Approach Paper

On

Developing Regulations for Bulk Water Pricing in the State of Maharashtra

Volume - II

Submitted to

Maharashtra Water Resources Regulatory Authority

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ANNEXURE – I

(INTERNATIONAL APPROACHES TO CALCULATING BULK WATER TARIFFS & IMPLICATIONS FOR THE MAHARASHTRA WATER RESOURCES REGULATORY AUTHORITY)

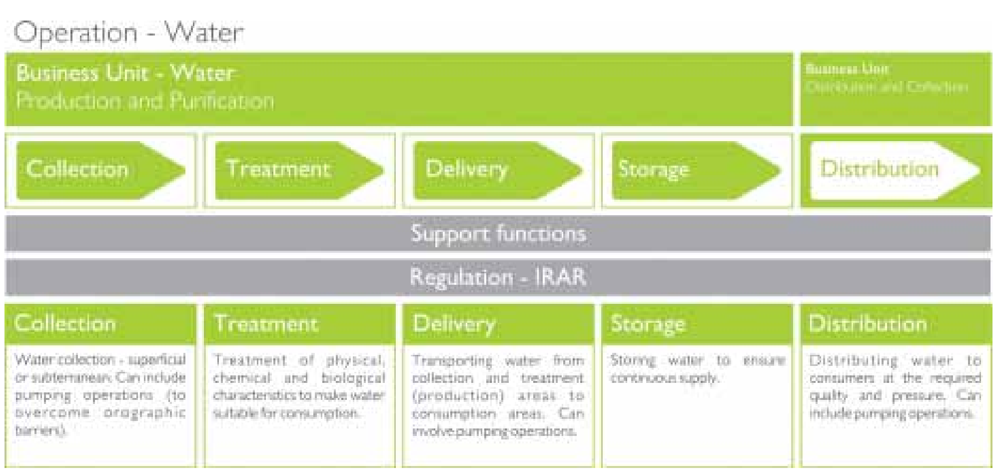
Annexure- I: A Report on International Approaches to Calculating Bulk Water Tariffs & Implications for the Maharashtra Water Resources Regulatory Authority

1. Introduction

1.1. What is Bulk Water?

The phrase 'bulk water' or 'wholesale water' normally refers to the process of transferring water either from one company to another or from one resource zone to another. The costs incurred in providing such a service include abstraction costs (e.g. associated with drilling boreholes or developing storage infrastructure), water treatment costs which will include the variable costs of chemicals and power (as well as the possible upgrading or expansion of a company's existing treatment capacity) and transportation costs.

The figure below (produced by South Africa's Department of Water Affairs) illustrates the water value chain. The bulk water process therefore encompasses the Collection, Treatment, delivery and Storage components.



In summary, bulk water charges are typically expected to cover the following costs:

- Raw water costs.
- Water treatment costs
- Storage infrastructure costs.

- Transportation infrastructure costs (to the point of delivery to the customer).
- Water losses.
- Chemical costs.
- Electricity costs (the majority of which is typically associated with pumping).

In addition, the bulk water provider is also entitled to earn a return on its investment (i.e. a level of profit which may be determined by the regulator, where one exists, with this profit amount typically being calculated by applying a calculated rate of return – say 7% - to the asset base of the company).

Finally, there may well be other cost components that will form part of the bulk water tariff. Such components may include:

- A provision to finance subsidies for disadvantaged consumers.
- Contributions to an investment fund.
- Regulatory fees.
- Payments to a pollution control / environmental protection fund.

1.2. Why Introduce a Bulk Water Tariff Framework?

A number of outcomes may be targeted from introducing bulk water pricing. Hanemann (1999) proposes the following primary objectives for implementing a rate structure:

- Raising revenue (for financial sustainability).
- Allocation of costs among different users (for social equity or political reasons).
- Changing behaviour (by providing incentives to users).
- Promoting economic efficiency (both in the use of water and in regard to new investment).

Two secondary objectives relate to:

- Ease of administration (transparency, simplicity, etc.)
- Avoiding negative environmental externalities and promoting environmental sustainability.

Any or all of these objectives may be applicable in different circumstances. The problem of course is that these objectives have conflicting implications for how rates are actually designed. For example:

- Reducing what users pay will meet the welfare objective but diminishes the incentive for efficient water usage and lowers revenue.
- Fixed charges promote stability and predictability but diminish incentives for efficient use of water.
- Charges based on consumption promote conservation and efficiency but cause uncertainties in the revenue stream.

In short, there is no universal best design but rather the optimal choice of pricing framework will be that which reaches an acceptable compromise among those objectives. In addition, there are a number of tariff design considerations to consider. A brief summary of some of the more important of these issues is presented below. In addition, many of the same concerns arise in the case study discussions presented in Section 2.

1.3. Marginal or Average Cost Pricing?

A common debate in the literature on water pricing is whether to price water by its average cost (based on financial reasons of cost recovery) or by its marginal cost (based on the economic reasoning of promoting an efficient use of the resource).

In order that consumers can reveal their willingness to pay for the water they consume (and thus its value), it is necessary that they be charged a price that reflects the real economic cost of using it. This requires that the cost be defined, not simply as the average historic cost of supply incurred by the water utility, but as the cost of producing additional or marginal supplies, which are required as demand increases. Such a pricing policy provides a signal as to whether investment in additional capacity is justified – a critical function where the cost of water is escalating rapidly.

In practice, therefore, long-run marginal cost should be used as a basis for cost recovery in order to avoid frequent price fluctuations that would otherwise be implied where investments in additional capacity do not follow a smooth trend over time. Long-run marginal cost in such cases can be approximated by discounting the future stream of unit costs (or costs per cubic meter), a concept sometimes referred to as "discounted unit cost" or "average incremental cost". A key implication of this approach is that where unit costs of water rise rapidly, marginal costs by definition are greater than average costs, and so a policy based on this principle would require tariff levels considerably in excess of those required for financial cost recovery alone.

However, although the consensual result in reviewing water pricing literature is that efficiency requires marginal cost pricing in contrast to the widely used average cost pricing practices of many water utilities, it is also accepted that pure marginal cost pricing may not be feasible or even desirable because of financial, fairness, political or legal reasons.

From a financial perspective, marginal cost pricing does not ensure that the water utility generates enough, and just enough, revenues to cover costs (including a reasonable amount of profit to guarantee the involvement of private firms in the industry). Some economists warn that marginal costs may fall below average costs, which is the situation to be expected in capital-intensive industries like water supply. Others point out that despite the fact that water utilities are commonly viewed as a natural monopoly due to capital costs, it is not straightforward that the marginal cost falls below the average cost. Because cheaper sources of water are naturally used before other more expensive sources, marginal cost can rise above the average cost of water supply.

Therefore, marginal cost pricing can raise a problem to the water utility and its regulators, not because of insufficient revenue, but because it would generate excessive profits. Using marginal cost pricing in a situation where average cost is lower than marginal cost can be an efficient way to raise revenues. Nevertheless, it is generally not allowed, namely because it has a "regressive incidence", hurting the poor the most, since water expenses have a greater weight in their budget. Balancing the budget of the water utility is therefore an objective on the same level of importance as achieving economic efficiency.

This raises the question of aiming at efficiency while respecting a revenue requirement. The most common ways of combining these two objectives are through the use of two-part tariffs, adjusting the fixed charge to meet the revenue requirement, or through second-best pricing, collecting the necessary extra revenue where it can be done more efficiently, that is to say, from customers with less elastic demands.

1.4. Marginal Opportunity Cost Pricing

Marginal Opportunity Cost Pricing (MOPC) goes beyond marginal cost pricing by including in the tariff calculation process all other, relevant, costs that may be associated with bulk water delivery. For example, the supply of water may involve a variety of environmental costs. These are typically very difficult to estimate precisely but may include issues such as the ecological impact arising from the construction of reservoirs or cross-country transmission pipelines.

Even with tariff levels based on long-run marginal costs of supply including environmental costs, there might still be absolute water shortages. In principle, efficient pricing in such cases requires tariffs to be raised to ration existing capacity so that consumers are required to pay a price for water equal to its value in the highest alternative use known as the opportunity cost. Therefore, when a community runs into absolute supply constraints, economically efficient water consumption requires that in addition to marginal production and environmental costs, the price of water should also include depletion or scarcity costs.

1.5. Tariff Design – Single or Two Part Tariffs?

For many economists, the optimal water tariff design is a two-part tariff – a variable element to recover operating costs and a fixed element to cover administrative and other non-variable costs.

If consumers are homogeneous a single two-part tariff may be implemented. However, in the presence of heterogeneous consumers a menu of two-part tariffs (with trade-offs between the fixed charge and the volumetric charge) must be implemented to reflect the different costs each imposes upon the service provider and also to respond to their differing abilities to pay i.e. poorer customers are unlikely to be able to afford to pay both a fixed and a variable fee component.

Assuming a heterogeneous two-part tariff approach has been agreed upon, further rate design considerations will include:

- Should the variable element of any tariff system be a flat rate or should increasing / decreasing rates be applied to different consumption levels? Many countries employ an increasing block system whereby pre-determined volume blocks of consumption have a different (higher in this case) price attached to them.
- If an increasing (or decreasing) block system is employed, how should the volume blocks and associated prices be determined?
- Other possible variations are the differentiation of price structures according to customer classes or seasons. Even the adoption of time-of-day pricing has been advocated for the water industry, although it is more frequent in the electric power industry.

1.6. Other Bulk Water Tariff Considerations

As illustrated by the case studies presented in Section 2, there are also a number of other tariff determination decisions that need to be made. These include:

- How is the revenue earned from the application of bulk water tariff to be used? In some countries, such as China, the law prescribes that all such monies enter into a central fund managed by the government. However, in other environments there is a strong belief that bulk water revenues should be reinvested in the river basin and catchment areas from where the water supply was harnessed.

- Should all users pay for bulk water services? In many parts of the world, some categories of customer find themselves exempt from paying bulk water tariffs even where a concerted effort is being adopted to implement a bulk tariff system. This is the case in China where agriculture customers pay little or nothing for irrigation water. More generally, in many environments around the world, the concept of water as being a 'free good' has not yet been overturned. It is often the case that acceptance of water pricing (particularly at bulk water level) only becomes acceptable when the sector is in crisis and there is considerable pressure to ensure that an increasingly scarce resource is managed properly.

2. CASE STUDIES

2.1. Case Study Introduction

The case studies presented below describe how different bulk water pricing approaches have been adopted in different environments according to the nature of the objectives needed to be achieved in these communities.

The studies were prepared using desk based research applied to discussion papers, technical notes and institutional reports from a large variety of sources. At the end of this Report a reference list is provided. In addition, study material and findings for some of the cases (in particular those relating to Australia) is based upon the personal experience of the consultants who prepared the study.

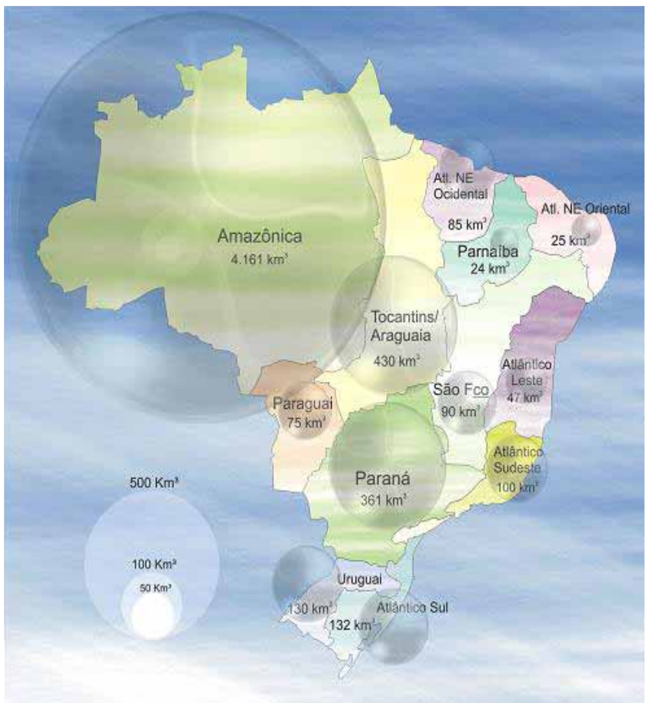
2.2. Brazil

2.2.1. Background

A great deal of work has taken place in Brazil to create an effective bulk water pricing framework. At first this may appear unusual as the country contains 12% of the world's fresh water supply. However, this statistic is misleading as 70% of the water is in the Amazon Basin where only 7% of the population lives. The remaining 93% of the country's population depends on only 30% of the available supply.

The per capita availability of water therefore varies from 1,460 m3 per person / per year in the semi-arid Northeast to 634,887 m3 per person / per year in the Amazon region.

Water Yield km3



Source – ANA presentation

More specifically, water supplies in four different geographic regions present a major contrast. The North, including the Amazon basin with abundant freshwater resources, is sparsely populated but poor. The Northeast, which is semi-arid with a constant threat of severe droughts, struggles to sustain a population of 40 million people living in oppressive conditions. The West, with two dominating ecosystems, the savanna and the wetlands, is devoted to cattle raising and intensive agricultural development. The South, which is the industrial and financial hub of the country, is noted for its unbalanced water supply/demand relation, due to excessive consumption and pollution in the larger, urbanized areas.

In addition, the combined pressures exerted by a growing population and a rapidly expanding industrial base mean that bulk water pricing has become a necessity in order to finance infrastructure provision and to send appropriate price signals to stakeholders with respect to allocation and use of the resource. Pricing was also expected to impact upon resource usage efficiency through encouraging a reduction in water losses (via better maintenance of distribution systems) and better monitoring of water quality.

