Tradeable recharge credits in Coleambally Irrigation Area: Report 1

What are the issues?

October 2003

CSIRO & BDA Group

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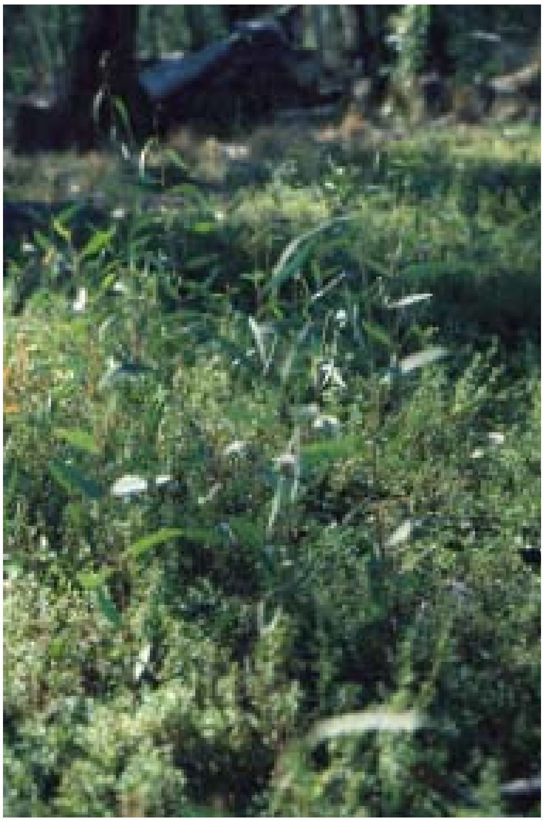

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This paper is the first in a series from a two-year research program. The focus in this paper is on laboratory tests of alternative institutional frameworks using experimental economics techniques. Papers in this series are:

- *What are the issues?*
- *Economic impact of tradeable recharge credits and other net recharge abatement policies for the Coleambally Irrigation Area*
- *Designing experiments to test tradeable recharge credits in the Coleambally Irrigation Area*
- *Laboratory tests of alternative institutional frameworks*
- *Field trial and farm case studies*
- *Biophysical modelling for linking farms with regional net recharge targets*
- *Experiences, lessons and findings*

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Executive Summary

Irrigated agriculture in Australia often leads to net recharge of shared groundwater systems beyond their capacity to convey water, causing local and regional salinity and water logging. In turn, salinity and water logging impose a range of costs on individual landowners, their neighbours and the wider community – primarily reduced agricultural productivity, damage to ecosystems and degradation of built infrastructure both locally and off-site. Some of these costs are not fully included in farm management decisions because they are external to landowners.

CSIRO in conjunction with Drew Collins of BDA Group and Coleambally Irrigation Cooperative has been funded to develop a pilot market-based instrument to manage irrigation induced salinity by the National Market Based Instruments Pilots Program under the National Action Plan for Salinity and Water Quality. The project builds on previous work by Shahbaz Khan and colleagues at CSIRO Land and Water in Griffith to develop methods to physically measure recharge from irrigation systems and the resultant biophysical and economic impacts.

This pilot is based on developing (cost-effective) incentives for individual irrigators that reflect their impact on a shared groundwater aquifer. The shared resource means that one individual's actions may affect other irrigators and the wider community. Any proposed solution must therefore be based on sound biophysical information, and development of individual incentives that reflect these biophysical relationships.

Behavioural responses to incentives are also dependent on the nature of the motivation. Prescription or standard based regulations allow no flexibility for individual responses. Persuasion relies on sufficient motivation through peer pressure and information about the impacts on others. Pricing and tradable property rights systems allow maximum flexibility whereby the lowest cost, individual management solutions may be sought across the shared aquifer.

Information is required about individual irrigator's impacts on shared groundwater aquifers and the consequences of these actions. In the Coleambally region there are more than 800 shallow and deep piezometers that have been used to model regional groundwater movement. Information from these wells and regional groundwater models has been used to build and calibrate the SWAGMAN® series of models by Shahbaz Khan and colleagues at CSIRO in Griffith. Their research has resulted in the development of the concept of "net recharge" as an important management tool in the region and beyond. Elements of the SWAGMAN® series are able to estimate biophysical relationships at the paddock, farm, sub-region and regional scale for different variables including soils, crops, irrigation technologies and climatic outcomes.

Communities are looking for ways to reduce salinity impacts associated with farming systems. In some situations market-based instruments can deliver environmental improvements faster and at lower cost. In this context, this report sets the scene by identifying issues important in developing a cap and trade model for net recharge management including:

- Developing property rights and markets for the management of problems which are difficult to measure because of their dispersed sources. In particular, we hope to learn more about the integration of advanced biophysical models (such as SWAGMAN®) with market mechanisms;
- Who should hold property rights –irrigators only or also water supply authorities and community organisations?
- How to allocate and monitor property rights for externalities – in this case net recharge from irrigated agriculture;
- How to include flexibility in adoption and management of net recharge – for example through banking and borrowing?
- What would a recharge market look like?
- Should activities to 'offset' net recharge be allowed?

For irrigators and the community, the development and implementation of an integrated market-based solution to the issue of net recharge presents substantial challenges and changes to their approach to recharge management. To adopt a new instrument, the community must be comfortable in engaging with and using the mechanism. The community will need to carefully consider the options available and will need support and information from biophysical and social scientists. This report begins the process of informing the community about the advantages and disadvantages of a cap and trade approach to managing net recharge in the Coleambally Irrigation Area (CIA). The lessons learnt in this project will be valuable in the development of other integrated biophysical models and market based instruments, especially those targeting nutrient and salinity management.

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Abbreviations

CIA	Coleambally Irrigation Area
CICL	Coleambally Irrigation Cooperative Ltd
CSIRO	Commonwealth Scientific and Industrial Research Organisation
LWMP	Land and Water Management Plan
MBI	Market Based Instrument
SWAGMAN	Salt Water And Groundwater Management

1. Introduction

Salinity and waterlogging is a serious threat to mature irrigation areas across Australia. It is caused by the rainfall and irrigation greater than crop water usage and system absorption capability. The consequences include production losses, increased production cost, and damage to environmental and infrastructure assets. The Coleambally Irrigation Area (CIA) is located in south western New South Wales and is fed by diversions from the Murrumbidgee River. Like other irrigation areas in Australia, Coleambally is increasingly suffering from the impacts of waterlogging and salinity. Watertables have risen from approximately 20m below the surface prior to irrigation with significant areas now less than 2m from the surface.

Strategies to address the threat that irrigation induced salinity and waterlogging poses to Coleambally and other communities historically included:

- Regulatory restrictions to crop areas or water use;
- Voluntary action facilitated by distribution of tools to measure the threat to salinity and waterlogging for individual farms; and
- Direct incentives to reduce recharge, through programs such as the Coleambally Irrigation Cooperative Ltd (CICL) Land and Water Management Plan (LWMP) programs.

