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SOME ECONOMICS OF ACT WATER RESOURCES: DETERMINING INITIAL "CAP" ENTITLEMENTS FOR THE ACT

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The Australian Capital Territory (ACT) became a full participant in the Murray Darling Basin (MDB) Initiative in 1998. This opened the opportunity for the ACT to establish water trading arrangements with the other MDB member States. Provisions to facilitate this trade are currently being developed. In addition, the ACT is required to negotiate an initial "Cap" level with the other MDB members before water trading can begin. The Cap defines the amount of water resources for which each State has extractive rights, and is based on 1993/94 levels of water utilising development. This paper investigates alternative trading strategies that could be used to "build" Cap over time, and explores the implications for negotiation of the initial ACT Cap endowment.

Key words: water resources, water markets, trading strategy, Australian Capital Territory

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1 INTRODUCTION

The ACT has access to significant water resources to meet the largely domestic water needs of its population of 320,000 (Demographics ACT 2001). In addition to the 2,400km^2 catchment area of the ACT, the ACT (through the Commonwealth) has been granted rights to the waters of the Molonglo and Queanbeyan rivers in NSW. This provides the ACT with total average water resources of 465 GL/year. This resource currently easily satisfies average environmental flow requirements of 272 GL/year and present average gross abstractions of 66 GL/year. These figures imply that significant excess physical water resource exists for the ACT to increase extractive use or to sell on an interstate market.

Two factors, however, introduce significant constraints into this picture of apparent water resource abundance. First, the ACT's water supply infrastructure (current dam capacity of 215.4 GL) has a physical yield limit of between 103-108 GL/year (Marsden Jacob 2000), with potential for significantly lower yield due to climate variability. Opportunities exist for potentially increasing storage capacity through the building of additional dams, and of associated treatment and supply infrastructure capacity. But community sentiment is strongly against the building of a new dam, because of the significant environmental and financial costs that would be involved. Consequently, water trading would be accompanied by significant additional storage related costs once the existing infrastructure capacity is fully utilised.

The second factor is an administratively imposed limit to the use of water resources, and relates to the 1998 agreement by the ACT Government to join the *Murray Darling Basin* (MDB) *Initiative*. The Memorandum of Understanding agreed by the ACT with the other initiative partners (Commonwealth, NSW, Victoria, South Australia, and Queensland) includes:

> "The ACT agrees to participate in the program to limit diversions from the Murray Darling River System, known as the Cap on Diversions[4], following the completion of discussions with the Commission and the Independent Audit Group to determine the detailed form of ACT's participation".

This Cap limit is the key to the ACT's participation in the MDB Initiative, and, when agreed, will also form a key constraint on the extent to which the ACT can access its water resources. Once the Cap is set, the ACT will be able to trade Cap entitlement with the other States who are partners to the agreement. This will mean that the ACT can generate income from the excess entitlement that it may not presently require, and if /when necessary will be obligated to purchase Cap entitlement for water use in excess of its agreed initial Cap level.

This paper investigates the minimum level of initial ACT Cap that must be achieved in the negotiations with the MDBC for the agreement to be of benefit to the ACT. The nature of this issue is largely intertemporal, with potential initial gains to the ACT from the sale of excess entitlement, and future costs to the ACT from the need to purchase entitlement as population growth increases the water requirements

[4]The MDBC Cap on diversions is defined as "the volume of water that would have been diverted under 1993/94 levels of development", and is assessed on a valley basis. Diversions are calculated net of returns for all jurisdictions. The Cap was put in place as an interim measure in 1995, and later confirmed as a permanent measure effective from 1 July 1997. Its introduction followed an audit of water use in the MDB that indicated continuing significant growth in diversions and declining river health (MDBC 1999).

of Canberra. The paper also investigates the relative value of alternative strategies for operating in the water market (using temporary and permanent water sales and purchases).

The structure of the remainder of the paper is as follows. Section 2 provides background on the water resources of the ACT. Section 3 outlines the MDB Cap negotiation problem for the ACT, and the analytical approach followed in this research for investigating this issue. Finally, sections 5 and 6 discuss the implications of the results in relation to key ACT water management issues, and draw conclusions about the choice of water trading strategy and the minimum Cap level to which the ACT Government should agree.

2 ACT WATER RESOURCES

2.1 Natural hydrological resources

The ACT ($2400km^2$) is located within the Upper Murrumbidgee Basin ($13,000km^2$), at the eastern end of the Murrumbidgee Catchment ($84,000km^2$). The ACT has a continental climate with hot summers and cold winters. The mean annual rainfall varies from 950mm in parts of the ranges in the south west of the Territory to 600mm in Canberra. This average rainfall is spread relatively evenly through the year, though variability within and between years is significant (Environment ACT 1999b, NCDC 1981).

The mean annual flow of the Murrumbidgee River at Burrinjuck Dam is 1383 GL, of which 426 GL is contributed from water resources controlled by the ACT. Measurements at Cotter Crossing gauge in the ACT over a 50 year period indicate variability in mean annual flow volumes by a factor of five (NCDC 1981). Average flow characteristics of ACT water resources are summarised in Table 1, below.

Table 1: ACT controlled water resources (average GL/yr)

Total water resources[a]	465
Environmental flow requirement[b]	272
Available for consumptive uses[c]	193
Annual yield from water storages[j]	103
Gross diversions[d]	66
Return flows[e]	35
Net diversions (= gross - returns)	29
Increased urban runoff[g]	19
Net consumptive use[h]	10
MDB Cap for net diversions for entire Murrumbidgee catchment[i]	2521

Source: Environment ACT (1999a:9)g,h; Environment ACT (1999b:11-12)a,b,c,d,e,j; DLWC (2003)i; Marsden Jacob (2000)a,b,c.

Management of these resources includes making careful provision for environmental requirements for the 32 subcatchments which, in whole or part, are under the control of the ACT Government. An average of 272 GL/year is reserved for environmental flows (Environment ACT 1999b).

The ACT Environmental Flow Guidelines, however, recognise that the values that the community holds vary for different ACT sub-catchments. Four categories of aquatic ecosystems are specified within the Guidelines (natural, modified, water supply and created). Separate guidance is provided in relation to achieving the different management goals (reflecting different values) for each of these. This includes guidance on low flows, flushing flows, special purpose flows and maintenance of impoundment levels for each type of ecosystem (Environment ACT 1999a). Consequently, the level of water extraction allowed varies significantly between subcatchments.

The quantity of water reaching the ACT in the Murrumbidgee is significantly affected by upstream regulation at Tantangara Reservoir. The environmental flow objectives of the ACT reflect management of post-Tantangara flows (not trying to replicate environmental flow conditions before the Tantangara effect). Almost all Tantangara water resources are diverted to Lake Eucumbene (approx 99%). A high proportion of Murrumbidgee flows join downstream of Tantangara Reservoir, but the Murrumbidgee still suffers an average (Tantangara induced) flow reduction of 26% at the point of reaching the ACT (Environment ACT 1999b).

The ACT has access to significant physical water resources to meet the growing needs of the ACT for a very long period into the future. As Table 2 indicates, even just within the water supply sub-catchments currently designated as principally being for water supply, there is high level of unallocated resource that could be used for extractive purposes. The constraint on the resource is caused by the current level of infrastructure development. Additional reservoir, treatment and delivery capacity would need to be developed in order to make extractive use of these resources beyond the current capacity of around 103 GL/year (ACTEW 2000). This infrastructure provides water for urban supply. In addition, around 5GL/year of water resource "diversion" occurs in the form of surface water use by rural industry, golf courses, parks, schools etc.

