Options for scarcity pricing

A FINAL REPORT PREPARED FOR SYDNEY CATCHMENT AUTHORITY

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Background

Scarcity pricing has figured prominently in the public debate on water pricing, particularly since the widespread imposition of severe water restrictions across urban Australia in recent years.

The basic idea of scarcity pricing is to set volumetric prices to reflect the opportunity costs of using water storages as dam levels change. For example, the price would be relatively low when the dam is full (and the probability of running out of water is low) and higher when storages decline (and there is a need to augment dam water with emergency supplies or impose restrictions).

In its 2009 price determination for Sydney Catchment Authority (SCA), the Independent Pricing and Regulatory Tribunal (IPART) expressed interest in possibly developing a form of 'scarcity pricing' for potential implementation at the 2012 SCA price determination, particularly for wholesale prices (i.e. SCA charges to Sydney Water).

In the context of pricing at the wholesale level, one of the key objectives is encouraging efficient water use and investment by Sydney Water and facilitating competition in bulk supply.

This paper examines a small number of potential options and assesses them against key pricing objectives taking into account SCA's strategic interests, as well as the broader implications for the metropolitan system. We compare each option to the status quo situation (of set fixed and variable bulk water charges) in both wet and dry inflow sequences.

Our analysis

Under current pricing arrangements there is an inherent conflict between achieving revenue stability for SCA on the one hand and IPART's desire to send a signal on the value of water to inform Sydney Water's sourcing and investment decisions on the other. A key issue in assessing options for scarcity pricing is whether they can provide appropriate signals for efficient use and investment while not exposing SCA to undue revenue risk. There is a strong argument that SCA, as a relatively passive manager of catchments and dams in accordance with government defined operating strategies, should be able to recover its efficient costs without being excessively exposed to demand risk over which it has no control.

Our view is that scarcity pricing (based on principles of marginal cost pricing) would address this issue. This model would broadly involve:

- Aligning SCA's volumetric price with its short-run operating costs, with a fixed charge to address any revenue shortfall. This would require a large increase in revenue generated from SCA's fixed charge compared to current arrangements.

- Setting a separate volumetric price that reflects the estimated marginal value of water in storage, which would be in addition to SCA's infrastructure charges but would effectively apply only when predefined triggers are reached.
  - The revenue collected through this additional scarcity charge represents a separate resource rent outside of SCA's required revenue requirement and could potentially be retained by government or alternatively used to offset Sydney Water's fixed charges in the current or future regulatory periods.

This pricing approach would reduce the revenue risk to SCA embodied in current tariff structures while providing an appropriate price signal for consumption and investment to Sydney Water (and other SCA customers) and potential new entrants at times when water is scarce. It does so by clearly differentiating between pricing for SCA's infrastructure services and the water resource itself.

The extent to which these prices will have a material effect on the current and future portfolio of supply options for Sydney will partly depend on broader institutional arrangements for urban water planning. For example, current government policies (for example, strict desalination plant operating rules) may lock in particular sourcing decisions and investments and thus limit Sydney Water's flexibility to respond to wholesale water prices.

The design of the scarcity pricing regime also needs to consider carefully how scarcity prices will combine with existing operating rules for the Sydney system to achieve the most efficient mix of options for balancing supply and demand. For example, to the extent the operating rules for the desalination plant already take into account risks to existing storages and therefore reflect an 'optimal' operating strategy, there is a risk that the addition of scarcity pricing for SCA supplies will double count the costs of consuming dam water. This is not so say scarcity pricing is not worthwhile, but rather that current operating rules may need to be reconsidered in light of this new option for balancing supply and demand.

Putting this pricing model into practice will be challenging. In particular, estimating the value of water in storage is a key issue to determine. In this paper we canvass potential options for estimating the marginal value of water in storage ranging from heuristic approaches based on existing operating rules (e.g. setting prices equal to the operating cost of alternative options such as desalination when dam levels trigger operation of the desalination plant) to economic modelling approaches.

In theory, an economic model that calculated an optimal price based on existing system constraints, planned investments and operating plans would produce efficient price signals. However, we recognise that much work would be required to develop such a model and for it to be accepted in a regulatory price setting context.

Conclusions

In summary, we would advocate replacing the current pricing arrangements based on setting SCA's volumetric charges with regard to its LRMC with a more cost-reflective approach based on SCA's SRMC together with an additional scarcity price based on the costs of predefined triggered alternatives. This would better protect SCA's revenue adequacy while also achieving IPART's aim of a more efficient price signal to SCA's customers and potential new suppliers.

1 Introduction

1.1 Study background

Scarcity pricing has figured prominently in the public debate on water pricing, particularly since the widespread imposition of severe water restrictions across urban Australia in recent years.

While a number of variants have been proposed, the basic idea of scarcity pricing is that the price of water would be higher when water was relatively scarce (e.g. dam levels were low) and lower when water was more plentiful (e.g. when dam levels were high). The underlying rationale for scarcity pricing is that it may be a more efficient way of balancing supply and demand, particularly for short-term shortages, and could signal the cost of using rainfall-dependent sources of supply.

Scarcity pricing could potentially occur at the wholesale level and/or retail level. In its 2009 Determination for the SCA, IPART decided not to implement retail scarcity pricing at that time but canvassed the idea of introducing a form of scarcity pricing at the wholesale level.

It flagged that it was interested in receiving stakeholders' views on the potential application of scarcity pricing in Sydney and in particular on the design and application of such a pricing model, implementation issues to be addressed, and its potential advantages and disadvantages.

Scarcity pricing at the wholesale level would obviously have major implications for the SCA, particularly in terms of its recovery of costs and revenue volatility in the context of a regulated price path. A wholesale scarcity price would also have broader implications for other stakeholders, agencies and customers in relation to the efficient optimisation of the portfolio of supply and demand side measures contributing to supply security and reliability in the Sydney metropolitan area.

1.2 Purpose and scope of this paper

Against this background, the key deliverable from the consultancy is a concise paper that identifies and assesses a range of wholesale scarcity pricing options for strategic discussion by the Board, prior to discussion with IPART.

The paper examines a small number of potential options and assesses them against key pricing objectives taking into account SCA's strategic interests, as well as the broader implications for the metropolitan system. We compare each option to the status quo situation (of set fixed and variable bulk water charges) in both wet and dry inflow sequences.

The project was largely a desktop exercise with consultation with the SCA's project manager as required.

1.3 Pricing options

We assessed the following broad approaches to setting SCA's wholesale water charges:

- **Current approach or status quo** - SCA recovers costs from Sydney Water using a two-part tariff (i.e. fixed and variable charge), with IPART setting the variable charge with reference to the long-run marginal cost (LRMC) of supply. There is no scope to adjust variable charges during the regulatory period in response to sudden reductions in dam levels or associated increases in supply costs.
- **Scarcity pricing based on SCA's operating costs** – this involves setting SCA's variable charge to Sydney Water based on its short-run operating costs and increasing this charge when dam levels trigger increased operating costs (particularly due to Shoalhaven pumping cost).
- **Scarcity pricing based on the cost of alternative triggered supply and demand options** – this involves setting a variable charge to Sydney Water based on estimates of the opportunity cost of using dam water (e.g. the cost of Sydney Water operating the desalination plant or imposing water restrictions). The price increases would have links to existing operating rules that require Sydney Water to deploy supply or demand management options when dam levels fall to a certain levels.
- **Dynamically efficient pricing based on a system optimisation model for Sydney** – involves using an economic model to calculate a schedule of efficient prices defined in terms of dam levels.

Consistent with IPART's proposal, we examined these pricing options on the basis that they would apply in conjunction with existing institutional and policy settings (e.g. desalination operating rules, restrictions policies etc) rather than as an alternative. Our analysis also assumes that scarcity pricing applies only at the wholesale level and not the retail level. However, we do identify the implications of these constraints for the efficacy of scarcity pricing options.

1.4 Paper structure

The structure of the rest of this paper is as follows:

- Section 2 describes current water supply and regulatory arrangements.
- Section 3 describes pricing objectives.
- Section 4 assesses the pricing options compared to the status quo.
- Section 5 provides our conclusions.

2 Current water supply and regulatory arrangements

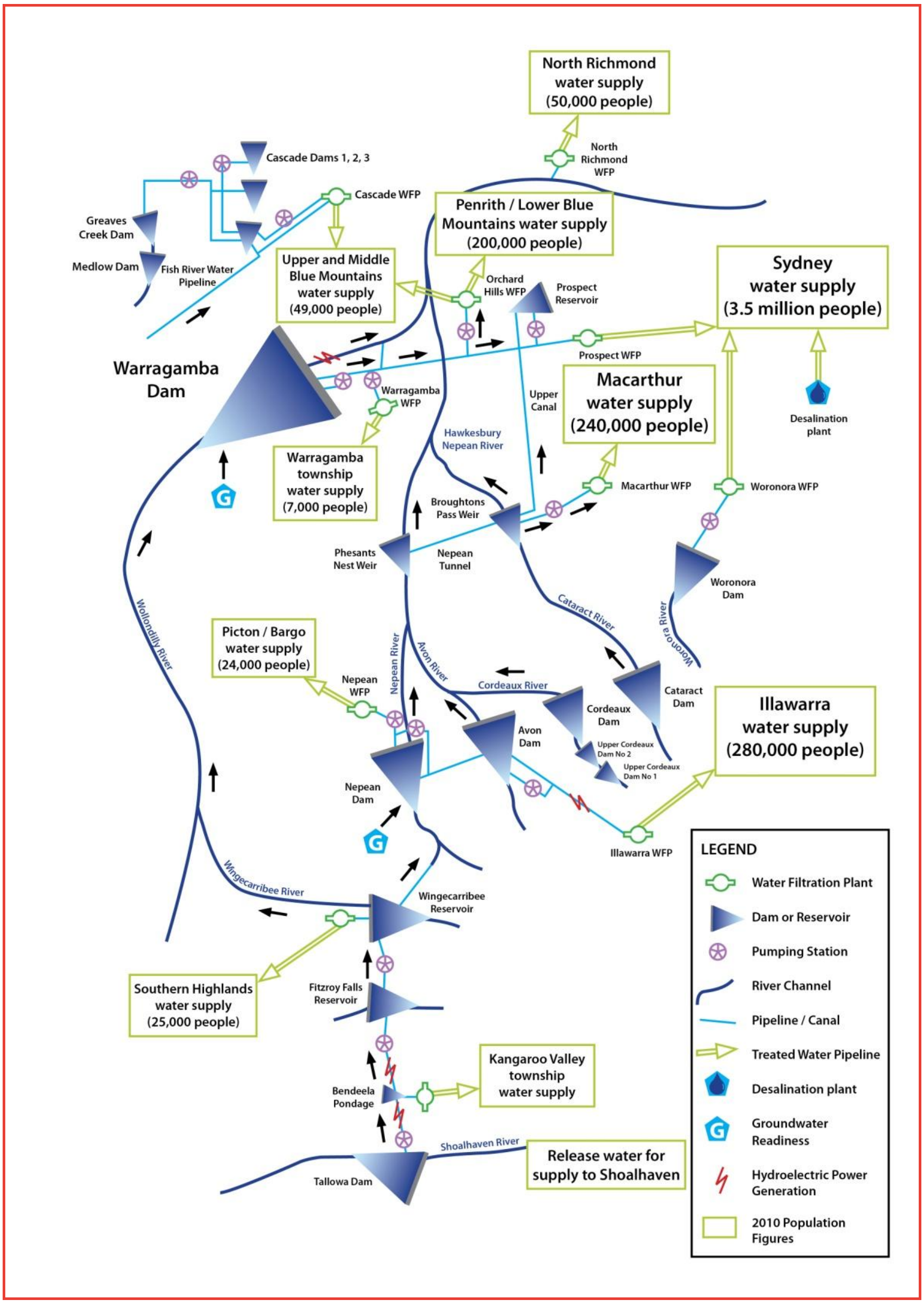
This section provides background information on current water supply and regulatory arrangements in Sydney, which is relevant to the design and implementation of scarcity pricing options at the wholesale level.

