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The Economics of Water: Taking Full Account of First Use, Reuse and Return to the Environment

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Cover Photograph: Effluent plume entering northern Barker Inlet from Bolivar Waste Water Treatment Plant, 1997.

EXECUTIVE SUMMARY

There has been a lot of discussion about water being undervalued in Australia. The nation's attention is presently focussed on water issues with the drought of 2002 - 2003, the deepening crisis with the River Murray and water rationing in a number of urban areas. Over 2003-2005, the States and Territories will be required to demonstrate progress against the water reform goals in the area of urban and rural water pricing. This is an opportune time as part of the Australian Water Conservation and Reuse Research Program to develop a framework for the introduction of mechanisms that reveal the full cost of using water. This paper emphasises the importance of looking at potable water, reuse and disposal and return of water to the environment together as part of a comprehensive framework.

In this project report a comprehensive framework for pricing potable first use water, reuse water and sewage is outlined. As part of a full cost approach, externalities or unintended damage to other users or the environment (which in turn has an impact on society and its present and future well-being), are incorporated in the framework. The emphasis will be on environmental externalities. The approach uses a framework to trace the cycle of extraction, storage, regulation, distribution and use, with return (or partial return of components) of water and wastewater to the environment as a means of identifying the potential set of externalities.

Conceptually, there are two ways that water can be priced: direct pricing and indirect pricing. Direct pricing involves the setting of prices and charges payable by those who use, reuse and dispose of water. Indirect pricing relies on the use of a wide array of mechanisms that reveal the cost of using water and associated resources.

Not all externalities are suitable for direct externality pricing. Where the causal links from an action to an outcome are tenuous and difficult to follow, such as in the case of water use and water quality, then a charge to reduce water use is unlikely to reduce the water quality problems. It is worth emphasising that the charge ideally will lead to a reduction in only the economic activity, that directly causes the water quality problem. Externalities relating to extraction (sometimes known as supply externalities), use and return could be estimated. Externalities relating to extraction are probably the most straightforward to estimate.

An externality charge works in a political and social context where there is reasonable acceptance of the principle of polluter or user pays. If there is a climate that supports economic development regardless of impact across the water cycle, then an externality charge is going to be difficult to implement.

In this framework, it is important that externalities associated with potable water, reuse water and sewage be treated consistently. Ideally the externality charges need to be implemented across potable water, reuse water and sewage. Excluding any one of these from the framework will create a distortion in inter-connected markets. One of the key ideas behind the framework is the importance of providing price information that resources used to treat and pump water in its various forms are scarce. Only by pricing to account for the full costs will investment address financial and environmental objectives.

Reuse projects initiated by the private sector are often driven by a need for water or a perceived marketing edge. Projects initiated by the wastewater utility are often driven by a need to meet a reuse target and to avoid water based disposal as per Environmental Protection Authority (EPA) guidelines. In this latter situation, the client base must be developed by the wastewater utility. This has led to a number of reuse projects where reuse water was priced at a considerably lower level than potable water. It is difficult to determine if this was a necessary step as part of overcoming the "yuck" factor associated with reuse. One of the potential outcomes of this type of pricing strategy is the over-use of reuse water. In a first best world, whenever prices are set at less than full cost, efficiency considerations dictate that the rationale for doing this needs to be revealed and a process for returning to full cost pricing needs to be put in place.

In summary, the framework is designed to facilitate rational investment in potable water, reuse water and sewage that takes the full costs of production and to the environment into account. This is not to say that if a project is not financially viable from the outset, it should not go ahead. There will be instances, where public investment is required in order for large costs to be avoided or critical ecosystems to be protected. For example, irreparable damage to delicate ecosystems or the large financial and environmental cost of constructing a large dam may be sufficient to justify projects that substitute reuse for potable water. A level playing field is a good starting point for social choices. Construction of a level playing field requires attention to price revelation in all markets and it will take time and targeted research.

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1 INTRODUCTION

Over 2002 - 2003, there was a deepening concern over the nation's water resources. As the drought in the Murray-Darling Basin cut deeply, water restrictions continued in locations such as Perth, Melbourne and the Gold Coast and restrictions were introduced in South Australia.

Water is now being seen as a precious commodity to be rationed. Even if rationing is not economically efficient or necessarily effective, this is the public mood across much of Australia. It is in this context that States and Territories attempt to come to terms with their policies and strategies to manage water.

One challenging option is to reconsider the efficient use of water including potable water, rainwater, stormwater and sewage.[1] Economic efficiency in this context means achieving the best use of the resource using markets given the current state of institutional relationships. Economic efficiency requires that prices reflect the costs of producing and delivering water including the costs imposed on others or on the environment. These latter costs are referred to as externalities in the economic and policy literatures.

This is challenging because there can be positive and negative externalities associated with the extraction, storage, regulation, distribution, use and return (or partial return of components) of water and wastewater to the environment. Externalities will relate to the biophysical impact, attributable to a human based action, which in turn have direct and indirect effects on communities. Positive externalities are the benefits that are external to those responsible for a particular human activity or market-based transaction. In a catchment, an example of a positive externality is the elevated water level created in large dams that benefit recreational boaters. A negative externality is an external cost imposed on others. In this case, there are negative externalities associated with the dam, which might include the disruption of fish migration and spawning. The impact on fish populations has a direct impact on anglers and commercial fishing as well as the indirect impact on society through the disruption of ecosystems and the potential for species to become extinct through loss of habitat. Typically negative externalities outnumber and outweigh the positive externalities in most resource use contexts. Often the question of whether or not an externality is positive or negative depends upon one’s perspective of the way rights and obligations have been (or should be) defined. In this report the focus will be on environmental externalities which are un-costed. The question of how rights and obligations have and/or should be defined is left for consideration by others as they apply the framework to site and content specific locations.

If households, firms or irrigators took all the external impacts of their decisions into account then we would be much closer to using water at an economically optimal level. At present water users may not be paying the full cost, as there are un-costed impacts on the

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[1] For the purposes of this report, potable water is defined as water fit for human consumption, rainwater is the water collected in rainwater tanks on the domestic scale, stormwater is water collected from the hard surfaces of urban areas following a storm event and sewage is the wastewater from urban domestic and industrial use.

environment associated with extraction through to disposal. If they are paying too little, there will be a tendency towards extracting and using too much. Further, the wastewater produced may not be seen as a resource that can be utilised and ultimately too much will be disposed of or returned in some form to the environment. The result can also be too much investment in infrastructure including wide roads, paved footpaths, etc.

There is, however, more theory than actual practice in the area of measuring and accounting for the cost of externalities in prices. Investment in research designed to reveal the full cost of water reuse is likely to return significant dividends. Conceptually, there are two ways that water can be priced: direct pricing and indirect pricing. Direct pricing involves the setting of prices and charges payable by those who use, reuse and dispose of water. Indirect pricing relies on a variety of mechanisms that reveal the cost of using and associated resources. For instance, the development of a full suite of tradeable property rights to extract, use and return water to the environment will result in markets for tradeable permits sending signals about conservation and the value of the resources. Considerable investments in institutions, research and political capital are required to set up full-fledged tradeable property right systems.

