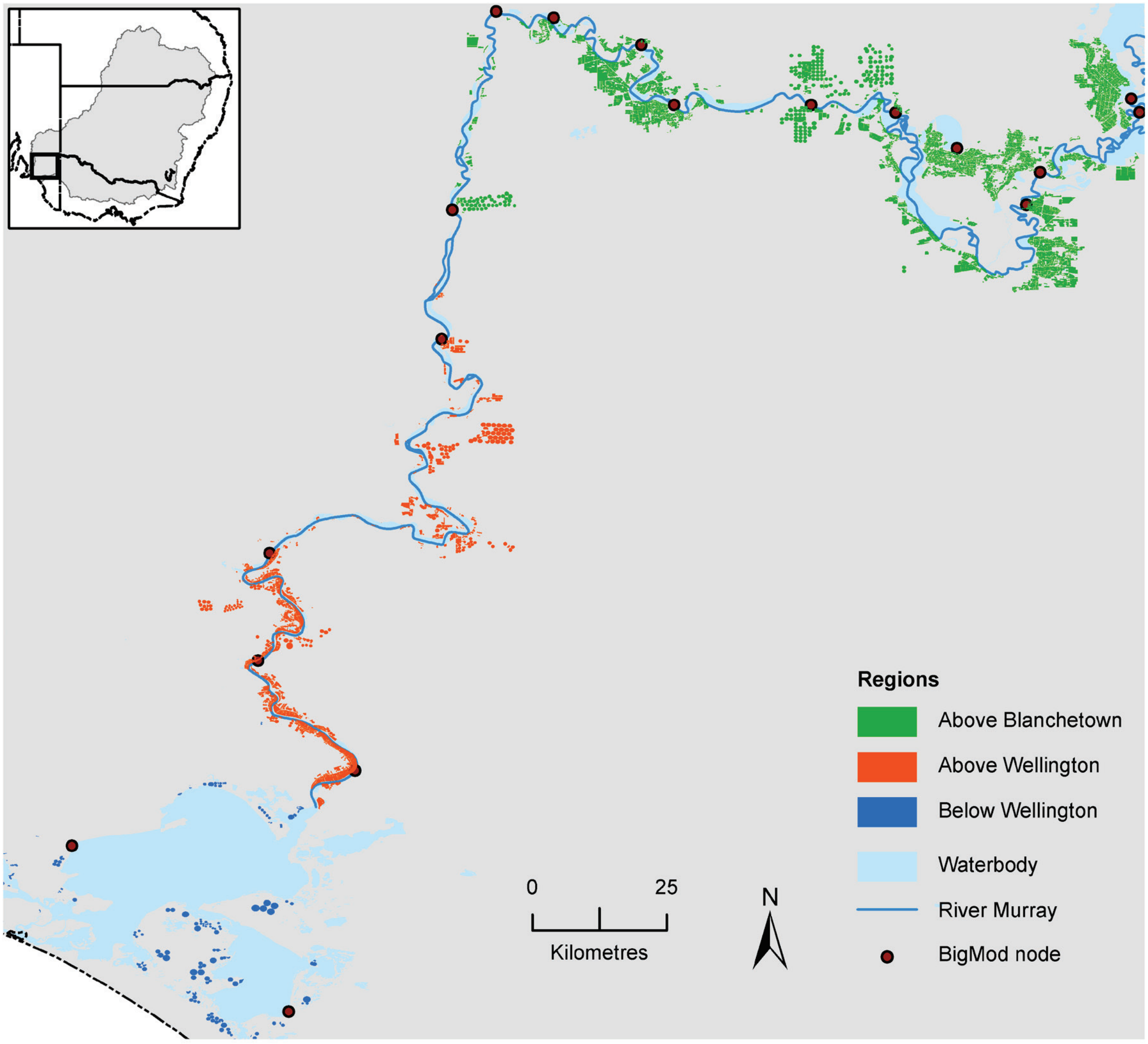

Figure 6. Sub-regions considered in irrigation sector economic impact assessment

Irrigation sector economic impacts were modelled for each of the three regions with an irrigation sector economic optimisation model following Connor et al. (2009). The model is based on a two-stage programming framework with recourse (Danzig, 1955; McCarl et al., 1999). The first stage represents long run capital investment decision-making. In this stage, an irrigator must choose levels of investment in irrigation equipment, permanent plantings, and other capital investment given expectations of annual stochastic variation in water allocation and water price. The second stage involves year-to-year decisions regarding variable input levels, including water application rates and the amount of land to actually irrigate or leave fallow. The second stage decisions depend upon stochastically determined water allocations, water prices and the levels of fixed capital investment chosen in the first stage.

The objective is to maximize profits for each of the three regions, namely the Riverland, Murray Gorge and the Lower Lakes, subject to land and water constraints. Regional profit, π, is represented as:

$$\Pi = \sum_s pr_s * \left(\sum_j (p_j * Y_{s,j}(W_{s,j}) - pw_s * (W_{s,j} - wa_{s,j}) - vc_j) \right) * AI_{s,j} - \sum_j fc_j * A_j \quad (1)$$

The parameters and variables in the model are indexed by crop *j* (wine, citrus, stone fruits, almonds, vegetables, and pasture) and state of nature *s* (States 1−4). These states of nature are the levels of allocation estimated to be available for irrigation diversion in the MDBA-provided modelling in the three water availability decades described above in Chapter 2. The water available for irrigation by decade and state of nature assumed in this modelling is summarised in Table 3 with: the driest year in the decade representing State 1; the second two driest years in the decade representing State 2; the 3rd driest two years in the decade representing State 3, and; the wettest five years in the decade representing State 4. These states have the associated probabilities (pr_s) of 10%, 20%, 20% and 50% for States 1 to 4 respectively. Regional profit is calculated for all four states in each of the three decade-long climate and water irrigation water allocation sequences modelled, and on average for the entire 114 years.

A_j is area in hectares, representing the initial area planted with capital investment in irrigation equipment and perennial stock (where present). For this analysis it is assumed that A_j represents observed area under production by crop for each region in 2005-06 as summarised in Table 4 and is based on data sourced from the most comprehensive survey of regional irrigated agriculture available (SAMRIC, 2010). This area (A_j) is assumed to have the prerequisite capital investment available for crop *j* in all years and states of nature, although it may not be irrigated in all states of nature. $AI_{s,j}$ is area (hectares) available for crop *j* that is actually irrigated rather than fallowed in state of nature *s*. Note that $AI_{s,j}$ can vary across states of nature while A_j remains constant. $Y_{s,j}$ is yield (tonnes) and $W_{s,j}$, is the water applied (ML/ha). The production function characterising yield as a function of water is described below.

Parameters are represented by lower case letters where fc_j represents the crop establishment and irrigation establishment costs treated as an annual cost; p_j is the crop price per tonne of yield; pw_s is the market equilibrium price per unit water traded on the market and $wa_{s,j}$ represents the allocation of water in state of nature s for crop j; vc_j represents variable costs of production for crop *j* not related to irrigation. Table 3 summarises the values of economic parameters fc_j; p_j; and; vc_j assumed in the analysis.

The second stage decision captures short run choices that can be varied once stochastically determined water allocations and water price are revealed. Land and water allocations in the second stage are represented by the variables $AI_{s,j}$ and $W_{s,j}$. This stage includes decisions on whether to irrigate or fallow land and a choice of the rate of water application given the fixed irrigation capital investment made in stage one.

The objective function is subject to a constraint requiring that water use in each state of nature in excess of the available water, $wa_{s,j}$, must be purchased at the market price of water pw_s. When less than the allocation is used, the excess allocation can be sold at water price pw_s.

The possibility that a portion of area, A_j, with irrigation infrastructure and hence the opportunity to irrigate, can be fallowed to save water is represented by equation (2).

$$AI_{s,j} \cdots \leq \cdots Aj \cdots \forall \cdots s \in S, j \in J \quad (2)$$

An overall land constraint is also imposed such that the sum of irrigated and fallowed land cannot exceed total available land.

3.1 Crop-water-salinity production functions

We include the quadratic crop water production function in our model of the form

$$Y = \alpha_1 + \alpha_2 \cdot W + \alpha_3 \cdot W^2 \quad (3)$$

There are several approaches to estimating parameter values for such production functions. One common approach is agronomic and based on crop water trials. Here we derive the parameters using an economic calibration approach. This involves inferring the technical nature of the relationship between water application rate and yield expressed in Equation 3 through parameters α_1, α_2 , α_3. We use information on observed yields and water application rates, given economic conditions relevant to the choice of water application. The starting point for this calibration is the assumption that irrigators have the objective of applying water at a rate that maximises profit per hectare (Equation 4) where Y(W) represents the underlying crop water yield function, P_w, the price of water, P the price of the crop and W the water applied per hectare.

$$\text{Maximise profit} = \alpha_2 + \alpha_3 \cdot W = \frac{Pw}{P} \qquad (4)$$

We then derive the first order conditions for profit maximisation with respect to water as an input into production, substituting Expression 3 for Y(W) in Equation 4, yielding Expression 5. The interpretation of this equation is that water is applied until the marginal return to water is equal to the marginal cost per unit water. The relationship expressed in Equation 5 holds true for different periods and when the price of water is higher, all other things equal, a higher rate of water application at a higher cost can be justified when it yields greater revenue.

$$\frac{\partial \text{profit}}{\partial \text{W}} = \alpha_2 + \alpha_3 \cdot \text{W} = \frac{\text{Pw}}{\text{P}} \qquad (5)$$

To infer α_1, α_2, and α_3 we use observations on P_w, P and W in periods of both higher water price and lower application rates, and lower water price and higher application rates. Determining the shape of the crop water production function involves solving for three unknowns α_1, α_2, and α_3, with three equations. Two equations are in the form of Equation 5, one equation with the crop prices, water prices and water application rates observed in 2005–06 substituted for W, P and P_w, and the second with values for W, P and P_w observed in 2007-08. The third equation is in the form of Equation 3 with observed yield in 2005-06 substituted for the Y term and water application rate in 2005–06 substituted for the W term.

Given the absence of a discernible time trend in vegetable water use per hectare and advice from agronomists that water application in vegetable production serves both yield and heat stress protection purposes, we assume constant water application rates in vegetable production. Given the similarities in stone fruit, citrus and almond production, we estimate the crop water production function for these fruit trees as one crop and scale the results to differences in evapotranspiration requirements. The parameter values assumed in the process of crop water yield function inference are summarised in Table 3. Table 4 shows the estimated crop water production function parameter values and Table 5 shows estimated yield as a function of water application that results with the estimated crop water production functions.

Table 3. Parameter values used to estimate crop water production function

		2006	2008	2006	2008
Crop	Commodity price	Water price		Water applied	
	$/tonne	$/ML		ML/ha	
grapes	350	$250	$810	4.8	4.1
fruit	6000	$250	$810	8.4	6.1
pasture	280	$250	$810	5.9	2.8

Table 4. The estimated crop water production function parameter values

	grapes	fruit	pasture
α1	4.221	1.707	–0.667
α2	7.944	0.266	3.401
α3	–0.753	–0.013	–0.213

Table 5. Yield as a function of water application estimated with the crop water production functions

Water application rate	Crop				
	grapes	stone fruit	nuts	citrus	pasture
ML/ha	tonnes/ha				
2.50					5.50
3.00					6.29
3.50					6.96
4.00	23.93				7.53
4.50	24.70				7.99
5.00	25.10				8.35
5.50	25.11				8.59
6.00		17.01	2.84	47.25	8.74
6.50		17.32	2.89	48.11	8.77
7.00		17.59	2.93	48.87	
7.50		17.82	2.97	49.51	
8.00		18.02	3.00	50.05	
8.50		18.17	3.03	50.48	
9.00		18.29	3.05	50.80	

Yield is also multiplied by a salinity loss term $Y_{sl.}$ We followed the methodology embedded in the BigMod daily model to estimate this value. River water salinity concentrations for a salinity monitoring point in each of the sub-regions modelled from the 35 of the 114-years time series data (1975 to 2009) provided the baseline and Guide scenario daily salinity estimates. River water salinity from this data was converted to soil water salinity, ecw, expressed in EC units, with the function:

$$ecw - 0.25 \cdot ece \cdot \left(1 + \frac{1}{1 - ie}\right) \qquad (6)$$

where ie is irrigation system efficiency. The yield impact of salinity expressed as a percentage of yield in the absence of yield reducing salinity levels is then computed with

$$\%Y_{sl} = a + b \cdot ecw \qquad (7)$$

3.2 Water price regression prediction

We followed Brennan's (2006) regression analysis to estimate a relationship between water allocation and water prices. The resulting equation ($R^2 = 0.89$), using annual temporary water price and water allocation data from 1998 to 2004, is as follows

$$\ln(P_w) = 7.84 - 1.308A - 0.00718R \qquad (8)$$

where P_w is the price of water ($/ML) and A is percentage of entitlement. Each irrigator in the region has an entitlement to be delivered an amount of water denominated in ML. Depending on dam storage levels, the water authority chooses a percentage of entitlement up to 100% to distribute to irrigators. This fraction of entitlement A is known as an irrigator's annual allocation. Finally, R in equation (8) represents the cumulative season rainfall (mm). We estimate water prices for each region with this equation while the water allocations and rainfall levels are assumed for each scenario. Estimated water prices are presented in Table 6. Allocation levels in SA were related to those observed in the Goulburn-Broken with a regression on data on October allocation in the two regions from 1998 to 2005 ($R^2 = 0.93$). The result is equation 9.

$$\text{Goulburn-Broken October allocation(year)} = 24.3{*}\exp(0.0206{*}\text{South Australian October allocation(year)} \qquad (9)$$

Table 6. Predicted annual allocation water price under the 3000 scenario

	driest 1-in-10 years	drier 2-in-10 years	dry 2-in-10 years	wet 5-in-10 years
	$/ML			
Without plan				
‘normal’ 94 in 114 years	222	161	93	44
1910–1919	222	131	98	44
2000–2009	749	614	102	44
With plan				
‘normal’ 94 in 114 years	338	314	233	139
1910–1919	614	476	233	135
2000–2009	777	744	422	159

3.3 Data

Data on cropped area by sub-region were derived from the South Australian Murray River Information Centre (SAMRIC, 2010). The baseline areas by crop are shown in Table 7. Economic parameters underpinning the analysis are summarised in Table 8.