2.1 Current metropolitan water supply sources

SCA and Sydney Water are the two main water businesses responsible for operating Sydney's water supplies. SCA is responsible for catchment operations and selling bulk water supplies to Sydney Water (as well as three local councils)[1] from its system of dams (including transfers from the Tallowa dam on the Shoalhaven River)(Figure 1). Sydney Water supplies retail water supplies to metropolitan customers drawing on raw water supplies from SCA and other bulk water sources (i.e. desalination, recycled water).

1 Shoalhaven City Council, Goulburn Mulwaree Council and Wingecarribee Shire Council.

Figure 1: Sydney water supply system



Source: Sydney Catchment Authority.

Current water supply and regulatory arrangements

Sydney Desalination Plant Pty Limited (SDP), a wholly owned subsidiary of Sydney Water, owns the Sydney desalination plant. The private sector operates and maintains the desalination plant facilities in return for monthly performance-based payments based on a formula that includes variable costs associated with the daily drinking water volumes from the plant (Sydney Water, 2011).

Although the NSW government has taken steps to diversify Sydney's water supplies in the past decade by investing in desalination and recycling, the majority of Sydney's water supply still comes from capturing rainwater and storing it in dams (NSW Office of Water, 2010). In 2011, water available from dams was 570 GL per year compared to 90 GL from desalination (Figure 2). The Metropolitan Water Plan for Sydney (NSW Office of Water, 2010) indicates that increases in recycling, desalination plant capacity and improvements in water-use efficiency could help meet future demand needs.

Figure 2: Current and future water supply sources for Sydney

Measure	2010	2015	Beyond 2025
Dams	570 billion litres can be taken from the dams each year (calculated as at December 2006)	the amount of water that can be taken from the dams each year is recalculated any time there is a change to the supply system	augmentation of the Shoalhaven water supply system will increase water supplied from Tallowa Dam and protect river health
Recycling	about 33 billion litres of water is being saved through reuse projects	70 billion litres will be saved through reuse projects	future large-scale water recycling schemes will be delivered in Sydney's west as population grows
Desalination	up to 90 billion litres (about 15%* of current water needs)	up to 90 billion litres (plus potential to upscale to 180 billion litres in response to severe drought)	potential to upscale to 180 billion litres in response to severe drought and/or population growth
Water efficiency	over 100 billion litres of water is being saved every year	145 billion litres will be saved every year	continued improvement in water efficiency through the BASIX and WELS programs

The adoption of the measures in the table above means that, under all modelled rainfall and dam inflow scenarios, the 2010 plan secures greater Sydney's water supplies until at least 2025. A process summary document has been developed which provides more detail on the portfolio approach to water planning and explains how the security of supply has been established. The document can be found at www.waterforlife.nsw.gov.au/review.

*Based on a long-term average usage of 600 billion litres per year

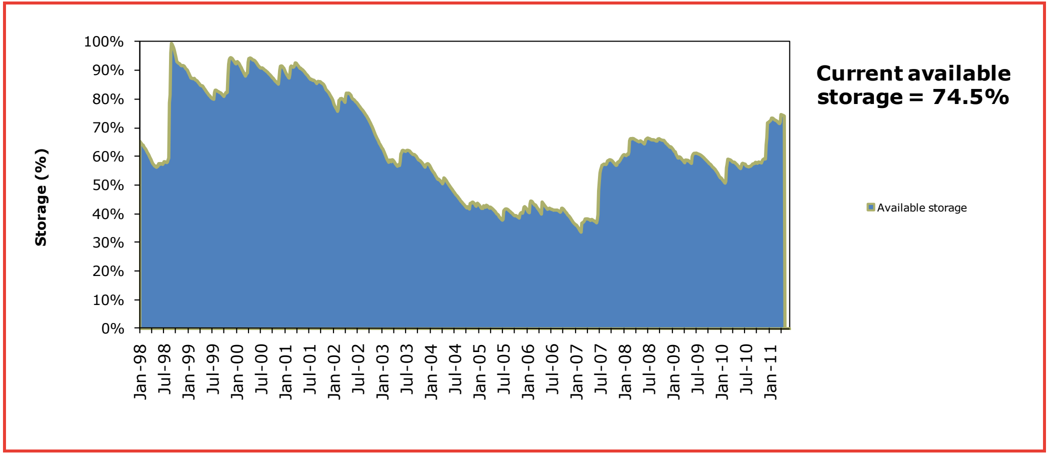
Source: NSW Office of Water, 2010.

2.2 Variability of dam inflows and levels

Although the capacity of Sydney storages is one of the largest in the world per head of population (NSW Office of Water, 2010) inflows are highly variable and dam levels can increase or decrease significantly from year to year. Since the early 1990s, average rainfall and inflows have declined compared to previous decades (1950s to early 1990s) and there have been substantial drought transfers from the Shoalhaven (CIE 2010). Examples of the variability of dam levels in Sydney include the decline in storages from 90% to approximately 30% between 2001 and 2007 (Figure 3). In the eight months leading up to March 2009, dam levels fell from above 65 percent to 58 percent (SCA, 2009).

These fluctuations in dam levels are greater than in other major cities. Although Melbourne also experienced large reductions in inflows between 2001 and 2007, for example, dam levels decreased from around 60% to 40% during that time (Melbourne Water, 2010).

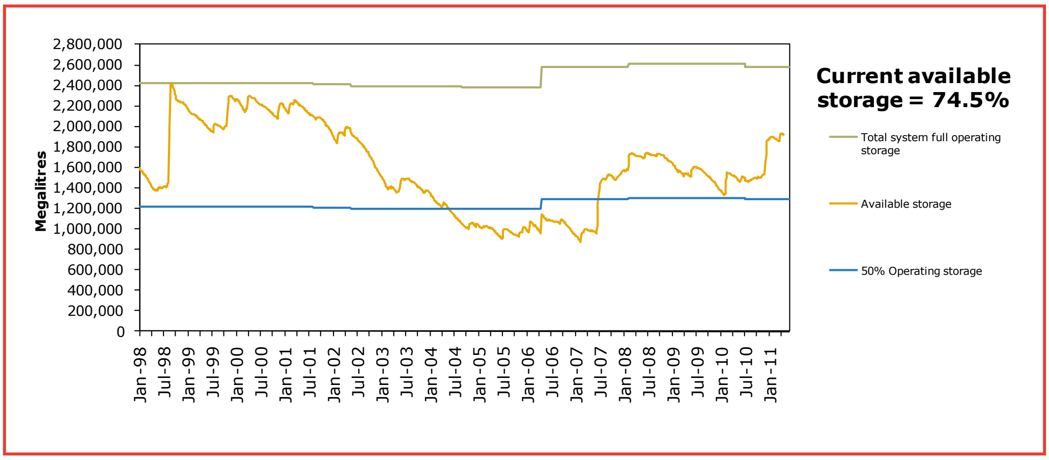
Figure 3: Sydney storage levels (%), 1998-2011



Source: SCA 2011

Figure 4 presents storage levels in volumetric terms. It shows that dam level can decrease several hundred GL (1GL = 1000ML) in one year.

Figure 4: Change in SCA storages (ML), 1998-2011



Source: SCA 2011

2.3 Current water security framework

2.3.1 Responsibilities for supply planning and operations

New South Wales has adopted a standing committee approach to formulate a water security framework for metropolitan Sydney. Chief executive officers from all water businesses and key government departments make up this committee, with the NSW Office of Water acting as a secretariat. The Minister for Water is responsible for approving the Metropolitan Water Plan. An independent panel, comprising specialists in environmental management, economics, social research and water industry experts oversee the planning process (PwC, 2010). The NSW government maintains ultimate control over the mix of measures to secure greater Sydney's water supply.

Under the metropolitan plan, Sydney Water is responsible for a wide range of initiatives, including wastewater recycling, desalination, demand management and leak reduction. Sydney Water's operating licence specifies water efficiency targets, demand management and recycling requirements issued by the Government.

Sydney Desalination Plant (a subsidiary of Sydney Water) holds a Retail Supplier and a Network Operator licence under the Water Industry Competition Act 2006, which include operating rules for the desalination plant issued by Government (Sydney Water, 2011).

SCA holds a water management licence under the Water Act 1912, which specifies rules for operating the Sydney bulk supply system, including environmental flows and Shoalhaven transfers. Its operating licence includes provisions relating to infrastructure management and water conservation including undertaking practicable actions to conserve water and minimise water losses, which may include working collaboratively with its customers (SCA, 2011).

2.3.2 Supply operating rules

Supply operating rules govern how the SCA and Sydney Water operate the metropolitan supply system. Specific rules in the metropolitan plan include:

- **Shoalhaven transfer rules (for SCA)**: under system operating rules, transfers from Tallowa Dam in the Shoalhaven can begin when Sydney's total dam storage level falls below 75 percent but only while the storage level of Tallowa Dam is above its minimum operating level of minus one metre from full supply level.[2] In severe drought, the plan allows the minimum operating level for transferring water from Tallowa Dam to Sydney to lower to minus three metres (NSW Office of Water, 2010).[3] The SCA must cease water transfers from the Shoalhaven system when total system storage reaches 80% (SCA Water Management Licence).

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2 The full supply level is the level of the water surface in storage when it is at its maximum operating level under normal conditions (not flood conditions). The minimum operating level helps ensure 'the Shoalhaven community's water supply is secure and the health of the lower Shoalhaven River system is maintained with ongoing environmental flows' (NSW Office of Water, 2010).

3 SCA's water management licence states 'The SCA must not commence transferring water from the Shoalhaven system via the Shoalhaven Scheme unless total system storage is less than 75%'.

- **Desalination operating rules (for Sydney Water)**: the desalination plant will run at full capacity (i.e. 90 GL/year) during a two-year 'defects correction period', which will end in mid June 2012. After this period, the plant will operate at full production capacity and supply desalinated water to Sydney Water's area of operations when the total dam storage level is below 70 per cent and will continue to do so until the total dam storage level reaches 80 per cent (NSW Office of Water, 2010). The metropolitan plan notes 'if necessary, the Government will be able to operate the desalination plant at other times to secure water supplies (for example if availability of water from other parts of the supply system were affected by technical or other problems)' (NSW Office of Water, 2010). As an input to developing the Metropolitan Water Plan, Sydney Water commissioned the Centre for International Economics (CIE) to assess the net benefits of different operating regimes for the desalination plant.[4] This review considered three alternative operating rules (30/40, 70/80 and 80/90)[5] and recommended the '70/80 rule' above based on assumptions about other aspects of system management, such as restrictions policies (CIE , 2010).
- **Drought restrictions (enforced by Sydney Water)**: In 2010, the NSW government announced a revised mandatory restrictions regime, made up of two levels commencing at around 50 percent and 40 percent of Sydney's total dam storage levels. Sydney's total dam storage level, predicted weather patterns, the season, and demand forecasts will influence the exact timing for introducing drought restrictions (NSW Office of Water, 2010). Sydney Water's operating licence notes it may place conditions on water use by customers at the discretion of the Minister or Government.

Figure 5 presents a stylised representation of the operating rules for the Sydney supply system. The triggers for commencing and ceasing operation of particular supply options and restrictions may differ. Some triggers are binding (e.g. Sydney Water must run the desalination when storages fall to 70%), while others are more flexible (e.g. SCA may transfers water when storages fall to 75%).

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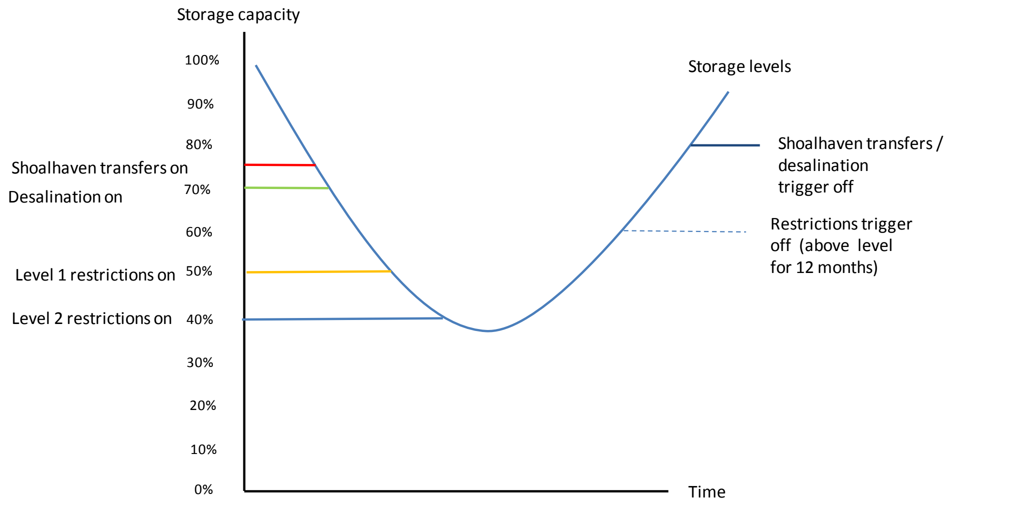
4 The estimate of net benefits included the costs of operating the desalination plant, the costs of water restrictions, avoided infrastructure costs, supply security benefits, and environmental impacts.