In the face of all these pressures, the Brazilian government, in 1984, opened discussion on what should be the country's water policy. However, the major change did not occur until 1997 with the promulgation of the National Water Resources Management Act which established the National Water Resources Policy and the National Water Resources Management System.

2.2.2. Institutional Framework

Administrative Arrangements

Brazil is organised as a Federative Republic, consisting of the Federal District and 26 states (further divided into approximately 5600 municipalities).

The legislative power and legal framework governing the relationship between the Federal government, the States and the municipalities is defined in The Federal Constitution of 1988. As a public good, the Constitution considers water from all rivers which crosses state boundaries and waters used to generate electricity as property of the Federal government and all other rivers and lakes as property of the States. The prerogative to grant concessions to use this water lies exclusively with the Federal government and the States.

Brazil Constitution – 1988 – Key Water related Articles

Article 20 [Propriety of the Union]
The following is property of the Union:
IV. river and lake islands in zones bordering on other countries, sea beaches, ocean and shore islands, the latter excluding the areas referred to in Article 26 II.

Article 21 [Powers and responsibilities of the Union]
XIX. to institute a national system for the management of hydric resources and define criteria for granting rights to the use thereof.
XII. operate, directly or through authorization, concession or permission:
b) electric services and facilities and energetic use of water courses, in cooperation with the States in the hydroenergetic potentials are located.

Article 22 [Legislative exclusivity]
It is incumbent exclusively upon the Union to legislate on:
IV. waters, energy, informatics, telecommunications, and radio broadcasting.

Article 24 [Concurrent Legislation]
It is incumbent upon the Union, the States, and the Federal District to legislate concurrently on:
VI. forests, hunting, fishing, fauna, reservation of nature, defence of the soil and natural resources, protection of the environment, and pollution control.

Article 26 [Property of the States]
III. river and lake islands which do not belong to the Republic.

This 1988 Constitution, for the first time, established a national water resource management system and began the formulation of a water resource national policy to coordinate cooperation between the different levels of government, as well as between different water users.

After a number of years of discussions and numerous redrafting the aims, principles and guidelines of the Water Resource National Policy were defined in Federal Law 9.433/97 (National Water Resources Policy law). This law was heavily influences by the French water resource model.

LAW Nº 9,433 DATED JANUARY 8, 1997

TITLE 1 - NATIONAL WATER RESOURCES POLICY

CHAPTER I - BASES

Article 1 The National Water Resources Policy is based on the following grounds:
I - water is an asset falling within the public domain.
II - water is a limited natural resource endowed with economic value.
III - in shortage situations, the top-priority use of water resources is for human consumption and watering animals.
IV - the management of water resources should always foster multiple water uses.
V - the river basin is the territorial unit for the implementation of the National Water Resources Policy and the activities of the National Water Resources Management System.
VI - the management of water resources should be decentralized, and include the participation of the Government Authorities, users and communities.

CHAPTER II - PURPOSES

Article 2 The purposes of the National Water Resources Policy are:
I - to ensure necessary amounts of water available to current and future generations, at quality standards adequate to the respective uses thereof.
II - the rational, integrated use of water resources, including water-borne transportation, fostering sustainable development.
III - prevention and defence against critical hydrological events, whether natural in origin or deriving from improper use of natural resources.

The National Water Resources Policy law set out the following key principles:

- **River basin as the territorial unit for the implementation of the National Water Resource policy** – despite some opposition from the States, it was agreed that the river basin was the most suitable unit for water resource planning.
- **Management of water should allow for multiple uses of water –** historically, priority was given to the use of water for electricity generation. With the increase in demand for water from sanitation, irrigation, industrial and other sectors, the need for equality of opportunity amongst users was recognised.
- **Water is a limited resource, which has economic value –** as a scarce economic resource, the efficient use of water would be encouraged through the introduction of tariffs.
- **Management of water resources should be decentralised and should involve participation by the government, the**

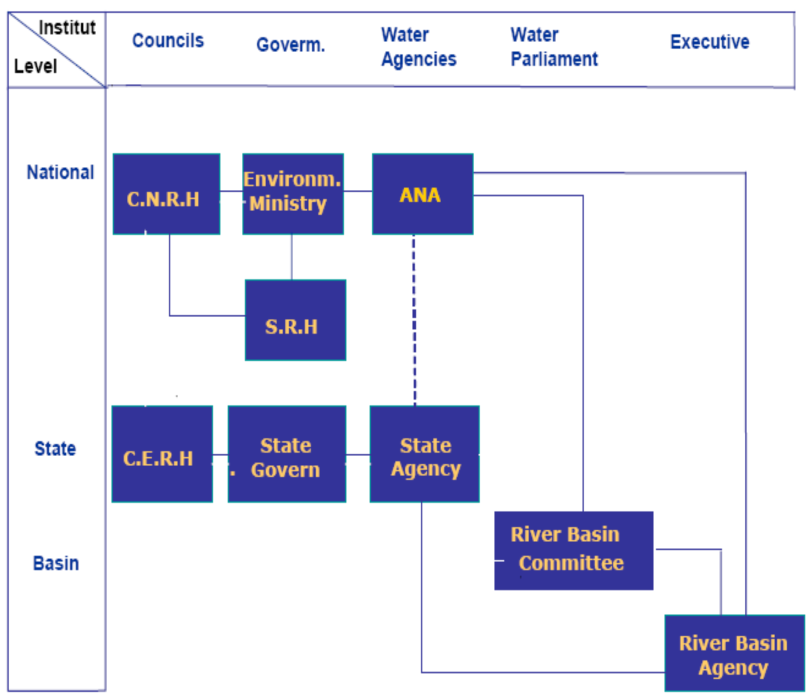
users and the community - no decision should be taken at a higher level of government when it could be decided satisfactorily at an appropriate lower level.

- **When there is a shortage of water, priority is given to human consumption and watering of animals –** this lays down basic principles for periods of extreme water scarcity.

ANA – National Water Agency

In 2000, the ANA – National Water Agency (Agenvia Nacionel de Aguas) was established to enforce the National Policy on Water Resources (NPWR) set out in Federal Law n. 9.433/97. ANA is mandated to regulate and manage the water sector and has a key role in mediating between water users.

National Water Management System, Brazil



CNRH – National Water Resource Council

CERH – State Council on Water Resources

SRH – National Water Secretariat

ANA – National Water Agency (Agenvia Nacionel de Aguas)

River Basin Committees

Below the National Water Resource Council (CNRH) and State Council on Water Resources (CERH), Brazil currently has six River Basin Committees which, through assistance from the ANA, approve and implementing long run river basin Water Resources Plans. The River Basin Committees include representatives of the various stakeholders in the water sector. A typical River Basin committee comprises:

30% – Civil society representatives (NGO's, universities, etc).

30% – Users (industry, water utilities and farmers).

40% – Municipality, states and federal government representatives.

The River Basin Committees are responsible for setting out guidelines and criteria for the issuing of water permits and water tariffs:

- **Water permits –** awards the right to use water, with the water remaining a public good. A permit can only be issued by the responsible authority in the executive branch of the Federal government or the State.
- **Water Tariffs –** as water is considered to be an economic good, tariffs are seen as a means to encourage its efficient use of water and as a means of raising revenue for financing programmes and activities within the water resource plans. To overcome concerns that tariff would be used as 'another tax', revenue from tariff are required to be invested in the River Basin in which they were generated and a maximum of 7.5% of tariff revenue can be used to cover administrative overheads.

Paraíba do Sul River Basin (PSRB)

The Paraíba do Sul River Basin in the South-East of Brazil represents one of Brazil most developed regions. The high level of urbanisation and industrialisation of the region has contributed to an increase demand for water and has contributed to high levels of water pollution, with untreated urban sewage and industrial effluent major problems.

These issues concerning water pollution and declining water quality forced a debate to take place on the introduction of bulk water tariffs. In 1996, the Paraíba do Sul River Basin committee (CEIVAP) was set-up, comprising 60 members, to analyse the investment needs of the river basin and to determine a bulk tariff structure. In September 2002, the water resource plan adopted by CEIVAP envisioned an investment programme of R$ 3 Billion over 20 years (R$ 150 Million / year). The plan was also accompanied by a bulk water pricing methodology as described in the next section.

2.2.3. Bulk Water Pricing Framework

The negotiation of bulk water prices in PSRB evolved in two separate stages:

- February to December 2001 – discussion and approval for charges for industrial and municipal users ratified by the National Water Resource council (CNRH) in March 2002.

- February to October 2002 – tariff extended to all other users (although they were still considered transitory and were approved for just three years).

Although the length of time needed to negotiate the new tariffs was longer than anticipated, the level of expected opposition from powerful vested interests such as industrial users and the public water and sanitation organisations was less than expected due to their involvement in the tariff design and setting process from the beginning. The following tariff methodology was finally accepted.

Each use is expressed in measured or estimated flows (m^3/s). For each flow abstracted, consumed or released, a corresponding charge is defined starting from a unit price (PPU – *Preço Público Unitário*) modified by use-specific coefficients.

$$C = \underbrace{Q_{cap} \times K_0 \times \text{PPU}}_{\text{Withdrawal}} + \underbrace{[Q_{cap} \times K_1] \times \text{PPU}}_{\text{Consumption}} + \underbrace{[Q_{cap} \times (1 - K_1)] \times [(1 - K_2 K_3) \times \text{PPU}]}_{\text{Effluent dilution (BOD)}}$$

Where:

Q_{cap} = Abstracted flow (m^3/s). Data provided by user.
K_0 = Withdrawal unit price multiplier. Defined by CEIVAP.
K_1 = Consumption coefficient by activity.Provided by user.
K_2 = Treated share (%) of effluent volume (industrial and municipal effluent treatment coverage). Provided by user.
K_3 = BOD reduction effectiveness of effluent treatment process. Provided by user.
PPU = Public unit price (R$/$m^3$). Defined by CEIVAP.

Essentially, therefore, monthly water charges are based upon a combination of:

- Volume of water diverted.
- Volume of effective consumed water.
- Volume of water required to dilute the effluents.

Each group of users are charged the following price units (PPU).

Bulk Water Price

	PPU (R$/m3)-(US$/m3)
Water Supply	0.02 – 0.0083
Industrial	0.02 – 0.0083
Irrigation	0.0005 – 0.000021
Aquiculture	0.0004 – 0.000017

The two main objectives driving the tariff methodology are, firstly, the need to raise sufficient revenue to finance investment in maintaining the required infrastructure, and secondly, the need to promote the efficient use of water as a resource i.e. to allocate water to the highest valued use.

As can be seen above, the eventual tariff methodology adopted in PSRB was relatively simple in form which allowed it to be clearly understood by all parties but was also effective in raising revenue. That said, revenue levels are still considerably below the full requirements of the water resource plan which means the government subvention is still required. This represents the main disadvantage of the adopted tariff methodology – because it was created through a process of compromise, the final accepted tariff does not truly reflect marginal costs i.e. they are not fully effectively in encouraging the efficient use of water nor in raising sufficient finance to fund all necessary incremental investment. Economic efficiency was 'sacrificed' to ensure the system was implemented and was acceptable to all users.

Bulk Water Tariff Revenue

YEAR	REVENUE (R$)/(US$)
2003	5.904.038
2004	6.316.321
2005	5.925.837

2.2.4. Outcome and Lessons to be Learned

Although Brazil has a relatively fragmented institutional framework, it successfully managed to introduce a bulk tariff pricing system that included industrial and agricultural users, the two sectors that are traditional most reluctant to participate in such schemes. A number of factors contributed to this achievement:

- The negotiation process was inclusive and open, rather than being imposed from the top.
- The process was flexible and allowed for institutional adaptation.

- The direct involvement of a federal agency helped to balance the interests of different groups whilst still allowing each stakeholder to negotiate terms.

- A condition of the participants for adopting the tariff framework was that the collected funds should be reinvested in the basin rather than being spent by the federal government.

- An important transformation took place in which water was perceived as an economic good rather that a free good (a "gift from God"). This was accompanied by acceptance of the concept of user payments and the 'polluter pays principle'.

- Users recognized that they were at a crossroads in which action was need to guarantee the long term sustainability of the water system.

- The technical capacity for implementing the framework was already in place.

2.3. Melbourne Water

2.3.1. Background

Institutional Arrangements

Melbourne Water was established in its current form in 1995. Previously, Melbourne Water was a vertically integrated monopoly provider of water supply and wastewater services for the Melbourne region. In 1995 the industry was disaggregated into:

- Three retailers (City West Water, South East Water and Yarra Valley Water).
- A wholesale supplier of water and wastewater services (Melbourne Water).
- Melbourne Parks and Waterways.

Melbourne Water and the three retailers are statutory corporations, fully owned by the Victorian government. The retailers operate under licence and their relationship to the bulk supplier (Melbourne Water) is governed both by regulatory arrangements and bilateral water and wastewater agreements.

Each retailer provides water and wastewater services in a defined geographical areas within the Melbourne region. The retailers operate the water reticulation system and non trunk wastewater network, provide meter reading and billing services and handle call centre inquiries and complaints. The retailers also provide trade waste services to commercial and industrial customers. Most wastewater treatment is undertaken by Melbourne Water, although the retailers own and operate a number of small wastewater treatment plants.

Melbourne Water provides bulk water and wastewater services to five retail water businesses (Western Water and Gippsland Water as well as the three Melbourne retailers). It provides 60% of Victoria's potable water and 11% of water supplied in Victoria for urban and rural purposes. Melbourne Water harvests raw water, stores, treats to potable standard and transfers water to the retail businesses.

