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Options Contracts for Managing Inter-Sectoral Water Trade: A Preliminary Investigation of the Feasibility of Urban-Irrigation Options Contracts in the Ovens Basin, Victoria, Australia.

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1. Introduction

There can be little doubt that water markets are now broadly accepted by policy makers in most Australian jurisdictions as an appropriate mechanism for allocating the resource between competing users. Arguably, the extant policy faith in water markets has outstripped the capacity of water resource managers to deliver, with important hydrological and property rights matters yet to be fully resolved (see, for instance, Brennan 2006). And yet from January 1 2007 permanent interstate trade was sanctioned in New South Wales and South Australia, having been brought forward as part of the reforms embodied in the National Water Initiative in response to the worsening drought in the Murray-Darling Basin. Importantly, this has occurred despite the reluctance of many water users to engage in permanent water trade.

The formidable technical demands required to facilitating permanent water trade (see, for instance, Brennan 2004) are at least matched by the political impediments. Moreover, these tend to be heightened in two circumstances. First, when water is permanently traded from one geographic region to another, political forces in the water-exporting region are frequently mobilised to constrain trade. Arguments commonly invoked in this context relate to the stranding of infrastructure (both physical and social) and the loss of options for one region versus the expanded capacity of the other. Communities have been encouraged to treat the water consumed by 'local' enterprises as a communal asset, which if moved elsewhere would bring forth unacceptable economic and social dislocation in their local region (see, for instance, Country News 2004). A second political impediment relates to inter-sectoral trade. In this instance, a regional component need not form part of the opposition to trade, although it often accompanies the debate. Trade which attracts considerable political attention involves the transfer of water from agricultural users to urban and/or industrial consumption (see, for instance, Nairn in Quiggin 2005). In this case the exporting sector (agriculture) is usually portrayed as possessing important non-economic attributes which require protection. Commentary about the historical contribution of agriculture or its role in preserving Australian values and culture are apparent in this context (Crase 2007). [1] By way of contrast the importing sector (urban/industrial) is caste as a profligate water user 'taking water from needy farmers'. Moreover, the policy dichotomy between these two sectors has become so pronounced as to constitute a 'Balkanisation' of rural and urban water markets (Freebairn 2005, p. 4).

Notwithstanding the problems of generating permanent water trade, particularly between sectors, seasonal trade is now common practice within agriculture, particularly in the southern Murray-Darling Basin. Here water rights have been defined as a proportionate share of a variable resource and

[1] For an excellent review of political constraints of this nature see Botterill (2006).

a vigorous market exists for trading annual allocations (see, for instance, Crase et al. 2004). This is generally referred to as ‘temporary’ trade and a variety of sophisticated mechanisms have evolved to support it (e.g. *Watermove*). However, these arrangements have not gone without criticism and Quiggin and Freebairn (2006) have argued that a system of property rights that comprises both high-security and low-security entitlements would produce superior outcomes to that based on a proportionate share. In addition, others have bemoaned the overall paucity of permanent trade contending that this is a precursor to genuine structural adjustment (see, for example, Bjornland and McKay 2001).

Three prominent and related events currently circumscribe the discussion about water trade. First, the status of water storages in southern-eastern Australia has reached all-time lows in most catchments. For instance, inflows into the Murray catchment have been the lowest on record prompting unprecedented popular interest in water allocations and encouraged some to describe this as the ‘millennium drought’ (see, for example, The Age 2006). Second, expanded interest in the long-term implications of anthropogenic climate change is evident. This has manifested in concerns about the usefulness of historical norms as a vehicle for governing and managing water allocations. Third, there is clear affirmation of the desire to address water policy in a manner that is coordinated across jurisdictions. The fact that all states are now signatories to the National Water Initiative demonstrates this commitment.

In the context of water markets and trading, an important ingredient of the NWI was the commitment to “enable the appropriate mix of water products to develop based on access entitlements which can be traded either in whole or in part, and either temporarily or permanently, *or through lease arrangements or other trading options that may evolve over time* [emphasis added]” (NWI 2004, p. 11). However, there is relatively little evidence that water trade has ‘evolved’ to the point that ‘water products’ beyond permanent and temporary trade have been seriously considered, at least in the context of agricultural-urban transactions. Moreover, there is anecdotal evidence that policy makers believe that ‘other trading options’ will only become feasible once the market has ‘matured’. Ironically, what has not been widely acknowledged are the political benefits embodied in water options contracts which might potentially stimulate increased interest in water markets and alleviate the aforementioned political opposition to trade.

This paper is used to provide insights into the merits of water options contracts and their capacity to overcome the political and economic constraints that accompany a permanent water trade. In addition, we provide some indicative results from an analysis of the feasibility of options contracts in an inter-sectoral setting by considering their deployment to remove the necessity for urban/industrial water restrictions. A case study of the urban community of Wangaratta and upstream agricultural interests has been selected. The analysis is primarily designed to highlight the important elements that need to be considered during the design of water options contracts and thus help identify settings where they might be of use.

The papers itself is organised into six additional parts. In the following section the mechanics of water options contracts are briefly described and a methodology for evaluating their feasibility developed by Michelsen and Young (1993) is reviewed. Section three is used to provide an overview of the study area touching on important hydrological, economic, social and political considerations. Section four provides details of the assumptions and data that were used to generate the results discussed in Section five. We endeavour to draw together salient lessons from the analysis in Section six in an effort to inform the use of water market derivatives elsewhere. The final section comprises brief concluding remarks.

2. The mechanics of water supply options and contract design

Water supply options contracts are designed to facilitate the temporary transfer of water from low-value to high-value users during critical drought periods. As such they are most comparable to call options on commodities, whereby the option is written on drought water allocation. It is envisaged that the owners of the secure water, typically parties within the agricultural sector with comparatively low value use, take a short position in the options contract. The long position of the options contract is taken by the water authority in the urban sector, who is buying the right to obtain a predetermined amount of water at a predetermined price in the event of a drought. This predetermined price in the options contract is known as the exercise price.