This project report will outline some practical approaches to pricing, given the nature of the externalities and the multiple conflicting objectives inherent to pricing policy. Some suggestions regarding which externalities are likely to be amenable to externality pricing are provided. Pricing policies will send signals to the private sector regarding scarcity of resources and this aids in encouraging investment to fall in line with financial, social and environmental objectives. There are limitations to pricing policies and situations where pricing may not produce desired outcomes. Governments and industry may still need to make strategic investments in water conservation and reuse projects even with full cost pricing, as prices cannot fully capture the complex interactions between water use and the biophysical processes of water-dependent ecosystems.

Overview

This report will consider how the price of reticulated, “first-use” or "potable" water, reuse water and the price of sewage can be used to manage the third party impacts including impacts upon the environment. The starting step is to look at the extent of water reuse in Australia and provide an overview of current pricing in potable water, sewage disposal and reuse water. The next step is to provide a pragmatic framework for full cost pricing that incorporates externalities and addresses some of the conflicting goals inherent to pricing policies. The framework considers various points in the water cycle from extraction, storage, distribution and use through to return to the environment. Some examples of supply externalities are drawn from the River Murray and potential use and return externalities are also discussed. Finally, the report concludes with some remarks about the role of cost benefit analysis in social choices, a summary of the role of full cost pricing using direct and indirect pricing mechanisms and opportunities for further investment are identified.

2 WATER REUSE IN AUSTRALIA

A relatively small component of all the wastewater produced in Australia is currently reused in Australia. Approximately 10% is being reused according to Radcliffe (2003b). Reuse is largely being driven by factors such as:

- Requirements by environmental protection authorities to reduce the volume of effluent being released to bodies of water;
- Requirements by licensing bodies to increase the amount of water reused as part of an overall demand management strategy;
- Desire to demonstrate new technologies and innovative urban design strategies; and
- Shortage of water for irrigation purposes or industrial purposes in certain locations.

Table 1 - Estimates of Water Reuse by State and Territory from Water Utility Sewage Treatment Plants in Australia 2001-2002

Region	Wastewater GL/yr	Reuse GL/yr	Percentage
Queensland	339	38	11.2
New South Wales	694	61.5	8.9
Australian Capital Territory	30	1.7	5.6
Victoria	448	30.1	6.7
Tasmania	65	6.2	9.5
South Australia	101	15.2	15.1
Western Australia	126	12.7	10.0
Northern Territory	21	1.1	5.2
Australia	1824	166.5	9.1

Source: Radcliffe (2003b)

Typical reuse water applications include the following:

- Amenity areas - parks, gardens, ovals, gold courses;
- Commercial agriculture - viticulture, floriculture, turf grass, pastures, hay cropping and vegetable production;
- Forestry - plantation forestry;
- Industrial applications; and
- Residential use as part of third pipe developments.

3 A FRAMEWORK FOR WATER PRICING

3.1 National Policy Issues

A pricing framework for potable water, wastewater and reuse water cannot be considered in isolation of the broader water resource management policies in Australia. Of critical importance has been the adoption of the National Competition Policy (NCP). The NCP water reform obligations in water arose out of the acknowledgement of the Council of Australian Governments (CoAG) that the management and regulation of Australia's water resources was in need of reform. The strategic framework that emerged set out a map of the economic, social and environmental objectives to be undertaken by governments. The critical component of the 1994 National Water Reform Agenda package included:

1. All water pricing is to be based on the principles of full cost recovery and transparency of cross-subsidies.
2. Any future new investment in irrigation schemes, or extensions to existing schemes, are to be undertaken only after appraisal indicates it is economically viable and ecologically sustainable.
3. States and Territory governments, through relevant agencies, are to implement comprehensive systems of water allocations or entitlements, which are to be backed by the separation of water property rights from land and include clear specification of entitlements in terms of ownership, volume, reliability, transferability and, if appropriate, quality.
4. The formal determination of water allocation entitlements, including allocations for the environment as a legitimate user of water.
5. Trading, including cross border sales, of water allocations and entitlements within the social or physical and ecological constraints of catchments.
6. An integrated catchment management approach to water resource management be adopted.
7. The separation, as far as possible, of resource management and regulatory roles of government from water service provision.
8. Greater responsibility at the local level for the management of water resources.
9. Greater public education about water use and consultation in the implementation of water reforms, and appropriate research into water use efficiency technologies and related areas.

Source: http://www.affa.gov.au/water-reform/facts2.html

Each State and Territory was given the flexibility to adopt its own approach to implementation depending on its own unique institutional and natural characteristics. Periodic evaluation of progress against goals has been undertaken as part of a system of inter-governmental transfers known as Tranche payments. Water reforms have proven to be a challenging area and different States have undertaken reforms in some areas faster than others. From the 2003-2004 NCP Assessment Framework for Water Reform, governments need to report on how externalities are to be dealt with in the price of water and potentially passed on to water users as part of the price:

"Governments agreed to set prices so water and wastewater businesses earn sufficient revenue to ensure their ongoing commercial viability but to avoid monopoly returns. To this end governments agreed that prices should be set by a jurisdictional regulator (or its equivalent) to recover:

- *at least the operational, maintenance and administrative costs, externalities, taxes or tax equivalents (not including income tax), the interest cost on debt, dividends (if any) and provisions for future asset refurbishment/replacement.*
- *at most the operational, maintenance and administrative costs, externalities, taxes or tax equivalent regimes, provision for the cost of asset consumption and cost of capital, the latter being calculated as being the weighted average cost of capital."*

(Source: National Competition Council 2003, p.12)

Accounting for externalities in the price of water represents a step towards this "full cost of water". Each of the States will be reporting on the rationale for how these costs are passed on in the form of prices. However, the Assessment Framework also makes reference to the potential for using a portfolio of tools including property rights, charges, rebates and standards to manage externalities effectively. The High Level Steering Group (HLSG) on Water in an exposure draft of guidelines for managing externalities has suggested that:

"[W]hile it may be possible to identify an externality it may not always be possible to identify and target its cause. Furthermore, even where the cause can be identified the benefits of taking action may not exceed the costs. Therefore, these guidelines have been formulated in the context of the following general goal:

... To achieve an efficient and acceptable level of externalities in water resources rather than to eliminate such externalities altogether."

(Source: Cope 2002, p.5)

Pricing is likely to be only part of the solution to restore health to Australia's working rivers. There are many objectives inherent to pricing strategies and these will be reviewed in the next sections. As we shall see there are also considerable difficulties, but not insurmountable, in quantifying externalities.

3.2 Current Pricing Policies for Potable Water

At present potable water is priced according to a two-part price or tariff consisting of:

- A fixed access charge that does not vary with the amount of water consumed; and
- A variable charge based on the volume of water purchased which may be stepped or multipart.

Hunter Water Corporation first introduced two-part tariffs in July 1982 (WSAA, 2001). Other utilities have been introducing similar charges as a result of the 1994 CoAG national water reforms.