Table 7. 2008 area by crop and region in economic impact modelling baseline

	grapes	citrus	nuts	stone fruit	vegetables	pasture	Total
	area/ha						
Riverland	24,810	7,806	4,086	2,692	7,096	1,371	**47,861**
Murray Gorge	963	392	390	207	3,591	8,009	**13,553**
Lower Lakes	899		16	100	70	5,105	**6,191**
Total	**26,671**	**8,199**	**4,492**	**2,999**	**10,758**	**14,485**	**67,604**

Table 8. South Australian Murray irrigation production economics parameter values used in modelling

Economic parameter	grapes	citrus	pasture	vegetables	stone fruit	nuts
Fixed irrigation costs ($/ha/y)	1317.28	1116.74	353.41	1321.09	1116.74	1116.74
Fixed non-irrigation costs ($/ha/y)	2623.95	2598.56	766.00	1326.84	2476.88	2473.28
Variable costs ($/ha/y)	3560.00	5284.00	468.55	4062.00	6285.00	4413.00
Price ($/t)	650.00	429.00	345.00	275.00	1100.00	6500.00
Assumed maximum yield (t)	25.00	50.00	12.00	30.00	18.50	3.00

3.4 Results

Figure 7 shows the estimated average annual irrigation sector cost under the Guide scenarios. These represent conservative upper bound estimates of potential cost to the irrigation sector as they are estimated assuming that irrigators face the full amount of allocation reduction under the 3000, 3500, and 4000 scenarios and that the water is not sourced by buyback. In fact, the Commonwealth has already bought back a considerable volume of water and should they choose to source any additional water required to meet SDL by buyback, irrigation sector economic impact would be much less than estimated here. It should also be noted that in this analysis, it was assumed that all allocation reductions are borne by irrigation rather than being shared across irrigation and municipal and industrial water users.

Both the total cost and the portion of that total cost estimated to be the cost of water purchases are shown. Notably, the results show a relatively linear relationship between increasing costs and the Guide scenarios. The estimated irrigation sector costs represent 4.0%, 5.3% and 6.4% of baseline irrigation revenue (gross value of irrigated agricultural production – GVIAP) under the 3000, 3500, and 4000 scenarios, respectively. Most of the increased cost is estimated to be the result of the expense of purchasing additional water. The remaining relatively small cost represents the value of reduced irrigated agricultural output. ABARE-BRS estimated a 7% reduction in the value of GVIAP in the SA Murray. The difference can likely be explained by the greater improvement in water use efficiency in response to water scarcity assumed in this study which is consistent with the recent drought response.

Note that the irrigation costs discussed in this section are best interpreted as an upper bound (or worst case) because we estimate the cost of meeting the SDL as the cost of reducing water available for diversion in SA and without offsetting regional income from buybacks or infrastructure investment.

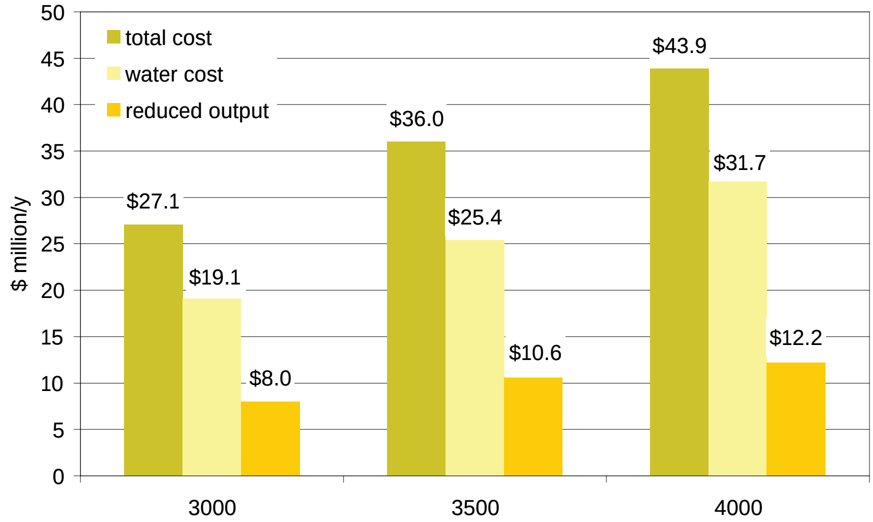

Figure 7. Worst case average annual costs to the South Australian irrigation under the Guide scenarios

More detailed results are summarised here for a comparison of the current diversion limits and the 3500 scenario. Figure 8 summarises the estimated annual costs for SA irrigation on average for 94 of 114 years where relatively constant allocations are expected, estimated average costs for a period similar to the Millennium Drought (2000–2009), and estimated average costs over a 114-year period. The average annual cost over the 114 years under the 3500 scenario is $36 million/year. Figure 8 also shows that the costs are estimated to be considerably greater during dry periods such as that experienced in the Millennium Drought since more severe allocation reductions are predicted and also because the model accounts for water prices which are predicted to be higher under more water scarce scenarios.

Figure 9 and Figure 10 demonstrate how economic impacts under the Guide scenarios are likely to vary across sub-regions. Figure 9 shows that in absolute terms, the Riverland is expected to bear the greatest impact; this is because the region produces the largest share of irrigated output in SA and the highest value crops per ML and hectare with its predominance of horticultural and viticultural crops. The Lower Lakes region below Blanchetown is estimated to be most severely impacted in relative terms with the cost incurred under the Guide scenarios highest as a percentage of GVIAP. This is primarily due to the predominance of irrigated pasture for grazing in the region. Recent drought experience shows that pasture is only marginally economical with high water prices; modelling predicts that pasture will be left fallow under very low allocation conditions such as is the case in the 1-in-10 and 3-in-10 dry years in the Millennium Drought sequence. One result of the modelling underpinning the Guide is that there will be a significant reduction in water availability in dry years and dry sequences. Buying water is not a cost-effective response for those irrigating pastures, so they reduce production. As irrigated grazing pasture is the dominant activity in the Lower Lakes, this region suffers the greatest cost impacts as a percentage of GVIAP.

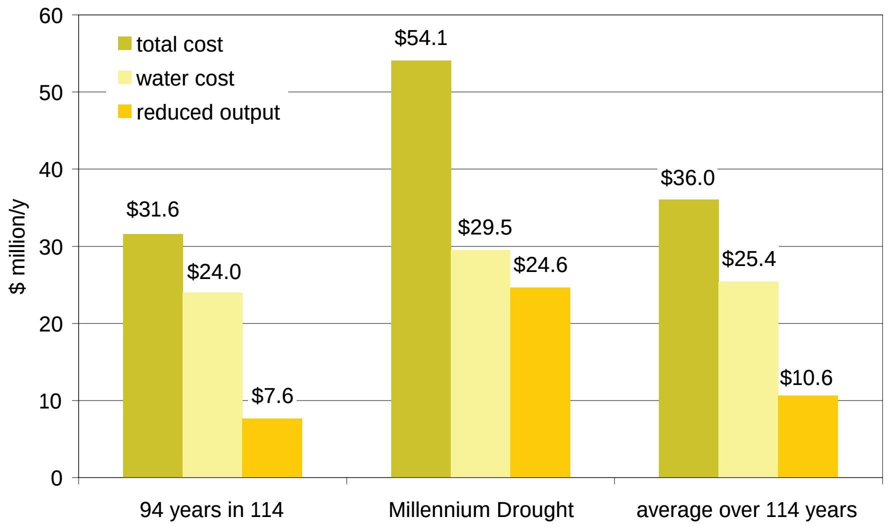

Figure 8. Worst case average annual costs to the South Australian River Murray irrigation sector in dry and average decades under the 3500 scenario

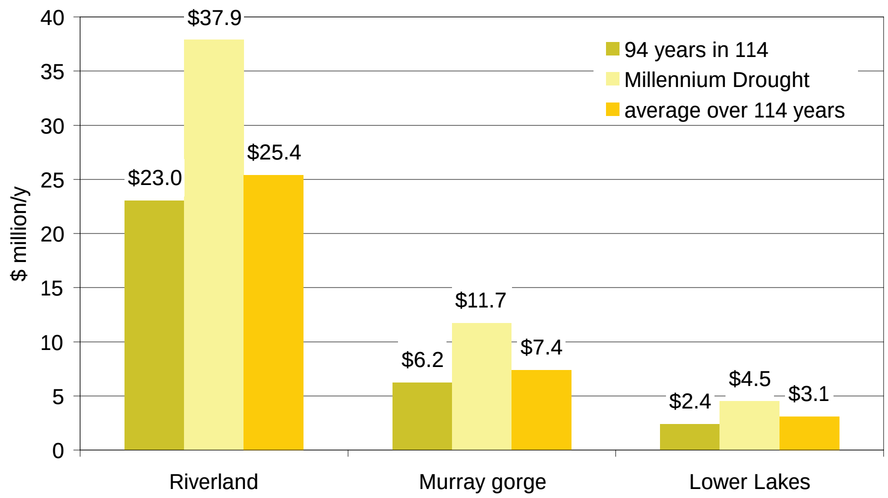

Figure 9. Worst case average annual costs to South Australian irrigation sub-regions in dry and average periods under the 3500 scenario

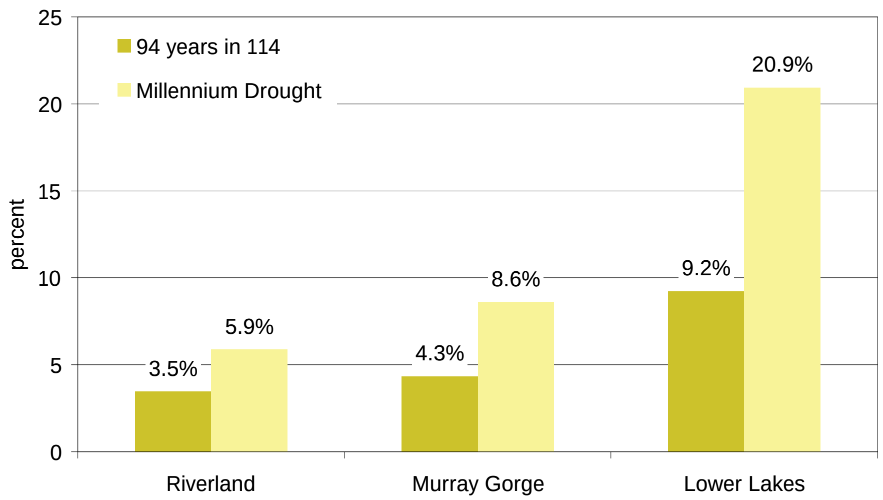

Figure 10. Worst case average annual costs to South Australian irrigation sub-regions, expressed as percent of baseline irrigation revenues, in dry and average periods under the 3500 scenario

Estimates of potential future irrigation sector costs necessarily have a degree of uncertainty, as the exact pattern of response to increased water scarcity under the Guide scenarios is not perfectly foreseeable. This evaluation is inherently conservative in the sense that it represents an upper bound estimate because it included assumptions that the full extent of reductions in allocations implied in the Guide scenarios are actually realised as reductions in water available for SA irrigators. Furthermore, it is assumed that these reductions in allocations are not achieved through water buyback or infrastructure investment which would introduce offsetting positive income streams into the regional economy. Within the context of the above caveat, the estimates provided here are likely to be somewhat sensitive to two key assumptions:

1. Buying water is a key modelled and observed response to water scarcity amongst irrigators in SA. An assumption of increasing water price with increasing water scarcity is factored into this analysis. In reality, water prices might be more or less than assumed depending on how supply and demand evolve across the Basin in response to SDLs. If in fact water were simply not available to meet the shortfall between supply and demand, costs could be significantly higher (Connor et al., 2009).
2. Relatively little reduction in irrigation area-response is modelled here as a result of our calibration to ABS and SAMRIC data. Both of these data sources show some reductions in the area of irrigated pasture in the SA Murray from 2005–06 to 2008–09, but no clear trend of decreasing vineyard or orchard area. Recent aerial survey data on changes in irrigated areas have come to the project team’s attention late in the project. This data show declines in orchard and vineyard area over the course of the recent drought (PIRSA, 2010). Re-calibrating the model to this new data would likely result in a greater reduction in irrigated area and consequently a greater cost incurred under the Guide scenarios.

Although Point 2 might tend to suggest an underestimation of the irrigation sector impact and Point 1 could lead to an over or underestimation, the mobility of farm assets might suggest an overestimation of the net impact.

More significantly, the estimated costs associated with SDLs reported here should be interpreted as an upper bound estimate. The reduced diversions available for SA considered in this analysis do not include any mitigating actions to reduce irrigation sector economic impact. The Commonwealth Government has committed to recovering all the water that is required under a Basin Plan by purchasing water from willing sellers or investing in water efficiency measures under the Water for the Future program. Through this program, the Commonwealth has already recovered a significant portion of the water that is likely to be required under a Basin Plan, thus reducing potential impacts on water entitlement holders. Should the Commonwealth achieve the aim of recovering all the water required through purchase from willing sellers or efficiency investments, there may be little residual impact on water entitlement holders. First, because the sale of entitlements to the Commonwealth will take place in all states, and second, if water purchases or efficiency investments do take place in SA, they are likely to generate regional economic activity which will offset at least some of the lost economic activity from reduced irrigation in the SA portion of the Basin.

