Urban Water Supply Optimisation and the NWI

Lin Crase

Introduction and Context

At a national scale the 'urban' sector accounts for a relatively modest amount of Australia's use of freshwater resources. For instance, in 2001 the urban sector was estimated to use about 13% of all freshwater. This was distributed such that around 8.8% was used by households and manufacturing accounted for 4% of all water use (ABS 2001). However, national data of this form can prove misleading on several fronts. First, the particular requirements of the urban sector often differ markedly from that of other sectors. More specifically, urban users, relative to many other users, have historically had a strong preference for normalised water supplies. In simple terms, urban water demand is not always easily comparable to other water demands which can sometimes be adjusted in line with resource availability (e.g. annual agriculture). Second, important geographic constraints can attend urban water which limits supply augmentation options. Thus, location-specific scarcities are often more important in the urban milieu than would be suggested by data on national water usage. Third, urban water use is attended by political sensitivities and, to date, a heavy emphasis has been placed on 'educating' urban water users (see, for example, Cooper 2010). Perhaps it is because of these peculiarities that urban water use features so prominently in the National Water Initiative (NWI), regardless of its modest standing as a claimant on the nation's water resources.

Notwithstanding the prominence of urban water in the NWI, I contend that the objectives assigned to urban water reform lack consistency. For example, on the one hand there are objectives to "facilitate water trading between and within urban and rural sectors" and an ambition to "achieve improved pricing for metropolitan water" (NWC 2010). And yet on the other hand, specific objectives target particular technologies, arguably with no reference to their economic merit or locational constraints. For instance, one of the objectives of the NWI is "increasing water use efficiency in domestic and commercial settings" (NWC 2010) with little attention to the economic efficiency of such measures[1]. To the uninitiated these objectives might appear synergistic but serious inherent contradictions emerge when these concepts are scrutinised more closely.

There is also some evidence that supply optimisation and/or augmentation decisions are not always well-linked to demand considerations. This is significant because uncoupling demand and supply choices can result in serious violations to economic efficiency[2]. This approach would thus seem to be at odds with Merrett's (2004, p. 29) suggestion that "we should always integrate in our thinking and our practice both demand-side *and* supply-side strategies" [original emphasis].

This brief report provides commentary on the notion of urban water supply optimisation in the context of the future direction of the NWI. The report does not deal with all supply alternatives but uses salient cases to highlight important policy lessons. The report itself comprises three additional parts. In Section 2 I consider the barriers to reform, especially those that relate to intersectoral water trade and the

[1] There has been a penchant to confuse water use efficiency with allocative efficiency and this is discussed in detail later in the report.

[2] Regrettably and in the context of the '*topic areas*' developed for this round of NWC assessment reports, '*supply optimisation*' and '*demand management, water use efficiency and restrictions*' appear as separate domains.

development of clearer price signals. Opportunities for improvement are detailed in Section 3 whilst summary recommendations and brief concluding remarks make up the final section of the report.

Barriers to Supply Optimisation

At its simplest, supply optimisation implies ranking all augmentation options and progressively choosing those of greatest merit through to those of least merit. From an economic perspective this would involve selecting low-cost options ahead of high-cost alternatives, presuming of course that each yielded the same 'water product'. In reality, the choices are more complex insomuch as supply alternatives will differ in their water delivery characteristics and locational parameters will rule some sources unviable in some cases and not others. For instance, treating and recycling reclaimed sewage or desalination will offer a more reliable water supply than rainwater tanks in many locations. Similarly, buying general security rights from a NSW irrigator is hardly comparable to purchasing high security rights in that state, or Victorian water rights for that matter. Notwithstanding these nuances it is still possible to establish an order of economic merit by factoring the supply risk of each alternative into investment decisions and using reasonably well-established probability distributions and/or historical data.

Ample work already exists in this field (see, for example, Marsden Jacob Associates 2006) and does not need to be duplicated here. And yet what frequently attends supply augmentation decisions is an array of political considerations, often imposed by superordinate bodies and in some instances supported by the NWI itself. In the space available I endeavour to deal with the most worrisome (or tedious) of these.