5 The first number is the storage level at which Sydney Water switches the desalination plant on and the second number is the storage level at which Sydney Water switches the plant off.

Figure 5: Stylised representation of operating rules based on dam levels



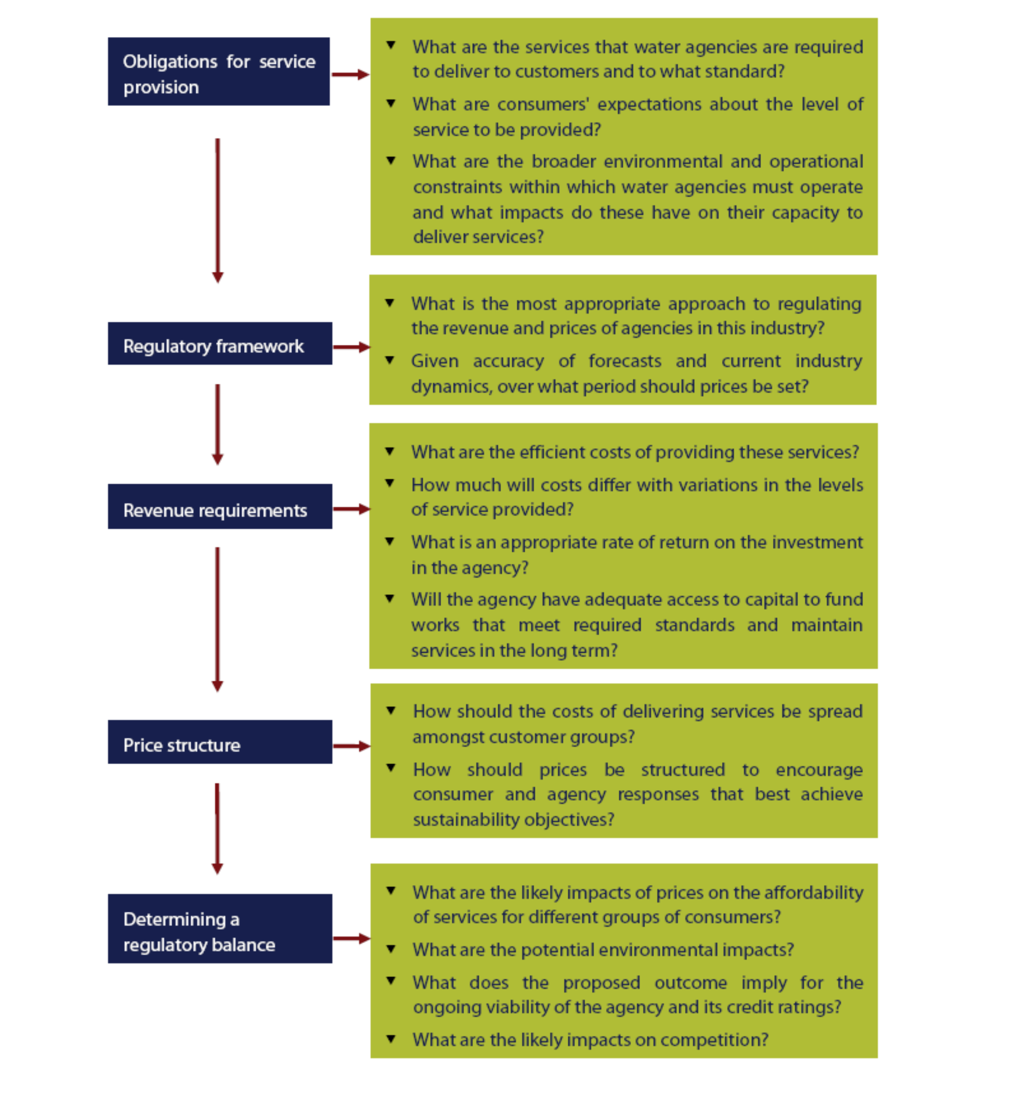
Source: Trigger levels based on *2010 Metropolitan Water Plan (NSW Office of Water, 2010)*

2.4 Price regulation

SCA and Sydney Water are subject to economic regulation by IPART. Figure 6 presents the broad framework for IPART's determination process.

Currently, IPART uses a building block approach to calculate SCA's notional revenue requirement. To apply this approach, it makes decisions on the revenue SCA will require for efficient operating expenditure and capital investment over the determination period (which is currently three years - July 2009 to 30 June 2012). It then considers appropriate price levels and prices structures taking into account objectives such as protecting SCA's financial viability, encouraging economic efficiency and protecting water consumers from price shocks (IPART, 2009).

Figure 6: IPART Determination process



Source: IPART 2009

IPART can adjust SCA's notional revenue requirement to account for unexpected developments during the previous regulatory period, such as differences between actual and forecast water sales or capital expenditure. It can also include regulatory mechanisms to address the risk of variations between actual and forecast required revenue in the upcoming regulatory period (such as by allowing SCA to pass through unexpected costs associated with Shoalhaven transfers). In the most recent determination in 2009, IPART did not allow a cost pass-through mechanism for Shoalhaven transfers as it deemed such transfers were unlikely during the regulatory period following the government imposing a temporary moratorium of such transfers (IPART, 2009).

Current water supply and regulatory arrangements

2.5 Current water prices and cost structures

In general, the short-run marginal cost (SRMC) of water supply is the cost of providing a unit of water when infrastructure capacity is fixed and the long run marginal cost (LRMC) of supply is the cost of providing a unit of water when it is possible to vary infrastructure capacity. Regulators sometimes set volumetric prices for water to reflect one of these costs.

Figure 7 presents current prices and indicative cost structures facing SCA and Sydney Water and relates these to storage levels[6]. It shows SCA's current volumetric price for raw water (approximately $250/ML) is above SCA's short-run marginal cost (SRMC) (up to $70/ML) but below the SCA's LRMC (at least $1200/ML)[7]. As recent estimates of the SCA's SRMC are based on pumping costs from the Shoalhaven (i.e. $70/ML), which are additional costs incurred by SCA when storages are below 75%, we have assumed a hypothetical SRMC of $30/ML to represent SCA's SRMC without Shoalhaven transfers.

Sydney Water's short-run cost when dam levels are above 70% is essentially SCA's raw water charge ($250/ML) plus additional filtration cost ($80/ML) (CIE 2010). The marginal operating cost of desalination is at least $422/ML[8] (IPART, 2009). IPART has previously estimated Sydney Water's LRMC as $1.93/kL (or $1930/ML) based on the cost of expanding the capacity of the existing desalination plant from 250ML/day to 500ML/day (Independent Advisory Panel, 2008).

In 2005, IPART increased the proportion of revenue SCA obtained from its volumetric charges to Sydney Water from half to two-thirds. It did this to 'send a pricing signal to Sydney Water that will help achieve the State Government's demand management objectives' and help achieve the objective of setting charges with reference to SCA's Long Run Marginal Cost of supply (LRMC)(IPART, 2009).

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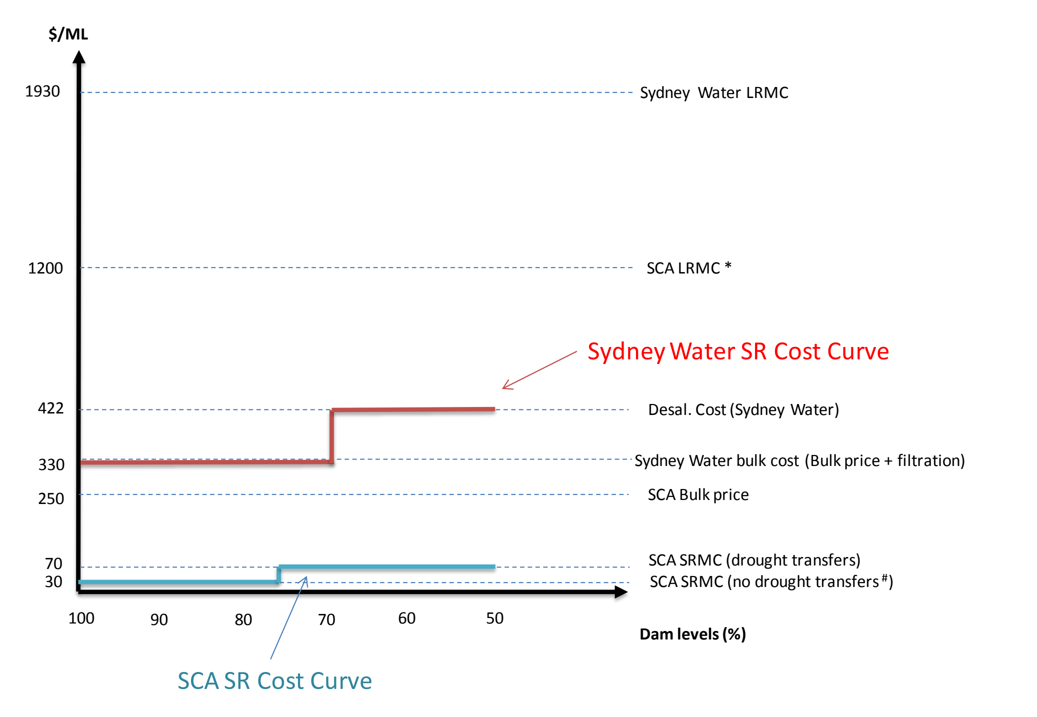
6 It is recognised that these prices and cost structure may increase in the future due to factors such as changes in energy prices. The numerical analysis in this report is for illustrative purposes rather than representing expectations of actual outcomes.

7 In general terms, SCA's LRMC is calculated as the present value of the cost of SCA's next supply augmentation measure divided by the present value of the amount of water supplied by the measure. IPART based its estimate of SCA's LRMC ($1200/ML) on indicative estimates of the cost and yield of SCA's next likely supply augmentation project (a form of Shoalhaven transfers project) (IPART, 2009).

8 CIE estimated additional water is produced by desalination at approximately 60 cents per kL or $600/ML (excluding start-up and shutdown costs)(CIE 2010).

Figure 7: Current prices and short-run costs related to dam trigger levels



Source: Triggers levels based on 2010 Metropolitan Water Plan *(NSW Office of Water, 2010)*

*Estimated as at least this amount # Hypothetical.

3 Objectives

3.1 What is scarcity pricing trying to achieve?

Currently, SCA's volumetric price to Sydney Water for raw water does not vary with short-term changes in water storages; the price is the same regardless of whether the dam is half full or spilling. A key concern about this approach is that the volumetric price does not send appropriate signals to Sydney Water about the true cost of using dam water as storages decline and can result in unintended consequences. These include triggering water restrictions more frequently (which imposes cost on water customers) or inhibiting investment in other supply options by underpricing SCA's raw water.

The basic idea of scarcity pricing is to set volumetric prices to reflect the opportunity costs of using water storages as dam levels change. For example, the price would be relatively low when the dam is full (and the probability of running out of water or imposing restrictions is low) and higher when storages decline (and there is a need to augment dam water with emergency supplies or impose restrictions).

In its 2009 price determination for SCA, IPART expressed interest in possibly developing a form of 'scarcity pricing' for potential implementation at the 2012 SCA price determination, particularly for wholesale prices (i.e. SCA charges to Sydney Water) (IPART, 2009).