Table 2: Water resources available for use from (designated) ACT water supply sub-catchments

Reservoir	**Sub-catchment**	**Water available for use (ML/yr)**	**Existing use (ML/yr)**	**Allocation provision (1999-2009) (ML/yr)**	**Available but unallocated (ML/yr)**
Googong	Tinderry	50,238	9,697	2,700	37,841
	Googong	5,100	1,361	300	3,439
	Burra	6,372	1,600	500	4,272
Corin	Corin	46,704	29,700	1,800	15,204
Bendora	Bendora	32,858	21,000	1,200	10,658
Cotter	Lower Cotter	32,023	0	10,000	22,023
Total		173,295	63,358	16,500	93,437

Source: Environment ACT (1999b:12, 80-1)

As well as surface water resources, the ACT has significant groundwater resources. The quality of this groundwater is within acceptable limits for human consumption and stock watering, though most is very "hard", with high cation concentrations of magnesium and calcium (Environment ACT 1999b). Groundwater is currently used in the ACT for domestic, stock supply, and irrigation on agricultural and rural residential developments, and for private garden and sports developments in urban areas.

2.2 ACT water supply infrastructure and institutions

2.2.1 Supply infrastructure

The ACT water supply is drawn from two separate catchment systems, the Cotter River catchment and the Googong system.

The Cotter system has had three reservoirs constructed within it (Cotter, Bendora and Corin). The total storage capacity of these dams is 91GL, with an average yield of 64-69GL/yr (Marsden Jacob 2000). Water is released from the highest dam (Corin) to maintain the level of storage in Bendora Dam. Water stored in Bendora flows by gravity to the Mount Stromlo Water Treatment Plant (WTP), where chlorination, fluoridation and pH correction is undertaken. Water from the small Cotter Dam (4.7 GL) must be pumped up to the Mount Stromlo WTP, and is consequently reserved as an emergency supply. The Cotter River catchment is part of a national park, and provides very high quality water that requires very low levels of treatment at the Mount Stromlo WTP (ActewAGL 2002).

Googong Dam has a capacity of 124.5GL and provides an average yield of 39GL/yr (Marsden Jacob 2000). The Googong catchment is largely used for agricultural purposes, and as a consequence the stored water is of a lower quality than water from the Cotter catchment, and requires full conventional water treatment. The water from Googong Dam must be pumped to the Googong WTP for this treatment, before being supplied into the ACT service reservoir network. (ActewAGL 2002).

Distribution from the water treatment plants occurs via gravity fed bulk supply mains to service reservoirs. There are 44 service reservoirs in the ACT network, each with a capacity of 912 ML. Due to the higher treatment and distribution costs of water from the Googong system, this system is only used in higher (summer) water consumption periods, or when other supply considerations limit the capacity of the Cotter system (ActewAGL 2002).

2.2.2 Institutions (ACTEW, ActewAGL, ICRC)

ACTEW Corporation Limited (ACTEW) is a holding company with interests in the provision of water, wastewater, natural gas and electricity services. The ACT Government wholly owns ACTEW. ACTEW owns the ACT's water and wastewater network, catchment and treatment infrastructure and associated water and wastewater assets (ACTEW 2002). ACTEW holds 95 per cent of ACT licensed allocation (62,700ML).

ActewAGL is an operating company that is 50 percent owned by ACTEW Corporation Limited, and 50 per cent owned by Australian Gas Light (AGL). ActewAGL provides water and sewerage operations and maintenance services as contractors to ACTEW Corporation Limited (ACTEW 2002).

As ActewAGL is a monopoly supplier of water and sewage services in the ACT, its pricing is strongly regulated. The ACT Water and Energy Charges Commission was established in 1996 by the ACT Government to determine maximum prices to be charged by ACTEW Corporation Ltd (EWCC, 1997). Three determinations have subsequently been made by the Commission for the periods 1997/98, 1998/99, and 1999/2000 to 2003/04. Over this period the Commission's responsibilities, powers and identity have evolved. The current Independent Competition and Regulatory Commission (ICRC) operates under the *IPARC Act 1997*.

The regulatory approach that the ICRC uses in guiding water and sewerage prices charged by ACTEW involves capping maximum average revenue per property, and imposing constraints on how much the household bill for any individual property can be increased (IPARC, 1999). This regulatory approach enables ACTEW to structure tariffs as it likes within these guidelines. ACTEW must however submit a full customer impact analysis for approval by the Commission prior to their implementation (ICRC, 1999). The current general domestic and commercial water tariff structure used by ACTEW involves a fixed component of $125.00 per property, and two step variable component of 41c/kL for the first 200kL/year and 97c/kL thereafter (ACTEW AGL, 2002).

In 1999, the ICRC was also requested by the ACT Government to provide advice on the approach to establishing an appropriate water charge to be paid by licensed allocation holders for abstracting water from the environment. The ICRC recommended that an abstraction charge of around 10c/kL would be appropriate in regard to the recovery of the cost of maintaining catchments, restoring damage caused to the environment as a consequence of collecting, storing, and delivering water and a value that reflects the scarcity of water as a resource. The scarcity value component of this was around 7c/kL (on the basis of temporary water trade values that ranged from $70/ML in the Murray Darling Basin at that time). It was recommended that this charge be passed directly through to ActewAGL customers as a separate abstraction charge (IPARC, 1999). The ACT Government accepted these recommendations and has implemented a 10c/KL abstraction charge.

2.3 Ownership of the resource

In addition to the rights to water within the boundary of the ACT, the (Commonwealth) *Seat of Government Acceptance Act* (1909) grants paramount rights to the waters of the Queanbeyan and Molonglo rivers in NSW to the Commonwealth for the purposes of the National Capital. These rights have been activated through the *Canberra Water Supply (Googong Dam) Act* 1974, and development of the Googong infrastructure.

The *Australian Capital Territory (Planning and Land Management) Act* (1988) defines land as including water and requires the establishment (by the Commonwealth) of a National Capital Plan. The National Capital Plan establishes the water requirements for the National Capital, including designated stream flow diversions from each catchment and the purposes for which they will be used. The Plan designates 108.3GL of diversions. The *Australian Capital Territory (Self Government) Act* (1988) provides for the ACT Government to exercise the Commonwealth's water rights. (Marsden Jacob 2000).

In addition, the ACT has its own plan, the Territory Plan. The Territory Plan must be consistent with National Capital Plan. The yield of the current 4 dams in the ACT of (103-108 GL) clearly corresponds to the water rights statutorily reserved for the use of the ACT. Evidently, the ACT has an activated water right of around 108 GL (Environment ACT 1999c).

However, the nature of the MDBC Cap agreement relates to diversion limits on the basis of 1993/94 levels of development rather than water rights. The point of contention in negotiating the ACT Cap is likely to be the interpretation of whether "level of development" relates to development of the infrastructure to supply water (which for the ACT clearly contained excess capacity at that time), or whether the "level of development" relates to the level of urban and industrial development that makes use of those water resources at that time. The NSW, Victorian and South Australian interpretations appear to relate to the latter in determining their Cap levels.

3 INTERSTATE WATER TRADING AND ACT CAP NEGOTIATIONS

3.1 Background

There have been a number of motivations for the ACT to investigate the development of institutions to facilitate interstate water trading. These include:

- the Council of Australian Governments (COAG) Water Reform Framework (1994). The facilitation of water trade is a key component of the framework. The implementation of the COAG water reform framework is explicitly linked to the broader National Competition Policy reform process and the multi-billion dollar NCP tranche payments from the Commonwealth to the States and Territories for demonstrated implementation of these reforms;
- the potential for the ACT to realise a financial gain from trading use rights to a portion of its natural resource base which currently accrues freely to other downstream jurisdictions; and
- the Australian Capital Territory (ACT) becoming a full participant in the Murray Darling Basin (MDB) Initiative in 1998, and the associated opportunity this brought for the ACT to establish water trading arrangements with the other MDB member States once "Cap" level is negotiated.

