Practice Change Research
Working Paper 04/06

A Tradable Permit Scheme for Salt Emissions to Promote Investment in Evaporation Basins in the Goulburn Broken Catchment

October 2006

Melinda Leth, John Ford and Geoff Kaine

Department of Primary Industries, Victoria

Published by the Victorian Government Department of Primary Industries
Tatura, October 2006.

Find more information about the Department of Primary Industries on the Internet at www.dpi.vic.gov.au

Acknowledgments:
The authors wish to thank Megan Higson, Department of Primary Industries, Victoria for allowing us to quote extensively from Kaine and Higson (2004) and Ian Reeve, Institute for Rural Futures, University of New England, Armidale New South Wales for allowing us to quote extensively from Kaine and Reeve (1993).

The authors also wish to thank the stakeholders who have supported this research and have provided regional context and technical information - GBCMA, G-MW, DPI and the Surface Water Management Working Group of the Shepparton Irrigation Region.

This is a milestone report for the project 'Scoping future directions of evaporations basins in the context of salt credits in the Shepparton Irrigation Region', funded by the National Action Plan for Salinity, a federal initiative of the Department of Environment and Heritage.

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1 Introduction

The Murray Darling Basin Salinity Management Strategy is the overarching policy framework for managing irrigation salinity in the Murray Darling Basin and informs the various state salinity programs. Under the Strategy the quality of water in the River Murray is managed by issuing Salt Disposal Entitlements to each state. These Entitlements limit the volume of salt that each state may be discharge into the River.

In Victoria, the Entitlements were shared amongst the catchments in proportion to the abatement measures required to implement their respective Land and Water Management Plans[1]. To date, Victoria has been allocated Salt Disposal Entitlements of 15.57 EC with the Goulburn Broken Catchment Management Authority receiving entitlements amounting to 4.9 EC (Sampson 2005). Estimates suggested additional entitlements of 10.8 EC would be required to implement the Shepparton Irrigation Region Catchment Strategy in full (Sampson 2005).

Most of the Entitlements that have already been allocated to the Authority have been committed to covering works such as construction of regional drainage networks. At the time this project commenced the Authority expected to utilise their remaining Entitlements within the next few years, given the rate at which they had been committed (GBCMA 2003). Hence, to continue implementing the Catchment Strategy and maintain a sustainable irrigation industry, the Authority believed there was a need to earn additional Entitlements or be forced to reallocate existing Entitlements to high priority works (GBCMA 2003).

Victoria has earned many of its' Salt Disposal Entitlements through contributing to the cost of constructing salt interception schemes along the River Murray. Over time,

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[1] Note, the Shepparton Irrigation Region Land and Water Management Plan is now referred to as the Shepparton Irrigation Region Catchment Strategy. This paper will use the latter term unless referring to historical documents.

the cost of these interception schemes has increased. The Victorian Salt Disposal Working Group estimated that reducing salinity in the Murray by one EC to be worth $90 000 to $140 000 in 2002 (GMW 2005). Hence, at the time the project commenced the Authority believed Victoria could not rely on salt interception schemes alone to create Entitlements and would need to investigate more cost-effective alternatives (Sampson 2005). These alternatives are described in the Shepparton Irrigation Region Catchment Strategy

The Shepparton Irrigation Region Catchment Strategy is supported by five sub-strategies of which the Groundwater Management Plan and Surface Water Management Plan are the two key sub-strategies that seek to manage salt emissions from irrigation. Salt emissions are generated where surface drains and streams intercept groundwater, where surface run-off leaves farms and where groundwater is mobilised by pumping. Of these, groundwater mobilisation is the main source of salt emissions.

The Strategy contains four options for managing salt emissions;

- Local reuse with dilution as required for low salinity groundwater
- Regional reuse with some disposal to the River Murray for low to medium salinity groundwater
- Opportunistic disposal to the River Murray for medium salinity groundwater
- Disposal of highly saline groundwater to evaporation basins.

Investment in evaporation basins has been limited relative to investment in local reuse and opportunistic disposal into the River Murray, with only two basins having been constructed to date. This was a concern for the Authority given the Strategy had a nominal target of 50 evaporation basins to be constructed by 2020 generating an estimated salinity benefit of 10.8EC (SKM 2002).

Given the apparently limited availability of Entitlements, the need for cost-effective alternatives to salt interception works and the potential benefit evaporation basins could provide in generating Entitlements, the Authority was interested in identifying ways to increase investment in evaporation basins. The implementation of a market-based instrument, such as a cap and trade market in salt emissions, was identified as one potential means of increasing investment in evaporation basins.

Funding was obtained from the National Action Plan for Salinity to investigate the appropriateness of a cap and trade market in salt credits to increase investment in evaporation basins[2]. The research was conducted in collaboration with the Authority, Goulburn-Murray Water and the community working groups of the Shepparton Irrigation Region. This paper reports on the findings of that research.

The purpose of the paper is to facilitate discussion and assist the Authority in making an informed decision on the merits of a cap and trade market as a mechanism for increasing investment in evaporation basins and other abatement works. The objectives of this paper were first, to outline the policies currently in place to manage salinity in the region, second, to provide a description of a potential market in salt credits and third, to consider the merits of this market in increasing investment in evaporation basins

In the next section we provide a brief overview of the Shepparton Irrigation Region Catchment Strategy. We then briefly outline the various market mechanisms that could be employed to manage salt emissions and promote investment in evaporation basins in the Region. We then describe a potentially feasible, though hypothetical, market in salt emissions. Included in the description is a discussion of the operation of the market, trading rules, and the allocation of emission permits. We then move to a discussion of compliance issues and finish by discussing the implications of the market with respect to the current policy framework for salinity.

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[2] The project was titled 'Scoping future directions for evaporation basins in the context of a market in salt credits'

2 The Shepparton Irrigation Region Catchment Strategy

The purpose of this section is to describe the current approach to managing salinity in the Shepparton Irrigation Region by providing an overview of the Shepparton Irrigation Region Catchment Strategy and the sub-strategies that are relevant to managing salinity in the catchment.

Understanding the current approach to managing salinity informs the design of new policy instruments such as a cap and trade market in salt emissions. Importantly, such an understanding provides insights into some of the challenges and implications that may result from the interaction of a market with the existing Strategy.

First, we describe the cost share principles that underpin the Strategy. We then provide an overview of the Groundwater Management Plan and Surface Water Management Plan. We conclude with a brief discussion of the potential role of additional instruments in increasing investment in evaporation basins.

2.1 Cost-share principles of the Strategy

The Shepparton Irrigation Land and Water Salinity Management Plan (1986) was originally drafted using the beneficiary pays principle where the costs of implementing the Plan were to be shared between landholders, local government, State Government and Federal Government (GBCMA 1997). Although the ratio of cost sharing is flexible from year to year, the general principles remain the same to this day (pers. comm. Sampson 2006). One practical implication of this cost share arrangement was the public provision of incentives for some private land works endorsed by the Plan.

Today, the Shepparton Irrigation Region Catchment Strategy provides incentives for activities such as irrigation recycle dams, private groundwater pumps and community surface drains. Irrigators and municipalities share the operation and maintenance costs of the Strategy, some of the capital costs for infrastructure development and most of the capital cost for works on private land. The State Government provides the capital for public infrastructure such as arterial drains and public groundwater pumps, extension, research, monitoring, funds for grants and incentives for works on private land.

2.2 SIR Groundwater Management Plan

The aim of the Shepparton Irrigation Region Groundwater Management Plan is to minimise on-site salinity impacts while also minimising downstream salinity impacts due to direct discharge of saline groundwater, seepage from containment or wash-off of salt from the soil surface by surface run-off (SKM 2002). The Plan comprises four sub-strategies relating to private groundwater pumping, public groundwater pumping, tile drainage for horticulture and evaporation basins.

Private pumps are constructed in accordance with the Plan's guidelines based on the quality and rate of groundwater extraction. Incentives are available for the exploration, construction and upgrade of bores for groundwater with salinity concentrations less than 3000 EC. These incentives are intended to increase investment in private pumps by the sharing of establishment costs. In principle they reflect the wider community benefit of private investment in groundwater pumps.

The cost share arrangement for a particular property is based on the number of endorsed management practices in place, up to a maximum payment. In addition to capital costs, landholders pay an annual charge based on the volume of water pumped. To help reduce on-site and off-site salinity impacts, the Plan also provides a number of guidelines for the operation of pumps and sustainable use of groundwater. Landholders with private pumps may also apply for salinity disposal to the River Murray where the salinity of the groundwater salinity is more than 1000 EC (SKM 2002)

Public pumps are constructed where the salinity of groundwater is more than 3000 EC and less than 7000 EC, and there is public benefit generated from its construction. The cost of construction is covered by the State Government. The operation and maintenance costs of public pumps are shared between municipal counsels, all irrigators and those landholders that directly benefit from the public pump (Irrigation Committee 1997)[3].

There are a couple of options for the disposal of groundwater from public pumps. In some cases there is some opportunity for local reuse. In others there is the opportunity for disposal to the River Murray when conditions in the River allow. The pumps are operated in accordance with the Murray Darling Basin Salinity Management Strategy, the Shepparton Irrigation Region Catchment Strategy and the Shepparton Irrigation Region Groundwater Management Plan.

Where orchards and vineyards experience problems due to high watertables and groundwater pumping is not a viable option, incentives are available for the installation of tile drains. The cost share arrangements that are available to landholders depend on the degree of water management development on the site, such as installation of pressurised irrigation systems, and the effectiveness of surface water drainage. The government bears a larger cost share for well-developed sites.