First, the NWI deliberately espouses the value of water use efficiency (WUE) in domestic and commercial settings. Perhaps not surprisingly, this has strong political appeal[3] even if the intellectual grounds for its specification in the NWI are weak. It needs to be understood that WUE is a technical/engineering concept that ostensibly aims to define the ratio of water inputs to outputs[4]. However, this is a very poor measure of technical efficiency in the economic sense or overall economic efficiency. Water is usually only one of many inputs in the production of outputs, including in household settings. Complementary inputs are also a requirement (e.g. the labour required to hand-water plants). Thus, to target only one input will inevitably result in poor input selection. For instance, elaborate capital investments at the household and commercial level can, in some cases, be used to offset water inputs, but this does not guarantee a low-cost means of production. To simply assume that WUE is superior to the efficient use of *all* inputs belies the expansive economic literature in this field. Moreover, to place WUE above overall economic efficiency seems an even greater misjudgement. Some outputs produced at the household and commercial level will be water-intensive and have few options for input substitution. Moreover, these same outputs may also be highly valued and in that context households and commercial enterprises will accept the necessity for increased water use and willingly carry the related costs (e.g. gardening for passionate gardeners). Overt attention to WUE in the NWI and the pervasive influence of the concept on program funding remains one of the major barriers to urban water supply optimisation.

[3] Chris Perry (2009) bemoans the use of value-laden terms in this context. 'Efficiency' for example is seldom cited as an undesirable outcome in any domain.

[4] The NWC has attempted to broaden the technical focus of WUE and claims that it sees "the objective as to facilitate a level and pattern of water use and related investment that maximises economic, social and environmental benefits" (NWC 2009, p. 158). Nevertheless, the relative weight of funding distributed by the NWC supports the view that excessive attention to engineering fixes continues to stymie progress on the economic front.

Second, and in a related tenor, the water use of some sectors continues to be determined by political agendas rather than strictly on the basis of economic merit. This has significant ramifications for the intention of the NWI to promote water trade within and between the urban and rural sectors. In this context the NWC observed that "during 2008-09 there was limited rural-urban trade and bulk water entitlement trade between urban users ... compared to the rural water market" (NWC 2009, p. 7). In simple terms, there remains strong political opposition to the free trade of water away from agriculture, especially to urban users. This is exacerbated by the spurious use of the WUE concept as the basis for expanded subsidy for irrigated agriculture (see, for example, Crase and O'Keefe 2009). The upshot is that agricultural use of water remains implicitly (and in some cases explicitly) subsidised by the public purse. For instance, the notion of 'water savings'[5] continues to be used as the basis for many infrastructure projects, such as Victoria's Foodbowl Modernisation Project. The water that is purportedly realised by this project has been estimated to be at least four times more costly than water entitlements purchased from the market (Productivity Commission 2010, p. 129). It is hard to conceptualise these arrangements as anything other than a subsidy from Melbournians to irrigators north of the divide. In economic parlance, subsidised infrastructure of this form also raises the marginal revenue product of water, thereby making it less likely that water will be freely traded away from irrigation districts to prima facie higher value uses. Given the emerging data on climate change, the longer term consequences of these types of policy decisions, is also problematic[6]. In any case, the consequence is that urban water supply optimisation is made more remote when some water-using sectors (and sub-sectors) are deliberately advantaged over others by public policy decisions.

Third, and perhaps ironically for those who reside in cities with a hydrological connection to agricultural users (e.g. Canberra), the response of water utilities to limit demand with mandatory water restrictions also acts as a barrier to supply optimisation over the medium and longer term. Water restrictions are now the norm for many towns and cities and the zealous promotion of 'water savings' creates its own set of dilemmas. For example, Cooper (2010) found that about 20 per cent of customers would actually pay an additional water charge to prevent other water users accessing the water market in order to alleviate the burden of water restrictions. This was traced to the public policy decision to promote water restrictions as an objective in their own right. Setting aside the social costs of restrictions[7] and what these data imply about the political challenges of now augmenting supply via the market, the immediate impact is to limit the volume of water that can be sold by utilities. Over the longer term this constrains the revenue on hand to pursue future supply augmentation works.

---

[5] It is important to understand that these are 'notional' in the sense that water in the Murray-Darling Basin is already fully allocated and 'saving' water is tantamount to reducing the availability of water to other right holders. Other overt barriers include the cap on water sales imposed by Victoria, arbitrary differential requirements for environmental contributions from rural water suppliers versus urban water suppliers and so on.

