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Recovering Water in the MDB
Productivity Commission
LB2 Collins St East
MELBOURNE VIC 8003

1 February 2010

Dear Commissioners,

MARKET MECHANISMS FOR RECOVERING WATER IN THE MURRAY DARLING BASIN SUBMISSION ON DRAFT RESEARCH REPORT

Judith Stubbs and Associates is carrying out a project for the Cotton Catchment Communities Co-operative Research Centre entitled "Exploring the Relationship between Community Wellbeing and Cotton Production in the Murray Darling Basin (MDB)". Co-operative Research Centres are an initiative of the Australian Government through the Department of Innovation, Industry, Science and Research.

As part of that study we have explored the relationship between employment and use of irrigation water in the MDB and have undertaken some preliminary estimation and quantification of costs and benefits associated with increases in environmental flows, with the two most likely benefits of increased environmental flows pertaining to maintenance of ecosystems and to reductions in river salinity.

Of relevance to the commission, we find that the costs of increased environmental flows are likely to be significant, with, for example, environmental flows proposed for The Coorong, Lake Alexandrina and Lake Albert Ramsar site likely to result in the loss of between 1,800 and 26,500 jobs if this water is sourced from agricultural irrigation and with the quantum of job loss dependent on the type of agriculture lost. Additional water will be required to offset transmission losses and this will result in additional job losses, suggesting that the lower figure is unlikely, with a probable minimum of 3,600 jobs. The wide range of the estimate is of particular interest, suggesting that impacts could be mitigated by careful targeting of sources and by redistribution of water between irrigation uses.

The wide variation in efficiency between different uses of irrigation water is a powerful argument for open water trading in the MDB. The difference in efficiency of various uses of irrigation water is marked, with some uses generating 15 times the output (measured in labour) for each Gl of water used by comparison with other uses. This suggests that the introduction of open water trading could lead to significant improvements in output as water is diverted to more efficient uses. Such efficiency gains and increases in output arising from a free market in water could be expected to offset, to some greater or lesser degree, loss of output arising from increased environmental flows and provide a strong argument for free and open trading of water.

With regard to salinity levels, the salinity criterion in the Water Act of 800 EC at Morgan has a large factor of safety, with regard to both potable water and to irrigation water. We have calculated a factor of safety of 1.14 against the value of 500 mg/l in the Australian Drinking Water Guidelines (itself a conservative value and equivalent to 910 EC), and a factor of safety of 2.3 against the upper limit of 1000 mg/l from the Australian Drinking Water Guidelines.

Salinity measures put in place as part of the Basin Salinity Management Strategy appear to have been quite effective, with large reductions in both salinity levels and in the variability of salinity levels since 2000. Using current data and predictions from the *Salinity Audit*, the conservative criterion of 5% exceedence of 800 EC at Morgan is not expected to be exceeded before 2040, suggesting that engineering and management approaches are likely to generate high returns, particularly by comparison with the high costs of environmental flows in lost agricultural production and employment.

Finally we believe that optimum outcomes will be best achieved with a high level of system management and carefully selected performance criteria, particularly by comparison with a regime based on "set and forget". This is because such approaches of "active management" significantly reduce standard deviations and hence allow the system to operate at higher average levels of water diversion, while still achieving environmental outcomes.

We believe this information will be of value to the Commission, particularly in the light of the statement on page xxii of the draft report which said:

> "… while some rebalancing of water resources between competing priorities is clearly required, there is no public record of rigorous cost-benefit analysis being undertaken before the buyback or infrastructure programs commenced. Nor is there a publicly available assessment of the incremental benefits and costs of environmental watering."