4 Municipal and industrial water impacts

The terms of reference for this study included an evaluation of the potential costs to SA municipal and industrial water supply. The 114-year flow and water allocation modelling provided for this study by the MDBA assumed that all reductions in annual water allocation available for diversion in SA would fall on the irrigation sector, and that the water entitlement for municipal and industrial water would be fully met in every year, even in very dry years. However, it is possible that the SA Government may decide to share any future reductions between irrigation and municipal and industrial water users differently. Under advice from the SA Government, we modelled a scenario where allocation reductions under the Guide scenarios were shared across all water users in proportion to their level of entitlements.

To estimate the potential impact of reductions in municipal and industrial water allocations under the Guide scenarios with this alternative assumption, we analysed the difference in allocations under the baseline scenario and under the Guide scenarios. Specifically, over the 114-year period (1895–2009) modelled by the BigMod daily model, assuming equal proportional sharing of reduced allocations, shortfalls in municipal and industrial water allocation for Adelaide under the 3000 scenario were compared with current diversion limits (CDL) as set in the baseline scenario.

The potential costs associated with these shortfalls under the 3000 scenario for Adelaide and country towns serviced by SA Water were estimated for three alternative strategies:

- water restrictions and their implicit costs
- buying water to meet demand
- the additional cost of operating the desalination plant above baseline scenario levels to meet demand.

Using historical data on yearly flows, periods between 1896 and 2009 with low, average and high mean yearly flow conditions were identified and the potential cost of shortfalls for Adelaide and SA country towns estimated using the three alternative cost estimators (see Table 9 to Table 11 in Section 4.5 for detailed results of these flow scenarios).

4.1 Shortfalls in allocation under the 3000 scenario

To capture the characteristics of variability and uncertainty in shortfalls, probability density functions were fitted to the difference in modelled historical data for municipal and industrial water annual allocations under the 3000 scenario and under the baseline over the 114 years period. Figure 11 and Figure 12 show the estimated probability density functions for shortfalls in municipal and industrial water allocation for Adelaide and SA country towns under the 3000 scenario compared to baseline. SA country towns serviced by SA Water include, but are not limited to, the Riverland, Eyre Peninsular, Port Augusta and Whyalla. The probability density function plots the relative likelihood (*y*-axis) of a range of probable magnitudes of shortfalls (*x*-axis). For example, the most likely shortfall for Adelaide is 30 GL and the likelihood of shortfalls over 60 GL are small (Figure 11). In Figure 11, shortfalls in municipal and industrial water allocation for Adelaide under the 3000 scenario when compared with CDLs were estimated to range between 6.2 GL/year and 112.1 GL/year with a mean of 35.6 GL/year. In Figure 12, shortfalls in municipal and industrial water allocation for country towns were estimated to range between 7.2 GL/year and 35.8 GL/year with mean of 16.5 GL/year.

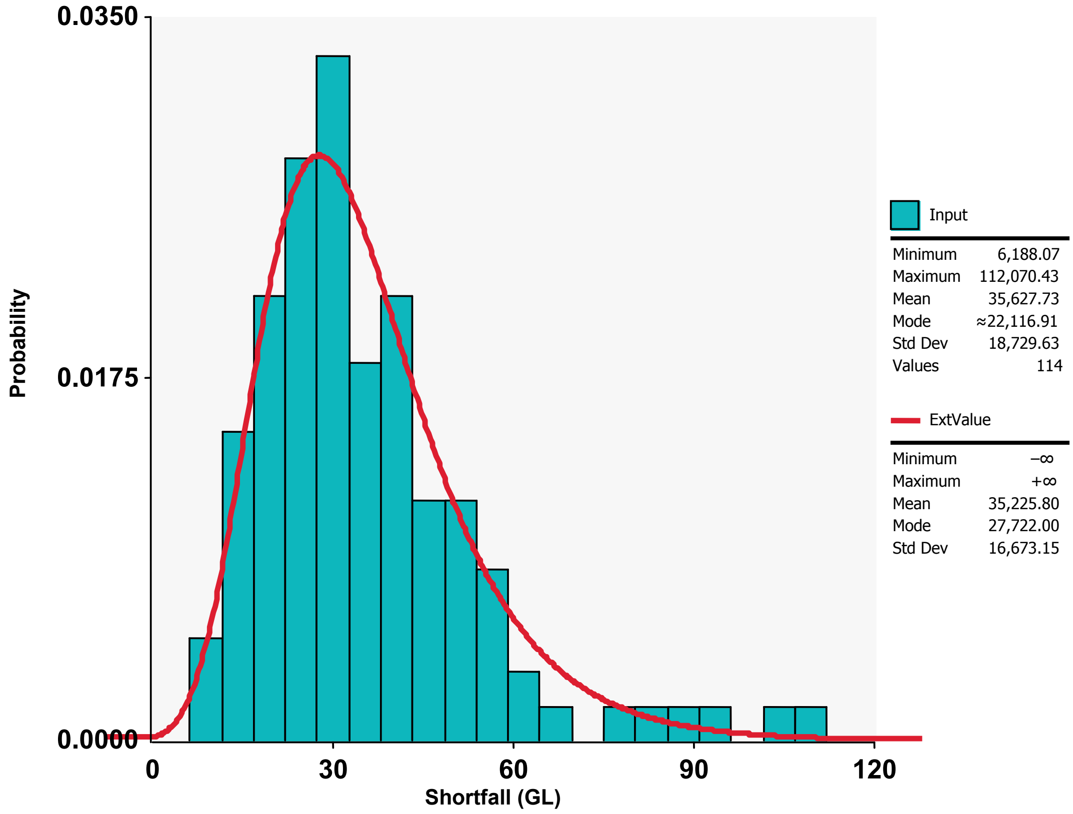

Figure 11. Probability density function for shortfall in municipal and industrial water allocation to Adelaide under the 3000 scenario compared to baseline

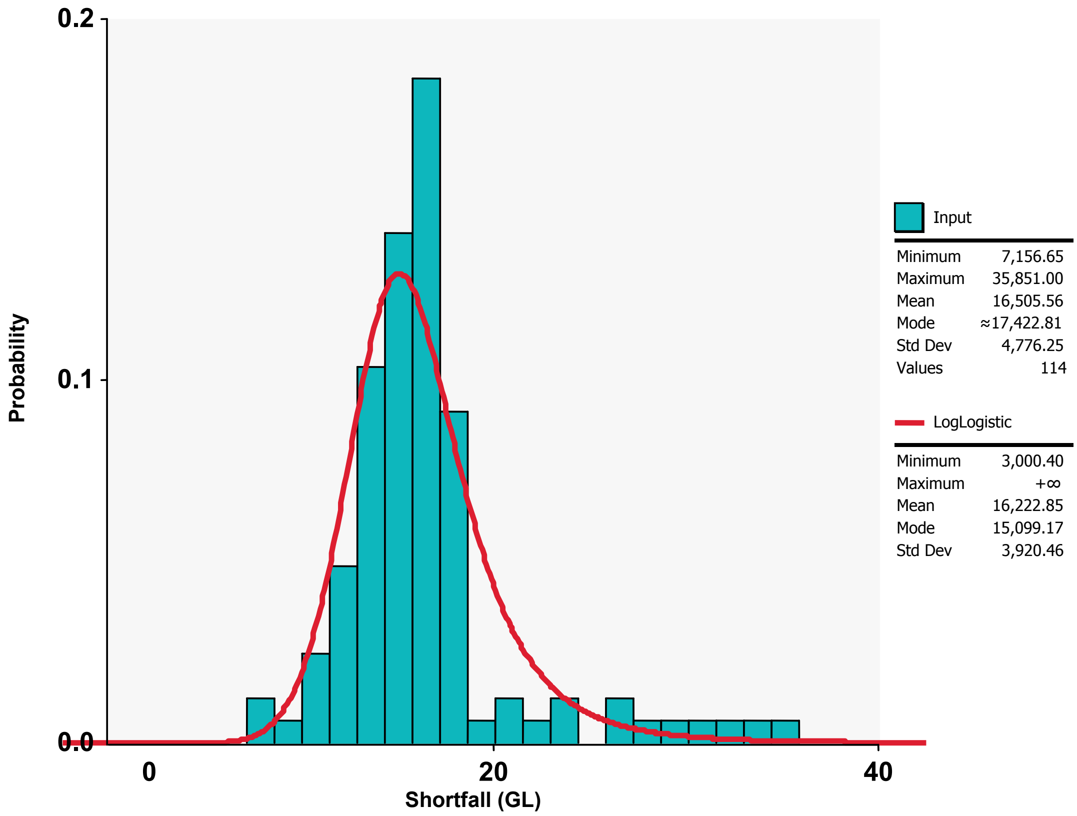

Figure 12. Probability density function for shortfall in municipal and industrial water allocation to SA country towns under the 3000 scenario compared to baseline

In the sections that follow, the additional costs to municipal and industrial water users under the 3000 scenario were assessed by estimating the cost of implementing each of the three alternative strategies for addressing shortfalls. Depending on factors such as the quality of water available for diversion and availability of water on the market, the shortfall could be met through water restrictions, water market purchases, or by operating the existing desalination plant at a higher level of production than would otherwise be the case, or through some combination of the three approaches. Analysing various combinations of the three alternatives in an optimization framework that accounts for reliability of and correlations between alternatives would be more comprehensive however, this is outside of the scope of this analysis.

4.2 Cost of doing with less water

One possible response to reduced water availability is for water restrictions to be imposed on municipal and industrial uses. The cost associated with such restrictions is estimated as the amount that consumers of water would be willing to pay to avoid such restrictions. The rationale behind this approach is that the amount that a consumer is willing to pay for water to satisfy a particular water use, often an outdoor water use, reflects the benefit they forgo when water restrictions are imposed.

This value can be estimated by understanding how aggregate per capita water consumption changes with changes in the volumetric price for water; this functional relationship is known in economics as the water demand function. We developed demand curves for Adelaide (Figure 13) and SA country towns (Figure 14) by adjusting Grafton and Ward's (2008) estimated demand curve for municipal and industrial water demand for Sydney. The adjustment involved scaling Adelaide and country town demands to Sydney demands as a function of water price such that: total demand at current price reflects actually observed demand; and reductions in demand in relative terms (as a percentage of baseline demand without restrictions) are assumed to be the same over a range of prices in Sydney, Adelaide and SA country towns (e.g. if a doubling of water price reduces water demand by one half for the Sydney demand function, the doubling of price also halves demand for the Adelaide and SA country towns estimated demand functions). Figure 13 and Figure 14 show that consumer demand for water decreases as the water price increases.

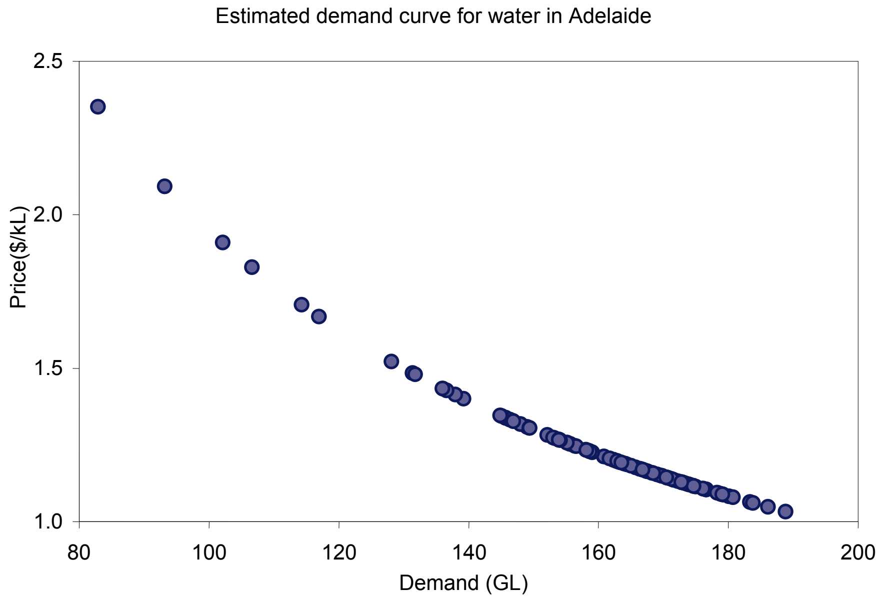

Figure 13. Estimated demand curve for water in Adelaide, scaled from Sydney data (Grafton and Ward, 2008)

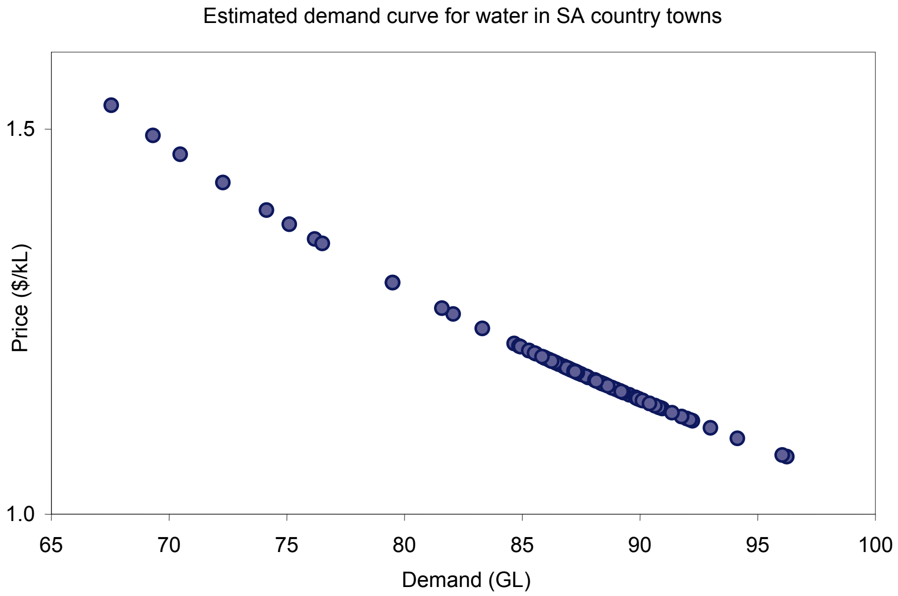

Figure 14. Estimated demand curve for water in SA country towns, scaled from Sydney data (Grafton and Ward, 2008)

The cost of water restrictions was calculated as the amount that consumers would have been willing to pay avoid water restrictions. Figure 15 shows that water restrictions reduce the amount of water available from the amount demanded at (q^T) current water price (p^0) to an a lesser amount q^A. The amount that consumers would have been willing to pay to avoid this level of water restriction is the area under the demand curve between q^T and q^A This area has two components: 1) the amount that consumers would have paid for additional water had it been available, amount q^T minus q^A at the current price of $1.00/kL, and 2) an additional amount above the current price that consumers would have been willing to pay to avoid shortfalls. This second amount increases with increasing levels of shortfall. P^1 represents the price that consumers would be willing to pay to avoid the last increment of water restriction towards reaching quantity q^A, the amount available with restrictions[1]. For each year in the 114-year time series where there was a shortfall in supply, consumer willingness to pay to avoid water restrictions, equal in magnitude to the shortfall, were calculated as the value of the shaded area under the estimated demand curve for water in Adelaide and SA country towns (see Figure 13 and Figure 14).