The relationship between the exercise price, the price of the underlying commodity and the price of the option is demonstrated in Figure 1 from the viewpoint of the party holding a long position in a call options contract. The exercise price is denoted E and the final price of the underlying commodity S(T). The call option will only be exercised if S(T)>E which coincides with the region where the payoff from holding the option is positive. The payoff is shown as the broken line in Figure 1. It is closely related to the option price (continuous line) which includes the adjustment for uncertainty with respect to the future value of the underlying asset.

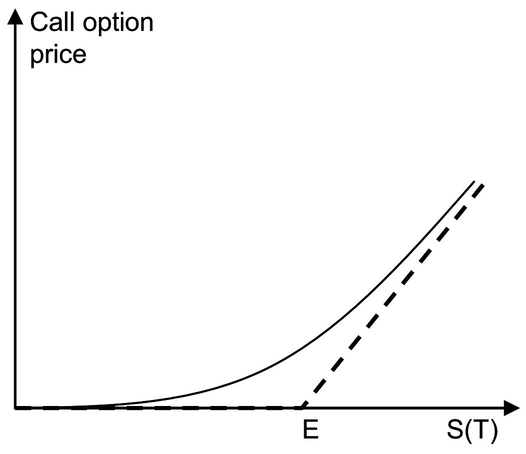

Figure 1: Payoff and Price of a Long Call Option

2.1. Water Supply Options Characteristics and Contract Design

Water supply options are distinct from plain vanilla options on financial assets or commodities in a number of important ways. These relate to property rights issues, the frequency of option exercise and the criteria on which the exercise decision is based and translate into contract designs, which are specific to the hydrological, social and economic conditions prevailing in the catchment.[2]

Unlike financial options, water option contracts do not stipulate the transfer of ownership rights of the underlying asset. Instead the water option buys the holder supply security, while the permanent water rights remain with the seller. Water supply options may also be exercised multiple times over the contract period. In this respect it resembles neither a European option which can be exercised once upon contract maturity, nor an American option which, although flexible with respect to the timing of the exercise, may only be exercised once. The decision to exercise a water supply option is linked to a critical supply condition (drought), whereas plain vanilla call options are exercised when the market price is above the strike price. This implies in terms of Figure 1 that the underlying commodity price is a function of water availability.

The distinctiveness of water supply options implies that option contracts need to be tailored to fit the prevailing hydrological, social and economic conditions of the catchment to which they apply. Water supply option contracts therefore tend to specify the contract length as a function of supply reliability and the exercise price as a function of the notice period. Similarly, in designing water option contracts supply quantities, transfer methods and delivery times need to be specified. Additional contract terms and provisions may include:

- Flexible quantity provisions to allow for variations in drought water allocations,
- Inflation adjustment provisions,
- Renegotiation clauses in case of unforeseen market changes - the case of the Tobacco farmers comes to mind,
- Provisions designed to prevent the writer of the option from being precluded from trade in the underlying water entitlements. Trade in water entitlements should still be allowed even if they are linked to allocations and ultimately the water option. But the holder of the option should be given the right to match the offered price for the entitlement,
- Option replacement with another irrigator's water rights,
- Arbitration and termination clauses

2.2. Valuing Water Supply Options for the Ovens Catchment

Valuing water supply options is distinct from the task of valuing financial options, where the price of the financial option is derived from the probability distribution of the underlying asset. Due to the distinct characteristics of water supply options, the standard financial option pricing models cannot be applied to determine the price of water options. As demonstrated by Michelsen and

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[2] See Michelsen and Young (1993) for a detailed discussion

Young (1993) this problem may be overcome by valuing water options against their cheapest alternative.[3]

The value of water supply options is primarily based on options contracts representing an alternative to investing in costly long term water rights as a means to service short term and periodic water demand. It is therefore important to evaluate water supply options against the next most economical alternative water supply. In the case of the Ovens catchment the present value from holding a drought water option is given by

$$f = \left[\sum_{t=1}^{T}\left(\frac{rK + M - \beta B - \iota I - \varepsilon E}{\left(1+r\right)^{t}}\right)\right] + \frac{K - K\left(1+\alpha\right)^{T}}{\left(1+r\right)^{T}}, \qquad (1.1)$$

where *K* is the capital cost of alternative water supply per ML at contract start, which appreciates at the annual rate of 0 ≤ α ≤1 and *M* are the annual maintenance costs of owning the alternative water supply. *B* is the price at which temporary bulk entitlements may be traded in non drought years, which occur with probability 0 ≤ β ≤1. *I* is the price per ML of internally transferred water, a trade which occurs with probability 0 ≤ ι ≤1. The likelihood, with which the option is exercised, given the exercise price (or cost) *E,* is given by 0 ≤ ε ≤1. The real interest rate is given by parameter 0 ≤ *r* ≤1 and the length of the option contract is denoted by *T.*

The value *f* in (1.1) could similarly be interpreted as the maximum price an investor is willing to pay for holding the option. In valuing water options it is assumed that the premium paid to those parties writing the option is significantly less than the option benefit to the urban sector (Hafi et al., 2005, Michelsen and Young, 1993). The overall net benefit from buying and holding the option in this case would be positive when *NPV = f – c > 0*, where *c* is the option premium, also referred to as the price of the call option. A positive net present value only ensues unambiguously if *f* > *E*, as the premium is always lower than its underlying asset (Hull, 2006). In order to determine the exact NPV the price and premium payment structure of the water option (lump sum up-front or continuous over option lifetime or a mixture of both) must be known. In addition, given the novelty of water supply options, developing a pricing model for such water products will yield important insights for the trading exercise in the case study areas.[4]

[3] Using this approach, the authors were able to derive the present value for urban water users in Colorado of a water supply options contract. Hafi et al. (2005) apply this approach to the task of valuing environmental flow options.