Four ministers have particular responsibilities relating to the water sector:

- The Minister for Water, supported by the Department of Sustainability and Environment (DSE), is responsible for developing water policy and administering Victoria's water legislation.

- The Minister for Health, supported by the Department of Human Services, is responsible for legislative and regulatory arrangements relating to drinking water quality.

- The Minister for the Environment, supported by the EPA and DSE, has responsibilities relating to the sector's environmental performance.

- The Treasurer, supported by the Department of Treasury and Finance (DTF), shares responsibility with the Minister of Water for corporate governance of Melbourne Water and the retailers.

The key regulatory instruments used to govern the metropolitan water sector are:

- Retail licences, through which the Minister imposes conditions on the retailers.

- Statements of obligation, which specify obligations on water corporations and retailers in performing their functions. The Minister for Water, in consultation with the Treasurer and the Essential Services Commission (ESC), can specify obligations relating to governance, quality and performance standards, community service obligations, sustainability principles and customer and community consultation.

- The Water Industry Regulatory Order (WIRO), which specifies the services to be regulated by the ESC and the approach that is to be adopted by the ESC in regulating prices.

- The corporate planning process, whereby Melbourne Water and the retailers are required to submit a three year corporate plan to both the Minister and the Treasurer. The plans set out the proposed strategic direction for the businesses and projected financial and non financial performance.

- Customer service codes, developed by the ESC, which specify customer service standards for urban and rural water supply services.

The ESC is the independent economic regulator for the water sector. Under their statement of obligations, the retailers and Melbourne Water are required to submit water plans to the ESC to inform the ESC's determination of prices. The plans provide the basis for retailers to consult with customers, regulators and the DSE. They identify the outcomes expected to be delivered, the projects or programs required to achieve the outcomes, the operating and capital expenditure involved, the revenue required to fund the expenditure and the prices proposed to deliver the revenue requirement.

The Minister for Water is responsible for long term resource planning and the preparation of a sustainable water strategy. Each water business is required to develop a program of works to manage its demand supply balance, consistent with the sustainable water strategy.

Drought/Climate Change

Low rainfall in recent years has resulted in a significant reduction in inflows to Melbourne Water's reservoirs. Inflows for 2006 were the lowest on record, and average flows for the ten years to 2006/7 were about 35% less than the long term average.

The Minister released the Central Region Sustainable Water Strategy (CRSWS) in October 2006, which set the agenda for water resource management going forward. The CRSWS stated that the potential impact of climate change needed to be recognised and that supplies could not be managed on the basis of assuming a return to long term average conditions.

In response to continuing drought and further reductions in reserves, the State government released, in June 2007, "Our Water Our Future: The Next Stage of the Government's Water Plan". The Plan identified a range of system augmentations and demand management programs that would diversify and boost water supplies. These included the construction of a seawater desalination plant, an interconnector pipeline to link the Melbourne system with the Goulburn River, rehabilitating the Goulburn irrigation system to reduce irrigation water losses, adding a new treatment plant and upgrading the Eastern Treatment Plant to tertiary standard to facilitate increased water recycling. The expenditure required for these augmentation projects will drive a rapid increase in future costs and prices of bulk water supplies.

Bulk Water Supply Arrangements

Since the passage of the Water Act in 1989, there has been a program of converting the historical, imprecise, rights of water supply authorities into tradeable bulk water entitlements.

In October 2006, Melbourne's bulk water entitlements were transferred to the three retailers on a pooled basis. Melbourne Water and the retailers make up a bulk entitlement management committee which acts as the decision-making body in respect of a range of issues relating to the bulk entitlements. Caps on the amount of water able to be extracted were introduced also: 400 GL per annum from the Yarra and 555 GL per annum from the total system.

Melbourne Water's bulk supplies are governed by bulk water supply agreements that are negotiated on a commercial basis with the retail water companies. The level and structure of bulk supply prices are subject to regulation by the ESC and the customers service standards specified in the agreement must be consistent with the Rural Water Customer Service Code. Service standards specified in the code cover complaints, billing, payments, collection, works and maintenance, guaranteed service levels, customer charters and information provision. The bulk water supply agreements also specify required standards on pressure, microbiological standards, disinfection products, and aesthetic standards for turbidity and aluminium.

As part of the rural reforms required by the National Water Initiative, water entitlements in Northern Victoria have been unbundled into a water share, a delivery share and a water use licence or registration. Water entitlements on regulated systems in Southern Victoria will be unbundled in July 2008. Unbundling provides greater flexibility, making water shares easier to trade, able to be mortgaged separately and leased, and held without land. As the unbundling of entitlements is directed at improving rural water trading, it is not directly relevant to Melbourne Water which supplies bulk water for urban uses.

2.3.2. Bulk Water Pricing Framework

Level of Bulk Water Prices

The ESC conducted its first water price review in 2004 to determine prices for water and sewerage services in metropolitan Melbourne and regional Victoria. Prices were set so that they delivered the revenue requirement forecast for each business, where the revenue requirement comprised operating costs, depreciation, a return on the regulatory asset value and an allowance for taxation.

The revenue requirement determined for Melbourne Water was based on an initial regulatory asset value (RAV) of A$4.2 billion as at 1 July 2004. The ESC determined the value as being consistent with Melbourne Water's profitability prior to the new regime. The RAV was rolled forward by adding capital expenditure, deducting depreciation on the RAV, disposals and capital contributions, and adjusting for inflation. For the period 2004/5 to 2007/8 forecast rather than actual expenditures were used to roll forward the RAV. The opening regulatory asset base for the next regulatory period will be adjusted to take account of any differences between actual and forecast expenditure. The ESC determined the vanilla WACC to be 5.2% real.

Melbourne Water uses a detailed average cost model to allocate costs between the five retail water businesses it supplies. Costs are identified separately for headworks (water harvesting and storage) and the transfer system (pipes and pumping stations). The total costs to be recovered include a return and depreciation on the RAV allocated to each part of the supply system, along with direct operating costs and an allocation of overheads.

Costs are allocated between the water businesses on the basis of their usage of different parts of Melbourne water supply system. The allocations are done on the basis of the principal drivers of water supply costs, volume and distance. Sunk costs are allocated on the basis of demand shares based on 1998 volumes.

Overall a retailer pays more if the business:

- Is geographically remote from water sources to the East of Melbourne.
- Uses higher volumes from more expensive sources (e.g. filtered water from the lower Yarra).
- Uses more water overall.

Structure of Bulk Water Prices

Once the cost charges have been allocated, the fixed and variable components of the charges are established. Variable charges are calculated on the basis of the long run marginal cost of supply to each business. Long run marginal cost comprises short term costs such as power and chemicals and long run costs such as brought-forward capital costs associated with augmenting supply and increasing transfer capacity. Fixed charges are calculated as the difference between the total revenue requirement allocated to the business and the revenue expected from variable charges.

The ESC required Melbourne Water to separately identify charges for storage operation and treatment from the charges for transportation of bulk water in order to clearly signal the costs involved and to facilitate the trade of bulk water entitlements.

Melbourne Water charges separately for headworks and transfer services, with a fixed service charge and variable charge specified for each. The table below shows the tariffs proposed by Melbourne Water in its 2008 draft water plan submission to the ESC.

Melbourne Water – Bulk Water Tariffs

		City West	South East	Yarra Valley
Storage and bulk water service - headworks	$m per month	1.60	0.82	1.96
Storage and bulk water service - transfer	$m per month	0.34	0.34	0.90
Storage and bulk water usage - headworks	$ per ML	425	425	425
Storage and bulk water usage - transfer	$ per ML	110	91	69
Direct connections for bulk water services usage	$ per ML	476	240	215

Recycled Water Prices

The Statement of Obligations requires Melbourne Water to comply with the Metropolitan Water Conservation and Recycling Plan and with the obligations set out in its recycled water agreements with the retail businesses. The draft version of the recycling plan specifies a target of recycling 20% of Melbourne's effluent by 2010. There were also potable substitution targets of 6.2 GL per year by 2015 and 10 GL per year by 2030, with requirements to investigate additional opportunities for reuse for non drinking purposes as well as storm-water recycling.

In the first water price review, the ESC determined principles for pricing recycled water which must be applied by the water businesses. These principles stated that recycled water prices should:

- Maximise revenue earned from recycled water services having regard to the price of any alternative substitutes and customers' willingness to pay.

- Include a variable component to provide appropriate signals to recycled water customers to manage the resource.

- Cover the full cost of providing the service, subject to exceptions.

The Commission recognised that government recycling targets may mean that businesses are unable to recover the full costs of recycled water from recycled water customers. Where there is a revenue shortfall, the ESC argued that the basis on which it is recovered from the broader customer base should have regard to the drivers or beneficiaries of the proposed project. Also, customers should be consulted about their willingness to pay for the benefits of recycled water.

In its draft 2008 water plan, Melbourne Water proposed that the anticipated revenue shortfall be recovered from sewerage customers which is consistent with the 'polluter pays principle' and the fact that sewage salinity is constraining recycled water opportunities.

2.3.3. Outcome and Lessons to be Learned

The second pricing review for Melbourne Water and the three retailers began in 2007, alongside the review for the regional urban and rural water authorities. However, the draft plans submitted by the retailers and Melbourne Water proposed price rises that were in some cases significantly above the level that the government was expecting. (Following the release of the government's Water Plan, "Our Water Our Future", the government indicated that prices would double over five years.)

The Minister asked the Victorian Competition and Efficiency Commission (VCEC) to examine options to improve the structure of the metropolitan retail sector to best ensure the efficient and least cost provision of water services, to examine alternatives to reduce costs and to investigate any related improvements to governance and industry structure. The ESC's price review for the metropolitan sector was put on hold while VCEC conducted its inquiry.

VCEC produced a draft report in December 2007 and has submitted a final report to the Treasurer but this has not yet been released publicly. The draft report concluded:

- There were only small net benefits in moving to a single retailer, which would be outweighed by potential costs and risks from the merger.
- The Commission sought comments on two other structural options: reducing the number of retailers to two, or retaining three retailers but introducing a shared services arrangement to improve the efficiency of competitive tendering.
- Sunk costs should be allocated between retailers on the basis of more recent 2004/5 volumes, that being the year that the independent regulatory process commenced. Future bulk water and sewerage costs should be allocated according to forecast volumetric demand.
- The ESC's second price review, when conducted, would be likely to further reduce the proposed price increases.
- If further adjustments are required, VCEC favoured deferring regulatory depreciation for the retailers to achieve pricing parity and the required level of prices.

VCEC also examined a range of governance reforms and whether there was scope for greater competition. The Commission made a range of recommendations, including the development of a state based access regime, amendments to bulk entitlements to reflect new water sources, and longer term options such as whether a centrally determined economic water value model could be developed to replicate the operation of a competitive urban water market, whether a market mechanism could contribute to system management and whether a grid manager and/or independent procurement agency should be established.

Further reforms are also being advocated by the National Water Commission (NWC) and the Productivity Commission. In its first biennial assessment of progress in the implementation of the National Water Initiative, the NWC made a wide range of recommendations, including:

- Continued expansion of water trading, with governments building the necessary institutions and conditions for markets to function smoothly.

- Government contributions to the costs of urban water infrastructure and water pricing should be managed to minimise distortions to water prices.

- Recent failures in urban water planning (evidence by urban water shortages during the drought and the rush to invest in new infrastructure) should be remedied by an enhanced set of urban reform commitments to:

  - Lift the standard of urban water planning.
  - Remove policy bans on water supply options (such as indirect potable re-use).
  - Encourage diversification towards less climate dependent water supply options.
  - Encourage fundamental reforms to institutional and market arrangements for water supply, including new water supply products that offer consumers a choice of water reliability, clearer specification of entitlement for new water sources such as recycled water, allocation of tradeable entitlements to major urban water users, structural reform to create

competitive pressure for water supply and delivery, and greater private sector investment opportunities.

The March 2008 Productivity Commission (PC) report "Towards Urban Water Reform: A Discussion Paper" also emphasised the potential benefits of further structural and institutional reforms. The PC particularly criticised charging regimes that recover operating costs and a return on assets but do not reflect the scarcity of water in times of shortage. Demand is managed through restrictions rather than prices, imposing costs on households that amount to billions of dollars.

Similarly, policies that restrict interaction between urban and rural water users limit the opportunities for inter-sectoral trade. This distorts water use and infrastructure investment decisions.

The Productivity Commission also endorsed the importance of improving water supply decision making, through the application of decision frameworks that better address climate-related uncertainty.

In addition the Productivity Commission recommended structural changes to introduce competition in the development of alternative supply sources. Private involvement could be expanded through innovative forms of competitive procurement. Options include outcomes based approaches and/or the use of an independent procurement agency. More ambitious reform would involve separating monopoly distribution functions from upstream and downstream activities.

The key lessons to be learned from Melbourne Water include:

- The importance of having robust pricing oversight undertaken by an independent regulator, and the desirability of removing pricing decisions from political influence.

- Water shortages put pressure on pricing (and institutional) arrangements. Robust processes are needed to avoid knee-jerk reactions.
- The potential benefits of scarcity pricing, but also the difficulty of implementing appropriate signals as to the true opportunity cost of resources in times of water shortages. While approaches to scarcity pricing have been under discussion in Australia for some time, no jurisdiction has yet implemented anything approaching a scarcity based approach. Moreover the widely used the revenue building block approach to setting the level of tariffs is not conducive to the development of scarcity tariffs.
- The importance of well defined water entitlements, structured in a way that facilitates water trading. Appropriate water entitlements need to be developed for new water sources (such as recycling and desalination) as well as for traditional surface and groundwater sources.