Evaporation basins are expected to play an important role in managing highly saline groundwater. The Plan stipulates the use of evaporation basins where the salinity of groundwater is greater than 7000 EC and disposal to the River Murray is not acceptable. Evaporation basins are intended to provide groundwater protection to surrounding land by enabling highly saline groundwater to be stored above ground thereby freeing up regional aquifers (as well as under the basin). The Strategy does not include cost-sharing, ownership or management arrangements specifically for evaporation basins. Only two evaporation basins have been constructed in the

[3] The shares are 17%, 41.5% and 41.5% respectively.

Region on private land. Both were entirely public investments in line with the general principle of public funding of public infrastructure.

2.3 Surface Water Management Plan

The aim of the Surface Water Management Plan is to remove excess rainfall runoff and irrigation tail water in a controlled and equitable manner via surface drains. In addition, surface drains reduce accessions to the watertable by up to 19 per cent and so reduce salinisation (GBCMA 1997). Surface drains also provide infrastructure for the disposal of saline groundwater removed by pumping and so assist to manage the salt balance in the Region.

The Plan outlines the cost share arrangements for the design, construction operation and maintenance of Goulburn Murray Water and community owned surface drains. The design and construction costs for Goulburn Murray Water primary drains are covered by Goulburn Murray Water, with operation and maintenance costs shared between municipalities, all irrigators and those landholders who directly benefit from the drains[4]. For community surface drains the State government covers 90 per cent of the survey and design costs and 50 per cent of the construction costs.

Landholders are charged an annual fee to cover the maintenance costs of drains based on their volume of emissions. Due to the impossibility of measuring actual emissions proxies are used to estimate emissions. The proxies are water use and area of land irrigated. Included in these charges is a salt levy that generates $85 000 per annum and is allocated to funding the implementation of the Strategy (Sampson 2006). The drainage charges and the salt levy could be interpreted as an application of the polluter pays principle.

On-farm storages provide an important role in managing salt and nutrients in the Region. Incentives are available for the construction of storages to hold diversion

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[4] The shares are 17%, 41.5% and 41.5% respectively

flows up to a maximum payment. A high flow diversion licence allows irrigators to divert drainage water and store the water during high flow conditions. The stored water may be used conjunctively with channel water for irrigation. High flow diverters are metered and charged for the volume of water diverted. A low flow licence allows farmers to divert drainage water in low-flow conditions and apply the diverted water directly to paddocks.

Recently, managing the concentration of salt emissions in river as well as salt loads has become an objective in the Plan. The Irrigation Drainage Memorandum of Understanding Steering Committee believes different river reaches have different beneficial uses that require management of salt concentrations (Hydro Environmental 2005). To achieve this objective requires the ability to control the timing of salty emissions into rivers.

2.4 Discussion

We have provided a brief description of the Shepparton Irrigation Catchment Strategy and the key sub-strategies that concern the management of salt emissions from the Region. The Strategy incorporates an extensive range of policy instruments including incentives, charges, levies, cost sharing and guidelines for best practice.

Groundwater mobilisation by public and private groundwater extraction is the main source of salt emissions in the Region. In the case of public pumps, they can be treated much like point sources given the Catchment Management Authority can control the volume and timing of salt emissions. The Murray Darling Basin Salinity Management Strategy, Shepparton Irrigation Region Catchment Strategy and Shepparton Irrigation Region Groundwater Management Plan regulate the disposal of saline groundwater from public pumps in line with the ability of the River Murray to assimilate salt in the long term.

Salt emissions from private groundwater pumping are more difficult to manage. A number of mechanisms are in place to help reduce the down stream impacts from groundwater mobilisation such as regulating water use, guidelines for the sustainable use of groundwater and incentives to increase investment in efficient irrigation technologies. These mechanisms help manage salt emissions in the long-term. However, landholders have limited control over the volume and timing of emissions in the short-term.

Landholders contribute to the administration, design, construction, operation and maintenance costs for activities endorsed in the Strategy. In addition, landholders are charged for their emissions into the drainage network which includes a salt levy. In theory, the charge shifts the costs to others of salt emissions back to the source of the emissions. However, at present drainage charges are an inconsequential fraction of the operating costs of irrigation enterprises. Hence the current charges are extremely unlikely to influence the behaviour of landholders.

The policy instruments in the Strategy are designed to manage salt emissions in a variety of ways including limiting the water applied through irrigation. Many of the instruments encourage investment in efficient water management technologies, encourage the conjunctive use of groundwater and encourage the re-use of water on-farm through recycle dams and drainage diversions.

In reviewing the Shepparton Irrigation Region Catchment Strategy we identified three important issues in the management of salt at the time this project commenced. First, there was a perceived need to generate additional Salt Disposal Entitlements to further the implementation of the Strategy. Second, in regard to this need evaporation basins were viewed as a potentially important component of the Groundwater Management Plan. The storing of highly saline groundwater in the landscape is one means of generating additional Entitlements. However, investment in evaporation basins had been limited. Third, although landholders can control salt emissions in the long-term, they have limited control over the timing of emissions in the short term.

Given these issues, there was potential for new market-based instruments to contribute to the Strategy by fostering investment in evaporation basins. We also believed an instrument that promoted control over the timing of salt emissions in the short term would contribute to achieving the water quality targets outlined in the Irrigation Drainage Memorandum of Understanding.

3 Alternative market based instruments

In general terms there are five possible market based instruments for encouraging investment in evaporation basins. These instruments range from incentive and levy mechanisms, sometimes termed price based market mechanisms, to set aside programs and cap and trade markets, sometimes termed quantity based mechanisms.

When considering introducing new policy instruments, the Shepparton Irrigation Region Catchment Strategy should be kept in mind, as the Strategy will influence the feasibility of implementing a new instrument. Depending on the type of instrument under consideration the policies contained in the Strategy may need to be reviewed or even revoked in order to implement the instrument.

We will describe five possible market-based instruments for increasing investment in evaporation basins.

3.1 Incentives and cost sharing

An incentive is a mechanism that is intended to increase the rate of production of works such as evaporation basins by reducing the capital costs associated with their construction. Incentives can take a variety of forms including fixed payments, cost sharing and provision for tax write-offs. Incentives are voluntary mechanisms in the sense that decisions to undertake actions that attract an incentive are at the discretion of the landholder or investor.

A major difficulty with incentives is identifying the level of incentive that is required to achieve the policy objective. Too small an incentive relative to the cost of constructing an evaporation basin would be likely to result in little extra investment in evaporation basins. Too high an incentive would result in excessive investment in basins at the cost of investment in other projects. Theoretically, incentives for investment in evaporation basins will be most attractive to those landholders that do not have access to the regional drainage network and whose properties are at risk from salinisation. Landholders whose properties are at risk of salinisation but have access to the regional drainage network will only consider disposing of emissions into evaporation basins if the cost of doing so is lower than the cost of using drainage. Hence, in addition to providing incentives to encourage investment in basins, substantial increases in drainage charges may also be required to make basins an attractive option for the disposal of emissions.

Incentives have a number of shortcomings that must be considered when analysing their appropriateness as a policy instrument. First, the environmental objective may not be achieved because even widespread adoption of abatement works is unable to reduce emissions to target levels. Second, achievement of environmental objectives may be uncertain with incentives because insufficient numbers of landholders may implement abatement works, or the works may be designed and constructed in an inappropriate manner. Third, landholders may adopt abatement works but implement them in ways that do not contribute effectively to achieving the environmental objective. Fourth, the level of incentives may need to be revised constantly to account for changes in construction costs, expansion or contraction in the drainage network, changes in land use and changes in irrigation technology and practice. Fifth, the environmental objective may be achieved but at greater economic cost to the community than is necessary because there is insufficient investment in other abatement measures.

Finally, a relatively large incentive in absolute terms may be required to appreciably increase investment in evaporation basins given the considerable construction and maintenance costs involved. There is the possibility that the incentive may need to be set at levels that are too high to attract support from the rest of the community.

Given these shortcomings, incentives are not likely to be a practical means of fostering widespread investment in evaporation basins in our opinion.

3.2 Drainage Charges and levies

Levies and charges are price-based instruments aimed at changing the behaviour of landholders by raising the cost of target behaviours. In this instance drainage charges raise the cost of discharging salt into the drainage network. The extra cost of emissions creates an incentive, in theory, to either reduce emissions or use alternative means of disposing of emissions, such as disposal into evaporation basins. As a consequence they may create an incentive for investment in evaporation basins. Levies are compulsory mechanisms in the sense that the landholder must pay the levy if they undertake a leviable action. However, in principle, the decision to undertake the action is at the landholders' discretion.

In principle, drainage charges are similar to load based taxes in that the charge exacted on a landholder is intended vary in accordance with the estimated volume of emissions entering the drainage network. Currently, for example, drainage charges in the Goulburn Broken depend on water use and location (Sampson pers. comm. 2006). By increasing drainage charges to reflect more closely the cost of salt disposal the charge could indirectly drive investment in evaporation basins.

A major difficulty with drainage charges, as with incentives, is determining the appropriate rate of charge on emissions. If the charge is set too low then investment in evaporation basins will be limited and the environmental objectives may not be met. If the charge is set too high then there may be excessive investment in measures to reduce emissions into the drainage network. This may lead to over-investment in evaporation basins.

The drainage charge may well require periodic revision to accommodate changes in the volume of emissions due to changes in agricultural production, and to allow for changes in the costs of abatement measure. The need for repeated changes in the charge may generate costly adjustments and readjustments on the part of landholders and investors in terms of production, input mix and investments in abatement works. The need for repeated changes in the charge to maintain is also an unattractive prospect from an administrative and political perspective.

Note that increasing drainage charges also encourages landholders to invest in abatement activities other than disposing of emissions into evaporation basins. There is the possibility that other abatement options are relatively inexpensive for the landholder. Hence, the increase in drainage charges may encourage landholders to invest in abatement measures on-farm rather than fostering investment in evaporation basins.