[4] Pricing water options correctly involves incorporating future water supply risk and trend effects into the probability distribution for the water option payoff from which the premium is derived. To this end it is necessary to estimate the probability distribution for water allocation, which may be done using historical allocation data.

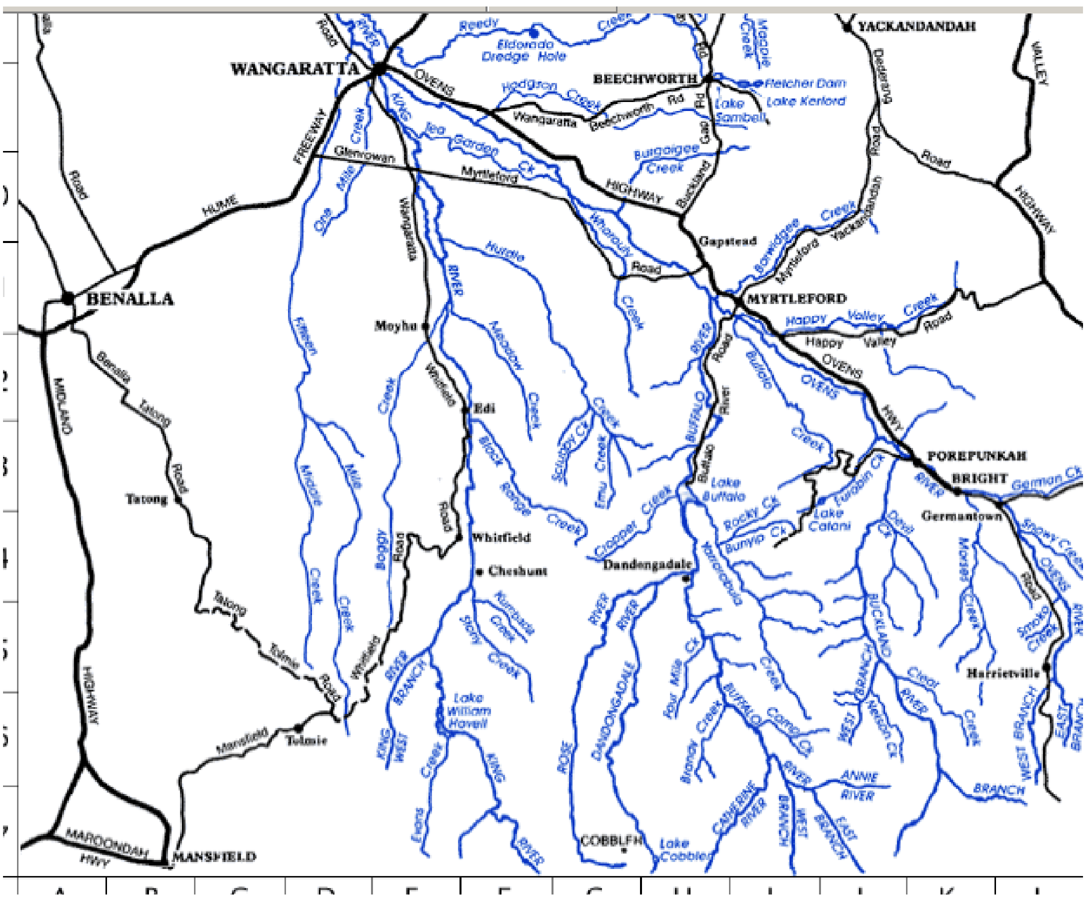
3. The study area

In order to assess the feasibility of an options contract in a given setting, a range of hydrological and economic parameters need to be specified. This section describes the relevant characteristics of the Ovens Basin, the area from which the urban water supplies of Wangaratta are drawn.

3.1 Hydrology of the Ovens Basin

The total water resources of the Ovens Basin comprise the Ovens, Buffalo and King Rivers and its tributaries and groundwater management areas at Murmungee and Barnawatha. Surface and groundwater resources were estimated to be 1,534,000 ML in 2004-05 most of which passes through to the Murray River (96%). Two main surface water storages provide a degree of regulation to surface water flows, although the extent of regulation is modest by comparison to that which occurs on the River Murray. The two regulated storages are Lake Buffalo (24,000 ML) located on the Buffalo River and Lake William Hovel (13,500 ML) located on the King River. A map of the Ovens Basin is included as Figure 2.

Figure 2: The Ovens Basin



Approximately 17,180 ML of licensed allocation occurs in the unregulated portions of the Basin (i.e. upstream of the storages) whilst a maximum of 26,105 ML can be drawn from regulated streams (DSE 2005). In 2004-05 the total permissible annual extraction that could have been undertaken by urban communities in the Basin was 17,180 ML, however actual extractions are typically much lower than this (see below). The total regulated entitlement for the Basin falls short of the capacity of both storages, which, on the basis of pre-2000 data, could be expected to fill throughout Winter/Spring with a reliability of about 98%. Historically, this has given rise to a highly reliability system for both urban and agricultural water users, although the sequence of exceptionally dry years since 2000 has prompted increased scrutiny of the modelling undertaken to estimate reliability. In this context it is anticipated that reliability estimates for the Ovens Basin will decline; first, because of enhanced measurement of inflows since 2000 and; second, simply as a result of including the low-rainfall data from the past 7 years (per com. Garry Smith, G-MW).

Importantly, in the context of options design the extent to which total flows can be adjusted by regulating structures to meet the consumptive demands of downstream users is modest. Most demand occurs between November and April, peaking in January and February. At this time of year inflows are typically negligible and in very dry years (such as 2006-07) about six times the volume of water needs to be released from Lake Buffalo to generate a single unit for extraction at Wangaratta (per com. Terry Wisener, NERWA).