[6] Crase (2010) has speculated that infrastructure will ultimately become a millstone for agriculturalists, especially if they face sequences of years with low or zero allocations. Connor et al. (2009) have also shown that perennial agriculture becomes less profitable than annual enterprises under some scenarios of climate change. It is difficult to rationalise the heavy investments to provide an ongoing supply of water to irrigation via exorbitant infrastructure under these circumstances, at least at current and likely future prices of agricultural commodities.

[7] These have been enumerated by Brennan, Tapsuwan and Ingram (2007), Grafton and Ward (2008), Centre for International Economics (2008) and others. In addition, Cooper (2010) has shown the divisive nature of restriction regimes and their relationship to spite.

There is also a related component to this argument that centres on the structure of water tariffs. Heavy reliance on fixed water charges limits the revenue risk for water utilities but simultaneously blunts any internal incentives to permit (let alone promote) increased water consumption by high value users. In this context Crase (2009) drew an interesting comparison between the behaviour of Albury City that supplies around 50,000 customers in NSW and North East Water that services the neighbouring town of Wodonga with around 40,000 residents. In the case of the former water tariffs are heavily weighted towards fixed charges and the volumetric charge comprises an inclining block tariff with the lowest rate set at about $0.50 per kilolitre. In contrast, North East Water has lower fixed charges but levies a single volumetric tariff about twice that of Albury City. It was instructive to note that residents of Albury were subjected to more onerous mandatory restrictions in the summer of 2009-10 than residents in Wodonga. Moreover, North East Water was active in the market for water allocations, in part because there was ample scope to purchase water, treat it and sell it at a profit. To the knowledge of the author Albury City did not enter the market to alleviate the costs imposed on its customers.

The reluctance of Albury City to use the water market to augment supply is not solely related to the tariff regime on hand. The influence of superordinate levels of government cannot be understated in this context and this constitutes the final barrier to supply optimisation dealt with here. There remains a penchant for state governments to mandate the same water using behaviour across their jurisdiction with limited scope for distinguishing local resource nuances. This ranges from mandatory building codes (e.g. Basix) that favour the installation of water tanks even when they have been shown to be of much greater (lower) value in some locations than others, to state-wide pressure to resist rural-urban water trade. Similarly, establishment of state-based targets for water recycling have a pervasive influence on local water supply decisions. Supply optimisation should be a function of the feasibility of local options, unless there are serious spill-over effects to other jurisdictions or scale economies from higher order decision making. The current attenuation of local decision making by state agencies would appear to go beyond the standard arguments for overriding subsidiarity and thus lead to sub-optimal outcomes.

Opportunities for Improvement

The previous discussion has attempted to highlight the folly of establishing onerous constraints at the state or federal level over local water supply augmentation decisions. The rationale is that water resource availability is inherently location-specific and water supply optimisation should be determined on the basis of localised influences (and costs). Thus, there would appear to be room for improvement by providing greater scope for local and informed decision making by water utilities.

The need for recognising heterogeneity goes beyond supply augmentation decisions by water utilities. There is also a greater need to recognise the heterogeneity of water users themselves, since acknowledgement of user heterogeneity is a precursor to the development of a wider suite of supply and demand management responses.

Currently, there is limited scope for urban water users to express their water using preferences, other than through technological choices that circumvent the control of water utilities. For example, if bore water is available and water users have a preference for unrestricted garden watering, they may install a pump, acquire the necessary licenses and thus maintain or improve their household amenity. Similarly, builders of new homes can opt for a range of technologies, such as grey-water recycling systems, that bestow more flexibility on the home owner. Perhaps

ironically, many of these options are far more costly than if supply augmentation was to occur at the utility level and customers were then offered choice though different tariff structures and supply contracts.