There is also potential for drainage charges to adversely affect private investment in surface drains and to reduce private investment in groundwater pumping. Given these are key elements in the Surface Water Management Program and Groundwater Management Program, these effects must be considered in any plan to substantially increase drainage charges.

In our opinion increasing drainage charges is unlikely to be a practical means of encouraging widespread investment in evaporation basins.

3.3 Set aside programs

Set aside programs occur in a variety of forms. Generally speaking these programs involve allowing landholders to undertake an activity with undesirable effects provided they make a commitment to contribute to works elsewhere that offset those undesirable effects. Set aside programs are voluntary mechanisms in the sense that decisions to undertake actions that require contributing to a set aside are at the landholders' discretion. However, they are compulsory mechanisms in the sense that the landholder must contribute to the set aside if they undertake the activity.

In this instance a set aside program might require landholders that generate salt emissions to make contributions to an investment fund to finance construction of evaporation basins. Landholders would be required to make such a contribution whether or not their particular emissions were discharged into a basin. In principle, the fund could contribute to the construction of basins by public agencies or by private business.

As with incentives and levies, a major difficulty with set aside programs is determining the appropriate rate of contribution on emissions. If the contribution is set too low then investment in evaporation basins will be limited and the environmental objectives may not be met. If the contribution is set too high then there may be excessive investment in measures to reduce emissions into the drainage network. This may lead to costly over-investment in evaporation basins and under-investment in other, less expensive abatement measures.

The set aside contribution will also require periodic revision to accommodate changes in the volume of emissions due to the changes in the volume and mix of agricultural production. The contribution would also need to be revised to accommodate changes in the costs and technologies of abatement measures.

There is also potential for set aside programs to adversely affect private investment in surface drains and to reduce private investment in groundwater pumping. Given these are key elements in the Surface Water Management Program and Groundwater Management Program, these effects must be considered in any plan to substantially increase drainage charges.

In our opinion set aside programs are unlikely to be a practical means of fostering widespread investment in evaporation basins.

3.4 Auction systems

Depending on their design auction or tender systems can operate in a manner similar to incentives or charges. An auction system is similar to an incentive program where the auction is used to attract bids from landholders for public funds to be invested in activities they will undertake that contribute to achieving an environmental outcome. In essence, an incentive is provided to landholders, in the form of bid payments, to undertake an action such as constructing an evaporation basin.

A major difficulty with this type of auction is identifying the size of the fund that is required to achieve the policy objective. Too small a fund relative to the cost of constructing evaporation basins would be likely to result in little or no extra investment in evaporation basins. Too large a fund would result in excessive investment in basins at the cost of investment in other projects. In addition, the fund may need to be revised regularly to account for changes in construction costs of pans, expansion or contraction in the drainage network, changes in land use and changes in irrigation technology and practice. The comments made earlier in regard to incentive programs apply to this type of auction.

An auction system is similar to a levy where the auction is used to attract bids from landholders to be allowed to undertake activities that detract from an environmental outcome. In this case landholders pay a levy, in the form of the bid price, to purchase rights to dispose of emissions to an evaporation basin. Landholders without such rights would have to eliminate salt emissions or, possibly, pay drainage charges.

A major difficulty with an auction of this type is deciding on the level of drainage charges since the charge will set an upper limit on the bids which landholders would offer to obtain access rights to evaporation basins. Too high a charge means the cost of using the drainage network will be relatively high, encouraging investment in abatement measures on-farm and an excessive demand for access to evaporation basins. Too small a charge means the cost of using the drainage network will be relatively low, discouraging investment in abatement measures on-farm and insufficient demand for access to evaporation basins. The comments made earlier in regard to drainage charges and set aside programs apply to this type of auction.

3.5 Cap and trade market

A cap and trade market consists of three components. The first component is the 'cap' which is the limit on the total emissions allowed over a given time and place. The second is an emission permit, which is a property right and specifies the volume of emissions each landholder is legally entitled to discharge, thereby making landholders accountable for their emissions. The total volume of discharges allowed by the emission permits must equal the 'cap' for the catchment. Trading is the third component. Trading enables the emission permits to be traded, either in whole or in part, and on a temporary or permanent basis. Investment in abatement works such as evaporation basins will be encouraged if the prices at which permits are traded in the market is sufficiently high.

A market in tradable salt emission permits overcomes the weaknesses of a policy based on voluntary adoption of abatement works. Most importantly, a market in emissions through the 'capping' of emissions provides certainty that the environmental objective can be achieved. A market in emissions also, in theory, enables the environmental objective to be achieved at the lowest possible economic cost to the community (Montgomery 1972).

The problem of defining the emissions of individual landholders can be a serious technical difficulty with markets for diffuse emissions as emissions must be measurable and controllable to be tradable. There can also be social and political difficulties with emission markets. One important political difficulty is that the 'capping' of emissions to create the market unavoidably redistributes wealth between different groups in the community. A second is that all producers that generate emissions are legally required to participate in the market. In other words, participation is compulsory.

To implement a cap and trade market in salt emissions, like any new policy instrument, would require a review of the current policy framework for managing salt emissions in the Catchment. This would help ensure that the new instrument aligned with the existing mix of policy instruments, legislation and inter-government agreements and strategies and so would reduce the chances of failure in implementation.

However, despite these difficulties, a cap and trade market in emissions does have the potential to foster investment in evaporation basins in our opinion. In the remainder of this paper we describe how the technical difficulties of a 'cap and trade' market in salt emissions from irrigated agriculture might be overcome so that such a market could be introduced in the Shepparton Irrigation Region.

4 A 'cap and trade' market in salt emissions

The aim of this section is to describe a hypothetical cap and trade market in salt emissions for the Shepparton Irrigation Region and consider if such a market is technically feasible. The purpose of this market is to increase investment in evaporation basins.

The cap and trade market was designed to be as consistent as possible with the Murray Darling Basin Salinity Management Strategy and Shepparton Irrigation Region Catchment Strategy. However, we suspect inconsistencies still remain between these policies and the market we have designed. We believe these inconsistencies do not affect the technical feasibility of the market. They do indicate, however, that review of these policies would be required if a cap and trade market were to be seriously considered and successfully implemented.

In the next section we describe the emission and disposal permits which are required to manage the long-term and short-term assimilative capacity of the Region's rivers. We then describe the circumstances under which these permits can be traded. Following this we outline the monitoring and compliance aspects of the market and the issues around establishing the market such as the distribution of adjustment costs and redistribution of wealth among landholders.

4.1 Introduction

A fundamental problem in designing tradable permit schemes for emissions from diffuse sources are the technical difficulties associated with measuring and controlling emissions, see (Higson and Kaine 2004). This has a number of consequences.

First, emissions from diffuse sources can only be estimated on the basis of land use factors that are associated with emissions such as type and areas of perennial or annual crops and pasture, soil type, and so on. Hence, the market we describe depends on the use of simulation models to estimate the salt emissions of individual landholders.

Second, the volume of emissions into rivers in the short term can depend on factors beyond the control of landholders (such as rainfall). Third, landholders' lack of control over emissions in the short term has the potential to increase river salinity to unacceptable levels as their emissions may, in total, exceed the assimilative capacity of the river in the short term. We resolve the problem of limiting total emissions in the short term to short term variations in the assimilative capacity of rivers by introducing two types of permits - salt emission permits and salt disposal permits.

The purpose of salt emission permits is to restrict salt emissions in the long term from irrigated agriculture to the long-term assimilative capacity of rivers in the catchment. All landholders that generate salt emissions are required to hold salt emission permits that match the average of their long-term emissions.

The purpose of salt disposal permits is to provide a mechanism for restricting salt emissions from irrigated agriculture in the short term to manage short term variations in the assimilative capacity of rivers in the catchment. A salt disposal permit may only be owned by a landholder that has the capacity to store and discharge salt at will such as those with a turkey's nest or evaporation basin for example.

All landholders with a salt emission permit must have a contract for disposal of their salt emissions with the owner of a salt disposal permit. The linking of salt emission permits with salt disposal permits creates incentives for investment in the harvesting and storing of salt emissions. This raises the possibility of matching salt emissions in the short term to variations in the assimilative capacity of rivers in the short term. The fundamental concepts underlying emission and disposal permits are illustrated in figure 4.1.