3.2 Agricultural water use

As with most other parts of the wider Murray-Darling Basin, agriculture constitutes the largest extractive user of water in the Oven Basin. In 2004-05 83% of all extractions were undertaken by agricultural enterprises although only 25% of extraction occurred by agricultural enterprises on regulated streams (DSE 2005). Tracing water use to specific agricultural enterprises is problematic due to a relative paucity of data.[5] However, the water-using enterprises are more diverse in the Ovens Basin than in many other parts of the Murray-Darling Basin and typically include a range of intensive horticultural enterprises like grapes, hops, vegetables and tobacco. Dairying also remains prominent in the region although precise quantification of the extent of water use by this industry is not feasible at this point.

Significantly in the present context, the tobacco industry was the subject of radical change in 2006. Prior to 2006 the industry in the Ovens Basin comprised about 140 growers, many of whom were located on the regulated tributaries upstream of Wangaratta. In October 2006 tobacco growers chose to accept an exit package offered by British-American Tobacco to terminate future delivery contracts. This was accompanied by a $16.8 million adjustment package funded by the federal government and additional assistance provided by the state government. Many tobacco growers in the region are

[5] To the knowledge of the authors no comprehensive, detailed and publicly available data on water use by enterprise type has been produced in this region since the 1960s.

presently considering alterative agricultural enterprises although this is confounded by asset specificity and the life-stage of many farmers.

3.3 Urban water use

Total urban water extractions from the Ovens Basin were estimated to be 6,700 ML or about 17% of the total consumptive use (DSE 2005). The urban area of Wangaratta accounted for about half of this consuming 3747 ML split evenly between commercial/industrial and residential water users. This is a distinguishing feature of the water use for a provincial city of this type insomuch as a large portion of water use can be attributed to water-intensive industrial uses, like textile production. Whilst the commercial demand for water remains relatively constant throughout the year residential demand peaks in summer, much the same as agricultural demand.

3.4 Water markets, institutional and political dimensions

Water resources in this region are managed through a range of state and national institutions. Since the Ovens Basin forms part of the Murray-Darling Basin, the management of its water resources are governed, in part, by the Murray-Darling Basin Minisiterial Council and its operational arm, the Murray-Darling Basin Commission.[6] Importantly, this implies that all water extractions are subject to the 'Cap' on extractions which sets maximum allowable consumptive use at 1993-94 levels of development.

Bulk water storage infrastructure is controlled by Goulburn-Murray Water (G-MW), a state-owned enterprise which also manages water infrastructure for irrigators. Thus, G-MW is ostensibly both wholesaler and retailer of water for the irrigation community. Urban water and wastewater services are provided to urban communities and most commercial/industrial users by state-owned urban water authorities; in this instance, the North-East Regional Water Authority (NERWA). Accordingly, NERWA acts as a retailer of water for urban and industrial end users, purchasing water from G-MW.

Entitlements to extract water from regulated streams in Victoria are expressed in the form of a Bulk Water Entitlement (or BE). Since the Murray-Darling Basin Cap limits total extractions, water users wishing to expand their use or hoping to provide greater surety of supply can purchase BE from other existing users to gain permanent access to the extractable amount. Alternatively, temporary water could be purchased from those with unused BE in a given season, but it would need to be available. An important nuance in the current setting is that the BE for both urban and agricultural users in the Ovens is managed by announced restriction.[7] Schedule 1 of the BE mandates the implementation of urban water restrictions "where the Authority (G-MW) is unable to supply the full water requirements of its customers" (DSE 1994, p. 10). The extent of urban water restrictions is also detailed in Schedule 1 of the

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[6] For a more complete description of the institutional makeup of the MDBC, see Quiggin 2001.

[7] In other systems, like the Murray and Goulburn, the bulk water authority (G-MW) manages water sharing via a series of allocation announcements. In essence, these announcements indicate the proportionate share that is available for extraction at a given point in time. For instance, at the start of the irrigation season G-MW might announce a '90% allocation', which implies that G-MW can assure users of 90% of their BE at that point. As additional inflows occur allocations have historically risen.

BE and defines the required contraction of urban consumption in terms of 'restrictable demand'. This represents the average difference between winter and summer water consumption over the preceding five years. Adjustments in restrictable demand in the face of scarcity vary between 50% and 100%, depending on the severity of the water shortage. These arrangement effectively bind urban and agricultural users into 'sharing the pain' of water shortages on the few occasions when there is a shortfall.

One problem of using the water market to increase the surety of urban supplies is the relative 'thinness' of the market in this region. The water market in northern Victoria is subject to a series of trading rules which divides catchments into trading zones.[8] The trading zone in question (9A) has been characterised by modest trade over the past six years; 447 ML of permanent water was sold and a roughly equivalent amount was purchased, whilst temporary purchases and sales over the same period total 6158 ML and 5954 ML respectively. By way of contrast, 37,000 ML was permanently traded in the Greater Goulburn trading zone along with 466,000 ML of temporary trade (*Watermove* 2007).

Notwithstanding that the paucity of trade in this zone is, in part, a function of the caveats applied to the BE, there is also considerable political pressure to stymie permanent trade of the resource out of the region. As we have already indicated much of the current water use occurs in agriculture which is located in the Alpine Shire. Permanently trading water to Wangaratta embodies both forms of political concern – movement of the resource between regional jurisdictions and between sectors. Arguably as a manifestation of the opposition to permanent trade the Alpine Shire and state governments have both undertaken to actively assist former tobacco growers to remain on the land and to support the development of new ventures that would see the resource retained in agriculture. To date, no consideration has been given to the role that options contracts could play in this milieu.

4. A preliminary specification of the value of an options contract

In order to transform this information into a form that can help deduce the feasibility of options contracts the perspective of the urban water authority has primarily been considered. At the time of writing, residents and businesses in Wangaratta were enduring Stage 3 water restrictions which prohibit particular uses of water, such as the watering of lawns, although gardens may be watered by hand twice per week. Stage 4 restrictions, which essentially prohibit all outdoor watering, were mooted and pumping 'dead water' from upstream storages was under consideration. These represent short-term (and arguably unsustainable) solutions and have not been considered in this analysis. Importantly, high level restrictions severely impact on the profitability of industrial water users by reducing both water quantity and water quality.