The MDB Cap is based on "the volume of water that would have been diverted under 1993/94 levels of development", but a range of additional issues have been raised in the negotiation of the ACT Cap level. These have included:

- differences in how the Cap has been set in other MDB jurisdictions;
- the high proportion of urban uses of water in the ACT;
- the ACT's responsible management and efficiency of use (relative to other jurisdictions) prior to Cap implementation; and
- whether the existing activation of the ACT's rights to water resources in a legal sense (through development of the infrastructure to supply water), should equate to an equivalent "level of development" under the Cap.

Consequently, a range of Cap level options and proposals have been developed during the negotiations (eg. Environment ACT 1999c, Marsden Jacob 2000). These have ranged from a level of 29GL/year through to 172GL/year, and includes the MDB Cap Independent Audit Group's preference for a Cap of 38GL/year.

This paper does not attempt to determine the criteria on which the Cap should be based. Instead, the approach taken has been to investigate the minimum amount that the ACT's initial Cap needs to be before it is in ACT's interest to accept the Cap. The alternative is for the ACT Government to renege on the MDBC MOU that it agreed to in 1998, and to supply future growth in water use from its own resources without trading. Such a withdrawal defeats the purpose of the MDB Cap, because it means that the ACT's growth in use will be a net increase in abstraction in the Murrumbidgee Valley (as no trading mechanism will exist to ensure that use elsewhere in the MDB is reduced by a corresponding amount).

Whether withdrawal from the MDB Initiative is a politically feasible option is a separate question. But the technical feasibility of the option arises simply because the initial basis of the Cap (1993/94 levels of development) is arbitrary and not related to physically sustainable levels of water use in the ACT.

Table 1 (in Section 1) clearly showed that the sustainable level of extractive water use by the ACT is much higher than used under 1993/94 levels of development. Without a Cap, the ACT would not be allowed to sell surplus water, but would also not have to buy from other jurisdictions to cover water deficits. Under a Cap agreement, the ACT will in the future need to buy water entitlement (in either temporary or permanent form) to meet the requirements of urban growth. For a Cap agreement to be in the interests of the ACT, the initial Cap level must provide the ACT with tradeable excess water that is sufficient to offset future water purchase costs.

3.2 Analytical approach

The Cap related water trading issues were analysed through both a theoretical optimisation model of water trade, and a spreadsheet based simulation model.

3.2.1 Theoretical model

A basic water trading model was developed to specifically investigate two questions:

- How much initial Cap would the ACT need to have for joining the Cap to be in its financial self-interest?
- What time profile of buying permanent water rights to meet future population growth maximises the ACT's financial self-interest?

The model assumes:

- Constant rainfall at long term average
- Constant real water prices
- The same real discount rate (r) for all participants in the market
- Price-inelastic, exogenous net water consumption in ACT assumed to be proportional to population. Population grows exponentially at rate Ω until year T, when growth suddenly stops. Hence:

$$W(t) = W_0 e^{\Omega t} \text{ for } 0 \le t \le T, = W_0 e^{\Omega T} \text{ thereafter; usually } T = 50$$

where:

W_0 = initial level of ACT water use (GL/yr)

π = price of permanent water flow (\$/(GL/yr))

p = price of temporary water stock (\$/GL)

$\delta = p/\pi$ = ratio of temporary to permanent water prices (%/yr)

$b(t)$ = rate at which new (permanent) flow is bought (in GL/yr)

$\Rightarrow$ expenditure on buying new flow = πb (in \$/yr)

$B(t)$ = accumulated new flow bought (in GL/yr)

$$\Rightarrow \dot{B} = b$$

C_0 = initial Cap owned by ACT on entry to MDB Cap (in GL/yr) (this is the key parameter subject to negotiation)

$C(t)$ = ACT's current ownership of flow (in GL/yr)

$s(t)$ = temporary water sales (in GL/yr)

$\Rightarrow$ temporary sales $s(t) := C(t) - W(t) = C_0 + B(t) - W(t)$ (in GL/yr)

$\Rightarrow$ revenue from temp sales $= ps = p(C_0+B-W)$ (in \$/yr)

$v(t)$ = net revenue from water trade (in \$/yr)

$\Rightarrow$ $v(t) = ps(t) - \pi b(t) = p[C_0+B(t)-W(t)] - \pi b(t)$ (in \$/yr)

V = present value of water trade (in \$)

$\Rightarrow$ $V = \int_0^T v(t)e^{-rt}\,dt$

A key conclusion of the model is that if the rate of return from holding permanent water rights is the same as the real discount rate (that is, $\delta = r$), then the trading strategy followed is irrelevant. The present value of an arbitrary water trading plan $b(t)$ (in units of permanent water, hence divide present value V by π)

$$V/\pi = (\delta/r)(C_0 - W_0 e^{-(r-\Omega)T}) - [\delta/(r-\Omega)]W_0(1-e^{-(r-\Omega)T}) + [(\delta/r)-1]\int_0^T b e^{-rt} dt \quad \text{(in GL/yr)}$$

3.2.2 Simulation model

The simulation model is a non-optimising spreadsheet model initially developed by Environment ACT to consider potential water trading issues. The model calculates the present value of alternative trading strategies, under a broad range of policy settings.

As the model is not optimising, it has been used for this research to determine initial break-even Cap levels by iteratively finding the level of initial Cap endowment that equates to a present value of net trading revenue =0.

Total ACT water use over time is divided into urban, industrial and privately diverted categories, with increased future use levels based on population projections and expected industrial demand. The model also endogenously determines Cap level on the basis of rainfall in a particular year.

Key parameters of the model include:

π = price of permanent water flow (\$/(GL/yr))

p = price of temporary water stock (\$/GL)

C_0 = initial Cap owned by ACT on entry to MDB Cap (in GL/yr)

C_m =maximum accumulated Cap (GL/yr)

r = discount rate (%/yr)

3.3 Alternative water trading strategies

The ability to realise financial returns from the temporary sale of water use rights, and to build MDB Cap entitlement through the purchase of permanent water rights, makes it relevant to evaluate alternative sequencing of temporary sales and permanent purchases over time. A fifty year evaluation period was used. This period is consistent with at least one of the key Cap level proposals under consideration (Environment ACT 1999c). The calculation of breakeven levels of initial Cap (in GL/year) under alternative scenarios and trading strategies, was undertaken using both the theoretical and simulation models. The following trading strategies were investigated (described in terms of formulae from the theoretical model).

3.3.1 Pay Now

Buy enough additional permanent water entitlements in the first year to meet ACT water requirements in the final year (year 50), and sell amounts surplus to annual requirements on a temporary basis.

- At $t = 0$, buy shortfall in permanent water, $W(T) - C_0$
  sell surplus temporary water between 0 and T
  $\Rightarrow$ breakeven Initial Cap
  $C_{01} = W_0\{(\delta/r)[1-(\Omega/r)e^{-(r-\Omega)T}]/(1-\Omega/r) - [(\delta/r)-1]e^{\Omega T}\}$

3.3.2 Pay As You Go

Sell amounts surplus to annual water requirements on a temporary basis, and use all the revenue each year to buy additional permanent water entitlement.

- Spend exactly all current revenue from temporary water sales on buying new permanent water
  $\Rightarrow$ breakeven Initial Cap
  $C_{02} = [W_0/(1-\Omega/\delta)][1-(\Omega/\delta)e^{-(\delta-\Omega)T})]$

3.3.3 Pay Later

Initially sell amounts surplus to annual water requirements on a temporary basis, and later buy shortfalls to annual water requirements on a temporary basis. In the final year, purchase enough permanent water entitlement to meet water requirements at that time.