1 Estimation of the relationship between irrigated water and employment in the MDB

We have estimated the agricultural employment associated with irrigation water use across the MDB by statistical and linear regression analysis of data sets prepared from the 2006 ABS census and other ABS data. A summary of results are shown in Table 1 below, with preferred estimates shown in bold. This data can be used to calculate the effect of reduced allocations of irrigation water. As an example, if one Gl of water was taken from cotton growing, around 1.2 jobs would be expected to be lost. At the same time, the land is likely to be used for either cereals or grazing. Using the figures for employment per ha, the net loss of employment would then be about 1.0 job per Gl if the alternative use was cereals, and about 1.1 jobs per Gl if the alternative use was grazing.

Table 1: MDB estimated employment by land and water usage (Preferred estimates shown in bold).

Landuse	Employment per '000 ha	Estimated employment per '000 ha from linear regression analysis	Estimated employment per Gl	Estimated employment per Gl from linear regression analysis
Vegetables	**109.3**	65.4	**20.8**	**15.2**
Fruit	**72.7**	**74.2**	**13.2**	**15.5**
Grapes	**98.9**	**97.3**	**20.1**	**16.8**
Grazing (2)	0.86	**0.4**	0.2 (1)	**3.8**
Cereals etc	**1.43**	**1.2**	0.4 (1)	not reliable
Rice	**17.1**	**16.0**	**1.4**	**1.3**
Cotton	**7**	**5.8**	**1.1**	**1.2**

Source: 2006 Census, ABS 46180, ABS Agricultural Commodities: Small Area Data, Australia, 2005-06, JSA calculations.

Notes:

(1) Unreliable as the value for employment per 1,000 ha includes a significant component of dryland farming.

(2) Regression coefficients are additive for grazing.

In addition to these job losses, there are flow on effects. We have estimated (via linear regression analysis of an extensive data set) that, in the MDB, for each agricultural job, there are another 0.9 jobs within the local community. A factor of 1.11 should also be applied to account for "not stated" and "inadequately described" in the census counts. Hence to calculate the likely total job losses in the local community, the numbers in Table 1 should be multiplied by 2.1. Expanding the example used previously, the loss of one Gl of water from cotton growing would be expected to result in a total job loss in the local community of between 2.1 and 2.3 jobs, depending on the next best use.

We are of the view that this loss of jobs in the local community is also a net loss of jobs at the national level and represents a loss of output. This is because one of the inputs to production, water, has been diverted to an unproductive use rather than an alternative productive use and because agriculture is a primary industry. If levels of unemployment in Australia were so low that output was limited by labour, this may not be the case, with the labour able to be reallocated, however based on continuing levels of inflation in Australia, labour does not appear to be a limit on output.

2 Estimating the impact of environmental flows

The first commonly cited benefit of increased environmental flows is the maintenance of ecosystems and biodiversity.

While there are a number of changes in indicators of socio-economic wellbeing and resilience arising from changes in agricultural mix, we have found these to be quite small in quantum. The primary impact of diverting water from irrigation to environmental flows will be a loss of output at the national level, with this reflected by net loss of employment at the local and national level. We have considered The Coorong, Lake Alexandrina and Lake Albert Ramsar site as a case study for the analysis of costs and benefits. This is probably a key site, as any environmental flows discharge to the ocean, with no possibility of reuse. In summary, this site is undergoing significant environmental change and degradation as a result of diversion of flows from the Murray-Darling River system.[1] Options for management are somewhat limited and appear to comprise either an increase in river flows to return the ecosystem to one characterised by freshwater and tidal flows, or alternatively, opening the barrages and abandoning the lakes to a marine environment. Considerations are further compounded by predictions of sea level rises associated with global warming which could lead to inundation by seawater of the area in 25-50 years.[2] Kingsford *et al* propose a median annual flow of at least 3,800 Gl per year at the barrages to maintain this ecosystem, an increase in

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[1] Department for Environment and Heritage (2000), *Coorong, and Lakes Alexandrina and Albert Ramsar Management Plan,* Government of South Australia, p. 16.