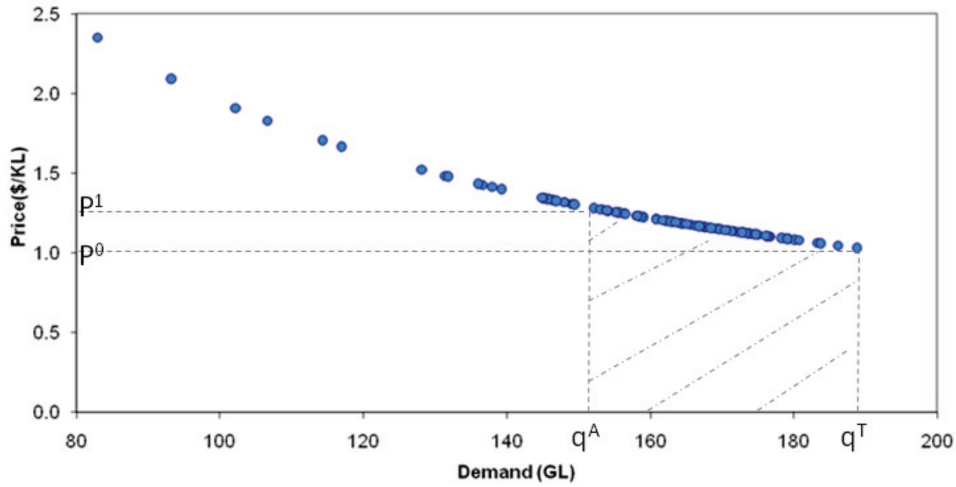

Figure 15. Consumer willingness to pay to avoid municipal industrial water shortfalls calculated as the value of the shaded area under the estimated demand curve for water in Adelaide (see Figure 13)

[1] Economists refer to this second amount as the consumer surplus loss.

To capture the nature of variability in willingness to pay and welfare loss from water restrictions, probability density functions were fitted to estimated levels of willingness to pay to avoid water restrictions over the MDBA-modelled 114-year time series data. Figure 16 and Figure 17 show the probability density functions for marginal willingness to pay (in $/kL) to avoid restrictions associated with shortfalls in municipal and industrial water allocation for Adelaide and SA country towns under the 3000 scenario when compared with baseline. Specifically, the estimated range of magnitudes of willingness to pay to avoid water restrictions (x-axis) are plotted against their relative likelihood of occurrence (y-axis).

Figure 16 shows estimates of how much Adelaide water consumers would be willing to pay to avoid the last incremental unit of water restriction over the 114-year time series. The estimated willingness to pay to avoid the last unit of water restrictions is estimated at between $1.03/kL and $2.35/kL. The values increase with the level of demand shortfall, and the average amount consumers would be willing to pay to avoid that last unit of water restriction is estimated at $1.25/kL. Figure 17 shows how much SA country town water consumers would be willing to pay to avoid that last unit of water restriction. The estimated willingness to pay to avoid the last kilolitre of water restrictions in SA country towns varies between $1.07/kL and $1.53/kL, with an average value of $1.19/kL.

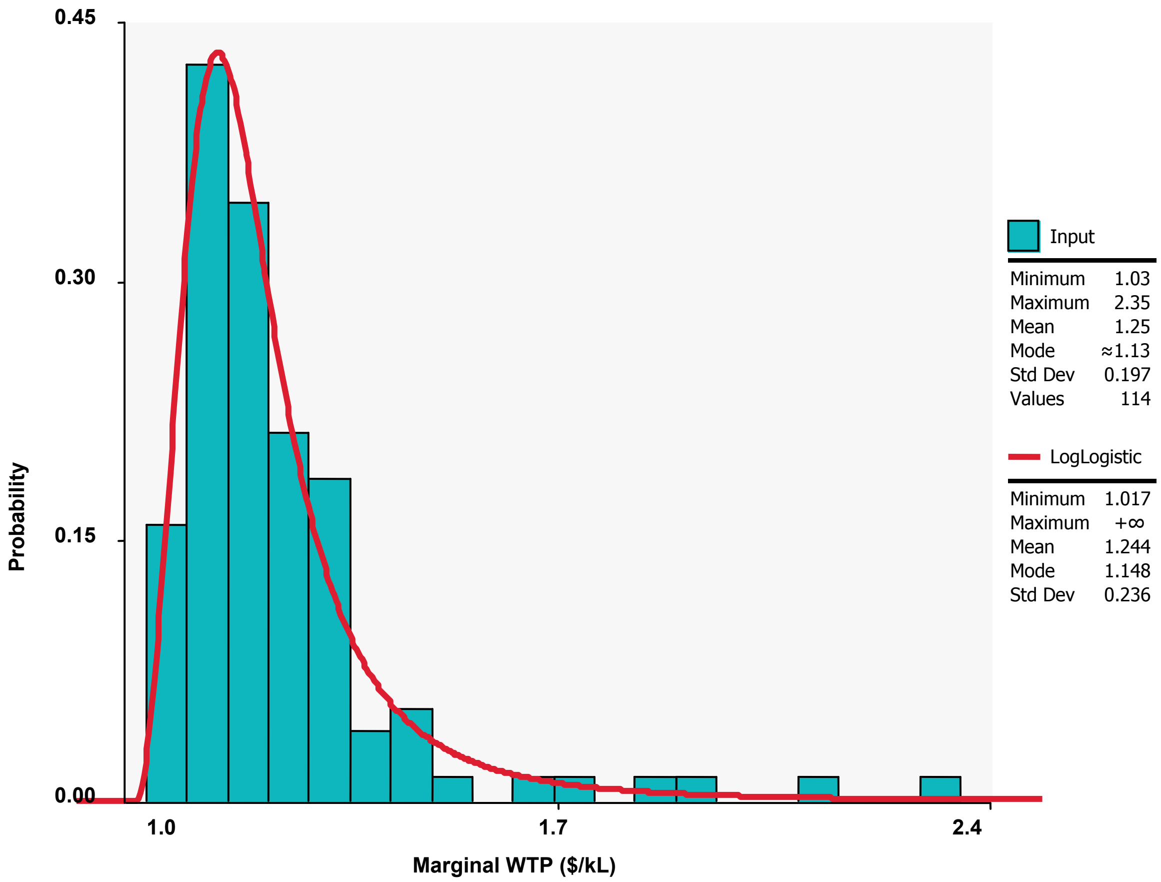

Figure 16. Probability density function for marginal willingness to pay (WTP) (in $/kL) by Adelaide water users to avoid water restrictions (1896–2006) under the 3000 scenario compared to baseline

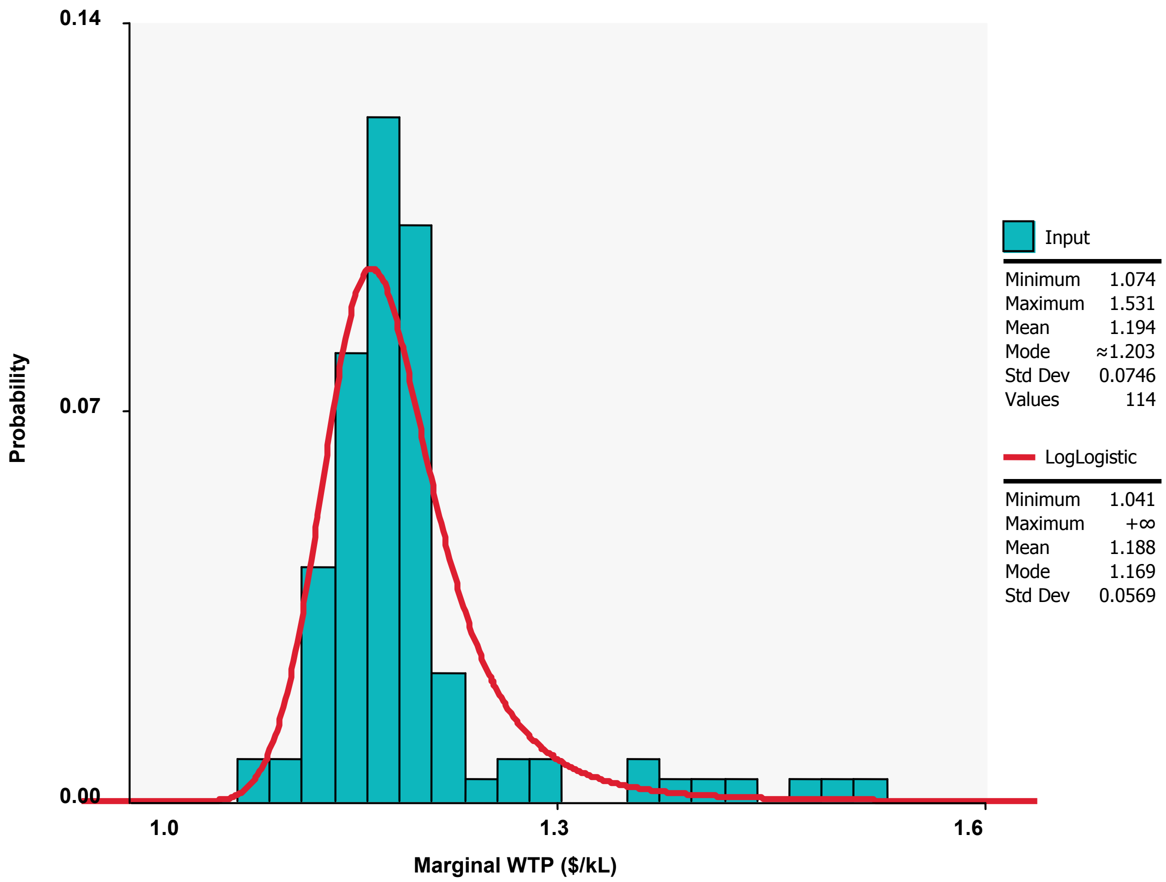

Figure 17. Probability density function for marginal willingness to pay ((WTP) (in $/kL) by SA country town water users to avoid water restrictions (1896–2006) under the 3000 scenario compared to baseline

Figure 18 and Figure 19 show the estimated probability density functions for the amount that water consumers would be willing to pay (in $ million per year) to avoid the levels of water restrictions for Adelaide and SA country towns that would arise as a result of implementing the 3000 scenario. Figure 18 shows that Adelaide water consumers would incur a loss that they value at between $6.4 million and $242.8 million per year as a result of water restrictions. This is the sum of willingness to pay for all consumers to avoid water restrictions equal to annual shortfalls under the 3000 scenario for years between 1896 and 2009. The average value of this loss is estimated at $46.6 million per year. Figure 19 shows that SA country town water consumers would incur a loss from water restrictions that they value between $7.7 million and $52.8 million per year; with the average value of this loss estimated at $19.7 million per year.