- Sell surplus temporary water, or buy temporary if short
  At $t = T$, buy shortfall in permanent water at time
  $\Rightarrow$ breakeven Initial Cap
  $C_{03} = \{\delta/(r-\Omega)-[\delta/(r-\Omega)-1]e^{-(r-\Omega)T}\}W_0 / [\delta/r-(\delta/r-1)e^{-rT}]$

[Note: further details of the models and derivation of the trading strategy formulae are not currently documented, but will be made available from the authors on request]

4 RESULTS

A range of scenarios were evaluated using both models (where possible) to investigate the effect of variations in key parameters on the level of initial Cap required for the ACT to "breakeven" in terms of the present value of financial transactions from trading activities over a 50 year period. These include the effects of the ratio of temporary to permanent water prices, the rate of growth in water demand within the ACT, and the discount rate used.

4.1 Water price effect

4.1.1 Assumptions

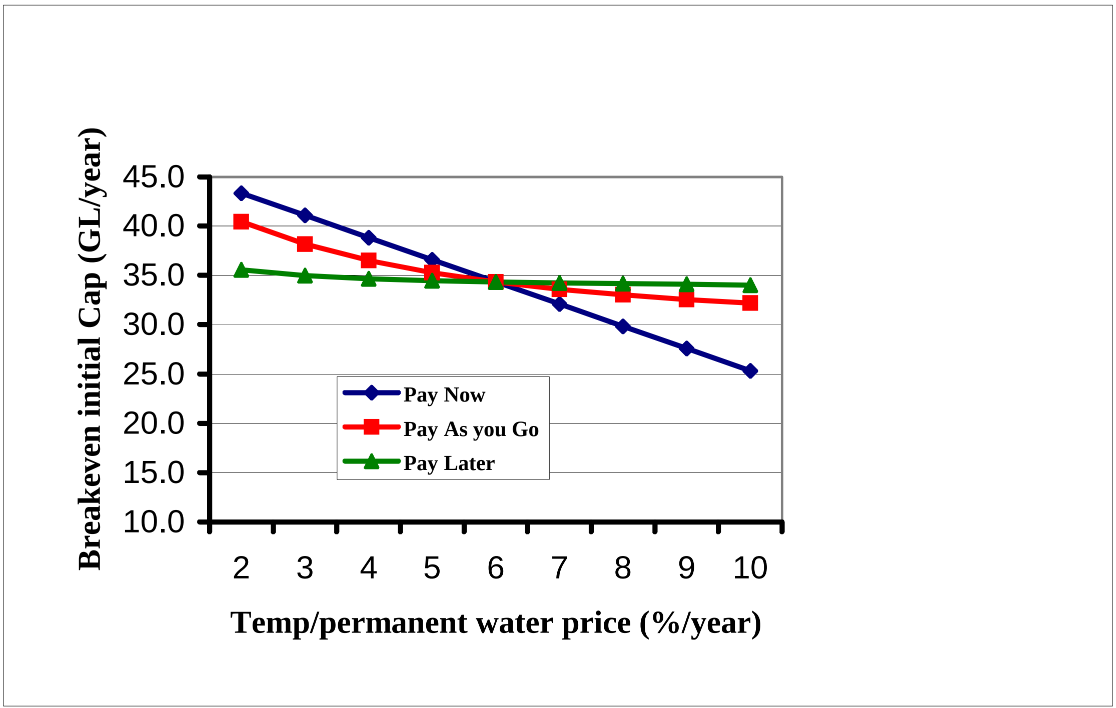
Temporary trade water prices in the Murrumbidgee valley generally trade at an average of $40-50/ ML, but are extremely variable due to climatic variations that affect annual water availability. Within season variability in temporary water prices is also very high. In the 2001/02 irrigation season, temporary water initially traded at $10-15/ML in the Murrumbidgee valley, but rose to levels well over $100/ML later in the irrigation season. The current drought conditions (announced allocations of 38 per cent for general security water entitlement in 2002/03 in the NSW Murrumbidgee) are expected to cause average trade prices to reach over $100/ML for this irrigation season (pers comm. P. Killen, DLWC, M. Wright, NSW Agriculture). Individual trades at prices up to $185/ML have already occurred this season in the Coleambally Irrigation Area (pers comm. I. Barbic).

Permanent trade water prices in the Murrumbidgee valley are currently in the range of $450-500(ML/yr), and are gradually increasing (pers comm. P. Killen, DLWC).

The analyses reported below (in section 4.1) assess the effect of a range of potential temporary/permanent water price ratios. In all other cases the theoretical and simulation analyses assume a constant annual temporary/permanent water price ratio of 10 (%/ year), corresponding to [$40-$50/ML]/[$450-500/(ML/yr)].

4.1.2 Constant water price ratio

Figure 2: Breakeven initial Cap (GL/year) with constant Temp/Permanent price ratio (theoretical model)

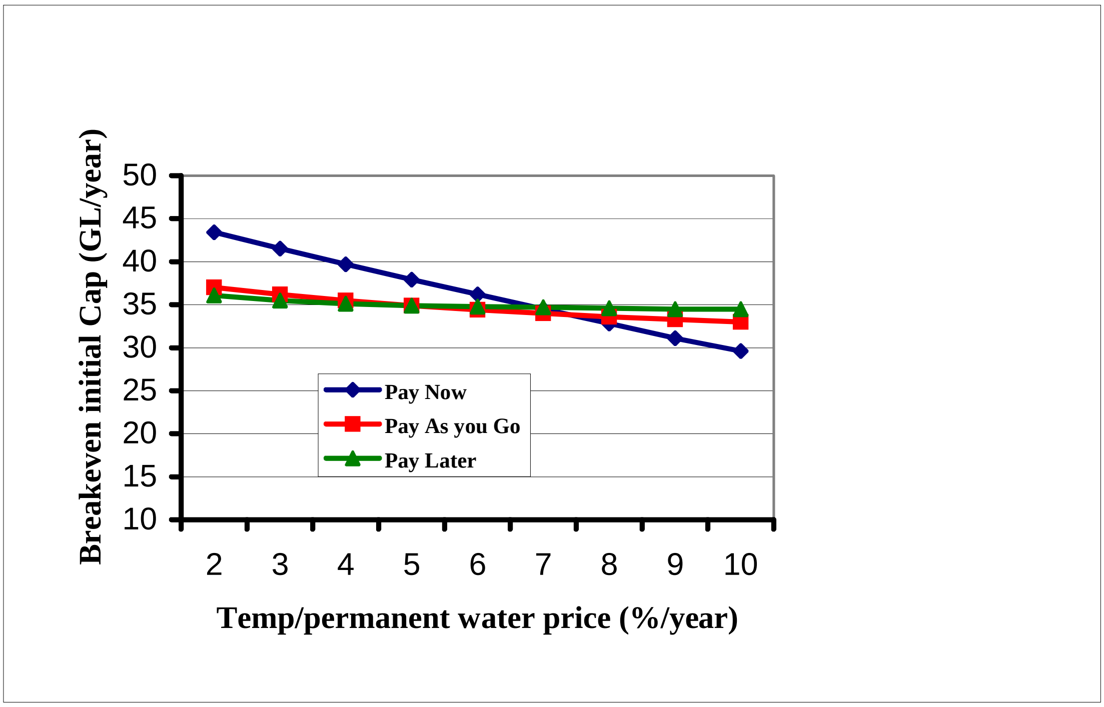


The effect of alternative temporary/permanent water price ratios on the performance of the alternative trading strategies, using the theoretical model, are presented in Figure 2. These results are also presented in Table 4, Appendix 1. This scenario assumes that the ratio of water prices remains constant over the 50 year trading period.

The results illustrate that when the trade price ratio (or the rate of return that could be achieved by purchasing permanent entitlement and "renting" it to others as temporary water) is the same as the discount rate (6 per cent), there is no difference between trading strategies. A breakeven level of initial Cap of 34.3GL/year is required under all trading strategies. A trade price ratio greater than the discount rate favours early purchase of permanent entitlement, while a trade price lower than the discount rate favours the delaying of permanent entitlement.