Sewage pricing takes different forms across utilities including:

- A fixed access charge;
- Based on number of pedestals;
- Meter size; or
- Property value.

Table 2 summarises the current set of charges across the major urban water utilities in Australia. The approach varies considerably across the utilities. All the major utilities in the assembled table use a two-part price for potable water. The fixed access charge for most utilities consists of a flat fee that applies to all users. Five utilities have a fixed access charge that is set at different levels based on meter size or flow factor.

At present, no water utilities explicitly charge a **resource rent** which is defined as the long term economic profit that can be earned as the result of having the rights to a resource and most often discussed in terms of land. For instance, superior resources such as better quality land will earn a rent that reflects this higher quality (Perloff, 1999). Scarcity rents are a related concept. **Scarcity rents** are the premium that a scarce factor of production can attract such as an oil and gas reserve. In general, tradeable rights to water in the lower connected Murray River attract a scarcity rent. Scarcity rents are a forward-looking concept that should anticipate future increases in demand and changes in costs of extracting the resource according to Tietenberg (1992). There is the potential for this sort of charge where a water utility holds tradeable rights to water in a catchment where the water entitlements are fully utilised and all potable water sources whether surface or groundwater, are largely controlled and managed. Either governments, utilities or the water resource users capture the rents.

In charging for sewage disposal, a few utilities use a fixed access charge that is set at a particular level based on location within the area being serviced. Two utilities have a fixed fee based on property values. Approximately two-thirds of the utilities impose only a flat fixed access charge for sewage disposal with no variable charge component. Sewage pricing is probably an area which would benefit from extensive review to ensure that economic and environmental objectives are being met.

Table 2 - Price of Potable Water and Sewage Disposal

		Fixed Component		Variable Charge
Water Utility		Minimum $	Basis	cents per kL
ACTEW Corporation	Water	125	fixed	41 <200; 97 >200*
	Sewer	339.20	fixed	none
Barwon Water	Water	102.60	fixed	70
	Sewer	125.50	fixed	86
Brisbane City Council	Water	100	fixed	82
	Sewer	315	fixed	none
Central Gippsland Water	Water	69.90	fixed	55
	Sewer	209.65	fixed	88
Central Highlands Water	Water	56.21	fixed	32 to 76
	Sewer	205.60 to 313.34	per town	none
City West Water	Water	81.92	fixed	77
	Sewer	89.04	fixed	88
Coliban	Water	92.70	meter size	33 to 62
	Sewer	229.10	per town	none
Gold Coast	Water	173	fixed	65
	Sewer	393	fixed	none
Gosford City Council	Water	70	fixed	70
	Sewer	340.30	fixed	none
Goulburn Valley Water	Water	85.30	meter size	35 to 43
	Sewer	172.70 to 215.30	per town	none
Hunter Water Corporation	Water	26.55	meter size	94 <1000; 86>1000
	Sewer	222.96	property	41
Ipswich Water	Water	162	fixed	52 <100; 90 101-150 and 128 >150
	Sewer	410	fixed	none
Logan Water	Water	145	flow factor	79
	Sewer	324	fixed	none
Power and Water Corp	Water	103.11	meter size	68
	Sewer	322.06	fixed	none
SA Water	Water	130	fixed	40 <125; 97 >125
	Sewer	241	property	none
South East Water Limited	Water	34.80	fixed	79
	Sewer	126.60	fixed	84
Sydney Water	Water	75	fixed	94
	Sewer	328.36	fixed	none
Water Corporation	Water	144.20	fixed	40 <150; 65 151-350; 88 351-550;101 551-750, etc.
	Sewer	228.55	property	none
Yarra Valley	Water	57.36	fixed	75
	Sewer	122.76	fixed	87

* Abstraction charge 20c/KL Source: Assembled from WSAA (2003)

3.3 Current Pricing of Reuse Water

Reuse pricing is determined on a project-by-project basis. Projects initiated by the private sector are driven by a need for water or a perceived marketing edge. Projects initiated by the wastewater utility are often driven by a need to meet a reuse target and to avoid water based disposal as per Environmental Protection Authority (EPA) guidelines. In this latter situation, the client base must be developed by the wastewater utility. The projects may require only the investment in infrastructure (or partial payment) where the user links into the existing pipelines or sewage treatment plant. An example is Dunheved Golf Club in NSW where the golf club receives up to 1 ML/day of tertiary treated and disinfected wastewater. The club is required only to repay the capital cost of the distribution system in the form of a monthly fee for 20 years (AATSE, 2004). A number of projects cited in AATSE (2004) have involved various subsidies in order to encourage the uptake of reused water. Examples include the Grampians Water project, which attracted some Commonwealth Government Landcare funding. Similarly the Springfield residential development in Queensland received funding from NHT Coasts and Clean Sea program.

In terms of water quality, residential and industrial users often require higher quality water. Industrial users may undertake additional desalination of the reused water such as the Townsville scheme listed in Table 3. In the case of Mawson Lakes in South Australia, treated reuse water is piped from the Bolivar treatment plant, mixed with stormwater to produce a high quality water and then piped through a third pipe system for outdoor use.

In terms of willingness to pay, agricultural and horticultural users often represent the lower end of the market. Industrial and residential users are willing to pay prices closer to the prices charged for reticulated potable water at present. However, the drought and changes in property rights to water may make reused water look more favourable in terms of security for uses in horticulture and viticulture in the future. As a general rule, the full cost of recycling, potable water production via desalination etc. and the cost of traditional supply sources. For efficiency, all estimates of full cost need to take into account the costs of infrastructure provision and maintenance as well as delivery costs and the cost of externalities.

Table 3 - Price of Reuse Water

Location	Use	Class	Price per kL	Reference
Northern Adelaide Plains, SA	Irrigated horticulture vegetables	A	7-15 cents	AATSE 2004
Sydney - Rouse Hill, NSW	Residential supply for toilets, home gardens	A	28 cents	AATSE 2004
Springfield, QLD	Residential supply for toilets, home gardens	A	43 cents	AATSE 2004
Southern Vales, Willunga Basin, SA	Vineyards	B/C	53 cents	AATSE 2004
Olympic Park/Newington NSW	Public facilities and residential supply for toilets, gardens	A	83 cents	AATSE 2004
Mawson Lakes, SA	Residential third pipe supply for toilets and gardens	A	75 % of potable for >125 kL	R. Marks Personal communication
Fyshwick Sewage Treatment Plant, ACT	Public parks and sporting fields	A	75% of potable water (stepped charges)	K.Dickson Personal communication
Barwon Water, Geelong VIC	Horticulture	A	35-58 cents	AATSE, 2004
Eastern Irrigation Scheme, VIC	Horticulture, golf courses, race courses	A	25-30 cents winter rate 12c	C. Wright Personal communication
Western Irrigation Scheme, VIC	Horticulture	A	12.6 cents	C. Wright Personal communication
Sandhurst, VIC	Residential area, parklands, golf courses	A	50 to 60 cents	C. Wright Personal communication
Lockhear, QLD	Horticulture	A	30 cents	C. Wright Personal communication
Toowoomba, QLD	Industrial	A	40 to 50 cents	C. Wright Personal communication
Luggage Point, QLD	Industrial	A	50 to 60 cents	C. Wright Personal communication
Townsville, QLD	Industrial	A	120 cents	C. Wright Personal communication
Clarence Scheme, TAS	Pasture, horticulture	A	5 - 10 cents	C. Wright Personal communication

3.4 Implications of Current Policies

Governments are currently reviewing pricing of potable water and irrigation water as part of the NCP water reform assessment process. Generally the move towards two-part tariffs has resulted in a decrease in overall water consumption and been useful in sending signals to consumers that water is not an unlimited resource. The previous section has demonstrated that the price of reuse water is often set at less than potable water. The full cost of reuse projects has been estimated to range from $1.45 per kL (Springfield, QLD) to over $3 per kL for projects such as Rouse Hill, NSW according to AATSE (2004).