Each of these strategies have contributed to achieving a reduction in the incidence of irrigation-induced salinity, however none have achieved Coleambally community management targets.

Regulatory approaches have focussed on control of a particular input to the problem but have not considered all of the factors threatening the landscape. As such, they limit landholder flexibility in directly and actively managing the threat. Further, regulations do not observe the complex interrelationships between these factors. An example of regulatory control for the CIA is the ‘Rice Policy’ which restricts individual landholders to a predetermined maximum area of rice regardless of the size of the property.

Voluntary actions informed by the application of recharge measurement tools, which measure the threat of salinity and waterlogging, are unlikely to be effective, because there are few real incentives to apply the knowledge acquired from their use. Salinity and waterlogging may manifest off-farm or alternatively the time lag before damage occurs is such that it provides no incentive for landholders to change their practices.

Direct incentives to reduce recharge have not been sufficiently tied to outcomes or have not been large enough to ensure adequate management change to meet targets.

The underlying reason for unsatisfactory progress in threat mitigation is that the costs of irrigation induced salinity and waterlogging are not always borne by those who contribute through their actions. Equally those who make efforts to reduce the impacts of their activities are often not directly rewarded for their achievements. This suggests that assigning ownership, with subsequent responsibilities and rewards tied to ownership, might address this fundamental flaw.

The unsatisfactory progress in meeting community recharge targets, in conjunction with community pressure to tailor suitable management options to individual holdings, represented an opportunity to develop a new market-based instrument to sustain agriculture in Coleambally.

The creation of a market to encourage sustainable management practices with more flexible regulatory controls may provide a cheaper solution and give latitude to the design of new management options, promoting innovation and efficiency.

Much recent work to sustain environmental and agricultural outcomes has tested assigning property rights to environmental resources. The fundaments to establish such rights to manage the threat of salinity and waterlogging are possible due to recent technological advances in groundwater monitoring and modelling. Rule development for the management of soil and water, the capability to assign new resource ownership categories, together with the design of mechanisms to facilitate trading between landholders, has led to the development of a pilot program to examine new market-based approaches in the CIA. CICL in collaboration with CSIRO and the BDA Group, are exploring the application of tradeable recharge credits in the CIA. This project has been funded under the National Market Based Instruments Pilots Program.[1]

The report is set out as follows. Section 2 details some background information about the causes of salinity and waterlogging in the CIA and the alternative policy approaches available to the community. Section 3 canvasses key design issues crucial to building a market-based recharge management tool. Section 4 concludes the paper with an outline of the next steps in considering future recharge management in the CIA. Sources for further information are provided at the end of the paper for interested readers.

2. Background and context

2.1 Biophysical issue

Irrigated agriculture often leads to net recharge greater than regional groundwater systems can absorb. Net recharge occurs because the aggregate water supplied exceeds the evapotranspiration of crops, leaching requirements of soils, and water movement within underlying groundwater systems.[2] The net recharge concept is illustrated in Figure 1.

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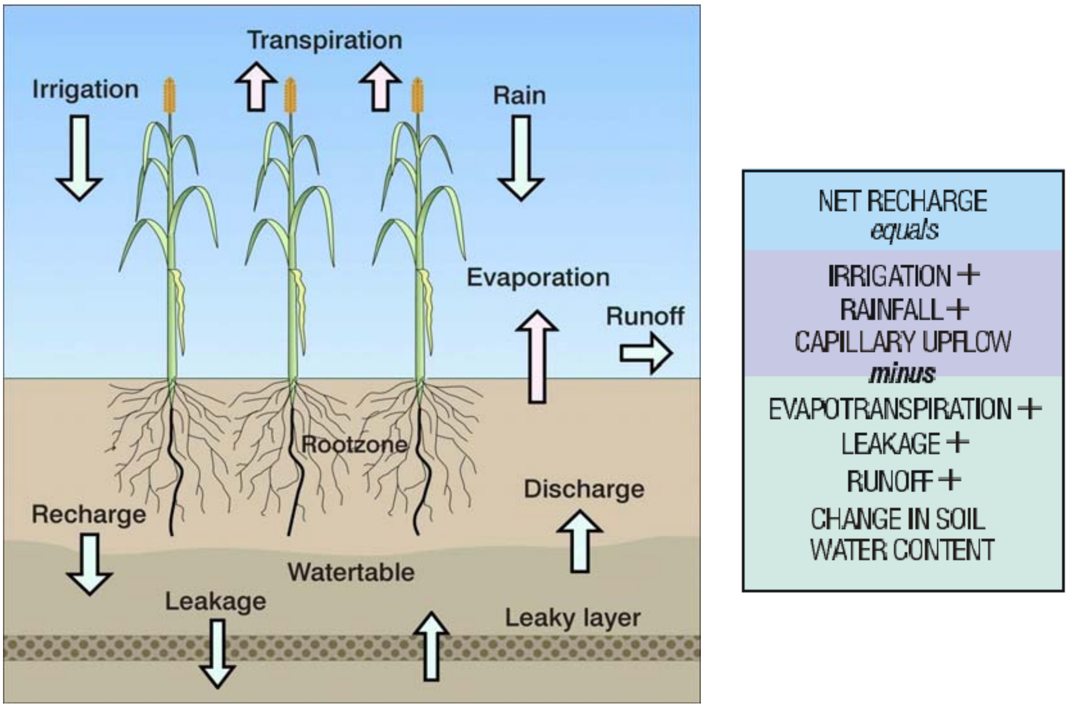
[1] The National Market-Based Instruments Pilots Program (NMBIPP) has funded the development and testing of a tradeable recharge credit scheme in the CIA. Significant in-kind contributions are also coming from CSIRO through the Markets for Ecosystem Services Project and from CICL through its extension, management and research programs.

[2] See for example the article by Shahbaz Khan and Tanya Ginns "Sustainable Irrigation Tools" in the Large Area Edition of the Farmers Newsletter (2003) No. 164, on pages 30 and 31 or CSIRO's

The impacts of net recharge include: waterlogging; soil salinity; and saline groundwater interception by natural water courses, irrigation channels and drains. In turn these impacts cause reduced agricultural production, damage to remnant vegetation, wetlands and aquatic life and damage to local and down-stream infrastructure. Many of these costs occur off-farm, away from the recharge site thereby imposing a range of costs not only for individual landowners, but also their neighbours and the wider community. These costs are external to the farm and are not normally included in farm-based irrigation management decisions.[3]

Figure 1: The net recharge concept



Source: More on net recharge can be found in CSIRO's Research Project Sheet No. 11: Irrigation: Getting the balance right by Shahbaz Khan.

At the farm scale there are a number of options available to reduce net recharge. These include changing crop mixes and rotations. For example, planting wheat following rice reduces net recharge as does the use of Lucerne in farm crop mixes. Engineering works (such as drainage works) and strategic tree planting can also be directed towards reducing farm scale net recharge.