Consistent results of the same trading scenario using the simulation model are presented in Figure3 below, and in Table 4, Appendix 1. The main difference in the results is that the minimum initial Cap required to breakeven has risen from 25.3GL/yr to 29.6GL/yr when the trade price ratio is 10 per cent (under the Buy Now trading strategy). This is caused by settings within the simulation model that reflect policy arrangements allowing the ACT to accumulate underuse of Cap since 1997 for later trade, and the inability to purchase permanent entitlement favoured by the "Buy Now" strategy until trading arrangements are established. The results indicate that a significant portion of benefit to the ACT that may have been realised if this scenario had been deemed reflective of actual circumstances, and acted upon earlier, have now been forgone due to the delay in implementing trading arrangements.

Figure 3: Breakeven initial Cap (GL/year) with constant Temp/Permanent price ratio (Simulation model)

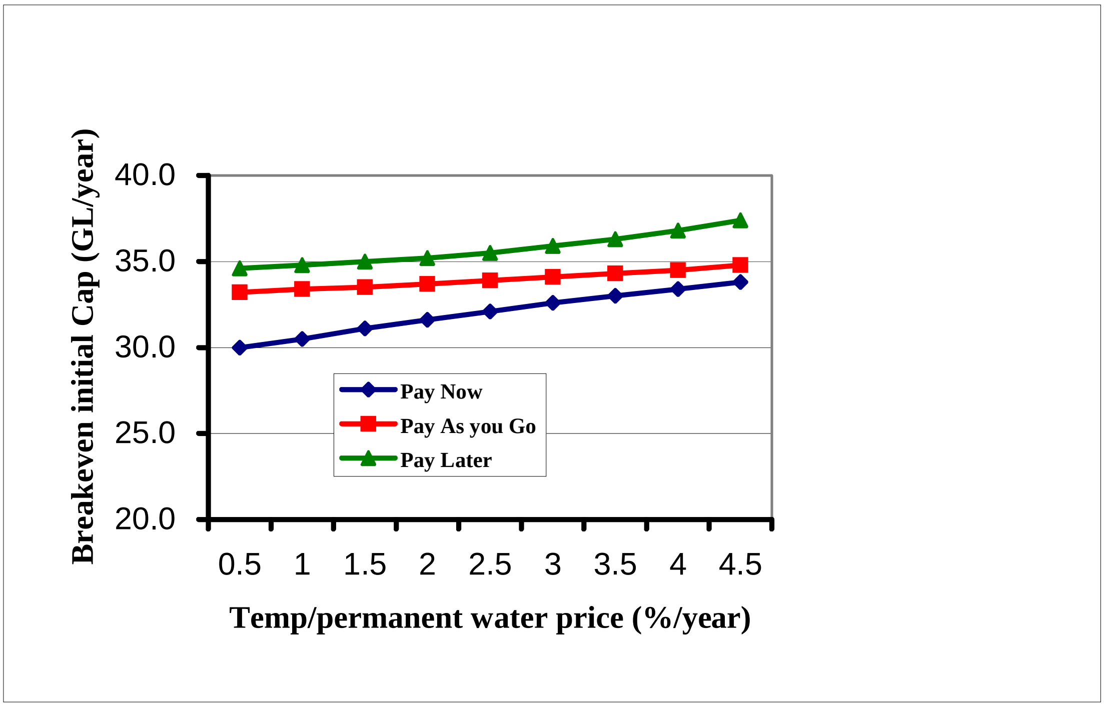


4.1.3 Rising permanent water (real) prices

This scenario assumes that the ratio of water prices gradually declines over the 50 year trading period, as permanent water prices rise in real terms relative to temporary water prices. The scenario assumes a starting water price ratio of 10 per cent. The effect of permanent water price rises of between 0.5 per cent and 4.5 per cent/year on the performance of the alternative trading strategies (using the simulation model), are presented in Figure 4. These results are also presented in Table 5, Appendix 1.

The results indicate that rising permanent water prices relative to temporary prices cause the outcomes of the trading strategies to begin to converge , but does not change the relative ranking of the alternative trading strategies. The "Pay Now" strategy remains dominant at all permanent water price increases evaluated.

Figure 4: Breakeven initial Cap (GL/year) with rising real Permanent water prices



4.2 ACT level of use effect

4.2.1 Assumptions

The rate of growth in net water consumption in the ACT is closely linked to population growth, because of the very high proportion of water used for domestic and other non-industrial purposes. Demographics ACT (2002) have published projections of population growth to 2021. These forecast population growth of around 0.7 rising to 1.0 per cent per annum by 2009 (and then stabilising). Australian Bureau of Statistics (2002) figures indicate that the actual rate of population growth in the ACT for the year to June 2001 was 1.0 per cent. No formal population projections are available post-2021. Original specification of the simulation model by Environment ACT assumed a constant population growth rate of 0.5 per cent per annum for the period 2022 – 2046.

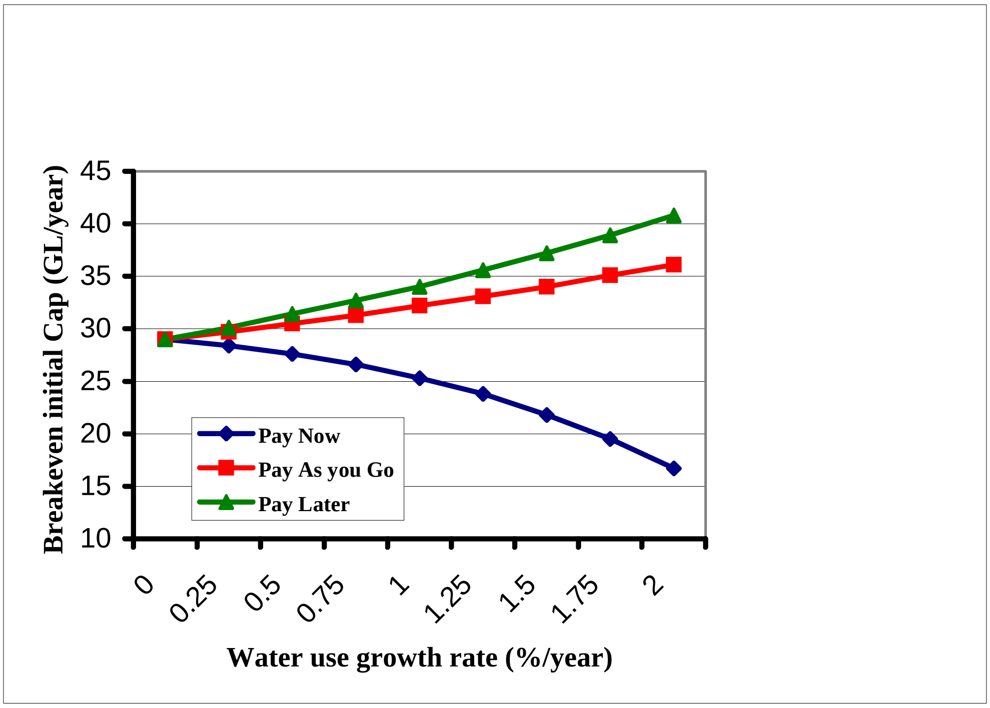
The Water Resource Management Plan (WRMP) for the ACT indicates that domestic water consumption is expected to fall over time. "However, when the consumption rate might drop, and by how much is speculation" (Environment ACT 1999b). Consequently, the WRMP plans future water needs on the basis of existing per capita rates of consumption continuing.

The analyses reported below (in section 4.2) assess the effect of a range of potential rates of increase in ACT annual water use. In all other cases the theoretical and simulation analyses assume a constant annual rate of increase in water use of 1 per cent/year.