To illustrate this case it may be helpful to reflect on the introduction of an urban water trading pilot program in 2007-08 by North East Water in Victoria. Ongoing drought and severe restrictions had led to the demise of many outdoor assets. Some of these facilities were perceived as community-based, such as bowling greens, and there was considerable angst about their decline and the likely cost of reinstatement. The options for preserving these assets under a water restriction regime included carting recycled water, acquiring a bore or simply flouting the restriction regime and paying any subsequent fines[8]. Many of these options also carry greater risks than simply accessing water from a reticulated supply, say in the form of ad hoc arrangements for dispensing carted water. In response to these concerns North East Water provided an opportunity for some organisations to access off-restriction supplies. An administrative charge of $200 was levied, participants then purchased water allocation from a willing seller in the water market (commonly around $1000 per Megalitre) and paid the standard volumetric rate (equal to around $680 per Megalitre at the time) to North East Water to ensure delivery. Universally, participants in the trading project reported being pleased with the outcome and rated the trading scheme as a much lower cost option than alternatives (Heiner and O'Keefe 2008).

Clearly, a prerequisite for the North East Water trading project was access to the market for irrigation water and thus hydrological connectivity to those users. However, there are now major urban centres that enjoy similar access, including the populations of Canberra, Adelaide, Melbourne and, to some extent, Perth. The NWC (2009, p. 7) noted that some jurisdictions had purchased water allocations from irrigators to supplement urban water during periods of shortage. Notably, SA Water purchased 231 Gl to supplement Adelaide's water supply and 'water saving' projects undertaken via bilateral agreement between Harvey Water and the WA Water Corporation have also been described as trade[9]. However, to the knowledge of the author there are few cases where the specific preferences of the customers of a water utility have been given the opportunity for revelation, other than via the water trading project described above. Rather, the modus operandi of utilities is to shore up community water supplies to some uniform level and then ration water by varying the severity of behavioural restrictions for <u>all</u> potential users. Notwithstanding the acknowledged welfare losses that attend this approach (see, for example Brennan et al 2007) and the deleterious equity consequences (see, for example Crase, Dollery and Byrnes 2005), this response also has the perverse effect of limiting the scope of different supply augmentation strategies.

The notion that urban water customers have differing demands should of itself not be particularly remarkable. However, the current policy setting runs contrary to this view. Outdoor water restrictions are equally stringent on residents in high-rise apartments with no outdoor space and suburban dwellers with the demands of a vegetable patch, all in the name of equity. Watering times are also rostered with no consideration of the hours available to different householders to hand-water portions of their garden. In most jurisdictions some dispensation is made for the elderly

[8] The penchant for imposing monetary penalties for breach of water restrictions varies markedly between jurisdictions. No breach of urban water restrictions has led to a fine in Victoria (Cooper 2010) although numerous fines are applied in NSW.

[9] The extent to which such deals amount to trade versus cross-sector subsidy has already been addressed.

although many are reluctant to seek relief for fear of the community backlash and a determination to share in the community's 'pain' (see, for example, Wells 2007). As already noted, there are even some who would apparently gain utility from seeing this pain extended and/or prolonged (Cooper 2010).

Notwithstanding these preferences, there is also evidence of a significant and positive willingness to pay to avoid or limit the costs of water restrictions, albeit far from universal or homogenous across the population. For instance, Cooper (2010) found that around the same proportion (20%) that would willingly see water restrictions extended in preference to accessing the water market would willingly pay extra to curtail water restrictions. The point is that such heterogeneity offers a market opportunity for different water supply options if only there was capacity for a more flexible response from utilities.

In recognising the scope for a more varied response to attendant demand some work has already been undertaken in the field of third party access regimes (see, for example, ESC 2009). Third party access offers an opportunity for competition to drive innovative supply options for heterogeneous customers. Needless to add, it also constitutes a considerable threat to government-owned monopoly water utilities hamstrung by a penchant for jurisdiction-wide approaches to rationing, mandated postage stamp pricing and centralised decisions that force-feed the ranking of supply augmentation options. Notwithstanding state nervousness about third party access, a significant opportunity exists, even within existing legislative arrangements. Wider acknowledgement and promotion of this opportunity by the NWC would appear warranted if it is genuinely interested in improving supply optimisation.