2.4. South Africa

2.4.1. Background

Pricing of raw water in South Africa is governed by the Department of Water Affairs and Forestry (DWAF) who, in turn, base their decisions upon a regulation entitled "Pricing Strategy for Raw Water Use Charges (November 1999)" which appears as Section 56(1) of the National Water Act (Act No. 36 of 1998). Water is supplied to Local Councils or water services authorities (WSA) through contracts governed by the Water Services Act (Act No. 108 of 1997).

This Case Study presents two examples of the application of these principles: the **City of Cape Town** and the **Trans-Caledon Tunnel Authority (TCTA)**.

The City of Cape Town's Bulk Water Department is responsible for the bulk supply of potable water to the Cape Metropolitan Area and to

Local Councils who are dependent on the City of Cape Town for all or part of their water supplies. Services include the storage of raw water in dams, the conveyance and treatment of raw water from these and Government Water Schemes and the distribution and bulk storage of the treated water. The Customers of the Bulk Water Department include the internal reticulating department(s) responsible for distribution to end-users.

The Trans-Caledon Tunnel Authority (TCTA) is a state-owned entity mandated by the Minister of Water Affairs and Forestry to implement and fund raw bulk water infrastructure to supply areas with limited water resources. TCTA implements bulk water infrastructure, with a key focus on sustainability. It is responsible for three major projects: the Lesotho Highlands Water Project (LHWP), the Berg Water Project (BWP), and the Vaal Eastern Sub-system Augmentation Project (VRESAP). TCTA also carries out other services as required by DWAF, including providing assistance to Umgeni Water.

LHWP is the largest project ever undertaken in Southern Africa and entails diverting water from the Senqu River system in Lesotho to the water-stressed Gauteng region of South Africa. It is a bi-national project implemented by TCTA, within South Africa, and the Lesotho Highlands Development Authority (LHDA), within Lesotho, overseen by the Lesotho Highlands Water Commission (LHWC). The oversight role of the LHWC is defined in Protocol VI to the Treaty. South Africa is responsible for all the costs incurred on the water transfer component of the project. TCTA has been mandated to finance and manage the liability of the water transfer component, while LHDA is responsible for the loans on the hydropower component to the Lesotho government. Repayment of the water transfer debt relies on the revenue stream from water sales to Vaal River system water users. This revenue is based on a tariff charged for actual water usage and was phased in over time.

BWP is designed to capture the winter rainfall and store it for supply to the City of Cape Town during the dry summer months. BWP is the first bulk water resource development project that was directly linked to water demand management. BWP increased the yield of the Western Cape Water System (WCWS) by 81 million m³ or 18% to 523 million m³ a year by 2007. The project impounded the Berg River in June 2007 and began delivery of water to Cape Town at the end of 2007. BWP is a public-public partnership between DWAF, City of Cape Town and TCTA. The agreements were signed in April 2003.

VRESAP, also known as the Vaal Pipeline Project, is being implemented to meet the growing water demands of Eskom and Sasol in the Mpumalanga Highveld region. The scheme will transfer water via a 121 km pipeline from the Vaal Dam near Vaal Marina to the Knoppiesfontein diversion structure which discharges into either the Trichardtsfontein or Bosjesspruit dams near Secunda. VRESAP will augment the yield of the Vaal River Eastern Sub-system (VRESS) by 160 million m³ per year. VRESAP is a separately ring-fenced project without a government guarantee, implemented and financed by TCTA. The borrowings are in TCTA's name with recourse against the income stream from the project.

Target employment percentages have been defined for the various Contracts under VRESAP to maximize employment opportunities for the local communities and minimise the utilisation of imported labour. The project is also expected to maximize contracting, training and development opportunities for local businesses, HDI-owned businesses and SMMEs so as to ensure maximum procurement opportunities. The performance of the contractor against the targets is monitored on a monthly basis. The project is expected to provide 750 temporary jobs during construction and 20 permanent ones during the operation and maintenance phase.

The relationship between TCTA and Umgeni Water was formalized in a two-year service level agreement on 11 July 2001. During July 2003 this agreement was extended for two years or until Umgeni Water could function independently. On 17 May 2004, the Minister confirmed that TCTA had completed its intervention role and that following a capacity-building and handover programme, TCTA and Umgeni Water should negotiate a commercial contract. The capacity-building and handover programme was completed in January 2005. In June 2005, TCTA and Umgeni Water signed a new service level agreement according to which TCTA provides assistance on:

- Tariffs.
- Funding and debt management.
- Risk and ALCO management.
- Reviewing treasury operational issues.
- Formulating interest rate views.
- Ad-hoc services.

2.4.2. Bulk Water Pricing Framework

City of Cape Town

The bulk water tariff is charged to external bulk consumers and internal consumers on the same basis. The Bulk Water Department also has various tariffs for non-bulk consumers and charges for non-core functions.

The general principles upon which the calculation of the bulk water tariff is based are:

- Full cost recovery.
- Long-term sustainability of the service.
- Financial ring-fencing of the service.

The bulk water tariff is determined each financial year by dividing an estimate of the net expenditure of the Bulk Water Department by an estimate of the expected total volume of water less the water allocated by special agreements and unaccounted-for water. The estimate of the total amount of water produced is based on short- and long-term water demand projections including areas external to the Cape Metropolitan Area. The effect of Water Demand Management

Programmes are taken into account in determining the water demand projections.

Total expenditure for these purposes comprises the following:

- The cost of raw water purchased from the Department of Water Affairs and Forestry (DWAF).

- Water treatment costs and all other operational costs associated with the bulk water system. The bulk water system is defined as the infrastructure (including dam catchment management costs).

- The repayment of loans taken out to finance capital costs.

- Contributions to a Bulk Water Reserve Fund to finance future capital infrastructure requirements.

- Contributions to a Water Demand Management Fund to assist distributors with their Water Demand Management initiatives.

- Contributions to a Stabilisation Fund to ensure tariff stability.

Miscellaneous income and income from special agreements are subtracted from the total expenditure to give the net expenditure. An additional charge is added to the bulk water tariff to cover the levy payable to the Water Research Commission. In order to facilitate long term planning and to ensure that the proposed tariff will enable the Bulk Water Department to sustain its proposed operating and capital expenditure over the following 10 year period, an affordability model is used. Capital expenditure in the Bulk Water Department is cyclical and the affordability model is also utilised to assist in tariff smoothing by drawing from or contributing to the stabilisation fund on a yearly basis. Further inputs into the affordability model are the envisaged

10 year capital and operating budgets, as well as any additional payments which will have to be made to the Department of Water Affairs and Forestry for capital infrastructure development.

The Bulk Water Department may also increase its bulk water tariff in certain circumstances: during periods of water restrictions, following the introduction of more stringent water quality standards and when construction of new water supply schemes by the Department of Water Affairs and Forestry so warrants. Financial ring-fencing of the service ensures that no cross-subsidisation of the service to external bulk consumers and vice-versa takes place. The tariff is determined on an annual basis, except where adjustments are necessitated by water restrictions etc.

TCTA

In 1988, a levy was introduced to fund part of the development costs of LHWP until it started to deliver water in 1998. The levy partially financed costs during the initial construction period and started at two cents per cubic metre in 1988. The total revenue generated in levies was R1 688 million and in tariffs to date is R12 108 million (2006: R10 157 million).

The bulk raw water tariff for the Vaal River system, and hence for LHWP, is now determined by a pricing policy that attempts to peg the price of raw water in real terms. It takes into account the demand for water and further Vaal River System augmentation schemes. The water tariff charged to end users comprises the following elements:

- Bulk raw water that includes the Lesotho Highlands Water Project (charged by the Department of Water Affairs and Forestry).
- Bulk purified water (charged by Water Boards).
- Reticulated water (charged by local authorities).

Revenue for LHWP comprises a portion of the bulk raw water tariff collected by DWAF. This revenue is generated over the life of the project and is sufficient to pay for the construction, maintenance, operation, royalty and finance costs of the water delivery component of the Project, within 20 years of completion of the construction of each sub-phase. On 3 August 2001, TCTA entered into an Income Agreement with the Department of Water Affairs and Forestry, whereby the tariff is adjusted annually by the year-on-year CPIX. Should the annual CPIX adjustment exceed 7.5%, or be lower than 4.5%, the adjustment to the tariff is negotiated. Other than these annual adjustments, negotiated adjustments can also be triggered by changes in water demand, changes in timing and capital expenditure for further augmentation.

Revenue generated in 2007 by the sale of 1,385 million m^3 (2006: 1,349 million m^3) of raw water was R 1,951 million (2006: R 1,775 million). This revenue was based on a 2007 bulk raw water tariff of 140.83 cents per cubic metre (2006: 131.60 cents per cubic metre). The higher revenue reflected a 7.03% increase in the water tariff and a 2.7% increase in water volume[1].

Despite these tariff adjustments, LHWP still has a net deficit after interest. Income is sufficient to repay all water transfer costs within approximately 20 years after completion of each subphase. However, interest is capitalised for the first years of operation to permit end-user affordability and tariff stability.

A financial model was agreed between DWAF and the City of Cape Town for financing the Berg Water project. A phased-in tariff commencing on 1 July 2003 until the commissioning of the project in 2007 was added to the City's Bulk Water Tariff. Water users in the City of Cape Town will repay this through a Berg Water Charge to be added to the tariff charged by DWAF on water supplied from the Western Cape Water System. This charge is based on water used by

[1] TCTA Annual Report 2007, p39

consumers and not by water delivered into the system. The charge will be phased in over a 4-year period to minimize the annual impact on consumers. The estimated cost of the project in January 2002 was R 1.4 billion and will amount to R 1.85 billion in 2008 at an escalation of 6% per annum.

The Berg Water Project was awarded an excellent Fitch credit rating (AA+). The R 1.5 billion funding for construction was negotiated successfully with three major financial institutions. The long-term loans will be repaid over a 20-year period from revenue generated by the sale of water to the City of Cape Town. The project debt will peak at R 1.3 billion in 2008 and will be repaid by 2028.

The estimated final cost of VRESAP was R 2.5 billion. It was funded on an off-budget basis; the capital costs are to be recovered from the revenue generated from the sale of water to Eskom and Sasol. The VRESAP tariffs are based on the total water required by Sasol and Eskom from VRESS (the overall system). There are differentiated tariffs for each user, levied on existing infrastructure usage and an augmentation tariff levied on the total usage per user out of VRESS.

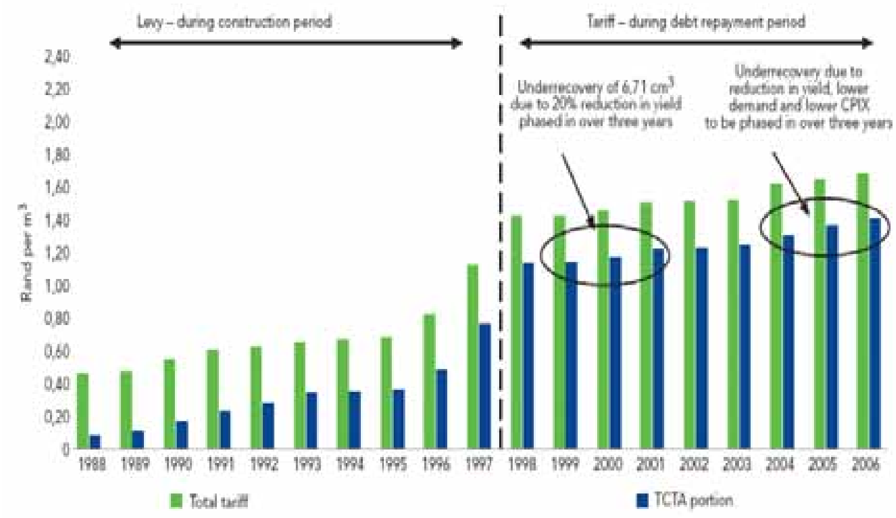
The TCTA 2007 Annual Report provides detail of the way in which tariffs are adjusted as new information becomes available. For example, during the 2000/01 tariff determination, the yield of the Vaal River system was determined to be lower than originally anticipated by DWAF. This resulted in an under-recovery in the tariff of 6.71 cents per cubic metre, which triggered a negotiated adjustment to be phased in over a three year period. During the tariff revision in 2006, a 5.5% increase in the yield of the Vaal and a slight upward revision in water demand, plus higher inflation and lower average real interest rates were all allowed for.

The table below provides detail of the agreed increases between 2000 and 2008.