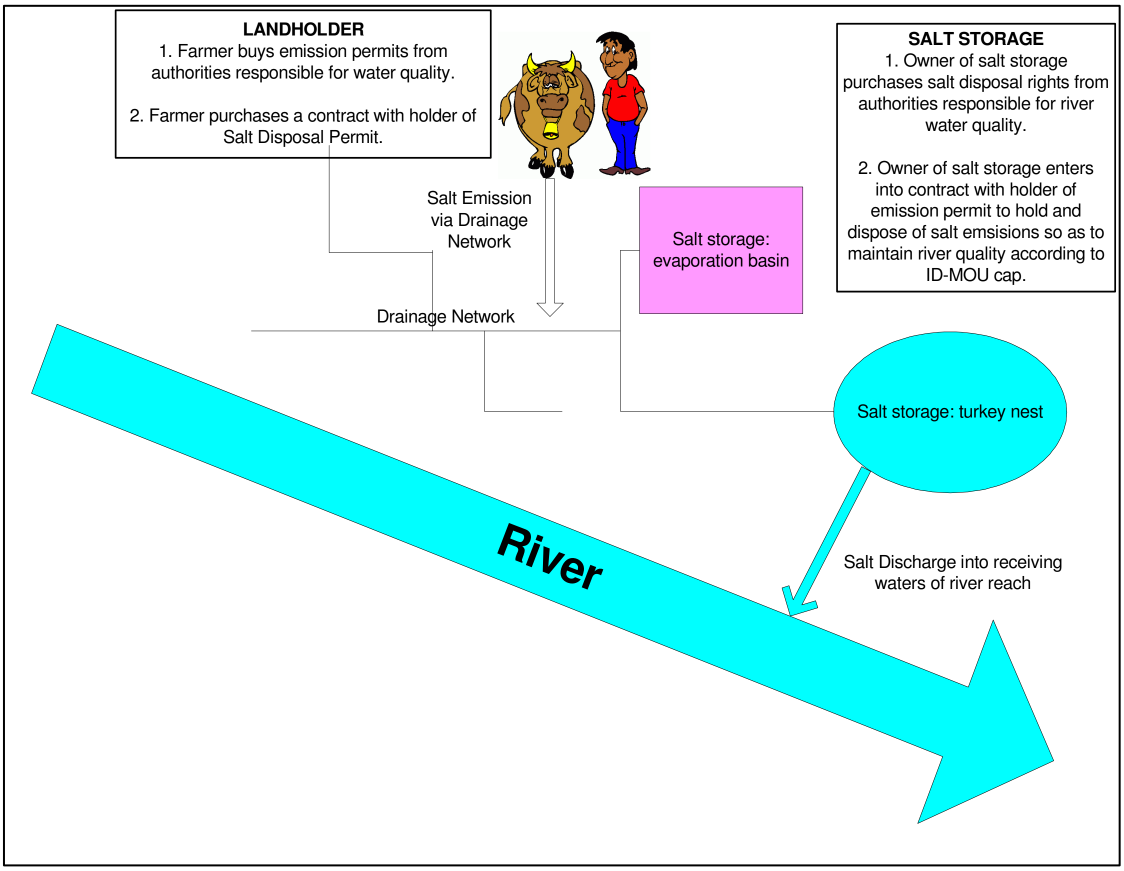

Figure 4.1. Schematic of market in salt emission permits and salt disposal permits to manage salt emissions in the Shepparton Irrigation Region

Salt emissions from landholders are intercepted by the regional drainage system. Landholders with a salt disposal permit harvest and store emissions from the drainage network. Stored emissions may then be disposed of by discharge into the river when conditions allow.

The design of this market means that in practice landholders with salt emission permits must have a contract with one or more downstream landholders that possess a salt disposal permit. Provided the volume of salt emission permits matches the volume of salt disposal permits then, in the long run, salt emissions from irrigated agriculture will match salt disposals into the rivers. Provided there is sufficient capacity for storing salt in the region, variations in emissions can be aligned with variations in the assimilative capacity of the rivers in the short term to ensure water quality standards are maintained.

4.2 Salt emissions cap

The 'cap and trade' markets in salt emission and salt disposal permits we have designed are based on the assumption that virtually all saline groundwater and run-off from irrigated agriculture in the catchment is intercepted by the local or regional drainage network. The drainage network may include natural streams. These networks then drain into one or more rivers in the catchment for which maximum salt concentrations have been set. These concentrations may be defined for points in the landscape such as end of valley, end of river, end of drain or end of river reach, depending on the preferences of stakeholders.

The maximum salt concentrations, together with the volume of water in rivers over a period of time, define for our purposes the assimilative capacity of the rivers with respect to salt. This capacity is the 'cap' aspect of 'cap and trade' markets. The salt emissions cap is the total amount of salt emissions available for distribution among landholders. The cap is the total amount of salt emissions landholders in aggregate may legally generate.

Hence, the salt emissions cap defines the supply of the resource (assimilative capacity of the rivers) available for trading among landholders. The smaller the cap relative to the emissions of landholders the scarcer and more valuable is the resource, and the more valuable the right to generate salt emissions.

For the purpose of salt emission permits we defined the salt emission cap between two points in a river as the average annual assimilative capacity of the river in the long term. For salt disposal permits we defined the salt emission cap between two points in a river as the daily assimilative capacity of the river. In the long term, the average daily cap for salt disposal permits should match the cap for salt emission permits. Hence, landholders' uncontrolled emissions of salt in the short term should equate over the long term with the assimilative capacity of rivers in the long term.

The cap for salt emission permits is defined algebraically by expression 1 in box 4.1. The cap for salt disposal permits, and its equivalence with the cap for salt emission permits, is defined algebraically in box 4.2

4.3 Salt emission permits

Salt emission permits entitle landholders to a specified share in the salt emission cap (see expression 2 in box 4.1). That is, the permit entitles the landholder to a percentage of the long term, average annual assimilative capacity of the relevant river. The salt emission permit can be expressed either as a percentage of the cap or as the equivalent load in kilograms per relevant unit of time.

The period of time in which emission permits are denominated is a critical issue in market design. On the one hand emission permits should not be denominated in periods of time that are shorter than the rate at which at least some landholders can implement abatement actions. Otherwise landholders may find themselves inadvertently contravening the conditions of their permits yet lacking the capacity to comply with these conditions. On the other hand, permits should not be denominated in periods of time that are substantially longer than the rate at which most landholders can implement abatement actions.

SEC is the salt emissions cap
E_j is the salinity emission permit allocated to landholder J
k_j is the percentage of the 'cap' allocated to landholder J
$\hat{c}$ is the maximum salt concentration permitted in the river
c_t is the salt concentration in the river in period t
v_t is the water flow in the river in period t
x_{pj} is the p-th emissions related input for landholder j

The 'cap' for salt emission permits (SEC) is given by:

(1) $SEC = 1/n \sum (\hat{c} - c_t)\, v_t$ for $t = 1, 2, \ldots, n$

And the salinity emissions allocated to landholder j are given by:

(2) $E_j = k_j \,.\, SEC = k_j /n \sum (\hat{c} - c_t)\, v_t$ and $\sum k_j = 100$ for $j = 1, 2, \ldots, m$

The salinity emissions allocated to a landholder can be expressed in terms of production inputs by:

(3) $E_j = f\,(x_{1j}, x_{2j}, \ldots, x_{pj})$

In the long run the total emissions allocated to landholders equal the cap:

(4) $\sum E_j = \sum (\hat{c} - c_t)\, v_t$ for $j = 1, 2, \ldots, m$; $t = 1, 2, \ldots, n$

Box 4.1 Algebraic expression for the salt emission 'cap' and permits

To do so would unnecessarily reduce the rate of transfer of emission permits between alternative land uses thereby reducing the efficiency of the market and imposing economic losses on the community.

The dynamic behaviour of the supply of the natural resource is another consideration in determining the time of denomination of permits. Generally speaking, the aggregate volume of emissions authorised through the permits should change over time in accord with changes in the capacity of the environment to assimilate emissions.

In the context of a Northern Victorian river, landholders may vary their emissions in the long term by, for example, altering their mix of crops and pastures. However, they do not have the capacity to adjust their emissions in line with short-term variations in the assimilative capacity of rivers. By defining emission permits as shares of the long-term average of the assimilative capacity of the river, the short term rate of salt emissions which is beyond the control of landholders is divorced from the long term volume of emissions which, we assume, they can influence.

Since actual emissions of salt produced by individual landholders cannot be measured their share of the cap must be translated into measurable production inputs related to salt emissions (see expression 3 in box 4.1). The translation of the share of the salt cap into measurable production inputs also describes the control landholders can exert over their emissions of salt in the longer term. The only practical means by which this translation can be done is through the use of salt budgeting models. Hence, as is the case with nitrogen emission market being introduced in New Zealand (Kaine and Higson 2004; Environment Waikato 2003) the cornerstone of the emissions market is a nutrient budgeting model for agricultural land uses.

The amount of salt emissions produced in the long term by landholders is known to be a function of their cultural practices, soil type, water use and other factors (Whitfield et al. 2004). There are a number of salt budgeting models currently used in the Entitlement accounting processes of the regions. However, there is some question as to whether existing models of salt emissions are sufficiently accurate to reliably predict emissions from individual properties. The degree to which this is a fundamental obstacle in the establishment of a market is unclear. We note that simple models based on water use allocation suffice for imputing amounts of emissions for levying drainage charges.

In using a model to calculate salt emissions the model acts as a mechanism for imputing landholders' use of their share of the salt emissions cap. To achieve the cap the aggregate volume of imputed emissions calculated using the model should be less than or equal to the cap. Therefore, each landholder should have an emission permit sufficient to match their imputed emissions. Furthermore, the total of the emissions calculated using the model for all landholders with permits should approximate emissions of salt across the catchment in the long term. This means estimates of salt emissions must be reasonably accurate at a catchment scale and free of bias at the level of the individual.

By defining emission permits in terms of the inputs into a salinity model, the difficulty of measuring actual salinity emissions is avoided. Hence, the measurement difficulties typically associated with diffuse source pollution are circumvented. Furthermore, as emissions are determined in the model on the basis of estimated relationships between emissions and production inputs the model can be used to infer constraints on those characteristics. This means that the salt emission permits for a particular landholding can also be expressed in terms of the contextual characteristics of that holding as well as units of salt emission.

This creates five advantages. First, because permits can be expressed in terms of contextual characteristics then, in principle, permits can define constraints on the permissible combinations and levels of inputs into agricultural production processes such as water use. This allows the landholder to evaluate salt emission permits in terms of the economic value of the combinations of production inputs and management practices possession that the permit allows. The inputs would be translated to give the emission equivalent of tonnes salt per annum to facilitate trading. In other words, the permits can be expressed in terms of the opportunities for using land they make available, which is precisely the basis on which landholders will value the permits.

This perspective is consistent with Lancaster's product attribute theory (Antonelli 2004; Hoehn et al 2003; Lancaster 1966; Lancaster 1971). In this fundamental work Lancaster argued that demand for a product is not for the product as such. Rather the value of a product lies in the attributes of the product and potential those attributes provide to purchasers to meet their needs. In the context of salt emission permits this means that the value landholders derive from permits resides in the additional economic opportunities the permits allow them in terms of land use.