Reuse water pricing appears to be the product of history, social acceptability and side-effect of other policy objectives. For instance, early projects such as the Rouse Hill may have needed relatively low prices in order to encourage users to overcome their potential aversion to the product, potential risks to human health and potential costs associated with learning to work with this source of water. In residential settings, relatively low transitional prices may be required to overcome the "yuck" factor until community acceptance of the concept begins to emerge. In the case of some utilities that must reduce potable water consumption and/or discharge to waterways, the utility may be prepared to provide the reuse water at less than full cost in order to satisfy licensing requirements and/or environmental guidelines. Efficiency considerations, however, dictate that whenever a licence requires such an action, regulators need to have a transparent rationale for imposing such a requirement and an understanding of the interconnected consequences of doing so.

Radcliffe (2003b) suggests that reuse water may well increase overall water consumption in some locations. In Rouse Hill, NSW, for example, reuse water is priced at 28c/kL while potable mains water is 98 c/kL, which represents a considerable savings over mains water in a residential community. Water consumption in Rouse Hill in 2001-2002 was approximately 20% more than the Sydney average (AATSE 2004). This may be due in part to the establishment of lawns and gardens but it is also likely that the relatively low price of reuse water was a factor.

There may be lessons from our collective experience with irrigation that could be considered. Providing water at a relatively low price may lead to over-use and over-investment in production processes that utilise water. As well, there can be environmental impacts, depending on the hydro-geological formation of an area such that over-application of reuse water could lead to problems with waterlogging, salinity and water quality issues within aquifers. "Mistakes of the past" need not be replicated if frameworks for potable and reuse water are set out early in the investment cycle. Ideally as the reuse water market grows and matures, reuse water will serve segments as markets open up assuming that social acceptability is achieved.

Thus in establishing a pricing framework for reuse, it is important to consider not only reuse water but also the pricing of potable reticulated water and sewage. If investment in public infrastructure is to address the triple bottom line (social, economic and environmental objectives) across the sectors of the economy, then one starting point would be to establish clear economic signals that accounts for the full set of investment, production and consumption related decisions surrounding water. In other words, transparent full cost pricing of potable water, reuse water and sewage may be required.

At present, only in a limited number of instances are water utilities and water reuse businesses competitors. Ideally the products should be competitive and with the water reforms that have been occurring in Australia, there is reason to believe that markets could evolve in this way, as there has been a distinct levelling of the playing field in various sectors of the economy with the National Competition Policy. Within the area of water, there has been a movement towards transparent pricing for irrigation and urban water. Thus any pricing strategy will need to fit within the broad industrial policy setting of the Australian States and Territories.

3.5 Using Price as a Management Tool

Economic theory has long suggested that the "correct" pricing of goods such as water has the potential to yield considerable gains in economic efficiency (Rogers *et al.*, 2002). By accounting for the full cost of resource use, including the unintended impacts on third parties and the environment, households and firms across sectors of the economy will make decisions in line with stated national economic goals. The gains in economic efficiency will come about through changes in consumption and investment patterns and reallocations of resources among sectors and across geographic locations. Essentially, whenever one changes a price, this in turn, causes behaviour to change and, in the longer run, different forms of infrastructure to be put in place. Significantly, pricing creates an opportunity to affect decisions associated with the maintenance and extension of existing buildings, infrastructure, etc., as well as the cost of new ones.

If the National Competition Policy process is successful in establishing a level playing field, prices will send signals through inter-connected markets. Increasing the price of water, as a result of taking a full account of the costs, will have a series of ripple effects. The cost structure of production processes will be altered with costs increasing in the short run and technological adaptations occurring over time. Substitutes, such as reuse water and desalinisation will become relatively more attractive, all other things staying the same. It is also through the inter-related nature of markets that unintended effects of second best solutions often arise. For example, increasing the price of reticulated potable water may lead to degradation of groundwater resources if too many bores are sunk in order to avoid the increased costs. Similarly, introducing volumetric sewage charges may result in inappropriate disposal with ensuing implications for general health and safety as well as jeopardising groundwater supplies.

3.5.1 Market-Based Instruments

Direct pricing is a useful tool when dealing with volumes of water. As an instrument for managing the interface between communities and the environment, price is one tool for managing externalities among a suite of potential market-based instruments (MBI). An MBI uses markets to change behaviour of consumers and businesses to come in line with a socially mandated objective. MBIs provide a means of managing particular aspects of the water cycle and can include a wide array of tools such as pricing, taxes, rebates and subsidies, tradeable property rights, offsetting policies and creating new markets. No one tool or signalling device though will be sufficient to encourage all the irrigators in the Murray-Darling Basin or all households and businesses in the Sydney region to act in a manner consistent with objectives of environmental health. In order to achieve optimal outcomes, both direct and indirect pricing are necessary.

While an important tool, direct pricing is not sufficiently robust to manage all the conflicting social and environmental objectives associated with water (HLSG, 2000). For example, pricing is not well suited to all aspects of water quality externalities. If the externality impacts are difficult to trace back to its original source, such as sedimentation, it is difficult to see how the externality could be incorporated in the price of water. The solution to sedimentation and nitrates probably relates to land management and changing input use and production processes. Hatton MacDonald *et al.* (2003) suggest that a pricing strategy can be reasonably employed if:

- There is a political climate that accepts a polluter pays principle;
- The water users are likely to be responsive to price changes; and
- There are no critical thresholds being approached such as a level of extraction where irreparable damage is likely to occur (otherwise critical safe-guards need to be employed).

In general, there is a reasonable acceptance of the user pays principle in urban Australia. Australians have become accustomed to charges for health services, education, etc.

Potential responsiveness to price is difficult to assess given the widespread use of volume restrictions in urban areas. Evidence from the ACT in the late 1980s/early 1990s indicates that households are not highly responsive to changes in price but do respond somewhat to price. Households tend to cut back on discretionary uses of water such as watering of lawns and gardens when faced with graduated volumetric pricing. Giurietto *et al.* (2002) suggest that a typical household in the ACT consumed between 150 kL and 500 kL of water per year prior to reforms and 150 kL to 300 kL after the reforms of the early 1990s.