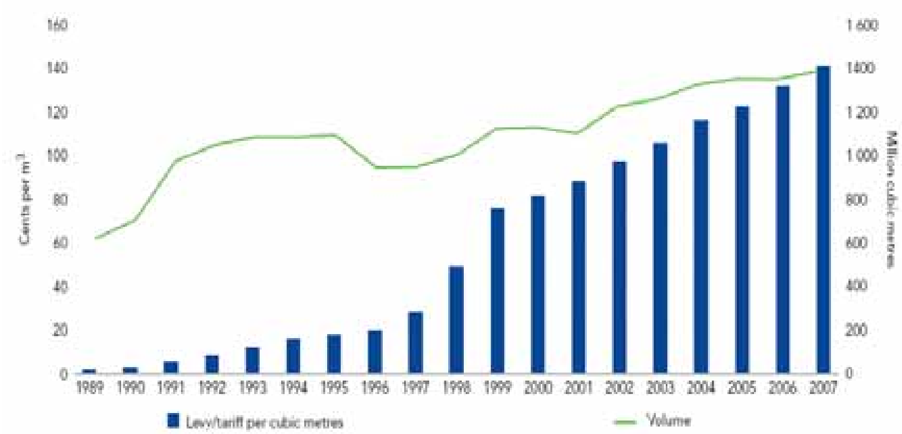
Vaal River tariff for augmentation schemes	Increase c/m³	% increase due to CPIX	% increase due to triggers	Total % increase
2000/01 tariff:	88,14			
Phase in portion one	2,11		2,39	
CPIX adjustment	7,05	8,00		
2001/02 tariff:	97,30			10,39
Income agreement signed August 2001				
Phase in portion two	2,33		2,53	
CPIX automatic adjustment	5,97	6,00		
2002/03 tariff:	105,60			8,53
Phase in portion three	2,57		2,43	
CPIX negotiated adjustment capped	7,93	7,50		
2003/04 tariff:	116,10			9,93
CPIX automatic adjustment	6,30	5,40		
2004/05 tariff:	122,40			5,40
CPIX automatic adjustment	6,14	5,00		
Phase in portion one of three	3,06		2,50	
2005/06 tariff:	131,60			7,50
CPIX negotiated adjustment	5,92	4,50		
Phase in portion two of three	3,33		2,53	
2006/07 tariff:	140,83			7,03
CPIX automatic adjustment	6,76	4,80		
Phase in portion three of three (waived)	–		–	
2007/08 tariff:	147,59			4,80

Source: TCTA Annual Report 2007 p40

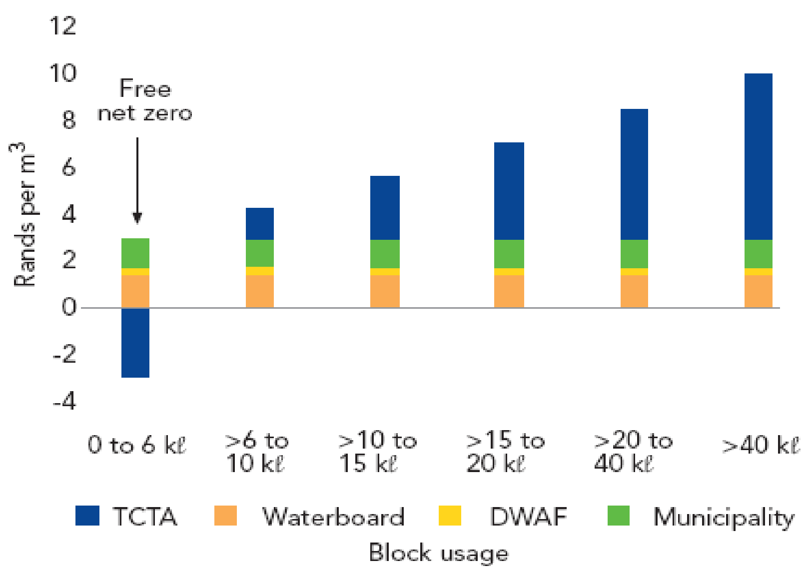
The figure below shows TCTA's share of total raw water tariff in 2006 prices.



The figure below shows the actual tariff charged each year for bulk water and the volume of sales on which the tariff was charged, highlighting the effective phasing-in of tariffs.



Finally, the figure below shows the composition of final tariff for domestic usage in the 2006/7 financial year.



2.4.3. Outcome and Lessons to be Learned

The rise in water tariffs in South Africa has caused concern among consumers as the commercialisation of water utilities in the country already has made clean water unaffordable to many poor households. Poverty and high water tariffs were blamed for the 2001 cholera epidemic in Johannesburg as many poor household were disconnected from water supply after failing to pay for the service. To help alleviate such concerns, municipal water authorities are implementing pro-poor policy measures. For example, Johannesburg Water supplies the first 6,000 litres free to every household.

With respect to the bulk water tariff framework, the following factors may be pointed to as being key factors in strategy development:

- Success in developing relationships between various public bodies and in ensuring 'level playing field' between internal and external stakeholders.

- Ability to achieve high credit ratings for major schemes through detailed financial models and tariff agreements.

- TCTA has been successful in adjusting tariffs to meet financial needs, following extensive stakeholder and major user consultation.

However, it should be noted that TCTA is not always successful in reaching tariff agreements. For example it was asked to participate in a dispute with the Impala Water Users and concluded that the tariffs were insufficient to finance the infrastructure, following which it withdrew from the discussions.

2.5. China

2.5.1. Background

China has major problems with water supply and pollution. China has as much water overall as Canada, but has 100 times more people. China's per capita water reserves of 2,500 m3 are one-fourth the global average. China's economic growth, industrialization, and urbanization, coupled with inadequate investment in basic water supply and treatment infrastructure, have resulted in widespread water pollution. Groundwater sources are polluted and dwindling, especially in the North China Plain.

2.5.2. Legal and Institutional Framework

The main laws which affect the China water sector are:

- Water Law of the PRC.
- Law of the PRC on the prevention and control of water pollution.
- Flood Control Law of the PRC.
- Law of the PRC on Water and Soil Conservation.

The 11th Five Year Plan (for 2006 to 2010) reflects the over-riding theme of the recent NPC towards 'Scientific Development' and sustainability. The key economic targets in the plan include shifting to an efficient growth model; upgrading the industrial structure; boosting the rural economy; improving resource allocation; achieving balanced spatial development (i.e. improving the relative performance of Central and Western Provinces); and improving public services. There is also an increasing focus on environmental protection.

A number of River Basin Commissions have been created for watershed management. In the late 1990's[2], they also given more responsibility for water quality, but still had difficulty implementing water use policies in some provinces. By the end of October 2004, institutional reform of water affairs management had been implemented in 30 PARs and 1,251 agencies – either in the form of newly established water affairs bureaux or as original water resources administrations – had begun to implement integrated water affairs management (in which 950 were water affairs bureaus), covering 53% of administrative regions at county level and above in China.

On April 19, 2004, the General Office of the State Council issued the "*Notice on Promoting Water Pricing Reform and Conservation and Protection of Water Resources*", which paved the way for water pricing reform. The Notice specifies the reform of water resources fees, wastewater treatment fees, water prices for water resources projects, prices of urban water supply and the price of reclaimed water. Regulation or implementation rules on water pricing were initially issued in the seven PARs of Hunan, Yunnan, Hubei, Guangxi, Jiangxi, Chongqing and Heilongjiang. A progressive block pricing structure has been adopted in more than ten PARs such as Hebei and Guangxi, and pilot projects have been implemented on the reform of agricultural water pricing in Hubei, Yunnan, Heilongjiang, etc.

[2] Following quality emergencies in 1995

The Ministry of Water Resources has recently been replaced by the Ministry of Construction as the leading agency for the water and wastewater sectors, because of the importance of developing new infrastructure, and this has also reduced the role of the State Environmental Protection Agency (SEPA). Municipal governments are primarily responsible for providing and regulating water and wastewater treatment services, owning and managing more than sixty per cent of capacity. Recently, many municipalities have restructured their water utilities as fully publicly-owned companies, with autonomous accounting structures, some of which have listed publicly. Municipalities have been encouraged to commercialise local wastewater companies and to seek foreign investment. Central and local governments have introduced various policies to support commercialisation. These include the provision of land for wastewater facilities, tax breaks, electricity and credit guarantees for private investors.

Since 1992, Suez has gained 18 bulk water contracts in high income areas such as Hainan, the Chinese equivalence of Hawaii. Veolia is involved in 13 projects and has signed a 50-year management contract in Pudong in 2002. Thames and Berlinwasser are also involved, with the latter recently winning a $58 million contract in the eastern city of Hefei. In southern China, direct negotiations between firms and municipalities are being replaced by a competitive bidding process. The multinationals often find themselves bidding against a proliferation of local companies, who are inexperienced, but offer far lower prices (20% to 30% cheaper).

An unusual feature of BOT-style projects in China has been that the intake and outflow assets are transferred to Chinese water authorities at no cost. The capital expenditure incurred in constructing these assets is absorbed within the overall project financing costs, becoming merely an aspect of the tariff charged under the off-take agreement. The tariff includes the capital and funding costs of the intake and outflow pipelines, as well as the capital, funding and operating costs of the water plant. The separation of asset ownership and tariff liability gives the water supply authority free intake facilities, while imposing additional costs on the relevant water off-taker.

2.5.3. Bulk Water Pricing Framework

The *Administrative Regulation on Urban Water Supply Pricing*, introduced in 1998, provides a legal basis for water supply pricing in China. The regulation states that:

- The general principles of setting water tariffs are "cost recovery, reasonable revenue, water conservation and social equity".
- Municipalities are responsible for approving water tariffs.
- Tariffs should cover operation and maintenance, depreciation, and interest costs.
- Tariffs should allow for an 8 – 10% return on the net value of fixed assets, depending on the sources of funds.
- Tariffs should be appropriate to local characteristics and social affordability.
- A two-part tariff consisting of a fixed demand charge and a volumetric charge or increasing block tariff (IBT) should be gradually adopted.
- The first block of IBT should meet the basic living need of residents.
- Public hearings and notices should be conducted in the decision making process of setting water tariffs.

Currently, typical large-sized and mega-cities in China charge between 1.00 – 3.00 (and sometimes over) RMB/cubic meter of water for residential use. The wastewater treatment fee ranges between 0.25 – 1.00 RMB/cubic meter[3]. Cross-subsidization between consumer classes is common, with industrial and commercial consumers typically paying 1.5 times as much per cubic meter than households.

In addition to tariffs for the water supply and wastewater facilities, water bills typically include a water resource fee and a water development fee, based upon the allocated cost of the raw water supply infrastructure. Guided by the *Ordinance of Water Permits and Water Resource Fee Management*, which replaced the old water permit management ordinance and became effective in April 2006, water resource fees are determined by the local government(s) concerned. Different areas have different levels based on the actual status of water resources. Beijing now charges 1.10 RMB for its water resource fee but Chongqing charges only 0.10 RMB.

Government guidelines require that municipalities establish a water pricing system that promotes water conservation. At the end of 2003, Wang Jirong, vice-director of SEPA, reaffirmed the government's position on this issue when releasing the annual Statement on China's Environment, "*Despite the severe shortage, water is too cheap to be used economically. Only a raised price could motivate consumers to conserve*".

Water tariffs in China have been rising steadily in recent years and are usually set at a local level. Budgetary constraints and falling subsidies, along with the increasing necessity to attract private investors, is making municipalities more and more aware of the necessity to increase water tariffs, start charging wastewater fees and introduce progressive billing for large customers.

Tariffs vary with category of user and most municipalities have a complex matrix of tariffs for different user types, reflecting social and political concerns. Enterprises or departments responsible for service

[3] Water Supply Pricing In China: Economic Efficiency, Environment, and Social Affordability. World Bank Policy Note December 2007.

provision make a written application for a price increase to the municipal government. This application must include information on the following:

- Justification for the price increase.
- Proposed amount of the increase.
- Estimation of the likely impact on consumers.
- Information on production and operating costs over the last three years, together with any other detailed information specified by the local Price Office.
- An independent audit report on the company's financial position.

The local Price Office considers the price application on behalf of the municipal government and decides whether the application should go to a public hearing. The Price Office may consult other organs of government or interested parties and ask for clarification or additional information before reaching a decision. The Price Office should make an initial response to the applicant within 20 days. If the price application is considered to have reasonable merit by the Price Office, a public hearing is convened within three months. Public hearings are open to the ordinary public and are advertised by the Price Office.

It is only where foreign investors have agreements which specify bulk tariffs that China provides direct evidence. Bulk tariffs in recent BOT agreements have often been higher than the tariff charged to residential users. For example, the bulk water tariff paid to the Chengdu No 6 project by the Chengdu water company was RMB 0.98 per cubic meter, higher than the water tariff charged to residential users, which stood at RMB 0.65 per cubic meter when the agreement was made.

Bulk tariffs charged on specific BOT projects (RMB per m^3)[4]:

Chengdu No 6	0.98	1998	
Lianjiang	1.25	1999	
Zhongshan Dafeng	0.77	2002	
Baoding	0.61	2000	
Nanchang	1.05	2002	
Siping	0.84	2002	
Shenyang No 8		1.09	2002
Changtu	1.1	2003	

The price of water in Beijing, for example, reflects a number of different cost items[5]. For example, the tariff in 2003 was 2.9 RMB/cubic meter. This tariff consisted of a water resource fee (for both surface and groundwater) of 0.6 RMB/cubic meter, a sewage treatment fee of 0.6 RMB/cubic meter, a tap water fee of 1.7 RMB/cubic meter to cover the fixed and variable (capital and O&M) costs of the water supply company, and a tax of 0.33 RMB/cubic meter paid to the Beijing municipality. This reflects the structure stipulated in China's Price Law and the National Guidelines on Water Tariffs. At present, the price of water in Beijing is the highest in all the cities in China and recent price adjustments for the residential sector have been focused on the sewage treatment fee and water resource charge, rather than the tap water tariff. Despite these reforms, including a further increase in the residential water tariff to 3.7 RMB/cubic meter in 2004, water and sewerage in Beijing remain subsidised.