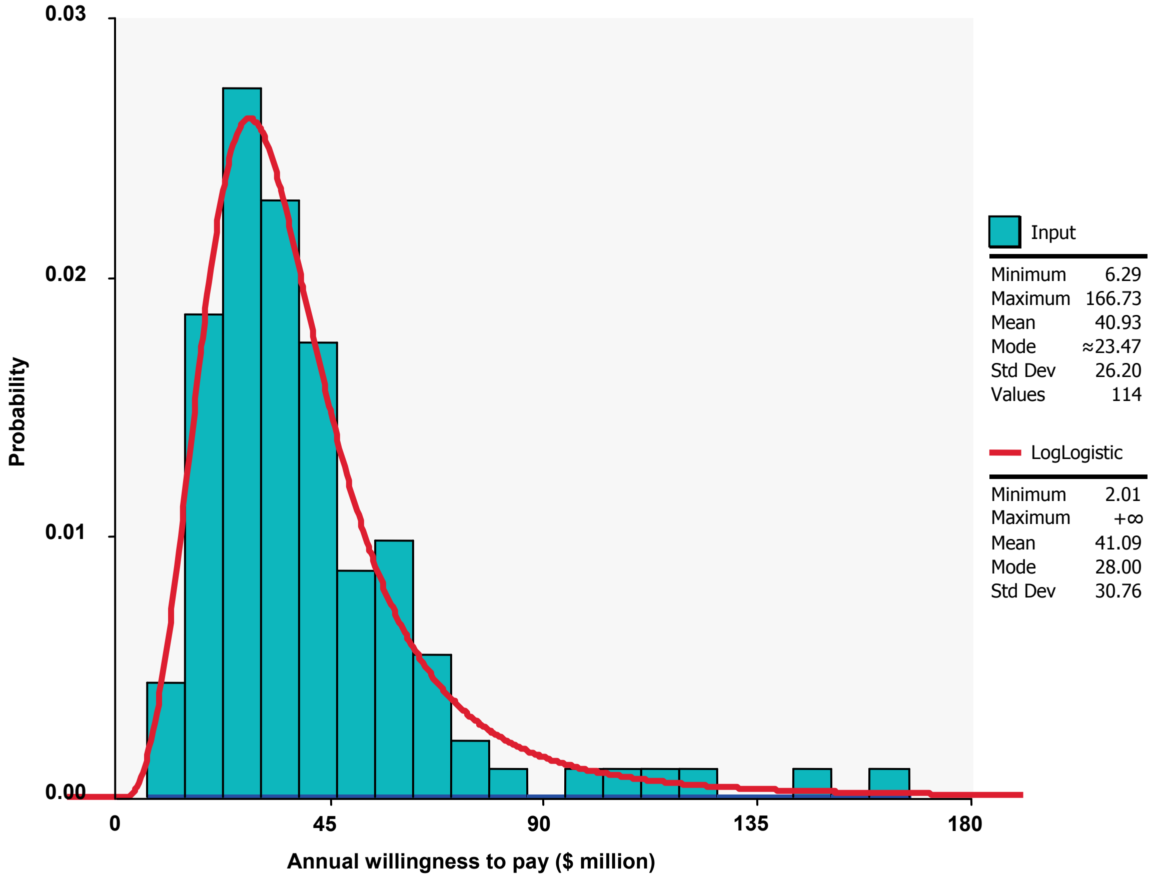

Figure 18. Probability density function for annual willingness to pay ($ million) by Adelaide water users to avoid water restrictions due to shortfalls (1896–2006) under the 3000 scenario compared to baseline

Overall, we find that Adelaide consumers would be willing to pay a price marginally higher than the current price to avoid water restrictions. This marginal price relates to the last incremental unit of water restriction only and is estimated to range from between $1.03/kL and $2.35/kL for Adelaide and from between $ 1.07/kL and $1.53/kL for SA country towns (see Figure 16 and Figure 17).

The willingness to pay to avoid water restrictions increases with the level of supply shortfall. In years with small shortfalls, wiliness to pay to avoid the last unit of supply shortfall was as little as $1.03/kL; whilst in the year with the greatest shortfall, marginal willingness to pay to avoid the last unit of supply restrictions was as high as $2.35/kL, indicating a willingness to pay to avoid the last unit of restriction in the year of greatest short fall that is signifcantly greater than the current water price for Adelaide.

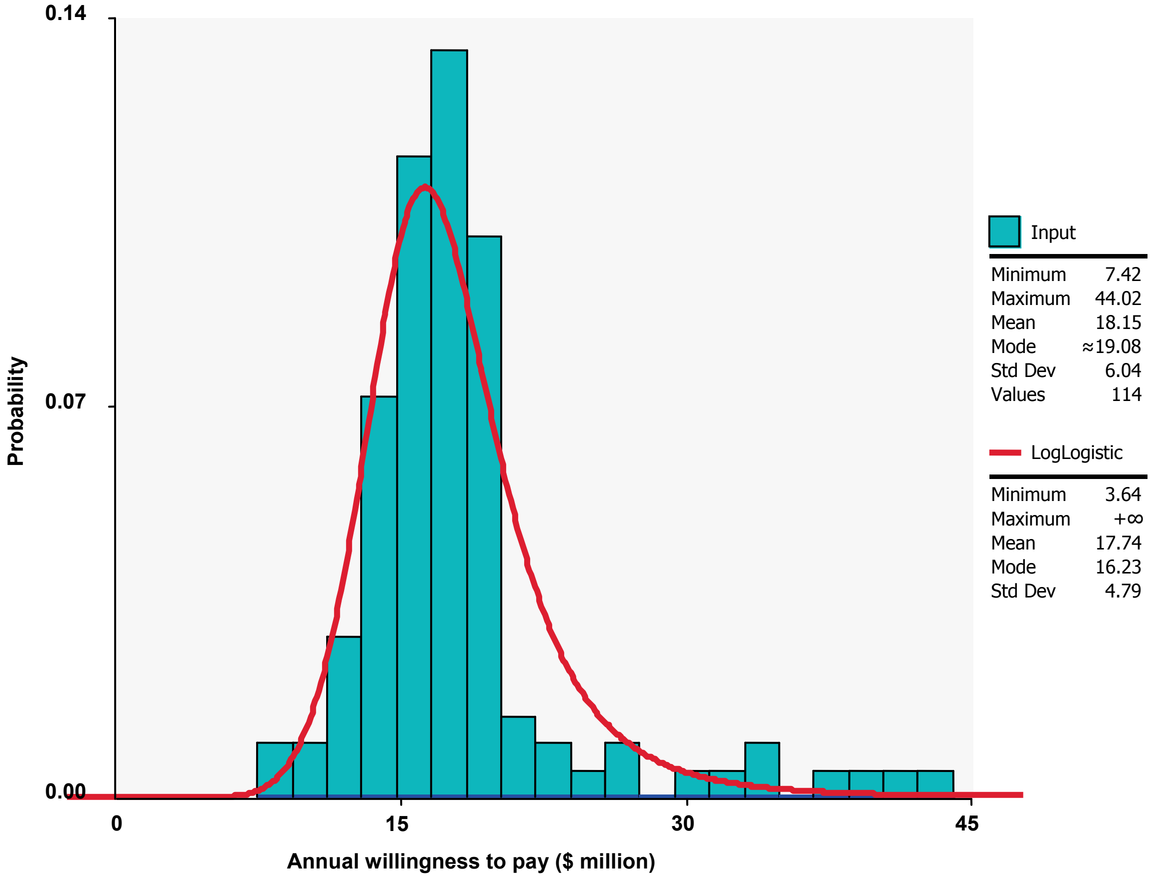

Figure 19. Probability density function for annual willingness to pay ($ million) by SA country town water users to avoid water restrictions due to shortfalls (1896–2006) under the 3000 scenario compared to baseline

4.3 Cost of buying water from the market

SA Water has the option to buy water from the market, if water is available, to make up for reduced allocations. The cost of buying water from the market was estimated as the product of the shortage and the market price of water. The market price for water as a function of allocation levels was estimated following Brennan (2007) for the 114-year time series water allocation data (Figure 20). The regression used Equation 8 and estimated the (log) price as a function of early-seasonal allocation as a proportion of entitlement, A, and total rainfall, R (in millimetres) over the irrigation season as described in Section 3.2. In addition to the cost of purchasing the water, there is a cost of pumping the water from River Murray offtakes to SA Water reservoirs estimated at $0.20/kL (Dillon, 2011).

Using this estimator, we estimated the unit cost of buying and pumping water. Results of this estimate are shown in Figure 20. The average estimated market plus pumping cost for water is $0.47/kL. This is the probability-weighted mean unit cost of buying plus pumping River Murray water over the 114 years.

This unit cost estimate was then used to estimate the cost of making up for the shortfall under the 3000 scenario for Adelaide and SA country towns by multiplying the unit cost by the estimated shortfall. Results are shown in Figure 21 and Figure 22. Figure 21 shows that the cost of supplying water from the market for Adelaide is estimated to range between $1.6 million and $91.9 million/year, with the probability-weighted mean cost estimated at $18.2 million/year. Figure 22 shows that the estimated cost of supplying water from the market for SA country towns would range between $1.9 million and $28.6 million/year, with the mean cost estimated at $8.0 million/year.

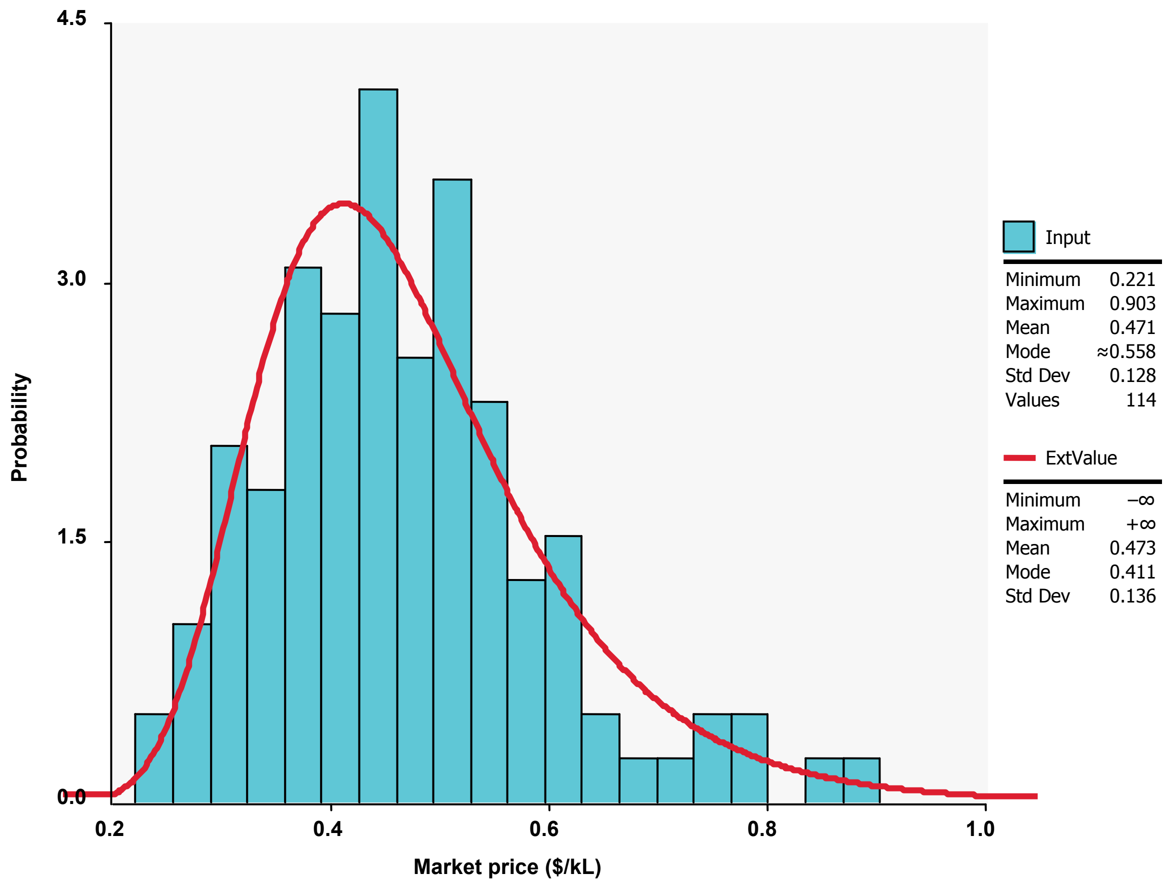

Figure 20. Probability density function for the market price of water ($/kL) plus pumping cost under the 3000 scenario

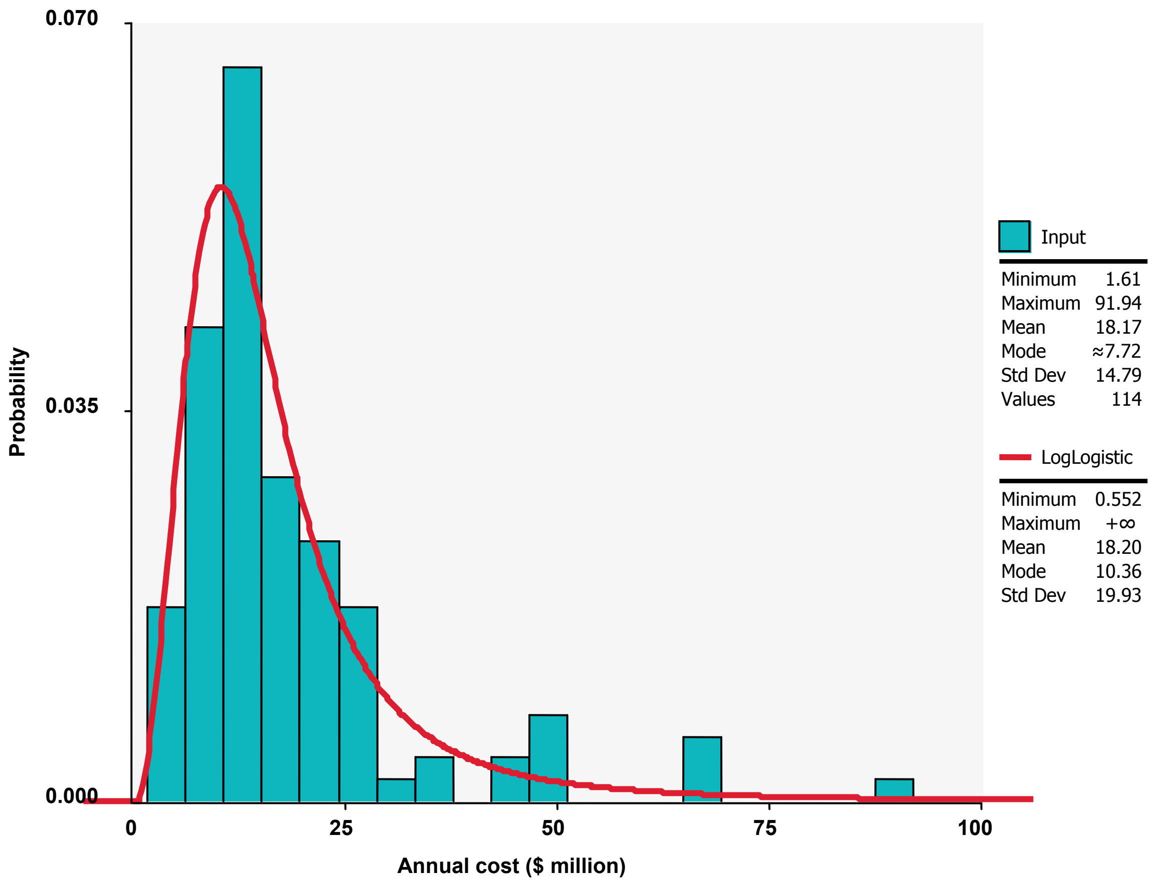

Figure 21. Probability density function for the cost ($ million) of buying water for Adelaide from the market under the 3000 scenario