To accurately manage net recharge, information about crops, soils and groundwater interactions under alternate land management strategies is needed. Much of the primary data for the CIA about soil type, climatic parameters, and crop-soil-water interactions has already been collected. Within the CIA and surrounds there are more than 800 shallow and deep piezometers, strategically placed over 79,000 hectares, that

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Research Project Sheet No. 11: Irrigation: Getting the balance right by Shahbaz Khan that can be downloaded from: http://www.clw.csiro.au/staff/khans/index.html.

[3] Costs may also not be fully in landholder's decisions because landholders are not fully informed about the future regional impacts of their actions.

can be used to accurately determine salinity and waterlogging impacts of recharge by measuring lateral groundwater flow and vertical leakage between aquifers.

The CSIRO has developed an integrated series of multi-layer groundwater flow and salt transport models called 'SWAGMAN'® for the irrigation area and the region. The models can be used to estimate the impact of irrigation on salt and water movement in the landscape for various soil, crop, irrigation, watertable, and climatic combinations within the CIA. These tools provide very accurate estimates of regional groundwater recharge on a farm, sub-regional, and regional basis and can also be used to estimate a range of off-farm impacts.[4]

2.2 Net recharge management objectives

NSW catchment management frameworks such as the Blueprints for Catchment Sustainability provide a regional context for recharge targets. Within the broad blueprint framework, the Coleambally community has targets for managing the local and regional impacts of net recharge in the CIA, reflecting the community's sustainability goals. The overall goal of this pilot market-based instrument project is to reduce the costs of managing the threat of irrigation induced salinity and waterlogging to CIA landowners, via improved management instruments and differential farm scale targets.

Specific targets representing sustainable volumes of net recharge in the CIA can now be considered due to the progress in building the SWAGMAN® series of models in conjunction with regional groundwater models, and models of regional flow capacity of aquifers in the CIA. Together these models enable the estimation of implications of alternate irrigation management strategies. This means that the point of source of recharge may be accurately identified, despite diffuse and widespread impacts. This is in direct contrast to the diffuse source approaches necessarily applied due to a lack of source information. Therefore, Coleambally community goals for managing local and regional impacts can now be directly linked to target aggregate net recharge volumes that are necessary to maintain depth to watertable and thus manage waterlogging and salinity. In turn, these aggregate net recharge targets can be linked to individual irrigation management decisions at the farm scale.

2.3 Current and potential policy approaches to net recharge management

Three broad policy approaches are normally suggested when seeking to achieve environmental outcomes:

- Facilitative or voluntary: Information provision is improved without direct incentives to change landholder management. For example, extension programs providing information about how to manage land to improve biodiversity conservation.

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4 Shahbaz Khan and others at CSIRO Land and Water in Griffith have developed the SWAGMAN® series of models. More information about these models can be found at: http://www.clw.csiro.au/publications/projects/projects22.pdf.

- Incentive: Payments to land managers are structured to substitute for market signals. For example, riparian buffer strip fencing grants (through either provision of materials or monetary payments).
- Coercive or regulatory: Non-voluntary measures designed to compel change in landholder management. Regulations designed to protect native vegetation are an example of coercive policies.

Practical policy applications usually involve a mix of these measures. For example, facilitative measures are often instrumental in the success of primarily incentive-based policies. Historically, recharge management in the CIA has been addressed using a combination of regulation (for example the Rice Environmental Policy and Water Licence Conditions)[5], incentives (for example, the CIA Land and Water Management Plan), and facilitative measures (such as voluntary management change informed by application of net soil survey results and SWAGMAN® modelling of whole farm planning).

A relatively new approach to environmental and agricultural management that has recently achieved a high level of exposure, is the use of market-based instruments (MBIs). MBIs are policy tools that encourage certain behaviours through market signals, rather than through explicit directives such as regulation. While MBIs are commonly included within the "incentive" category of interventions, they consist of a carefully designed mix of instruments.

There are three broad groupings of MBI instruments:

- Price based instruments act to modify prices to reflect environmental damage or generate an incentive for beneficial actions. Examples include auctions for biodiversity and subsidies for fencing remnant vegetation or riparian buffer strips. Price based instruments offer budget certainty and are particularly useful where it is difficult to define the product suited to a standard market. For example, biodiversity may be measurable but it is difficult to package as well;
- Quantity based instruments which set limits on resource use or pollutants thus creating scarcity. Examples include the water market in Australia, the international carbon market, and offsets for vegetation clearance in Victoria (also proposed in NSW). These offer certainty for a targeted biophysical outcome, but not for the cost to achieve that outcome; and
- Market friction instruments that are intended to reduce or remove obstacles to existing or self-generating markets. Examples include revolving funds for conservation purchase, labelling to advertise good environmental management, and sustainable investment funds. Market friction outcomes are reliant on existing property rights and tend to be less certain and may be slower to take effect compared to alternative instruments.

5 For example, the Rice regulations impose conditions on the soil types and maximum area on which rice can be grown and the maximum water usage allowable. Other regulations impose standards on maximum water use per hectare for other crops.

There are three likely advantages of a market-based net recharge mechanism over existing policy approaches that have been utilised in the CIA:

1. Enhanced individual landowner flexibility to adjust irrigation management to meet CIA community targets;
2. Improved targeting of incentives towards reducing net recharge. The incentives are likely to drive innovation in net recharge management and reduce future costs of meeting recharge targets. This advantage is important because substantial innovation benefits have been shown in many other market-based mechanisms; and
3. Avoidance of the costs and inefficiencies involved in collecting and redistributing levies or other charges into a common pool to pay for recharge management.

Some benefits of recharge management extend beyond the CIA (for example, reduced salt exports to rivers), which implies a justification for government assistance for improved landholder management. However, these payments can just as easily be made through a market-based mechanism as through grants, tax relief, or other methods.

The overarching goal of the 'Tradeable Recharge Credits in the CIA' project is to explore the potential application of a market-based mechanism to improve net recharge management in the Coleambally Irrigation Area. The key outcome in Coleambally is to manage the threat of waterlogging and salinity caused by net recharge to shared aquifers. Successful management is reliant on achieving quantity targets, the estimation and monitoring of which, is made possible by the SWAGMAN® series of models and regional groundwater models.

Exploration within the project is focussed on:

1. Identifying the issues that will need to be overcome in designing an effective quantity-based MBI;
2. Addressing the biophysical requirements and trade-offs in MBI design;
3. Estimating the relative benefits of such a MBI compared to alternative policy approaches; and
4. Testing the market practicality of alternate market designs.

The remainder of this report concentrates on the issues that will need to be overcome in designing an effective quantity based MBI. Further reports will investigate the remaining issues.