Increasing block tariffs are used quite widely in China. For example, the water tariff scheme adopted in Lijiang City (2005 figures) has first block up to 25 cubic meters per household per month charged at 1.40 RMB/cubic meter (excluding 0.40 RMB/cubic meter for wastewater

[4] Data from 'Water Market China' by Olivia Jensen and Frederic Blanc-Brude, Global Water Intelligence 2004

[5] This paragraph taken from Water Supply Pricing In China: Economic Efficiency, Environment, and Social Affordability. World Bank Analytical and Advisory Assistance (AAA) Program China, 2007

treatment), the second block from 25 to 35 cubic meters at 2.10 RMB and the third and final block above 35 cubic meters at 2.80 RMB / cubic meter.

2.5.4. Outcome and Lessons to be Learned

Some of the key features of China's water pricing strategy that may be relevant in other environments include:

- Recognition both at central and local levels of importance of price in rationing quality.
- Extensive consultative processes over water tariffs.
- Authority at local level to set tariffs.
- Inclusion of water resource feeds and water development fees.
- Intake and outflow assets transferred to state at no cost.
- Competitive bidding processes found to be valuable even in a planning environment.

A recent study of water pricing in China[6] provided the following key messages:

a) *Pricing policy is an essential tool to improve the efficiency of water use, protect the water environment, and address water scarcity problems.*

[6] Water Supply Pricing In China: Economic Efficiency, Environment, and Social Affordability. World Bank Analytical and Advisory Assistance (AAA) Program China, 2007

b) *Given the magnitude of water scarcity in China, the country should aggressively implement tariff reforms based upon the Marginal Opportunity Cost (MOC) concept.*

c) *Public acceptability of price reform and affordability of water by the poor are important concerns although these can be resolved by appropriate water tariff structures and community outreach programs.*

d) *Since international experience offers limited guidance in this area, China should exercise its own leadership before the water crisis in the country becomes unmanageable.*

The MOC pricing approach has been investigated by the China Council for International Cooperation on Environment and Development (CCICED). The rapidly escalating costs of water and its disposal demonstrated the need for prices in excess of those required to cover the purely financial costs7 in order to reflect environmental and scarcity factors.

An example from the Hai River Basin.is given in the World Bank water pricing report. This region has severe water resource problems. The study states:

> *While water production costs, at 5.08 RMB/ cubic meter, are relatively high, they are minimal in comparison with the potential costs of a water shortage in the region. The study estimates the economic value of water (EVW) – or opportunity cost – in terms of value added in alternative industrial or agricultural uses, and finds that the average EVW for economic sectors based on integrated water withdrawal in eight study areas to be 41.8 RMB/cubic meter, in which that for tertiary industry is as high as 208 RMB/cubic meter, the next highest is for construction at 180 RMB/cubic meter, the third is for mining and quarrying at 114 RMB/cubic meter and the lowest is for various agricultural uses, ranging between 3–16 RMB/cubic meter. There is*

[7] Warford, Jeremy and Li Yining (eds), Economics of the Environment in China, CCICED 2002

considerable variation in EVW between different areas, with the average EVW in Beijing being the highest and that in Xinxiang is lowest.

China has also been successful in reducing public opposition to tariff increases as shown in the following case study taken from the World Bank pricing report:

An attempt to obtain public support for price increases that were required to provide funding for improvement and expansion of facilities in Chongqing received a hostile reception at public hearings. Consequently, the Chongqing municipal government conducted a research effort to facilitate a public awareness campaign. This was aimed at educating the population about the costs of supplying water and managing wastewater generated in the city and the impact on service quality if the municipal water supply system was unable to increase revenues. It showed that the primary losers when prices are too low were the poor, whose service standards remained inadequate. Indeed, the wealthier consumers, who consumed the most water, were the biggest beneficiaries from the subsidies involved.

In addition to the educational process, and in recognition of the problems the poor had in paying higher water prices, the Chongqing municipality decided to implement a number of parallel subsidies for disadvantaged groups including the unemployed which would be sufficient to maintain basic living standards which included paying the increased water bills. The study also recognized that a step-by-step approach must be used, and a schedule for gradual increases in prices over a number of years was introduced. Since the public was made aware of the findings of the study and in particular the rationale for the price increase, subsequent public hearings attended by representatives of disadvantaged groups were very constructive. The whole process was instrumental in making the required price increases socially acceptable, and the reforms have apparently been effective in reducing water consumption in the city.

Finally, the World Bank pricing report makes a number of useful recommendations:

a) *Utilities should be required to estimate the long run marginal cost of their own operations (investment and operating costs) over say a 20- year period. Such estimates should be monitored and updated on a continuous basis, requiring an expanded long-term planning capability.*

b) *Local governments should develop the capacity to assess the environmental consequences of alternative water development programs and estimate the costs of environmental damage, including the costs of environmental protection measures where appropriate.*

c) *Local governments should also develop the capacity to estimate water depletion costs on a regional level.*

d) *Estimated environmental and depletion costs should be charged to the concerned utility by the local authority, and, in addition to the long run marginal supply cost, be the components of a pricing policy based upon MOC.*

e) *Water tariffs for commerce and industry should cover full MOC; for residential consumers, the first block should be about 40 litres per capita per day, with the second block gradually increasing to full MOC.*

f) *Utilities should be required to submit strategies to concerned local government so they can fully implement MOC pricing within a time frame, which will be based upon costs, incomes, and public acceptability; the strategies should involve a program of public education and stakeholder involvement.*

g) *A system should be devised in which such MOC estimates can be integrated into regional and national water management and economic planning systems.*

h) *Parallel pricing reforms should be carried out for other water uses, in particular for agricultural use and large scale industrial abstraction.*

i) *Existing policy is to meter individual industrial, commercial, and residential consumers on a case-by-case basis, but this will need to be accelerated as water supply costs increase.*

j) *Utilities should study demographic and income patterns in their area, while continually updating such information, in order to devise efficient and equitable cost recovery mechanisms using non-price mechanisms if metering is not justified.*

2.6. Harvey Water (Western Australia)

2.6.1. Background

Institutional Arrangements

The supply of water and wastewater services in Western Australia (WA) is dominated by the Water Corporation, which is a government owned entity. The Water Corporation supplies potable water to the major metropolitan area of Perth and surrounds, as well as the majority of regional centres and towns.

The towns of Busselton and Bunbury are served by separate water suppliers (Busselton Water and AQWEST), with local governments and mining towns also responsible for supplies in specific areas. The Water Corporation supplies the vast majority of potable water (97%). In addition, large volumes of non potable water are used by agriculture, mining and other industry. The vast majority of non potable supplies are self-sourced (largely from groundwater supplies).

Water resources are managed within a broad policy framework set at the national level. The Council of Australian Governments (COAG) has agreed a series of water reforms implemented through the National Water Initiative (NWI). The NWI addresses issues such as urban and rural water pricing, water trading, water access entitlements and water resource accounting. The two key national agencies responsible for implementing the reforms are the Department of Environment and Water Resources and the National Water Commission.

Within WA, the Department of Water oversees water policy development. The Economic Regulation Authority (ERA) has responsibility for overseeing the determination of prices for water and wastewater services supplied by Water Corporation, AQUEST and Busselton Water. Various agencies are involved in the regulation of water quality including the EPA and the Swan River Trust for river water quality and the Department of Health for drinking water quality.

Water Corporation supplies Perth through the Integrated Water Supply Scheme (IWSS). The IWSS also supplies water to towns in the South West, the Perth Hills and to towns along the goldfields pipeline to Kalgoorlie.

Water Corporation is a corporatized body, formed through the 1995 Water Corporation Act. In 1996, the Corporation transferred its South West irrigation distribution system to the South West Irrigation Management Co-operative which now trades as Harvey Water. At that time, a ten-year water storage agreement was entered into.

Water Corporation owns and operates the eight dams in the South West that are used to provide water to farmers and private industry (supplied through Harvey Water's distribution system) and customers in Perth and elsewhere via the IWSS. While the Corporation owns and operates the dams, Harvey Water was granted water access entitlements to the majority of water in the dams. Thus, the Corporation does not charge for the water itself but only the costs of storing the water.

Harvey Water owns and manages three separate irrigation systems – Waroona, Harvey and Collie – supplied by water from eight dams. In 2005/6, Harvey Water had a total allocation of 152 GL. However, water trading between Harvey Water and the Corporation will reduce this to 136 GL by 2009/10. The Waroona and Harvey Irrigation Schemes are linked to the IWSS via the Stirling Trunk Main.

Bulk Water Supply Agreement

The Bulk Water Supply Agreement (BSWA) entered into in 1996 specifies the terms and conditions under which the Corporation provided water storage services to Harvey Water. The BWSA also provided for Harvey Water to meet a share of the future costs of safety improvements on the South West irrigation dams.

Water storage charges to Harvey Water were set on the basis that 85% of the future operating and renewal costs for dam headworks would be recovered from Harvey Water and other direct users, with the remaining 15% of costs paid for by government (on behalf of other beneficiaries such as recreational users).

In 2004/5 water charges amounted to around $0.8 million, of which $0.39 million was for dam safety, $0.25 million for storing water for Harvey Water and $0.16 million for storage for non irrigation users. The government made a Community Service Obligation (CSO) payment to the Corporation to cover the difference between its water storage costs and revenue recovered, and the CSO provides the Corporation with a return on the dam assets that were in place at the time of the transfer.

The BWSA expired in mid June 2006 and the agreement has been rolled forward under the existing terms and conditions since then. ERA was asked to undertake an inquiry into the appropriate level and structure of water storage charges to Harvey Water and completed its inquiry in June 2007.

In conducting the Inquiry, ERA had regard to a number of issues including:

- The long term reduction in rainfall compared to the historical average experienced in South West WA.
- The significantly higher than expected expenditures on dam safety required to meet the ANCOLD dam safety guidelines.
- Obligations under the NWI that require the State government to ensure that charges for water supply

services lie within the lower and upper bound pricing limits determined by the COAG agreement.

ERA recognised that, in setting a new bulk supply agreement, it was necessary to apply pricing frameworks that were consistent with current policy and regulatory approaches and that these had changed significantly from the time of the original agreement. Doing this involved interpreting the intent of the original agreement to maintain equity to those involved, while taking account of changed circumstances and providing appropriate incentives to customers.

2.6.2. Bulk Water Pricing Framework

Recommended Level of Charges

Under the NWI, lower bound prices are intended to ensure that a water supplier remains financially viable. To this end, prices are required to recover at least operational, maintenance and administrative costs, externalities, taxes or tax equivalents, the interest cost on debt, dividends (if any) and make provision for future asset refurbishment/replacement.

Upper bound pricing is designed to prevent water businesses from earning a monopoly rent. It requires that the business recover no more than operational, maintenance and administrative costs, externalities, taxes or tax equivalent rates, provision for the cost of asset consumption and cost of capital (calculated using a WACC). The deprival value methodology is to be used for asset valuation unless a specific circumstance justifies another method.

The NWI requires that urban water prices be based on the upper bound, and that rural water prices at least meet the lower bound and move towards the upper bound where practical.

In line with this recommendation, ERA determined a revenue requirement that was based on the upper bound pricing principle. This involved determining an appropriate asset value, on which a return and depreciation would be allowed as part of the revenue requirement. Using deprival value principles, ERA determined that the initial asset value at the signing of the original agreement should be rolled forward by adding appropriate dam safety (and other) expenditures incurred since by Water Corporation, subtracting inflation and adjusting for inflation. The initial value was set at zero for the purpose of setting dam storage charges for Harvey Water's irrigation water and written down replacement value for the purpose of calculating the dam storage charges for Harvey Water's non irrigation water.

Issues for Discussion

A number of issues were considered by ERA in the course of the inquiry. These included:

- Whether a scarcity value should be assigned to the water.
- Whether lower bound or upper bound pricing principles should be applied and how these should be defined.
- Whether a depreciated optimised replacement cost (DORC) approach to valuation should be applied.
- The level of future dam safety expenditure to be included in the revenue requirement for the duration of the new BSWA.
- The allocation of costs between beneficiaries (including customers, recreational users and government).
- Approaches to revenue smoothing.

These factors are each examined in turn in the following sections.

Scarcity Value

ERA recognised that entitlements to the water in the dams are held by the Corporation and Harvey Water. This means that customers of the storage service already own the water and are free to trade the water should they wish to do this. Given these institutional arrangements, ERA considered that it would be inappropriate to assign a scarcity value to the water and charge this value to customers.

Lower Bound vs. Upper Bound Pricing

ERA considered that lower bound pricing would be inappropriate. Lower bound pricing could be defined by setting tariffs to cover future costs only (and allowing for asset renewal), but ignoring the return on assets that had been constructed over the period of the first BWSA. ERA considered that it would be inconsistent with the original BWSA to ignore the return on this investment. Accordingly ERA found that upper bound pricing was appropriate.

Choice of Initial Value

DORC valuation involves estimating the cost of replacing the dams, optimised for the latest engineering standards and depreciated to be consistent with the current service level. The WA Department of Treasury and Finance stated a preference for the application of a DORC methodology, on the grounds that it is utilised by many regulators[8] and is appropriate for long lived assets.

ERA considered that estimating a DORC asset value for the South West dams would be a complex and expensive exercise that would need to be repeated at the outset of each new BWSA. Also DORC valuations involve a substantial amount of judgement with regard to the costing and optimisation process. ERA noted that the estimation process needs to take account of the costs that a new entrant would incur in providing equivalent dam services and that an entrant building a new dam from scratch would incur lower costs than the Corporation would spend in retrofitting the existing dams. How much less, however, was a matter of contention.

[8] In fact DORC is used more in electricity and gas than in water within Australia

ERA was of the view that the deprival value method of valuation offered advantages over the DORC method or written down replacement cost. The deprival value method is consistent with the pricing principles of the NWI. It is also consistent with the original BWSA. Deprival value avoids the cost and complexity of a DORC valuation and offers flexibility in dealing with the allocation of dam safety costs (rather than the all of the costs faced by a new entrant being incorporated into a DROC valuation).

