Capacity sharing in the St George and MacIntyre Brook irrigation schemes in southern Queensland

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Foreword

The recent ABARE report *Management of irrigation water storages: carryover rights and capacity sharing* highlighted a number of the theoretical advantages of capacity sharing as an alternative approach to water allocation.

To date, the only irrigation systems to implement capacity sharing at an end user level in Australia have been the St George and MacIntyre Brook systems in southern Queensland. This report examines these capacity sharing schemes in detail, drawing lessons from the experiences of water users and water managers in the two regions.

This project received funding support from the National Program for Sustainable Irrigation as well as significant cooperation from Queensland water utility SunWater. The report presents a large volume of information on the two capacity sharing schemes gathered by researchers during the course of the project, including insights from interviews with key stakeholders and an analysis of quantitative data provided by SunWater.

It is intended that this report will become a useful reference document for irrigators, water utilities and policy-makers who have an interest in alternative water allocation systems.

Phillip Glyde
Executive Director
June 2009

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Summary

This report represents the second part of a two part project investigating the management of irrigation storages. The first report: *Management of irrigation water storages: carryover rights and capacity sharing* (Hughes and Goesch 2009) focused on the economics of storage management and the potential advantages of capacity sharing. This report examines in detail two capacity sharing schemes implemented in Queensland - St George and MacIntyre Brook.

The report contains a large volume of information relating to the implementation of capacity sharing in St George and MacIntyre Brook. It is hoped the report will become a useful reference for water managers who have an interest in reforming water allocation/storage management policies. While the theoretical advantages of storage rights/capacity sharing are relatively well established, there has until recently remained scepticism over the feasibility of this approach in practice. The experience of St George, and to a lesser extent MacIntyre Brook, has demonstrated that capacity sharing is feasible and practical. While there are challenges to face in refining the approach and in introducing it into other systems, capacity sharing shows significant potential.

Background

In Australia, access to irrigation water is traditionally governed by a system of water entitlements with nominal volumetric limits and seasonal allocations. Under this system, water managers effectively determine the proportion of total water available released for use in the current season and the proportion which remains in storage for use in future seasons.

Such a centralised approach to water allocation may, for a number of practical reasons, lead to an inefficient allocation of irrigation water. One way of addressing these potential inefficiencies is to introduce carryover rights, which allow water users to hold over a proportion of their seasonal allocation for use in future seasons. However, carryover rights while beneficial are subject to a number of practical limitations.

Capacity sharing is an alternative system of water allocation first proposed by Dudley and Musgrave (1988). Under capacity sharing, traditional volumetric water entitlements are redefined into shares of storage capacity and shares of inflow. The first report of this project discussed a number of the advantages of capacity sharing over the traditional announced allocation/carryover rights approach. Ultimately, capacity sharing provides a more transparent system which offers water users more flexibility over how and when they use available water resources.

Region profiles

Capacity sharing has been in operation in the St George region since 2000 and was introduced into the nearby MacIntyre Brook region on 1 July 2008. To date, these are the only irrigation regions in Australia where capacity sharing has been implemented at the end user level.

St George

St George is located on the Balonne River in southern Queensland, approximately 500 kilometres west of Brisbane. The St George irrigation region covers a total area of around 19 000 hectares, of which 12 000 hectares are set up for irrigation. The main irrigated crop in the region is cotton, with some grapes and vegetables also being produced. The St George irrigation region has relatively limited off-farm storage capacity and is subject to very high storage losses.

MacIntyre Brook

The MacIntyre Brook irrigation region is located on the MacIntyre Brook, near the town of Inglewood, approximately 270 kilometres west of Brisbane. The MacIntyre Brook irrigation region is smaller than the St George region, with an irrigated area of around 2000 hectares. The main irrigated crop grown in the region is lucerne. The MacIntyre Brook system is subject to relatively large delivery losses.

Capacity sharing rules

With the introduction of capacity sharing at St George, SunWater has formalised a comprehensive set of rules to enable the conversion of traditional water entitlements into capacity sharing entitlements; these rules are summarised in this report. SunWater's approach includes accounting for delivery losses via a system of defined zones with associated loss factors.

SunWater has also established a set of accounting rules and systems for managing the balance of water in each user's capacity sharing account and for recording each user's water use against a specific annual water use cap. This includes a system of periodic reconciliations to ensure that the aggregate volume of water in the accounting system matches the physical volume of water in storages.

Interviews

The report presents information gathered from interviews held with irrigators, water managers and members of the finance sector in the St George and MacIntyre Brook regions.

SunWater's perspective

From SunWater's perspective, capacity sharing has been a highly successful policy in the St George region. SunWater has suggested that capacity sharing has led to a reduction in operating costs and a reduction in disputes with irrigators in the region. SunWater also observed interest in capacity sharing in a number of other irrigation systems across Queensland.

Irrigator interviews

ABARE conducted informal interviews with six irrigators (four at St George and two at MacIntyre Brook). All of the irrigators interviewed were supportive of capacity sharing. The irrigators listed a number of advantages of capacity sharing relative to the previous arrangements. The irrigators noted that capacity sharing provided flexibility over inter-year water use/storage decisions without the external effects associated with carryover rights. For example, capacity sharing ensured that irrigators were responsible only for their own contributions to storage losses. The irrigators also felt that capacity sharing offered increased flexibility with regard to the timing of water use within the water year (financial year).

The irrigators indicated that capacity sharing had led to a reduction in uncertainty relative to the previous announced allocation system. The irrigators suggested that capacity sharing facilitated diversity, allowing water users with different crop types and risk preferences to adopt personalised water use strategies. The irrigators at MacIntyre Brook noted that, in the past, carryover rights were severely limited in their region and that capacity sharing provided much more control over storage decisions, and in turn, water supply reliability.

All of the irrigators interviewed indicated that the transition to capacity sharing was well handled by SunWater. The irrigators also indicated that capacity sharing imposed no significant time or inconvenience costs, and that it was generally simple and low cost to use.

Finance sector interviews

Interviews were conducted with four members of the rural finance sector. Three of the financiers were supportive of capacity sharing. These financiers indicated that capacity sharing was a more transparent system subject to less uncertainty. One of the financiers expressed concerns regarding the delivery loss zones in the MacIntyre Brook system, suggesting that some irrigators who regularly traded water to downstream regions were adversely affected. Similar concerns were also expressed by irrigators interviewed in the MacIntyre Brook region.

Addressing some concerns

SunWater's entitlement conversion rules take steps to minimise distributional effects associated with the introduction of delivery loss zones. However, there is still the possibility that certain irrigators (those in low loss zones who regularly trade large proportions of their water allocations downstream) could observe a reduction in income from water trading under the new system. In practice, these costs may be offset by other positive effects. In any case, delivery loss factors will tend to minimise the adverse external effects that downstream water trade previously imposed on other irrigators in the system. Further, well specified delivery loss rules will lead to an overall improvement in the efficiency of water allocation, which will benefit irrigators in aggregate.

A number of irrigators identified the restrictions on carryover in the water use cap as an issue. However, given the potential problems associated with water use exceeding traditional maximum levels, regulators may be justified in restricting carryover in water use cap rights.

Carryover in the water use cap may allow irrigators to use more than 100 per cent of entitlement volumes in some years leading to an overall increase in mean water diversions/use.

In the capacity sharing schemes implemented by SunWater, rights to storage space and rights to inflows are bundled together and cannot be traded separately. In practice, because of the presence of transaction costs in water trade, separable inflow and storage rights may be desirable. The benefits of separating inflow and storage rights would need to be compared with any administrative costs that might be involved.

Quantitative data

In this report, a range of quantitative data relating to the capacity sharing schemes at St George and MacIntyre Brook are presented, including hydrological data, water accounting data and capacity sharing adoption rates.

Hydrological data

Historical inflow data for the St George region demonstrate a relatively high level of variability (both at an annual and monthly time scale). In particular, St George (as with many Queensland systems) is subject to extreme high inflow events. In recent years (since 1999-2000), St George inflows have been well below the historical average. Capacity sharing (introduced in 2000) has therefore been operating during a period of unprecedented water scarcity.

Adoption rates

In both schemes, the adoption of capacity sharing by irrigators is voluntary. Adoption rates show that, among eligible irrigators, the take up of capacity sharing has been strong. As of the 2008-09 water year, more than 99 per cent of entitlements by volume were operating under capacity sharing at St George and more than 98 per cent at MacIntyre Brook, in its first year in operation.

Aggregate accounting data

Aggregate water accounts were constructed for both St George (for four water years) and MacIntyre Brook (the first six months of operation). These accounts show monthly aggregate water inflows, withdrawals, storage losses and reconciliation volumes for the two capacity sharing schemes.

The St George water accounts show significant end of year storage reserves, despite the relatively low inflows during the period and the relatively high storage losses. The water accounts also show how annual storage reserves serve to minimise variation in water use between years and within years. For example, the storage reserves proved particularly useful during the 2006-07 year when minimal inflows were received.

User level data

User level water accounting data from the two capacity sharing schemes are also presented in the report. The user level data demonstrate the extent of variation in water use/storage strategies across individual irrigators. For example, significant variation is observed in the end of year storage levels (account balances) of individual users in the capacity sharing system at St George.

The user level data presented in the report demonstrate that even in relatively small systems, with limited diversity in agricultural activity, individual irrigators display highly variable water use/storage preferences. As noted in the first report of this project (Hughes and Goesch 2009), one of the advantages of capacity sharing is that it permits irrigators to adopt diverse water use/storage strategies, without affecting other irrigators in the same system.

User level inflow data were used to estimate internal spill volumes for St George. Internal spills occur when an individual capacity share becomes full and receives surplus inflows (while other users' shares are less than full), necessitating the reallocation of surplus water to other water users.

The estimates of internal spills show that internal spill events at St George are relatively infrequent. However, there were a small number of particularly large internal spill events. These internal spill events were exclusively associated with extreme high inflow events, where the main dam filled (from in some cases less than half full) in only a few days. It is likely that in other systems with greater storage capacity and less variable inflows than St George (such as those further south in the MDB), internal spill volumes would be significantly lower on average.

1 Introduction

This report represents the second part of a two part project investigating the management of irrigation storages. The first report: *Management of irrigation water storages: carryover rights and capacity sharing* (Hughes and Goesch 2009) focused on the economics of storage management and the potential advantages of a capacity sharing approach. This report examines in detail two capacity sharing schemes implemented in Queensland – St George and MacIntyre Brook.

Capacity sharing is an alternative system of water allocation first proposed by Dudley and Musgrave (1988). Under capacity sharing, traditional volumetric water entitlements are redefined into shares of storage capacity and shares of inflows. Users can manage these shares independently; determining how much water to use and how much to leave in their share of storage. The first report from this project highlighted a number of the potential advantages of capacity sharing over traditional water property rights systems, including carryover rights.

Following the original development of capacity sharing by Dudley (Dudley and Musgrave 1988), some interest was shown in the concept by Australian policy-makers. An Industry Commission (1992) inquiry into water resources considered both capacity sharing and continuous accounting (an advanced form of carryover rights). The Industry Commission (1992) recommended the adoption of continuous accounting, but was more cautious in its appraisal of capacity sharing. While the report noted the potential advantages of capacity sharing, it held concerns over whether capacity sharing at the individual irrigator level would prove feasible (or cost effective) in practice given it had not been tried in any region at that time.

The Victorian Government opted to pursue capacity sharing at a bulk (water utility) level rather than at an end user level (Dudley 1993), while the New South Wales Government opted to pursue continuous accounting, which was introduced into a number of northern New South Wales irrigation regions (Border Rivers, Namoi and Gwydir). One example of a bulk level capacity sharing arrangement in Victoria is at Lake Eppalock near Bendigo, which is shared between Coliban Water (town water utility) and Goulburn-Murray water (irrigation water utility). Water sharing arrangements between the states is another form of bulk capacity sharing; an example being in New South Wales and Victoria on the Murray River, where each state has a share of flows and of storage capacity in major storages.

Capacity sharing has been in operation in the St George region in southern Queensland since 2000 and was introduced into the adjacent MacIntyre Brook region on 1 July 2008. To date, these are the only irrigation regions in Australia where capacity sharing schemes have been implemented at the end user level. In this report, a range of qualitative and quantitative information on the capacity sharing schemes in these regions is presented. This includes information gathered from interviews held with irrigators and members of the finance sector in the St George and MacIntyre Brook regions, as well as a range of empirical data provided by SunWater on the capacity sharing schemes operating in the two regions.

SunWater commonly refers to its particular capacity sharing arrangements as 'continuous sharing', a term which should not be confused with continuous accounting carryover. SunWater uses this term to reflect that its particular approach involves some extensions to the original capacity sharing concept as proposed by Dudley and Musgrave (1988). However, to avoid confusion, the 'continuous sharing' schemes in Queensland will be referred to as capacity sharing in the remainder of this report.

The first section of the report provides a summary of the main conclusions from the first report of this project. The second section of the report provides information on the St George and MacIntyre Brook regions. The third section summarises the capacity sharing rules surrounding water accounting and entitlement conversion, as they are specified in the relevant resource operation plans. The fourth section of the report provides information gathered from interviews with irrigators and members of the finance sector in St George and MacIntyre Brook. The fifth section presents a range of quantitative data relating to the two capacity sharing schemes, including adoption rates and aggregate and user level water accounting data.

2 Background

In this section some of the findings from the report *Management of irrigation water storages: carryover rights and capacity sharing* are summarised.

Management of water storages

Water storages (reservoirs) play a vital role in the supply of water for irrigation farms. Storages serve to smooth variation in the supply of water, and in doing so, maximise the economic value of water over time. For example, storages effectively allow water to be transferred from high availability (low need) periods to low availability (high need) periods in which additional water is likely to be of greater value.

The management of water storages is an important but difficult task. Determining what proportion of available water to store for the future and how much to consume now is a complex problem given the presence of substantial uncertainty over future inflows and water demands. Storage policies can be thought to vary along a yield-reliability spectrum, ranging from conservative (low yield-high reliability) to aggressive (high yield-low reliability). Yield refers to the long run mean water release/use level, while reliability refers to the variability of releases. A conservative rule would on average release a smaller percentage of available water for immediate consumption, holding more over in storage for future periods, resulting in higher reliability.

In Australia, major irrigation water storages are centrally managed via the announced allocation system, where each season a water manager determines the amount of water available for use now (water allocations) given prevailing storage levels. Under certain conditions, a centralised approach could achieve an efficient allocation of water resources. Specifically, this could occur if the water manager had perfect information on the water demand preferences (water needs) of irrigators and there existed an efficient (costless) market in water allocations.

In practice, the water manager is unlikely to have perfect information on the water preferences of irrigators. There is likely to be asymmetric information – irrigators are likely to know more about their water demands than the water manager. Second, in practice there are likely to be significant transaction costs in water trade. A centralised (announced allocation) approach relies heavily on trade in water allocations to allocate water between irrigators with varying reliability preferences. Given these practical difficulties, a decentralised approach, where irrigators are enabled to make their own storage decisions, may be preferable.

Carryover rights and capacity sharing

In the report *Management of irrigation water storages: carryover rights and capacity sharing*, two decentralised approaches to storage management were considered in detail: carryover rights and capacity sharing.

Carryover rights are present in many irrigation systems in the Murray-Darling Basin. They allow each water user to hold over a proportion of their seasonal water allocation for use in future seasons. Carryover rights have the potential to overcome some of the problems of centralised storage management. However, carryover rights are an incomplete solution since they do not define explicit property rights to storage capacity or to losses associated with storage. As a result, carryover rights generate external effects, where individual irrigators' carryover decisions affect other irrigators in the system. In an attempt to minimise these external effects, significant restrictions are often placed on carryover rights, which further weaken their effectiveness.

Capacity sharing is an alternative approach proposed by Dudley (Dudley and Musgrave 1988), which involves redefining water entitlements into separate storage capacity rights and water/inflow rights. Users are free to manage these shares independently; determining how much water to use and how much to leave in their share of storage. Unlike carryover rights, capacity sharing ensures that storage space is efficiently rationed and that storage losses are internalised (users are responsible for their contribution to storage losses). Capacity sharing has a number of other potential benefits relative to systems of carryover rights. Capacity sharing replaces the traditional announced allocation system and, in doing so, removes a layer of regulatory uncertainty from existing water entitlements. Capacity sharing involves redefining water rights at the source, which creates a number of potential efficiency improvements, including the potential to internalise water delivery losses.

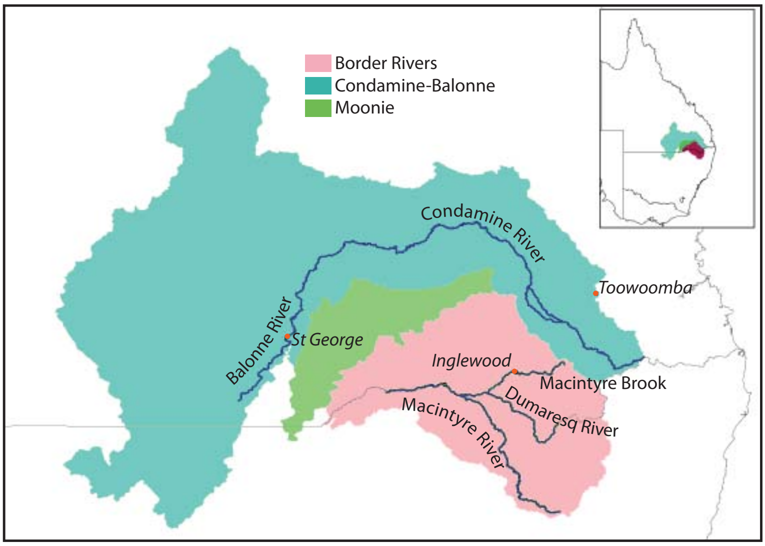
Capacity sharing may be viewed as a new system of property rights to water or alternatively as a bundle of reforms to existing property rights systems. Capacity sharing embodies such reforms as explicit storage capacity rights, internalisation of storage losses and delivery losses, source tagging, continuous (daily) water accounting, removal of restrictions on carryover rights, and simplification of the allocation determination process. Ultimately, capacity sharing provides water users (irrigators) with more flexibility over how and when they use available water resources. This increased flexibility allows individual water users to adopt water use practices which are optimal (profit maximising) for them, given the specific requirements of their agricultural enterprise. Overall, this serves to maximise the economic value of available water resources.