Second, expressing emission permits in terms of contextual characteristics such as water use means that trades can be visualised in terms of familiar farm management measures which facilitates the exchange of emissions between landholders.

Third, a unit of salinity emissions creates different economic opportunities in different locations depending on the farming context. Conversely, a particular combination of different crops and pastures will require a different volume of emission permits in different contexts. Hence, any trade in emission permits between landholders requires determining the relevant changes in the production possibilities for each of the landholders. In other words, an exchange rate must be calculated to determine the rate at which emissions in one context convert to a unit of emissions in another context. This exchange rate is embodied in the salt emissions model and is given by the relationship between agricultural inputs and estimated emissions.

Fourth, expressing emission permits in terms of permissible combinations and levels of inputs into agricultural production processes such as water use monitoring of landholder compliance. In principle, inputs to agricultural production processes are measurable whereas emissions are not.

Fifth, by expressing emission permits in terms of combinations of best management practices and water use, emission permits are defined and documented in a manner consistent with the new regulatory framework planned for governing the use of water. For example, the proposed water use component of an 'unbundled' water right is likely to be defined by variables such as: permitted crops and pastures; best management practices; and maximum limits on water use (Victorian Government Department of Sustainability and Environment 2004).

Note that by describing emission permits as shares in the long run assimilative capacity of rivers and defining those shares in terms of a production process embodied in a salt budget model, the permits are defined, and the market operates largely independently of actual salt emissions in the short term. This does not mean the market in emission permits is unrelated to emissions of salt and the salinity of rivers. As new knowledge is acquired about the relationship between the contextual characteristics of agriculture and emissions then the salt emission model may be refined. As a consequence we would expect that over time estimated and actual emissions will become more closely correlated.

The market in emission permits may also be linked to actual emissions of salt and the salinity of rivers through the market in salt disposal permits.

4.4 Salt disposal cap and salt disposal permits

Salt disposal permits are shares in the actual assimilative capacity of rivers over a specified period of time (see box 4.2). Hence, the 'cap' for salt disposal permits is the actual capacity of rivers to assimilate salt over a specific period. Since the capacity of rivers to absorb salt will vary over time depending on water flow and salt loads from other sources, the cap on salt disposals is a 'variable' cap that changes over time depending on conditions in the rivers.

Provided the 'cap' for salt emission permits matches the long term average of the 'cap' for salt disposal permits, the volume of salt emissions from landholders should match the capacity of the rivers to assimilate salt in the long run (expression 6 in box 4.2). Landowners with salt disposal permits align the short term, uncontrolled emissions of landowners with salt emission permits with short-term variations in the assimilative capacity of rivers.

SEC is the salt emissions cap
SDC_t is the salt disposals cap for period t
D_j is the salinity disposal permit allocated to landholder J
k_j is the percentage of the 'cap' allocated to landholder J
$\hat{c}$ is the maximum salt concentration permitted in the river
c_t is the salt concentration in the river in period t
v_t is the water flow in the river in period t

The 'cap' in a particular period t for salt disposal permits (SDC_t) is given by:

(5) $SDC_t = (\hat{c} - c_t)\, v_t$ for $t = 1, 2, \ldots, n$

Note that as t approaches the long run the average salt disposal cap is:

(6) $1/n \sum SDC_t = 1/n \sum (\hat{c} - c_t)\, v_t$ for $t = 1, 2, \ldots, n$

The right hand side of expression (5) is the same as the expression for the salt emissions cap (SEC) given earlier by expression (1) in box 3.1. In other words, the average salt disposal cap will approximate the salt emissions cap in the long run.

The salt disposal permit allocated to landholder j is given by:

(7) $D_j = k_j \,.\, SDC_t = k_j \sum (\hat{c} - c_t)\, v_t$ and $\sum k_j = 100$ for $j = 1, 2, \ldots, m$

Box 4.2 Algebraic expression for the salt disposal 'cap' and permits

They do this by harvesting and storing salt emissions from the drainage networks then releasing the stored emissions into rivers when they have the capacity to absorb salt.

For this arrangement to succeed a condition of ownership for salt emission permits is that the owners enter a contract for disposal of their emissions with an individual or organisation with a disposal permit. The arrangement also requires that a condition of ownership for salt disposal permits is that the owners have a demonstrated capacity to store saline water and discharge it at will. This condition could be fulfilled by an individual or organisation with drainage diversion rights, a purpose built storage or evaporation basins.

In addition, a procedure for periodically notifying owners of disposal permits of the assimilative capacity of rivers is required. Notifications could be made through broadcast media and the Internet.

The concept of storing salt within the landscape and then disposing of it when suitable capacity to assimilative salt becomes available in the river is able is not new. The Shepparton Irrigation Groundwater Management Plan operates on the premise that salt will be stored within the landscape and discharged when conditions allow. The difference in our proposal is that disposal permits give individuals and organisations flexibility in how they manage salt storage and disposal. Theoretically, this flexibility will allow the equating of the marginal costs of abatement across the scarce assimilative capacity of the river, drainage diversions, purpose built storages and evaporation basins.

4.5 Trading rules for salt emission permits

Trading rules should be simple and enhance the managerial flexibility of permit holders (Stavins 2001). We suggest trading in salt emission permits can occur between market participants at anytime and throughout the region.

A central register would be established that would record details of permits and record those interested in buying or selling permits. This would help coordinate market transactions in a number of ways by reducing compliance costs and reducing search costs for landholders. For example, the establishment of a central register would also facilitate enforcement of the conditions attached to ownership of permits. That is, purchasers of emission permits arrange matching contracts for disposal of their salt.

We described earlier that, for a number of practical reasons, emission permits were expressed in terms of the contextual characteristics of land holdings such as combinations of crop and pasture as well as shares in the emission cap. Consequently, when a trade is negotiated between landholders, the limits on these characteristics must be adjusted correspondingly for both landholders. Presumably, the catchment management authority would calculate these adjustments and amend their records accordingly, especially if the authority is responsible for monitoring and enforcing compliance with conditions attached to emission permits.

In addition, trades in salt emission permits would require matching adjustments in the contracts both landholders have arranged for the disposal of their emissions.

In principle, trading of permits may be initiated in two ways. Typically, trading will be initiated by landholders in response to changes in their circumstances. Our view is that trading of this type should be possible at any time, as this will be consistent with current water trading arrangements. However, trading may also be initiated in response to changes in the parameters and relationships in the salt budgeting model. These changes may arise perhaps as a result of calibration of the model with new information on aggregate salt emissions or the introduction of new agricultural technologies and practices.

A change in the parameters and relationships in the salt budgeting model means the relationships between relevant contextual characteristics such as areas of crop and pastures and estimates of salt emissions will change. This has two implications. One implication is that changes are made to the estimated emissions for each landholder would be revised accordingly given the schedule of agricultural inputs and practices allowed by their emission permit. Landholders whose re-estimated salt emissions were in excess of their share of the salt emissions cap would be allowed a period of grace to reconcile the difference, for example, three-months. They may increase their share of the cap by purchasing or leasing additional emission permits in order to continue their farming operations as specified in the original permit. Alternatively, they may adjust their farming operations appropriately to reduce emissions to their original share of the cap.

The second implication of a change in the relationships between contextual characteristics and emissions of salt as predicted by the salt budgeting model is that the total of the emissions estimates made with the model may differ from the cap for salt emissions based on the assimilative capacity of rivers. The simplest way to consider this implication is to treat the difference as an indirect change in the emission cap. Note that new information on say, climatic data, may lead directly to a revision in the emissions cap itself. This raises issue as to how to adjust salt emission permits in aggregate to match direct, or indirect, changes in the salt emissions cap.

A variable cap and trade program is one approach to resolving this issue (Higson and Kaine 2004). Generally, a variable cap suits situations where the supply of the natural resource is highly variable and market participants can adjust their use of the resource rapidly. This approach involves expressing emission permits as a fixed proportion of a variable target rate of emissions that is revised on a regular basis. The actual volume of emissions authorised under a permit would then be revised each time the salt budgeting model is revised. This concept is similar in principle to the annual revisions made to the total allowable catch in fisheries (Guerin 2003). We believe this method to be impractical in the case of salt emission permits because such revisions would place unrealistic demands on landholders to alter their land use in order to accommodate changes in the cap.

Alternatively, the issue as to how to adjust salt emission permits in aggregate to match direct or indirect changes in the salt emissions cap could be resolved by implementing a fixed cap and trade program as we have proposed, and authorising the catchment management authority to trade emission permits. The Catchment Management Authority purchases emission permits from landholders when the total emissions estimated using the model exceeds the cap and sells emission permits when the cap exceeds estimated emissions. This approach appears feasible provided the real or implied changes in the emission cap are small relative to the total volume of emission permits issued.

Modifications to the salt budgeting model or the salt emissions cap could introduce a significant element of uncertainty into the emission permits market, both for landholders and the catchment management authority. A number of possibilities involving insurance, futures and options may be considered that would allow market participants to manage their exposure to this uncertainty.

Insurance might be most appropriate in situations where the salt budgeting model is updated infrequently and the likelihood of a substantial change in estimates of emission is small. In this instance, landholders would use insurance to protect their income in the event of a dramatic change in their estimated emissions.

Futures and options may be most appropriate in situations where alterations to the model are relatively frequent. Futures allow landholders to limit their financial risk should they have to purchase additional permits following a change in emission estimates.

Options allow landholders the right but not the obligation to purchase or sell emission permits for an agreed price if certain conditions are fulfilled at some point in the future. In principle, options can be designed to automatically activate the purchase or sale of a specific quantity of emission permits depending on the outcome of the modification of the salt model. Options may also apply to leasing of emission permits.