[2] Kingsford R, Fairweather P, Geddes M, Lester R, Sammut J and Walker K (2009), *Engineering a Crisis in a Ramsar Wetland: the Coorong, Lower Lakes and Murray Mouth, Australia*, Australian Wetlands and Rivers Centre, UNSW, p.3.

median annual flows of 700 Gl per year at the barrages.[3] This is further quantified in a supplementary report by Kingsford *et al* showing the additional water required over the years 1994 to 2008. Mr Kingsford was unable to provide digital data, however the quantum can be scaled from figures in the supplementary report. On average, additional flows of 790 Gl per annum are required, with annual values ranging from zero to 2,400 Gl.

That diversion is likely to come at a significant social and economic cost with the cost being dependent on where the water is sourced. For example, and using the various factors and multipliers from section 1 above, 790 Gl of water would be equivalent to the loss of between 1,660 and 1,820 jobs if the water came from cotton communities. This will be a lower end estimate, as there are likely to be significant transmission losses as water in dams in the upper Gwydir and Namoi rivers travels the 1,500 km to the Murray mouth, passing through a range of wet lands on the way. Typically transmission losses in the MDB in the absence of flow regulation and consumptive use are estimated to be about 48%.[4]

If water was to be diverted from higher order irrigation uses such as grape and fruit growing, 790 Gl of water would be equivalent to the loss of 26,500 jobs in the MDB with this an upper estimate, noting that 790 Gl was around 85% of the water used for irrigation of grapes and fruit in 2006.

Using 2006 census figures of about 2.8 people per household, and assuming one job per household, the lower estimate of job losses is equivalent to the loss of a town of the size of Yass, and the upper estimate is equivalent to the loss of three towns of the size of Albury. It can be seen from this example that the social and economic cost of providing environmental flows could be significant. At the same time, those costs could be minimised by careful analysis of the source of the water, with differential impacts suggesting a need for extensive optimisation as to the source of environmental flows. In this regard, given the wide range in efficiency of various irrigated water uses, open trading of water is likely to result in significant increases in output, and these increased outputs may offset the reductions in output arising from increased environmental flows.

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[3] *Ibid,* p. 3.

[4] CSIRO (2008), *Water Availability in the Murray-Darling Basin.* CSIRO, Australia, p. 6.

3 Estimating the impact of decreased salinity

Salinity is the other commonly cited benefit of increased environmental flows. Despite this, there appears to be quite strong evidence that:

- salinity levels generally in the MDB are well below levels where effects on drinking water quality are experienced, and are well below levels at which reductions in agricultural output will be experienced; and
- management strategies put in place under the Basin Salinity Management Strategy have been quite successful. At the same time, a caveat is required as salinity levels in areas such as Lake Alexandrina and Menindee Lakes have been quite high as a result of evaporation and lack of diluting inflows.

Salinity level criterion

A value of 800 EC is commonly cited in literature around water quality and the Murray Darling Basin as a desirable limit for drinking water. EC, or electrical conductivity, is a proxy measure for total dissolved solids (TDS) in water, whereby increasing salt levels are reflected in increased electrical conductivity, and measured in EC. An EC unit appears to be generally taken as one micro-Siemen per centimetre in Australia.[5] The Salinity Audit[6] refers to the World Health Organisation in support of this value, however the WHO Guidelines for Drinking Water Quality (2008) do not provide a guideline value for TDS.[7] The 1984 guidelines suggested 1000 mg/litre on taste considerations. 1200 mg/litre is considered to be a threshold at which consumers may find it objectionable.[8] The 2008 guidelines suggest values of 600 mg/litre as giving good palatability, with palatability deteriorating at levels greater than 1000 mg/litre.[9] No guidelines are given for chloride and sulphates, the other common salts. The value of 800 EC is also found in the Water Act, but is unreferenced.[10]

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[5] Murray Darling Basin Ministerial Council (1999) *The Salinity Audit* Murray Darling Basin Commission, Canberra, p. 13.

[6] *Ibid,* p. 13. The report also conflates salinity with total dissolved solids (TDS).

[7] World Health Organisation (2008), *Guidelines for Drinking Water Quality,* 3rd Edition, Geneva, see for example p. 490.