In the context of pricing at the wholesale level, one of the key objectives is encouraging efficient water use and investment by Sydney Water and facilitating competition in bulk supply. IPART (2009), for example, have expressed interest in scarcity pricing on the basis it may:

- provide incentives to Sydney Water to invest in water conservation and demand management measures, where efficient
- signal to Sydney Water when it is more appropriate to obtain water from sources other than SCA, and vice-versa
- provide signals to potential new suppliers of bulk water as to when it may or may not be viable for them to invest in new water supply infrastructure

IPART clearly wishes to explore the scope for scarcity pricing to assist in the optimal utilisation of and investment in the range of alternative sources of supply. This appears to reflect an underlying concern that if SCA prices do not reflect the underlying value of the water itself, there may be an incentive for Sydney Water (and other SCA customers) to use too much of water from storages and undermine future security of supply, as opposed to using desalination or recycled. IPART (2009) note:

> 'While acknowledging the dominant role that SCA is likely to continue to play in the provision of water, IPART considers that it is also important to recognise that Sydney is likely to increasingly have alternative sources of water supply. In addition to SCA's dams, desalination and the use of recycled water for non-potable purposes will become increasingly important. Some alternative sources of water are owned by Government, but others may be privately owned. In these circumstances, it is worth investigating the role that pricing can play in providing effective signals to both Sydney Water and potential new suppliers of bulk water, to ensure that Sydney's water needs are supplied at least cost to the community.'

In theory, scarcity pricing at the wholesale level could feed through to the retail prices of Sydney Water and provide signals to consumers of the resource to reduce consumption in times of scarcity. However, scarcity pricing at the wholesale level does not require water charges to Sydney Water customers vary with dam levels. In fact, IPART (2009) notes:

> A separate question is whether Sydney Water's retail prices should also vary with SCA's dam levels to reflect the economic value of water. IPART notes that this does not necessarily need to occur, even if SCA's wholesale price to Sydney Water does vary with dam levels.
>
> If a form of scarcity pricing were to be introduced at the retail level, IPART envisages that it would be applied at the margin, targeting discretionary water consumption only and operating to support the water restriction regime in equating water demand with supply.

As noted earlier, the focus of this paper is scarcity pricing at the wholesale level.

3.2 Principles of efficient pricing of water

The objectives espoused by IPART are essentially ones relating to the concept of economic efficiency, which requires allocating resources across all consumption and production activities (present and future) in a manner that maximises benefits to society.

Theory of marginal cost pricing

Economic theory suggests pricing resources at social marginal cost (defined as the cost of meeting an incremental increase in demand for water) provides an efficient basis for allocating resources.

Griffin (2006) argues that the marginal cost of supply potentially can include:

- short-run infrastructure operating costs - these costs typically encompass pumping and treatment costs that vary with output. Short-run operating costs can increase during drought as the water business uses higher cost supply options.

- the marginal value of water - the value of an extra unit water from renewable natural water sources to society.[9] This increases if water availability decreases. If water is not scarce, however, the marginal value of water will be zero.[10]
- the marginal capacity costs – the social costs incurred when infrastructure capacity (e.g. storage and delivery infrastructure) is fully employed and the quantity of capacity demanded exceeds the quantity supplied. For example, over time population growth may mean that a city's annual water requirement increases relative to the supplier's delivery capacity. At the extreme, the supplier may need to ration supply capacity thus imposing costs on customers. The marginal capacity cost will only be non-zero when infrastructure capacity is constraining (e.g. capacity constraints in delivering water). In practice, investments in infrastructure capacity are typically lumpy and generally avoid infrastructure constraints that require rationing of capacity. Hence, the marginal value of capacity in this context is defined as the incremental cost to the water business of installing additional infrastructure capacity to meet supply needs (i.e. the basis of LRMC pricing).

The estimates of short-run marginal cost in section 2.5 only relate to infrastructure operating cost incurred by SCA in undertaking its supply activities. However, from society's perspective the marginal cost of water supply may exceed operating costs as either water becomes scarce (the marginal value of water increases) or infrastructure capacity becomes scarce and limits supply (the marginal capacity cost increases). The marginal value of water (or marginal user cost) rises as water availability/dam levels fall.

Figure 8 provides an example of how the social marginal cost of supply might vary with dam levels. As dam levels fall, SCA incurs additional operating costs associated with managing drought supplies (i.e. Shoalhaven transfers). At the same time, the opportunity cost of using dam storages (marginal value of water) gradually increases. Hence, the overall increase in the social marginal cost of water as dam levels fall reflects both an increase in operating costs of delivering the water *and* an increase in the value of water itself. We assume that there are no infrastructure constraints and the marginal capacity cost for SCA is zero. Based on this broader definition of the SRMC, SRMC pricing could exceed the current volumetric bulk charges.

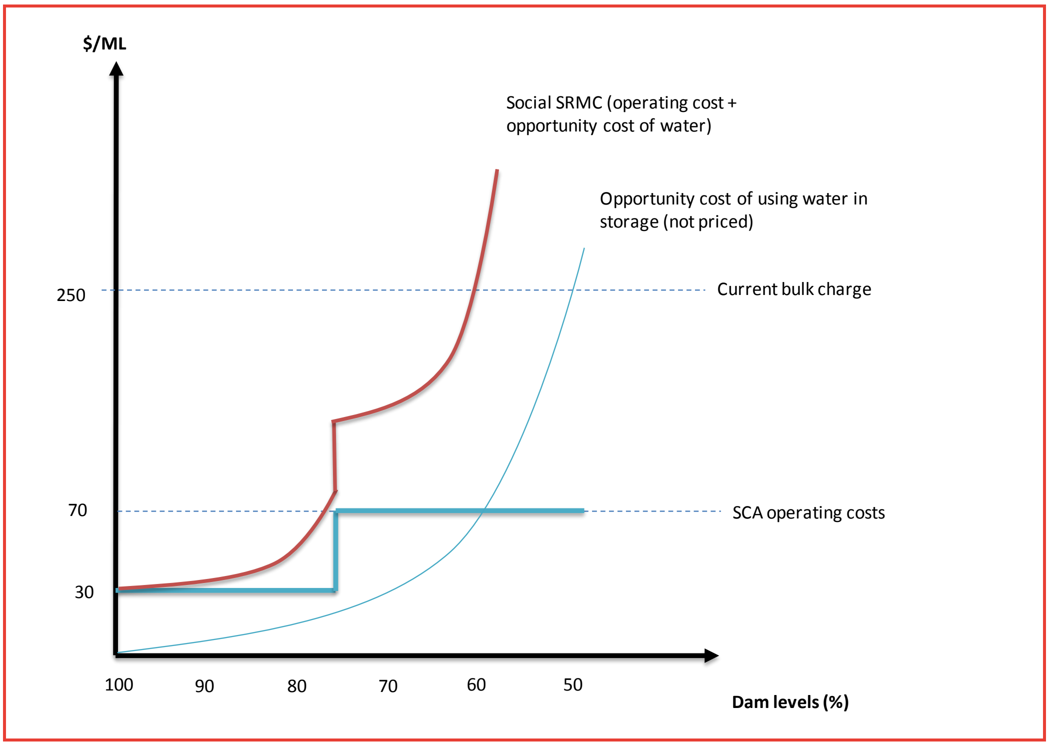
In practice, the marginal value (opportunity cost) of water is notoriously difficult to estimate as it is not readily observed in a market, as in the rural sector. As

9 Where a source is depletable, Griffin (2006) suggests the appropriate measure is the marginal user cost – the present value of an extra unit of water in the future. Griffin suggests this mostly relates to groundwater but could apply to a dams containing tight supply over the next several periods.

10 Griffin assumes this water has a zero accounting costs to the water business (i.e. it is not purchased in a market).

discussed below, stakeholders have proposed a variety of approaches to estimate the marginal value of water ranging from rules of thumb to sophisticated models.

Figure 8: Social SRMC (including the opportunity cost of water)



Despite the efficiency properties of short run marginal cost pricing, regulators have typically not applied SRMC but rather have tended to have regard to LRMC. For example, IPART (2004) has previously noted:

> The Tribunal considers that the appropriate next step towards wholesale water price reform is to review the balance between the fixed access charge and the variable usage charge and, if possible, set the usage charge with reference to the SCA's long run marginal cost. Long run marginal cost here refers to the additional costs of the measures that the SCA must incur to balance supply and demand, divided by the amount of additional water provided by those measures.

The LRMC approach to pricing has tended to focus on providing a smoothed long-term pricing signal to customers. An implicit assumption is that the service is being provided by a monopoly supplier where its availability is determined solely by the supply capacity which will need to be augmented when demand grows to take up all of the existing capacity. While this may be a reasonable assumption for many services – and for water when the supply is reliable, it is increasingly recognised that this may not hold for water supply in Australia.

Pricing at long-run marginal cost communicates the expected cost of consuming an additional unit of water. If the expectations underpinning the calculation of long-run marginal cost are accurate, then the incentives created for water use and conservation will be efficient. However, given uncertainty about future demand, the efficient investment path, and particularly supply from rainfall-dependent water sources, these expectations will almost certainly not be accurate. Periods of short-run scarcity are likely, and during these times long-run marginal cost pricing will fail to represent accurately the increases in the opportunity cost of water stemming from that scarcity.

Further, given that Sydney Water has alternative options for meeting demand other than SCA dam water there is a question of whether SCA's LRMC is appropriate or relevant for informing Sydney Water's water sourcing and investment decisions or as a basis for efficient competition from new suppliers. In particular:

- SCA's LRMC of infrastructure may be problematic for sending efficient signal for consumption, particularly given SCA only has some of the available supply augmentation options. That is, Sydney Water may well have alternative options such as recycling that it would take up prior to any augmentation of SCA's system.
- If Sydney Water bases its decisions about operating the desalination plant or deploying demand management options according to their short-run marginal cost, pricing SCA's supplies to Sydney Water at LRMC will distort Sydney Water's sourcing decisions (i.e. it may produce too much desalinated water compared to drawing on dam water).
- Similarly, in a competitive market, prices will tend to short run marginal cost. While pricing SCA water at LRMC may make potential alternative supply sources more attractive, this would not represent efficient competition.
- Setting prices with respect to LRMC requires a great deal of information to estimate future demand and supply conditions, in order to plot the efficient path for investment. Consequently, there may be a great deal of uncertainty about whether such prices reflect the efficient price.

The Independent Panel (2008) notes that changes in the water supply environment may require rethinking the current approach of LRMC pricing:

> In light of quite dramatic and ongoing change to the nature of water supply businesses in Sydney, there is a risk that price determinations made along existing guidelines might fail to keep pace with change
>
> The impact of drought and climate change is indeterminate and still unfolding. It has influenced the introduction of readiness options, one important one of which has been exercised in the form of the desalination plant.
>
> The existence of this source raises questions about using LRMC as a basis for bulk water pricing in particular.
>
> The advent of the Water Industry Competition Act means that there are potentially many smaller water suppliers to enter the market in Sydney, which changes the landscape in comparison to the earlier model of a single monopoly provider of both bulk and retail water.

> Sending suitable price signals to consumers, and maintaining consistency of signals through the supply chain becomes more of a challenge in this environment.

In practice (as seen in the previous chapter), SCA's volumetric prices is between the two extremes of the SCA's short-run marginal operating costs (i.e. the SRMC when water and infrastructure capacity are not scarce) and an estimate of SCA's long-run marginal cost. This perhaps reflects attempts to compensate for the lack of an explicit price signal for the marginal value of water.

Benefits of efficient pricing

Scarcity pricing could provide a more cost-reflective signal to Sydney Water regarding the cost of drawing on dam water during drought (i.e. increased operating costs and the marginal value of water). As dam levels fall, for example, the increase in price for dam supplies would provide Sydney Water with an incentive to substitute dam water with other sources (e.g. recycling, demand management) which would in turn take pressure off dam supplies and reduce the risk of restrictions.

Hence, guiding questions relevant to assessing specific pricing options include:

- Do pricing arrangements provide Sydney Water with incentives to source supplies and invest in demand management in manner that maximises net social benefit?
- Does the approach provide incentives for efficient competition in the provision of water services?