The buyer of the options has the right or choice to exercise the agreement while the seller of an option must fulfil the conditions of the trade should the buyer choose to exercise the option. For example, in buying a call option the purchaser secures the right to purchase a nominated quantity of emission permits should the modification to the model lead to a change in their estimated emissions. The purchase of a call option also enables the purchaser to 'lock in' the price at which emission permits will be purchased. This may be an advantage if the market price of emission permits is volatile.

4.6 Trading rules for salt disposal permits

Trading in salt disposal permits appears to be a much simpler affair than trading in salt emission permits. Disposal permits are defined simply as shares in the measurable assimilative capacity of, say a reach in river, over a period of time. Consequently, the complications attached to using a model to estimate emissions are avoided with disposal permits. We suggest trading in salt disposal permits can occur between market participants at anytime and throughout the region so the capacity to store and discharge drainage water is able to move in line with water trading in the region and to maximise use of the assimilative capacity of rivers

A central register would be established that would record details of disposal permits and record those interested in buying or selling permits. This would help coordinate market transactions in a number of ways by reducing search costs for landholders wishing to trade permits. The establishment of a central register would also facilitate enforcement of the conditions attached to ownership of permits regarding infrastructure for harvesting, storing and releasing salt flows from the regional drainage network.

Trades in salt disposal permits between different reaches in a river would require corresponding adjustments to be made in the salt disposal cap in each reach. In addition, any trade in disposal permits would require that those landholders with contracts for the disposal of their emissions that are covered by the permits be notified of the change in ownership of the permits.

There are some practical issues that would need to be considered when the contracts for disposal of salt emissions from a drainage network are shared between two or more owners of salt disposal permits. The complexity of these issues depends on the degree of spatial separation of the owners of the disposal permits, and the degree of spatial segregation among the landholders with which they have contracts for salt disposal.

The contracts for disposal describe the relative shares in salt emissions to which the owners of disposal permits are entitled. Consequently, owners of disposal permits could share emission flows in the network according to these relativities when the degree of spatial segregation among landholders is low. When owners of disposal permits are located at different points in the drainage network harvesting of salt emissions will require adjustments to allow for any upstream releases for disposal purposes. This means that owners of salt disposal permits would be required to monitor salt concentrations and flow rates in the drainage network at the point of extraction, as well as flow rates at the storage intake and release points.

Variations in the salt disposal cap due to fluctuations in river flow and salt loads from other sources introduce a significant element of uncertainty into the market for disposal permits. There is the possibility of using futures and options as a way to manage exposure to this uncertainty. Since there will be considerable and frequent variations in the capacity of rivers to assimilate salt, futures and options in contracts for disposal rights may be the most a practical way of managing these variations.

5 Monitoring and compliance

5.1 Monitoring

Compliance with the conditions of salt emission permits would be monitored with reference to the mix of inputs into agricultural production processes (such as hectares of perennial or annual pasture) that are used to estimate emissions in the salt budgeting model and are specified in the permit.

Monitoring may entail monthly, quarterly or annual self reporting of inputs and management practices by landholders with random checks conducted under the auspices of the catchment management authority.

Monitoring of compliance with regard to salt disposal permits would require the installation of flow and salinity concentration meters on the outlets from storages.

5.2 Penalties for illegal emissions

Landholders should be liable to pay a penalty for emissions in excess of their entitlement and the penalty for unauthorised emissions must be sufficient to deter landholders from illegally discharging on a systematic basis.

The determination of the penalty to be exacted per unit of emissions needs careful consideration since the penalty will effectively place a ceiling on the prices at which permits are traded. If the penalty is set too low the penalty for discharging illegally will be lower than the cost of purchasing emission permits to discharge legally. Consequently, the demand for permits could fall to zero. Hence, if penalties are not set at sufficiently onerous levels the price of permits could be bid down to the level of the penalty. Since the price of permits cannot rise above the ceiling imposed by the penalty the market for emission permits would fail to function effectively.

Ideally, for the market to function without being unduly influenced by the penalty, the penalty must be set at a rate higher than highest marginal net benefit a landholder will gain from salt emissions. In terms of conventional economic analysis this rate is given by the intersection of the demand curve for emission permits with the price axis (Kaine and Reeve 1993). At a minimum, we suggest that penalties be applied per unit of discharge in excess of the permitted level and those landholders be liable for fines at least equivalent to the unit price at which emission permits trade. Repeat offenders may be penalised by forfeiting their permits.

The likelihood of prosecution for unauthorised emissions must also be sufficiently high to deter landholders from illegally discharging on a systematic basis. This means legislative support must be available so that landholders can be prosecuted for breaching the terms of either their emission or discharge permits. If prosecutions for recovery of penalties and forfeiture of permits do not have a high probability of success then penalties can be effectively evaded. Establishing a market in emission permits is problematic in such circumstances, as the right to discharge is no longer exclusive to those in possession of emission permits.

6 Issues in market establishment

A critical issue in establishing markets, as with any policy intervention, is the way in which property rights and wealth are redistributed within the community. The distribution of gains and losses among landholders by establishing a market in salt emissions is determined by the initial allocation of permits among landholders in conjunction with the standard set for water quality. Having described a market in emission and disposal permits in detail the issues entailed in allocating these permits will now be addressed for the market we have described.

6.1 Distribution of adjustment costs

The setting of a standard for water quality both in terms of an acceptable salt concentration within a river reach and tonnes of salt allowed to discharge into the river are the most important determinants of distribution of adjustment costs between landholders and the rest of the community. As noted earlier, the limited control landholders can exert over emissions of salt effectively prevents them from substantially adjusting their emission rate in the short term without making highly disruptive changes in their land management. In practical terms the more rapidly the total rate of emissions need to be reduced to achieve the desired standard of water quality, the greater the burden of adjustment that will fall on landholders.

A case might be made that other stakeholders should at least partially compensate landholders for the adjustment costs incurred by the latter if a relatively rapid reduction in emissions is desired. Such compensation could be made in a variety of ways such as using public money to purchase and retire land from agricultural production.

The initial allocation of emission permits is probably the most important determinant of the way in which adjustment costs are distributed among landholders themselves. As noted earlier, the limited control landholders can exert over emissions effectively prevents them from substantially adjusting their emission rate in the short term without making highly disruptive changes in their land management. Consequently, the adjustment costs faced by landholders increases the smaller their allocation of emission permits relative to their historical rate of emissions. Hence, a rule that gifts all landholders an equal allocation of emissions, sometimes termed 'averaging', effectively transfers wealth from landholders with relatively high emissions to landholders with relatively low emissions. Landholders with high emissions are forced to cease operations and make disruptive changes in land use or purchase permits from landholders with low emissions in order to continue their activities.

In the context of Goulburn Broken such a rule may disadvantage landholders with high emissions such as dairy farmers relying on flood irrigation of perennial pastures, compared to landholders with low emissions such as orchardists with micro-irrigation. This may not be socially acceptable to the rural community. Hence, allocation of permits on the basis of historical emissions may be the most widely acceptable rule and the least likely to require compensation for those landholders most affected.

There maybe some concern with this approach in relation to the adoption best management practices. Gifting on the basis of historical emissions could be seen as disadvantaging those who have adopted best management practices before emissions are capped. This would depend on the extent that models used to describe emissions incorporate best management practices and the differences in abatement costs between landholders.

Allocation of permits on the basis of historical emissions does, however, raise the issue as to how the initial allocation of permits should be adjusted over time to be consistent with changes in the emissions cap. One approach is to institute proportionate reductions in the volume of emissions that permits allow until the aggregate volume of permits matches the cap. These reductions may be phased in over a period of time. This approach places the burden of the cost of adjusting to the cap on landholders. This approach distributes the costs of adjustment unequally among landholders. Those landholders that are least able to adjust their emissions will bear a relatively greater proportion of the costs compared to landholders that are better able to adjust their emissions.

An alternative approach is for the catchment management authority to institute a program of purchasing emission permits from landholders until the volume of emission permits remaining in the ownership of landholders matches the emission cap. The program may operate over a considerable period. This approach places the burden of the cost of adjusting to the cap on the rest of the community, assuming the government provides the funding for the purchasing program. This approach is consistent with the view that, as the cap on emissions is instituted at the expense of landholders for the benefit of the community, the community should meet the costs of adjustment.

We suggest a share of the salt disposal cap be allocated to landholders that have invested in evaporation basins and, thereby, already possess an implicit right to dispose of salt. Subsequently, tenders could then be invited for the purchase of the remaining share of the salt disposal cap. Landholders submitting tenders would need to demonstrate a capacity to develop the infrastructure for harvesting and storing saline flows from the regional drainage network.

6.2 Price discovery for emission permits

Ideally, a high volume of trading on the emissions and disposal market in the short term would promote price discovery, which would facilitate decisions by all parties regarding the return to investing in abatement measures. In principle, the prices at which permits are exchanged are a function of the differences in the marginal abatement costs faced by landholders and differences among landholders in the economic return to emissions. Provided there is some variation in economic returns to emissions to landholders, and some variety among them in the cost of implementing abatement measures, then trading should occur.

The greater the degree of variability among landholders in economic returns to emissions and the greater the extent to which those returns change over time, the more likely a high volume of trading will occur in the short term. For example, the price of agricultural products such as fruit, grapes, milk, lamb, beef and wheat are key determinants of the profitability of agricultural operations. Consequently, these prices are also key determinants of the economic value of emission permits. To the degree that these prices vary over time, both in absolute and relative terms, the economic value of an emission permit will differ across agricultural enterprises. In theory this means the price that landholders are willing to pay in order to lease or purchase an additional permit will change over time in accord with changes in the economic returns to different land uses. Those landholders experiencing an increase in returns may seek to acquire additional permits to take advantage of the increase. Those landholders experiencing a decrease in returns may choose to lower production and sell or lease permits to offset their loss.