One complication with capacity sharing is the occurrence of internal spills – where individual water accounts reach capacity and forfeit their inflows to other water users. However, the allocative efficiency implications of internal spills are negligible and in practice internal spills are likely to occur infrequently. Another important consideration in the transition to capacity sharing will be to minimise any actual or perceived distributional effects, by ensuring the newly defined capacity share water entitlements adequately preserve all existing irrigator water entitlements. Capacity sharing is typically considered in the context of relatively simple water supply systems, where all water is sourced from a single storage. While there may exist some concern about the suitability of capacity sharing in more complex systems, it is not obvious that the concept could not be sufficiently generalised.

3 Region profiles

This chapter contains a brief description of the St George and MacIntyre Brook irrigation regions in which capacity sharing has been introduced.

map 1 Condamine-Balonne, Moonie and Border Rivers catchments



1 Land use in the St George irrigation region 2005-06

	area ha	approx. application rate ML/ha
Cotton	8 700	6.5
Grapes	800	3.5
Vegetables	200	4.0
Other irrigated area	2 300	–
Total irrigated area	12 000	–

Source: ANCID 2007.

St George

The region

St George is located on the Balonne River in southern Queensland, approximately 500 kilometres west of Brisbane (maps 1 and 2). The St George irrigation region covers a total area of around 19 000 hectares, of which 12 000 hectares are set up for irrigation (table 1). The main irrigated crop in the region is cotton, with some grapes, rockmelons and vegetables also being produced.

map 2 Condamine-Balonne catchment

2 Water entitlements and allocations in the St George region 2005-06

	number of customers	entitlement ML
Agriculture (medium priority)	155	71 703
Town (high priority)	1	3 000
Conveyance losses	-	9 721
Total	156	84 424

Sources: ANCID 2007; QLD Department of Natural Resources and Water 2007.

The St George irrigation region is one of the larger systems operated by SunWater in Queensland. However, St George is relatively small when compared with the major irrigation regions in southern New South Wales and northern Victoria, in terms of both land area and water use. The system supplies water to irrigators holding approximately 71 700 megalitres in medium priority water entitlements. The scheme also provides water for the town of St George (table 2).

Historically, the St George system has provided a highly reliable source of water to irrigators, with irrigators receiving their full allocation 90 per cent of the time (ANCID 2007). The main water storage in the St George irrigation system is the EJ Beardmore Dam, which has a storage capacity of 81 700 megalitres (table 3).

Water harvesting and on-farm storage

Irrigators in the St George region typically own two main types of water entitlements, standard 'supplemented water' entitlements and 'water harvesting' or spill entitlements. Supplemented water is a term used in Queensland to describe water provided through the irrigation system, that is, water which is captured and then released on demand from the irrigation system storages. Water harvesting licences allow holders to directly access a certain volume of

3 Storage capacity in the St George region

	storage capacity ML	dead storage ML	effective storage ML
EJ Beardmore Dam	81 700	3 120	78 580
Jack Taylor Weir	10 100	1 670	8 430
Mollabah Weir	2 580	440	2 140
Buckinbah Weir	5 120	780	4 340
Total	99 500	6 010	93 490

Source: QLD Department of Natural Resources and Water 2007.

stream/channel flows during high inflow spill periods, that is, when the main storage is full and overflowing. Supplemented water licences are the domain of SunWater, while water harvesting licences are the domain of the Queensland Department of Natural Resources and Water. Water harvesting licences are not to be confused with 'overland flow' licences where irrigators can capture water flowing on their land.

Many irrigation regions in the MDB have similar spill rights in place; however, in most regions these rights yield much less water than standard irrigation water entitlements. St George is relatively unique in that these water harvesting entitlements are a major source of water for many irrigators. For some farms, water harvesting rights provide more than half of total irrigation water.

The St George irrigation region has limited dam storage capacity relative to the inflows it typically receives. As such, large spill events have historically been relatively common, driving the demand for water harvesting licences. In addition, because the main storages are relatively shallow (and therefore have a high surface area relative to water volume) they are subject to high evaporation losses (table 15). The inefficiency of the central storages at St George is so severe that in many cases on-farm storages are significantly more efficient.

The region's limited and inefficient dam storage, together with the prevalence of water harvesting licenses, has driven development of on-farm storage capacity in the form of large earth embankment ring tanks. On-farm storage capacity in St George has been developed to a far greater level than that typically observed in most MDB irrigation regions.

Capacity sharing at St George

The introduction of capacity sharing at St George was motivated by a number of problems experienced with the previous announced allocation system. As discussed, there had been a large expansion in on-farm storage capacity. Irrigators who had made these investments had an advantage relative to other irrigators, since they could store unused allocations on-farm rather than surrender them to the common pool. In an effort to address these problems, SunWater introduced carryover rights (SunWater 2008, pers. comm., 21 January). However, this exacerbated the problem, since some irrigators were carrying over large volumes of water, which in turn adversely affected other irrigators. In some years, this effect was so extreme that more than half of the storage was being reserved for carryover water (SunWater 2008, pers. comm., 21 January).

An additional problem with the announced allocation system was ongoing disputes between irrigators and SunWater regarding SunWater's allocation policy, particularly its intra-seasonal allocation policy. SunWater tended to adopt a conservative approach, with low initial allocations which were typically increased later in the season as additional inflows arrived. This policy conflicted with the needs of a number of irrigators who required more water earlier in the season (SunWater 2008, pers. comm., 21 January).

SunWater began considering capacity sharing as early as 1996 and subsequently engaged in substantial consultations with irrigators, including a trial simulation of capacity sharing during the 1998-99 water year (financial year) (Thorstensen and Nayler 2005). Capacity sharing was officially introduced in the region on 1 July 2000.

MacIntyre Brook

The region

The MacIntyre Brook irrigation region is located on the MacIntyre Brook, near the town of Inglewood in the Border Rivers catchment, approximately 270 kilometres west of Brisbane (map 3). The MacIntyre Brook irrigation region is smaller than the St George irrigation region, with an irrigated area of 2050 hectares. The main irrigated crop grown in the region is lucerne, with some citrus, stone fruit, vines, olives and cereals also grown.

map 3 Border Rivers catchment

4 Water entitlements in the MacIntyre Brook region 2005-06

	number of customers	entitlement ML
Agriculture (medium priority)	83	17 322
Town (high priority)	1	450
Other **a**	na	828
Dumaresq River irrigation project (downstream)	1	6 400
Total	na	25 000

a Includes 'industrial', 'unallocated' and 'amenities'. **na** Not available.
Sources: ANCID 2007; QLD Department of Natural Resources and Water 2008.

The irrigation system supplies water to local irrigators holding approximately 17 000 megalitres in medium priority water entitlements. The system also provides water for the town of Inglewood and water for other downstream irrigation systems (table 4).

The MacIntyre Brook irrigation system has a large storage capacity relative to the volume of water entitlements. The main water storage is the Coolmunda Dam, which has a storage capacity of 69 000 megalitres. The total effective storage capacity exceeds the total annual water entitlement volume in the region by approximately 45 000 megalitres (table 5).

5 Storage capacity in the MacIntyre Brook region

	storage capacity ML	dead storage ML	effective storage ML
Coolmunda Dam	69 000	300	68 700
Greenup Weir	370	40	330
Whestone Weir	506	40	466
Ben Dor Weir	734	40	694
Total	70 610	420	70 190

Source: QLD Department of Natural Resources and Water 2008.

Water harvesting, on-farm storage and downstream trade

Unlike in the St George region, there is little scope for water harvesting in the MacIntyre Brook region. Irrigation water in the region is sourced primarily through the supplemented scheme (from the central storage). There is also minimal on-farm storage capacity in the MacIntyre Brook region. The main storage system (the Coolmunda Dam) is significantly more efficient (in terms of evaporation losses) than that in the St George scheme. However, delivery losses in the MacIntyre region are relatively high, with most water being delivered via the natural watercourse of the MacIntyre Brook (see the SunWater estimated loss factors in tables 6 and 7).

Unlike the St George region, there is substantial irrigation development directly downstream of the MacIntyre Brook, including the Dumaresq River irrigation project. There is strong demand for irrigation water from these regions, with irrigators in the MacIntyre Brook region historically trading significant amounts of their water allocations into these downstream regions.

Capacity sharing at MacIntyre Brook

The move to capacity sharing in the MacIntyre Brook region was largely driven by local irrigators who had observed the success of the capacity sharing scheme in the nearby St George region (Sunwater 2008, pers. comm., 21 January). One of the problems local irrigators were experiencing with the announced allocation system was a lack of access to carryover. Carryover rights were present in the region but were of little use to local irrigators given the strict restrictions placed on them (Sunwater 2008, pers. comm., 21 January). As in the St George region, there were also concerns regarding an overly conservative intra-seasonal allocation policy (low early season allocations). Another central issue in the MacIntyre Brook was the allocation of delivery losses, given the large volumes of downstream trade which typically occurred. Capacity sharing officially began in the region on 1 July 2008.

4 Capacity sharing rules

The specific rules governing the operation of the SunWater capacity sharing schemes are outlined in this section. These rules apply in both the St George and MacIntyre Brook regions. These capacity sharing rules are documented extensively in Queensland Government resource operation plans for the Border Rivers (MacIntyre Brook) and Condamine-Balonne (St George) catchments (QLD Department of Natural Resources and Water 2007, 2008).

Converting entitlements

In both regions, SunWater maintains a capacity sharing system side by side with an announced allocation (or bulk sharing) system. At the start of each water year, irrigators can decide whether to switch their entitlements over to capacity sharing, or alternatively, back to announced allocations. In the capacity sharing schemes implemented by SunWater, each capacity share defines an equal and inseparable proportional share of inflows and storage. For example, a 10 per cent capacity share includes a right to 10 per cent of the storage capacity and a 10 per cent share of available inflows. The implications of this inseparability are discussed later in the report.

For the purposes of capacity sharing, SunWater treats multiple storages within a system as a single conceptual storage. A capacity share defines a share of the system's total effective storage capacity (tables 11 and 13). SunWater maintains control over the operation of the multiple storage system, so irrigators do not have to deal directly with this complexity. For example, SunWater will determine which storage to release water from and may, as required, make transfers between storages to optimise the operation of the system (SunWater 2008, pers. comm., 21 January). However, it should be noted that both St George and MacIntyre Brook are relatively simple irrigation supply systems, involving a single major dam and a small number of downstream weirs.

When converting existing entitlements into capacity shares, SunWater applies a set of rules which account for differences in water entitlements, such as differences in reliability levels and expected delivery losses. Under the conversion rules, differences in reliability are addressed by converting entitlement volumes to a common reliability level, using a conversion factor. For example, in the St George system a 1 megalitre high priority entitlement is equivalent to a 1.75 megalitre medium priority entitlement (QLD Department of Natural Resources and Water 2007). However, in the St George and MacIntyre Brook regions, no high priority entitlements are held by irrigators.

Entitlements are then converted to an equivalent 'at storage' volume by dividing entitlement volumes by a transmission efficiency factor. Capacity shares are then calculated by multiplying total effective storage capacity by each irrigator's share of 'at storage' volume (equations 1 and 2).

The transmission efficiency factor (TEF) can be interpreted as the volume of water available for use by an irrigator given a 1 megalitre release of water from the storage. The transmission efficiency factors therefore reflect expected delivery losses. The transmission efficiency factors are calculated for specific zones within the irrigation region (tables 6 and 7) based on mean annual historical data.

1 $$SV_i = \frac{EV_i}{TEF(Z_i)}$$

2 $$CSV_i = S\left(\frac{SV_i}{\sum_i SV_i}\right)$$

Where:

i = individual entitlements, i: 1 to n

z = transmission loss zones, z: 1 to m $(m < n)$

Z_i = loss zone z applying to entitlement i, z: 1 to n

EV = reliability adjusted entitlement volume

$TEF(z)$ = transmission efficiency factor applying in zone z

SV = 'at storage' entitlement volume

CSV = capacity share (storage space) volume

S = total effective storage capacity

6 Transmission efficiency factors, St George

zone	description		TEF
1	Balonne River	53.6 kms upstream to 21.8 kms downstream of Beardmore Dam	1.00
2	Thuraggi Watercourse	0 to 27.5 kms downstream of Beardmore Dam	0.95
3	Balonne River	21.8 to 54.4 kms downstream of Beardmore Dam	0.80
4	Balonne River	54.4 to 88.8 kms downstream of Beardmore Dam	0.80

Source: QLD Department of Natural Resources and Water 2007.

7 Transmission efficiency factors, MacIntyre Brook

zone	description		TEF
A	MacIntyre Brook	0 to 4.6 kms downstream of Coolmunda Dam	1.00
B	MacIntyre Brook	5.6 to 38.5 kms downstream of Coolmunda Dam	0.85
C	MacIntyre Brook	38.5 to 78 kms downstream of Coolmunda Dam (i.e. to the junction of the MacIntyre Brook and Dumaresq River)	0.65

Source: QLD Department of Natural Resources and Water 2008.

In addition to transmission losses, transmission efficiency factors also have the potential to account for tributary flows. For example, irrigators located downstream of an unregulated tributary flow may require less water to be released from storage to achieve an equivalent level of water use compared with irrigators located upstream of the tributary. As such, a higher TEF (lower losses) may be applied to irrigators in these locations.

Water accounting

The SunWater capacity sharing system includes a limit on total annual water usage. Each entitlement holder receives an annual water use cap equal to the nominal volume of the original water entitlement. Water trade includes trade in capacity shares (i.e. permanent trade), trade in stored water (i.e. temporary trade) and trade in water usage cap rights.

The capacity sharing system involves daily water accounting. The accounting system records 'at storage' water volumes held in each user's account, as well as total seasonal usage against each user's share of the usage cap. Under SunWater's approach to water accounting, the 'at storage' volume of water in each user's account is calculated in equation 3:

3 $$V_{i,t} = V_{i,t-1} - L_{i,t} - \frac{W_{i,t}}{TEF(Z_i)} + IN_{i,t} + T_{i,t}$$

Where:

$V_{i,t}$ = volume of water in account i at the end of period t

$L_{i,t}$ = share of estimated total storage losses for user i in period t

$W_{i,t}$ = water orders/use for user i in period t

$IN_{i,t}$ = share of total storage inflows for user i in period t

$T_{i,t}$ = net water trade for user i in period t

Daily losses for the conceptual storage are calculated based on the storage volume and monthly evaporation loss factors estimated from historical data. These storage losses are allocated to individual water users in proportion to the water in their accounts. Estimated transmission losses are allocated to individual user accounts by applying the estimated transmission efficiency factors to user withdrawals. For example, an account withdrawal is equal to the water order (water taken by an irrigator at off-take) divided by the applicable transmission efficiency factor.

Given that transmission and storage losses applied to user accounts are only indicative, there is a need to reconcile individual water accounts with the actual volume of water in storage over time. These reconciliations occur in the SunWater capacity sharing system on a monthly basis. Reconciliation involves comparing the total water in accounts with the volume of water in storage as estimated by storage gauges. In the event there is a positive discrepancy, this is allocated to users in proportion to their capacity (storage) share, while a negative discrepancy is allocated to users in proportion to the volume of water in each user's account. SunWater tends to adopt conservative (relatively high) evaporation and seepage loss factors such that reconciliations generally involve small positive additions to users' water accounts (SunWater 2008, pers. comm., 21 January).

The accounting system also allocates internal spills, which occur when an individual user receives excess inflows after their account has reached capacity. At St George, any internal spills are dealt with in the same way as system inflows in that they are allocated to remaining users in proportion to the capacity share sizes.

To manage the additional water accounting requirements associated with capacity sharing, SunWater developed a customised computerised water accounting system. As of 2005, the system was integrated within SunWater's main corporate accounting and billing system, which facilitated the addition of an internet facility, allowing users to view their account volumes and conduct transactions, including ordering water, online (Thorstensen and Nayler 2005).

Other rules

Town water

In most of the water supply systems managed by SunWater in Queensland, local governments hold and manage town water entitlements, to satisfy town water demands. Temporary trade in water between town and irrigation water entitlement holders is also permitted. SunWater has historically held the town water entitlements for St George and Inglewood. With the introduction of capacity sharing, these town water entitlements have been converted to equivalent capacity shares which are managed by SunWater. Under the capacity sharing system, SunWater maintains the ability to sell excess town water to irrigators when appropriate, in accordance with water supply contractual arrangements (SunWater 2008, pers. comm., 21 January).

Environmental water

In both capacity sharing schemes, provisions are made for a minimum volume of environmental water. At St George, these provisions specify that the first 730 megalitres of water a day be deemed 'compensation' water, which is essentially water for environmental use (QLD Department of Natural Resources and Water 2007). This water can be temporarily stored where there is sufficient dam airspace; in effect this water is temporarily stored across the available airspace in individual users' capacity share accounts. In the event that the storage spills, any environmental water in storage is deemed to spill first. This arrangement is not necessarily ideal. Preferably, the environmental water manager would hold an explicit capacity share which would provide more flexibility to store water and make strategic releases.

Critical supply rules

Critical supply rules are also in place in both regions. These rules override water sharing rules in situations of extreme water scarcity and are triggered by specified storage level thresholds. In the event of an extreme water shortage, these rules stipulate that certain users (usually high security entitlement holders) are to be given priority over available inflows, rather than sharing inflows according to capacity shares as would normally occur. There may be a number of justifications for these critical supply rules. First, it may be preferable to have in place explicit rules for such situations, rather than face the risk of unpredictable discretionary changes as situations emerge. Second, these rules may be welfare enhancing if there are significant transaction costs in water trade. That is, these rules may achieve an allocation of water closer to a market outcome, reducing the volume of trade required (and exposure to transaction costs). However, such rules have the potential to create some perverse incentives where certain users (high reliability entitlement holders e.g. town water holders) actually benefit from a decline in storage levels below the critical threshold and as such have less incentive to manage their water conservatively.