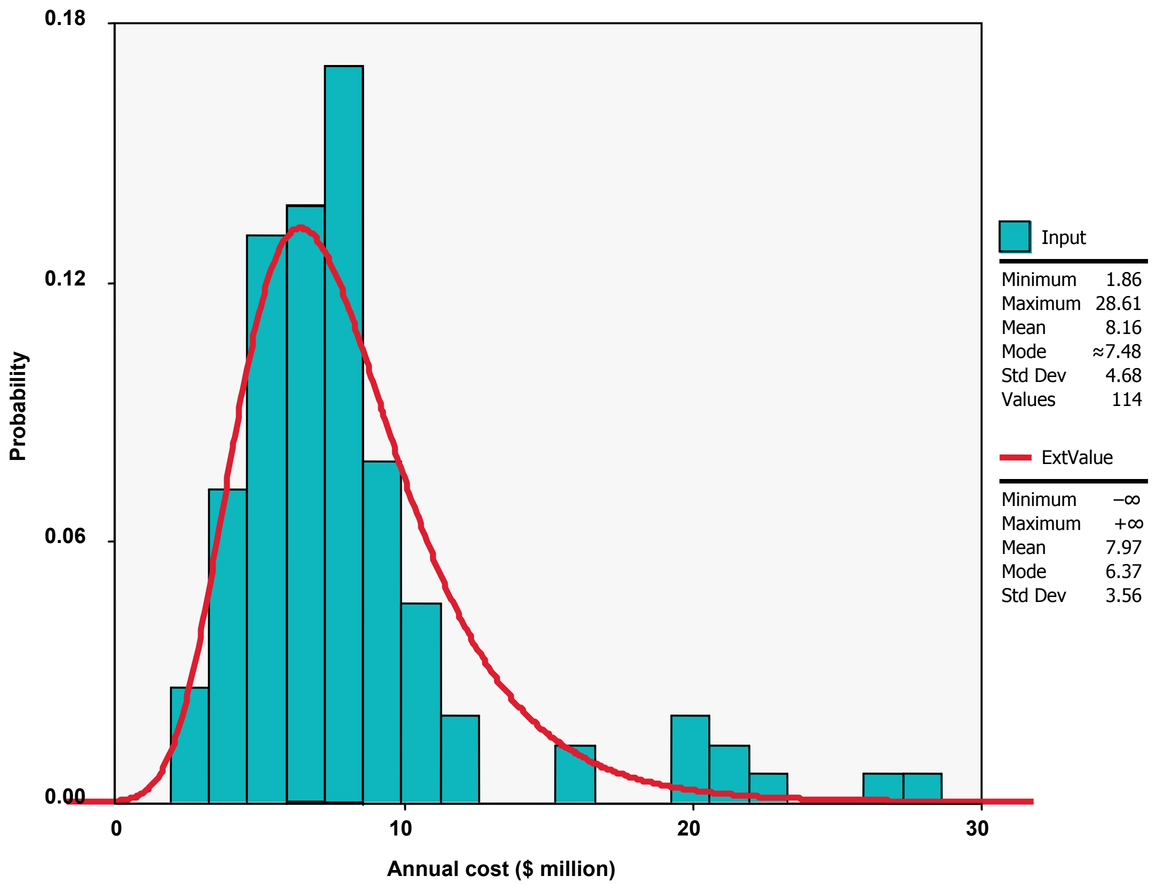

Figure 22. Probability density function for the cost ($ million) of buying water for SA country towns from the market under the 3000 scenario

In summary, the estimated expected cost of buying water from the market to make up for shortfalls associated with the 3000 scenario is $18.2 million/year for Adelaide (Figure 21) and $8.2 million/year for SA country towns (Figure 22).

4.4 Cost of running Port Stanvac desalination plant

An alternative way to make up for reduced allocations for municipal and industrial water for Adelaide would be to run the already existing Port Stanvac desalination plant at a higher level of production than would otherwise be the case. The estimated cost is the additional cost (variable costs) of operating the plant above baseline scenario levels to meet additional shortfalls under the 3000 scenario.

These cost estimates do not include fixed costs associated with building and maintaining the plant as these costs would be incurred regardless of SDLs. The cost of running the plant is estimated as the product of unit costs and shortages modelled for the MDBA's 114-year time series data. Note that the cost of not pumping water from the River Murray has not been discounted from the cost of running the desalination plant to meet the shortfall. We used unit marginal variable costs of running the desalination plant to meet shortfalls from a number of sources including published literature and SA Water technical staff. Energy costs were the main component of variable cost of running the desalination plant estimated at $0.60/kL. This assumes electricity price at $0.13/KWh and energy usage of 4.5 KWh/kL. The energy use estimate falls within the range of published values for operating plants in Sydney at 4.96 KWh/kL (SCCG, 2005) and Perth at 4.11 KWh/kL (WAWC, 2006).

Other variable non-energy operating and maintenance costs considered include chemicals, membrane replacement, maintenance and parts (Wittholz et al, 2008; CSIRO, 2009). Some of the cost associated with these inputs would be incurred regardless of the level of plant operation, others would vary depending on the level of operation. The lower-bound estimate for unit cost of other variable non-energy operating and maintenance costs were assumed at one-third of energy cost (Wittholz et al, 2008) – $0.20/kL, whilst the upper-bound estimate was assumed at one-half of energy cost (CSIRO, 2009) – $0.30/kL. Thus in this analysis, the unit variable operating and maintenance costs of running desalination were estimated as ranging between $0.80/kL and $0.90/kL, with a median of $0.85/kL.

Figure 23 is a probability density function of the estimated annual cost of meeting the shortages in municipal and industrial supply under the 3000 scenario over the MDBA's 114-year time series data. In Figure 23 the cost of running the desalination plant at a higher production level than would be the case without any reduction in allocations was estimated to average $32.1 million/ year.

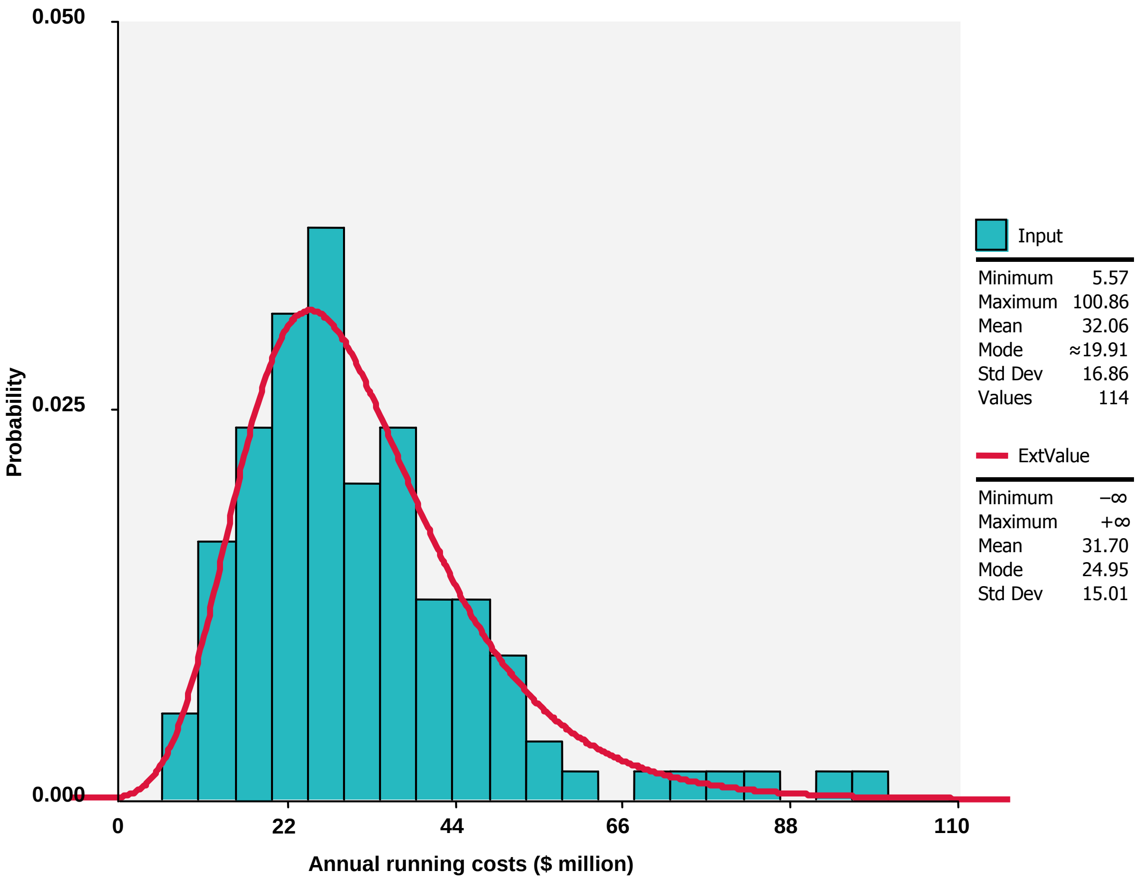

Figure 23. Probability density function for the cost ($ millon) of running the Port Stanvac desalination plant under the 3000 scenario

4.5 Estimating the cost of shortfalls under various flow conditions

We estimated the cost of shortfalls under the 3000 scenario for various flow conditions by considering municipal and industrial water allocations in various periods between 1895 and 2009. These periods represent low, average and high flow conditions. Specifically, we estimated average yearly costs of shortfalls under conditions during the decade including the Federation Drought (1896–1905), moderate drought conditions (1906–15), average flow conditions (1970–79), and Millennium Drought conditions (2000–09). Further, we estimated costs of shortfalls in five of the driest years over this period – 1945, 2006, 2007, 2008, and 2009. This was done by estimating water consumer willingness to pay to avoid water restrictions, the cost of buying water and the additional cost of operating the desalination plant over and above the level that would be required to meet Adelaide and SA country municipal and industrial water demands under the baseline. The estimated costs are summarised in Table 9 to Table 11. Table 9 summarises average yearly welfare loss from restrictions and average willingness to pay to avoid water restrictions for Adelaide and SA country towns for the specified periods between 1895 and 2009. Table 10 summarises the cost of buying water from the market for Adelaide and SA country towns for the specified periods between 1895 and 2009. Table 11 summarises additional costs of running the desalination to meet shortfalls for Adelaide and SA country towns in flow conditions in the specified periods between 1895 and 2009.

Comparison of the relative cost of desalinisation and market water supply shows that the unit cost of market water varies considerably depending on flow conditions, and in extremely dry years, the unit cost of market water purchase could exceed that of running the desalination plant in the unlikely event that there was enough water available for purchase on the market to make up for shortfalls of the orders of magnitudes likely to be observed in such periods. For example Table 10 shows a price of up to $0.90/kL for market water supply under 2008 flow conditions in comparison with the $0.85/kL cost of running the desalination plant.

Table 9. Yearly and marginal willingness to pay by water users to avoid water restrictions under the baseline

Years	Estimated cost based on willingness to pay to avoid water restrictions		Willingness to pay for the last increment of water		Comment
	Adelaide water users	SA country town water users	Adelaide water users	SA country town water users	
	$ million/y		$/kL		
Average					
Average overall 1895–2009	47	20	1.25	1.19	
Average 1895–1905	58	23	1.30	1.23	Federation Drought
Average 1906–1915	47	23	1.25	1.22	moderate drought
Average 1970–1979	34	16	1.18	1.16	average allocations
Average 2000–2009	104	29	1.56	1.29	Millennium Drought
Five years with the highest average					
1945	153	38	1.83	1.38	
2006	131	43	1.71	1.43	
2007	243	47	2.35	1.47	
2008	199	30	2.09	1.30	
2009	167	27	1.91	1.27	

Table 10. Cost of buying water from the market

Years	Estimated cost of buying water		Price	Comment
	Adelaide	SA country towns	Adelaide and SA country towns	
	$ million/y		$/kL	
Average				
Average overall 1895–2009	18.2	8.2	0.47	
Average 1895–1905	26.1	11.2	0.57	Federation Drought
Average 1906–1915	19.5	9.7	0.49	moderate drought
Average 1970–1979	11.5	5.5	0.39	average allocations
Average 2000–2009	43.1	15.0	0.64	Millennium Drought
Five years with highest average				
1945	49.3	15.8	0.56	
2006	69.1	26.6	0.86	
2007	68.5	20.1	0.61	
2008	91.9	21.6	0.90	
2009	65.3	15.3	0.70	

Table 11. Estimates for cost of running Port Stanvac desalination plant

Years	Estimated cost of running the plant	Comment
	$ million/y	
Average		
Average overall 1895–2009	30	
Average 1895–1905	38	Federation drought
Average 1906–1915	31	moderate drought
Average 1970–1979	24	average allocations
Average 2000–2009	53	Millennium drought
Five years with highest average		
1945	75	
2006	69	
2007	95	
2008	87	
2009	79	

4.6 The risk mitigation benefit value of desalination

As stated in the SA Government's Water for Good plan, the key rationale for building a desalination plant was to have a non-rainfall dependent source of water for Adelaide (SA Government, 2009). Conditions could arise in the future where water from the River Murray was not available for purchase if flow levels or quality of water at the offtake precluded River Murray use for municipal and industrial supply.