This would require a non-trivial change in the policy approach to water affairs. As has already been highlighted, the heavy emphasis on narrow concepts such as WUE has already created within government and community circles a view that less water use by the urban sector constitutes a superior state under any circumstance. Moreover, the near ecumenical enthusiasm of state agencies to promote urban water saving at any cost has resulted in an environment where a shift to more rational investment decisions is likely to attract criticism from some parts of the citizenry. The negative response of some Melbournians to the relaxation of water restrictions as a result of recent widespread rains is a case in point (see, for example Scott 2010).

Thus, while there is scope for more diverse responses to supply augmentation these are only likely to be realised if accompanied by a successful 're-education' campaign on the part of water agencies. Cooper's (2010) research is again instructive in this regard. Half of the sample from which she sourced data was presented with information on sectoral water use drawn from the ABS. In essence, these data were designed to indicate to respondents the relative magnitude of sectoral claims on water use and the comparatively modest impacts that arise from curtailing urban water use, at least at a national scale[10]. An interesting result was that exposure to this information significantly reduced the predictability of responses to specific questions, suggesting that the information itself has the capacity to disturb the underlying preferences held by respondents.

[10] Obviously these results need to be interpreted in the context of earlier remarks re the importance of local supply availability. Nevertheless, they do indicate the pervasive influence of state-sponsored information campaigns that shape perceptions about water use.

As it stands urban consumers with a preference for higher water consumption than the norm are encouraged to satisfy those preferences by accessing relatively expensive non-reticulated supply options that offer some autonomy over water use. Alternatively, they must succumb to the coercive pressures from government agencies and other community members acting as water vigilantes. This is neither socially nor economically desirable in the medium to longer term. Put simply, there is ample evidence of pent-up demand for choice at the customer level when it comes to water supply options. The sticking point appears to be the undue influence of state and federal agencies that rein in the potential for local responsiveness.

The nature of economic regulation is also worth considering in this regard. State jurisdictions have generally recognised that monopoly supply of water and wastewater services needs to be tempered by regulation to limit the extraction of rents[11]. On the face of it economic regulation established at arms length from government-owned monopolies makes sense. However, closer scrutiny of the mechanics of regulation reveals areas for improvement. Of particular importance in this regard is the breadth of issues for which economic regulators are expected to be responsible. For example, it is common place for state regulatory bodies to include within the suite of considerations, the affordability of water for different customer segments (see, for example, Watkins 2006). Of course the upshot is that regulated water prices do not strictly reflect resource availability and thus the cost (benefit) of supply augmentation options[12]. In some jurisdictions prices to remote areas are politically managed and thus mute the influence of cost and scarcity – water prices in Whyalla in SA and Kalgoorlie in WA are obvious cases. State and commonwealth-based subsidies for particular projects also distort the incentive to optimise supply across options[13].

As noted earlier, recognition of customer heterogeneity is an important element for encouraging supply optimisation. In addition, there is scope for a more lateral approach to market instruments on the part of water agencies.

It is now widely accepted that climate change will have a significant influence on water availability, although the modelling at a relevant scale is far from complete (see, for example Beverley 2010). Moreover the uncertainty around regional scale modelling gives some indication of the value of *not* undertaking water supply projects heavily premised on existing and historic engineering responses. For example, even the modest economic merits of WUE projects in urban systems soon deteriorate when there is little water to be 'saved'. It is against this background that a broader suite of market alternatives to manage risk and uncertainty need to be considered.

The Australian water market is currently dominated by agricultural interests and is primarily limited to two forms of trade: 1. Trade in entitlements to access water, and; 2. Trade in annual water allocations that attend existing entitlements.

[11] This does not apply to all urban water supplies but is focussed on 'major' utilities. For instance, non-metropolitan water supply in NSW is not subject to the same level of economic scrutiny as occurs in Sydney.

[12] In addition, in some jurisdictions economic regulation does not result in binding prices and political forces can blunt price signals.

[13] Much is made, for example, of the notion of water-sensitive urban design. Regrettably, the economic merits of some projects in this genre are not always assessed using standard evaluation processes. The case for intervention on the basis of purported market failure is also debatable. An additional consideration is the impact of moral hazard. Whilst some projects may be worth pursuing in their own right, utilities are now adept at only undertaking works once additional financial support is forthcoming. Since these additional contributions seldom attract a return from customers, prices will again be distorted.

Notwithstanding the rapid growth of water trade (especially trade in entitlements), there remains considerable scope for other market instruments for managing supply augmentation and customer heterogeneity[14].