4.1 Capital cost of alternative

Prima facie, the urban water authority (NERWA) could avert urban water restrictions by entering the water market and purchasing additional BE.

[8] For an excellent overview of the operation of the water market in northern Victoria see Brennan 2006.

However, in this setting this would involve securing a large volume of entitlement and deliberately making a modest call on it. Put differently, since the BE rules allow G-MW to invoke restrictions whenever the supply of *any* of its customers is under threat, restrictions can only be avoided if the surety of supply is increased for all users. For the urban water authority to avoid imposing restrictions on its customers it would need to purchase and leave idle enough water to underpin the surety of supply for agricultural users.

For the purposes of this exercise we have assumed that the conditions held in Schedule 1 of the BE can be amended and the Authority is then able to purchase the volume of entitlement that secures its own supply. The water authority has been an active participant in the permanent water market, particularly since 2004. A review of the purchases undertaken by the urban water authority shows that $1,200 per ML is the most common price. In order to account for the likely 'transmission losses' at a time of severe drought (such as 2006-07) this implies a necessity to hold an additional 4,300 ML of BE and allowing most of it to be discharged to the environment.[9] The likely total cost of additional BE is around $54 million.[10]

Poignantly, this is broadly equivalent to the anticipated $50 million price tag for a pipeline directly linking Lake Buffalo and Wangaratta and is also similar to the anticipated cost of an alternative pipeline to the Murray River, which enjoys greater regulated capacity than the Ovens Basin (NERWA 2005). The permanent purchase of BE also compares favourably with the $65 million pipeline from Lake Buffalo to Wangaratta via Myrtleford; an investigation of which is currently being sponsored by the state government.[11]

4.2 Cost and benefits of the alternative

Were NERWA to hold additional water entitlement they would be required to pay a range of fees and charges to G-MW which are independent of use. The current fixed annual charges imposed by G-MW on NERWA amount to $39 per ML (per com. A. Hernan, NERWA).[12]

Under the present management regime water released to the environment by an urban water authority gains no monetary reward from the resource manager. Arrangements are currently being developed that will see regional Catchment Management Authorities (CMAs) assume responsibility for

[9] The property rights that attend these 'losses' deserves closer scrutiny and can have a marked inpact on the value of options in this context. This is given greater attention later in the paper.

[10] Restrictable demand is presently 244 ML per month. It has been assumed that, at worst, 3 months of restrictable demand held in storage would avert all restrictions. In addition it is assumed that in order to deliver 1 ML at Wangaratta 6 ML must be released from Lake Buffalo, as per the current observations. Clearly, this also makes the heroic assumption that water remains available within the trading zone at the going rate.

[11] A pipeline of this nature is being promoted on the basis of its 'water use efficiency'. To date no consideration of the environmental impacts of reducing these 'transmission losses' has been published. For a review of the deficiencies of water property rights in this context see Brennan and Scoccimarro 1999.

[12] G-MW has developed a model for applying different fixed charges in different locales. Currently, this approach results in urban water users paying a higher fixed charges than irrigators with an equivalent BE.

managing an 'environmental reserve'. Arguably, any surplus BE held by an urban authority could form part of such a reserve, but on the basis of the current policy stance monetary benefits are unlikely to be bestowed on the urban water authority for a contribution of this kind[13].

Alternatively, monetary benefits from holding additional BE could arise from the sale of temporary water during seasons when there is no call on the resource by NERWA customers. Establishing the monetary value of future temporary water sales requires detailed analysis of the temporary water market, where prices vary in response to a range of factors. For instance, Brennan (2006) has argued that prices in the temporary water market in Victoria are a function of the trading zone, seasonal demand (embodied in allocation announcements) and timing within the season.[14] We have assumed that the urban authority is likely to offer up any surplus BE at the start of November.[15] This trigger point is consistent with the scenario for the options contracts, detailed below. We further assume that the average pool price paid for temporary water in the most active trading zone on this date over the past five years (excluding drought years) is reflective of the price received by the Authority. Net of transaction costs this equates to $88 per ML.[16]

In addition, since the BE relates to water held at the top of the catchment the urban water authority could benefits from internal transfers to resolve any excess water demand in other downstream communities, particularly those communities serviced by a less reliable supply. Since the Murray system enjoys a slightly lower annual reliability (97%) we have assumed that the benefits of temporary trade to other parties are restricted to 97 years in 100. In the remaining years the BE is fully deployed for 2 years and internally transferred at a value of $480[17] per ML for 1 year. We have further assumed that the any reduced reliability in the Oven Basin is matched by less reliability in the Murray.

4.3 Capital appreciation of the alternative

In addition to the short-term gains achievable by selling water on the temporary market, there are potential capital gains for the urban water authority. Estimating and including this element is confounded by two factors. First, the likelihood that the urban water authority would be able to realise these gains is quite remote. A recent decision by the Victorian Office of the

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[13] All water users in Victoria are expected to make an environmental contribution to the state government. This is presently set at a rate of 5% of an urban water authority's revenue. Payments to be made by irrigators are set at a lower rate and have been deferred to a later date.

[14] Brennan (2006, p. 415) observes that prices decline in many seasons but rise, peak and then fall in extremely dry years.

[15] Lake Buffalo and Lake William Hovell are presently operated on an annual 'fill and spill' scenario where gates are usually left open until September. Storages usually fill in Spring and are drawn down by the end of April. Earlier triggers might be employed to exercise the option held by NERWA although the assumption of a November 1 trigger is not too onerous for a preliminary investigation of this type.

[16] There is considerable inter-seasonal variability in temporary water prices and the distribution upon which this assumption is based is very limited. The need for additional refinement of this measure is acknowledged.