3.3 Other pricing objectives

There is a number of other pricing objectives, including:

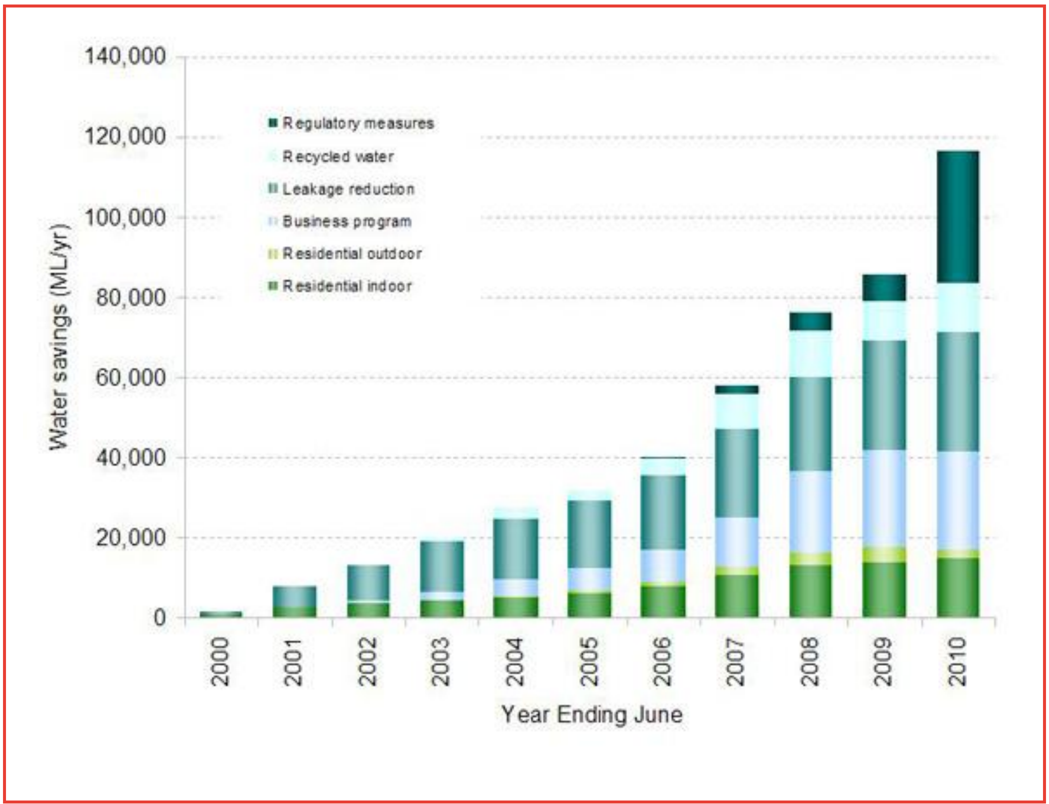
- Effectiveness
- Revenue adequacy and stability
- Appropriate allocation of risk
- Administrative simplicity
- Transparency.

Effectiveness

While scarcity pricing may provide more efficient sourcing and investment signals to Sydney Water, its effectiveness in influencing Sydney Water's sourcing and investment decisions is another matter. SCA (2009) notes IPART has previously argued that financial incentives are not as effective for a Government owned business such as Sydney Water which respond to other imperatives.

Conceptualising Sydney Water's operating decisions as being strongly influenced by current wholesale prices can be overly simplistic for several reasons. As noted above, for example, Sydney Water has licence obligations that require it to meet specific supply standards and/or invest in recycling and demand management. These obligations internalise, or at least reduce, the risks associated with water restrictions even in the absence of price signals reflecting the marginal value of water. [11] Hence, although the marginal cost of recycling and demand management projects can significantly exceed the current raw water price, investment in recycling and demand management in Sydney has nevertheless grown over the past decade (Figure 9).

Figure 9: Demand management and water savings in Sydney, 2000 to 2010.



Source: Sydney Water, 2010.

Similarly, the operating rules for the Sydney Water desalination plant (developed by government) currently limit Sydney Water's flexibility to change its operations in to response to price signals from SCA. Hence, the likely effect of scarcity pricing on Sydney Water's bulk water sourcing decisions needs to be considered within the broader institutional setting

11 Modelling underlying the metropolitan plan presumably places a social value on different options based on their contribution to supply security.

A further point to note is that Sydney Water knows that it will incur higher costs as dam levels fall and thus it will have a financial incentive to undertake actions to mitigate this risk even in the absence of an explicit price on dam water.

Guiding questions relevant to assessing specific pricing options include:

- Does Sydney Water have the capacity to respond to the price signal from SCA?
- Is the level of the price signal likely to be material?

Revenue adequacy and stability

Pricing principles adopted at the state and national levels recognise the principle that regulated business should be able to recover efficient costs of supplying services (Council of Australian Governments, 2004 and 2010).

In a regulated setting, revenue adequacy relates to ensuring all legitimate costs are included in the revenue requirement and the pricing structure provides the business with reasonable opportunity to recover this revenue.

Typically, regulated businesses recover required revenue through a two-part tariff, with the volumetric charge designed to send an appropriate signal to customers about the 'marginal costs' of additional consumption. Because pricing at marginal cost (particularly where this is low) may not generate sufficient revenue to recover total costs, the fixed charge is designed to recover the balance of the revenue requirement (based on estimates of likely demand and hence revenue likely to be generated from the volumetric charge).

In practice, the actual level of revenue from tariffs depends on the actual demand that eventuates. If demand is less than forecast then the business will collect less revenue; if demand turns out to be higher than expected, the business will collect more revenue than expected.

The extent to which forecasting errors lead to under- or over-recovery of costs depends on the extent to which the tariff structure is reflective of the business' underlying cost structure. In particular, if the volumetric price is set to reflect the costs that vary with output (i.e. SRMC operating cost), then any change in demand will be offset by a change in the business' costs of supply. If the volumetric price is set at a level that does not reflect the variable costs incurred by the business, then variations in demand from those forecasts will lead to revenues diverging from costs, with the extent of this divergence depending on how far away the volumetric price is from the actual marginal costs of the business.

Currently, SCA recovers approximately two thirds of its revenue requirement through its volumetric charge. This is despite the fact SCA's cost structure is predominantly fixed – with relatively few costs varying with the level of water sold to Sydney Water or other customers. In submissions to past determinations, SCA has pointed out that this introduces considerable revenue volatility when combined with other factors such as a high degree of uncertainty in demand forecasting. In 2008, for example, SCA reported that its water sales for the 2005 determination period were 12 per cent less than the forecasts IPART used to set prices in 2005 due to restrictions. SCA estimated that this resulted in a total shortfall in revenue of approximately $57 million ($14 million of which relates to variations greater than the 10 per cent dead band allowed by IPART) (IPART 2009).

IPART (2009) has suggested scarcity pricing (whereby prices vary inversely with dam levels) could mitigate sales risk.

> A pricing approach that varied SCA's volumetric price inversely with its dam levels could also mitigate sales risk to SCA. Presently, if SCA's sales are less than forecast when setting its volumetric price (e.g. due to the effect of higher than forecast restriction levels in reducing water demand), it is at risk of under recovering its revenue requirement – particularly as its costs are mostly fixed. To date, this has acted to limit the extent to which IPART can increase SCA's volumetric charge at the expense of its fixed charge.

Another specific concern identified by SCA in past determinations is that current volumetric prices do not vary when it incurs additional operating costs when dam levels fall and it must pump supplies from the Shoalhaven.

> Given the high and unpredictable costs associated with pumping, the SCA proposes that the full cost of future pumping be a pass through component of SCA's cost recovery from Sydney Water as it is no longer viable for the SCA to carry these significant costs, and not equitable for the charges to be borne by all NSW taxpayers through the resulting reductions in returns (SCA 2009).

Hence, guiding questions in assessing the alternative pricing options include:

- Does the approach provide for sufficient revenue for SCA to finance its activities?
- Does it ensure against excessive volatility in SCA's revenues?
- Does the option prevent monopoly rents? How does it deal with over recovery?

Appropriate allocation of risk

Closely related to the issue of revenue adequacy and stability is the question of how risk should be allocated between the parties. Of particular relevance here is how to allocate demand risk between the SCA and Sydney Water.

IPART notes that the allocation of financial risk (between SCA, Sydney Water and water customers) arising from any new water pricing arrangements is an issue that requires further consideration.

Currently, SCA has little control over many of the levers that influence demand risks, such as investing in new supplies to avoid restrictions.

Hence, guiding questions in assessing the alternative pricing options include:

- Is risk allocated to the party best able to manage or bear it?

Administrative simplicity

Ease of operation is concerned with ensuring that a pricing approach is practical to implement. In particular, ease of operation is concerned with ensuring there are no institutional, administrative or other barriers that would prevent the approach being implemented. Administrative simplicity means that the resources required to implement a pricing approach (in terms of administration, compliance, enforcement and information costs) are proportional to the benefits of the approach.

There is a range of approaches to implementing scarcity pricing with different levels of complexity. One key factor will be whether prices relate to increased operating costs incurred by SCA, which are relatively easy to estimate and incorporate within the current pricing regime, or based on the opportunity cost of water in dams, which adds a layer of complexity (e.g. estimating the value of water and dealing with excess revenues).

Another factor that will influence administrative complexity is the overall design of the pricing regime (i.e. number of steps in the pricing schedule and frequency of prices charges).

Guiding questions in assessing this criterion include:

- Is it practical to implement?
- Are there institutional, administrative or other barriers that would prevent an approach being implemented?
- What are the administrative costs for water service providers, regulators and customers (and do these costs outweigh the benefits that are likely to accrue by implementing the approach)?

Transparency

Transparency ensures that water users and others can understand and hence have confidence in the arrangements. The NWI objectives highlight the importance of price transparency in water storage and delivery systems (Council of Australian Governments, 2010).

While scarcity pricing provides a means of providing more cost-reflective and efficient price signals, there will be a trade-off between the sophistication of the pricing regime and transparency.

The guiding question in assessing this criterion is whether customers and other stakeholders readily ascertain and understand what prices are being charged and how they are determined

4 Assessment of options

4.1 Overview

IPART's 2009 determination for SCA highlighted several options for introducing scarcity pricing at the wholesale level. These broadly include:

- **Scarcity pricing based on SCA's operating costs** – this involves setting SCA's variable charge to Sydney Water based on its short-run operating costs and increasing this charge when dam levels trigger increased operating costs (particularly due to Shoalhaven pumping cost).
- **Scarcity pricing based on the costs of alternative triggered supply and demand management options** – this involves setting a variable charge to Sydney Water based on estimates the opportunity cost of using dam water (e.g. the cost of Sydney Water operating the desalination plant or imposing water restrictions). The price increases would have links to existing operating rules that require Sydney Water to deploy specific supply or demand management options when dam levels fall to a certain levels.
- **Dynamically efficient pricing based on a system optimisation model for Sydney** – involves using an economic model to calculate a schedule of efficient prices defined in terms of dam levels.

Below we compare these options to current arrangements.

4.2 Scarcity pricing based on SCA's operating costs

4.2.1 Description

One option for sending more efficient signals about the marginal cost of using dam water is to base SCA's volumetric prices on its short-run operating costs, which would increase as SCA activates drought supply measures triggered by dam levels. For example, Shoalhaven drought transfers currently commence when dam levels fall to 75%. Hence, the volumetric price of dam water could be say $30/ML (non-drought operating cost) when dam levels were above 75% storages and $70/ML (marginal pumping costs of Shoalhaven transfer) when dam levels were below 75%. A similar logic would apply if further decreases in dam levels triggered even higher marginal operating costs for SCA.

IPART could adjust SCA's variable price annually (or some other period) to reflect storage levels at the time. A benefit of this option from SCA's point of view is that there would be an inbuilt mechanism to increase the variable price during the regulatory period, which would mitigate the risk of incurring additional pumping costs when dam levels fall unexpectedly.

In its submission to IPART's 2009 price determination, SCA suggested that increasing charges to Sydney Water to reflect Shoalhaven pumping costs during drought was a form of scarcity pricing.

> The commencement and cessation of pumping from the Shoalhaven is directly triggered by dam levels. The SCA contends that passing through SCA's Shoalhaven pumping cost, if and when it occurs, is consistent with this approach.

A fixed charge would recover any estimated revenue shortfall from SCA's variable charge. As SCA's volumetric prices would relate to its operating costs (SRMC), which are less than the current volumetric price set with reference to LRMC, SCA's fixed charge would account for a larger proportion of SCA's revenue than under current arrangements. For example, the fixed fee might account for around 90% of revenue as opposed to 35%.