[8] *Ibid* p. 445.

[9] *Ibid* p.218.

[10] The Water Act (Cth) 2007, clause 7(1).

The Australian Drinking Water Guidelines[11] give guideline values for chloride of 250 mg/l (aesthetic); Calcium Carbonate of 200 mg/l (aesthetic); sulfate of 250 mg/l (aesthetic) and 500 mg/l (health); and TDS of 500 mg/l (aesthetic) with 500-1000 mg considered acceptable and levels above 1000 mg considered unacceptable.

Further detail is provided in the fact sheet on TDS. "Based on taste, total dissolved solids in drinking water should not exceed 500mg/L. The equivalent figure in electrical conductivity units (EC units) can be roughly determined by doubling this value." "The most common and least expensive method [of measurement] is to convert electrical conductivity measurements to TDS values by multiplication with a factor that varies with the type of water (APHA Method 2510A 1992). Method 2510A[12] states "estimate total dissolved solids (mg/l) in a sample by multiplying conductivity by an empirical factor. This factor may vary from 0.55 to 0.9, depending on the soluble components of the water and on the temperature of measurement". Using recent data provided by SA water, we have calculated the empirical factor at 0.55 for raw water at Morgan.

A higher criterion could be considered. Using the upper limit of 1000 mg from the Australian Drinking Water Guidelines and the factor of 0.55, the limit for salinity would be 1,820 EC. Adoption of a higher criterion would essentially be cost free. Alternatively, the criterion of 800 EC could be said to have a factor of safety of 1.14 against the Australian Drinking Water Guidelines, and a factor of safety of 2.3 against the upper limit of 1000 mg from the Australian Drinking Water Guidelines, with the latter being the more likely statement, that is that the level adopted contains an inherent factor of safety of 2.3. The *Water Act* limit of 800 EC not to be exceeded 5% of the time at Morgan effectively adds another factor of safety to this factor of safety.

The criterion of 800 EC is well below the level at which reductions in agricultural output are expected. The Salinity Audit (1999) cites a value of 1,500 EC as a level where irrigation of most leguminous pastures and forage crops is very risky. Rice, maize and grain sorghum should not be irrigated at this salinity, and soybean only on well drained soil.[13] No reference is provided. The FAO (1976)[14] provides tables

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[11] National Health and Medical Research Council (2004), *Australian Drinking Water Guidelines 6*, Australian Government, table 10.10.

[12] American Public Health Association (2005) *Standard methods for the examination of water and wastewater*, 21st edition, American Public Health Association and others, Washington.

[13] *Op cit* p. 13.

[14] Food and Agricultural Organization of the United Nations (1976), *Water Quality for Agriculture,* Rome, table 5 (note tables are in mmhos/cm and need to be multiplied by 1,000 for comparable EC).

estimating yield decrement to be expected for certain crops due to salinity of irrigation water when common surface irrigation methods are used. A wide number of crops are listed. A 10% reduction in crop yields is predicted for crops as set out below. Crops with thresholds above 1,500 EC are not shown in the table.[15] By inspection, the criterion of 800 EC would appear to be quite conservative for all crops with the exception of strawberries, and with yield reductions of between 0 and 10% expected for the most sensitive crops at levels above 800 EC.

Table 2: Yield decrement values for various crops

Crop	Threshold E.C. for reduction in yield	E.C. for 10% reduction in yield
Sesbania	1,500	2,500
Corn	1,100	1,700
Flax	1,100	1,700
Cowpea	900	1,300
Broadbean	1,100	1,800
Beans	700	1,000
Grapefruit	1,200	1,600
Orange	1,100	1,600
Lemon	1,100	1,600
Apple	1,000	1,600
Walnut	1,100	1,600
Peach	1,100	1,400
Apricot	1,100	1,300
Grape	1,000	1,700
Almond	1,000	1,400
Plum	1,000	1,400
Blackberry	1,000	1,300
Boysenberry	1,000	1,300
Avocado	900	1,200
Raspberry	700	1,000
Strawberry	700	900
Cantaloupe	1,500	2,400
Spinach	1,300	2,200
Cabbage	1,200	1,900
Potato	1,100	1,700
Sweet corn	1,100	1,700

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[15] Including rice (2,000 EC) and cotton (5,100 EC).