3. Issues and options in designing a market-based mechanism for net recharge management

Despite the potential advantages of market-based systems, and their current high profile, a number of complexities exist in designing and implementing a mechanism for managing net recharge. First, it may prove costly to set up and manage a market-based scheme. Second, it is paramount that an enduring set of rules be established to realise net recharge goals without creating other problems in the CIA. These costs and complexities must be examined against the potential benefits when deciding whether to implement a market-based mechanism and when determining the rules within the system. The key issues for consideration include the:

- Definition of the net recharge rights;
- Measurement of net recharge commodity;
- Initial allocation of net recharge rights;
- Process for setting net recharge targets, year on year;
- Rules for management flexibility, such as banking and borrowing of net recharge;
- Rules for trading in net recharge rights;
- Determination of monitoring provisions; and
- Penalties for violation of the supporting rules.

These decisions will define the mechanism and its relative efficiency and effectiveness as a management tool. It is particularly important to ensure that incentives accurately reflect the relative costs of net recharge imposed on irrigators, neighbours, and the wider community. This will mean that net recharge needs to be accurately measured, that individual and collective actions and their consequences, are monitored, and that the rules for buying or selling net recharge do not distort outcomes.

3.1 What might 'net recharge rights' look like?

The implementation of any market-based mechanism to improve management of net recharge requires a means to establish and enforce ownership of net recharge from different sources – termed 'net recharge rights'. These rights define whether and how much irrigators can contribute to net recharge in the CIA.

Net recharge rights may be defined either through legislation or via contract. CICL's NSW legislative base provides for recharge management within the Coleambally region via the contractual arrangements defined within the Coleambally Water Management Works License (sections A.6.4 and A.7), and within the rules of CICL (Sections 9.11 and 10). Provisions within the Coleambally Land and Water Management Plan further support contract based net recharge management.

Implicit rights at the regional scale can be devolved to the property scale through contractual arrangements. Specifically, all Coleambally irrigators must hold a supply contract with CICL. Irrigators current supply contracts are in part, dependent on adhering to 'Rice Policy' regulations governing rice areas, and rice water use, as well water use restrictions for other crops. One option is to supersede these regulations in future contracts, by the incorporation of contractual property rights governing the quantity of net recharge allowed under the water supply contract.

What's in a name: what to call net recharge rights?

Rights to net recharge from irrigation activities are generally termed *permits* because the rights specify permitted or allowable recharge under applicable regulations.

Rights to reductions in net recharge through non-irrigation or other activities (such as groundwater pumping) are generally termed *credits* because they are voluntary and additional to any regulated requirement. Trading rules can be designed to allow permits and credits to be interchanged (see Section 3.7).

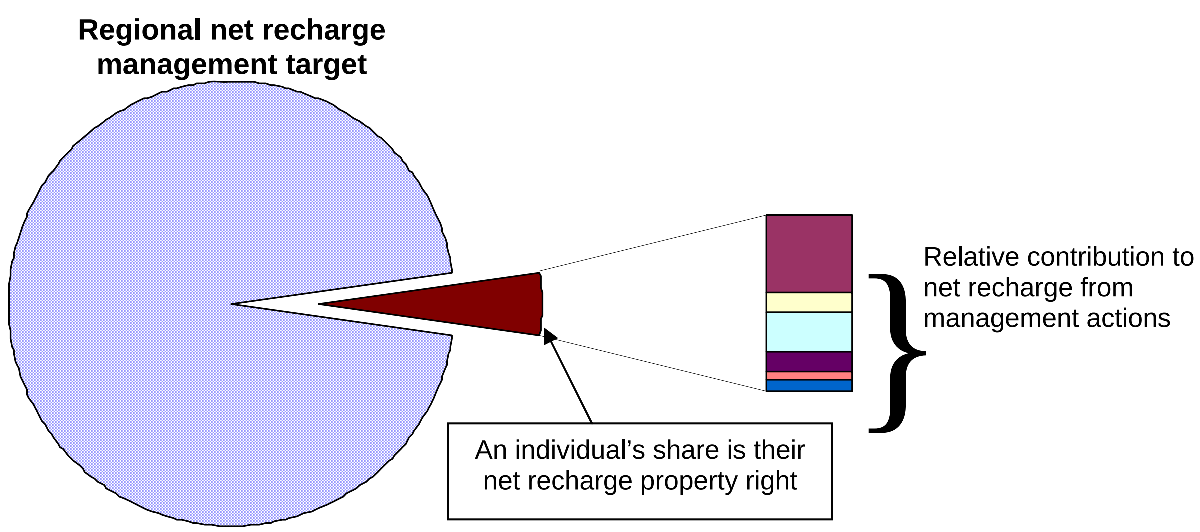
Despite the generally accepted meaning of the terms *permits* and *credits*, their use has varied in practice. For example, the Hunter River Salinity Trading scheme has allocated 'permits' to a number of point sources of salinity in the catchment (mainly coal mines). In practice these 'permits' are labelled 'credits' in the Hunter scheme because stakeholders are more comfortable with the positive message incorporated in 'credit' based terminology. Some consideration should be given to the labelling of potential permits and credits in Coleambally because the perception of participants is important. Indeed potential labelling should not be limited to permit-credit terminology and could use any label favoured by the community. For example, other acceptable terms that have accepted meanings in the context of irrigation water supplies include *entitlements* and *allocations*.

3.2 Measurement of net recharge rights

At a regional level the total quantity of net recharge rights would need to be less than or equal to the regional net recharge target. For an individual irrigator, the total impact of their farm management actions would need to be less than or equal to their individual net recharge rights.

'Net recharge rights' for each individual contributor would be linked to aggregate recharge targets at the regional scale and to farm-scale management decisions as shown in Figure 2. Therefore, a net recharge right must be able to be measured, allocated to individuals, and monitored. The options for linking regional targets to individual net recharge rights are discussed in Section 3.3. Issues that must be addressed to link the impacts of farm management decisions on net recharge to net recharge rights are discussed in Section 3.4.

Figure 2: Linkages between regional targets, net recharge rights and farm management decisions



3.3 Regional net recharge targets and net recharge property rights

When establishing regional net recharge targets and net recharge property rights held by individuals, there are three questions to address:

1. Who should own net recharge rights?
2. Are there others who should be able to hold net recharge rights?
3. What information should be held about right owners?
4. What net recharge targets should be in the scheme? and
5. How is the initial allocation of rights between individuals determined?
6. When and how should the cap be met?

Who should own net recharge rights?

A market-based net recharge mechanism effectively allocates shares of a recharge target to individuals that are called net recharge rights. The goal of any net recharge mechanism is for actual net recharge to be less than or equal to the net recharge target. Therefore, the total net recharge property rights allocated must be less than the aggregate recharge target. There are two reasons for this:

1. To create a buffer to increase the certainty that the net recharge target will be met (particularly for when there is a large unanticipated rainfall event); and
2. Some contributors to net recharge will not be allocated rights because the costs of their allocation outweigh the benefits for net recharge management. For instance, the costs may outweigh the benefits where the individual contributors are too small to have any significant impact on achieving targets, or where recharge cannot be impacted by the contributor's management actions.