Leroux and Crase (2010) investigated the scope for options contracts to manage urban water supply along the Ovens catchment. They showed that for a range of agricultural pursuits an option contract between the water utility and farmers could be negotiated that would yield gains for both parties. Their work drew on evidence in the US where options contracts between water utilities and agricultural communities have been shown to increase welfare for both parties. The question that remains unanswered is 'why have so few water market derivatives, such as options, emerged to date in Australia?'. A major contribution would be to better understand the impediments to the formulation of a broader suite of market instruments, like options contracts, split season leases and the like.

Recommendations and Concluding Remarks

The preceding section points to three strands of reform covering industry-wide issues, water utility responses and consumer behaviour. These are not strictly separable and should be considered simultaneously to improve urban water supply decisions. To reiterate, it would also be folly to consider improvements on the supply front without integrating demand considerations.

At the national level (i.e. NWI) the WUE mantra needs to be reconsidered and re-crafted. This will be a formidable task given the momentum developed around the notion of 'saving every last drop'. Nevertheless, unless this is tackled the objective of optimising supply in the longer term will be unattainable. It is difficult to see this being accomplished in less than 10 years.

In the context of industry governance, reform of economic regulation appears warranted. This should have two elements: 1. tightening the focus on economic regulation such that the aim is to better align prices and costs - broader welfare objectives should be clearly assigned to other policy domains; 2. a staged reduction in the political discretion over regulated prices. The outcome would be clearer incentives to both utilities and end users to optimise supply and demand. The necessary reforms should be manageable in the medium term – 3 to 5 years.

Lying between the industry and utility areas of influence is the requirement to devolve greater decision making power to local utilities. As has already been noted this is a prerequisite to supply optimisation insomuch as water availability and appropriate responses to demand are best managed at a local level. This should not be confused with calls for privatisation of water and wastewater services from some quarters or the emerging interest in third party access. The extent to which local responsiveness can be achieved without undue influence from superordinate bodies is an argument based more on the appropriate assignment of decision making power and should not be distracted by arguments around ownership or the role of the private sector.

Accompanying this devolution will be the requirement to consider and, where necessary, bolster decision making capacity. Ensuring that local water utilities have sufficient intellectual capability to undertake analysis of supply options will be an important task. The current divergent institutional arrangements within the different

[14] The Productivity Commission (2010) reached a similar conclusion in the context of dealing with heterogeneous environmental requirements and the buyback programs being used to secure the Commonwealth environmental water reserve.

states provide an opportunity to explore the best means of garnering local decision making capability (see, for example Byrnes et al. 2010). Progress is already underway in some states on this front and a timeframe of 5 to 7 years seems realistic.

Decision making by utilities will also be bolstered by exploratory work around market alternatives and options. This has implications for both the urban sector and other water claimants since a wider suite of water market products offers considerable gains to all sectors. Inertia around annual and permanent trade is unlikely to be rapidly overcome, although declining water availability may hasten interest in this field. A medium term timeframe of 5 to 7 years appears feasible for this work.

At the customer level two areas of reform emerge from the earlier analysis. First, an exploration of differing supply contracts, price and tariff structures needs to be undertaken. Clearly, there are strong synergies with this work program and the work focused on water market products and a similar timeframe is probably required. Second, much needs to be done to re-shape community thinking about urban water use. The expansive effort to promote WUE as dogma has resulted in urban water use being almost demonised (see, for example, Watermark 2010). As I have already argued, this has serious consequences for rational supply augmentation decisions. However, there is also promise, for instance, in the results of Cooper's work on customer preferences. Encouraging households to approach water use from a more rational viewpoint is not insurmountable and provides the necessary stimulus for better supply optimisation decisions. It is difficult to see this taking less than a decade in the current circumstances.

References

ABS 2001 Water Account Australia 2000-01, available at http//www.environment.gov.au/soe/2006/publications/drs/pubs/527/set/hs_40_national_water_account.pdf accessed 10 September 2010

Beverley, C. (2010). Historical Climate Change and Water Availability. North East Victoria Adapting to a Low Water Future. Wodonga, North East Greenhouse Alliance.