5 Interviews

This section contains information gathered from interviews held with irrigators and members of the finance sector in the St George and MacIntyre Brook regions, as well as general discussions with SunWater.

SunWater's perspective

In this section information gathered though discussions with SunWater staff, specifically Tom Vanderbyl, manager of corporate strategy, is summarised.

From SunWater's perspective, capacity sharing has been a highly successful policy in the St George region (T Vanderbyl [SunWater] 2008, pers. comm., 21 January). SunWater suggested that capacity sharing has proven to be more cost effective to operate at St George than the previous announced allocation system. SunWater noted that the announced allocation system was more labour intensive, requiring the services of a number of water engineers, whereas capacity sharing requires only one main manager who is responsible for overseeing the water accounting system.

SunWater also indicated that capacity sharing at St George has resulted in a reduction in disputes and arguments between SunWater and irrigators and among different irrigators. Under the previous system, debates would develop regarding the timing and size of allocation announcements particularly between irrigators with divergent water preferences (e.g. those with/without on-farm storages or those with grapes rather than cotton). SunWater indicated that capacity sharing has significantly reduced the frequency and severity of these arguments, by allowing irrigators to manage their water entitlements independently of each other and SunWater.

SunWater felt that capacity sharing had been of benefit to irrigators by providing them with greater flexibility, particularly in helping them to respond to the recent drought conditions in the region. SunWater is of the view that irrigators have quickly adapted to the new system and are able to use it to their advantage. For example, SunWater noted that under capacity sharing irrigators appear to have responded to incentives to minimise storage losses and spills. They have done this by withdrawing water from their accounts when storage levels are high and withdrawing water to store in on-farm storage wherever the losses involved are less than expected dam storage losses. SunWater also observed that under capacity sharing cotton farmers have been able to (when economic conditions are favourable) plant winter crops such as wheat. This was difficult under the previous system since early season allocations were generally insufficient to sustain winter wheat crops.

SunWater noted anecdotal evidence of a recent increase in investment in intensive agricultural activities (requiring high water reliability) in the MacIntyre Brook region, which was attributed, at least partially, to the impending introduction of capacity sharing. SunWater is positive about the potential for capacity sharing to be introduced into other irrigation schemes in Queensland. SunWater observed that in many regions there is irrigator support for the introduction of capacity sharing and in some cases irrigators have been lobbying SunWater to speed up its introduction (SunWater 2008, pers. comm., 21 January).

Irrigator interviews

Informal face-to-face interviews were held with a number of irrigators in the St George and MacIntyre Brook regions. A full account of each of these interviews is contained in appendix A; in this section a summary of the main findings is presented. The purpose of these interviews was to obtain feedback from irrigators on the performance of the capacity sharing schemes. In particular, questions were asked about how capacity sharing may have influenced farm operations and water management decisions and whether there were any potential drawbacks or areas where capacity sharing could be improved. The anonymity of the irrigators interviewed is maintained by referring to them as irrigator 1, irrigator 2 and so on.

Background

St George irrigators

Four irrigators were interviewed at St George. Irrigator 1 and irrigator 3 are cotton farmers (traditionally the major crop grown in the region). Irrigator 1 owns a 470 hectare property, while irrigator 3 owns two properties (730 hectares and 810 hectares). Irrigator 2 grows table grapes on a 27 hectare property. Irrigator 4 runs a major horticultural operation growing a range of fruit and vegetables over two properties (310 hectares and 150 hectares).

All of the irrigators interviewed at St George had significant on-farm storages on their properties; these storages ranged between 600 megalitres and 1000 megalitres in capacity. The extent of the irrigators' reliance on water harvesting licences varied significantly, with irrigator 2 estimating 10 per cent of water was sourced through these licences on average and irrigator 3 estimating water harvesting to be around 50 per cent of total water use.

MacIntyre Brook irrigators

Two irrigators were interviewed in the MacIntyre Brook region. Irrigator 5 owns a 120 hectare property undertaking mixed cropping and livestock activities, which is fairly typical of the region. Irrigator 6 runs an organic chicken operation on a 2400 hectare property which also grows irrigated wheat for chicken feed. According to irrigator 5, on-farm storage and water harvesting are far less prevalent in the MacIntyre Brook region than at St George.

General views on capacity sharing

St George irrigators

All of the St George irrigators interviewed were supportive of capacity sharing. The irrigators indicated that one of the benefits of capacity sharing was the removal of third party effects, which occurred under the previous system as a result of carryover rights and sharing of storage losses. The cotton growers (irrigators 1 and 3) in particular emphasised this as a major benefit. The irrigators noted that this was a particularly important issue at St George because of the small central storage capacity and relatively high storage losses.

Irrigators 1, 3 and 4 all indicated that under the previous system the initial allocations announced by SunWater were often overly conservative and that there was an unnecessarily long time delay before allocations were increased. The irrigators felt that under capacity sharing these artificial constraints on water availability were reduced, since water was available as soon as inflows were received (at least within one day) rather than having to wait for the announced allocation process. The irrigators also indicated that significant uncertainty surrounded the previous announced allocation process. The irrigators felt that capacity sharing had removed a layer of this uncertainty, in that water availability was no longer influenced by the potentially unpredictable SunWater announced allocation process. Irrigator 4 emphasised this as a major benefit of capacity sharing.

All of the irrigators noted that capacity sharing facilitated diversity within the region by allowing irrigators to adopt personalised water strategies without affecting other irrigators in the system. For example, irrigators noted that capacity sharing made it easier to plant alternative crops with different water requirements (e.g. grapes and vegetables) and for irrigators to adopt different land allocation strategies (e.g. plant large or small crop areas). Irrigators 3 and 4 both suggested that the announced allocation system was more suited to systems where all irrigators grew similar crops. The ability of capacity sharing to facilitate differing water use strategies was emphasised as a major benefit by irrigators 2 (grape grower) and 4 (fruit and vegetable grower) who noted that their water needs were very different to those of cotton growers, with a greater emphasis on reliability. Irrigator 4 stated that capacity sharing was vital in his farm moving from traditional crops into horticulture.

The irrigators also generally felt that capacity sharing had led to a reduction in debates and argument between different irrigators and SunWater. Irrigator 3 indicated that meetings with SunWater over allocation policy would often generate fierce arguments between cotton growers and grape growers who had very different preferences regarding water use.

MacIntyre Brook irrigators

Both of the irrigators interviewed at MacIntyre Brook were strong proponents of capacity sharing. However, their reasons for favouring capacity sharing were slightly different to those raised at St George. Both irrigators noted that prior to capacity sharing carryover rights were practically non-existent. As iritator 5 explained, although carryover rights were officially available, significant restrictions meant that these rights were of little practical value to irrigators. Restrictions included limitations on the length of time carryover water could be held, a requirement for prior approval from other irrigators in the system and the forfeiture of carryover water in the event of a dam spill. These restrictions were placed on carryover rights owing to concerns about potential third party effects.

According to irrigators 5 and 6, the major advantage of capacity sharing, relative to the previous arrangements at MacIntyre Brook, was that it afforded irrigators more control over water use/storage decisions. In particular, capacity sharing allowed irrigators to adopt a conservative approach to water use and to maximise reliability where this suited their particular needs. Both irrigators indicated that the ability to improve water entitlement reliability was of use to their farming operations. Irrigator 6 in particular strongly emphasised the importance of water supply reliability for his business, to ensure a constant source of feed for chickens and to ensure agreements with suppliers could always be met.

Irrigator 5 noted that under the previous announced allocation system, early season allocations were often unnecessarily low (a situation similarly described by a number of St George irrigators). Irrigator 5 noted that with no on-farm storage and no carryover rights, a low initial season allocation was a major constraint on water availability. While at the time of the interview capacity sharing had only been in operation for a few months, irrigator 5 indicated that already significantly more water was available for irrigators early in the season than would have been under the previous system. Irrigator 5 also felt that overall, capacity sharing removed a degree of uncertainty over water availability that had been created by the announced allocation system. Irrigator 6 stated that another benefit of capacity sharing was the user level allocation of delivery losses, which was a significant issue for the region given the typically large volume of downstream water trade.

The transition to capacity sharing

The irrigators interviewed generally agreed that the transition to capacity sharing was well handled by SunWater. The irrigators noted that when capacity sharing was first proposed there was a general lack of understanding and awareness. SunWater's first task was educating irrigators and most felt that SunWater did a reasonably good job of this, through workshops, written materials and personal communication. The irrigators interviewed suggested that once irrigators had developed an understanding of the new system it quickly gained acceptance. As noted by irrigator 3, the problems occurring under the traditional system provided a willingness to pursue alternatives.

Generally the irrigators indicated there was minimal debate at St George over the entitlement conversion rules; irrigators were comfortable that capacity sharing was going to preserve their existing entitlements. For example, irrigators understood that those located further from the storage (deemed to be in higher delivery loss zones) would be compensated by receiving a larger proportion of 'at storage' volume. Irrigator 2 noted that the absence of high reliability entitlements at St George greatly simplified the conversion process.

A number of irrigators (1, 4 and 6) indicated that more resistance to the change was received from older irrigators who were generally averse to change. When capacity sharing was first introduced, a minority of older and other sceptical irrigators opted to remain under the announced allocation system. However, most of these irrigators moved to capacity sharing after one to two years, after observing other irrigators' positive experiences with the new system.

Irrigators 5 and 6 indicated that there had been significant interest in capacity sharing in the MacIntyre Brook region for some time, with local irrigators observing its introduction at nearby St George. Irrigators at MacIntyre Brook were dissatisfied with the existing system and the restrictions on carryover, and viewed capacity sharing as a viable alternative. While the experience of irrigators 5 and 6 generally mirrored those at St George, both did indicate that there was some debate in their region over the conversion rules, specifically the delivery loss factors and associated zones.

Using SunWater's capacity sharing system

Overall the irrigators interviewed found that capacity sharing did not impose any significant time or inconvenience costs. The irrigators suggested that the capacity sharing system as implemented by SunWater was relatively simple and easy to use.

Irrigator 1 suggested that the capacity sharing accounting framework may be more difficult to understand for some older irrigators. All of the irrigators indicated that they regularly used SunWater's internet system to monitor their water balance and to make water orders. While irrigators generally found the system convenient and easy to use, a number noted that the website can be quite slow at peak times.

Other issues

Irrigators 2 and 4 indicated that in the event their water accounts were approaching 100 per cent of capacity, they would withdraw water into on-farm storage to avoid internal spills. Irrigator 5 indicated that in the event his account was approaching 100 per cent of capacity, he would (in the absence of on-farm storage) most likely sell water.

A number of irrigators at St George (1, 2 and 3) indicated that water trade in the region was subject to significant search costs given the absence of a viable exchange. These irrigators noted that water trade was easier for regular traders who had over time developed a contact list of potential traders. For example, irrigator 4 could be considered a regular water trader who has over time developed such a contact list. Water trade seemed more common in the MacIntyre Brook region, although irrigator 5 noted that while there were a number of water brokers, there was at this time no viable central exchange in the region.

Irrigator 3 raised concerns regarding the water use cap rules. In particular, irrigator 3 noted that under the existing rules any water withdrawn from central storages counts toward the cap. This may create a disincentive for irrigators to transfer water from central storages into on-farm storages to minimise storage losses. Irrigator 3 also felt that restrictions on carryover in water use cap limited flexibility and proposed an alternative where the cap was based on a multiple year time frame.

Irrigators 5 and 6 noted that there had been some concerns raised in the MacIntyre Brook region from irrigators who regularly traded water into downstream systems. Some irrigators were concerned that the introduction of individual accounting of delivery losses meant that water entitlements would have less value when traded to downstream regions. Irrigators located in high loss zones were compensated for this by receiving a greater proportion of 'at storage' volume. However, irrigators located in low loss zones (close to the storage) and who regularly traded their water allocations downstream could possibly be worse off. While admitting the potential for some distributional effects, irrigator 5 noted that overall the individual accounting of delivery losses was a beneficial change for local irrigators because it limited external effects (where delivery losses were socialised (shared equally) among all irrigators).

Finance sector interviews

Phone interviews were held with four members of the finance sector, who had experience dealing with irrigators in the St George and MacIntyre Brook regions. A full account of each of these interviews is contained in appendix B; in this section a summary of the main findings is presented. The anonymity of the participants has been maintained by referring to them as financier 1, financier 2 and so on.

Background

Financier 1 holds the position of 'senior account manager – finance' for an agribusiness company with extensive experience dealing with irrigators in the St George region. Financier 2 is a regional agribusiness manager of a major Australian bank, who has extensive experience in dealing with irrigators in the MacIntyre Brook region. Financier 3 is the branch manager at Inglewood (MacIntyre Brook) for a prominent agribusiness company. Financier 4 holds the position of regional agribusiness manager (St George) for a major Australian bank.

General views on capacity sharing

Financiers 1, 2 and 4 were supportive of capacity sharing. Financier 1 was a particularly strong advocate for capacity sharing, suggesting that capacity sharing should be introduced nationwide. Financier 2, while supportive of capacity sharing overall, raised concerns regarding the effects of delivery loss rules on regular water traders in the MacIntyre Brook region. Financier 2 also questioned whether capacity sharing could easily be introduced in other regions where irrigators may not be as sophisticated and open to change. Financiers 1, 2 and 4 all noted that local irrigators were on the whole strongly supportive of capacity sharing.

Financiers 1, 2 and 4 also stated that capacity sharing is more transparent and subject to less uncertainty than traditional allocation systems, making it easier for farmers to make forward planning decisions. Financier 1 stated that capacity sharing provided irrigators with more certainty over the immediate water availability situation facing a farm. Financier 1 noted that this in turn provided lenders with greater confidence in the financial position of the farm and in extending financial support to the farm, at least in the short term.

Financier 1 also stated that capacity sharing encouraged irrigators to be more proactive managers of water resources and in doing so reduced dependence on and conflict with water authorities (SunWater). Financier 4 noted that the benefits of capacity sharing included a reduction in third party effects of water use decisions and greater flexibility to carry water over (without restrictions). Financier 4 also indicated that capacity sharing had led to a reduction in conflicts among irrigators in the St George region. Financier 2 stated that capacity sharing would likely be beneficial to the region of MacIntyre Brook (and the town of Inglewood) simply because it may lead to a reduction in water trade to downstream regions because of the internalisation of delivery losses.

Financier 3 held very strong concerns over the effects of delivery loss rules on regular water traders in the MacIntyre Brook region. Financier 3 felt that the delivery loss rules were having a significant detrimental financial effect on irrigators in the region who had typically traded a large volume of water allocations downstream each season. While financier 3 did not disagree with the principal of internalising delivery losses, he felt that the loss factors applying in the region were a significant overestimate and were not subject to adequate analysis.

Addressing some concerns

In this section, some of the concerns raised in the interviews with irrigators and financiers and other issues raised in general discussions with other stakeholders are considered in more detail.

Water use cap rules

The water use cap refers to a volumetric limit placed on each water user under the capacity sharing system. While each user owns a share of storage and inflows, water use in each year is limited to a maximum level equal to the nominal volume of the original water entitlement. At St George, irrigators can carry unused cap volumes in one year over to future years (so that greater than 100 per cent of entitlement volume can be used) up to a limit of 120 per cent. In the MacIntyre Brook region, no carryover in cap is permitted. Annual water use cap credits are tradeable in both regions.

The cap on water use is necessary from a regulator's point of view for a number of reasons. First, to ensure the regions achieve their obligations under the Murray-Darling Basin cap on water extractions. A catchment could potentially exceed its annual cap if water use in the region exceeds historical maximum levels (e.g. 100 per cent of total entitlement volume).

Second, the water use cap allows capacity sharing to be introduced without an official redefinition of existing water entitlements. Under capacity sharing, water entitlements are effectively redefined into shares of storage and inflows. However the entitlements in these capacity sharing schemes are not legally redefined; they are still water entitlements with the same nominal volume, only the method of water allocation has been altered.

Under an announced allocation system where there exists sufficient storage capacity, a maximum limit on water use results in additional storage reserves in wet years improving the reliability of future water supply. Where there exists a binding storage constraint (the storage is full) a maximum limit on water use results in dam spills, which may flow to downstream users, the environment or be captured by irrigators through water harvesting rights. Under capacity sharing, maintaining a maximum limit on water use will tend to protect the implicit rights of the environment and downstream users to storage spills in wet years.

There may be a number of pragmatic reasons for maintaining a limit on water use under capacity sharing, in addition to the motivations discussed above. For example, there may be constraints on delivery capacity or there may be negative environmental consequences from applying higher volumes of water (e.g. water and soil quality issues). Where possible, such issues would be better dealt with through explicit property rights.

A number of irrigators were critical of the restrictions on carryover in water use cap. However, given the potential problems associated with water use exceeding traditional maximum levels (i.e. the nominal volume of entitlements) regulators may be justified in restricting carryover in water use cap rights. Carryover in water use cap will allow irrigators to use greater than 100 per cent of entitlement volumes in at least some years and as such may lead to an overall increase in mean water diversions/use (potentially at the expense of downstream water users and/or the environment).

The definition of water use under the cap is another complex issue. Under the existing capacity sharing rules, any water withdrawn from off-farm storages counts toward the water use cap, even if this water is only being temporarily transferred into on-farm storages. Irrigator 3 noted that this creates a disincentive for irrigators to transfer water from central storages into on-farm storages to minimise storage losses. While these rules may create some perverse incentives, they are consistent with the rules of the Murray-Darling Basin cap where water diversions are defined as water released from storages, rather than inflows into storages.

Transmission efficiency factors and zones

In both the St George and MacIntyre Brook capacity sharing schemes, SunWater introduced a system of zoned transmission efficiency factors to account for delivery losses. The aim of such a system is to ensure irrigators take into account their marginal delivery losses. A well designed system of TEFs (which closely reflects real world delivery losses) will result in an improvement in the efficiency of water allocation and may result in a desirable shift in water use toward low loss regions and away from high loss regions. While a well designed system of delivery loss factors should result in an improvement in allocative efficiency, it has the potential to generate some distributional (equity) effects (where some irrigators are better off and others worse off).