The exact level of the fixed charge will depend on SCA required revenue (e.g. $190m) and expectations about the revenue generated from variable charges, which will in turn depend on expected water sales and dam levels (e.g. low dam levels will trigger a higher volumetric price and more revenue per ML of water sold). If prices are set during a non-drought period when water sales are expected to be 500 000ML and SCA's volumetric price is $30/ML, for example, variable charges will recover $15m and the fixed charge could be set to recover the $175m shortfall from required revenue.

If predictions are wrong and dam levels and water sales decline during the regulatory period, the variable charge will increase automatically. IPART could adjust SCA's fixed charge when it changes the variable charge or simply set the fixed charge for the regulatory period and address any under or over recovery at the next price review. The table below assumes that a fixed charge would apply for the regulatory period but the variable charge would change as dam levels change.

Table 1: Illustrative scarcity pricing schedule to Sydney Water (based on SCA operating costs)

Storage level	Scarcity price/Cost	Basis
Above 75%	$30 per ML (plus fixed charge, e.g. $175m)	SCA non-drought operating cost
75%	$70 per ML (plus fixed charge, e.g. $175m)	SCA marginal pumping costs for Shoalhaven transfers

An alternative option for addressing revenue shortfalls from unexpected pumping costs during drought is for SCA to simply pass through these costs on an annual basis, as and when they occur (either through the fixed or variable charge). However, this is less akin to marginal cost pricing.

4.2.2 Assessment

Efficiency and effectiveness

Efficiency of price signal

Economic theory suggests setting SCA's variable charge with respect to its short-run marginal costs of operating infrastructure will send an efficient signal to users of those infrastructure services. As falling dam levels trigger Shoalhaven pumping costs and a higher volumetric price, for example, Sydney Water would have an incentive to reduce demand for dam supplies.

Prices based on infrastructure operating costs would not, however, account for the marginal value of water itself and hence not reflect the full social cost of using water in SCA storages.

Impacts on Sydney Water's bulk water sourcing decisions

As the SRMC of operating water supply infrastructure (e.g. ranging from $30/ML to $70/ML) is lower than the current bulk charge ($250/ML), a move to more cost-reflective pricing for infrastructure would theoretically provide Sydney Water with an incentive to use more dam water relative to other supplies when it was not scarce. In practice, Sydney Water's existing regulations and desalination operating rules potentially reduce the extent to which this would happen in practice (particularly in the short term).

Given the estimated magnitude of the increase in operating costs attributed to Shoalhaven transfers (e.g. from $30/ML to $70/ML) it is debateable whether a price increase to reflect increased drought supply costs would loom large in Sydney Water's procurement decisions.

Revenue adequacy and stability

The move from setting SCA's volumetric price with reference to its LRMC to its SRMC of operating infrastructure would increase SCA's revenue stability as it would mean SCA would generate a much higher proportion of revenue from its fixed charge (e.g. increasing from 35% to 90%) which is not responsive to changes on water sales. This would be more reflective of SCA's underlying cost structure.

Introducing prices that more accurately reflected increased costs associated with Shoalhaven transfers when dam levels fall would also address revenue adequacy for SCA. From a cost recovery perspective, drought costs associated with Shoalhaven transfers would appear to be a potentially significant component of SCA's operating costs and hence likely to have a material effect on revenue adequacy. For example, SCA estimates that unforeseen costs of pumping water from the Shoalhaven over the 2005 determination period amounted to $31 million to the end of 2007/08, with annual drought pumping costs of $8.5

million in 2005-06, $9.5 million in 2006-07, and $12.8 million in 2007-08. For perspective, allowed operating expenditure for the period was $334.3m (or approximately $81m – $85m annually) (IPART, 2009). This means drought transfers accounted for approximately 10 per cent of operating costs.

In general, we believe there is a strong case for SCA to be able to recover efficient costs associated with Shoalhaven transfers when they are required.

Table 2 is an illustrative example of the impact of SRMC pricing on revenue adequacy for SCA compared to current arrangements under different dam levels and water sales. It broadly shows how actual revenues from tariffs may diverge from expected revenue as dam levels and sales fall. In this example, we assume:

- The expected revenue requirement is $190m.
- Water sales vary with dam levels. This might arise because existing operating rules for Sydney Water reduce its demand for SCA water when dam levels fall (e.g. desalination operation, restrictions).
- Sales of 500 000ML is the basis for setting the fixed charge to ensure revenue adequacy and fixed charges are constant for the regulatory period.
- Actual revenues are annual revenues generated from tariffs under different storage and water sales scenarios (i.e. volumetric price multiplied by sales at a given dam level plus revenue from the fixed fee). Under scarcity pricing, the volumetric price will be higher in years when dam levels are below 75% (i.e. $70/ML instead of $30/ML). For simplicity, we assume a single volumetric price applies in any one year.

Given these assumptions:

- Under current arrangements, a volumetric charge of $250/ML is expected to recover $125m when dams are full and annual water sales are 500 00ML (i.e. 500 000ML multiplied by $250/ML) with a fixed charge of $65m recovering the residual of the revenue requirement (i.e. $190m-$125m)
- Under the SRMC pricing approach, the variable charge (of $30/ML) is expected to recover $15m (i.e. 500 000ML multiplied by $30/ML) in revenue when dams are full with a fixed charge of $175m recovering the residual of the revenue requirement.

Table 2: Indicative revenues from volumetric and fixed charges under different pricing regimes and dam levels

Annual Sales (000's	Storages (%)	Revenue from charges ($000)

ML)		Actual revenue Current volumetric price ($250/ML)	Current fixed charge	Difference between actual and expected revenue ($190m)	Actual revenue SRMC ($30/ML above 75%, $70/ML below 75%)	Higher fixed charge	Difference between actual and expected revenue ($190m)
500	90-100	**125 000**	**65 000**	**0**	**15 000**	**175 000**	**0**
490	80-90	122 500	65 000	**-2 500**	14 700	175 000	**-300**
480	75-80	120 000	65 000	**-5 000**	14 400	175 000	**-600**
470	70-75	117 500	65 000	**-7 500**	32 900	175 000	**17 900**
460	60-70	115 000	65 000	**-10 000**	32 200	175 000	**17 200**
450	50-60	112 500	65 000	**-12 500**	31 500	175 000	**16 500**
400	Under 50	100 000	65 000	**-25 000**	28 000	175 000	**13 000**

Note: This is a simplified example for illustrative purposes only.

As shown in the table, the current pricing approach consistently recovers less revenue than expected as dam levels and water sales fall, with the annual shortfall ranging from $2.5m to $25m. In practice, the reduction in water sales will reduce SCA operating costs, which will partially offset the amount of revenue under-recovered. For example, the reduction in operating costs when sales are 490 000ML rather than 500 000 ML is $300 000 (i.e. $30/ML multiplied by 10 000ML). However, this leaves a shortfall of $2.2 m.

Under the SRMC pricing approach, the volumetric price initially recovers less revenue than expected when water sales and dam levels fall (from 100% to 75% storages). As explained above, however, reduced operating costs due to lower sales will exactly offset this shortfall between actual and expected revenue from sales.

Below 75% storage levels, the SRMC pricing approach generates higher revenue than expected due to the higher volumetric charge (i.e. $70/ML instead of $30/ML). As all water supplied is priced at the marginal cost of Shoalhaven transfers, the pricing regime will generally generate revenue sufficient to cover at least the additional operating costs associated with Shoalhaven transfers.

A potential issue with using dam levels to trigger an increase in the SCA's volumetric prices is that the price would apply to all SCA water supplies below 75% storage, regardless of whether it was pumped from the Shoalhaven or not. This may create a perverse incentive for SCA. For example, SCA could decide to not pump water when dam levels fall below 75% (and thus not incur additional operating costs) and it would still earn additional revenue from the increase in the volumetric price. In practice, the regulator could claw back this additional revenue at the end of regulatory period.

An alternative approach to recovering pumping costs would be to include an annual surcharge to reflect the cost of transfers as and when they occur (i.e. the price would not be directly linked to dam levels). The cost pass-through could be averaged across the volumetric price or added as a lump sum to the fixed fee. This is more aligned with the cost pass-through mechanisms proposed by SCA in the most recent price determination. A cost pass-through mechanism (based on average or total pumping costs) may dilute the efficiency properties of marginal cost pricing, but as noted Sydney Water may have limited flexibility/incentive to respond to these signals in any event.

Appropriate allocation of risk

A move to SRMC pricing for SCA's infrastructure services would arguably be more consistent with efficient risk allocation given SCA currently has few tools with which to manage sales risks. However, this would increase risks to Sydney Water. Under current arrangements, reductions in Sydney Water's revenues from reduced sales are offset by reductions in purchases from SCA. If SCA charges Sydney Water a higher fixed charge, however, reductions in Sydney Water's revenues from reduced sales would result in a larger shortfall in cost recovery for Sydney Water.

Administrative complexity

A change to the structure of SCA's tariffs (balance of fixed and variable charges) could occur within the existing regime. However, introducing a cost-pass through mechanism to reflect supply costs may require adjusting prices during the regulatory period. Administrative costs would increase if Sydney Water was required to pass on these price signals to customers. Sydney Water has previously expressed concerns about the administrative costs associated with passing on Shoalhaven pumping costs to retail customers and suggest prices changes be limited to once per year.

> Sydney Water submitted that it would be concerned if Shoalhaven pumping costs were to be passed through to its customers *immediately* after they were incurred (i.e., at the next bill). It opposed this approach as it could involve up to four price changes to its customers in a year, and result in high administrative costs to reconfigure billing systems and inform customers. However, Sydney Water indicated that if IPART assesses that SCA is not able to absorb Shoalhaven pumping costs in between determinations, the pass-through mechanism in Sydney Water's determination could be used to pass through these costs on an *annual* basis (IPART 2009).

Transparency

As SRMC pricing on based on operating costs would relate to costs incurred by SCA, it is arguably more transparent than the current approach of setting the volumetric price somewhat arbitrarily between SRMC and LRMC based on a mix of different objectives.

Overall

While pricing based on short-run operating costs is consistent with efficient pricing, using dam levels as the trigger for price increases in SCA's volumetric price may create perverse incentives for SCA as it would be able to earn additional revenue regardless of whether it actually incurred pumping costs. In practice, the regulator could claw back this additional revenue at the end of regulatory period.

An alternative would be to include a surcharge to volumetric prices to reflect the average cost of transfers as and then when they occur. While it is debateable whether this would affect Sydney Water's procurement decisions it would help SCA recover its efficient expenditure in providing drought supplies.

By itself, this option would not reflect the full cost of Sydney Water drawing on dam water as it excludes the marginal value of water itself.

4.3 Scarcity pricing based on the cost of alternative triggered supply and demand options

4.3.1 Description

Another option for using prices to reflect the social marginal cost of using dam water is to set prices that reflect the marginal value of water at different dam levels based on the cost of alternative options triggered. For example, under current operating rules the Sydney Water desalination plant begins operation when dam levels fall to 70%. This would suggest that the marginal value of water is at least equal to the marginal cost of producing desalination water. To send signals to Sydney Water about the cost of using dam water, SCA's volumetric price for water could potentially increase by an amount commensurate with the operating cost of desalination (adjusted for avoided system costs etc).

Similarly, SCA or IPART could assign a value to the social marginal cost of water restrictions when dam level fall to a certain trigger levels (e.g. 50%). IPART (2009) appears to allude to this option when it notes 'under a scarcity pricing approach, higher level water restrictions (as a result of low dam levels) will result in proportionally higher volumetric SCA prices'.

Table 3 shows an illustrative schedule of scarcity prices and triggers that SCA/IPART could potentially apply. The pricing schedule could have more or less steps depending on the availability of options and cost estimates. The price assigned to the cost of water restrictions is a hypothetical cost for illustrative purposes.

These prices would be in addition to, but separate from, SCA's charges to recover infrastructure costs discussed in section 4.2.1. As discussed below, the revenue from scarcity charges based on the opportunity cost of water would not necessarily accrue to SCA.