Brennan, D., S. Tapsuwan and G. Ingram (2007). "The Welfare Cost of Urban Outdoor Water Restrictions." The Australian Journal of Agricultural and Resource Economics **51**(3): 243-261.

Byrnes, J., L. Crase and B. Dollery (2005). Regulation versus pricing in urban water policy: The case of the Australian National Water Initiative. University of New England Working Paper. Armidale, UNE School of Economics. **2005**.

Byrnes, J., L. Crase, R. Villano and B. Dollery (2010). "The Relative Economic Efficiency of Urban Water Utilities in Regional New South Wales and Victoria." Resource and Energy Economics **32**(1): 439-455.

Centre for International Economics (2008). Updated estimates of the cost of water restrictions in the ACT region. Canberra, Prepared for ACTEW Corporation. **September**.

Connor, J., K. Schwabe, D. King, D. Kaczan and M. Kirby (2009). "Impacts of Climate Change on Lower Murray Irrigation." Australian Journal of Agricultural and Resource Economics **53**(3): 437-456.

Cooper, B. (2010). Urban Water Restrictions: Compliance, Attitudes and Willingness to Pay. Regional School of Business, Faculty of Law and Management. Wodonga, La Trobe. **PhD**.

Crase, L. (2009). "Water - The Role of Markets and rural-to-Urban Water Trade: Some Observations for Economic Regulators." Connections - Farm, Food and Resources Issues **9**: 1-5.

Crase, L. (2010). "The Spin and Economics of Irrigation Infrastructure Policy in Australia." Australian Quarterly **82**(2): 12-20.

Crase, L. and S. O'Keefe (2009). "The Paradox of National Water Savings." Agenda **16**(1): 45-60.

Grafton, Q. and M. Ward (2008). "Prices versus Rationing: Marshallian Surplus and Mandatory Water Restrictions." The Economic Record **84**: s57-s65.

Heiner, C. and K. O'Keefe (2008). Facing Challenges and Seeking Solutions'. Urban Water Conference. Wodonga.

Leroux, A. and L. Crase (2010). "Advancing Water Trade: A Preliminary Investigation of Urban-Irrigation Options Contracts in the Ovens Basin, Victoria, Australia." Economic Papers **forthcoming**.

Marsden Jacob Associates (2006). Securing Australia's Urban Water Supplies: Opportunities and Impediments. Discussion Paper Prepared for Department of the Prime Minister and Cabinet
Canberra, DPMC.

Watermark 2010 Welcome to Watermark Australia available at http://watermark.org.au/watermark/get_your_copy_Our_Water_Mark.html accessed 10 September

Watkins, G. 2006 'Water Pricing Concepts and Principles', Paper presented at IRR Water Pricing Conference, Sydney 25th October, available at http://www.erawa.com.au/cproot/3094/2/Water%20Pricing%20Concepts%20and%20Principles%20Presentation%20to%20the%20IIR%20Water%20Pricing%20Conference%20Sydney%2025%20October%202006.pdf accessed November 2006

Wells, J. (2007) Water Vigilantes are out of Order: Off Tap. *The Border Mail*, 30 January: 18.

Merrett, S. (2004). "The Demand for Water: Four Interpretations." Water International **29**(1): 27-29.

NWC (2009). Australian Water Markets Report 2008-09. Canberra, NWC.

NWC (2009). Second Biennial Assessment of Progress in Implementation of the National Water Initiative. Canberra, NWC.

NWC. (2010). "Urban Water Reform." Retrieved 10 September, 2010, from http://www.nwc.gov.au/www/html/129-urban-water-reform.asp?intSiteID=1.

Perry, C. (2009). Pricing Savings, Valuing Losses and Measuring Costs: Do We Really Know How to Talk about Improved Water Management? The Management of Water Quality and Irrigation Technologies. J. Albiac and A. Dinar. London, Earthscan.

Productivity Commission (2010). Market Mechanisms for Recovering Water in the Murray-Darling Basin: Final Research Report. Melbourne, Productivity Commission.

Scott, E, 2010 Melbourne Water Restrictions Eased, Sydney Morning Herald, August 23, available at http://news.smh.com.au/breaking-news-national/melbourne-water-restrictions-eased-20100823-13fgc.html accessed 10 September