[17] This represents the opportunity cost of the alternative i.e. the average pool price of temporary water at the start of November in trading zone 1A during the most recent dry years, net of transaction costs.

Auditor General, which requires authorities to treat BE purchases as an 'expense', implies that the permanent sale of BE by water authorities is considered contrary to government policy. Urban water authorities are state-owned and it is feasible that any perceived excess BE would be allocated in line with government objectives rather than those that might profit the urban water authority. Second, there are non-trivial technical limitations which make the estimation of this component problematic. As we have already noted, permanent water markets are relatively thin and the data on long-term trends limited. Accordingly, in this instance, we have omitted capital appreciation from this preliminary analysis.

4.4 Length of contract and probability of exercising an option

In line with the analysis offered by Michelsen and Young (1993) we have assumed that the length of the contract is sufficient for the option to be exercised once. Current reliability estimates are based on hydrological modelling sourced from G-MW and indicate that there should be "no *significant* restrictions in supply" 99 years in 100 for the Ovens River and 98 years in 100 for the King River (per com Garry Smith, G-MW 2007 – emphasis added[18]). Accordingly, we have assumed that *all* urban and industrial water restrictions can be avoided 98 years in 100 under the status quo.

In light of the concerns emerging about the reliability of historic modelling of this nature we have also undertaken sensitivity analysis showing the value of options contracts with reduced hydrological reliability (i.e. P = 0.05 and P = 0.10) and an adjusted contract length to correspond with these probabilities. The benefits of holding BE have also been modified to reflect these scenarios.

4.5 Exercise price

The data that is presently available to assess the attractiveness of options contracts for agricultural water users is seriously deficient. Theoretically, the exercise price that is acceptable to a farmer is based on the marginal value of water at a given point in the production cycle. Whilst gross margins provide some indication of the value of water in different activities they can also prove grossly misleading. At best the gross margin represents the marginal value of water only at the commencement of the season and only if the farmer has no obligations to supply her output. Using these data would also require us to ignore the specificity of other assets in agriculture. An alternative approach would employ data from the temporary water market, but as we have already observed, there is a paucity of this information for the study area on this occasion.

A related issue in this context is the current status of some farming enterprises in the region. Tobacco growers ceased production in 2006 and many are presently considering their options. Historically, these growers would have made crucial production decisions that would determine their seasonal requirements for water at the beginning of November. Given that

[18] The concept of 'significant' has not been defined with precision by G-MW. One presumes that this corresponds with significant imposts on irrigators since these are the principal clients served by the authority.

these growers no longer have supply commitments and much of their tobacco-related assets might be considered sunk, they might come close to meeting some of the heroic assumptions required to employ gross margins as a foundation for estimating an exercise price. Moreover, analysis of the (admittedly patchy) data on water use in the region suggests that tobacco growers in regulated streams upstream of Wangaratta used about 5,000 ML in 2005-06 and would therefore hold sufficient BE to meet the requirements of an options contract with NERWA.

Returns to tobacco growers have trended downwards in recent years, although the crop generally occupied about 1,500 hectares in the Ovens Basin. Estimated returns are around $17,700 per hectare, which net of variable costs is equivalent to a gross margin of around $575 per ML.[19] This is less than the published gross margins for other horticultural enterprises like grapes, stone fruit and pome fruit (G-MW 2005), although tobacco differed insomuch as it was grown as an annual crop (albeit with long-term supply commitments). using this as a starting point we assume that an exercise price of $575 per ML is the upper bound required to induce a former tobacco grower to take up an options contract.

Clearly, the attractiveness of this group of farmers for the purpose of this analysis is the absence of any ongoing commitments to supply outputs. In order to consider the broader implications of options contracts in this setting we have also included a scenario pertaining to dairy production, which is also represented in the Ovens Basin.

In the case of dairy production the farmer is likely to have ongoing supply commitments and faces the necessity to maintain livestock over the period for which the option is exercised (3 months). Under these circumstances (and for a variety of other reasons), the gross margin of about $220 per ML (G-MW 2005) is unlikely to represent the marginal value of water. Unlike some other forms of agriculture, dairy producers are able to substitute fodder for water, although additional expenses may accrue in the form of the necessity for future pasture renovation and the like. Moreover, during the 2001-02 and 2002-03 drought seasons a range of alternatives were evident ranging from agistment, de-stocking and 'parking' cows (Armstrong et al. 2004). The expenses attributed to each of these activities can be expected to vary markedly between producers depending upon their preparedness for drought, financial resources and so on (see, for instance, Armstrong et al. 1998). However, in order to assign a lower bound to the exercise price for the options scenarios we have attempted to estimate the approximate costs of substituting fodder in these circumstances.[20] The resulting estimate of $213 is

[19] Published production costs are unavailable for this region, although Strahan (1998) suggests that they are in the order of $10,400 per hectare for similar crops in Queensland. Unofficial estimates put the gross margin at $1.17 per kilogram in the study region. The estimated yield is 27,000 kg per hectare and irrigation demand in the study region is assumed to be around 5.5 ML per hectare (per com. Gary Baxter, DPI).

[20] Conventional irrigated pasture production employs about 10 ML per ha and yields about 10 to 15 tonne DM per ha annually (Jacobs et al 2004; Armstrong 2001). We have assumed that the urban water authority makes a call on water in November at which time 20% of the water has been used. Thus, the farmer is required to purchase sufficient dry matter to replace the foregone water and to carry them

assumed to represent the lower bound exercise price to attract producers to an options contract.

4.6 Interest rate
In this instance the current ten year Australian Government bond rate has been applied.

A summary of the specified parameters for each of the options scenarios is provided in Table 1. Scenario I is based on a 98% hydrological reliability as compared with 96% and 90% reliability assumed for Scenarios II and III. The length of the contract is determined from the expectation that the option is exercised once over its lifetime. It is further assumed that external influences that affect the hydrological reliability in the Ovens catchment are similarly present in the Murray system, so that the probability of NERWA being able to transfer BE internally remains constant at 1%.