The TEF system appears to have generated some concerns for irrigators in the MacIntyre Brook region. In particular, there is a view that the introduction of TEFs has adversely affected irrigators who regularly trade water allocations out of MacIntyre Brook into downstream areas.

Under the entitlement conversion rules, those irrigators located in higher loss zones are compensated by receiving a larger initial proportion of storage and inflows. This adjustment is calculated so that for all irrigators, capacity share entitlements provide an equivalent volume of water on-farm to existing entitlements. However, the adjustment results in a decrease in the 'at storage' volume of water entitlements in low loss zones relative to those in high loss zones. Irrigators in the low loss zones have less water to trade than they did under the previous system, meaning that the market value of their water entitlements has effectively decreased. Where there is a large volume of downstream water trade, as in the MacIntyre Brook region, irrigators in low loss zones may observe a reduction in income from water trading.

However, irrigators located in the low loss zones benefit in other ways. For example, these irrigators have to purchase less water 'at storage' than irrigators in high loss zones to receive an equivalent volume on-farm. That is, while they may receive less for selling their water, they may pay less when purchasing water. This may mean irrigators in low loss zones observe a relative increase in the market value of their land which may to some extent offset any relative decline in the market value of their water entitlements.

Another important issue is ensuring the TEFs are accurately defined so that allocative efficiency is maximised in the long run. It is clear that the TEFs as they are currently implemented are a substantial simplification of reality. One way in which the rules may be refined would be to adopt smaller zones or a system of continuously defined TEFs. Another potential refinement would be to allow for variable TEFs, to reflect variation in real delivery losses: in different times within a year (as already occurs with storage losses), in different weather conditions and under differing levels of river flows.

In practice, the efficiency benefits of such refinements would need to be evaluated against any potential added administrative costs. The feasibility of adopting more complex delivery loss rules remains a potential subject for future research.

Separability of storage and inflow rights

In theory, capacity sharing defines separate rights to storage space, future system inflows and physical water held in storage. In the capacity sharing schemes implemented by SunWater, rights to storage space and rights to inflows are bundled together and cannot be traded separately. However, where rights to physical water are separately tradeable and there exists an efficient market, the bundling of storage and inflow rights should not generate significant inefficiencies. For example, if a water user wishes to purchase additional storage space (but does not require additional inflows) he or she could purchase additional capacity shares (storage and inflows) and then sell the additional inflows on the physical water market as they occur.

However, in practice water markets are likely to involve significant transaction costs. Therefore, separable inflow and storage rights may be desirable since they will tend to reduce irrigators' reliance on temporary water trade. In practice the benefits of separating inflow and storage rights would need to be compared with any administrative costs that might be involved.
In addition to separable storage and inflow rights, there may be some advantages from introducing a facility allowing users to temporarily trade or lease storage capacity.

Capacity sharing in more complex systems

In the course of the project, a number of parties raised concerns about the potential for capacity sharing to be introduced in complex water supply systems, particularly those with multiple storages and/or unregulated tributary flows. This is less of an issue for the relatively simple St George and MacIntyre Brook systems; however, it may be a significant issue for many other supply systems in the Murray-Darling Basin. However, there are a number of ways of extending the capacity sharing concept to deal with this complexity; for example, introducing separate rights to different storages or to unregulated river flows. SunWater (2008, pers. comm., 21 January) is confident that capacity sharing would be feasible in many of their other water supply schemes in Queensland (a number of which are significantly more complicated than St George and MacIntyre Brook).

One potential issue would be managing the transition to capacity sharing. It may be more difficult to minimise distributional effects (maintain the yield of existing entitlements exactly) in complex systems with multiple water sources. The implementation of capacity sharing in more complex water supply systems remains a subject for future research.

6 Quantitative data

This section contains some quantitative data relating to the capacity sharing schemes in St George and MacIntyre Brook, including data on capacity sharing adoption rates, historical hydrological data and data from the SunWater capacity sharing accounting system. All data have been provided by SunWater unless otherwise indicated.

Capacity sharing adoption rates

As discussed, SunWater maintains an announced allocation (or bulk sharing) system side by side with their capacity sharing systems, with the adoption of capacity sharing by irrigators being voluntary. In both schemes, water entitlements with a volume of less than 10 megalitres (as well as any unmetered entitlements) are restricted from adopting capacity sharing. Table 8 displays the number of SunWater customers at St George operating under capacity sharing since 2002-03. The vast majority of customers remaining in the bulk sharing system are ineligible because of the 10 megalitre requirement.

8 Number of customers adopting capacity sharing, St George

water year	capacity sharing	bulk sharing	total
	no.	no.	no.
2002-03	75	83	158
2003-04	88	70	158
2004-05	87	71	158
2005-06	84	74	158
2006-07	82	76	158
2007-08	82	76	158
2008-09	82	76	158

Note: There are a number of instances (2005-06 and 2006-07) where the number of customers under capacity sharing declined. SunWater (2009, pers. comm.) suggests this is the result of the 10 megalitre rule being breached following the subdivision of water entitlements, rather than any voluntary exit from capacity sharing back to bulk sharing.

Table 9 contains data on the adoption of capacity sharing by entitlement volume as of 2007-08, with more than 99 per cent of entitlement volume operating under capacity sharing. Table 10 displays the percentage of eligible customers who adopted capacity sharing between its introduction in 2000-01 and 2004-05. In its first year, 77 per cent of eligible customers adopted capacity sharing, with the adoption rate increasing steadily thereafter.

Table 11 displays the total number of customers adopting capacity sharing (and the volume of water entitlements) in its first season of operation in MacIntyre Brook. The adoption of capacity sharing at MacIntyre Brook was very high in 2008-09 in comparison to the first year of the St George capacity sharing scheme.

9 Volume of water entitlements under capacity sharing, St George

water year	capacity sharing ML	bulk sharing ML	total ML
2002-03	82 840	1 644	84 484
2003-04	83 908	576	84 484
2004-05	83 938	546	84 484
2005-06	83 958	526	84 484
2006-07	83 939	545	84 484
2007-08	84 032	452	84 484
2008-09	84 077	407	84 484

Note: There is one instance (2006-07) where the volume of entitlements under capacity sharing declined marginally. SunWater (2009, pers. comm.) suggests this is the result of the 10 megalitre rule being breached following the subdivision of water entitlements, rather than any voluntary exit from capacity sharing back to bulk sharing.

10 Percentage of eligible water entitlements adopting capacity sharing, St George

water year	percentage adopting
2000-01	77
2001-02	90
2002-03	91
2003-04	93
2004-05	96

Source: Thorstensen and Nayler 2005.

11 Adoption of capacity sharing in 2008-09, MacIntyre Brook

water year	capacity sharing	bulk sharing
Number of customers	73	24
Volume of entitlements (ML)	24 519	478

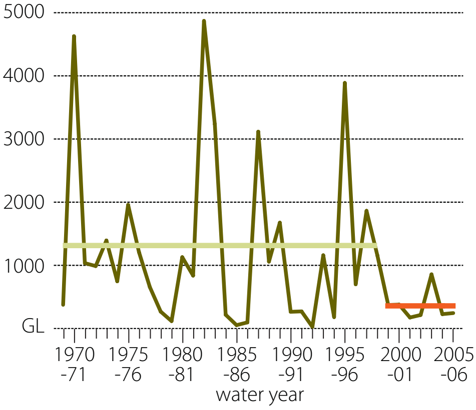
Historical hydrological data

Annual inflows into the St George irrigation system (Balonne River flows, upstream of Beardmore Dam) are shown in figure a.

Inflows at St George are highly variable and (as with many Queensland systems) prone to extreme high inflow events. Mean historical annual inflows are more than 10 times greater than the region's water entitlement volume and total storage capacity. Historically, the binding constraint in the St George irrigation region has been storage capacity (rather than water availability).

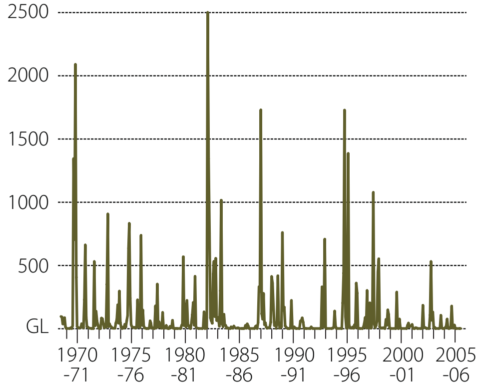
In recent years (between 1999-2000 to 2005-06) mean inflows have been well below historical averages. This reduction in mean inflows is not statistically significant given the variability of inflows. That is, it is not possible to determine whether this change represents a structural shift (e.g climate change) or if it is just the result of existing variability. Regardless, it is important to note that capacity sharing (introduced in 2000) has been operating during an extended period of low inflows, which has seen the St George irrigation system record its most serve water shortages since establishment.

a Historical annual flows, Balonne River Weribone upstream of St George



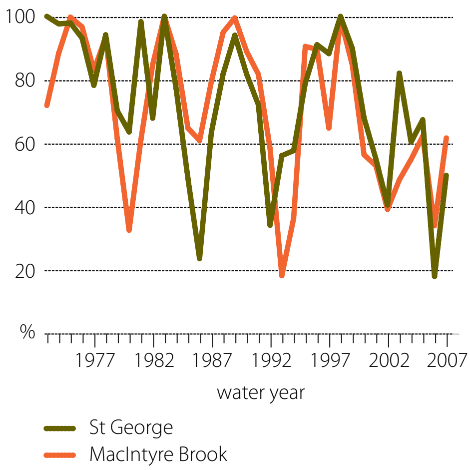
Source: QLD Department of Environment and Resources 2009.

b Historical monthly flows, Balonne River Weribone upstream of St George



Source: QLD Department of Environment and Resources 2009.

c Historical mean annual storage level



Monthly inflow data (figure b) demonstrate the occurrence of extremely high flow events, including several where monthly inflows significantly exceeded mean annual inflows. Summary statistics on monthly inflows into the St George system are presented in appendix table 22 Inflows are historically highest in January and February and lowest (often next to non-existent) in October.

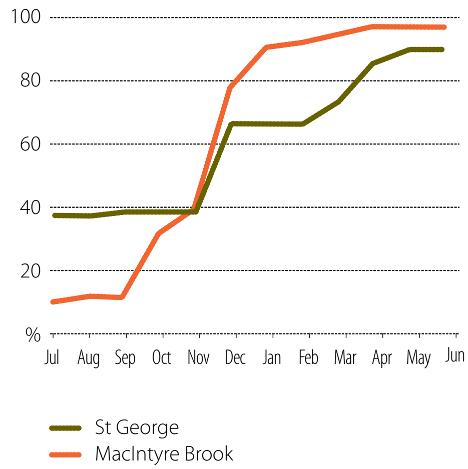
Mean annual (water year) storage levels of the main storages (Beardmore and Coolmunda) in the St George and MacIntyre Brook systems are displayed in figure c. The storage levels of the two schemes show a high degree of similarity as might be expected given their proximity (figure c).

Announced allocations

Announced allocation percentages for the two irrigation systems for six water years between 2002-03 and 2007-08 are displayed in appendix tables 23 and 24. For St George, these allocation percentages are relevant only for irrigators remaining in the bulk sharing system (those who chose not to join or were ineligible to join the capacity sharing system).

Despite the relatively low inflows during this period, final water allocations in both schemes were reasonably high, particularly relative to other irrigation systems further south in the MDB.

d Mean allocation percentages
2002-03 to 2007-08



However, the allocations recorded during this period, particularly those in St George, would still be substantially below the historical average; irrigators at St George have historically received a 100 per cent allocation in nine out of 10 years (ANCID 2007).

Between 2002-03 and 2007-08, final allocations in the MacIntyre Brook region were significantly higher on average than those in St George (figure d). Importantly, the data also display the typical intra-seasonal allocation pattern of the two systems, low initial allocations with significant increases during the mid water year high inflow period (December to February). This pattern is even more pronounced in the MacIntyre Brook system, where in four out of the six years no allocations were made for the first three months of the water year.

Aggregated water accounting data

Water accounting data for the St George and MacIntyre Brook capacity sharing systems were provided by SunWater. In this section, aggregated data from these accounts are presented, while in the next section an analysis of individual user level data is presented.

St George

Aggregate water accounts were calculated by aggregating individual user level data for each transaction type, for example, inflows, withdrawals, storage losses etc. Separate water accounts are reported for irrigators, town water and environmental water. Table 12 shows annual water accounts for irrigators in the capacity sharing system at St George between 2004-05 and 2007-08. A set of monthly water accounts for irrigators at St George is contained in appendix C. Annual water accounts for the town water and environmental water shares in the St George capacity sharing system are contained in appendix D.

In table 12, the opening storage volume represents the total volume of water across irrigators' capacity sharing water accounts on the first day of the water year. Inflows represent total inflows credited to irrigators in the capacity sharing system, rather than total system inflows. That is, this number excludes inflows credited to other users (i.e. town and the environmental water shares) and inflows which pass through the system when storages are full (dam spills).

SunWater's treatment of dam spills involves a degree of complexity. The environmental water account receives the first 730 megalitres of inflows each day. While the environmental manager (QLD Department of Environment and Resources) is entitled to store this water in the dam, it does not own an explicit right to storage capacity. In effect, environmental water is temporarily stored in the available capacity of irrigators' storage shares. In the event of a

12 Aggregate annual water account, irrigators, St George

2004-05 to 2007-08

	unit	2004-05	2005-06	2006-07	2007-08
Opening storage volume	ML	54 167	32 837	31 529	5 431
Inflows					
Inflows	ML	66 944	101 021	12 895	92 828
Overflows **a**	ML	3 969	9 485	0	18 454
Total inflows	ML	70 913	110 506	12 895	111 282
Outflows					
Storage losses	ML	36 421	40 817	12 759	36 152
Reconciliation	ML	+11 117	+5 801	+5 918	+6 655
Withdrawals **b**	ML	67 983	76 427	33 144	49 998
Total net outflows	ML	93 287	111 443	39 985	79 495
Est. ending storage volume	ML	31 792	31 900	4 439	37 217
Act. ending storage volume	ML	32 837	31 529	5 431	36 027
Ending storage percentage	%	42	40	7	46

a Water credited to irrigators (debited from environmental water account) in the event of storage spill. **b** Including water delivery losses.
Note: Estimated ending storage volumes are calculated as the balance of all water year transactions (opening storage volume plus inflows and overflows less storage losses and withdrawals plus reconciliations). Actual ending storage volumes are those reported in end of year remaining balance data.

dam spill, environmental water (held in irrigators' storage capacity) is deemed to spill first (the environmental water account is debited for the amount of the spill). These spills are then credited (effectively as additional inflows) to irrigators' accounts. In the water accounting data these transactions are referred to as 'overflows' and represent positive additions for irrigators and losses for the environmental water share.

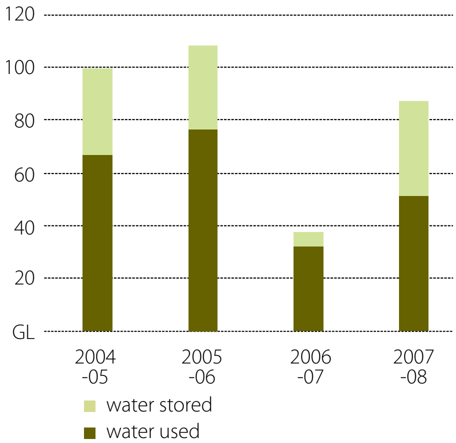
Storage losses represent the losses assigned to individual capacity share accounts based on established storage loss factors. Given that actual losses may differ from those estimated using loss factors, periodic reconciliations are required to ensure the volume of water in the storage matches that recorded in the water accounts. In the SunWater system these reconciliations occur on the last day of each month and can be ether positive or negative (net annual reconciliations are reported). Withdrawals represent water orders placed by irrigators plus associated delivery losses (as estimated via established delivery loss factors).

For each water year, table 12 reports both the estimated ending storage volume (opening storage volume plus the sum of annual transactions) and the reported ending storage volume from the accounting data. In most years the estimated ending storage level provides a reasonable approximation of the reported ending storage level.

The four water years from 2004-05 to 2007-08 all represent low inflow years relative to the historical average for the region. However, 2006-07 was an extremely dry year in which inflows credited to irrigators were barely sufficient to cover storage losses.

The water accounting data demonstrate the extremely high storage losses observed in the St George region. For example, in 2005-06, 40 817 megalitres of storage losses were

e Total water available, St George



credited to irrigators' accounts. Given the loss factors applied by SunWater, this figure is an overestimation of actual losses with 5801 megalitres of water being returned to irrigators in the monthly reconciliations. However, even net of reconciliations, storage losses in 2005-06 were 35 016 megalitres, approximately 37 per cent of the effective storage capacity.

As expected the annual net reconciliations are positive in all years (the loss factors tend to overestimate losses). However, the size of these reconciliations is quite large, particularly in 2004-05 where 11 117 megalitres was credited to irrigators; between 2005-06 and 2007-08 the aggregate annual reconciliation averaged around 6000 megalitres.

Table 12 and figure e show that users in the capacity sharing system at St George in aggregate carried over significant volumes of water in off-farm storage at the end of the water year in three of the four years (2004-05, 2005-06 and 2007-08). This is despite extremely high annual storage losses and the presence of significant (and often more efficient) on-farm storage capacity. The water accounts demonstrate how annual storage reserves serve to minimise variation in water use between years. For example, the storage reserves proved particularly valuable during the 2006-07 year when minimal inflows were received.

Table 13 displays water use against the aggregate water use cap for irrigators in the capacity sharing system. The data show that the cap on water use was not binding in any of the four water years. This confirms that the storage reserves accrued by capacity sharing users were voluntary and not the result of the cap on water use.