Crop	Threshold E.C. for reduction in yield	E.C. for 10% reduction in yield
Sweet potato	1,000	1,600
Pepper	1,000	1,500
Lettuce	900	1,400
Radish	800	1,300
Onion	800	1,200
Carrot	700	1,100
Beans	700	1,000
Trefoil	1,500	1,900
Alfalfa	1,300	2,200
Lovegrass	1,300	2,100
Corn (forage)	1,200	2,100
Clover (berseem)	1,000	2,100
Orchard grass	1,000	2,100
Meadow foxtail	1,000	1,700
Clover (alsike, ladino, red, strawberry)	1,000	1,600

Source: FAO

Salinity control since 2000

There are a number of methods of controlling salinity, both in the source water and in the delivered water. These include salt interception, dilution flows, improving irrigation and dryland farming practice, restricting irrigation, alternative water supply and desalination of water supply.

The first three are discussed below, as these appear to be the strategies adopted under the Basin Salinity Management Strategy.[16] The Basin Salinity Management Strategy was implemented around 2000 and has been quite successful, both in reducing salinity, and in reducing the variation in salinity levels.

The figures below illustrate the moving five-year average of salinity (measured in EC) and the standard deviation of salinity levels measured at Morgan. In 1998, the average EC at Morgan was 650 EC, with a standard deviation of 95 EC. For 2009, the average was 490 EC with a standard deviation of 70 EC, suggesting a considerable reduction in both average salinity and in the variability associated with

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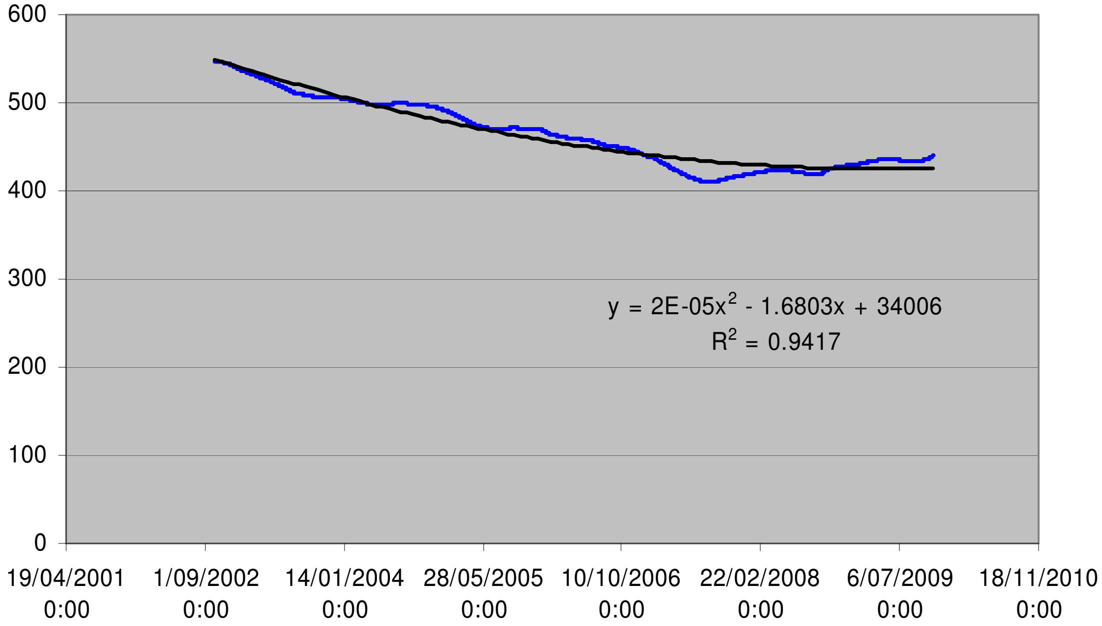
[16] Murray Darling Basin Commission (2007) *BSMS 2006-07 Summary Basin Salinity Management Strategy 2006-07 Annual Implementation Report,.* p. 4.