4.2.2 Constant rate of growth in ACT water use

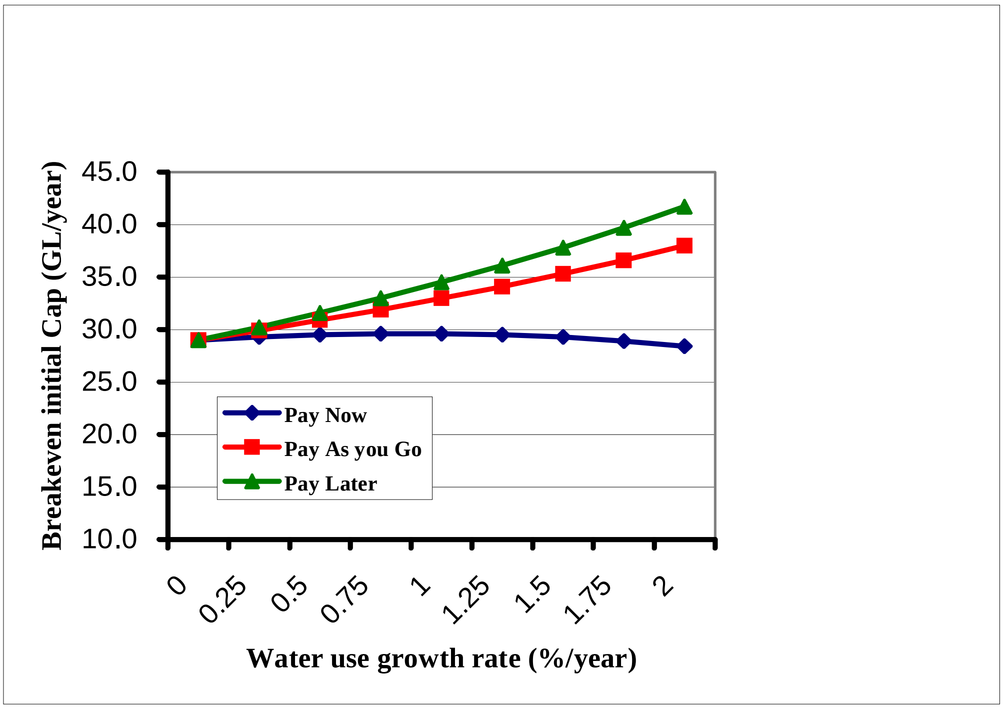
The effect of alternative rates of growth in ACT water use on the performance of the alternative trading strategies, using the theoretical model, are presented in Figure 5. These results are also presented in Table 6, Appendix 1. This scenario assumes that the rate of growth in ACT water use remains constant over the 50 year trading period. Consistent results of the same trading scenario using the simulation model are presented in Figure 6 below, and in Table 6, Appendix 1.

Figure 5: Breakeven initial Cap (GL/year) with constant rate of growth in ACT water use (theoretical model)



The main difference in the results between the two models again relates to the effect on the "Pay Now" trading strategy in from the policy settings specified in the simulation model (which prevent permanent water purchase in the initial six years of the analysis).

Figure 6: Breakeven initial Cap (GL/year) with constant rate of growth in ACT water use (simulation model)



4.2.3 *Falling rate of growth in use*

The ACT Future Water Supply Strategy (ACTEW 2000) proposed the use of a range of demand management activities, including education and awareness, regulation and water pricing reforms in order to achieve the following water conservation targets:

- 15 per cent of annual per capita demand by 2000;
- 25 per cent of annual per capita demand by 2010; and
- 35 per cent of annual per capita demand by 2020.

Sensitivity analysis was undertaken using the simulation model to assess the effect of the achievement of these targets, relative to the base case assumption of a constant rate of growth in water use of 1per cent/year.

Table 3: Breakeven initial Cap (GL/year) with water use efficiency gains over time

Strategy	Pay Now	Pay As You Go	Pay Later
Constant growth (1%/yr)	29.6	33.0	34.5
Water efficiency targets	25.1	26.6	26.6

The results indicate that achievement of the water use efficiency targets would significantly lower the breakeven initial level of Cap, and result in some convergence of the relative performance of the alternative trading strategies. It should be noted, however, that the costs of achieving the efficiency gains have not been incorporated into the analysis. If these were incorporated, and incurred in a relatively even manner across the period of the evaluation, it would result in the breakeven initial level of Cap increasing for all trading strategies.

4.3 Cost of capital (discount rate) effect

4.3.1 Assumptions

The discount rate (*r*) has a considerable influence in the evaluation of the alternative trading strategies because of the large variations in the amount of capital that is required by the different trading strategies. The appropriate discount rate varies for different potential trading participants, with commercial businesses generally facing a discount rate based on the real cost of capital from commercial lenders, while government bodies basing the real discount rate on broad government determinations of the opportunity cost of capital if invested in other projects.

Commercial lenders currently face a base business lending rate of approximately 6.65per cent (eg Westpac 28/10/02), plus a margin of 1.5 –2.5 per cent depending on size of loan and other customer specific aspects. This results in a nominal cost of capital of around 8.65 per cent. Alternatively, a longer term (10 year fixed) rate would be around 7.31per cent base rate plus a margin of 2 per cent, providing a nominal rate of 9.31per cent.

The Reserve Bank of Australia (RBA) maintains a policy of retaining inflation within a band of 2-3 per cent. Assume the mid-point of 2.5 per cent inflation over the medium term. Therefore the real discount rate faced by commercial lenders would be in the range of 6.0 – 6.6 per cent. That is:

(Short term rate)
$r = (1.0865/1.025)-1$
$= 6.0\%$

(10 year rate)
$r = (1.0931/1.025)-1$
$= 6.6\%$

The ACT Government does not currently have guidelines specifying the preferred discount rate for use in Government investment evaluations. These guidelines are currently being developed, following criticism of previous project assessments, and the ACT guidelines will be based on NSW Treasury guidelines. Currently NSW Treasury recommends use of a base real discount rate of 4 per cent. ACT Treasury indicate that they would also add a systematic risk premium (which varies according to the sector of the economy that the investment relates to). Investments associated with utility services fall within the medium risk category and would attract a systematic risk premium (nominal) of 3.6% (pers comm.. D. Hughes, ACT Treasury).

Therefore real risk premium of: $r = (1.036/1.025)-1$
$= 1.1\%$

Resulting in a real discount rate of around 5.1 per cent.

The analyses reported below (in section 4.3) assess the effect of a range of potential discount rates. In all other cases the theoretical and simulation analyses assume a constant discount rate of 6 per cent/year.

4.3.2 Constant cost of capital (discount rate)

The effect of alternative discount rates on the performance of the alternative trading strategies, using the theoretical model, and simulation model are presented in Figure 5 and Figure 6 respectively. These results are also presented in Table 7, Appendix 1. This scenario assumes that the discount remains constant over the 50 year trading period.

Figure 7: Breakeven initial Cap (GL/year): sensitivity to cost of capital (theoretical model)