Table 3: Illustrative scarcity pricing schedule to Sydney Water - cost of alternative triggered supply and demand options

Storage level	Scarcity price/Cost	Basis
Above 70%	Marginal value of water $0/ML (plus SCA infrastructure charges)	Full storages imply low scarcity value of water
70%	$422 per ML (plus SCA infrastructure charges)	Marginal cost of operating desalination
50%	$650 per ML (hypothetical) (plus SCA infrastructure charges)	Marginal cost of prolonging water restrictions

SCA or IPART could potentially develop a smoothed pricing schedule based on these estimates (table 4). This approach may require defining steps based on the average cost of two options (i.e. the marginal cost of the present option and the marginal cost next option) or assigning probability weights as falling dam levels increase the chance of incurring costs associated with triggering the next source. This would avoid large price changes as a trigger point is reached.

Table 4: Illustrative scarcity pricing schedule to Sydney Water (smoothed prices)

Storage level	Scarcity price/Cost	Basis
90%	Marginal value of water $0/ML (plus SCA infrastructure charges)	Full storages imply low scarcity value of water
80%	$211 per ML (plus SCA infrastructure charges)	Half the cost of operating desalination
70%	$422 per ML (plus SCA infrastructure charges)	Cost of operating desalination
60%	$536 per ML (plus SCA infrastructure charges)	Mid-point of the cost of operating desalination and cost of prolonging water restrictions
50%	$650 per ML (hypothetical) (plus SCA infrastructure charges)	Cost of prolonging water restrictions

An alternative approach is to estimate a schedule of scarcity prices using sophisticated modelling techniques, such as stochastic dynamic programming, that considers pricing, storages, and investment decisions in an integrated way (this is discussed as a separate option on 4.4 below).

4.3.2 Assessment

Efficiency and effectiveness

Efficiency of price signal

Defining robust scarcity prices that reflect the marginal value of water in dams can present significant theoretical and practical challenges. While a price based on the cost of desalination could act as a proxy for the opportunity cost of using dam water, for example, the regulator would need to consider whether a relatively basic regime (as described above) would be sufficient to send an efficient signal for investment or whether a more sophisticated pricing approach would be required. The Independent Panels for the Metropolitan Water Plan suggested that that a 'shadow price' based on desalination operating costs would not fully capture the system wide opportunity costs associated with substituting desalinated water for dam water.

> The harder the plant is operated on average, the less air space is available in storages and there is a reduction in the value of this harvesting option. This is a cost that needs to be added to obtain the social operating costs of operating the plant. Further information would be required to calculate an adjusted shadow price along these lines.

Another issue when estimating the opportunity cost of water based on the operating costs of desalination (or other technologies) is determining what the scarcity price should be when production reaches full capacity but dam levels continue to decline. That is, the opportunity cost may exceed the operating cost of desalination following a sequence of low inflow months or years. Notably, the desalination plant produces up to 90GL per year while dam levels can fall up to five hundred GL per year (see Figure 4).

Estimating the cost of water use in prolonging restrictions (triggered when dam levels are below 50%) could draw on studies on the costs of water restrictions (e.g. willingness to pay studies) incorporated in the recent review of desalination plant operating rules (CIE 2010). However, including these costs in a simple pricing schedule based on dam levels would require converting them into costs per megalitre of use.

Given the operating rules for the desalination plant take into account the risk of restrictions, it is arguable that Sydney Water already internalises these costs to some degree.

Impacts on Sydney Water's bulk water sourcing decisions

The magnitude of price increases related to scarcity pricing is potentially significant (e.g. $422/ML for desalination) and is therefore much more likely to influence Sydney Water's water sourcing and investment decisions than cost-reflective pricing for raw water operating costs alone.

Revenue adequacy and stability

Scarcity prices based on the opportunity cost of water (e.g. desalination costs, water restrictions) would generate additional revenues without SCA incurring a corresponding cost (i.e. it is a resource rent). These revenues could potentially be substantial. For example, annual sales to Sydney of 450 000 ML per year (IPART, 2009) and a scarcity price of $422/ML would generate approximately $190m in revenue per year (assuming dam levels were below the trigger level the whole time).

The table below presents information on revenues from pricing SCA's infrastructure services at SRMC from section 4.2.2 along with annual revenues from the two illustrative scarcity pricing models. Notably the revenues generated by scarcity charges exceed SCA's fixed infrastructure charge to Sydney Water when dam levels fall below 70%.

Table 5: Indicative revenues from volumetric charges under different pricing regimes and dam levels

Annual Sales (000's ML)	Storages (%)	Revenue from charges ($000)				
		SRMC ($30/ML above 75%, $70/ML below 75%	Fixed	Difference from expected revenue ($190m)	Scarcity pricing	Scarcity pricing (smoothed)
500	90-100	**15 000**	**175 000**	0	0	0
490	80-90	14 700	175 000	-300	0	0
480	75-80	14 400	175 000	-600	0	101 280
470	70-75	32 900	175 000	17 900	0	99 170
460	60-70	32 200	175 000	17 200	194 120	194 120
450	50-60	31 500	175 000	16 500	189 900	241 200
400	Under 50	28 000	175 000	13 000	260 000	260 000

Note: This is a simplified example for illustrative purposes only.

This raises the key issue of what happens to the revenues from the scarcity charge. One option would be for SCA to return this revenue to government (i.e.

as a resource rent tax). With respect to the potential for over-recovery of scarce resources, a recent Productivity Commission staff working paper (Barker, Murray, & Salerian, 2010) advocated a resource rent tax rather than regulating returns:

> Capacity rents are distinct from monopoly rents and have different implications. Monopoly rents arise from exploiting market power, creating costs to community Capacity rents, on the other hand, accrue to the owners of capacity-constrained resources (such as aquifers), and act to ration limited supply so as to achieve an efficient market equilibrium. Whereas the existence of monopoly rents might mean there is a role for government regulation to address market power, capacity rents should not be regulated away. Where firms make excessive profits as a consequence of capacity rents, this can be addressed more efficiently through resource-rent taxation that does not distort the price of water.

Alternatively, IPART could use some of the revenue to decrease the fixed charge to Sydney Water on the basis this would result in lower costs to customers/the public and offset the increase in overall variable charges to Sydney Water (including SCA infrastructure costs and the opportunity cost of water). Given there would potentially be a link between Sydney Water's current operating decisions, which influence supply scarcity, and the size of the fixed charge rebate in the next period received by Sydney Water, this approach may have unintended consequences on Sydney Water's sourcing and investment decisions.

IPART could also adjust SCA's required revenues in the next regulatory period to account for excess revenues reflecting scarcity rent.

To the extent SCA's infrastructure prices are set according to its short-run operating costs (see above) with an appropriate fixed charge, its revenues should be sufficient to cover costs and provide revenue stability without the additional scarcity rents from water.[12] In fact, if SCA did collect revenue from the scarcity charge its revenues could potentially be more volatile and more difficult to forecast in a regulatory setting (i.e. variable prices would be $422/ML rather than $250/ML). Separating resource pricing and infrastructure pricing mitigates this effect.

Appropriate allocation of risk

Compared to current arrangements, scarcity pricing would increase bulk supply costs to Sydney Water when water became scarce. This would present financial risks to Sydney water given current retail pricing arrangements are invariant to dam levels and dams remain its main source of supply. In the longer term, however, Sydney Water has tools to manage these risks such as investing in new supplies and demand management and changing the retail price structure or

12 As noted earlier, leaving fixed charges as they currently stand would not achieve revenue adequacy.

levels. As noted, IPART could use some of the revenue from the scarcity charge to offset Sydney Water's fixed charge.

There may be a case for introducing additional steps to smooth prices. This would avoid large price spikes to Sydney Water (e.g. from $70/ML to $422/ML) while still providing an incentive to respond to prices over the short to medium term. It would also potentially help signal the increased likelihood of incurring higher costs.

Administrative complexity

Introducing a simple scarcity charge with a small number of prices/triggers and that only changed infrequently (e.g. less than once a year) would arguably be administratively feasible, particularly given it essentially only applies to one large customer (although it will be important to address specific issues for the three smaller local councils). This pricing option has some similarities to the ACT water abstraction charge, whereby water provider ACTEW faces a volumetric charge for water use (0.55c/KL) that, among other things, is claimed to reflect the scarcity value of water. The ACT government collects the revenue from this charge (ACTEW, 2011).

A more sophisticated regime, with multiple scarcity prices/triggers, which required frequent price changes, would add to the administrative burden.

A major issue will be developing an appropriate proxy for the value of water in storage that stakeholder can agree upon. Notably, there have been (unsuccessful) legal challenges of the ACT water abstraction charge.

Transparency

In contrast to water markets, administered scarcity pricing requires estimating values associated with water, which rely on a number of assumptions. By its nature, this process can be highly contentious. However, links to the costs of alternatives at least provides a defensible benchmark.

Under current arrangements, the regulator is already implicitly estimating these values when setting the volumetric charge. The basis for calculating the LRMC is often not transparent.

Overall

Setting a charge based on the marginal value of water in dams (which is separable from a charge to recover SCA's short-run operating cost) could reduce the revenue risk to SCA embodied in current tariff structures while still providing a more efficient price signal for sourcing decisions by Sydney Water.

A relatively basic approach to valuing water in storage, such as setting prices based on the cost of desalination (when operating rules based on dam levels trigger operation of the desalination plant), may achieve the broad aim of sending a price signal to Sydney Water. SCA could introduce additional steps in the pricing regime to smooth prices to reduce price volatility to Sydney Water.

Developing an appropriate proxy for the value of water in storage, which stakeholders agree upon, is likely to be a key challenge.

4.4 Scarcity pricing based on a system optimisation model

4.4.1 Description

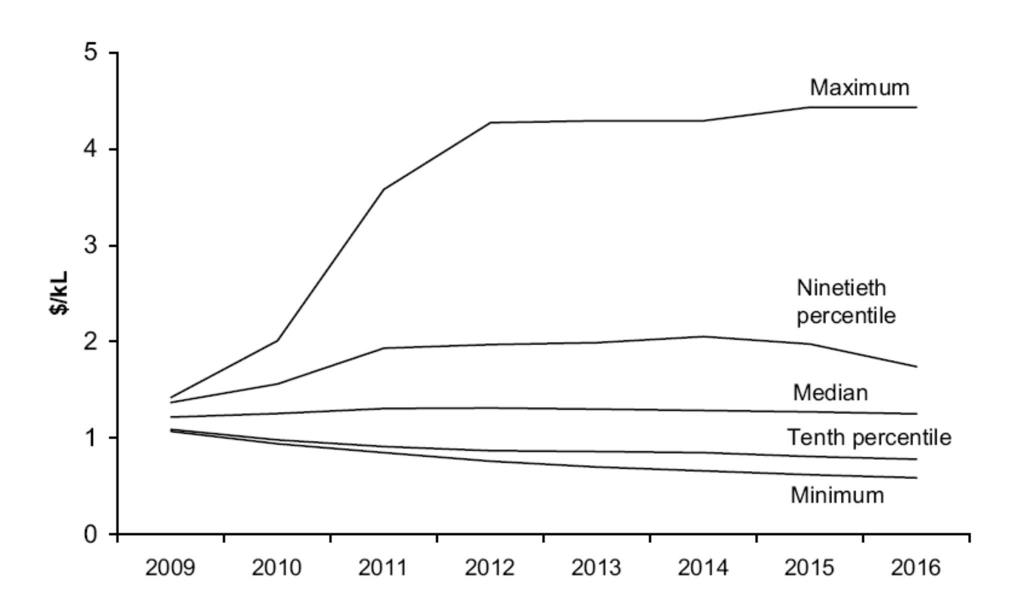
Instead of the heuristic approaches above, IPART could adopt a more sophisticated approach. In particular, it could use economic modelling techniques such as stochastic dynamic programming to define a schedule of prices that optimise community welfare given expected policy constraints, planned investments, future inflows, storages and demand forecasts.

In theory, it should be possible to define a schedule of efficient prices in terms of dam levels, which could be updated either annually or at the start of the regulatory period to account for new information on rainfall, inflows and dam levels. The regulator (drawing on expert advice) would need to make judgments about whether the assumptions underpinning modelled scarcity prices (e.g. chosen inflow scenarios) are reasonable.