The Authority considered that zero was an appropriate initial asset value given the original BWSA, which envisaged that future revenue would offset future costs. Both Harvey Water and the Corporation endorsed this approach for irrigation services. However the Corporation argued that the Corporation recoups a higher charge from Harvey Water for its non irrigation water sales, and that such customers should pay the full cost based on the written down replacement value of assets. Under this method customers would still obtain the benefit of the relatively cheap existing water sources (which are cheap relative to the cost of procuring new water sources for the IWSS).

The higher charge for non irrigation water reflected a State government desire to maintain consistency with other major customers, and ERA agreed that the new BWSA should broadly reflect the terms and conditions of the original BWSA. Accordingly, ERA determined that written down replacement value should be applied for the purpose of calculating the dam storage charges for Harvey Water's non irrigation customers.

Efficient Dam Safety Expenditures

A major element of ERA's inquiry concerned the amount of dam safety expenditure to be undertaken by the Water Corporation and included in the revenue requirement for charges to Harvey Water.

When the original BSWA was negotiated, an estimated cost of $17 million for dam safety upgrades was mentioned, although it was recognised that this estimate was highly uncertain. Subsequent work undertaken by Water Corporation gave 2002 estimates of dam safety upgrade costs of $101 million. By the time of the inquiry, Water Corporations capital budget for safety improvements had reached $136 million. This huge increase in estimated costs followed from improvements in the quality of the risk analysis undertaken by Water Corporation.

ERA concluded that most of the proposed expenditures were justified under the Australian National Committee on Large Dams (ANCOLD) Guidelines, subject to some technical reassessments that were to be confirmed prior to resigning the BWSA.

The Authority presented two options for charging Harvey Water. The first was to apply the ANCOLD framework and pass through the compliance costs to customers. Under this option, charges to Harvey Water would increase from an average of $6.66 per Megalitre (ML) to $34.43 per ML (in real dollars at 30 June 2006). ERA considered that it would be appropriate to phase in the charges over a long period, such as ten years. The phase in would be funded by a CSO payment to the Corporation.

The second option recognised the possibility of the Government moving to manage the wider portfolio of risks facing the Western Australian community on a whole of government basis. This would recognise that the dam safety costs associated with Stirling, Drakes Brook and Samson Brook dams would be expected to be deferred in favour of more effective options for reducing risk to life. Only the dam safety costs associated with Wellington dam and Stage One of remedial works on Waroona dam would be expected to proceed and be recovered from customers. Under the second option, charges to Harvey Water would increase from $6.66 per ML to $21.10 per ML. Again ERA considered that it would be appropriate to phase in the increase in charges.

Cost Allocation

In considering the costs to be allocated to Harvey Water, the Authority had regard to legacy costs, the classes of beneficiaries and the value derived from dam services by the different beneficiaries. Costs attributable to identifiable private beneficiaries (such as water supply customers) were shared between Harvey Water and the Corporation.

Legacy costs are costs that are resulted from the activities of past users, and ERA considered that it would be unfair if they are charged to current and future users. Harvey Water maintained that the cost of restoring the dams to ANCOLD standards which prevailed at the time of signing of BWSA in 1995 should be viewed as legacy costs. However, Water Corporation maintained that there were no legacy costs associated with the original agreement as Water Corporation was obliged to meet the ANCOLD standards and Harvey Water was expected to meet its share of future costs.

The Authority determined that dam safety expenditure could possibly be regarded as a legacy cost, given an implicit understanding at the time of the original BWSA that charges to irrigators needed to be affordable. However, ERA argued that the decision to use water from irrigation dams should be based on the costs of accessing that water, which appropriately includes the efficient costs of dam safety. Therefore ERA determined that dam safety costs incurred after the signing of the original BWSA should not be regarded as a legacy cost and should be recovered from customers.

ERA considered how the costs of operating the dams should be apportioned among the beneficiaries. The Authority determined three classes of beneficiaries:

- Identifiable private beneficiaries. These include farmers using irrigation water and Corporation customers in the

IWSS. They are private beneficiaries because they have identifiable property rights over the water in the dams.

- Identifiable public beneficiaries. These include recreational users such as water skiers and bush walkers whose enjoyment of the dam does not diminish the value that accrues to others. Traditionally such users have not been charged for their usage although in theory it would be possible to preclude them from using the dams.
- Non identifiable public beneficiaries. These beneficiaries gain from the existence of the dam in an indirect communal sense and cannot be excluded from obtaining benefit from the dams. They include local residents who benefit from reduced risk of natural flooding, local communities who benefit from the maintenance of the structural integrity of the dam, and those who enjoy the aesthetic and environmental attributes of the local countryside that result from the dams.

ERA used a number of studies to assess a value of recreational benefits from the dams. Based on these studies, the Authority concluded that recreational benefits were of the order of $1m per annum or around 20% of total benefits. Thus ERA determined that the total costs of providing dam storage services should be reduced by 20% and that Harvey Water should be allocated its share of costs after this deduction has been made. The value assigned to recreational benefits is funded by a CSO payment to Water Corporation.

As there are positive and negative aspects to aesthetic benefits of dams and natural flood mitigation, ERA determined that no further allocation of costs should be attributed to the government.

All of the parties agreed that costs should be allocated between customers on the basis of annual water entitlements (rather than annual volumes actually taken). Thus, for each of the Waroona, Logue Brook, Drakes Brook, Wellington, Samson Brook and Samson Brook Pipehead dams, costs were allocated between the Corporation and Harvey Water on the basis of water entitlements from each dam. Past reconfigurations of the dam system and transfers of entitlements between the Harvey, Stirling and Wokalup dams resulted in a disagreement between the parties on the appropriate basis of allocation of costs for Stirling dam. ERA determined that the costs of Stirling dam should be allocated on the basis of the share of entitlements to the water in the entire Harvey, Stirling and Wokalup system.

Smoothing

ERA considered whether the payment schedule should be smoothed or not (i.e. whether the revenue requirement should be constant from year to year). Where significant expenditure is anticipated at some relatively distant time, smoothing provides security that there will be sufficient revenue to fund the expenditures. However where the expenditure is imminent (as in this case), smoothing allows customers to defer their payments.

Smoothing can also inhibit efficiency, as annuities based on long run forecasts of expenditure tend to be very uncertain and lead to conservative estimates. In addition smoothing can commit a company to a particular capital works program, even if the economic case for that program weakens subsequently.

Irrigation cooperatives have tended to prefer a smoothed approach to charging. ERA decided that the timing of revenue recovery should be left to Harvey Water and the Corporation to agree, and both supported a smoothed approach. ERA considered that the new BSWA should be for a period of five years, at which point the future capital expenditure profile would be reconsidered.

Recommended Structure of Charges

Under the original BWSA water storage charges to Harvey Water comprised a fixed annual charge and a variable component based on price per ML of water used. In 2005/6 the fixed charge accounted for 30% of the total payment.

The parties were agreed that water storage costs incurred by the Corporation are largely fixed by nature and generally independent of the volume of water delivered. Harvey Water submitted that charges should relate to the entitlements held in the dams.

ERA argued that the structure of water storage charges is unlikely to be relevant for ensuring that water is allocated to its most valued use because an effective water trading market will achieve this result. While water trading within the irrigation co-operative is working well, ERA considered that trade between the co-operative and other potential purchasers, such as the Corporation, could be more effective. As the government had announced that it intended reviewing the water trading legislation, ERA concluded there was no need for the government to prescribe the structure of the charges that the Corporation levies on Harvey Water.

Instead the structure of charges was left for the Corporation and Harvey Water to negotiate commercially. ERA considered that the mix of fixed and variable charges was primarily a commercial issue to do with managing the volume risk of uncertain annual streamflows.

2.6.3. Outcome and Lessons to be Learned

Water Corporation and Harvey Water agreed with the main principles used by ERA to propose a revised pricing agreement. In particular, they agreed with the revenue requirement framework, the choice of a zero initial value for the purpose of setting prices to irrigators, the basis of allocating costs between parties and the use of water entitlements as the basis of charges.

The Department of Treasury and Finance was keen to address the issue of dam safety standards in order to reduce the dam safety expenditures required. However, DTF have been unable to gain traction with other areas of government in WA and, in the absence of formal direction from government, Water Corporation is obliged to continue with its existing dam safety expenditure program.

ERA has no formal jurisdiction over the bulk water charges, having completed its inquiry and provided its advice to government. Water Corporation is in discussions with Harvey Water, and expect to sign a revised BWSA at some stage soon. By default this is likely to involve Option 1 (i.e. the higher level of dam safety expenditures), and Harvey Water may well seek additional CSO funding from government to cushion the impact of the price rises on its farmers.

The key lessons to be learned from the Harvey Water case study are:

- The importance of ensuring that bulk supply customers face appropriate incentives in terms of the cost consequences of their decision to continue to take water supplies. Thus, ERA considered that all future dam safety costs should be incorporated within the costs to be recovered from beneficiaries.

- The importance of ensuring that future costs are efficient and warranted. Strict application of the ANCOLD guidelines would result in safety benefits that are small relative to those that could be gained in other spending areas (such as transport). Government is in a position to alleviate Water Corporation’s strict legal liability by interpreting the ANCOLD requirements within WA. Doing so would greatly improve the affordability of future dam safety activities for water customers.

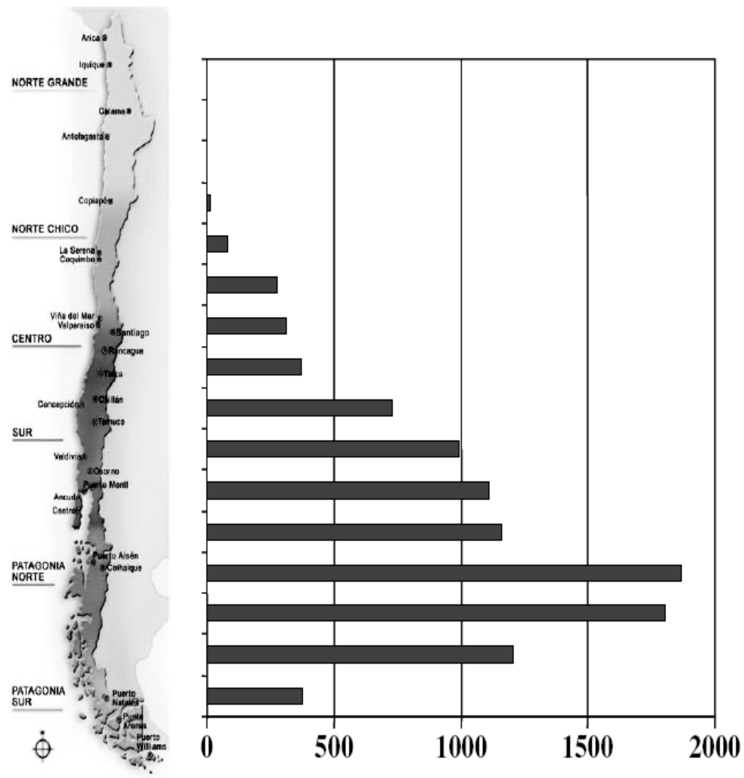
- The treatment of sunk costs is governed largely by equity considerations. Thus the value attributed to assets in existence at the start of original BWSA reflected their value to the water supplier (Water Corporation), given the existing level of charges. This value can be very low – zero in the case of irrigation customers – if this is consistent with the starting level of charges.

- The allocation and recovery of costs should be transparent. Where charges are reduced to particular groups (such as recreational users or water customers) these costs should not be recovered through cross subsidies from other customers. Rather the government should make available a transparent CSO.

2.7. Chile

2.7.1. Background

Chile's unique geographical position provides for a wide range of climatic conditions ranging from near zero precipitation levels in the north to annual rainfall greater than 2,000 mm in the south. Generally the climate is hot and dry in the north and becomes increasingly colder and wetter in the south. Chile contains a number of small rivers and valley system feed by water from the Andes. The countries arid agricultural centre is highly productive through the use of irrigation which accounts for 85% of the countries total water consumption. The construction of canal and the irrigation system began with private canal users associations during the colonial era and the concept of water use right as protected property rights were included in the 1855 civil code and further developed in the 1930 and 1951 Water Codes.



Map of Chile and average rainfall (mm/yr).

In the 1960's, Chile pursued a more 'statist' polices to help protect the emerging working classes during industrialisation and to increase agricultural production by redistributing large landholding to small landholders. The Agrarian Reform Law and the 1967 Water Code increased the States authority over water rights.

The overthrow of the Allende's government in 1973 saw a reversal of these policies. With the new military government adopting radical free-market policies, that curtailed the power of the state and encouraged the role of the private sector.

The 1981 National Water Code, reflects the military governments overall economic and political objectives, as it reduced the role of the state and increased the legal status of private water rights. The military government wished to encourage more efficient use of water through the use of market mechanisms. Inefficiencies in the use of water would be reduced by allowing the sale and transfer of water rights to higher valued users in the agricultural sector or other sectors of the economy. Although water was still seen as public property, once the state has granted a party the right to use water, this entitlement was then fully protected as private property rights under the Constitution and could be subsequently freely bought and sold like other forms of real estate. For the first time, water rights were separated from land ownership allowing water to be freely tradable by being sold, bought, mortgaged and inherited.

The 1981 National Water Code is laissez-faire, being built around the principles of a free market with strong private property rights, strong private economic freedoms and weak government regulations.