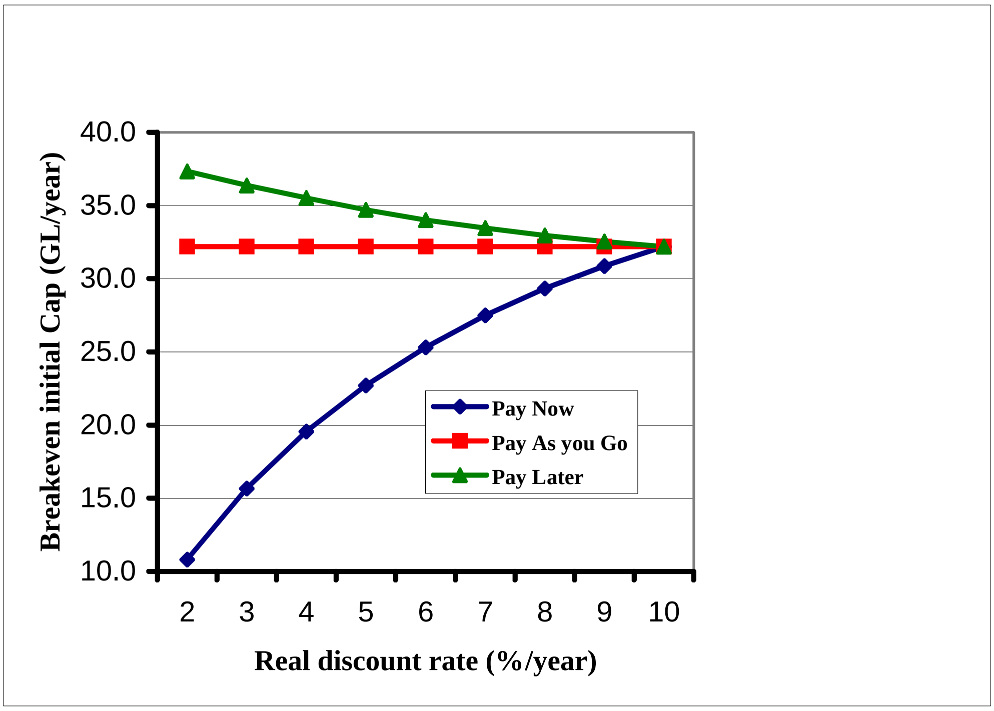
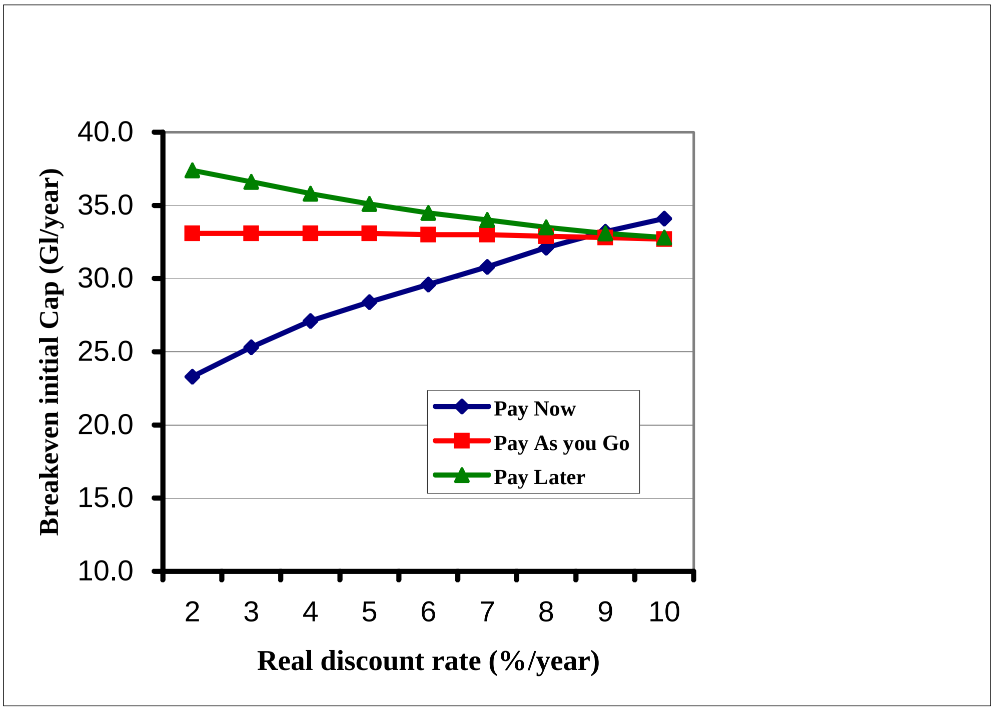


Figure 8: Breakeven initial Cap (GL/year): sensitivity to cost of capital (simulation model)



The results (as expected) indicate indifference between the choice of trading strategy at higher discount rates, where it is equivalent to the own rate of return of holding permanent water rights. At a discount rate of 6 per cent, the trading strategies result in a breakeven initial Cap range of 25.3 – 34.5 GL/year.

5 DISCUSSION

The results indicate a clear preference for the "Pay Now" strategy. However, careful consideration needs to be given to the appropriateness of the parameter settings assumed in this analysis before accepting this strategy. Issues specific to the "Pay Now" strategy include:

- The higher levels of risk associated with this strategy. The "Pay Now" strategy is preferred under the base assumptions chosen in the above scenarios, but these analyses also indicate that the "Pay Now" strategy is more risky than other strategies with respect to parameters such as the rate of growth in water use, and water price ratio (eg. Figures 2 and 7).
- The potential effect on permanent entitlement prices of this strategy. Total annual permanent water trade in the NSW Murrumbidgee (since it commenced in 1990/91) has never risen above 13,500ML/year. In the past 5 years it has averaged around 6000ML/year (DLWC 2002). This current small permanent water market does not have the capacity to immediately absorb an increase in demand of the scale required under a "Pay Now" trading strategy without causing significant increases in permanent water prices (which would undermine the strategy).

In addition, there are a number of other issues of relevance that are discussed below. In combination, these will influence final judgements of an appropriate trading strategy, and the consequent minimum level of initial Cap that must be achieved by the ACT in negotiations with the other MDB Initiative partners.

5.1 Uncertainty about price changes

The trading prices used in the above analyses relied on anecdotal evidence and informed opinion from reliable informants. A statistical evaluation of NSW temporary and permanent water prices in the Murrumbidgee catchment has not been undertaken. The evidence at hand however, indicates a significant difference between the discount rate (or cost of capital) and average rates of return that could be achieved by purchasing permanent water rights and selling them annually as temporary water rights. This raises the question of why this situation has not encouraged more people to invest capital in permanent water licences in the Murrumbidgee (and consequently place upwards price pressure on permanent licence prices). Two prominent factors arise in this regard. First, while the NSW Water Management Act 2000 provides for the separation of water from land (and facilitates the separate trade of water), the new water licensing and approvals system to do this has not yet been implemented. Anecdotal evidence in the Murrumbidgee indicates that there is significant enquiry from potential buyers waiting for this constraint to be lifted (pers comm. P. Killen, DLWC).

Second, while the NSW Water Management Act 2000 provided greater clarity in the specification of property rights over water by licence holders, uncertainty over property rights in the longer term remains. NSW authorities are committed to following an adaptive management approach to water resource administration. This appears to be a continuing source of sovereign risk in the minds of many NSW water licence holders (and potential licence holders). In contrast, ACT water allocations are more secure, and would be expected to be priced higher once a market is established. Indicative of the security of water allocations in the ACT, there are no provisions within the ACT Water Resources Management Act 1998 to enable the Territory's water management authorities to announce annual allocation levels below the licensed quantity (reflecting the conservative level of water resource allocation in the ACT).

The above factors could significantly close the gap between discount rate and trade price ratio in a future ACT/NSW water market.

5.2 Infrastructure implications

There are significant water infrastructure implications associated with the interstate purchase of permanent entitlement and then selling it interstate as a temporary (regulated) entitlement as is assumed in the trading scenarios. Just as there are costs associated with increasing the capacity of the existing ACT water supply infrastructure to service the increasing needs of a growing population, there are costs in ensuring the storage capacity to provide the regulated flow services to temporary water purchasers interstate. These potential costs have not been included in the evaluations above.

Some of the options available include:

- constructing additional infrastructure once existing infrastructure is fully utilised. The additional (financial) costs of a new dam in the ACT are estimated to be around $200 million, and there is broad community opposition on environmental grounds. Current capacity is capable of servicing the equivalent demand of a population of around 400,000 (Canberra Times 18/1/2003);
- that the storage and regulation functions are supplied by non-ACT infrastructure, for example Burrinjuck Dam, under a leasing arrangement. In the expected circumstance that ACT population growth will eventually raise ACT water needs above the capacity of existing storages, similar services may be able to be leased from Tantangara Reservoir;
- that capacity be accommodated by offsetting increases in efficiency within the ACT. Additional detail on this option is included in Section 5.3, below; and
- that interstate water sales by the ACT are completed as unregulated system transfers.