This section describes an evaluation of the value of desalination under such circumstances. To do this, we estimated the difference between the cost of operating the desalination plant to meet shortfalls in extremely dry years and the cost associated with not being able to supply additional water from the Murray in low flow years with no water available for purchase. The analysis focussed on the 5% of the driest years under the 3000 scenario between 1896 and 2009. The 5% of the driest years are represented by the tail-end of the fitted distributions with a cumulative probability of 0.05 to the right of the curve. The risk mitigation benefit that the desalinisation plant would provide in 5% of the driest years were River Murray water not available was estimated with the cost of water restrictions that would be imposed under these circumstances. To estimate this value, we calculated the probability-weighted expected willingness to pay to avoid water restriction levels associated with the 5% of the driest years. We also calculated the probability-weighted expected cost of running the desalination plant at higher levels than would otherwise be the case to meet shortfalls associated with the 5% of the driest years. The difference between these two values represents the risk mitigating value of the desalinisation plant under such circumstances.

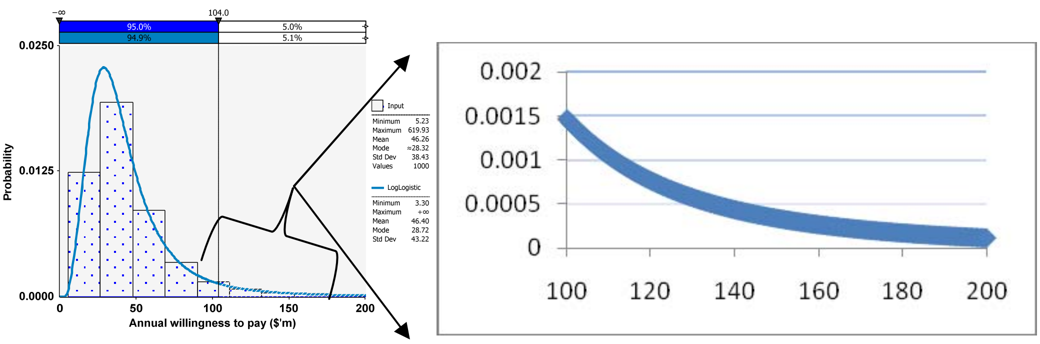

Figure 24. Calculating the probability-weighted expected willingness to pay to avoid water restriction levels associated with the 5% of the driest years (in $ million)

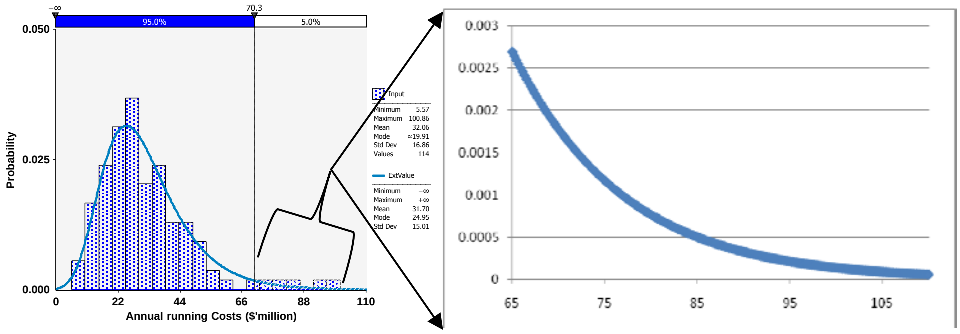

Figure 25. Calculating the probability-weighted expected cost of running the desalination plant to meet shortfalls asscoaited with the 5% of the driest years

Figure 24 shows that the weighted average cost estimate for willingness to pay to avoid water restrictions in these years was $127.8 million/year. Figure 25 shows that the weighted average annual cost estimate for running the desalination plant in the 5% of lowest water availability years was estimated at $71.2 million assuming the median marginal variable unit cost of running the desalination plant estimate of $0.85/kL.

Thus, it can be inferred that the risk mitigating benefit of the desalination plant would average $56.6 million/year for the 5% of driest years with the greatest estimated municipal and industrial shortfall in a circumstance where water of adequate quality is not available to purchase from the River Murray. This estimate of risk mitigating benefit, $56.6 million/year in 5% of driest years, is the difference between the consumer willingness to pay to avoid of water restruction equal to the supply shortfall and the cost of supplying the shortfall with desalinisation.

Comparison of the relative cost of desalinisation and water restriction for five of the driest years (1945, 2006, 2007, 2008 and 2009) is shown and discussed in the following section.

4.7 Conclusion

From this analysis, we conclude that the expected cost of meeting the shortfall in municipal and industrial water supply that would result if the reduction in allocation available for diversion in South Australia were shared between municipal industrial and irrigation diverters would be between $26.4 million and $58.3 million/year[2] for the municipal and industrial sector. The actual value would depend on the mix of options used to address the supply gap.

We recognise that analysing various combinations of the three alternatives in an optimisation framework that accounts for timing of availability of alternatives, limits to supply available on the water market and limits to quality in supply available for diversion would be more comprehensive however, this is outside of the scope of this analysis.

[2] This range ($26.4–58.3 million) differs from the range of $11–47 million reported in the synthesis report (CSIRO, 2011, p. 29), as a result of additional analysis.

5 Ecosystem service losses associated with low base and environmental flows

An ecosystem service framework was utilised to categorise ecosystem service loss in the absence of adequate base and environmental flows in the SA portion of the Basin. This framework classifies ecosystem services into four categories, namely, provisioning, regulating, habitat, and cultural and amenity services. Provisioning services include the production of food and fibre while regulating services include climate change mitigation and erosion prevention; habitat services include the supply of breeding habitat while cultural and amenity services include recreation and tourism values.

Underpinning the provision of ecosystem services are ecosystem functions which are dynamic and exhibit thresholds and complementary relationships. An ecosystem reaches a threshold when one or more of its attributes are degraded below a specific level. An ecosystem may then transition to a new equilibrium state with albeit an eroded capacity to provide the original range and level of environmental benefits or ecosystem services. Surpassing the ecosystem thresholds described in 'A science review of the implications for South Australia of the Guide to the proposed Basin Plan: synthesis' CSIRO (2011) would result in significant economic consequences for the Commonwealth and South Australian Governments as well as individual citizens. What follows is an overview of expenditure and cost-based methods of ecosystem service valuation and a brief overview of the data. Using these methods and the experience of the recent drought, the section closes with a preliminary estimate of the ecosystem service losses in the absence of adequate base and environmental flows in the SA MDB.

5.1 Cost and expenditure-based measures of ecosystem service value

Cost and expenditure-based approaches estimate the value of ecosystem services through the costs associated with replacing, restoring or substituting the services; through the costs of avoiding or defending against loss, and; through the costs of managing damage caused by ecosystem service loss as well as mitigation and adaptation expenditures. All these methods are similar and not mutually exclusive; they are all based on realised expenditures or market-based estimates of costs. These methods may be legitimately used in instances where: the alternative considered provides the same level of ecosystem services as the ecosystem in question; any alternative used for cost comparison purposes is the least-cost alternative, and; there is evidence that society would demand the service if it were provided by the least cost alternative (Shabman and Batie, 1978).

In this analysis, mitigation and adaptation expenditures and damage cost were the primary techniques utilised to measure the value of ecosystem service losses. Mitigation expenditures reflect what consumers are willing to pay or what they have already paid for a good or service which reduces a negative environmental externality, whereas adaptation methods reflect costs associated with adapting to a new equilibrium ecosystem dynamic. Damage cost techniques were used to estimate the cost of urban and commercial salinity damage.

Salinity causes damage to urban fixtures and systems such as plumbing fixtures and fittings, hot water systems, water filters, rainwater tanks and water softeners. This household salinity damage, based on the most recent work available by Allen Consulting (2004), was estimated as:

$$\mathrm{HouseholdCost}\left(\frac{\frac{\$}{\mathrm{household}}}{\mathrm{yr}}\right) = 0.2458 \cdot T + 135 \qquad (10)$$

Where *T* is equal to total dissolved solids (TDS) in milligrams/litre.

General commercial and industrial salinity damage can affect cooling towers, boilers and process water. Based on the most recent work available by Allen Consulting (2004), general commercial and industrial salinity damage cost was estimated as:

$$\text{CommercialCost}\left(\frac{\frac{\$}{\text{kL}}}{\text{yr}}\right) = 0.00063 \cdot T + 0.35 \tag{11}$$

5.2 The data

Mitigation and adaptation expenditure data were collected from the South Australian Department for Water's Riverbank Collapse Hazard Program (2010), the Department of Environment and Heritage (2009), the Department of Resources, Energy and Tourism (2010) and Kingsford et al. (2010). Data collated by the South Australian Department for Water's Riverbank Collapse Hazard Program (2010) was sourced internally as well as from Department for Transport, Energy and Infrastructure and Local District Councils. Salinity data were obtained through the MDBA-supplied 114-year time series data while salinity damage cost equations follow Allen Consulting (2004).

Provisioning service data were largely comprised of the losses resulting from the decline in the dairy industry in the vicinity of SA's Lower Lakes. Data on regulating services included expenditure estimates on the dredging of the Murray Mouth since 2002. Levee remediation and emergency repair data were related to the sinking and consolidation of floodplain soils and the restoration of levee heights. Repairs to bridges involved works with bridge footings while adaptive measures were required to adjust ferry landings to low flow conditions. Various expenses were incurred in the installation of pipelines and standpipes to reduce community reliance on water from the Lower Lakes. A large proportion of investment in irrigation upgrades was lost due to riverbank collapse and cracking including damage to pump sheds. Some investment in laser-levelling has also been lost as a result of flood plain consolidation. Expenditures on flow regulators and bunds were required in some cases to retain freshwater, maintain soil saturation and prevent further soil and water acidification. Riverbank collapse as a result of the drought led to the creation of a Riverbank Collapse Program to monitor and mitigate riverbank hazards. Collapse also resulted in property damage and falling property values. Losses in habitat services were estimated through the costs associated with acid sulphate soil mitigation by vegetation works and liming of soils. Cultural values were estimated through reduced tourism revenues between 1999 and 2008.

5.3 Quantifying ecosystem service losses

Both the SA and Commonwealth Governments incurred costly expenditures to adapt to ecosystem service losses and to mitigate further damage. In the case of the SA portion of the Basin, during the Millenium Drought, reduced inflows into the system pushed ecosystem function beyond various thresholds resulting in significant environmental damage and ecosystem service loss. An ecosystem reaches a threshold when one or more of its attributes are degraded below a specific level. An ecosystem may then transition to a new equilibrium state with albeit an eroded capacity to provide the original range and level of environmental benefits or ecosystem services. A preliminary estimate of the economic value of ecosystem service loss related to reduced river system inflow for the SA portion of the Basin was completed.

Figure 26 shows the average annual level of Lake Alexandrina and damage, mitigation and adaptation costs associated with ecosystem service loss as a result of ongoing reduced system inflows over the Millenium Drought. Monitoring and planning costs increase significantly when lake levels dropped to between 0.0 and –0.5 Australian Height Datum (AHD). Between 2008 and 2009, a threshold was reached when lake levels dropped below sea level. With this threshold breached, there was a steep increase in ecosystem service loss as measured by damage, mitigation and adaptation expenditures. The cumulative value of this loss was estimated at over $790 million.

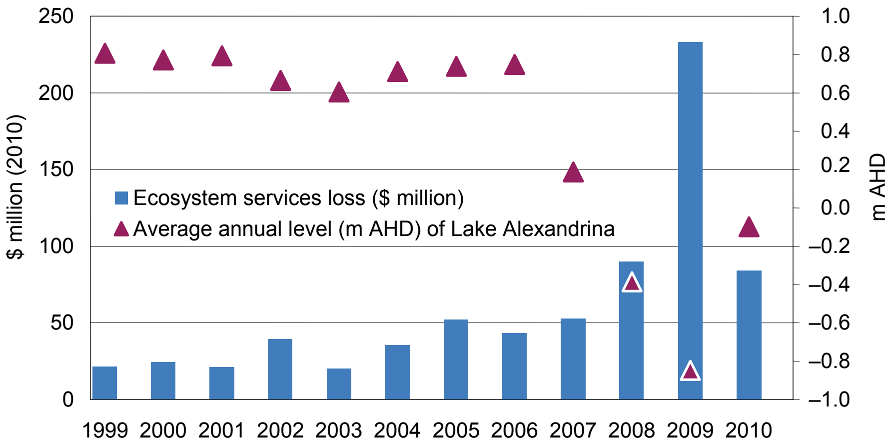

Figure 26. Magnitude of ecosystem services loss (in $ million) and levels (m AHD) of Lake Alexandrina

Most of these damages can be related to three ecological thresholds. First, reduced inflows into the SA portion of the Basin and the Lower Lakes specifically meant inflows were exceeded by evaporative losses in the system. A lake level of –1.0 m AHD had never before been reached until 2009. With the exposure of saturated sulphidic sediment, large areas of the former lake bed acidified upon drying producing acid sulphate soils. These soils are problematic for the acidic water they create which then releases heavy metals and toxins and alters soil structure (Department for Environment and Heritage, 2010). Second, ongoing evaporative losses and reduced system inflow resulted in the breaching of salinity thresholds which rendered locally-sourced water unfit for human or irrigated agricultural use without expensive treatment. A third threshold was maintenance of a minimum in-river channel water depth. When channel water depth did not meet minimum thresholds, riverbanks began to collapse, floodplains and levees cracked, roads and other infrastructure required remediation, and significant investment in laser levelling of paddocks and irrigation infrastructure efficiency upgrades was lost.