Therefore, anyone who can change their management practices to reduce net recharge, *and* is large enough that the benefits of changing their management outweighs the costs of granting them net recharge rights, could be granted ownership. In the CIA, irrigators are both able to change their management to reduce net recharge, and in many cases are significant sources of recharge. Other recharge sources include water supply channels, residential areas, and industrial enterprises. CICL Water supply channels are likely to be a significant source for which improved recharge management can be considered. However, the costs of allocating ownership to residents and small industry must be balanced against the benefits that accrue to recharge management. Due to the likelihood that the costs will be greater than the benefits, residents and small industry are unlikely to be allocated net recharge rights.

Are there others who should also be able to hold net recharge rights?

The question of who can trade and hold the new rights will determine the participants in any market-based mechanism. Ideally, all significant positive or negative contributors to net recharge should be included.

While irrigators would be automatically included, a second class of right-holders may include individuals or organisations (such as CICL) that could reduce, or 'offset' net recharge via remediation actions, such as regional groundwater pumping or strategic tree planting. Whether this second class is restricted to a predetermined set of net recharge management activities, or whether possible management actions are assessed on a case-by-case basis, is a matter for further consideration.

A third class of net recharge right holders may include individuals or organisations that cannot directly manage net recharge, but may wish to take ownership of credits for various reasons. For example, local environmental groups wishing to protect wetlands may purchase credits to further lower watertables and thus reduce discharge in wetland areas. This latter group could include for example, investors, organisations representing nearby interests, or indeed the general public.

An important aspect of deciding the scope of the market is the principle of 'enforceable ownership at reasonable cost'.[6] Enforceability means that the net recharge right owners can be identified along with the quantity of the rights that they own or use. As the number of potential right holders grows, the opportunities for lower cost recharge management are generally increased, but this must be balanced with the additional costs of designing and managing a larger system.

What information should be held about right owners?

In most tradeable rights schemes a registry is created, containing relevant details such as name and contact details of right holders, relevant details about the right, and any third party interests in the right (such as whether the right forms security over a loan).

Details that could be considered for inclusion on any CIA net recharge right register may include (among others):

- name and contact details of the owner;
- quantity of net recharge;
- any third party interests (such as whether it forms collateral for a bank loan);
- any restrictions on the location within the CIA that the net recharge can be contributed; and
- other restrictions on right use or trading.

The registry is updated each time a permanent trade takes place. Registries need not be maintained in-house, and specialist firms are available to provide the service such as The Marketplace Company, who maintain the registry for all Renewable Energy Certificates on behalf of the Commonwealth Government.

What net recharge target should be in the scheme?

The goal of adopting a market-based mechanism is to improve irrigation induced salinity and waterlogging management, and generate positive outcomes for the Coleambally community. Fundamentally this means that net recharge property rights must be less than, or equal to, some total quantity of net recharge across the CIA, and potentially also at some sub-regions. That is, total recharge must be reduced (or

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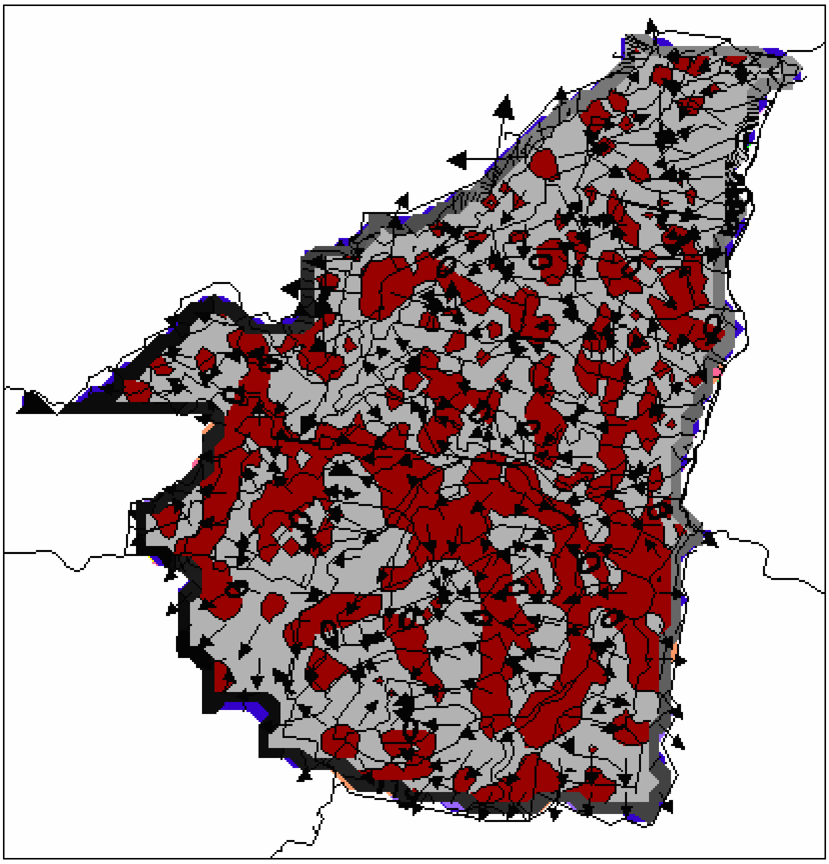
[6] More information on this concept can be found in 'Creating Markets for Ecosystem Services' by Greg Murtough, Barbara Aretino and Anna Matysek (2002). This publication can be downloaded from: http://www.pc.gov.au/research/staffres/cmfes/index.html

capped) in order to achieve the recharge targets, to reduce the costs of salinity and waterlogging.

Within the CIA there are a number of local and regional recharge and salinity and waterlogging impact zones as shown in Figure 3. A CIA region wide cap may reduce the total volume of net recharge, but fail to reduce the impacts where salinity and waterlogging impacts are most acute. Worse, a system wide cap may reduce some better quality net recharge that is beneficial to deeper aquifers and reduce future groundwater reserves.

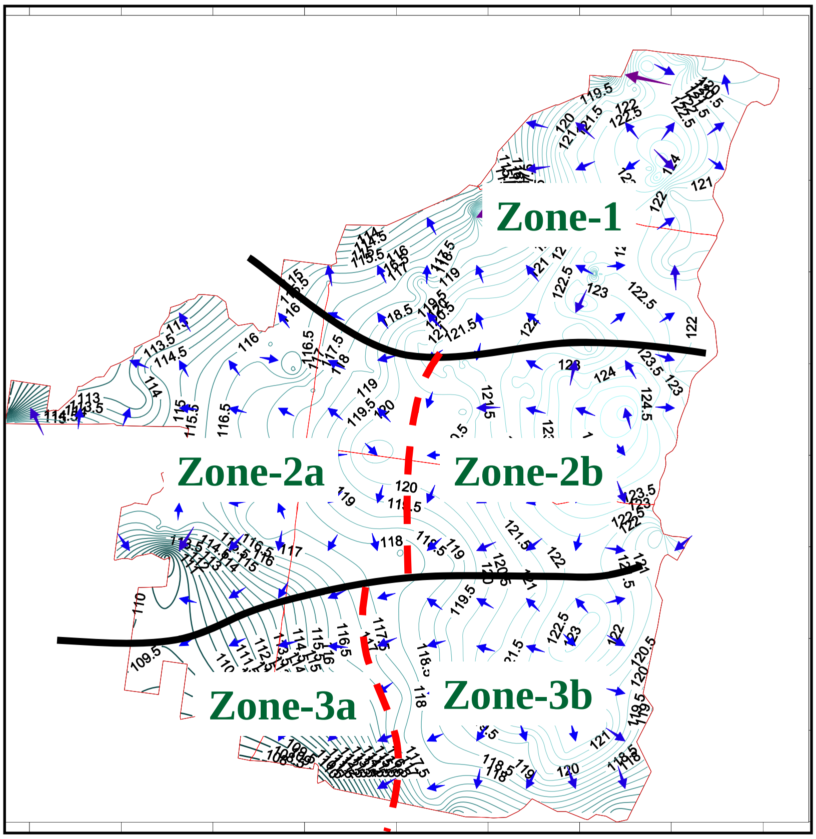
Figure 3: Groundwater movement and recharge and discharge zones in Coleambally