5.3 Demand management policies

A range of factors are relevant in addition to the rate of population growth, in determining the actual rate of growth in water consumption for the ACT over the next 50 years. These include:

- the potential for growth in water intensive industries. Potential increases in industrial use of water in the ACT are considered by Environment ACT (1999c) to be quite limited. Expectations are that allowances for increased agricultural use of 10GL/year and secondary industrial use of an additional 5GL/year will be sufficient to satisfy these potential sources of demand. Total industrial use is expected to grow by a maximum of 16GL/year by 2050.
- efficiency gains in domestic water use brought about by changing demographics that reflect trends in the number of people per household, different styles (densities) of housing, adoption of water use efficient techniques and technologies in gardens and inside homes. Examples include changes in ACT building regulations that now require new dwellings to have dual flush toilets installed, and the subsidy offered by the ACT Government to install rainwater tanks. In relation to household size, they

are projected to decrease from 2.71 persons to 2.41 persons by 2010, and to then remain relatively constant (Demographics ACT 2001);

An extensive community consultation component was undertaken during development of the ACT Future Water Supply Strategy (ACTEW 2000). This indicated a clear desire by the community to defer the construction of a new dam for as long as possible. The ACT community strongly prefers the use of demand management techniques including water pricing reform, water use efficiency education initiatives, and regulations such as water restrictions during periods of drought, rather than bearing the financial and environmental costs associated with the construction of new reservoir capacity (ACTEW 2000). As noted in Section 4.2.3, the costs of achieving these reductions in per capita water use must be incorporated into decisions about the use of water trading to build MDB Cap (where efficiency gains are being considered as a means of lowering the amount of permanent entitlement that needs to be purchased).

5.4 Climatic variability

Climatic variability is generally a key driver of water trade. The results of evaluations reported in this paper however, have all be undertaken assuming average climatic and water availability conditions.

However, as the focus of the evaluations has been on trading strategies over a long period of time (50 years), normal annual rainfall variation should not significantly affect the assessment of individual trading strategy performance. Initial investigations with the simulation model of the effect of variable rainfall (and its consequences on water use and annual adjusted Cap) for the breakeven level of initial Cap under various trading strategies, provides preliminary confirmation of this view. Further investigation of this issue however, remains a future priority for research.

6 CONCLUSIONS

The paper first reviewed the state of ACT water resources, and the circumstances surrounding the need for the ACT Government to negotiate a MDB Cap level with the other Murray Darling Basin Initiative members.

Agreeing to a Cap level will bring the opportunity for the ACT to trade water interstate. This ability to trade interstate subsequently provides the ACT with the opportunity to build MDB Cap allowance by raising revenue through temporary water sales and purchasing permanent water entitlement. Three trading strategies were investigated: "Pay Now", "Pay As You Go", and "Pay Later".

Analysis of these trading strategies using the theoretical and simulation models reveals a clear preference for the "Pay Now" trading strategy, in terms of its ability to minimise the breakeven level of MDB Cap entitlement required for the ACT to be no worse off under a Cap regime than from being outside the Cap regime. Key findings include that:

- Under assumptions of 1%p.a. growth in water use (Ω), a temporary: permanent water price ratio (δ) of 1:10, and a real discount rate (r) of 6%p.a., a breakeven initial Cap of between 25GL/year and 34GL/year is necessary (depending on the trading strategy followed).

- Divergence between the trade price ratio and the discount rate is the key source of variation in choice of best trading strategy (and that under the assumptions used this consistently advantages the "Pay Now" strategy).
- The "Pay Now" trading strategy also carries the greatest risk if the true nature of the growth in water use, trade price ratio and real discount rate variables are unclear. In addition, problems in sourcing sufficient water from a relatively "thin" permanent water market in the first year of trade (under this strategy) are likely to arise.

A number of additional issues were also discussed in relation to their effect on the choice of trading strategy, and potentially the negotiated Cap level. In particular:

- infrastructure considerations;
- demand management costs; and
- potential changes in institutional arrangements that alter trade price ratio/discount rate relativities; may all be very influential.

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8 APPENDICES

Appendix 1: Results of the trading strategy evaluations

Table 4: Breakeven initial Cap (GL/year) with constant Temp/Permanent price ratio

Strategy	Pay Now		Pay As You Go		Pay Later	
Temp/Perm price ratio (%/yr)	Theoretical model	Simulation model	Theoretical model	Simulation model	Theoretical model	Simulation model
2	43.3	43.4	40.4	37.0	35.5	36.1
3	41.1	41.5	38.2	36.2	35.0	35.5
4	38.8	39.7	36.5	35.5	34.7	35.1
5	36.6	37.9	35.3	34.9	34.5	34.9
6	34.3	36.2	34.3	34.4	34.3	34.8
7	32.1	34.5	33.6	34.0	34.2	34.7
8	29.8	32.8	33.0	33.6	34.2	34.6
9	27.6	31.1	32.6	33.3	34.1	34.5
10	25.3	29.6	32.2	33.0	34.0	34.5
11	23.1	28.5	31.9	32.8	34.0	34.4
12	20.8	27.6	31.6	32.6	34.0	34.4

Table 5: Breakeven initial Cap (GL/year) with rising real permanent water prices (ie. falling price ratio)

Strategy	Pay Now	Pay As You Go	Pay Later
Real rate of permanent water price increase relative to temporary price (%/yr)	Simulation model	Simulation model	Simulation model
0.5	30.0	33.2	34.6
1.0	30.5	33.4	34.8
1.5	31.1	33.5	35.0
2.0	31.6	33.7	35.2
2.5	32.1	33.9	35.5
3.0	32.6	34.1	35.9
3.5	33.0	34.3	36.3
4.0	33.4	34.5	36.8
4.5	33.8	34.8	37.4
5.0	34.3	35.1	38.0
5.5	34.7	35.5	38.7

Table 6: Breakeven initial Cap (GL/year) with constant rate of growth in ACT water use

Strategy	Pay Now		Pay As You Go		Pay Later	
Growth in ACT water use (%/yr)	Theoretical model	Simulation model	Theoretical model	Simulation model	Theoretical model	Simulation model
0	29.0	29.0	29.0	29.0	29.0	29.0
0.25	28.4	29.3	29.7	29.9	30.1	30.2
0.5	27.6	29.5	30.5	30.9	31.4	31.6
0.75	26.6	29.6	31.3	31.9	32.7	33.0
1.0	25.3	29.6	32.2	33.0	34	34.5
1.25	23.8	29.5	33.1	34.1	35.6	36.1
1.5	21.8	29.3	34.0	35.3	37.2	37.8
1.75	19.5	28.9	35.1	36.6	38.9	39.7
2.0	16.7	28.4	36.1	38	40.8	41.7
2.25	13.3	27.6	37.2	39.4	42.8	43.9
2.5	9.4	26.6	38.4	40.9	45.0	46.2

Table 7: Breakeven initial Cap (GL/year): sensitivity to cost of capital (discount rate)

Strategy	Pay Now		Pay As You Go		Pay Later	
Cost of capital (discount rate) (%/yr)	Theoretical model	Simulation model	Theoretical model	Simulation model	Theoretical model	Simulation model
2	10.8	23.3	32.2	33.1	37.3	37.4
3	15.7	25.3	32.2	33.1	36.4	36.6
4	19.6	27.1	32.2	33.1	35.5	35.8
5	22.7	28.4	32.2	33.1	34.7	35.1
6	25.3	29.6	32.2	33.0	34.0	34.5
7	27.5	30.8	32.2	33.0	33.5	34.0
8	29.3	32.1	32.2	32.9	33.0	33.5
9	30.9	33.2	32.2	32.8	32.5	33.1
10	32.2	34.1	32.2	32.7	32.2	32.8
11	33.3	34.9	32.2	32.6	31.9	32.5
12	34.3	35.6	32.2	32.5	31.6	32.3