Similar arguments can be advanced to suggest the greater the degree of variability among landholders in terms of abatement costs the greater the opportunities for the exchange of permits among landholders. Much will depend on the flexibility with which landholders are able to modify their emissions by changing cultural practices or differences in cost of implementing abatement options of different industries.

Relatedly, changes in the relationships between contextual characteristics and estimated emissions as embodied in the salt budgeting model will prompt the exchange of permits. As discussed earlier, modifications to the salt budgeting model are likely to result in changes to estimates of landholders' emissions given the combination of agricultural inputs they are allowed by their permits. Differences among landholders in the opportunity costs of taking measures to adjust emissions relative to the prices of emission permits and contracts for salt disposal, are likely to encourage some landholders to dispose of a portion of their permits and to encourage other landholders to acquire permits. The greater the sensitivity of estimates of emissions to changes in the salt budgeting model the greater the volume of trading in permits.

The functioning of the price mechanism for emission permits in the short term may also be influenced by the manner in which emission permits are allocated among landholders. In circumstances where landholders are allocated permits using a rule that results in their initial allocation of permits differing from estimates of their historical emissions, a high volume of trading may be expected in the short term. While this encourages price discovery there are, as described earlier, significant equity implications arising from the wealth transfers entailed in such rules.

The price of emission permits will also be influenced by the availability of capacity for disposing of salt. If the volume of disposal permits is substantially lower than the volume of emission permits in a particular sub-catchment then contracts for disposal of emissions will be relatively expensive. This would mean that emission permits would trade at a discount relative to other sub-catchments. Alternatively, if the volume of disposal permits is substantially higher than the volume of emission permits in a particular sub-catchment then contracts for disposal of emissions will be relatively inexpensive. This would mean that emission permits would trade at a premium relative to other sub-catchments.

Finally, price discovery will be influenced by the rules governing eligibility to enter the market and trade in emission permits. The more restricted the number of participants that may trade in the market the greater the degree of distortion in prices for emission permits. Ideally, market participation should be unrestricted if the market is to be contestable (Langridge and Sealey 2000; Baumol 1982; Paech 1998). This would mean individuals may purchase emission permits without being landholders but individuals who are landholders and are undertaking activities that discharge salt must possess emission permits. Some stakeholders may not be comfortable with tradable emission permits unless the right to possess emission permits is restricted. See (Schillizzi 2006) for a further discussion of the equity issues associated with market mechanisms.

6.3 Price discovery for disposal permits

In principle, the prices at which disposal permits are exchanged will be a function of the availability of assimilative capacity in rivers and the capacity to store salt to the overall demand for disposal created by landholders with emission permits. And the demand for emission permits depends in turn, on the marginal abatement costs faced by landholders and differences among landholders in the economic return to emissions.

A key issue in the establishment of the market for disposal permits is the process by which landholders owning emission permits enter into contracts for salt disposal when few landholders will possess the infrastructure needed to satisfy the conditions for owning a disposal permit. A period of time is required to allow investment in infrastructure to occur.

We suggest allowing landholders, initially, to own emission permits without a contract for disposal provided they pay a levy proportional to the volume of emissions their permit allows. The rate of the levy could be increased over time thereby rendering salt emissions increasingly expensive. Landholders with emission permits who have entered a contract for disposal are exempt from the levy. Landholders will increasingly seek to enter disposal contracts as the rate of the levy increases. Hence, the imposition of the levy creates a 'demand' for disposal contracts which, in turn, creates an incentive for entrepreneurial landholders to invest in disposal infrastructure and acquire a disposal permit.

Variation in economic returns to emissions to landholders, and variety among landholders in the cost of implementing abatement measures will generate differences across sub-catchments in the premiums landholders with emission permits will pay for the disposal of salt. Variations across sub-catchments in the costs of disposal infrastructure and suitability for evaporation basins, together with variations among reaches in the assimilative capacity of rivers, will generate differences across sub-catchments in the premiums landholders with disposal permits will accept for disposing of salt.

The greater the degree of variability among reaches in the availability of assimilative capacity through time the greater will be the opportunity for landholders with disposal permits to lease their permits and engage in futures and options trading in disposal permits.

As the price of disposal permits depends partly on the demand for disposal contracts from landholders that own emission permits, the factors that influence price discovery in the market for emission permits will also indirectly influence price discovery in the market for disposal permits. These factors include:

- the price of agricultural products;
- the costs landholders incur when modifying their emissions by changing agricultural practices;
- changes in the relationships between contextual characteristics and estimated emissions as embodied in the salt budgeting model;
- the allocation rule used to distribute emission permits to landholders;
- rules governing eligibility to enter the market and trade in disposal permits

Finally, as with emission permits, price discovery for disposal permits will be influenced by the rules governing eligibility to enter the market and trade in emission permits. The more restricted the number of participants that may trade in the market the greater the degree of distortion in prices for emission permits.

6.4 Gifting of emission permits and windfall gains

The nature of the emission permits that have been proposed in this report is such that whatever procedures are followed in allocating permits, there will be an element of 'gifting' in the allocation procedure. Landholders that are allocated permits will, in effect, be freely granted the right to discharge salt within the limits of the assimilative capacity of rivers in the region. We believe that 'gifting' may be defended as compensation for the curtailing landholders' previously unlimited emission rights in exchange for the enforcing the rights of others in water quality. We also believe that it may be impractical as well as impolitic to compel landholders to purchase permits in this context.

Given then, that the allocation of permits would necessarily involve an element of 'gifting', at least some transactions in permits will involve an element of 'windfall' gains. In most cases, however, this windfall will represent only a fraction of the price at which permits are exchanged. For example, when a landholder sells permits, the sale must be associated with a measurable reduction in emissions in order to proceed. Hence, for the landholder to realise a profit on the transaction, the revenue obtained from the sale of permits must exceed the cost of the measures they undertake to lower their emissions. While such profits may be regarded as a windfall they also reflect the fact that relatively low cost measures are being employed to reduce emissions.

The size of such windfall profits will be limited by the operation of the market mechanism. Through trading, the price of permits is equated with unit abatement costs thereby eliminating supernormal profits. If abatement is inexpensive then the demand for permits will be relatively low since emissions can be reduced at low cost. At the same time, the potential supply of permits for sale will be relatively high since landholders can reduce emissions at relatively low cost thereby releasing surplus permits for sale. Thus, if there is ample scope for lowering emissions by implementing abatement measures that are relatively inexpensive, then the price at which permits will be exchanged in the market will be correspondingly low. Hence, the opportunities for landholders to secure windfall gains will be limited.

7 Discussion

The introduction of a market in salt disposal permits of the type of we have described creates economic incentives for landholders to invest in abatement measures off-farm such as evaporation basins. The more restrictive the cap on salt disposal compared to salt emissions the higher the return to owning a disposal permit and investing in disposal infrastructure such as storages and evaporation basins. Hence, the creation of markets in emission and disposal permits creates incentives for investment in structures such as evaporation basins.

The introduction of a market in salt emission permits of the type of we have described also creates economic incentives for landholders to invest in abatement measures on-farm. The more restrictive the cap on emissions compared to historical emissions the higher the price of an emission permit. The higher the price of emission permits the greater the return to investing in abatement measures and selling permits. Also, the higher the price of emission permits, the greater the return to offsetting any increase in emissions associated with increasing agricultural production by investing in abatement measures rather than purchasing permits.

Given the costs of abatement vary across landholders, landholders facing relatively low abatement costs will tend to undertake abatement works and sell surplus emission permits. Landholders facing relatively high abatement costs will tend to purchase emission permits to maintain production and emissions.

The creation of markets in both emission and disposal permits allows the timing of salt emissions to be aligned with the seasonal flows in major rivers. The market in emission permits provides control over aggregate emissions in the long term but, of itself, does not influence the timing of emissions. This is achieved by linking the market in emission permits to a market in disposal permits. The market in disposal permits provides an economic incentive for investment in infrastructure for harvesting and storing salt emissions either by evaporation basin or purpose built storages, with the potential to release emissions from purpose built storages in line with seasonal variations in the capacity of rivers to assimilate salt.

Importantly, cap and trade markets also offer greater surety than other policy instruments that permanent reductions in salt emissions into rivers are achieved, that the lowest cost mix of investment in abatement is obtained, and that the limited emissions that are deployed to their highest value use.

There are four further issues we will consider in this discussion concerning the compatibility of the market in emission and disposal permits with the current policy framework. The first concerns the markets and the existing allocation of drainage diversion licences under the Shepparton Irrigation Region Surface Water Management Plan. Drainage diversion licences allow landholders to harvest water from regional drainage network under certain conditions. Landholders pump the harvested water in storages for subsequent use in irrigations. In principle, the markets in salt emission and disposal permits can operate independently of drainage diversion licences. Although the diverters are harvesting salt emissions, they are simply modifying the distribution of emissions at the end of the drainage network in the short term. Theoretically, the average volume of salt emissions in the long term is unaffected by their activities.

The presence of landowners with drainage diversion licences does raise the interesting possibility that owners of disposal licences may pay diverters to intercept and store emissions on their behalf (provided the diverter can control releases back into the drainage network).

The presence of landowners with drainage diversion licences may add a practical complication to the exercise of disposal permits in situations where the owner of the licence is located downstream of the owner of a disposal permit. A mechanism may be required to ensure the downstream diverter does not inadvertently extract disposal releases.