If there are some uncertainties about threshold levels combined with uncertainty about the estimates of incremental damages, then regulation and market-based instruments, which focus on quantities or volumes, may be more suitable.

In summary, pricing is an important tool for managing resource scarcity by imposing fiscal discipline. Pricing is also useful for environmental management but must be backed up with sound regulation, policy and incentives.

3.6 Conflicting Goals in Pricing

Economic efficiency, cost recovery, revenue maximisation, regional equity, ability to pay and demand management are often cited as some of the potential objectives in setting a price, particularly for reticulated potable water. These goals may be considered quite reasonable on their own. However, these goals are not always simultaneously achievable and as a result social choices where society faces trade-offs are often required.

Economic efficiency can be achieved by maximising the net benefit of water use. This is also described as the marginal cost pricing rule where the optimal volume to be supplied is where the incremental cost of supplying an additional unit or marginal cost equals the incremental amount that will be paid for a volume of water or marginal willingness to pay

(McNeil & Tate, 1991). There is a short run and a long run interpretation to this rule. In the short run, capital cannot be easily altered and, as a result, marginal cost is based on the factors that are variable in the short run. As long as there is capacity in the system, this pricing rule will result in an economically efficient solution. In the long run, however, expansions and replacements of infrastructure are required and planned for and as a result, capital is said to be variable. In the long run, a pricing rule where long run marginal costs equals willingness to pay will result in an economically efficient solution.

However, a water utility may not generate sufficient revenue to cover all its costs with a marginal cost-pricing rule if there are significant fixed costs. Laying pipe represents a significant fixed cost for reuse and potable reticulated water service providers. With significant fixed costs, following a marginal cost-pricing rule can result in revenues being inadequate to cover all the costs and the utility running a loss. A solution to this is to use what is commonly referred to as a two-part price (Call & Holahahn, 1983) that fulfils the **cost recovery** objective while still retaining efficiency aspects. Summarising the approach again, the two-part price consists of a fixed charge and a volumetric charge based on the marginal cost of supplying water. A number of utilities in Australia and in other industrialised nations (OECD, 1999) employ this strategy. This strategy would allow a utility to recover costs through the fixed cost component and send economic signals through a volumetric component. The closer the volumetric component is to long run marginal costs, the more efficient the outcome.

Net revenue maximisation for water utilities, whether private or public entities, may also be an important objective. Most water utilities in Australia face some form of regulator or some arm of government that approves price increases. In the case of urban water demand, there is a range of demand where little response in terms of the volume of water consumed might be expected from a change in price. For instance, if the percentage increase in price is greater than the percentage decrease in volume demanded, demand is said to be inelastic (absolute value less than one). Over the elastic range of demand, the percentage change in price is less than percentage change in volume demanded. In the inelastic range, price increases result in revenues increasing and not until in the elastic range will revenues begin to fall.

Across Australia there are checks and balances on the incentive to maximise revenue. Independent regulators will be concerned with demonstrating that an increase in price is justified. A government dependent on votes as well as revenue from public utilities will have to weigh up the political trade-offs of losing votes from an electorate who doesn't want to pay more and lost revenue which would have come from a price increase. With such tradeoffs, consideration also needs to be given to the large public investments associated with infrastructure. Often there are considerable economies of scale in the supply of water and a political requirement that prices remain fixed in the short term.

Issues of **regional equity** and ability to pay are often at odds with economic efficiency. One price across regions will not reflect different supply costs as a result of differential distribution costs or costs to the environment. This strategy is employed in South Australia where water has one price for all residential customers of SA Water. As a consequence, one would expect that water use in most, if not all, areas would be sub-optimal. Water may well be used in some locations at levels that incur net social losses.

Similarly, using **ability to pay** may result in businesses judged to be in a position to pay higher rates, potentially cutting production and potentially employing less people. This may correspond to a net social loss in economic well being to society. Providing cheap water or cheap reuse water in regional centres may be viewed as providing necessary incentives for business development.

The basic idea behind pricing for demand management is to price so that there is an incentive to conserve water. The approach can be justified if failure to conserve will result in need for large fixed investments to meet demand. Pricing water for the purposes of **demand management** can take many forms. The price of potable water can be increased by some arbitrary amount or the price of reuse substitute can be set at some arbitrarily lower amount. An example of this might be the decision by the NSW government to postpone indefinitely the construction of a dam on the Shoalhaven and instructing Sydney Water to reduce per capita water consumption by 35% by 2010-2011. As a result, Sydney Water has embarked on a multi-pronged approach to decrease potable water consumption. One strategy has been to promote reuse. In order to develop consumer acceptance, reuse water has been priced between one-third to three-quarters of the price of potable water.

The downside of pricing for demand management is that the approach is very sector orientated and may result in unintended reductions in economic activity as well as hampering future opportunities in the urban or rural economy. This is most likely to occur when only one price is charged and least likely to occur when the prices of water of all qualities, including sewage disposal, are adjusted.

There may well be an argument to be made about the reuse industry being like an "infant industry" which requires protection and encouragement in order to develop the scale of operations that make technologies and processes viable. National and international experience with trade protection suggests that these measures often result in infants that do not grow up. Painful decisions are later required. Adopting a pricing framework early in the investment cycle will aid in avoiding over-investment. As argued above, this problem is best dealt with by introducing transparent transitional arrangements.

3.7 Dealing with the Conflicting Goals

Thus with all the conflicting goals inherent to pricing and the difficulty of employing a marginal cost pricing rule in the presence of fixed costs, a second best solution is probably all that is possible at present. As a pragmatic approach, the current two-part price structure used by many water utilities might be adapted to incorporate volume-related externalities as part of an externality charge.

3.7.1 Pricing to balance cost recovery and economic efficiency goals

The two-part price approach in

Figure 1 allows for the recovery of fixed costs, while the volumetric charge portion retains the marginal properties that send important conservation messages to users. The fixed cost side will incorporate costs that will occur regardless of the volume of water or sewage involved. Fixed costs would include the expenses relating to the existing infrastructure including some accounting for the capital costs and scheduled and unplanned maintenance relating to the existing capital. The fixed cost component ensures that costs are covered and that system assets are not simply run down in the short term.

How much of future expansions and upgrades are to be included in the calculation of long run marginal costs for the volumetric charge is an important decision. Again, the closer the volumetric charge is to the long run marginal costs, the more efficient the charge will be. It is a difficult calculation, as it will often include future expansions and upgrades to infrastructure over time horizons of 20 to 30 years. Clearly the calculations depend on a number of critical assumptions that need to be accounted for in sensitivity analysis. Analysis from the ACTEW in Canberra suggests that long run marginal costs may be in the order of $1.10 per kL and this is broadly comparable to international studies (Giurietto, *et al* 2002).

3.7.2 The Volumetric Charge

The volumetric charge would include all **volume related** costs including the obvious expenses relating to the operating side such as:

- Pumping costs;
- Labour costs;
- Treatment; and
- Future capital costs in so far as the volumetric charge approaches a long run marginal cost.

The volumetric charge would at a minimum cover short run marginal costs but ideally would approach long run marginal costs, including some of the major infrastructure changes that may be required to manage volume-unrelated externalities for water users in a manner consistent with society's aspirations with respect to sustainability.