13 Total irrigator water use against water use cap, St George

2004-05 to 2007-08

	total water use cap ML	total unused cap ML	percentage of cap unused ML
2004-05	83 353	16 860	20
2005-06	80 383	9 415	12
2006-07	79 844	46 704	58
2007-08	86 228	36 235	42

Table 14 shows average monthly values for each of the water transactions for irrigators at St George. A full set of monthly water accounts are presented in appendix C.

14 Mean monthly water account data, all Irrigators, St George

2004-05 to 2007-08

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Opening storage	28 941	37 966	35 663	29 604	24 085	25 790	50 495	40 964	33 080	31 534	27 044	26 611
Inflows												
Inflows	10 073	214	1 192	479	6 495	36 540	3 226	1 781	5 353	0	2 043	1 027
Overflows a	979	0	0	0	0	4 375	747	1 876	0	0	0	0
Total inflows	11 052	214	1 192	479	6 495	40 915	3 973	3 657	5 353	0	2 043	1 027
Outflows												
Storage losses	1 368	1 767	2 322	2 435	2 631	5 784	4 677	3 543	3 010	1 867	1 242	890
Reconciliation	+45	+286	-471	+848	+986	+1 024	+803	+1 355	+1 288	-252	+449	+1 009
Withdrawals b	705	1 035	4 458	4 411	3 145	11 449	9 631	9 354	5 176	2 372	1 682	3 470
Total net outflows	2 028	2 516	7 251	5 998	4 790	16 209	13 505	11 542	6 898	4 491	2 475	3 351
Est. ending storage	37 966	35 663	29 604	24 085	25 790	50 495	40 964	33 080	31 534	27 044	26 611	24 288
Storage percentage	47	44	37	30	32	63	51	41	39	34	33	30

a Water credited to irrigators (debited from environmental water account) in the event of storage spill. **b** Including water delivery losses.

f Mean monthly inflows and water withdrawals, all irrigators, St George 2004-05 to 2007-08

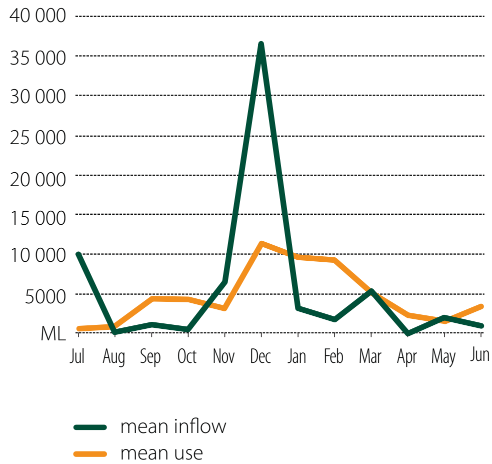


Table 14 and figure f show mean monthly inflows and water withdrawals for irrigators in the capacity sharing system. Over the four year period, the majority of inflows tended to occur in December (December flows accounted for more than 60 percent of inflows in 2007-08 and approximately 75 per cent in 2004-05).

The peak water use period occurred between December and February (being the primary growing/watering period for cotton crops), although significant amounts of water were used at other times of the year, with a smaller peak between September and October (being the likely planting period for cotton crops) and at the end of the water year in June. However, it should be noted that water withdrawals may be an imperfect proxy for on-farm water use, given some of this water may be placed in on-farm storages.

Figure f demonstrates the important role storage plays in smoothing out intra-seasonal variability in water availability. This role is very important in a system like St George which is prone to extreme variability in inflows both within and between water years.

g Mean monthly reconciliations and storage losses, all irrigators, St George 2004-05 to 2007-08

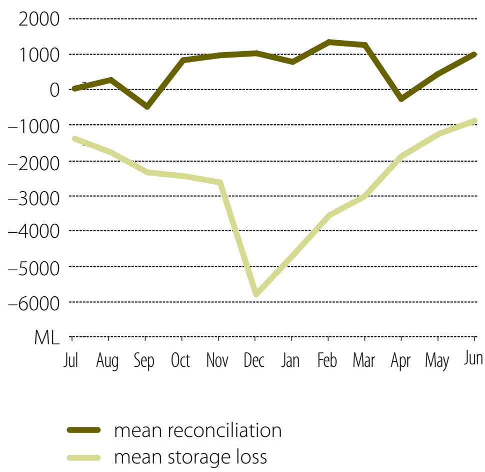


Figure g shows mean monthly storage losses and reconciliation volumes for irrigators in the capacity sharing system at St George. Storage losses were highest in December, when storage levels and evaporation rates tend to be at their highest. Reconciliation amounts averaged around 1000 megalitres a month between October and March. In each of the four years, a negative reconciliation was recorded for September.

This type of consistent pattern in reconciliation amounts (overestimating losses in some months and underestimating in others) could be the result of monthly storage loss factors being consistently too high or too low.

While there is a degree of consistency in the reconciliation volumes across years, these averages do hide some variability. For example, the highest monthly reconciliation amounts occurred consecutively in March and April in 2007-08; a positive reconciliation of 2730 megalitres followed by a negative reconciliation of 225 megalitres.

MacIntyre Brook

Table 15 contains a monthly water account for the first six months of the MacIntyre Brook capacity sharing system (July to December 2008). Over the period, minimal inflows were received and storage levels steadily declined.

As would be expected, storage losses (relative to storage volumes) were significantly lower over the same period of the year at MacIntyre Brook than at St George. However, reconciliation volumes were quite high: over the first six months of the scheme reconciliations were higher than the average reconciliation volume over the same period for St George, despite MacIntyre Brook being a smaller system with lower relative storage losses.

15 Monthly water account, all irrigators, MacIntyre Brook

July 2008 to December 2008

	Jul	Aug	Sep	Oct	Nov	Dec
Opening storage	20 670	20 185	19 125	18 590	14 494	13 653
Inflows						
Inflows	0	0	0	0	1 929	1 445
Overflows a	0	0	0	0	0	0
Total inflows	0	0	0	0	1 929	1 445
Outflows						
Storage losses	400	525	676	746	na	na
Reconciliation	+515	+173	+522	+1 113	+768	+721
Withdrawals b	600	708	380	4 462	3 537	1 819
Total net outflows	485	1 060	534	4 095	na	na
Est. ending storage	20 185.0	19 125.0	18 590.3	14 494.5	13 653.2 c	14 000 c
Storage percentage	29	28	27	21	20	20

a Water credited to irrigators (debited from environmental water account) in the event of storage spill. **b** Including water delivery losses. **c** Storage levels calculated from available data (excluding storage losses). **na** Data not available.

User level water accounting data

In this section individual user level data from the SunWater capacity sharing accounting system are presented. As discussed previously, a key motivation for capacity sharing is its ability to facilitate diversity in water use/storage practices. The disaggregated data presented in this section provide a detailed picture of the variation in water use strategies across different irrigators in the St George and MacIntyre Brook schemes.

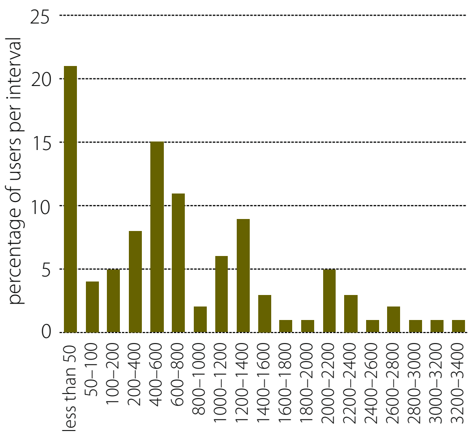
Storage share sizes

In the St George capacity sharing scheme, approximately 80 700 megalitres of the systems effective storage capacity is allocated to individual irrigators. Each water user in the scheme may have multiple water accounts (for example, some farmers own multiple properties and water entitlements) although most own one. From here on the data are analysed at the water

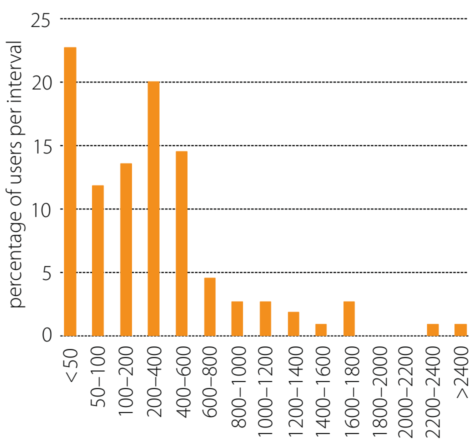
16 Storage shares, St George

size of storage capacity share	number of accounts
Less than 50 ML	18
50 to 500 ML	25
500 to 1500 ML	29
More than 1500 ML	22
Total	94

h Storage shares, St George



i Storage shares, MacIntyre Brook



account level. Each water account has an associated share of storage capacity. Table 16 summarises the distribution of storage capacity shares at St George while figure h is a histogram of the same distribution.

At St George the average storage share is around 800 megalitres. However, there are a number of very small storage shares of less than 50 megalitres and a number of relatively large shares up to 3400 megalitres.

The distribution of storage shares at MacIntyre Brook is shown in table 17 and figure i. In MacIntyre Brook the storage shares are smaller on average (average of approximately 600 megalitres compared with 800 megalitres at St George) reflecting the small total storage capacity (69 437 megalitres) and the greater number of water accounts. The distribution of storage share sizes shows a similar pattern to that at St George. At MacIntyre Brook there is one very large share (greater than 17 000 megalitres) which is held by a downstream irrigation area.

17 Storage shares at MacIntyre Brook

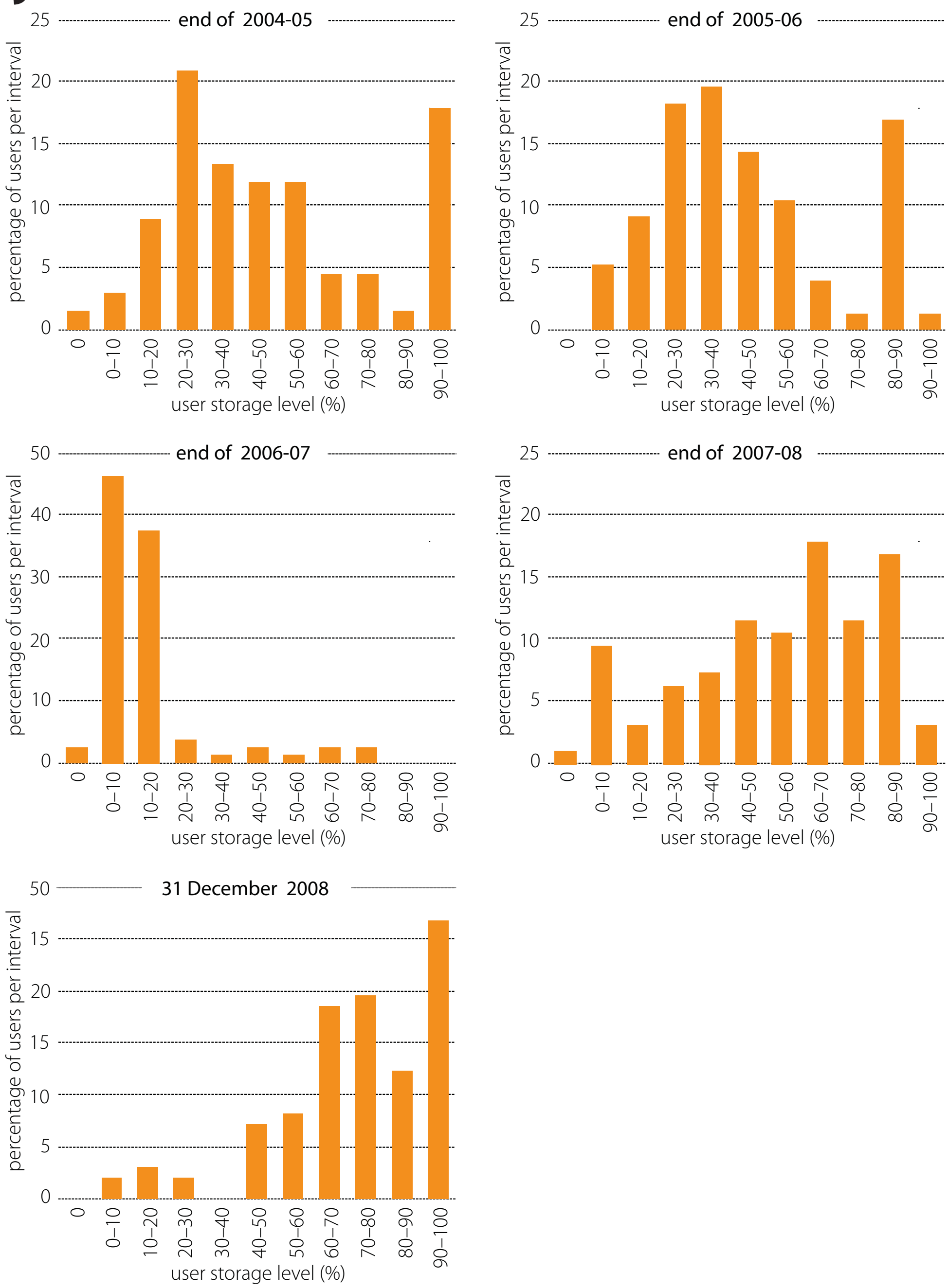
size of storage capacity share	number
Less than 50 ML	25
50 to 500 ML	61
500 to 1500 ML	19
More than 1500 ML	8
Total	113

User storage levels

Figure j contains histograms depicting the end of water year storage levels of individual water accounts in the St George capacity sharing scheme, between 2004-05 and 2007-08, as well as the storage levels at the half way point of the 2008-09 water year.

Figure j shows significant variation in the storage levels across individual user accounts. If

j Individual user storage volume (percentage of full capacity), St George



irrigators had relatively similar water preferences and were adopting similar water use patterns, individual water account storage levels would be similar. The fact that individual storage levels display significant variation demonstrates that irrigators in the St George capacity sharing scheme are adopting diverse water use strategies.

As noted in *Management of irrigation water storages: carryover rights and capacity sharing* one of the advantages of capacity sharing is that it permits irrigators to adopt diverse water use/ storage strategies, without having external effects on other irrigators in the same system.

At the end of 2004-05, the aggregate storage level for the St George capacity sharing system was 42 percent. Figure j shows that individual user storage levels ranged from zero to 100 per cent, with a large number (around 20 per cent) of users in the range of 20 per cent to 30 per cent, and a similar amount in the range of 90 per cent to 100 per cent. At the end of 2005-06, a similar distribution (and a similar aggregate storage level of 40 per cent) is observed, although there were fewer irrigators with storage levels of above 90 per cent.

The 2006-07 water year was particularly dry and the aggregate end of year storage level was only 7 per cent. A compression of the variability in storage levels is observed in 2006-07, with most water accounts being in the range 0 to 20 per cent by the end of the year. In 2007-08, storages improved in aggregate (46 per cent) and the variation in storage levels across individual water accounts increased significantly. This increase in storage level diversity between 2006-07 and 2007-08 is interesting, because it confirms the existence of significant differences in annual water use strategies across irrigators. That is, it demonstrates that storage level variation is not just the result of small differences in water use practices accumulated over an extended period of time.

At the middle of 2008-09 (31 December 2008) the aggregate storage level in the St George capacity sharing system was 77 per cent and more than one-quarter of the users' storage levels were in the range of 90 to 100 per cent.

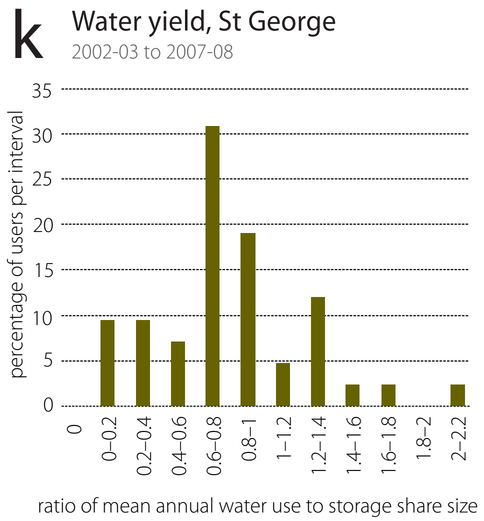
Water withdrawals

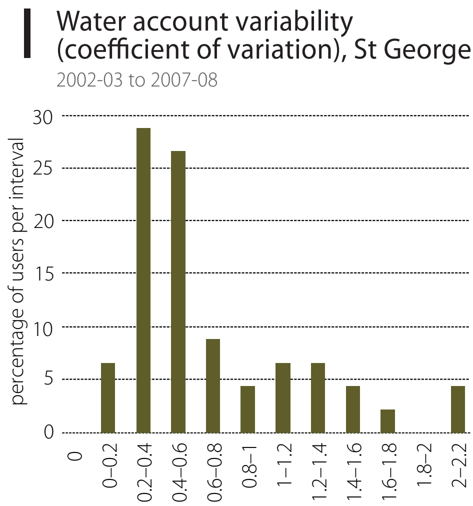
User level water withdrawal data at St George were available for the period 2002-03 to 2007-08. Given migration in and out of the capacity sharing scheme, not all water accounts are present in the accounting data over the entire period. In total 55 individual water accounts were identified for which a complete (six year) series of water use data were available.

Figure k shows the distribution of average water yield for the six year period (mean water use divided by storage share size) across the 55 water accounts. The estimated mean water yield was 0.8.

Figure l shows the distribution of water use variability for the six year period (the coefficient of variation) across the 55 water accounts. The estimated mean variability was 0.7. The coefficient of variation is defined as the ratio of the standard deviation to the mean.

Significant diversity is observed in the water yield and variability of individual user water accounts. Diversity in six year average yield and variability are evidence of consistent





differences in the annual water use strategies adopted by irrigators, for example differences between growers of different crops such as cotton and grapes. In addition to differences in crop requirements, different levels of reliance on water harvesting and/or on-farm storages may also lead to variation in water use practices.