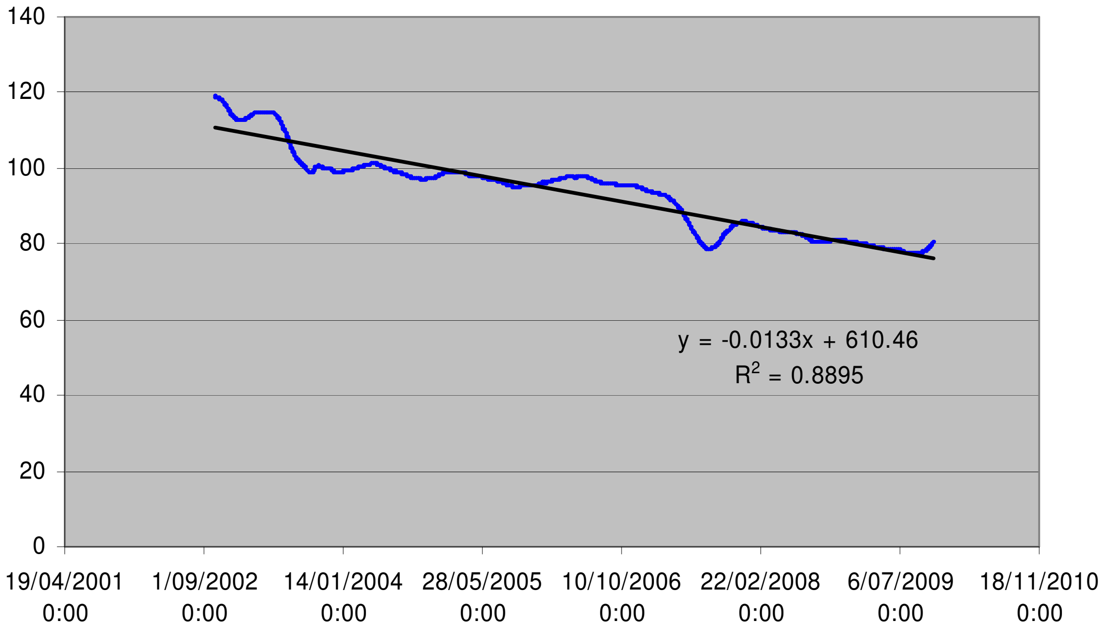
salinity. In order to minimise the effects of year-to-year fluctuations in both averages and standard deviation, we have taken a five-year moving average to identify trends. The data suggest a reduction in EC since 1998, but with diminishing returns, and with average levels plateauing. While there may be an upward trend occurring since 2007, this could also be a result of low EC levels due to low flows (and hence cessation of irrigation) through 2007. A longer record is required to determine if in fact such an upward trend is occurring, particularly in the light of the long term decreasing trend. In late 2009, the five year average was 440 EC with a standard deviation of 80 EC.

Figure 1: Average five year EC levels at Morgan



Source: Data from http://data.rivermurray.sa.gov.au/ accessed 9/1/10, JSA analysis

Figure 2: Average five year standard deviation of EC levels at Morgan



Source: Data from http://data.rivermurray.sa.gov.au/ accessed 9/1/10, JSA analysis.

Using the five year averages and projections from *The Salinity Audit*, salinity projections have been calculated. These are based on a 130 EC reduction in average salinity from 2010, with a standard deviation of 80 EC, and the assumption of constant relative standard deviation, that is standard deviation increases proportionally as salinity increases. Figures are also shown using constant standard deviation.

Table 3: Predicted Salinity at Morgan (E.C.)