3.7.3 The Fixed Charge

The fixed charge is designed to ensure that all costs are covered and be roughly related to costs that do not vary in the short term. Thus the fixed charge will incorporate:

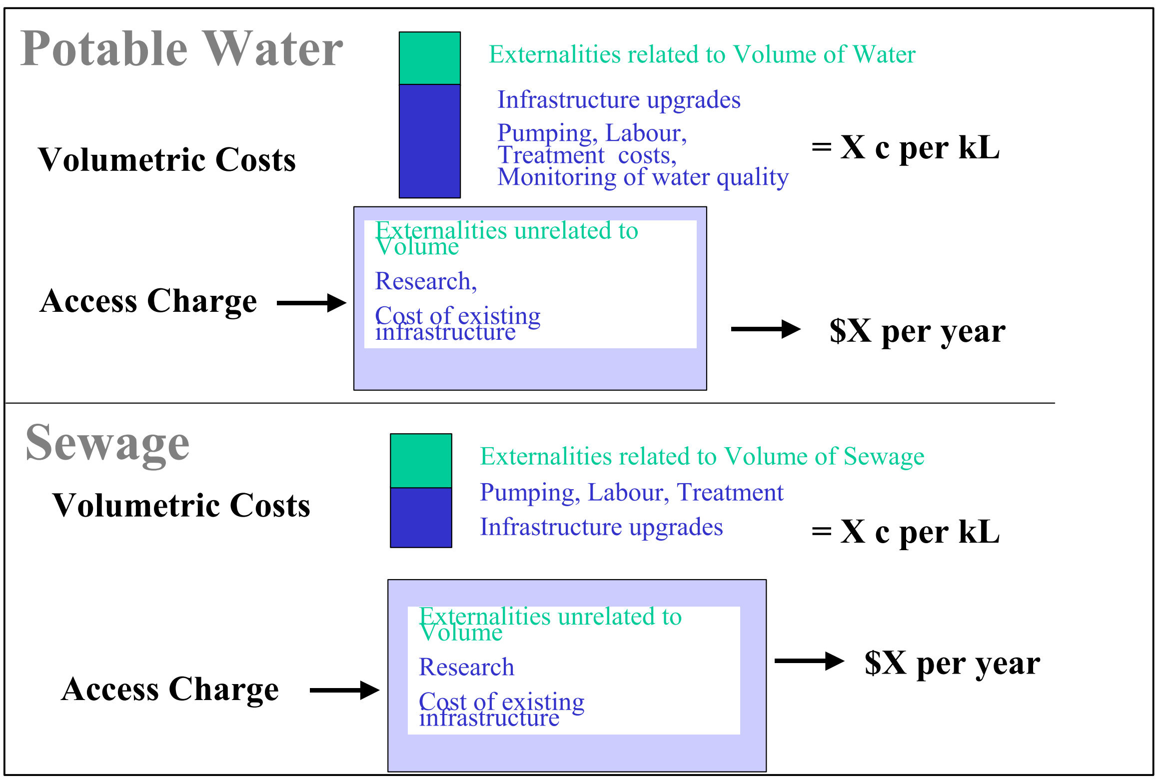
- The cost of research including the cost of monitoring environmental impacts; and
- Reasonable estimates of the cost of existing infrastructure.

These charges could also include some smaller capital costs that are planned for the near future to deal with the volume-unrelated externalities. The major capital upgrades planned for the long run, would enter the volumetric cost side as part of long-run marginal costs. Care must be taken to avoid double-counting.

3.7.4 Pricing to account for external costs

The volumetric side will include the externality charge as the charge is linked to volumes of water. It is important that the externality charge relates as closely as possible to the incremental damage associated with volume of potable water, reuse water or wastewater being extracted and returned to the environment. This means that, in many cases, it will be necessary to set different charges for extraction and return via a sewage treatment works or equivalent. For the externality charge to be effective, it must retain its incremental properties to balance the value of the water use against the incremental damage at each point in the water cycle. Ideally, the externality charge does not attempt to recover costs of infrastructure. The same process of identifying all the external costs associated is used for potable water, reuse water and/or the disposal or return of wastewater to the environment

Figure 1 - A two-part price involving externalities



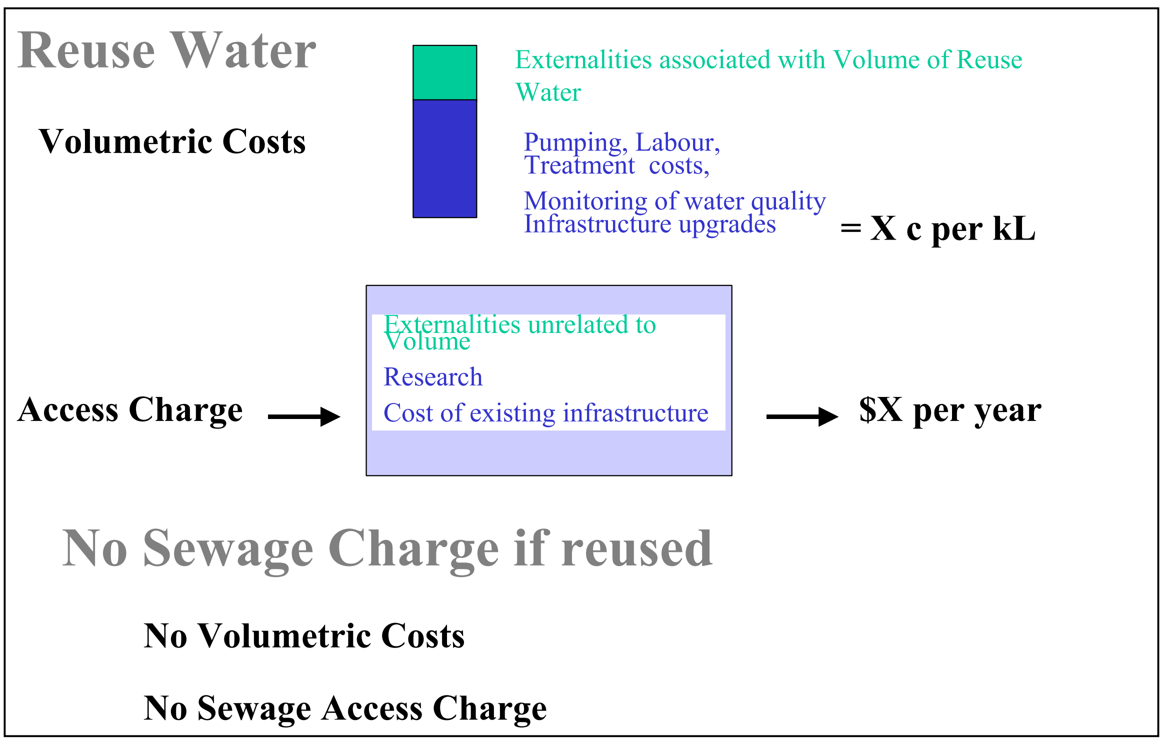
As set out in Figure 1, to send clear economic signals while fostering an environment amenable to investment, the system of pricing would also need to incorporate opposing features of flexibility and security. The fixed access charges could be reviewed periodically according to a publicly announced schedule. By running a transparent process of review as described by Musgrave (1999), water utilities and industries dependent on water would be able to plan investments with some certainty about revenues streams and about how the components of price and regulations that determine costs of delivery would be reviewed.