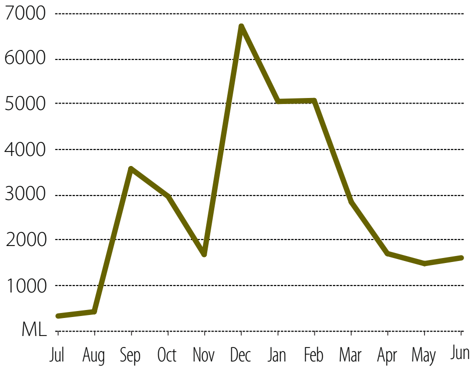
In general it is expected that yield and reliability are inversely related; that is, higher yield is associated with lower reliability (higher variability). However, in the water withdrawal data a number of accounts use water very infrequently (in some cases going multiple years without withdrawing water). These accounts contradict the usual relationship, having both low yield and high variability. It is likely that these water accounts are owned by users who are relying heavily on water harvesting and on-farm storages. In this case, water use yield and variability would be more accurately measured by analysing total water use (from all sources); however, such data are not available.

The water withdrawal data also provides an accurate picture of intra-seasonal water use patterns. Figure m presents mean monthly water use (aggregated over the 55 water accounts) and demonstrates a similar pattern to that observed in figure f, with peaks in September/ October and December/January/February. However, these aggregate data hide significant variation in intra-seasonal water use across individual accounts.

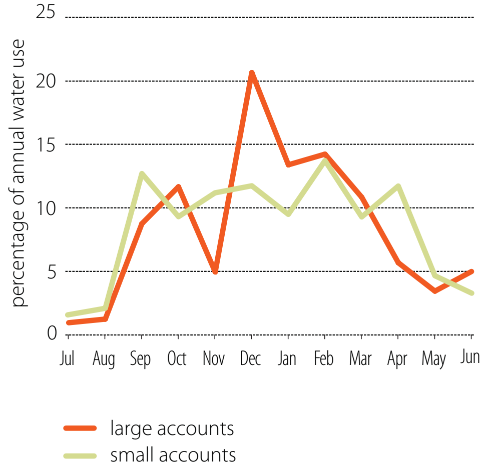
Figure n shows mean monthly water use as a percentage of annual water use for two groups within the sample of 55 accounts, those with small water accounts (less than 500 megalitres – 28 accounts) and those with large water accounts (greater than 500 megalitres – 25 accounts), with two outliers removed.

Figure n demonstrates that the small water accounts use water more consistently throughout the year, particularly between September and April. The larger water accounts are clearly those responsible for the peaks in water use, particularly the December peak. While it is not possible to determine from the data the crops grown by specific water users, it is likely (given the

m Mean monthly water use (total for 55 water accounts), St George 2002-03 to 2007-08



n Monthly water use strategies, St George



volumes of water involved and the timing of water use with the year) that irrigators with large water shares are growing cotton, while irrigators with smaller shares are growing grapes and other horticultural crops.

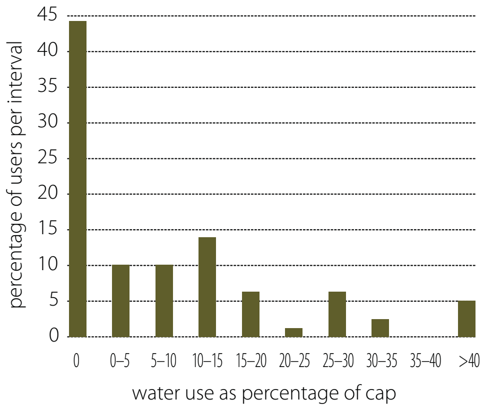
The water withdrawal data highlight the significant variation in intra-seasonal water use strategies across irrigators. This variation becomes even more evident when observing water use at a particular point in time, rather than over a six year average. Figure o and figure p show season to date water use as a percentage of water use cap as at October 2008 for irrigators at St George and MacIntyre Brook respectively. These figures demonstrate significant variation in the amounts of water used in the first four months of the water year.

A number of irrigators noted that under the announced allocation system early season allocations were often inadequate. In *Management of irrigation water storages: carryover rights and capacity sharing*, a number of explanations are proposed for the occurrence of undesirably low early season allocations under centralised announced allocation systems. Even where announced allocation percentages are adequate (a sufficient aggregate amount of water is available early in the season), substantial trade in allocations may need to occur between irrigators, because of the large variability in early season water requirements. For example, irrigators who require more than the announced allocation percentage at a point in time, would be required to purchase water from those who need less at that time. These requirements may therefore increase irrigators' exposure to transaction costs associated with water trade.

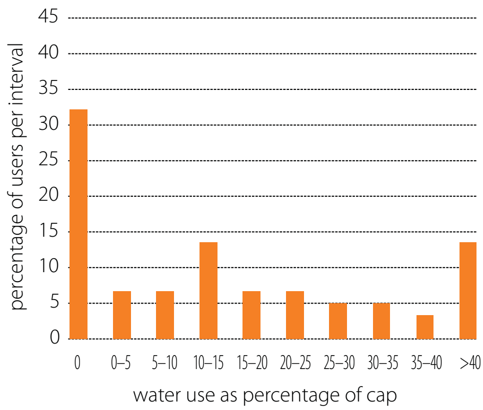
Internal spills

Internal spills occur when an individual capacity share becomes full and receives surplus inflows (while other users' shares are less than full), necessitating the reallocation of surplus water to other water users. Internal spill amounts are not recorded explicitly in the capacity sharing water accounting data. However, it is possible to estimate them by analysing the user level inflow data.

o Season water use at end of October 2008 (as percentage of water use cap), St George



p Season water use at end of October 2008 (as percentage of water use cap), MacIntyre Brook



On each day where inflows are credited to irrigators, the total inflow amount (in excess of water provided to the environment) is shared across individual water accounts in accordance with their specific storage share sizes (their proportional share of total storage capacity). However, when internal spills occur, deviations in inflow shares are observed. For example, an account which reaches full capacity on an inflow day will receive less than its usual share of inflows, while other accounts will receive more than their usual inflow share. By examining these deviations it is possible to estimate internal spill volumes. A summary of this analysis is contained in table 18.

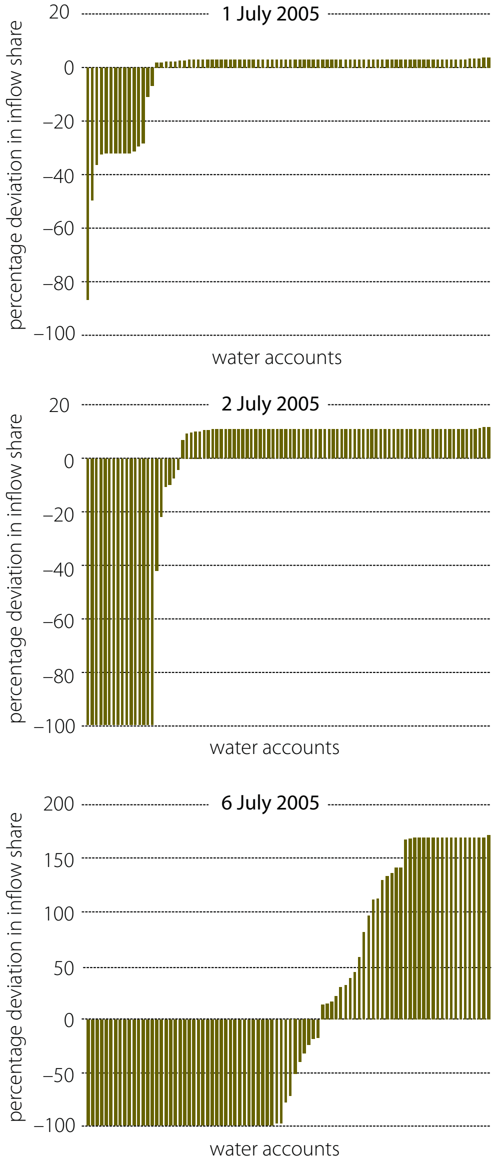
Table 18 shows that between 2004-05 and 2007-08 at St George, internal spill events were relatively infrequent. Significant internal spill events appear to be exclusively associated with dam spill events. That is, where the dam approaches full in aggregate, some individual shares are likely to reach capacity and begin to spill internally. As might be expected, in 2006-07 when very few inflows were received, no internal spills were recorded.

While internal spill events are relatively infrequent at St George, when they do occur they can be quite large. Over the four year period, the total volume of water reallocated through internal spills was slightly less than 28 000 megalitres, or approximately 8.6 per cent of total inflows over the period. The three largest internal spill events (one in 2004-05 and two in 2005-06) accounted for around 84 per cent of total internal spill volumes over the period (around 23 300 megalitres).

The three large internal spill events were all associated with extreme high inflow events which resulted in a rapid filling and eventual spilling of the water storages. In December 2004, 40 900 megalitres was received by irrigators in six days; in July 2005, 36 200 megalitres was received in four days; and in December 2005, 45 000 megalitres was received in five days, including one day where more than 17 800 megalitres was credited to irrigators' accounts.

With daily accounting, such extreme high inflow events provide limited time for irrigators to react to avoid internal spills. Even where irrigators have time to make water withdrawals, it is likely that during such high inflow events water could not be released from storage (or used by

q Percentage deviation of water account inflow shares during internal spill event July 2005, St George



irrigators) at a fast enough rate. Irrigators' only alternative in such a case would be to sell water on the temporary market or to purchase (lease) storage capacity (if such a market did exist).

As discussed previously, the St George irrigation system has a small total storage capacity relative to mean inflows and is subject to large inflow variability including extreme high inflow events. It would be reasonable to expect that internal spill events would be smaller and less frequent in systems further south in the Murray-Darling Basin, which are likely to have greater storage capacity and less variable inflows.

Figure q provides an anatomy of a significant internal spill event, which occurred at the beginning of the 2005-06 water year. In the first six days of the 2005-06 water year, a large and unseasonal inflow event occurred. As shown in figure j, there was substantial variation in water account storage levels at the end of the 2004-05 water year, with just under 20 per cent of water accounts in the range of 90 to 100 per cent full (well above the aggregate storage level of 42 per cent).

In figure q, negative inflow deviations represent water accounts which have reached capacity and internally spilled, while positive inflow deviations represent the additional inflows received by water accounts with free storage capacity. Inflow share deviations are shown for each water account, ranked in order from smallest (most negative) to largest positive deviation.

On 1 July 2005 a small number of shares reached capacity and internally spilled, with the remaining water accounts receiving a small percentage increase (around 3 per cent) in inflows. On 2 July the inflow event continued and more water accounts reached full capacity. Many of these shares had filled on the previous day and were now spilling their entire water inflow share (-100 per cent deviation). By 6 July, a majority of the water accounts had reached full capacity and those remaining users with storage capacity received very large increases in inflow share. By 7 July all shares were full and the storages filled in aggregate and began to spill, thus ending the internal spill event.

appendix A Irrigator interviews

Irrigator 1

Background

Irrigator 1 manages a 470 hectare cotton farm in the St George irrigation region. In addition to cotton (grown in summer), a variety of winter crops are also grown on the property including soybeans, chickpeas and sunflowers. As is typical of many farms in the region, irrigation water is sourced from both 'supplemented water' rights and 'water harvesting' rights. The property's supplemented water entitlement has a nominal volume of 2600 megalitres. The property has one major 'ring tank' (on-farm storage) with a capacity of 855 megalitres.

General views on capacity sharing

Irrigator 1 opted to join the capacity sharing scheme in its first year in operation and has remained in the scheme since. Irrigator 1 indicated that one of the main benefits of capacity sharing was the removal of the external effects which typically occurred under the previous system, for example because of carryover rights and socialised sharing of evaporation losses.

Irrigator 1 noted that individual accounting of losses was particularly important in the St George system because of the relatively high system evaporation losses. Irrigator 1 suggested that under the capacity sharing system irrigators now had an incentive to minimise these losses, by changing their crop and water use practices and by transferring water into on-farm storage (where the evaporation losses are lower). Overall irrigator 1 suggested that capacity sharing afforded irrigators more flexibility to adopt their own water use strategies without adversely affecting any other water users in the system.

Irrigator 1 noted that under the previous announced allocation system, SunWater's initial season allocations were often conservative (SunWater did not allocate all available water). Further, irrigator 1 noted that a degree of uncertainty surrounded the timing and size of allocation announcements, while capacity sharing provided more certainty, and gave users 'a clearer picture of where they stand'. Irrigator 1 found capacity sharing accounting to be predictable, noting that he was able to accurately replicate his capacity share account through a homemade spreadsheet.

Irrigator 1 held concerns that the previous system could generate situations where allocation announcements might be influenced by particular groups of irrigators. Irrigator 1 gave the example of where, in dry years, irrigators may adopt either a conservative approach, planting small crop areas, or a more risky approach, planting full crop areas and betting on later season allocations. Irrigator 1 suggested in such situations irrigators who plant large crop areas may place pressure on SunWater to allocate them water to avoid crop destruction, while irrigators who were more conservative would potentially be unrewarded.

The transition to capacity sharing

Irrigator 1 noted that when capacity sharing was initially proposed there was a general lack of awareness and understanding of the new system and its many rules. Capacity sharing presented a steep learning curve for many of the irrigators in the region. However, irrigator 1 indicated that overall the transition period was well handled and that with time irrigators' understanding of the rules improved. Once irrigators developed an understanding of the system it was quickly accepted. For example, irrigators located in the higher loss zones were willing to be exposed to delivery losses knowing they would be compensated by receiving a greater share of storage and inflows.

Irrigator 1 recalled there being resistance to capacity sharing from a small group of irrigators who were opposed to daily accounting of storage losses. This was more a psychological issue than anything; some irrigators didn't like the idea that their water balance was going down on a daily basis. Irrigator 1 estimated it took around two water years for all of the irrigators to develop a full understanding of capacity sharing and for the remaining sceptical irrigators to make the transition to the new system. Irrigator 1 noted that some of the irrigators who delayed the move to capacity sharing felt they were at a disadvantage relative to those who transferred in the first year. For example, irrigators who transferred when the dam was low received a lower initial balance in their accounts.

Using SunWater's capacity sharing system

Overall, irrigator 1 indicated that the capacity sharing system was relatively easy to use and did not impose any significant burden on an irrigator's time. However, irrigator 1 did indicate that the capacity sharing system may have been more difficult for older irrigators to understand, with some possibly having more trouble understanding the accounting rules and the distinction between water and water use cap. Irrigator 1 also indicated that for some irrigators, the SunWater statements may be confusing because of the extensive use of jargon and abbreviations.

Irrigator 1 made frequent use of the SunWater internet system to check his account (the volume of water in his share and the volume of water use cap remaining) and to place water orders. Overall, irrigator 1 has found SunWater's internet water accounting system to be useful, but he did note that at times the site can be very slow and has the occasional bug.

Other issues

Irrigator 1 noted that as a cotton farmer he was not particularly interested in carrying over water in storage from one season to the next to manage risk. His approach to dealing with water availability risk was more to vary cropping areas and maximise water use each season. Holding water over to increase reliability of supply would be more of an issue for those with perennial crops, which in the St George region means primarily grape growers.

Irrigator 1 indicated that he had never traded water, but had on occasion traded in water use cap. The main reason for not participating in water trade was simply a lack of heterogeneity, given that the majority of the farms in the region grew cotton. Irrigator 1 also suggested that while the costs of processing trades may be quite low, trade in St George may be subject to substantial search costs given the thinness of the market and the absence of a central exchange.

Irrigator 2

Background

Irrigator 2 runs a 27 hectare table grape farm in the St George irrigation region. Water for the property is obtained primarily from supplemented water rights, with only around 10 per cent of water being obtained through water harvesting, on average. The property's supplemented water entitlement has a nominal volume of 225 megalitres. Typically the water application rate for the table grapes would be in the range of 5 megalitres to 7 megalitres a hectare.

General views on capacity sharing

Irrigator 2 adopted capacity sharing in its first year of operation. Irrigator 2 indicated that he was in favour of capacity sharing and had no complaints with it. Irrigator 2 suggested that capacity sharing allowed irrigators to fully pursue individual water use strategies. For example, as a grape farmer, irrigator 2 was more likely to use less than his full entitlement and hold over excess water for future seasons relative to traditional cotton farmers. Irrigator 2 found that under capacity sharing, transferring water between seasons was easier. Irrigator 2 also suggested than in recent times he has adopted an increasingly conservative water use strategy, owing to increased concern about water availability given recent drought conditions.

The transition to capacity sharing

Irrigator 2 indicated that the transition to capacity sharing did not generate any major problems or any arguments from irrigators in the region. Irrigators were accepting of the move to individual allocation of delivery losses, understanding that irrigators located in high loss zones would be adequately compensated with larger shares of storage. Further, there were no high security entitlements at St George which made the conversion process simpler. Irrigator 2 indicated that he found capacity sharing relatively easy to learn. Irrigator 2 noted that at first it was natural for irrigators to feel slightly suspicious of the system but that once the rules were adequately explained it very quickly became second nature.

Using SunWater's capacity sharing system

Overall, irrigator 2 found that once an understanding of the system was gained, capacity sharing was relatively easy to use. Irrigator 2 commonly used SunWater's online water accounting system to place water orders. Irrigator 2 noted that while the system works well and is easy to use, it can be slow at times, particularly just prior to the water ordering deadline (at midday). Irrigator 2 also noted that the SunWater online site provided access to a wide range of current and historical hydrological data (e.g. inflows and storage levels).

Irrigator 2 suggested that he would be likely to transfer water out of his capacity share account and into on-farm storage during periods when his share was near full. Irrigator 2 noted that this would only be feasible for irrigators with reasonable on-farm storages, while other irrigators may look to lease (on-farm) dam space from neighbouring farms. Irrigator 2 noted that this may only work where irrigators have good trusting relationships with their neighbours.

Water trade

Irrigator 2 indicated he had not undertaken water trades with other irrigators. However irrigator 2 noted that many of the other grape farms in the region more regularly engaged in water trading. Irrigator 2 suggested that while the processing of trades is relatively easy, the main barrier to water trade was search costs; that is, you need to know who in the region to trade with and this is easier for regular water traders.