The second issue is the compatibility of a market in emission and disposal permits with the Shepparton Irrigation Region Groundwater Management Plan and Surface Water Management Plan. Under these Plans, guidelines exist around the use and disposal of groundwater from private and public pumps such as conjunctive use of groundwater when salinity is less than 3000 EC. Under a cap and trade market, the regulated use and disposal of groundwater may not be required. Landholders are afforded the flexibility to manage groundwater to meet their individual contexts as long as they have the appropriate permits to cover their activities. This flexibility provides surety in achieving the water quality targets by establishing a cap on total emissions based on the assimilative capacity of rivers and distributing a share in the cap via emission permits to landholders. The addition of disposal permits enables the short-term assimilative capacity of rivers to be achieved, that is the concentration target or river reaches. Given the differences between the current approach and that of a market, any inconsistencies could be addressed by reviewing guidelines and use agreements before implementation of the market.

Third, there is the issue of the compatibility of a market in emission and disposal permits with the Salt Disposal Entitlements issued under the inter-government agreement on the Murray Darling Basin (Murray-Darling Basin Commission 2003). Ownership of these entitlements is vested in the relevant state governments. As such they cannot be traded among individuals, though the right to exercise the discharges these entitlements allow could be tradable.

The complications ownership of salt disposal entitlements introduces can be avoided by restricting the emission and disposal permits we have designed to rivers other than the Murray. We have assumed that the assimilative capacity of these rivers is defined at the point at which they enter the Murray and that the salt concentration target for these rivers is consistent with the salt targets for the Murray.

The fourth issue we consider is the possible consistency between the markets we have proposed and the provisions covering the proposed water use licences. Water use licences are being developed as part of the ‘unbundling’ of water rights foreshadowed by the Victorian government (Victorian Government Department of Sustainability and Environment 2004). The purpose of water use licences is to provide a policy mechanism specifically for regulating the environmental effects of the use of water including the effects of the use of water on water quality (Victorian Government Department of Sustainability and Environment 2004). In this regard, the intent of the markets we have designed is entirely consistent with the purpose of water use licences. In addition, the national policy for managing water resources specifically endorses the concept of market mechanisms as a means for regulating water use (Productivity Commission 2005). Consequently, we believe the market designs we have presented in this paper are, in principle, consistent with the concept of a water use licence and provide one means of giving expression to such licences with respect to regulating salt emissions.

Finally it is also worth considering if a market in tradable emissions to increase investment in abatement measures including evaporation basins is worthwhile. Since beginning the research, the impact of drought, water trading and improved efficiency of water use on salt emissions has become clearer. Research indicates that salt emissions have decreased and the storage capacity of regional aquifers has increased. Consequently, evaporation basins for managing salt may have limited relevance in the current context.

8 Conclusion

Our research into the feasibility of a cap and trade market in transferable emission and disposal permits resulted from an interest by the Goulburn Broken Catchment Management Authority to investigate ways to increase investment in evaporation basins. At the time, the Authority was concerned the potential scarcity of Salt Disposal Entitlements may inhibit implementation of further works endorsed by Shepparton Irrigation Region Catchment Strategy. Consequently, promoting investment in evaporation basins was a potentially important in the management of salt in the Region.

Cap and trade markets have attracted considerable interest given their theoretical benefits, which include incentives to encourage investment in abatement works and incentives for investment in infrastructure to align the timing of salt emissions with the seasonal flows in major rivers. Importantly, cap and trade markets also offer greater surety that permanent reductions in salt emissions into rivers are achieved, that the lowest cost mix of investment in abatement is obtained, and that the limited emissions that are permitted go to their highest value use.

In this paper we have explored the rationale for considering a cap and trade market in the face of alternate market-based instruments. We have also described hypothetical 'cap and trade' markets in transferable salt emission and salt disposal permits for irrigated agriculture for the Goulburn Broken region of Victoria. In designing our markets we drew on our knowledge of the market in salt discharges operating in the Hunter Valley of New South Wales and the market in nitrogen emissions proposed for Lake Taupo, New Zealand. Our aim in designing these markets was to provide a concrete example of how 'cap and trade' markets in salt emissions could foster investment in abatement works including evaporation basins.

Our research indicates that a market in transferable emission and disposal permits is technically feasible. The market was designed to align as much as possible with the current policies. However, given the number of policy strategies, guidelines and instruments that govern natural resource management in the Region, we suspect there will be instances where the market is inconsistent with current policy. Consequently, should policy makers in the future seriously consider a market of the kind we have described, a review of current policy would be required to ensure successful implementation.

9 References

Antonelli, C., 2004. 'Localized production innovation: the role of proximity in the Lancastrian product space. ' Information Economics and Policy, 16(2): 255-74.

Baumol, W. J., 1982. 'An uprising in the theory of industry structure. ' American Economic Review, 72: 1-15.

Duncan, R., Bethune, M., Christen, E., and Hornbuckle, J., 2005. 'Review of salt mobilisation and Management in irrigated areas of the Murray-Darling Basin.' Technical Report 05/01, Cooperative Research Centre for Catchment Hydrology.

Environment Waikato, 2003. 'Protecting Lake Taupo: A Long Term Strategic Partnership', Environment Waikato, Hamilton, New Zealand.

GBCMA, 2003. 'Shepparton Irrigation Region Catchment Strategy, draft update 2003'. Goulburn Broken Catchment Management Authority.

GBSPAC, 1995. 'Shepparton Irrigation Region Surface Drainage Strategy'. June 1995. Goulburn Broken Salinity Program Advisory Council.

GBSPPAC, 1989. 'Shepparton Irrigation Region Land and Water Salinity Management Plan.' Draft report August 1989. Goulburn Broken Salinity Pilot Program Advisory Council.

Guerin, K., 2003. 'Property rights and environmental policy: A New Zealand perspective.' New Zealand Treasury Working Paper: 03/02, New Zealand Treasury, Wellington, New Zealand.

Higson, M and Kaine, G., 2004. 'Tradeable Permit Systems for Natural Resource and Environmental Management.' Social Research Working Paper 03/04, Agresearch, Hamilton, New Zealand.

Hoehn, J. P., Frank L., and Kaplowitz, M.D., 2003. 'Untying a Lancastrian bundle: valuing ecosystems and ecosystem services for wetland mitigation.' Journal of Environmental Management, 68(3): 263-72.

Hydro Environmental 2005. 'Irrigation Drainage Memorandum of Understanding rapid management decision support system, first draft'. August.

Irrigation Committee, 1997. 'Shepparton Irrigation Region Land and Water Salinity Management Plan'. Brochure produced on behalf of the Goulburn Broken Catchment Management Authority and North Central Catchment Management Authority, September.

Kaine, G and Higson, M., 2004. 'A Tradable Permit Program for Nitrogen Emissions to Lake Taupo.' Social Research Working Paper 08/04, Agresearch, Hamilton, New Zealand.

Kaine, G. and Johnson, F., 2004. 'Applying Marketing Principles to Policy Design and Implementation.' Social Research Working Paper 02/04, Agresearch, Hamilton, New Zealand.

Kaine, G. and Reeve, I., 1993. 'A Proposal for a Market in Phosphorus Discharge Permits.' Report to the NSW Department of Water Resources, The Rural Development Centre.

Lancaster, K., 1966. 'New approach to consumer theory.' Journal of Political Economy, 74(2): 132-57.

Lancaster, K., 1971. 'Consumer Demand: A New Approach.' Columbia University Press, New York.

Langridge, R. and Sealey, R., 2000. 'Contestability in the UK bus industry? The National Bus Company and the 'Tilling Mark II' effect.' Transport Policy, 7: 105-15.

Montgomery, W.E., 1972. 'Markets in Licenses and Efficient Pollution Control Programs.' Journal of Economic Theory, 5: 395-418

Murray-Darling Basin Commission, 2003. 'Basin Salinity Management Strategy (BSMS) Operational Protocols.' Murray-Darling Basin Commission, Canberra.

Paech, N. P., 1998. 'Contestability reconsidered: the meaning of market exit costs.' Journal of Economic Behaviour and Organisation, 34: 103-17.

Petris, S., 2005. 'Think Piece: New Ways of Developing Policy and Strategy in DPI.' Strategic Policy Unit, Department Primary Industries, Melbourne.

Productivity Commission, 2005. 'Rural Water Use and the Environment: The Role of Market Mechanisms.' Productivity Commission Issues Paper, Australian Government, Canberra.

Robertson, D, Wang, QJ, McAllister, A, Abuzzar, M, and Haines, C., 2004. 'INTECA: Bayesian Networks for Water Resources and Catchment Management Decision Analysis.' Milestone Report, Victorian Government Department of Primary Industries, Tatura.

Sampson, K., 2005. ' Victoria Salt Disposal Working Group'. Agenda paper to the Shepparton Irrigation Region Implementation Committee. March 2005.

Schillizzi, S., 2003. 'Should Equity Concerns Impose Limits on the Use of Market Based Instruments?' 6th AARES Annual National Symposium on Market Based Tools for Environmental Management. Canberra, September.

Sinclair Knight Merz, 2002. 'Sub-surface drainage program review 1999/2000'. Report for Goulburn Broken Catchment Management Authority and North Central Catchment Management Authority.

Sinclair Knight Merz, 2003. 'Bar Creek Catchment Data Review'. Draft Report for Victorian Government, Sinclair Knight Merz, Armadale, Victoria, Australia.

Sinclair Knight Merz, 2003. 'Statistical Analysis of Barr Creek flow and salt load.' Draft Report for Victorian Government, Sinclair Knight Merz, Armadale, Victoria, Australia.

Stavins, R., 2001. 'Experience with market-based environmental policy instruments', Discussion Paper 00-99, Resources for the future, Washington.

Victorian Government Department of Sustainability and Environment, 2004. Securing Our Waters Future Together.

Whitfield D.M., Finger L., Cairns R., and Wang Q.J., 2004. 'Relationships between incentives and goals of the Loddon-Murray Land and Water Management Strategy', Final Report - Project No. 14076, Victorian Government Department of Primary Industries, Tatura.