Year	Predicted Average River Salinity (*The Salinity Audit)*	Adjusted Prediction based on 2009 five year average	Standard deviation	5% exceedance level	1% exceedance level
2010	570	440	80	570	630
2020	670	540	100	700	770
2050	790	650	120	850	930
2100	900	770	140	1,000	1,100

Source: *The Salinity Audit* and JSA calculation

Table 4: Predicted Salinity at Morgan (E.C.) assuming constant standard deviation

Year	Predicted Average River Salinity (*The Salinity Audit)*	Adjusted Prediction based on 2009 five year average	Standard deviation	5% exceedance level	1% exceedance level
2010	570	440	80	570	630
2020	670	540	80	670	730
2050	790	650	80	780	840
2100	900	770	80	900	960

Source: *The Salinity Audit* and JSA calculation

There are three conclusions from the analysis. The first is that the salinity management measures put in place have been quite effective, reducing peak EC measurement through both a reduction in average EC, and through a reduction in variability. The second is that, assuming current management techniques, the target of 5% exceedance of the 800 EC threshold would be expected to be exceeded in about 2040. The third is that if management techniques continued to improve, such as through higher levels of system feedback and targeting of dilution flows, resulting in a constant standard deviation or a further reduction, the target of 5% exceedance of the 800 EC threshold would be expected to be exceeded in about 2060.

Salinity diversion works are continuing to be constructed within the basin. We have attempted a preliminary analysis of costs associated with such diversion works. The Pyramid Creek Scheme became operational in 2008-09. The Scheme diverted 26,632 tonnes of salt at an energy cost of 123,922 kWh.[17] The scheme was costed at $10 million in 2001.[18] Based on the Consumer Price Index,[19] the cost at 2010 would be about $13 million, equivalent to an annual capital cost of $0.9 million. Operational costs are less easy to estimate. Domestic electricity rates are about $0.18 per kWh, suggesting an annual cost of at least $22,000, although industrial electricity charges are likely to be somewhat lower. There are likely to be other operational costs around labour and machinery. For these reasons, an annual cost of $2.0 million (including capital and operation) has been assumed for the purpose

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[17] Murray Darling Basin Authority Annual Report accessed on 11 January 2010 at http://www.mdba.gov.au/MDBA-Annual-Report/chapter2-4.html.

[18] http://www2.mdbc.gov.au/salinity/basin_salinity_management_strategy_20012015/salt_interception_scheme.html accessed 11 January 2010.

[19] Australian Bureau of Statistics.

of calculation. 800 EC is approximately equal to 440 mg per litre, or 440 tonne per Gl. At 800 EC, the salt load of 26,632 tonnes would require a minimum of 47 Gl of water to dilute it for disposal, noting however the demand for water is likely to be higher because the water used for dilution will be carrying an initial salt load. (Storage water in the upper Murray has typical EC values of 30-50 EC.[20]) This gives a cost per Gl of dilution water saved of about $35,000. For 2008-09, GDP for Australia was reported as $1,194,695 million.[21] For the same period, average employment was reported as 10,695,900,[22] giving an average GDP per person employed of $112,000.[23] Using these figures, the value of one Gl of water to the community varies between $200,000 and $3.9 million depending on the agricultural use. This suggests that salt interception would have a benefit-cost ratio of the order of six by comparison with dilution where the irrigation use is cotton production and up to 110 compared to uses such as vegetable production. Based on this preliminary scoping analysis, such schemes appear to be highly cost effective, particularly when associated with savings in dilution water that would otherwise be used for vegetables, fruit, grape and irrigated grazing and dairy production.

It is likely that as time goes on, salt interception schemes may become less efficient as good sites are developed. However this preliminary analysis suggests that such schemes could be relatively inefficient (between 5 and 100 times less efficient than Pyramid Creek for example) in reducing salt load, and still be expected to be cost effective.