Table 1: Summary of Parameter Values under Optimal Contract Designs

Parameter		**Tobacco**		**Dairying**
K	Capital cost of alternative ($ / ML)	1200		1200
α	Annual real rate of capital cost appreciation	0		0
M	Maintenance costs of alternative ($ / ML)	39		39
E	Exercise price of option in ($ / ML)	575		213
I	Benefit from internal transfer ($ / ML)	480		480
B	Benefit from temporary trade in BE ($ / ML)	88		88
r	Interest rate (%)	5.89		5.89
		Scenarios		
Probabilities and contract length		I	II	III
	Hydrological reliability	0.98	0.96	0.90
ε	Annual probability of option exercise	0.02	0.04	0.10
ι	Annual probability of internal transfer	0.01	0.01	0.01
β	Annual probability of temporary trade	0.97	0.95	0.89
T	Contract length (years)	50	25	10

5. Results
The following section reports the results and sensitivity analyses of the preliminary investigation of the feasibility of inter-sectoral water option contracts in the case study area.

The present value benefit for the urban sector of holding water options as compared with purchasing permanent water rights are reported in Table 2 for the three hydrological reliability scenarios discussed in Section 4. Assuming

through till the beginning of April i.e. 5 months. Taking the lower bound of WUE this implies 0.8 tonnes of dry matter must be substituted for each 1ML. Assuming 90% DM per tonne for lucerne (DPI 2004) and hay is priced at $240 per tonne in the region during a drought (Armstrong et al. $240) this equates to a lower bound exercise price of $213.
We acknowledge that the approach taken here is a 'back-of-envelope' technique requiring further refinement.

98% reliability, a water supply options contract for 1ML of drought water is worth up to $128 and $244 for exercise prices of $575 and $213 respectively. Depending on the option premium demanded, these figures suggest that it may be worthwhile for the urban water authority to consider water option contracts instead of purchasing permanent water rights as a means of overcoming water restriction in drought years. This is especially true if the exercise price is based on the marginal value of water in the dairy industry, for which the resulting present value exceeds the exercise price. As explained in Section three, this implies unambiguously a positive net present value from a water supply option.

Table 2 also shows that water option contracts designed to allow for less than 98% reliability are only worth considering if the specified exercise price is $213 or below. Whether or not water options are worth pursuing under these conditions is questionable; the present value of a 10 year option on one ML of drought water when reliability falls to 90% is as low as $39. Exercise prices sufficient to induce tobacco farmers to 'option off' their water allocation are too high to yield a positive present values from the urban authorities' perspective. Under base case assumptions and low reliability, the urban sector may be better off purchasing permanent water rights.

The results of this preliminary analysis suggest that water options could seriously be considered as long as hydrological reliability remains high at 98%. Given some misgivings about the data used to derive the base case parameter estimates, we test the sensitivity of this finding to changes in the underlying assumptions. The results of the sensitivity analysis are reported in Table 3.

Table 2: Water Supply Option Contract Present Value for Hydrological Reliability Scenarios I, II and III

		WSOC PV ($ / ML)	
		Exercise Price ($ / ML)	
Scenarios		Tobacco 575	Dairying 213
Scenario I	98% Reliability	128	244
Scenario II	96% Reliability	-22	165
Scenario III	90% Reliability	-229	39

Table 3: Water Supply Option Contract Present Value: Sensitivity to Scenario I Base Case Assumptions

		WSOC PV ($ / ML)	
		Exercise Price ($ / ML)	
		Tobacco	Dairying
Parameter Values		575	213
Capital cost of alternative ($ / ML)	1000	-60	56
	1200 *	128	244
	1400	317	433
Annual rate of capital cost appreciation (%)	0 *	128	244
	2	12	128
	5	-590	-474
Benefit from temporary trade ($ / ML)	75	330	446
	88 *	128	244
	100	-58	58
Interest rate (%)	4	-315	-159
	5.89 *	128	244
	7.5	355	449
Expected exercise frequency (no of times over 50 years)	1 *	128	244
	2	-28	204
	5	-495	84

* Solution with Scenario I base case parameter values

While simulated option contracts are positive for a range of parameter values, negative option contract values result in a number of cases. For example, a capital cost of the alternative water supply of $1000 leads to a negative present value of the water option if the exercise price is high. On the other hand, the value of an options contract can be as high as $433 if the alternative capital cost were to increase by only $200.

Table 3 further illustrates the sensitivity of the results to a key assumption; namely, zero annual capital appreciation of the alternative. Relaxing the impediments associated with state-ownership of the urban water authority implies positive values for α, which quickly translate into very low and even negative present values for water options. The price of temporary water traded during non-drought years was also found to be an important determinant of the option contract value. A decrease in the base price of $88 to $75 more than doubles the option contract value for a 'tobacco' exercise price and potentially increases the option contract value from $244 to $446 for the lower marginal value enterprise.

The present value of water option contracts is positively related to the interest rate as shown in Table 3. Higher interest rates increase the opportunity cost of securing the alternative water supply and lead to greater discounting of the costs from exercising the option at a future date.

The length of the contract is based on the assumption that the option is exercised once over its lifetime. Table 3 illustrates that underestimating the likelihood of option exercise is costly, especially if the exercise price is high. For instance, whilst an option contract has a positive value of $128 for an exercise price of $575 under the base case scenario, this turns into a cost if the option is exercised twice rather than once over a 50 year period. Higher exercise frequency reduces the option contract value for those based on a lower strike price, although they remain positive for the range of values explored here.

6. Policy lessons

Clearly, the previous section indicates that options contracts can offer urban water authorities positive values in this instance, although the practical magnitude of those values and the capacity to attract the interest of agricultural producers has yet to be tested. The analysis also reveals some fundamental lessons about the usefulness of water options contracts in this context.