Note: Red areas are groundwater recharge areas and grey areas are groundwater discharge areas

The risks of these undesirable outcomes require further analysis before deciding whether to set subregional caps rather than a Coleambally-wide cap. Sub-regional caps can be targeted to reduce specific damage resulting from net recharge. For example, four potential zones are shown in Figure 4. These are delineated by local and regional modelled groundwater flow paths. There is however a trade-off between the number and size of any sub-regional caps and the cost of defining these caps, and managing the net recharge property rights in each. Additional sub-regions also create the potential for poor outcomes to arise from inappropriate trading rules between regions or insufficient numbers of participants in markets.

Figure 4: Possible Zones in the Coleambally Irrigation Area



In order to set CIA wide or sub-regional caps an appropriate measure of groundwater assimilation and movement within and beyond the region is required. Options include:

- Targets based on groundwater outflow rates within and between different aquifers; and
- Targets based on historic recharge and discharge rates from individual areas.

Setting targets on groundwater outflow rates or assimilative capacity is a preferred option because it is more accurate than historic recharge and discharge rates that may change, as thresholds are reached.

The groundwater outflow approach has been made possible in the CIA through CSIRO research over the past five years to develop regional groundwater flow and salt transport models. These models have been developed using historic piezometric data from over 800 piezometers in the region and aquifer composition information from thousands of bore logs. The regional groundwater models have been calibrated to historic data sets, and tested under a range of irrigation and climate scenarios. It is possible to delineate net recharge areas from net discharge areas and identify leakage between different aquifers in these models, to specify quantitative regional and sub-regional targets.[7]

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[7] More details on targets and target setting can be found in the sixth report in this series "Biophysical Modelling for Linking Farms with Regional Net Recharge Targets".

Targets based on outflow rates must be expressed as quantity over time (for example, gigalitres of net recharge per year, with the start and end dates coinciding with annual crop-cycles). This raises the issue of whether the net recharge target is the same in each year or whether it will change from year to year. The net impact of irrigation in any year will differ depending on other factors – particularly rainfall. Winter rainfall induced recharge on fallow areas may be a significant factor under shallow watertable conditions.

A constant net recharge right means property rights can be specified as a defined constant quantity (for example, specified as Ml per year); whereas annual aggregate recharge rates mean that rights will need to be specified as a share of a total recharge target that varies each year. Annual targets allow more flexibility in overall recharge management, but constant net recharge rights increase the certainty to landholders.

A clear mechanism for adjusting rights for any errors in the initial application due to scientific uncertainty, unforeseen consequences or application errors, will also need to be specified. The most common options include:

- Limiting the duration of the right (for example, guaranteed for ten years);
- Permanent rights with compensation for any future changes;
- Proportional adjustment as required (for example, a percentage reduction to all rights); or
- A combination of the above mechanisms (for example, up to ten percent adjustment at ten year intervals without compensation).

Retaining flexibility to cope with the scientific and market uncertainty should be weighed against the risk this introduces to the market, and the implications of uncertainty on trade and recharge that result.

How is the initial allocation of rights between individuals determined?

The overall net recharge target at either the CIA or sub-regional level must be sub-divided between individual right holders. There are a number of options for allocating rights between individuals based on:

- Existing or past net recharge performance;
- Existing or past net recharge performance adjusted for recent changes to management or conditions;
- Net recharge under best management practice; or
- Auction of rights to the highest bidder.

Combinations of the above methods may also be employed. To date, most mechanisms involving tradeable rights allocate these rights based on historical performance.[8] However, basing the allocation of net recharge rights purely on past performance may be inequitable because of the failure to take into account actions already undertaken by some irrigators to reduce their net recharge. Therefore, it could

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8 Auctions have been more prevalent where property rights to new or previously un-used resources, such as a new communication spectrum bandwidth such as for mobile phones, have been allocated.

penalise some farmers who have already adopted improved recharge management strategies compared to farmers who have not yet changed their practices.

Consideration should be given to the increased costs that would result from employing a more detailed allocation procedure. Each progressive adjustment to past behaviour induces computational complexity, and would therefore impose additional costs, to gather and verify information. However, this sort of detailed record and recalibration of rights, particularly if individual actions and their results were tracked, could lead to evidence based guidance on better management of net recharge.

When and how should the cap be met?

Should the CIA target cap and any sub-regional caps be achieved immediately or at some point in the future? For example, in some schemes, such as the Regional Clean Air Incentives Market (RECLAIM) in the United States of America, caps have initially been set close to current levels and reduced over time, as experience and alternative management practices have evolved. This issue is only important if there is a large gap between the current net recharge performance and the target outcome.

Another option is to cap net recharge rights at modest levels and purchase recharge credits from the market to achieve the target. Spreading such purchases over time can also help to stimulate market activity and encourage trading.

The determination of any time lag will have important implications for the pace and cost of reducing net recharge, and the bearer of the cost. For example, progressively declining allowable net recharge under a defined schedule until the target is met would provide producers with regulatory certainty and time to adjust irrigation practices. This might be particularly appealing to irrigators with large investments in crop specific enterprises (such as equipment for rice farming) who would otherwise incur substantial costs if net recharge reductions were significantly large and imposed at short notice. Of course, such an approach will lengthen the time to achieve recharge reduction goals. Alternately, purchasing and retiring net recharge rights would shift some compliance costs to those funding the purchases, such as the broader irrigation community via CICL, or to the government.

Finally, the time period given to achieve a target may in fact impact on the level of future targets. This is because a delay in reducing current recharge may require greater reductions in the future to compensate for lower initial reductions. Alternately the current drought may have already reduced future targets with falls in groundwater levels.

3.4 Measurement of individual net recharge rights

There are a number of factors affecting net recharge at the property level, including[9];

1. Total water application and irrigation application technology;
2. Soil type and underlying hydrogeology;
3. Crop type; and
4. Climatic conditions and variability (including soil water content at the commencement of the irrigation season).