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[20] Data for site 409016, Murray River at Heywoods accessed at http://www.vicwaterdata.net/vicwaterdata/ExtractData/ExtractionDetailForm.aspx?SiteID=1705&MDefID=536&MDefDesc=ELECTRICAL+CONDUCTIVITY+%28AT+STREAM+TEMPERATURE%29&ObsCount=218#table

[21] ABS 5206.0 *Australian National Accounts: National Income, Expenditure and Product,* Sep 2009, p. 63.

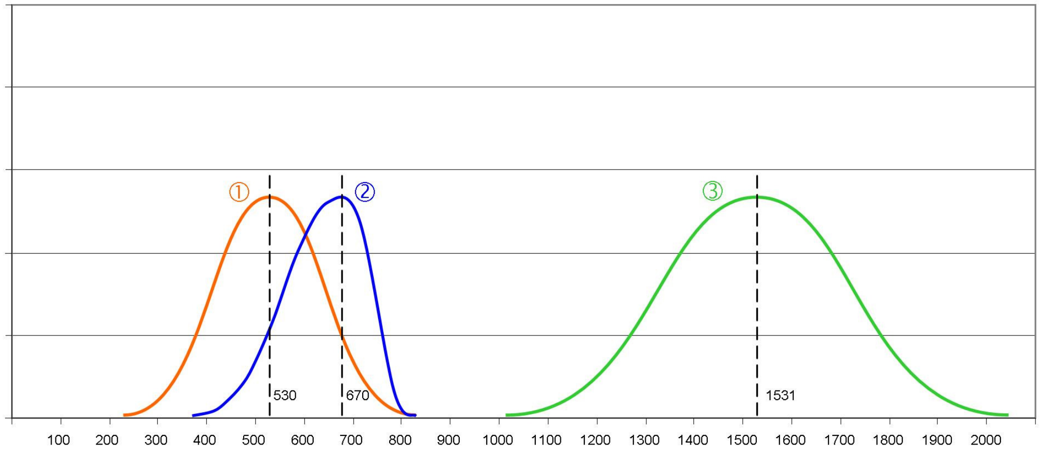
[22] ABS 1350.0 *Australian Economic Indicators,* Jan 2010 p. 103, using average of estimates for August and November 2008.

[23] Note that this is an average value across the industry. Some sectors may be more or less productive, however detailed information is not available.

Management options

Figure 3 below shows schematically three approaches to salinity management for illustrative purposes. The approach can be expanded to other uses of water such as maintenance of ecosystems and the like.

Figure 3: Three approaches to salinity management



We have assumed three different approaches.

Approach 1 is a "set and forget" approach based on the 5% exceedance of the 800 EC criterion. The lack of system management in such an approach is likely to be reflected in larger standard deviations, with a target average EC of 530 required. To achieve this target, higher environmental flows on average will be required.

Approach 2 is based on "active management" whereby salinity levels are continually monitored, and, when salinity levels reach some critical value, targeted dilution flows are released. Such an approach allows the system to be operated with lower average levels of environmental flows, leaving more water for other users such as irrigation.

Approach 3 shows the importance of setting appropriate limits. Too low a criterion can result in setting a factor of safety on a factor of safety. For example the real criterion may be that 95% of the time salinity is below a level such as 1,800 EC, allowing a much higher target, say 1500 EC. Such an approach will again allow the system to be operated with lower average levels of environmental flows, again leaving more water for other users such as irrigation. The essential point is that criteria such as salinity limits should not be arbitrarily imposed, but should be carefully considered based on considerations of risk, cost and benefit.

It can be seen that benefit is maximised when realistic limits are set and there is a high level of system control. A similar approach could be taken to ecosystems. For example, a community of river red gums may require flooding every three years to ensure long-term survival. With careful monitoring, an artificial flood using stored water can be provided to ensure survival in the event of low flows. However, in wetter years, such artificial floods may not be required, and on average, more water will be available for irrigation.

Yours faithfully,

JD Stubbs

Dr Judith Stubbs

Mr John Storer