Irrigator 3

Background

Irrigator 3 operates two properties in the St George irrigation region. Both of these properties are traditionally cotton farms, but in recent times have been growing irrigated wheat. The two properties are 730 hectares and 810 hectares in size and have on-farm storage capacity of 1000 megalitres and 6000 megalitres respectively. Irrigator 3 holds supplemented water entitlements with a total nominal volume of 3470 megalitres. Irrigator 3 estimated that on average around 50 per cent of total irrigation water would be obtained through water harvesting rights.

General views on capacity sharing

Irrigator 3 was strongly supportive of capacity sharing, noting that one of the primary benefits was that it prevented external effects and allowed users to adopt their own water use strategies without affecting others. Irrigator 3 noted that under capacity sharing irrigators could adopt strategies to match their risk preferences. For example, risk averse farmers could plant small crop areas and conserve water while others were free to adopt more aggressive strategies. Irrigator 3 noted that in the past some irrigators (often those who relied on their water harvesting licences) were carrying over large amounts of water, filling up the dam and adversely affecting the rest of the users in the system. Under capacity sharing, these external effects had been reduced.

Irrigator 3 felt that the announced allocation system only worked well where irrigators in the region all operated their farms in similar ways. However, the St George region has a lot of diversity of water preferences, not just because of diversity in crop types, but because of different levels of reliance on water harvesting and on-farm storages. He also noted that the announced allocation system generated conflicts between different groups of irrigators. For example, SunWater had regular meetings with a representative group of irrigators to discuss allocation policy. These meetings often generated fierce argument between cotton growers and grape growers who had very different preferences regarding water use.

Irrigator 3 also noted that under the previous system there was a time lag between inflow events and allocation announcements, whereas under capacity sharing water is available virtually straight away (at most one day after received in the dam). Irrigator 3 noted that in some instances in the past the seasonal announced allocations had been revised downward (in one case from 60 per cent down to 50 per cent). Irrigator 3 felt under the previous system there was a degree of uncertainty surrounding SunWater's allocation policy.

Irrigator 3 noted that in the past when governments had created additional water entitlements in the region, this had resulted in a larger than anticipated reduction in the reliability of all other entitlements. Irrigator 3 noted that under capacity sharing no such situation could arise, because each entitlement is more precisely defined and the total capacity of the system (storage and inflows) is allocated. New entitlements could not be created without formally reducing the shares of existing entitlement holders.

Concerns with cap rules

While irrigator 3 was supportive of capacity sharing as a whole, he raised some concerns regarding the water cap rules. First, he noted that the water cap actually applies to water withdrawn from central storage (e.g. Beardmore Dam) rather than water use on-farm. Irrigator 3 felt this could discourage irrigators from reducing evaporation losses by storing water on-farm.

To illustrate this point a simple example (assuming zero delivery losses) is considered: an irrigator transfers 1000 megalitres from the dam to on-farm storage. If storage losses amount to 200 megalitres, then 800 megalitres is left for use but the irrigator's water cap is reduced by 1000 megalitres. If the 1000 megalitres is left in the dam and storage losses are 300 megalitres, then the irrigator could withdraw and use 700 megalitres of water, reducing his water cap by only 700 megalitres. If this irrigator is cap constrained (rather than water constrained) he may prefer to leave water in the dam, even if the losses are greater.

Irrigator 3 also felt that determining the cap over a fixed water year was not ideal because different irrigators have different growing seasons. Irrigator 3 also felt that the 20 per cent limit on carryover in water cap was too restrictive, preventing broadacre irrigators from taking full advantage of high inflow years. Irrigator 3 proposed an alternative approach in which the water cap is calculated over a longer time period, possibly three years.

The transition to capacity sharing

Irrigator 3 indicated that the transition to capacity sharing was smooth and that it did not involve any significant opposition from irrigators. Irrigator 3 suggested that rather than opposing the change most of the irrigators in the region were strongly supportive of it and were in fact driving the change. Irrigator 3 noted that the region's enthusiasm for change stemmed from the problems it had experienced with the previous announced allocation system (as outlined above). Irrigators were aware that the announced allocation system was not particularly suited to the St George region because of the diversity of water preferences in the region, the prevalence of water harvesting licences and large on-farm storages, and the relatively small central storage (relative to inflows).

Using SunWater's capacity sharing system

Irrigator 3 believed that capacity sharing did not impose any significant administrative or time costs on irrigators and that the benefits far outweighed the costs. Irrigator 3 was a regular user of SunWater's online water accounting system and has found it easy and convenient to use. Like other irrigators, irrigator 3 suggested that the website can be a bit slow at times. Irrigator 3 noted that access to historical hydrological information through the website was good but suggested that there could be better data on upcoming inflow events, for example data on stream flows upstream of Beardmore Dam.

Water trade

Irrigator 3 indicated that he had not engaged in water trade outside of transferring water between his two properties. Irrigator 3 suggested that trade in water in St George was subject to significant search costs (irrigators need to know who to trade with); as such he suggested that water trade was limited mostly to those who had extensive experience in trading and had built up a network of contacts.

However, irrigator 3 indicated that he had commonly undertaken trades in water use cap, noting that for cotton growers cap was more of a constraint than water. Irrigator 3 also noted that the restrictions on carryover in water use cap generated a lot of opportunities for trade. For example, as the end of the water year approaches there is typically a lot of trade in cap from those who have reached their carryover limit (20 per cent) to those who haven't.

Irrigator 4

Background

Irrigator 4 operates two major horticultural properties (310 hectares and 150 hectares) in the St George irrigation region. Irrigator 4's family started farming at St George in 1979 growing cotton. Rockmelons were first trialled in 1994 and since then the family has continued to expand its horticultural operations, to the point where their business is now 100 per cent engaged in horticulture. The main crops grown are rockmelons, onions and table grapes, with some pumpkins and watermelons. The properties include facilities for on-farm processing, with around 50 per cent of their products being sold to Coles and a significant proportion exported to New Zealand and Asia. The business is a major local employer, at peak times employing up to 250 staff. Both properties make use of trickle irrigation technology. Total on-farm storage capacity is 600 megalitres.

General views on capacity sharing

Irrigator 4 is a strong advocate for capacity sharing, stating that capacity sharing had revolutionised water management in the St George region. Irrigator 4 noted that capacity sharing allowed irrigators to manage their water independently to suit their particular needs. Irrigator 4 noted that the water needs of horticulture are different to the predominant crop of the region, cotton. Horticulture typically requires lower volumes of water with reliability being much more important. Further, most crops have shorter cycles. For example, a typical melon crop takes around eight weeks from planting to harvest.

Irrigator 4 suggested capacity sharing is akin to having one's own storage which can be managed independently and avoiding many of the external effects which occur under the traditional announced allocation system. Irrigator 4 suggested that the previous allocation system made it difficult to be different from the rest; it tended to suit situations where all irrigators were growing the same crops (i.e. cotton). Irrigator 4 felt that in the absence of capacity sharing, their farm would still be predominantly cotton with some opportunistic vegetable crops, saying that he 'couldn't imagine doing what we are now without capacity sharing'.

Irrigator 4 felt that under the previous system there was significant uncertainty surrounding allocation policy. Irrigator 4 felt that capacity sharing reduced this uncertainty and provided more confidence to make forward planning decisions, undertake new investments and to enter into agreements with purchasers. Irrigator 4 also noted that under the announced allocation system there was often a substantial time delay between inflows and allocation announcements, which made it particularly difficult to plant winter crops. Irrigator 4 noted that this short-term uncertainty over the timing of allocation announcements was an important issue for a horticultural farm because of the reasonably short growing cycles involved.

Irrigator 4 also noted that capacity sharing had reduced much of the tension and argument that had previously been common between water managers and different water users in the region.

The transition to capacity sharing

Overall, irrigator 4 found the transition to capacity sharing relatively straightforward. Irrigator 4 noted that younger farmers had no problems understanding the new system, however, it may have been more difficult for older irrigators (irrigator 4 is a second generation farmer; his father was the original manager of the property). Irrigator 4 transferred to capacity sharing in its first year of operation, while some (typically older) more sceptical irrigators made the move in later years. Irrigator 4 felt that the advantages of capacity sharing were clear and because of this the irrigators were generally supportive of the change. Irrigator 4 suggested that he could see that capacity sharing would provide a more transparent system where the rules would be 'set in concrete' rather than being subject to debate and change.

Using SunWater's capacity sharing system

Overall, irrigator 4 has found capacity sharing relatively simple to use. Irrigator 4 did note that the water cap rules were one area which occasionally generated confusion. The water cap is based on an annual accounting cycle. Irrigator 4 suggested that the change over between water years can become complicated because of carryover restrictions (a maximum of 20 per cent carryover in cap). Irrigator 4 noted that in most years they tend to carry over the maximum amount of cap.

Irrigator 4 indicated that he was a regular user of the SunWater internet system, using it to make water orders, check the water balance and to process temporary water trades. Irrigator 4 has found the internet system to be convenient and has had no significant problems with it. Irrigator 4 indicated that he closely monitors the water balance and in the event the account approaches its maximum balance he would most likely transfer water into on-farm storage to minimise the chance of spills.

Water trade

Irrigator 4 noted that in years with high water availability they typically use less than their full allocation, carrying over any remaining water in storage, thus improving the reliability of future water supply. In dry years, their farm is an active buyer of water. Irrigator 4 suggested that capacity sharing has simplified water trade in the region because entitlement holders 'know exactly what they have to sell'. Irrigator 4 noted that often they will buy a number of small parcels of water, for example 10 megalitres from the local golf club. Irrigator 4 noted that he had used SunWater's online water exchange, however, admitted that most water trades at St George were conducted privately. Irrigator 4 noted those interested in buying water needed to develop a network of contacts of irrigators who commonly sell water and that this was something that took time to achieve.

Irrigator 5

Background

Irrigator 5 operates a 120 hectare broadacre farm in the MacIntyre Brook region. Both livestock and cropping activities are undertaken on the farm. Crops are grown in a rotation (200 acres at one time) with the main crop grown being lucerne. The property has a supplemented water entitlement with a nominal volume of 500 megalitres. The property has no significant on-farm storage capacity; on-farm storage and water harvesting are generally far less prevalent in the MacIntyre Brook region than in St George. Irrigator 5 is also a director of two local cooperative businesses: a cattle feedlot and a lucerne drying plant.

General views on capacity sharing

Irrigator 5 noted that prior to capacity sharing strict limits were placed on water carryover in the MacIntyre Brook region. Previously, irrigators needed to seek formal approval from 75 per cent of irrigators to carryover water. There was a three month limit placed on carryover (after three months, carryover water was surrendered to the common pool) and in the event of a dam spill all carryover water was immediately surrendered. These restrictions reflected the region's generally negative opinion of carryover rights owing to concerns over potential external effects. These strict limits on carryover provided a major part of the motivation for introducing capacity sharing in the region. Irrigator 5 noted that with capacity sharing irrigators can carry over water freely without adversely affecting others, allowing them to manage their water 'how they see fit', whether that be in an aggressive or conservative fashion.

Irrigator 5 noted that under the announced allocation system early season allocations would often be too low: there would be water available that would, at least initially, remain unallocated. One of the reasons for this was that SunWater's allocation rules required the estimated storage losses for the remainder of the water year to be held in reserve. With limited access to carryover water and little on-farm storage, a low or zero initial allocation becomes a major problem for irrigators who need water during winter. Irrigator 5 noted that with capacity sharing water is available for use virtually immediately after it is received in the dam.

While at the time of the interview capacity sharing had only been in operation for a few months, irrigator 5 stated that it was already possible to observe the benefits of the new system. Irrigator 5 suggested that under capacity sharing significantly more water was available early in this season, than would have been allocated had the previous system still been operating. Irrigator 5 also stated that capacity sharing reduced uncertainty and provided more confidence in making forward planning decisions.

Irrigator 5 indicated that the introduction of capacity sharing was a positive influence on local farmers' decision to invest in a lucerne drying plant. The plant, which involved a combined investment of more than $10 million, consists of a large scale thermal drying plant, with a coal fired furnace, which is attached to an automated bailing and packaging system. The purpose of the plant is to convert lucerne into a high quality feed product for horses. Irrigator 5 noted that water reliability is vital to ensure a reliable supply of lucerne for the plant, especially given that lucerne is a semi-permanent crop.

Irrigator 5 noted that one concern with the capacity sharing system in the MacIntyre Brook was the absence of any carryover rights for the water cap. In St George, carryover in cap is permitted up to a limit of 20 per cent. Irrigator 5 suggested that a three year rather than a one year cap would provide irrigators with more flexibility. Irrigator 5 also suggested that the defined zones, to which transmission efficiency factors applied, were too large and that ideally there would be continuous variation in transmission efficiency factors or else much smaller zones (e.g. every 1 kilometre along the river). Irrigator 5 noted that the large zones can create perverse incentives for irrigators located near zone boundaries, noting that his farm straddles a zone boundary.

Irrigator 5 indicated that capacity sharing was relatively easy to use, noting that he commonly made use of SunWater's internet accounting system to make water orders. Irrigator 5 did note that the SunWater website can at times be a bit slow.

Irrigator 5 indicated that in the event that his capacity share approached its limit, his likely strategy would be to temporary transfer (trade) water, given the absence of on-farm storage and the strong demand for water from downstream users.

Trading water downstream

Irrigator 5 suggested that water entitlement holders in the MacIntyre Brook region could be broadly classified into two groups: those who are committed to using their water allocations each season and those who commonly sell their water allocations downstream. Irrigator 5 noted that capacity sharing had caused concerns for entitlement holders who regularly trade water to downstream irrigation systems. The source of this concern has been the transmission efficiency factors, which determine the delivery losses allocated to entitlement holders.

Prior to capacity sharing, water entitlements were not explicitly subject to delivery losses, with all delivery losses effectively socialised or shared among all entitlement holders. Irrigator 5 noted that in the past there had been some opposition to out of system water trade because the significant delivery losses were effectively shared among the entitlement holders in the MacIntyre Brook region, rather than being incurred directly by those who traded water. Irrigator 5 noted that under capacity sharing this socialisation was minimised through a system of transmission efficiency factors.

Irrigator 5 noted that while assigning delivery losses to water users was an advantage overall, irrigators who regularly traded water downstream may actually be at a disadvantage. Irrigator 5 noted that under the existing rules irrigators who use their water allocations on-farm are not adversely affected because those in the high loss zones were compensated with a greater proportion of at storage volume. However, irrigators located in low loss zones (close to the storage) who regularly sell their water downstream may be worse off because delivery losses are now applied to any water they sell. Irrigator 5 anticipates that in the long run the trend will be toward increasing use of water entitlements in the MacIntyre Brook region and a reduction in trade of water downstream (at least partially because of the delivery loss rules).

The transition to capacity sharing

Irrigator 5 noted that irrigators in the MacIntyre Brook region were generally supportive of the move to capacity sharing. Many irrigators were for some time actively lobbying SunWater to introduce capacity sharing. Irrigator 5 suggested that capacity sharing represented a simple and transparent set of rules, but admitted that it can at times be difficult to explain capacity sharing.

Irrigator 5 noted that some resistance to the change was received from those irrigators who were consistently selling their water allocations downstream, for reasons outlined in the previous section. Irrigator 5 also noted there was some opposition from the Border Rivers Food and Fibre Association which was in favour of introducing continuous accounting, which had already been implemented in other regions within the Border Rivers catchment. However, irrigator 5 recalled that the more the irrigators learnt about the two systems the more they realised that capacity sharing was a superior system.

Water trade

Irrigated 5 noted that processing of temporary water trades in the region is simple and low cost. However, irrigator 5 noted that at present there was not a viable exchange for trading water in the region. Irrigator 5 noted that in the past the region had established a 'water pool' which was essentially an automated computer exchange. However, this was abandoned when water brokers, who could operate at a lower cost, developed a greater presence in the region. Irrigator 5 noted that the brokers help to address water trade search costs by building up a network of contacts of irrigators in the region who commonly trade water. Irrigator 5 noted that Elders recently held a one-off water auction, where water allocations from willing sellers were auctioned off to the highest bidder. Most of the water sold at the auction was purchased by irrigators downstream of MacIntyre Brook.

Irrigator 6

Background

Irrigator 6 manages a 2400 hectare certified organic poultry farm in the MacIntyre Brook region. The farm is a highly vertically integrated operation including: egg incubation; growing of organic irrigated wheat for feed; and on-farm slaughtering, processing and packaging. Substantial investments have been made in recent years in modern slaughtering and processing facilities. The farm sells the majority of its products to major supermarket chains. Drinking water for the chickens is sourced from groundwater, whereas water from the MacIntyre Brook irrigation system is used for growing irrigated wheat. The farm has on-farm storage of 1200 megalitres built for the purpose of capturing overland flows, although overland flows have not occurred on the property in the past 12 years.

General views on capacity sharing

Irrigated 6 suggested that capacity sharing gave irrigators greater control over managing their water resources. Irrigator 6 noted that for his particular farming business water reliability was vital, since it ensured constant access to organic feed through the growing of irrigated organic wheat. Irrigator 6 noted that while in emergency situations it may be possible to buy feed, the cost of purchasing organic wheat in drought periods is likely to be prohibitive. Further, irrigator 6 noted that reliability is critical in maintaining relationships with purchasers, particularly major supermarket chains.

Irrigator 6 suggested that capacity sharing allowed individual farms to manage their water to suit their individual risk profiles. In irrigator 6's case, capacity sharing allows them to adopt a conservative approach to water management to maintain the desired level of reliability. That is, capacity sharing allows them to carry over water in storage to increase reliability without affecting other water users.

Irrigator 6 noted that under the previous system water carryover rights were very limited (including a three month time limit on carryover water). It was effectively a 'use it or lose it' system. Irrigator 6 noted that in downstream irrigation areas on the Dumaresq River there were relatively few restrictions on carryover and that this tended to encourage trade in water out of the MacIntyre Brook region. Irrigator 6 also noted that under the previous system there was no accounting for delivery losses, which meant that the large delivery losses incurred when water was traded downstream were effectively shared across the remaining irrigators in the MacIntyre Brook system.

Overall, irrigator 6 was a strong advocate for capacity sharing, suggesting that capacity sharing should be adopted nationally and saying that there should be a concerted effort at a national level to eliminate all socialisation of water losses in irrigation water schemes.