Mechanisms for charging, at least approximately, for sewage volumes need to be introduced. The volumetric charge could be revised more frequently based on the temporal issues relating to water extraction, storage, distribution, use and disposal externalities. The next section will outline the nature of the various externalities and outline how to account for them in the price of potable water, reuse water and sewage using an example.

Reuse water could also be priced according to a two-part price with a fixed access charge and a volumetric charge. This pricing approach is outlined in Figure 2. The critical difference from

Figure 1 is that there would be no sewage disposal charges if the water was subject to reuse. That is, those who opt not to use the sewage system could be given exemption from the access charge as well as a volumetric charge. The simple introduction of such an option would cut a significant driver for investment in reuse technology.

Figure 2 - Two -part price for reuse



3.7.5 Summary of the Potable, Sewage and Reuse Charging Framework

For potable water, or first use water, any externalities associated with the extraction, storage, distribution and use of potable water would be included in either the fixed or the volumetric side of the two-part price. If the water was not reused, then a sewage charge (fixed and volumetric) would involve any disposal related costs including externalities. For reuse water, the two-part price would need to account for the fixed costs, volumetric costs and any externalities. It should be possible to disconnect from the sewage system and not pay a fixed sewage charge. Many of the extraction and distribution related externalities would be avoided and thus not included in the cost. Further, a fixed access and volumetric charge for sewage would not apply to reuse water that is reused again.

4 EXTERNALITY CHARGES

A first step towards developing a set of externality charges would include an examination and categorisation of all the unintended impacts associated with the various steps in the hydrological cycle and the construction of the databases necessary to facilitate their introduction. In particular, this requires the introduction of metres for supply and emission databases. The critical steps in the cycle appear to be the extraction, storage, distribution, use and finally, disposal or return of wastewater to the environment.

Externalities relate to the biophysical impact, attributable to a human based action, which in turn have direct and indirect effects on communities.

An externality charge is a fee included in the price of potable water, sewage disposal or reuse water which accounts for the incremental cost to the environment associated with an additional volume of potable water, sewage disposal or reuse water.

A first best charge would perfectly reflect the volume related incremental damages that one expected to occur and would be perfectly flexible in terms of the temporal changes in costs.

A second best charge is an approximation of likely future incremental damage. With periodic review, the charges could be updated to convey temporal cost differences and changes in information and knowledge about the nature of damages.

4.1 Extraction and Transport of Potable Water

Many Australian rivers are managed for multiple objectives such as drinking water quality, irrigation, recreation and the environment. The River Murray is an important example of the multiple uses of a river. Water extractions from the River Murray for irrigation and drinking water result in less water being available for the environment. Irrigation often depends on water being stored and released in the summer. This pattern is opposite to the natural flow regime of the Murray where there would be irregular flows through the year but the highest flows occurring during winter.

On the other side of the analysis, allowing a river to return to a natural flow regime and removing weirs which are barriers to fish migration and taking back water for the environment will have implications for irrigators and recreationalists. There will be difficult public policy discussions ongoing concerning where the rights to water ultimately reside and who holds rights to compensation with regard to flooded property, irrigators being unable to pump, etc.

Table 4 provides a summary of the main positive and negative externalities associated with the extraction through to the distribution of water using the River Murray as an example.

Table 4 - Summary of the main environmental externalities associated with the extraction, storage and transport of water using the River Murray as an example.

	Impacts
Negative Externalities	Decline in annual median flows
	Loss of the natural cycle of floods and droughts
	Reduction in river and floodplain biodiversity
	Floodplain and river salinisation
	Invasion by exotic fish and plant species
	Decreased water quality (increased alkalinity and turbidity)
	Barriers to fish migrations
	Increased incidence of blue-green algal blooms
	Coldwater releases from reservoirs
	Salinisation and loss of fish production from the Coorong
	Loss of estuarine habitat and fish production from the lower lakes
	Closure of the mouth
Positive Externalities	Recreational Use such as Boating
	Flood mitigation

Source: Analysis by Sébastien Lamontagne, CSIRO Land and Water.

4.2 Some externality charges

4.2.1 Extraction

From this list, the loss of environmental flows is probably the most practical application upon which to concentrate for an externality charge for potable first use water. By returning environmental flows, a number of the impacts can be at least partially mitigated including a reduction in algal blooms and potentially opening the mouth of the Murray (without continued dredging). Other elements such as barriers to fish migration and the impact of cold water releases are probably best dealt with by modifications to infrastructure and thus would enter the fixed access charge component of a two-part price. Water quality including alkalinity and turbidity may well require approaches that address the source of these problems such as land management practices.

The externality charges in the volumetric side could be placed in an environmental account and/or go into consolidated revenue and the funds used to undertake the longer term infrastructure upgrades as well as buy water for the environment.

Extraction related and use related externalities are likely to be location specific. Some cities for instance draw on different sources of water. For example, Adelaide draws water from the River Murray, in amounts varying from 40 to 85%, with the remainder drawn from catchments in the Mount Lofty ranges. The environmental costs associated with extraction from the different sources are likely to be considerably different. Further, it is likely that water extracted in the summer months, particularly during a drought, will impose higher costs. Thus the volumetric charge might be reviewed and potentially revised on a wet and dry seasonal basis. A difficulty that must be acknowledged is that systems are generally not set-up at present "to tag" water as being extracted from a catchment at a high stress versus low stress time. Water resides in storage until required. However, thresholds of storage levels could be used as proxies for environmental scarcity costs. As a threshold level is approached an additional externality charge, over some base might come into effect. As water trading becomes more sophisticated and urban water supply authorities are forced to compete with other water users including irrigators and environmental managers, the opportunity costs associated with such tradeoffs are starting to emerge.

4.2.2 Use of Water

The use of water, whether urban or rural, can present problems for the watertable and salinity. For urban areas, a growing body of evidence worldwide suggests that rates of recharge are enhanced by urbanisation as a result of groundwater irrigation of domestic lawns and public parks and gardens despite the increase in impermeable land surface (Foster *et al.,* 1999). Leakage of water and sewerage pipes into aquifers can also be a problem. This is altering the water balance in many cities. In some locations, the use of water as part of urban irrigation of lawns and gardens is resulting in salt being brought up to the root zone of plants and trees. As the watertable rises, it carries dissolved salts that are normally locked in the soil and rock profile. The end result can be vegetation dying, damage to roads, corrosion of underground water, gas and sewerage systems and salt damage to buildings. Salt damage can reduce the life of a road from 25 years to 10 years and the reconstruction of a road in a town block can cost an estimated $300 000 per kilometre (NSW Government, 2003). Use externalities must be reasonably related to local water use and not dry land salinity where the rising groundwater is related to land clearing in the catchment.