The regional groundwater and SWAGMAN® series of models described in Section 2.1 rely on accurate identification of these factors at the appropriate regional or paddock scale to identify groundwater outflow rates under each farm. The SWAGMAN® Farm model is then used to estimate net recharge for an individual paddock or whole farm.

The SWAGMAN® Farm model computes units of recharge and net recharge per Ml of irrigation water used, or per hectare of land, or per area of specific crop type. Each measure will focus management decisions in a slightly different direction. For example, units of recharge per Ml of water used will give maximum incentive to minimise total water use rather than recharge directly. Alternatively, units of recharge per crop type give incentives to change crop mix but not water management and net recharge.

Measures that deliver incentives more closely focused on reducing net recharge also require more complex information about farm management decisions. In this regard, real-time, secure internet-based landholder access to the SWAGMAN® Farm model has been established and tailored to individual farms.[10] Again, care needs to be taken to ensure that the costs to landholders of collecting and entering information do not outweigh the benefits from improved incentives to manage net recharge.

Estimation of the impact of net recharge reduction schemes such as agro-forestry or groundwater pumping, generally classed as offsets, will also be possible using modules of the SWAGMAN® series. Net recharge rights that result from offsets are not equivalent to those discussed above because the impact of these schemes is not indefinite but is a change in the groundwater dynamics for the life of the project. Hence, rights can only be issued for the term of the project rather than a perpetual share of a target. For example, a groundwater-pumping scheme may reduce local recharge, but only for the life of the project. The actual impact of this scheme will depend on operation, maintenance and climatic variability throughout the life of the scheme. The implications of these differences are discussed in detail in Section 4.5.

Applying net recharge property rights at the farm scale

There are two aspects to applying net-recharge rights at the farm scale:

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[9] There are also potentially carryover impacts from irrigation in previous years – these can also be taken into account in SWAGMAN® measurement procedures using initial soil moisture or other methods. Leakage from other sources such as irrigation canals or evaporation basins can be taken into account by the extension of this methodology.

[10] A working example of the SWAGMAN® Farm model developed by Shahbaz Khan can be viewed at: http://www.colyirr.com.au/swagmanfarm/allUser/SwagFarm.asp.

1. Initial allocation of rights; and
2. Determination of net recharge each year.

The initial net recharge right allocation needs to be based on the application of the individual allocation method outlined in Section 3.4. The process to determine individual farm scale shares is as follows:

1. Determine regional and sub-regional recharge targets using recharge rates, net recharge and discharge rates; and
2. Apportion the sub-regional recharge target amongst individual landholders based on the allocation method in Section 3.2.

Ongoing assessment of net recharge would follow a similar process but be dependent on the target setting process selected (see discussion in Section 3.2) and the selected measurement unit. Each landholder would undertake the following generic process:

1. Determine quantity of net recharge rights held for the year;
2. Determine the net recharge for the proposed crop mix and management strategy using SWAGMAN® Farm models;
3. Review the quantity of net recharge rights held against that generated by the proposed crop mix, and decide whether to buy or sell net recharge shares.

Within this application process, the specific information required for computing net recharge at the farm level would include:

- Initial soil water conditions, crop decisions and water application.
- Net recharge would than be estimated using the SWAGMAN Farm model.

3.5 Other design issues

Monitoring rule violations and imposition of penalties

Cost effectively verifying who holds and uses recharge rights, is necessary to ensure that net recharge targets are met.[11] The basic information on a rights register should identify who owns recharge rights (as described in Section 3.3). Rights must be policed with appropriate penalties for illegal use to make the system effective. Options for a regulator to monitor and police rights include CICL or a third party service provider.

Strategies for monitoring the area and location of rice crops in the CIA could be leveraged for monitoring a major proportion of recharge within the region. An example is to use remote sensing of the total area of rice grown on individual farms for assessing recharge amounts. An alternative monitoring option is a combination of random and targeted audits of crop area and water use. These options can be used separately or in a complementary manner to effectively ensure compliance with right ownership.

The contractual arrangements that facilitate use of rights as an instrument can also facilitate levying penalties. Incorporation of recharge rights within water supply

[11] More information on verification can be found in 'Creating Markets for Ecosystem Services' by Greg Murtough, Barbara Aretino and Anna Matysek (2002). This publication can be downloaded from: http://www.pc.gov.au/research/staffres/cmfes/index.html

contracts that all CIA irrigators currently must have with CICL would provide the legal foundation for the imposition of penalties. Recharge management provisions within contracts are also supported by the environmental compliance conditions within the CICL water supply licence and within the Environmental Management Plan conditions. A contract based framework allows civil court mechanisms to enforce penalties.

The range and severity of penalties for violating recharge credit rules could range from suspension of water supplies to less severe penalties such as fines (levied as money, net recharge rights or water supply) or remedial works. It is important that penalties are sufficiently strong and that the community as a whole supports their imposition.

Management flexibility

A major reason for the consideration of net recharge rights as a management tool is their potential to increase management flexibility when compared with existing mechanisms. Flexibility is attained via banking and borrowing provisions along with the potential for trade. Banking and borrowing provisions are particularly important in systems subject to substantial year on year variation such as that driven by climate induced, irrigation water availability. However, these provisions may also increase the potential for system abuse if rules are not carefully constructed. For this reason, there are usually limits to both the quantity and duration for which property rights can be carried over or borrowed. Time limits should coincide at least partially with the expected duration of climatic cycles (for example the average length of an El Nino Southern Oscillation event). Special rules on banking and borrowing may also be considered if there is a transitional period to achieving the target cap.

Potential barriers to implementation

Potential barriers to implementation include social barriers to market-based systems; and risk of future government intervention. Social barriers to market-based systems include concerns about the social impacts of rights (for example, equity considerations in right allocation and trading), impacts of any additional costs on farm viability, or cultural impediments to the creation of new rights that irrigators consider they already hold.

Uncertainty over future government intervention of net recharge management rules may be weighed against the risk of increased regulation. A comprehensive framework for a market-based right structure that ensures compliance with water supply licence conditions may reduce the risk of increased regulation. Therefore it is essential to ensure the community is fully involved in development of a transparent and clear mechanism with a high degree of information provision and feedback to address specific concerns. Consultation and feedback with government agencies may also minimise the risk of future legislative or policy changes.

Who will fund market development and administration?

The design, implementation and ongoing management of any net recharge rights system will generate significant costs. These include the definition and allocation of rights, registry maintenance and administration, ongoing compliance audits and the application of penalties. The majority of preparatory costs to define rights and to design an allocation mechanism are funded by CSIRO, CICL and the National Market-Based Instruments Pilots Program.

There are a number of options for funding ongoing administration costs including user-pays fees, incorporation within CICL costs (representing the CIA irrigators), a levy on net recharge right owners, or a combination of these.

User-pays fees are those directly attributable to costs imposed by a recharge right owner's actions. These include costs to update the registry of right owners for any changes to right ownership and costs directly attributable to penalising any violation of rights (for example, court costs). Any costs associated with right carryover or borrowing from future years are also directly attributable to users. Often user-pays fees are applied where possible and remaining costs are socialised (for example through a levy or inclusion in CICL costs).