First, the attractiveness of this approach increases when targeted at relatively low-value agricultural enterprises with few ongoing commitments or those with a capacity to substitute other inputs for water. This is not an especially remarkable finding although it seems to have escaped the attention of policy makers who are keen to offer financial assistance to retain water in purportedly high-value agricultural production. For instance, in the case of the tobacco industry the federal government has provided almost $17 million of taxpayer-funded adjustment to the 140 farmers formerly engaged in the industry and applied virtually no caveats. Similarly, the state government is funding investigations into alterative agricultural enterprises that could be undertaken in the Ovens Basin on land previously used to produce tobacco. Curiously, the same government is supporting an investigation of a $65 million pipeline to increase surety of supply for the Wangaratta community. To the knowledge of the authors there has been no attempt to integrate these projects. An alternative approach would see these two concerns addressed in a more holistic fashion. More specifically, lower value agricultural enterprises in concert with options contracts instigated by urban water authorities may offer a more efficacious outcome than public sponsorship of irrigated agriculture and grandiose engineering ‘solutions’. Hopefully, the information provided herein on options contracts might encourage a broader conceptualisation of these issues.

Second, there are a number of important and volatile parameters that could markedly influence the value of options contracts. For instance, the price of temporary water (which has traded for as little as $12.50 per ML in recent seasons) has a significant bearing on the attractiveness of options contracts. This occurs for two reasons. First, if the water authority were to permanently purchase water and yet only be able to sell it seasonally for much less than $88, then options contracts become more feasible. Second, if temporary water is trading for much less than the estimates used here, this would support the view that the marginal value of water is much lower than the $213 lower bound employed in this analysis. Accordingly, the exercise price would be significantly lower and the value of the option increased.

Similarly, the price of permanent water was shown to be an important consideration. In this case the values employed in the sensitivity analysis are not improbable in the current setting. In January 2007 the published pool price for permanent water in trading zone 1A was between $1,900 and $2,000 per ML (see, *Watermove*), much higher than the $1,400 per ML which produced a doubling of the options values. Put simply, options contracts may be much more attractive than the relatively conservative scenarios used in this analysis and it is difficult to see the price of permanent BE falling over the longer term.

Notwithstanding this positive outlook there are significant challenges to implementing options contracts in this setting and these offer additional insights to policy. Perhaps most notable is the current treatment of 'transmission losses' in this system and how the present approach stifles the incentive for options to emerge (and other inter-sectoral trade for that matter). We observed earlier that there is a practical/hydrological impediment in the study area insomuch as much more water must be released from Lake Buffalo to generate the capacity to extract water at Wangaratta – a ratio of six to one has been observed in the present dry season. Thus, if the urban community is to have genuine surety they would need to hold six times the volume of accounted water and enjoy sufficient influence over the managers of the infrastructure (G-MW) to have those volumes released. In addition, under the current institutional arrangements any benefits that arise from these 'distribution losses' would be an externality, since the property rights to this portion of the water is ill-defined. Invariably, much of this water would assist in maintaining the riverine ecosystems[21] or to recharge aquifers depleted during drought. In the absence of more precise hydrological data and property rights that encompass that hydrology the incentive for the urban water authority to hold options (or indeed additional BE) is weakened. Specifying the rights to water that is euphemistically described as 'lost' in the current milieu would also enhance the rigour of any benefit cost analysis of engineering schemes built on the premise of reducing such losses. This is a more general lesson yet to be fully appreciated by water policy makers.

A related matter concerns the status of water accounting. For options contracts to be of value the water must be accounted for with sufficient accuracy to ensure that it is actually available when called upon. Even a cursory review of the available data reveals significant deficiencies on this front. Holders of 'stock and domestic' entitlements remain un-metered and the systems for quantifying how much BE is taken and by whom are no where near as advanced as many presume. Similarly, enhanced monitoring of

[21] An additional nuance arises if these 'distribution losses' generate environmental harm. For instance, it could be argued that the river should run dry during a sever drought to mimic natural flows.

aggregate inflows is required to improve predictions of water shortages. Again, these are generic problems with Australian water management but their impact on the feasibility of employing options contracts is clearly non-trivial.

Finally, there are behavioural hurdles to be overcome to instigate options contracts. First, in order to initiate a contract of this type an urban water authority would have to be convinced of its usefulness. Using institutional and market solutions to resolve conflicts over water use have not always easily entered the psyche of urban water managers. Historically, engineering solutions have been favoured as the means of adding surety to urban water supplies and there are no obvious signs that this trend is about to change.[22] Second, options contracts result in farmers being paid for doing nothing during a dry season. This is a notion that is unlikely to sit easily with many involved in agriculture where the nobility of yeomanry continues to have a powerful influence over decision making.

7. Concluding remarks

The principal motivation for this work was to test the feasibility of options contracts in a given setting. Moreover, we have contended that, if economically feasible, options contracts might be employed as part of a suite of solutions to address urban water shortages and provide a mechanism for overcoming the political constraints that have hitherto limited permanent water trade between sectors and regions.

To date options contracts between urban and agricultural water users have received limited attention in Australia, often on the premise that they will 'organically emerge' when the water market grows and matures. This case analysis shows that options contracts do have positive values under a range of scenarios and deserve consideration alongside other policies aimed at enhancing the efficient allocation of water resources. Admittedly, there are institutional impediments to the practical deployment of options contracts but the costs of addressing these is likely to be no more than the alternatives that are presently on offer. Moreover, policy makers who ignore the benefits of options contracts run the risk of exacerbating the Balkanised approach to urban and agricultural water management and placing additional and significant imposts on the public purse.

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[22] Arguably, the penchant for engineering 'fixes' in this context now manifests in enhanced enthusiasm for recycling and the modest economic scrutiny that often attends schemes of this type (see, for instance, Crase, Byrnes and Dollery 2007)

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