4.2.3 Disposal

Sewage effluent can contain a variety of physical, chemical and microbiological constituents that can be of concern to human health or to the environment. The broad classes include inorganics, microbial pathogens, organic compounds, disinfection by-products, algal toxins, pharmaceuticals, hormones, radionuclides and endocrine disruptors. Dillon (2000) stresses the need to evaluate the potential risks associated with all these water quality parameters, within a risk management context.

For many Australian coastlines, the presence of nitrates in wastewater and sewage disposal has the potential to damage estuaries and coastline areas. Coastal areas have been experiencing some level of disturbance since European settlement. However, the ability of a coastal system to assimilate human wastewater is highly variable. Some coastal ecosystems have been experiencing losses in seagrass. Various hypotheses for the seagrass losses are suggested including smothering, eutrophication (nutrient enrichment), toxicity effects of inflow contaminants, modifications to grazing dynamics or the combined effects of increased turbidity, and reduced salinity levels and eutrophication. The most common belief is that nitrogen is principally implicated in the eutrophication and smothering/loss process. Thus it should be possible to measure the incremental damage associated with increasing volumes of sewage. From this, zone based sewage externality charges could be developed and mechanisms put in place to share costs accordingly.

4.3 Differences in Pricing First Use and Reuse

Reuse applications include:

- Land-based amenity applications such as golf courses and parks;
- Agricultural and forestry applications;
- Industrial uses; and
- Urban residential.

The externality costs of reuse water will vary based on the use of the water. Unintended third party impacts on the environment are likely to be only minimally different from the use of potable water in industrial uses. However, the externality costs associated with land based applications need to be carefully accounted for. If the application of reuse water raises watertables or imports salt to an area, then salinity costs and the potential for leaching need to be considered as part of pricing and as part of a catchment plan.

Monitoring and research costs for reuse water, on the fixed cost side, might also be higher in order to address the issue of pathogen detection and treatment. As there are public health issues associated with pathogens from reuse water, some known and others unknown, pricing is potentially affected by public health authority's risk management decisions. There are a number of different strategies for managing risk. One strategy is to set very high standards and restrict uses of reuse water, in which case, the costs may be largely fixed capital costs associated with adopting these high standards. Alternatively there is the potential for managing the risk through pilot projects and on-going research. In the latter case, research costs will tend to be higher with reuse water than with potable water as cost-effective detection and treatment strategies are developed and tested.

There are also numerous competing public policy trade-offs to be considered. Environmental quality issues can be managed through any number of strategies. For example, if sewage is being disposed of in a sensitive coastal ecosystem, the public policy approach can be to reduce the amount of sewage produced through an externality charge or upgrade the treatment processes. Many factors will influence the approach, including whether critical thresholds are being approached or there are increasing risks to human health to be considered, etc. If a strategy of engineering and infrastructure enhancement is taken, the cost of the upgrade will need be reflected in the volumetric price.[2]

5 CONCLUDING REMARKS

This report has outlined some fundamental principles of pricing commodities according to economic theory. The approach is laid out in a manner consistent with expressions of public policy such as the National Competition Policy. If solutions are to work in the real world, policies must stand up to financial scrutiny by the private sector. Governments, faced with revenue constraints, must also look closely at investments of public money to ensure financial, social and environmental goals are met. This pricing framework is designed to encourage private sector investment to line up with the goals of governments in setting their environmental policy regarding water use.

Strict financial analysis would suggest that many reuse projects should not get up. Where the private sector is unlikely to develop technologies or address environmental concerns, is there a role for public investment? The answer, from an economic perspective is "sometimes". Where there are critical environmental assets to be protected or there are costs too difficult to incorporate in an externality charge, public investment may be required and/or mechanisms put in place to impose the costs of protecting these assets on the community. For instance, projects that capture nutrient rich water before the nutrients reach critical estuaries and coastal ecosystems may be justified by the environmental benefits. Avoidance of irreparable damage may require direct public investment in alternative approaches and technologies. While this is an atypical application of the precautionary principle, investments in reuse and water sensitive design may similarly be required to avoid damages to water dependent ecosystems. Similarly there may be cases where the avoidance of large infrastructure costs such as building a dam may justify investments in reuse projects. For example, whenever such projects are put in place, efficiency criteria would suggest that they should be accompanied by agreed arrangements for removal of the underlying pricing and other distortions that have created the need for the subsidy.

At present very few reuse projects are financially viable as independent business entities. A number are explicitly subsidised as pilot projects and others are implicitly subsidised by water utilities in order to reduce wastewater. There may be some argument for the need for transitional subsidies and protection from competition while technologies and economies of scale are developed. Pilot projects are a tried and true method of testing technologies, working out problems and minimising risk. It is important that the transition from pilot

[2] As these are changes and upgrades that are undertaken over the longer term the costs should enter long run marginal costs. Unintended bias towards the current pattern of use and disposal of potable water may be introduced if the costs are loaded on the fixed cost side. The access charge is intended to ensure costs are covered.

projects and demonstration sites be mapped out and be driven by sound economic principles.

If the reuse industry is to grow into a viable competitive industry in its own right, then a pricing strategy that accounts for the full cost of potable first use water, reuse water and sewage would contribute to a levelling of the playing field. While there are numerous conflicting objectives with respect to pricing, the consensus seems to be forming in Australia for a two-part price consisting of a fixed access charge and volumetric charge. This project report has suggested how externality costs could be incorporated in these charges.

Considerable modelling and analysis remains to be done to cost many of the volume related externalities. A research priority has to be how to best estimate a sophisticated set of externality charges. The difficulty is that the charges need to reflect incremental damage and, that in order to do this, new data sets need to be built so that responsibility can be assigned via a mix of charges on those who cause externalities.

However, a process is underway to develop and review pricing strategies. With the work that is going on throughout the States and Territories, it is important to get approaches and methodologies into forums for debate and scrutiny. Externalities are plagued by the problem of perspective and the concept is a slippery one.

Economists have long considered externality pricing a good idea. The CoAG water reforms have been moving the water industry towards more transparent, efficient forms of pricing. While a two-part price is not the ideal, it represents an approach that is pragmatic and allows progress to be made in a manner that can be expected to deliver more efficient outcomes. The two-part price as suggested in this project report allows costs to be recovered as well as sending a message of economic efficiency and conservation.

If the principles of full cost pricing were implemented across the potable water industry, sewage disposal and reuse water industry, one might expect to see some change in the structure of the industry over time.

Empirical estimation of externalities begins with identifying potential examples and this project report has identified some practical examples. Extraction, use and return externalities are likely to be the easiest to trace in terms of causality from water related action to outcome. In some locations, there may only be extraction externalities and other locations may have a number of externalities. The research problem is challenging but getting prices right is important for ensuring sound investment and avoiding mistakes of the past. Changing institutional settings and developing and implementing regulations takes a long time. Full cost pricing is challenging but has the potential to send signals early in the investment cycle. Investment in the development of mechanisms to do this and the testing of them in real world situations is likely to offer a significant return on investment.

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