The transition to capacity sharing

Overall, irrigator 6 felt that capacity sharing was a simple and transparent system which was not difficult to learn. Irrigator 6 indicated that SunWater managed the transition to capacity sharing well, engaging with irrigators, running workshops and generally helping to improve understanding. Irrigator 6 indicated there was in general very little resistance to the change from local irrigators, who could see the potential benefits and were encouraging SunWater to implement capacity sharing.

Irrigator 6 did note that there was some resistance from a small number of older irrigators in the region who were concerned about the daily accounting of evaporation losses. Irrigator 6 also noted there had been some controversy surrounding the transmission efficiency factors and their associated zones, with concerns that irrigators who regularly sold their water downstream had been adversely affected. Irrigator 6 admitted that there were still some areas where the capacity sharing rules could be refined including the transmission loss rules and water cap rules. However, irrigator 6 stated that capacity sharing is still a superior system overall and that the rules will only improve over time as irrigators and irrigation authorities gain more experience.

Other issues

Irrigator 6 indicated that he regularly engaged in water trade and was on average a net seller of water. Irrigator 6 noted that he owns more water entitlements than required and often opportunistically sell excess water. Irrigator 6 noted that as the operation expands he may move towards becoming a net buyer of water. Irrigator 6 indicated he is unlikely to store irrigation water in on-farm storage because the evaporation losses are much higher in on-farm storage. Irrigator 6 noted that he regularly used SunWater's online capacity sharing water accounting system, finding it easy to use and not at all slow.

appendix B Finance sector interviews

Financier 1

Financier 1 is a rural finance manager for an agribusiness company, with extensive experience dealing with irrigators in the St George region. Financier 1 has a good understanding of capacity sharing, having sat on a committee involved in drafting the Condamine-Balonne resource operations plan (ROP), in which the capacity sharing rules are specified. Financier 1 noted that the committee involved in drafting the ROP were in agreement over the advantages of capacity sharing. However, their only concern was in getting the details right: appropriately defining all of the capacity sharing rules so that the system worked smoothly.

Overall, financier 1 indicated he was a strong supporter of capacity sharing, noting that it represented a more transparent set of rules. Financier 1 felt that capacity sharing was clearly superior to the standard announced allocation system common in most of the Murray-Darling Basin. Financier 1 noted that 'irrigators know exactly how much water they have' at any point in time. Under capacity sharing, financier 1 felt that irrigators faced less uncertainty and were better placed to make forward planning decisions.

Financier 1 felt that capacity sharing encouraged irrigators to more proactively manage their water. Financier 1 said that it 'changes their mindset'. Rather than 'what water are they going to give us', their attitude becomes 'how can I manage my water to maximise its benefits'. Financier 1 noted that one of the main improvements of capacity sharing was that losses (in storage and delivery) were now transparent and irrigators were individually accountable for them. Financier 1 noted that this provided irrigators with an incentive to minimise their exposure to losses.

Financier 1 noted that in his experience, irrigators at St George have a strong understanding of capacity sharing, noting that they are able to develop strategies to capitalise on capacity sharing to maximise their available water (minimise their losses). Financier 1 noted that capacity sharing had facilitated a diversification of cropping activities in the St George. Financier 1 believes capacity sharing should be included into the national water initiative and introduced nationwide.

Financier 1 noted that as a lender his organisation is continually assessing the financial position of irrigation farms and deciding whether to extend or withdraw financial support. Financier 1 felt that, from their perspective, making these assessments was easier under a capacity sharing framework. Financier 1 felt that under capacity sharing there was more certainty about the immediate water availability situation facing a farm. This allowed irrigators to more confidently plan their activities for the upcoming season; this in turn provided lenders with greater confidence in the financial position of the farm at least in the short term.

Financier 2

Financier 2 is a regional agribusiness manager of a major Australian bank, who has extensive experience dealing with irrigators in the MacIntyre Brook region. Overall, financier 2 indicated he was in favour of capacity sharing as a concept, but noted there were some issues with the MacIntyre Brook capacity sharing scheme that needed to be addressed. Financier 2 noted that one of the main concerns with the MacIntyre Brook scheme was the effect of transmission loss rules on traders of water. However, Financier 2 noted that in general the irrigators are supportive of capacity sharing and that even those adversely affected by the transmission loss rules would admit that it is a good system overall.

Financier 2 noted that the irrigators in the MacIntyre Brook region are proactive and that the change towards capacity sharing was driven largely by them. Financier 2 noted that it was hard to determine at this stage what effect the capacity sharing scheme may be having on irrigators and on economic outcomes in the region. Financier 2 noted that the MacIntyre Brook irrigation system has been reliable in recent times (especially relative to much of the Murray-Darling Basin) and that more may be learnt about the performance of capacity sharing when it operates under drought conditions. Financier 2 noted that capacity sharing may in the long run have a beneficial effect on the local region, purely because of the accounting for transmission losses, which may discourage the trading of water to downstream systems.

Financier 2 felt that capacity sharing provided irrigators with more certainty and made it easier to make forward planning decisions. Financer 2 noted that introducing capacity sharing in the MacIntyre Brook region was easier because of the support and encouragement received from local irrigators. Financier 2 noted that introducing capacity sharing may be more difficult in other regions where irrigators may lack understanding or be generally averse to change.

Financier 3

Financier 3 is the branch manager at Inglewood for a prominent agribusiness company. Financier 3 held strong concerns about one particular aspect of the MacIntyre Brook capacity sharing scheme: the delivery loss rules. Financier 3 noted that in the MacIntyre Brook scheme there are three zones defined and that in zone C (the furthest from the dam) SunWater applies a loss factor of 35 per cent. Financier 3 noted that these new rules have a significant detrimental effect on irrigators who are located in zone A who regularly trade water to irrigators downstream of MacIntyre Brook (including the Dumaresq irrigation project).

Financier 3 noted that under the new rules any water traded from zone A to irrigators downstream of MacIntyre Brook has the 35 per cent loss factor applied, plus an additional 10 per cent loss factor, meaning that irrigators downstream receive around half (55 per cent) of any water they purchase from MacIntyre Brook. Financier 3 noted that irrigators located in zone C are compensated for the loss factors by having their share of the storage scaled up, such that if all water is used on-farm no irrigators would be better or worse off. However, this system means that irrigators located in zone A that trade water downstream are adversely affected.

Financier 3 noted that irrigators who sold water downstream this year would have received about half of what they received in previous years prior to the allocation of transmission losses. Financier 3 noted that this has a significant financial effect on these irrigators given the typically large volumes of water which are traded downstream each year. Financier 3's opinion is not that the capacity sharing system is flawed as such, but that the transmission loss factors are incorrect: he believes the 35 per cent loss factor for water travelling from the dam to zone C is a significant overestimate.

Financier 4

Financier 4 holds the position of regional agribusiness manager in St George for a major Australian bank. Financier 4 indicated that he was in favour of capacity sharing at St George. Financier 4 suggested that capacity sharing was a more equitable system, where each user has their own 'bucket' which they can manage independently without affecting others. Financier 4 noted that capacity sharing avoided the 'use it or lose it' problem that existed under the previous system where limits were placed on carryover.

Financier 4 indicated that the previous system generated much tension and argument in the region between different groups of water users and SunWater. Financier 4 indicated that capacity sharing had limited some of these divisions. Financier 4 noted that the transition to capacity sharing took around six months for all of the irrigators to gain a thorough understanding of the new system and the associated rules. Financier 4 indicated that capacity sharing made it easier for irrigators to plan ahead and to undertake budgeting. Financier 4 indicated that overall the irrigators of the region were very supportive of capacity sharing.

18 Monthly capacity sharing water accounts for irrigators at St George

2004-05 to 2008-09

2004-05		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Opening storage	ML	54 167	52 010	48 839	40 046	34 106	31 143	65 636	48 682	35 499	28 283	25 078	32 549
Inflows	ML	0	0	1 598	216	869	49 985	1 857	140	0	0	8 172	4 107
Overflows **a**	ML	0	0	0	0	0	3 969	0	0	0	0	0	0
Storage losses	ML	1 794	2 317	2 883	3 056	3 362	6 560	6 107	3 772	2 646	1 654	1 272	999
Reconciliation	ML	-237	-157	-1 296	+931	+1 732	+1 902	+686	+2 266	+1 370	+405	+1 181	+2 334
Withdrawals **b**	ML	125	697	6 212	4 031	2 203	14 803	13 391	11 817	5 939	1 956	611	6 198
Ending storage	ML	52 010	48 839	40 046	34 106	31 143	65 636	48 682	35 499	28 283	25 078	32 549	31 792
2005-06		**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Opening storage	ML	32 837	72 598	67 468	55 387	50 849	44 008	64 730	44 675	27 116	37 601	35 307	33 633
Inflows	ML	40 221	0	0	1 702	4 427	38 458	205	0	16 009	0	0	0
Overflows **a**	ML	3 917	0	0	0	0	5 567	0	0	0	0	0	0
Storage losses	ML	2 387	3 185	4 016	4 178	4 695	7 091	4 497	2 959	3 208	2 139	1 447	1 015
Reconciliation	ML	-209	+115	-265	+2 026	+325	+588	+1 465	+562	+549	-23	+68	+600
Withdrawals **b**	ML	1 782	2 059	7 801	4 088	6 898	16 800	17 229	15 161	2 866	132	295	1 317
Ending storage	ML	72 598	67 468	55 387	50 849	44 008	64 730	44 675	27 116	37 601	35 307	33 633	31 900
2006-07		**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Opening storage	ML	31 529	30 319	28 677	24 345	14 389	12 425	5 310	3 497	4 579	8 456	7 836	5 679
Inflows	ML	0	0	0	0	846	0	3 600	3 047	5 403	0	0	0
Overflows **a**	ML	0	0	0	0	0	0	0	0	0	0	0	0
Storage losses	ML	1 011	1 288	1 791	1 755	1 649	1 463	908	499	837	770	468	320
Reconciliation	ML	+214	+316	-309	-320	+511	+803	+736	+2 256	+501	+897	+139	+173
Withdrawals **b**	ML	412	671	2 232	7 880	1 672	6 455	5 240	3 723	1 191	747	1 828	1 092
Ending storage	ML	29 261	27 618	23 286	13 330	11 366	4 251	2 439	3 520	7 397	6 778	4 621	3 381

continued....

18 Monthly capacity sharing water accounts for irrigators at St George

2004-05 to 2008-09 *continued*

2007-08		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Opening storage	ML	5 431	5 134	5 865	6 837	5 194	23 782	74 504	75 201	73 324	59 996	48 153	42 783
Inflows	ML	69	855	3 169	0	19 837	57 719	7 244	3 936	0	0	0	0
Overflows **a**	ML	0	0	0	0	0	7 963	2 987	7 505	0	0	0	0
Storage losses	ML	280	280	596	752	819	8 024	7 195	6 942	5 351	2 906	1 782	1 225
Reconciliation	ML	+414	+870	-12	+755	+1 377	+804	+327	+338	+2 730	-2 285	+406	+931
Withdrawals **b**	ML	500	713	1 589	1 645	1 807	7 739	2 666	6 713	10 708	6 652	3 995	5 272
Ending storage	ML	5 134	5 865	6 837	5 194	23 782	74 504	75 201	73 324	59 996	48 153	42 783	37 217
2008-09		**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Opening storage	ML	37 362	36 187	33 764	32 419	27 601	na						
Inflows	ML	0	0	2 206	0	9 144	40 950						
Overflows **a**	ML	0	0	0	0	0	0						
Storage losses	ML	1 150	1 443	2 045	2 095	na	na						
Reconciliation	ML	+691	+53	+728	+1 269	+1 242	+461						
Withdrawals **b**	ML	716	1 034	2 234	3 993	1 501	13 382						
Ending storage	ML	34 852	32 428	31 084	26 266	na	63 180						

a Inflows credited to irrigators (debited from environmental water account) in the event of storage spill. **b** Including water delivery losses. **na** Not available.

appendix

D Town and environmental water accounts

As with the irrigator accounts, the town water accounts are calculated based on the water accounting system data and as such there are some deviations between estimated and reported ending balances.

19 Annual water account, town water, St George

2004-05 to 2007-08

	unit	2004-05	2005-06	2006-07	2007-08
Opening storage volume	ML	2 330	2 051	879	263
Inflows	ML	2 724	3 212	362	2 426
Overflows **a**	ML	0	211	0	261
Storage losses	ML	1 786	2 015	647	1 152
Withdrawals **b**	ML	1 725	2 276	1 445	820
Net trade	ML	0	0	+950	na
Reconciliation	ML	+473	+180	+168	+150
Est. ending storage volume	ML	2 016	1 362	266	1 323
Ending storage volume	ML	2 051	879	263	1 599
Ending storage level	%	100	43	13	78

a Water credited to town water holder (debited from environmental water account) in the event of storage spill. **b** Including water delivery losses. **na** Not available.

The town water holder owns a storage capacity share of 2055 megalitres, while the irrigators collectively hold 80 650 megalitres of storage capacity. In the drought of 2006-07, the town water account received a transfer (trade) of water from the environmental account. In the same year, water was also traded from the environmental account to irrigators

The environmental water accounts are based on SunWater annual interim resource operations licence (IROL) reports. The environmental water accounts show how the environmental water holder's right to the first 730 megalitres each day protects it from some of the variability in annual inflows, providing a more stable supply of water than that available to irrigators.

20 Aggregate annual water account, environmental water, St George

2004-05 to 2007-08

	unit	2004-05	2005-06	2006-07	2007-08
Opening storage volume	ML	3 237	13 906	720	285
Inflows	ML	42 577	56 015	31 540	67 828
Overflows **a**	ML	6 040	12 427	0	32 247
Storage losses	ML	3 599	1 099	2 663	2 163
Withdrawals **b**	ML	23 358	55 885	27 685	33 896
Net trade	ML	0	0	–1 869	na
Reconciliation	ML	+1 087	+210	+242	+193
Closing storage volume	ML	13 904	720	285	0

a Water debited from environmental water account (credited to irrigators) in the event of storage spill. **b** Including water delivery losses. **na** Not available.

appendix

E Historical data

21 Monthly flow summary statistics, Balonne River (Weribone upstream of St George)

month	mean	standard deviation	coefficient of variation	maximum
	ML	ML		ML
January	165 481	333 268	2.01	1 725 467
February	209 954	391 849	1.87	2 086 301
March	122 695	202 212	1.65	736 015
April	97 909	309 703	3.16	1 726 208
May	133 329	456 222	3.42	2 496 748
June	56 101	220 259	3.93	1 341 209
July	48 695	138 361	2.84	752 078
August	38 015	166 899	4.39	1 013 464
September	46 421	183 330	3.95	1 075 074
October	9 951	19 416	1.95	95 094
November	77 449	134 983	1.74	528 420
December	116 144	243 115	2.09	1 341 964

Source: QLD Department of Environment and Resources 2009.

22 Bulk sharing, allocation percentages, St George

month	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
July	40	40	50	50	45	0
August	40	40	50	50	45	0
September	40	40	50	50	45	5
October	40	40	50	50	45	5
November	40	40	50	50	45	5
December	40	75	80	85	45	73
January	40	75	80	85	45	86
February	40	75	80	85	45	96
March	40	75	80	85	89	96
April	100	75	80	85	89	96
May	100	100	80	85	89	96
June	100	100	80	85	89	96

23 Bulk sharing, allocation percentages, MacIntyre Brook

month	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
July	0	0	0	0	60	0
August	0	0	0	0	60	11
September	0	0	0	0	60	11
October	60	3	40	17	60	11
November	60	3	40	34	60	42
December	60	35	95	100	80	100
January	60	100	100	100	85	100
February	70	100	100	100	85	100
March	85	100	100	100	85	100
April	85	100	100	100	100	100
May	85	100	100	100	100	100
June	85	100	100	100	100	100

24 Summary of internal spills in the St George capacity sharing scheme

2004-05		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Internal spill volume	ML	0	0	0	0	0	7 393 **a**	0	0	0	0	0	0	7 393
Inflows	ML	0	0	1 598	216	869	49 985	1 857	140	0	0	8 172	4 107	66 944
% of inflows	%	0	0	0	0	0	14.8	0	0	0	0	0	0	11.0
Internal spill days **b**	no.	0	0	0	0	0	9	0	0	0	0	0	0	9
2005-06														
Internal spill volume	ML	8 132 **a**	0	0	0	0	7 796 **a**	0	0	358	0	0	0	16 285
Inflows	ML	40 221	0	0	1 702	4 427	38 458	205	0	16 009	0	0	0	101 021
% of inflows	%	20.2	0	0	0	0	20.3	0	0	2.2	0	0	0	16.1
Internal spill days **b**	no.	7	0	0	0	0	8	0	0	2	0	0	0	17
2006-07														
Internal spill volume	ML	0	0	0	0	0	0	0	0	0	0	0	0	0
Inflows	ML	0	0	0	0	846	0	3 600	3 047	5 403	0	0	0	12 895
% of inflows	%	0	0	0	0	0	0	0	0	0	0	0	0	0
Internal spill days **b**	no.	0	0	0	0	0	0	0	0	0	0	0	0	0
2007-08														
Internal spill volume	ML	0	0	0	0	0	1 752 **a**	262 **a**	657 **a**	0	0	0	0	2 671
Inflows	ML	69	855	3 169	0	19 837	57 719	7 244	3 936	0	0	0	0	92 828
% of inflows	%	0	0	0	0	0	3.0	3.6	16.7	0	0	0	0	2.9
Internal spill days **b**	no.	0	0	0	0	0	23	5	8	0	0	0	0	36
2008-09														
Internal spill volume	ML	0	0	0	0	0	1 552	1 552						
Inflows	ML	0	0	2 206	0	9 144	40 950	52 300						
% of inflows	%	0	0	0	0	0	3.8	3.0						
Internal spill days **b**	no.	0	0	0	0	0	15	15						

a Coincided with dam spill event. **b** Number of days with significant internal spills (may exclude some insignificant spills less than 1% of total internal spill volume).

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