Surpassing the aforementioned thresholds has resulted in significant economic consequences for the SA and Commonwealth Governments as well as individual citizens. Table 12 provides a snapshot of the environmental damage caused in the absence of adequate base and environmental flows during the Millenium Drought. Regulating ecosystem services were the most affected, representing a loss of over $421 million in value. Next were cultural and amenity values for an ecosystem service loss of over $294 million. Habitat losses, in particular, maintaining a base water level in Lake Albert to preserve critical ecosystem services and the management of acid sulphate soils amounted to ecosystem service losses of $24 million. Finally, a conservative estimate of the loss of provisioning services surpassed $50 million, primarily the consequence of a significant contraction in the dairying industry around the Lower Lakes. These ecosystem service losses may have been significantly reduced had the system been provided with base and environmental flow requirements.

Table 12. Damage, mitigation and adaptation costs of ecosystem services losses for the South Australian Murray System and Lower Lakes (2000–2009)

Ecosystem function	Costs
	$ (2010 base)
Provisioning	
Agriculture and livestock[1]	50,739,840
Regulating	
Dredging Murray Mouth[2]	32,000,000
Salinity damage cost [3]	122,434,969
Levee remediation[4]	11,380,000
Repairs to bridges, ferry landings and pipelines[4, 5, 6, 7]	1,000,000
Lost expenditure from irrigation upgrades and laser levelling[4]	82,000,000
Flow regulators, bunds and pipelines[2]	160,000,000
Riverbank collapse including property damage[4, 8]	12,520,000
Habitat	
Acid sulphate soil works[1, 2]	10,000,000
Water pumping[2]	14,000,000
Cultural and amenity	
Tourism[9]	294,830,000
Total	**790,904,809**

[1] Department for Environment and Heritage, 2009
[2] Kingsford et al., 2010
[3] CSIRO salinity damage cost calculations; equations detailed in Allen Consulting, 2004
[4] SA DfW, Riverbank Collapse Hazard Program
[5] DTEI as reported to SA DfW, Riverbank Collapse Hazard Program
[6] SA Water as reported to SA DfW, Riverbank Collapse Hazard Program
[7] Councils for affected infrastructure as reported to SA DfW, Riverbank Collapse Hazard Program
[8] Local Councils as reported to SA DfW, Riverbank Collapse Hazard Program
[9] Department of Resources, Energy and Tourism, 2010

The damage, mitigation and adaptation costs of ecosystem service loss are presented here as a one-off payment made as a result of the Millenium Drought. The expectation is that intermittent droughts will also occur periodically in the future. To compare annualised costs to irrigated agriculture to the benefits of avoiding ecosystem service loss under the Guide scenarios would require annualising the benefits of avoided damage, adaptation and mitigation over future sequences of allocations, flows and droughts. The annualised benefit of ecosystem service loss avoided would depend heavily on how climate change impacts develop, the frequency and duration of future droughts, the effect of discounting, and the sequencing of drought; that is, whether drier periods are anticipated to occur in the earlier or later years of the period of analysis. More lengthy droughts occurring earlier in the next decades lead to higher estimates of annualised benefits under the Guide scenarios.

It should be noted that cost and expenditure-based estimates enumerated for this study can lead to both under and over estimation. On the one hand, economists tend to argue that they underestimate benefits as they do not capture non-use values such as bequest value, existence value and values communities place on the aesthetics of a healthy system. To provide an indication of the relative magnitude of these values for the Murray region, Australians valued a 1% increase in native vegetation at $79 million; a 1% increase in native fish populations at over $73 million; a 1 year increase in colonial waterbird breeding at $375 million; a unit increase in the number of waterbirds and other species at $12 million; and improving the condition of the Coorong from poor to good health at $4.3 billion (Morrison and Hatton MacDonald, 2010).

On the other hand, since expenditure-based techniques are based on actual expenditures realised, they are often regarded as more reliable estimates (King and Mazzotta, 2000). Where mitigation expenditures become far removed from societal preferences, however, an expenditure may in fact exceed society's real willingness to pay for the mitigation of environmental *bads* (Garrod and Willis, 1999). Essentially, the argument is that in some cases public expenditure may not necessarily represent least cost measures and may not always be justified by the benefits that result. However, it seems difficult to argue that the expenditures quantified in this work, from acid sulphate soil mitigation to levee remediation and riverbank collapse hazard monitoring are not aligned with society's preferences and the role of government in keeping the public safe.

6 Regional income impacts

The irrigation sector analysis presented in Section 3 did not consider the flow-on effects under the Guide scenarios on the regional SA portion of the Basin economy nor the potential offsetting impacts of the purchase of water for the environment through a Commonwealth-initiated buyback process. Such analysis requires an economy-wide modelling framework, known to economists as a computable general equilibrium (CGE) approach. Researchers at Monash University's Centre of Policy Studies have developed such a model for analysis of water policy on disaggregated Basin regions, including the SA portion of the Basin.

Dixon et al. (2011) evaluated the economic effect of a buyback of irrigation water on the southern portion of the Basin using the Monash TERM H_2O CGE model. This involved two model runs, a baseline run and a policy run. The baseline run assumes 'business as usual' in the absence of a SDL or water buyback policy. The policy run introduces the SDL scenario and water buyback. The comparison of the baseline and policy runs reveals the net impact of the SDL reducing irrigation economic activity while the water buyback introduces an additional source of regional income. The model structure captures all aggregate economic sectors by region including irrigated and dry land agricultural sectors and how spending from these sectors ripples through the regional economy. TERM H_2O has 35 economic sectors, 19 regions and 10 agricultural commodities, 7 of which are produced by both dry land and irrigated agricultural systems.

Dixon et al. (2011) simulated a water buyback of 1500 GL over the period 2009–2016. The Commonwealth was assumed to purchase 187.5 GL in 2009 and an additional 187.5 GL in 2010 and so on until 2016. By 2016, the buyback is complete with the Commonwealth having acquired a total of 1500 GL of permanent water entitlements. Assuming average rainfall and full allocations, the purchase of 1500 GL represented a 22.8% reduction in irrigation water supply in the sourthern portion of the Basin. In the model, water may be freely traded in the southern portion of the Basin. Water prices were assumed to be equalised across regions and the buyback was assumed to occur at a uniform rate across all Basin entitlement holders. An annual rate of water-saving technological change of 1% per annum was assumed, implying an improved ability to produce equal output with 1% less water each year for the simulation period.

The result of the modelling exercise was an estimated 0.0059% reduction in gross domestic product (GDP) for the nation as a whole. Dixon et al. (2011) did not report employment impacts of the SDL and water buyback. Analysis commissioned by the MDBA and conducted by Wittwer (2010), however, used the same TERM H_2O model to conduct similar scenario analysis. In this case, the Commonwealth was assumed to purchase 3500 GL of permanent entitlements from irrigators. Employment impacts were estimated at −0.01% by the year 2017 for the SA Murray Natural Resource Management Region while an earlier study by Dixon et al., (2010) estimated that employment in the SA Murray Lands could decline by approximately 0.13% by 2018.

The 2018, long-run impact of the SDL and buyback on farm output in the SA Murray Lands was estimated to produce a 1.1% reduction in irrigated agricultural output. However, the net impact of the SDL and buyback was an estimated overall increase in household consumption for both SA Murray Lands and the southern portion of the Basin of 0.39% and 0.34% respectively. Specifically, the reduction of water available for irrigation was estimated to reduce income in the southern portion of the Basin by $97 million but the income from Commonwealth water buyback represented an income transfer of $173 million to the southern portion of the Basin. This difference was a 0.2% increase in regional consumption and after the effect of local re-spending multipliers, the overall impact on consumption was a 0.34% increase for the southern portion of the Basin under the 1500 GL buyback scenario (Dixon et al, 2011). A key assumption behind this result is that farmers would spend buyback revenues in the same way that they spend irrigation revenue. As it is conceivable that some farmers may change their spending patterns or take this income and leave the Basin entirely, Dixon et al (2011) tested the implications of 50% of buyback revenues being spent in the region and 50% spent outside of the region. The result of this analysis was a smaller net benefit, that is, a Basin-wide increase in household consumption of 0.09%.

It is worthwhile noting that the water purchased and returned to the environment was not modelled as providing any economic benefit (Dixon et al., 2011). In light of the analysis presented on the costs of damage, mitigation and adaptation expenditures in Section 4.5, it is likely that the increased base and environmental flows reduce mitigation, damage and adaptation expenditures in drought periods.

7 Structural adjustment

There is a link between the regional economic impacts of SDLs and pressures for structural adjustment. The Productivity Commission (2001) defines structural change as 'the ongoing process of change in the relative size of industries, in the characteristics of the workforce, and in the size and mix of activities within regions.' As such 'adjustment and structural change is a natural process of growth and decline that is essential for improving national productivity and driving innovation' (Musgrave, 1982).

Key drivers of structural change in the irrigation industry in the SA portion of the Basin include:

- market conditions including crop and input prices
- exchange rates and consumer preferences
- trends in regional demographics
- water scarcity and variability
- government policy
- combinations of these factors.

Over the past decade, pressure for structural adjustment has been particularly severe in irrigation regions in the SA portion of the Basin as a result of severe reductions in water allocation, coinciding with a precipitous drop in the price of the most significant irrigated crop in the region, wine grapes. A notable result has been a small decline in area of irrigated perennial crops especially wine grapes, citrus and a larger decline in the area of irrigated pasture (Connor et al., 2011).

SDLs will directly impact water scarcity and variability in the Basin and will in its implementation influence autonomous structural adjustment choices. The impacts are difficult to quantify ahead of time as its implementation may coincide with plentiful or scarce water allocation, high or low commodity prices, etc.

Policy can generally either impede or facilitate adjustment (McColl and Young, 2005). Policies facilitating structural adjustment include measures to further free market trade in water and to develop carryover arrangements. Temporary carryover arrangements were introduced as a drought measure in 2007 so that River Murray water users could manage their annual inter-seasonal risks during the drought. A precondition was the negotiation of capacity to temporarily retain some water in upstream storages for delivery the following year. Successful negotiation of permanent provisions for carryover would mitigate risk, facilitate planning and increase flexibility to adapt for irrigators.

Irrigation infrastructure investment programmes provide some incentives for adjustment. For example, Northern Victoria's Irrigation Renewal Project,[2] part of The Water for the Future programme, provides a roadmap for smarter restructuring that secures the most efficient parts of an irrigation system. Further targeting of investments in irrigation district reconfiguration and water purchases could not only reduce water delivery costs but also provide multiple co-benefits such as enhanced ecosystem service provision, reduced salinity loads and carbon sequestration (Crossman et al., 2010). Another opportunity at the irrigation district level is private initiatives like VicSuper's Future Farming Landscapes investment initiative.[3] This initiative is aimed at improving land and water resources management practices by providing a financial mechanism for supporting farm land reconfiguration to enhance production efficiency and support stewardship activities by irrigators.

There are other softer policy options that could facilitate autonomous structural adjustment through the provision of alternatives for farmers seeking to exit the irrigation industry. These options could consist of education and training or changes to taxation rules to ensure there are fewer disincentives for those farmers that wish to sell their entitlements. On the flip side, there may be sound reasons for policies that support the development of a new cadre of younger, innovative farmers that is well equipped to respond to changing market forces and water variability.

Policies that currently impede structural adjustment could be revisited, such as the structure of exit packages (ACCC, 2006). The Victorian small block irrigator exit grant packages aim to assist irrigators in difficult circumstances to exit and thereby reduce the number of small farms. As part of the package all permanent plantings must be removed and the land must not be irrigated for five years. The requirement hinders adjustment to larger farm sizes. In contrast, the exit package provided through the Climate Change Adjustment Program makes irrigable land, with intact on-farm

[2] See http://www.environment.gov.au/water/policy-programs/pubs/nvirp-stage2.pdf
[3] See http://www.vicsuper.com.au/www/html/1726-future-farming-landscapes.asp?intSiteID=1

infrastructure, available for anyone looking to increase the size of their farming operation. There is a real opportunity to rethink exit packages to ensure that they not only achieve the desired goal, i.e. facilitating the exit of, at least in theory, marginal farmers from irrigation and the transfer of their water entitlements to either more efficient farmers or to the government as environmental water, but also to facilitate smarter restructuring of the remaining irrigators within an irrigation system.

Finally the Basin Plan itself and its roll out can be designed to facilitate autonomous structural adjustment. Deadlines for buybacks could be extended giving irrigators more time; the accreditation guidelines for state environmental watering plans could promote good practices in co-managing irrigation and environmental water within a shared system that might be rewarded by significant efficiencies; and the commitment to adaptive management based on the best available ecological and hydrologic science and socioeconomic data might assist in building irrigator trust and cooperation to maximise whole-of-system net benefits.

The process of structural adjustment is in essence the process by which the economy reinvents itself in more efficient ways consistent with evolving market conditions, technology and changing social preferences. Naturally, some assets can become excess to requirements in the process (stranded assets) and impacts are typically uneven with some kinds of businesses and assets more severally impacted than others. A concern for government are situations where stranded assets might concentrate, for instance in a particular irrigation district and the associated local community impacts. Consideration of local contextual information suggests that: small- to medium-size irrigation enterprises, particularly those currently owned by older farmers without successors, those blocks irrigated for crops and varieties facing the most significant downward price pressures, and those small public irrigation trust blocks with less modern delivery and ordering to farm gate, may be contexts where significant assets including labour, land, irrigation capital and delivery infrastructure may be most vulnerable to becoming stranded (Thompson, 2006).

The Basin Plan through the setting of the SDLs will reduce overall supply of water available for diversion. The analysis presented here showed that SDLs could lead to increased production costs and foregone production opportunity in the irrigation sector. This has the potential to further intensify and accelerate the structural adjustment pressures that currently exist as the result of natural drought, demographics, Australian and world agricultural commodity markets, and currency exchange rates. Meaningful quantitative estimation of the likely incremental structural adjustment pressures and impacts on stranded assets is not possible given the considerable uncertainty regarding the likely future combination of developments in Basin inflows, commodity price developments, and key SDL settings.

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