Figure 10 illustrates modelled scarcity-based prices under a range of rainfall/inflow scenarios. As these prices relate to end-consumer prices provided by a vertically integrated service provider, further consideration would need to be given to applying the same principles to SCA wholesale operations and how this fits within the broader Sydney supply system. For example, Sydney Water's decisions on how to operate the desalination plant would influence the optimal pricing, storage, and investment patterns of SCA as it would affect demand. To the extent SCA and Sydney Water are subject to operating rules, however, these might be included as constraints in the model.

In theory, however, an increase in SCA's wholesale prices should have an effect on the optimal operating rules for the desalination plant. That is, the review of desalination plant operating rules by CIE estimated costs and benefits of alternative operating regimes assuming scarcity pricing had no role in managing supplies. If SCA introduced scarcity pricing, this may affect the estimated costs and benefits of alternative operating rules and their relative rankings.

Figure 10: Prices under scarcity-based pricing, across various rainfall scenarios



Source: Barker, Murray, & Salerian, 2010.

In Western Australia, the ERA (2009) has developed a model to estimate the short-run value of water. The model is based on a hypothetical wholesale market for metropolitan water supply. The model calculates the price at which supply equals demand for each of the next five years, given the available supply options, supply security requirements and an assumption about the responsiveness of demand to price (ERA 2009). The ERA notes that the model is useful as one source of information for price setting purposes.

The ERA model does not seek to attach a value to water in storage through specific scarcity prices. Instead, it defines a demand schedule for bulk water that achieves 'the amount of water that would ideally be retained in the dams at the end of each year to secure the system'. For example, the security target is to retain enough water in the dams at the end of each year to ensure 'saturated' demand[13] will be met in the following year even if zero inflows occur.

4.4.2 Assessment

Efficiency and effectiveness

Efficiency of price signals

Although economic modelling to generate a dynamically efficient scarcity price represents a theoretically attractive approach for efficient pricing, its practical

13 Saturated demand is defined as 30 per cent above the level of demand that would occur under a total sprinkler ban.

application in the water sector is in its early stages. Further, such models need to be tailored to specific systems or policy questions.

By their nature economics models rely on value judgements and technical assumptions and are information intensive. The quality of the model design, inputs and application will therefore be a key factor influencing whether modelled prices are likely to enhance efficiency. That said, existing pricing arrangements also embody similar types of value judgements and technical assumptions and require similar information.

Overall, however, modelled scarcity prices would be expected to lead to more efficient pricing than the status quo. Modelling by Barker, Murray, & Salerian, (2010) for example showed that scarcity pricing was associated with higher community welfare than pricing based on LRMC.

Impacts on Sydney Water sourcing decisions

Although prices modelled by the Productivity Commission are broadly indicative at best, they suggest prices could diverge significantly from the short-run marginal cost of supplying and distributing water from dams (i.e. minimum price) depending on rainfall and inflows. Largely, the estimated price rise remains within a relatively narrow band 90 per cent of the time. Under more extreme scenarios, the modelled scarcity price rises to many times the short-run marginal (operating) costs. Such prices may well be material to Sydney Water's procurement decisions under drier scenarios.

As noted above, the introduction of scarcity pricing may change the optimal operating rules for the desalination plant and hence Sydney Water's sourcing decisions.

Revenue adequacy and stability

Recent theoretical applications of economic modelling to estimate scarcity prices tend to abstract from institutional issues such as price regulation and tariff structures or deal with them in a general way. The Productivity Commission (Barker, Murray, & Salerian, 2010), for example, notes 'fixed charges (under a two part tariff) are not included in the modelling undertaken for this study'. To the extent this model is an extension of the SRMC scarcity pricing models described above, it should enable SCA to achieve revenue adequacy.

Appropriate allocation of risk

As with other forms of scarcity pricing, a common concern about economic modelling approaches to efficient pricing is the fluctuation in prices. In response, the ERA notes that price variations implied by its wholesale level model would not necessarily translate to similar changes in retail prices and could actually help identify required prices over a set regulatory period.

> The submission from the Water Corporation that a short run water model produces prices that fluctuate from year to year does not mean that usage charges need to fluctuate to the same extent from year to year. Indeed, the model is likely to be most useful if it is used to identify the value of water (and hence usage charges) over the course of the regulatory period (ERA 2009).

Administrative complexity

As an initial step, the NSW government, SCA or IPART could develop a model specific to the Sydney system (likely drawing on existing models, such as WATHNET and economic models developed to assess options under the metropolitan plan) that considers scarcity pricing in a system wide context. This would help establish the workability of this approach to setting scarcity prices and identify any interactions between optimal scarcity prices and other operating rules.

Transparency

One key issue associated with economic modelling is whether stakeholders, such as the regulator, Sydney Water and its customers, would be willing to accept prices determined though this complex 'black box' process. In Western Australia, for example, there has been much debate about the specification of the ERA's proposed short-run value of water model:

> From a practical perspective, the ERA's proposed SRMCP model is not well specified, calibrated or tested, and provides highly unstable results under a wide range of foreseeable circumstances. Without a strong theoretical driver, adopting a methodology that has a high probability of being abandoned at the next price review (due to the potential for unreasonably high or low prices) is not good regulatory practice (Water Corporation submission on Draft Report, Part A, cited in ERA 2009)

There is a risk that such modelling would be simply set aside or rejected when it provides results that stakeholders do not agree with and which IPART cannot easily communicate.

Overall

In theory, an economic model that calculated an optimal scarcity price based on existing system constraints, planned investments and operating plans would produce efficient price signals. However, much work would be required to develop such a model and to achieve buy-in from stakeholders. Further, consideration needs to be given to how these models would interact with the models underpinning the existing operating rules for desalination.

5 Conclusions

In considering options for scarcity pricing at the wholesale level, stakeholders will approach the issue with different perspectives. As a business, a primary objective of SCA is to ensure its prices to Sydney Water enable it to earn sufficient revenue to fulfil its supply functions, including managing its infrastructure efficiently and in accordance with sound commercial principles. IPART, on the other hand, must consider broader issues relating to the efficient operation of the supply system, consisting of multiple sources, and the possible development of a wholesale market. In particular, it must consider whether SCA's prices provide sufficient incentives for Sydney Water to undertake efficient investment in, alternative supplies and demand management.

Under current pricing arrangements, there is an inherent conflict between achieving revenue stability for SCA on the one hand and IPART's desire to send a signal on the value of water to inform Sydney Water's sourcing and investment decisions on the other. A key issue in assessing options for scarcity pricing is whether they can provide appropriate signals for efficient use and investment while not exposing SCA to undue revenue risk. There is a strong argument that SCA, as a relatively passive manager of catchments and dams in accordance with government defined operating strategies, should be able to recover its efficient costs without being excessively exposed to demand risk over which it has no control.

Our view is that scarcity pricing (based on principles of marginal cost pricing) would address this issue. This model would broadly involve:

- Aligning SCA's volumetric price with its short-run operating costs, with a fixed charge to address any revenue shortfall. This would require a large increase in revenue generated from SCA's fixed charge compared to current arrangements.
- Setting a separate volumetric price that reflects the estimated marginal value of water in storage, which would be in addition to SCA's infrastructure charges but would effectively apply only when predefined triggers are reached.
  - The revenue collected through this additional scarcity charge represents a separate resource rent outside of SCA's required revenue requirement and could potentially be retained by government or alternatively used to offset fixed Sydney Water's charges in the current or future regulatory periods.

This pricing approach would reduce the revenue risk to SCA embodied in current tariff structures while providing an appropriate price signal for consumption and investment to Sydney Water (and other SCA customers) and potential new entrants at times when water is scarce. It does so by clearly differentiating between pricing for SCA's infrastructure services and the water resource itself.

The extent to which these prices will have a material effect on the current and future portfolio of supply options for Sydney will partly depend on broader institutional arrangements for urban water planning. For example, current government policies (for example, strict desalination plant operating rules) may lock in particular sourcing decisions and investments and thus limit Sydney Water's flexibility to respond to wholesale water prices.

Another advantage of this approach is that it would be more flexible to adjust to changing circumstances in the urban water industry under which Sydney Water must make increasingly complex water sourcing and investment decisions across a range of supply and demand management options.

The design of the scarcity pricing regime also needs to consider carefully how scarcity prices will combine with existing operating rules for the Sydney system to achieve the most efficient mix of options for balancing supply and demand. For example, to the extent the operating rules for the desalination plant already take into account risks to existing storages and therefore reflect an 'optimal' operating strategy, there is a risk that the addition of scarcity pricing for SCA supplies will double count the costs of consuming dam water. This is not so say scarcity pricing is not worthwhile, but rather that current operating rules may need to be reconsidered in light of this new option for balancing supply and demand.

Putting this pricing model into practice will be challenging. In particular, estimating the value of water in storage is a key issue to determine. In this paper we canvass potential options for estimating the marginal value of water in storage ranging from heuristic approaches based on existing operating rules (e.g. setting prices equal to the operating cost of alternative options such as desalination when dam levels trigger operation of the desalination plant) to economic modelling approaches.

In theory, an economic model that calculated an optimal price based on existing system constraints, planned investments and operating plans would produce efficient price signals. However, we recognise that much work would be required to develop such a model and for it to be accepted in a regulatory price setting context.

In summary, we would advocate replacing the current pricing arrangements based on setting SCA's volumetric charges with regard to its LRMC with a more cost-reflective approach based on SCA's SRMC together with an additional scarcity price based on the costs of predefined triggered alternatives. This would better protect SCA's revenue adequacy while also achieving IPART's aim of a more efficient price signal to SCA's customers and potential new suppliers.

References

ACTEW. (2011). *Water Abstraction Charge*. Retrieved February 2, 2011, from ACTEW: http://www.actewagl.com.au/water/networks/wac.aspx

Barker, A., Murray, T., & Salerian, J. (2010). *Developing a Partial Equilibrium Model o fan Urban Water System*. Melbourne: Productivity Commission Staff Working Pape.

CIE . (2010). *Review of operating regime for Sydney Water's desalination plant*. Sydney: Centre of International Economics.

Council of Australian Governments. (2004). *Intergovernmental Agreement on a National Water Initiative*.

Council of Australian Governments. (2010). *NWI Pricing Principles*.

ERA. (2009). *Inquiry into Tariffs of the Water Corporation, Aqwest and Busselton Water*. Perth: Economic Regulation Authority of Western Australia.

Griffin, R. (2006). *Water resources economics: Analysis of scarcity, policy and projects*. London: MIT Press.

Independent Advisory Panel. (2008). *Submission from the Independent Advisory Panel for the Sydney Metro Water Plan, IPART inquiry into the SCA price path, October 2008*.

IPART. (2004). *Investigation into Price Structures to Reduce the Demand for Water in the Sydney Basin*. Sydney: Independent Pricing and Regualtory Tribunal.

IPART. (2009). *Review of prices for the Sydney Catchment Authority From 1 July 2009 to 30 June 2012, Water — Determination and Final Report (June 2009)*. Sydney: IPART.

Melbourne Water. (2010). *Melbourne Water Storages*. Retrieved February 2, 2010, from Melbourne Water : http://www.melbournewater.com.au/content/water_storages/water_report/water_report.asp?bhcp=1

NSW Office of Water. (2010). *2010 Metropolitan Water Plan*. Sydney: Department of Environment, Climate Change and Water.

Productivity Commission. (2008). *Towards urban water reform: A discussion paper*. Melbourne: Productivity Commission.

PwC. (2010). *Review of Urban Water Security Strategies*. Prepared by PricewaterhouseCoopers (PwC) at the request of Infrastructure Australia.

SCA. (2011). *Operating licence*. Retrieved February 2, 2011, from Sydney Catchment Authority: http://www.sca.nsw.gov.au/publications/publications/5

SCA. (2009). *Response to IPART's Review of prices for the Sydney Catchment Authority: Draft Determination and Draft Report*. Sydney: Sydney Catchment Authority.

SCA. (2011). *Water storage and supply reports*. Retrieved February 2, 2011, from Sydney Water: http://www.sca.nsw.gov.au/dams-and-water/weekly-storage-and-supply-reports

Sydney Water. (2011). *Overall project documentation: Desalination*. Retrieved February 2, 2011, from Sydney Water: http://www.sydneywater.com.au/Water4Life/desalination/overalldocumentation.cfm

Sydney Water. (2010). *Water Conservation and Recycling Implementation Report 2009-10*. Sydney: Syndey Water.

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