3.6 Creating a net recharge right market

A major goal of a market-based system for managing net recharge is to increase flexibility in net recharge management by making available the opportunity to buy and sell net recharge responsibilities subject to a target within an overall framework. The effectiveness of a market for net recharge will be determined by the ease with which participants can trade and by the equity or efficiency outcomes of the trades.

Trading arrangements

Many potential trading arrangements are possible including:

1. Direct trades between individuals;
2. Indirect trades using agents such as stock and station agents; or
3. A centralised market place.

Direct trades are possible, especially between neighbours, but in many cases it might be difficult for buyers and sellers to find each other. Irrigators in the CIA are familiar with water trading using agents like stock and station agents and impersonal trading mediums such as the Internet. It is likely that both means of trade will emerge for exchanges of recharge permits and credits. In particular, use of Internet trading facilities, linked to the existing water market, is likely to ease trades where individuals are comfortable with the technology. The costs of establishing such systems are also likely to be low, but their success is reliant on irrigator acceptance and their ability to manage the technology.

Associated administrative arrangements must also be considered. Specifically, an administrator must exist to approve trades (to ensure compliance with the registry and any trading rules) and maintain a trading log that feeds into the registry of rights. Again, the role of market administrator could be filled by either CICL or by a specialist private sector firm.

Market power

If an individual player or small group of landholders can directly influence market outcomes then a market-based mechanism may be less effective than other options. Market power is generated in two main ways:

1. By controlling a large segment of the market and thus influencing market prices; or
2. By influencing decisions to participate in a market in other ways.

In the CIA it is unlikely that any single irrigator or group of irrigators will control a significant share of credits across the CIA or in any single sub-region. However, the risk of market power grows as the number of participants fall.

3.7 Including recharge offsets from other activities

Future land management actions or engineering solutions that may 'offset' the net recharge from irrigation sources include for example, strategic tree planting or groundwater pumping to evaporation. Issues for consideration include establishing,

- Who is able to generate offsets?
- How offset property rights might be defined and measured?
- Whether the enforcement processes differ? and
- Are specific trading rules required?

A new class of potential right owners may be required if offset actions can be undertaken by non-irrigator resource owners who could than use or onsell rights to others in the CIA. These may include landowners outside irrigation areas or non-irrigating landowners within the irrigation area. The decision about who is able to generate additional rights should take into account the costs of measuring and monitoring offset impacts. One means of minimising such costs is to use existing measurement, monitoring and enforcement structures where possible and only develop additional structures where required.

A key decision about recharge offset rights is when and where the benefits to net recharge. For example, a strategically placed woodlot will generate increasing benefits until maturity. However, there is a time lag between planting and the commencement of benefits. Moreover, the largest benefits do not commence until well into the future. Two examples of ways to incorporate these future benefits are:

- a constant benefit across the life of the project (for example total benefits divided by the life of the project); or
- a modelled benefit for each year that may or may not include climatic variation (see discussion in Section 3.3).

Averaging benefits from future years effectively represents a forward borrowing of future benefits. At the extreme, the entire future benefits of the action could be sold at the start of the project but at the expense of increased risk if the project fails after commencement (for example because trees die after five years).

4. Next steps in considering market-based options for net recharge management

There are many considerations for establishing a net recharge management market. Some options will deliver recharge management more effectively than others; some options will be more acceptable to the community than others; and some options will be more expensive than others. This paper has endeavoured to cover a broad range of options available to the CIA.

A number of subsequent research reports will report on our progress in investigating the net recharge trading concept and issues arising that were identified in this report. These reports will deal with the relative costs and benefits of alternative recharge management strategies, setting recharge targets, and testing alternative institutions for recharge markets.

Sources of further information

The following documents can provide more information about irrigation recharge management and design, and the use of market-based tools. Where possible a web address from which they can be downloaded has been provided.

Information on market-based management tools:

Information about existing MBI schemes to manage natural resources in Australia can be downloaded from the National Action Plan for Salinity and Water Quality website at: www.napswq.gov.au/about/mbi_download.html

Murtough, G., Aretino, B., and Matysek, A., 2002. Creating Markets for Ecosystem Services. Productivity Commission Staff Research Paper, Ausinfo, Canberra. Available at: www.pc.gov.au/research/staffres/cmfes/index.html

Hockenstein, J.B., Stavins, R.N., and Whitehead, B.W., 1997. Crafting the Next Generation of Market-Based Environmental Tools. Environment, 39:13-20 & 30-33 pp. Available at: ksghome.harvard.edu/~.rstavins.academic.ksg/cvweb.html

Stavins, R.N., 2000. Experience with Market-Based Environmental Policy Instruments. Resources for the Future Discussion Paper 00-09. Available at: ksghome.harvard.edu/~.rstavins.academic.ksg/cvweb.html

Organisation for Economic Co-operation and Development. Domestic Transferable Permits for Environmental Management: Design and Implementation. 2001. Paris, OECD. Available at: oecdpublications.gfi-nb.com/cgi-bin/OECDBookShop.storefront/EN/product/972001071P1

National Wildlife Federation. A New Tool for Water Quality: Making Watershed-Based Trading Work for You. 1999. NWF. Available at: www.nwf.org/watersheds/learnmore.html

Faeth, P., 2000. Fertile Ground: Nutrient Trading's Potential to Cost-effectively Improve Water Quality. World Resources Institute, Washington, DC. Available at: pubs.wri.org/pubs_alpha.cfm

Whitten, S.M., Salzman, J., Proctor, W. and Shelton D. 2003, Markets for Ecosystem Services: Applying the concepts, RIRDC.
Fact sheets summarising aspects of the Markets for Ecosystem Services project are available at: www.ecosystemservicesproject.org/html/publications/fact_sheets.htm

Information on recharge modelling and management:

Khan S., Xevi E., and Meyer W. S. (2003) Salt, Water and Groundwater Management Models to Determine Sustainable Cropping Patterns in Shallow Saline Groundwater Regions – Special Volume of the Journal of Crop Production titled Crop Production in Saline Environments. 325-340. Co-published simultaneously in Crop Production in

Saline Environments, Global and Integrative Perspectives, Ed Sham S. Goyal, Surinder K. Sharma and D. Williams, Haworth Press.

Khan S., Connell N. O' , Wang Z. , Robinson D. and Xevi E. (2002) Environmental Concepts and Models for Participative Management of Irrigation Areas – Applications in the Murray Darling Basin. Irrigation Advisory Services and Participatory Extension in Irrigation Management Workshop organized by FAO – ICID. Montreal, Canada. Paper No. 2.

Khan S. and Ginns T. (2003) Sustainable Irrigation Tools. Farmers Newsletter, Large Area Edition, No. 164. 30-31.

SWAGMAN Farm (online version): www.colyirr.com.au/swagmanfarm/Default.aspx