Administrative Arrangements

The entitlement to extract water from streams is issued by an administrative authority, the General Directorate for Water (DGA– a part of the Ministry of Public Works). The DGA issues these rights free of charge and has no discretion to deny request for the right to use water where sufficient resource is available i.e. the DGA cannot establish priorities amongst different users as this should be determined by private parties and the free market.

To deal with multiple requests for rights for scarce water, the DGA holds public auctions and sells the right to use the water to the highest bidder. As a technical and administrative agency that is responsible for preparing studies and plans that require the approval of other branches of government, the powers of the DGA are limited and it can only exercise authority over private water use during periods of water emergencies.

The issuing of water rights is seen as a means of facilitating the market for the transfer of water. However, as the process of water rights registration has proved burdensome for many small farmers, many entitlements have remained unregistered.

The expected increase in efficiency in water use through the transfer of water to higher value users (e.g. from agriculture towards urban usage) has also been curtailed by the hoarding of water rights by farmers who wish to protect themselves in times of drought. In addition, there has also been speculative hoarding of water rights in the expectation that the value of these entitlements will rise in the future.

The trading of water has been more prevalent in areas of relative water scarcity, such as the upper Mapocho watershed, where water is traded between Water User Associations (WUA) and housing association. More generally, although the trade in water rights remains quite limited it is becoming more frequent in areas of high economic growth.

The success of Chile’s economy in the last three decades has placed greater demand upon its water resources especially from companies operating in export oriented markets. Demand for water from the mining, fresh fruit and wine sectors has increased water extraction in many water poor basins. The rising value of water in these areas has led to increase in the investment in sophisticated water management and better irrigation systems.

Although the government intended for investment in all areas of the water sector to be led by the private sector, the issuing of property rights and incentives to irrigators have not always been sufficiently strong to encourage increased investment. In an explicit recognition of the weakness of the market led approach, the government began to subsidise private investment in irrigation through the National Commission of Irrigation (CNR) from 1985 onwards.

2.7.2. Bulk Water Pricing Framework – Urban Utilities

The reform of public water utilities occurred in three main steps:

The national agency Servicio Nacional de Obras Sanitarias (SENDOS) was set up to carry out the production, commercialisation, regulation and supervisory functions of the water utilities. The main aims of SENDOS were to introduce modern management tools, eliminate cross subsidies and rationalise investment in the sector.

1989-1998
A greater role was given to the private sector in terms of water utility management with public sector spending being limited to those areas where the private sector was unlikely to be interested. The regulatory and supervisory functions of the water utilities were separated and independent regional utilities with geographic concessions established. These state owned water and sanitation companies were then subject to the same rules as those governing public traded corporations.

1999-2004
Privatisation of the main water and sanitation utilities took place.

As natural monopolies, these private water utilities are subject to price controls that limit the maximum tariff that they are able to charge. The procedure for determining tariffs is set by the Office of Water Services which tries to ensure that companies are able to generate sufficient profit to ensure their long term viability.

In determining tariff levels, the Office of Water Services considered the cost that a 'model company' would incur by calculating separate investment costs for each component of the water service value chain (extraction, production and distribution of potable water and disposal of wastewater) and then prices were set so as to meet the long run marginal cost of provision of these services.

A 'model company' is considered to be a utility that provides water and wastewater services in the most efficient manner given a particular set of regulation, geographical and technological constraints.

The tariff methodology and formula adopted for each utility is valid for five years. In the interim, if the tariffs set for that utility are determined to be insufficient to generate sufficient income to cover the long run total costs of the company, then an adjustment is made to cover these costs.

Estimation of Marginal Cost

For each element of the water service chain, fixed costs, variable costs for peak periods, variable costs for non-peak periods and costs associated with the capacity of the company are calculated (with peak periods representing the 4 or 6 months of high consumption).

Table 1. Individual marginal costs for water services, per phase

Phase of the service	Fixed cost $/m^3	Volume assoc. costs non-peak	Volume assoc. costs, peak	Capacity assoc. costs $/m^3	Average costs $/m^3
Drinking water production	-	CVP1 O&M costs of prod. Vol. non-peak	CVP2 O&M costs of prod. Vol. peak	CVP3 Investment in production development plan	-
Drinking water distribution	CFP = Admn. expenses per household CFC = Admn. expenses per consumers	CVD 1 O&M costs of distr. Vol. non-peak	CVD2 O&M costs of dist. Vol. peak	CVD3 Investment in distribution development plan	-
Sewage collection	CFR = O&M expenses per household	-	-	-	CVR O&M costs, total volume
Sewage treatment and disposal	-	-	-	-	CVT O&M costs, total volume

Source: Concepts Of The Chilean Sanitation Legislation: Efficient Charges And Targeted Subsidies - Damaris Orphanópoulos

The calculated marginal costs are then transformed into an 'efficient tariff' using the following formulae:

- Fixed costs – no transformation formula.
- Variable tariffs (CVinp) = Variable Costs (CVi1) + Np/12 * Capacity cost (CVi3) (non-peak).
- Variable cost (CVip) = Variable Cost (CVi2) + Np/12 * Capacity cost (CVi3) (peak).

  (Where np = number of peak months in each year).

The difference between average consumption during non-peak periods and peak periods is used to calculate the value of over-consumption. The variable tariff associated with the over-consumption volume, CVOC, is obtained using the following formula:

- Over consumption (CVOC) = variable cost (CVi2) + capacity cost (CVi3)

The calculated tariffs are adjusted to allow them to generate total income sufficient to cover a utility's total cost and the law allows for a price index to be used to automatically allow tariff adjustments during the five year period of the price control.

Presented below are some of the actual charges levied by the main water companies.

Charges levied by a selection of water companies in Chile CH$/m^3

Charge	**A**	**B**	**C**	**D**	**E**
Company	Fixed Charges	Charge per m^3 Non-	Charge per m^3	Over-Consumption	Charge per m^3

		Peak Drinking Water	Peak Drinking Water	Peak Drinking Water	Sewage
ESSAT S.A I Region	570	505	548	1070	188
A. Andina Metropolitan Region	442	201	192	495	117
Maipú Metropolitan Region	506	153	150	376	143
Aguas Décima S.A. X region	354	217	215	550	381

2.7.3. Outcome and Lessons to be Learned

The Chilean approach to the allocation of bulk water in the 1981 Water Code represents a relative extreme with water being regarded as an 'economic good' to be freely trading in an unregulated market with its economic value determined to be the same as its free market price. This is in contrast to the more traditional approach adopted in many other parts of the world in which water is regarded as an essential human right which needs to be isolated from market forces.

The 'success' of this economic approach can be seen in certain parts of the economy, particularly in the urban water sector where there has been significant progress in extending access to water and wastewater services as well as improvements in water quality. This has lead Chile to be put forward as the leading example of the free-market approach to water resource management. However, some exaggerated claims of success in this market lead approach has resulted in a more realistic realisation of some of the shortcomings of this strategy.

The Water Code Reform, passed in 2005 aims to correct many of the problems of the 1981 Water Code by pursuing a more balancing approach to water management that takes into account the need to guarantee property rights, to provide stronger economic incentives for encouraging investment and, at the same time, to protect public interests by granting a greater role to government in the management of water resources.

Some of the key features of the Water Code reform include:

- The President is given the right to exclude water resources from economic competition where it is necessary to protect the public interest.
- DGA is required to take into account issues of sustainability when establishing new water rights.
- A license fee is charged for unused water rights so as to discourage hoarding and speculation.

3. CONCLUSIONS

A number of common themes are evident across the case studies presented in this Report which is interesting because of the very different geographic, economic and environmental climate of the examples provided. These themes include:

- The introduction a formal bulk water pricing framework typically requires a crisis to occur in terms of the availability of water as a resource before implementation is likely to be achieved. Such crises are important in achieving the cultural transformation of perceiving water as an economic good together with associated features such as the concept of user payments and the 'polluter pays principle'. In the context of the case studies presented in this Report, Chile may be seen to be the exception to this rule as the country introduced a pricing model before having to deal with a significant scarcity of water.
- Success in implementing bulk water pricing arrangements requires the cooperation and engagement of all key stakeholders. It is particularly

important for agriculture and industry representatives to be involved at all stages of the design and implementation process.

- An interesting mix of local and national involvement appears to be required for developing a bulk water pricing framework. The local element relates to issues such as the need to involve regional stakeholders (rather than having decisions imposed from 'above') and the wish to reinvest collected funds in the water basin whose resources are being charged for. The national element relates to issues such as the need for a formal (and ideally transparent) subsidy policy to be implemented alongside the pricing framework as it is unusual for the identified full costs of water allocation to be imposed on all customer groups in the short term.

- Allied to the previous point, a successful bulk water pricing framework needs to be formally administered and organised – relying purely on market forces (as was tested in Chile) to allocate value to water resources does not work. In addition, the direct involvement of a federal agency helped to balance the interests of different groups whilst still allowing each stakeholder to negotiate terms. This central administration involvement can take many forms, but a robust and independent (as perceived by stakeholders) regulator may be the best alternative.

- Bulk water pricing arrangements need to be accompanied by a well defined water entitlement framework that is flexible enough to adjust rapidly to changing environmental conditions.

- Competitive bidding processes have been found to be valuable at all stages of the water value chain, even in a planning environment.

- In terms of pricing approach, marginal cost pricing (or variants thereof) is generally perceived to be the preferred option. Within this framework, two part pricing methodologies are commonly adopted in an attempt to send appropriate pricing signals and to help maintain the financial integrity of water utilities.

4. APPENDIX 1
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ANNEXURE – II
(A REPORT ON WATER CONSERVATION TECHNOLOGIES)

Annexure II: A Report on Water Conservation Technologies

1. Introduction

Rapid industrialization and urbanization coupled with continuous decline in per capita water availability is putting a lot of pressure on the available water resources in India. As per the Central Water Commission (India) estimates, the future water requirements for meeting the demands of various sections in India would be about 1093 BCM for the year 2025 and 1447 BCM for the year 2050. The increasing gap between water availability and demand highlights the need for conservation of water. To meet the increasing demand, the efficiency of utilization in all the diverse uses of water should be optimized and an awareness of water as a scarce resources should be fostered. Water conservation means putting the available water resources for the best beneficial use with all the technologies at our command. Water conservation is needed, not only to restore the fast deteriorating eco-system but also to meet the inevitable emergency of shortage even for drinking and domestic water in the near future. Water conservation basically aims at matching demand and supply. The strategies for water conservation may be either demand oriented or supply oriented.

Water resources are theoretically “renewable” through hydrological cycle. However, what is renewable is only the quantity, but pollution, contamination, climate change, temporal and seasonal variations have affected the water quality and reduced the amount of ‘usable water’. The water conservation practices especially in urban areas by industries, municipal uses and domestic uses can reduce the demand as much as by one third, in addition to minimizing pollution of surface and groundwater resources.

2. Efficient Water Use and Conservation

Efficient water use means reducing the demand by improving personal habits; reducing wastes; creating an adequate rate schedule; deriving benefits from technical developments as well as from water management techniques, coordinating the management of hydraulic resources with that of the land and economical and social aspects; promoting norms and regulations. In short, efficient water use consists of optimizing water usage. There is absolute efficiency, to use the least amount of water possible; economic efficiency, which seeks to derive maximum economical benefits; social efficiency, which strives to fulfil the needs of the user community; ecological efficiency, which guarantees natural resources conservation; and institutional efficiency, which qualifies the function of an institution regarding its water related tasks.

2.1 Efficient water use in industry

There are various avenues where industry can use water more efficiently. Machinery, industrial processes and related support services require large quantities of water which can be reduced significantly by introducing water efficient technologies. The quality of water required depends not only on the type of Industry, but also on its use within the processes, so that a single industrial plant may need different qualities of water for different processes. Generally industrial water use can be grouped into three main categories: heat transfer, power generation and use in industrial processes.

The main methods for water efficiency in Industry are: recycling, reuse and reduction in consumption. Two basic activities are necessary in all three cases: measuring the amount and monitoring the quality of the water. Metering is the most basic activity for any efficient-use program in the industrial sector and practiced to get the consumption rate. All industrial processes or related areas do not require the same water quality. Hence recycling, reuse or reduction at each stage in the industrial process is absolutely essential.

One way in which recycling is used in Industry is to cool equipment that generates heat. In this case, water is recycled through cooling towers, which cool the water by partial evaporation. Recycling is also used in washing processes. In reuse system, the outflow from one process whether treated or untreated, is used in another requiring a different quality of water. For example water used in washing processes can be reused in others requiring a lower quality, such as cooling systems. Also it is possible to optimize processes, improve operations or modify the equipment or the attitude of users.

3. Reuse in Industry to meet water shortages

The usual objective of industrial reuse is to meet chronic water supply shortages. The solution usually starts with simple water conservation (just careful usage) and follows the principle that the greater the extent of reuse one wants, the higher the degree of treatment that will need to be given. The typical strategy followed by industries is as follows:

- First, practise as much conservation of water as possible.
- Second, recycle only that fraction of wastewater which is in a relatively good condition and can be recycled back with little or no treatment.
- Thirdly, arrange more 'reuse' after some treatment to make the industry's own wastewater fit for reuse.
- Finally, if still more reuse is needed, get external source of wastewater.

3.1 Measures of Water Conservation in Industries

Many of the Indian Industries practice some form of water conservation, recycle or reuse in response to shortage of water supply or high cost of fresh public supply or high cost of waste disposal. Some of the more common measures undertaken to conserve water in industries are of the 'reduce-recycle' type such as the following:

- Use of pressure reducing orifices in water supply piping to reduce the rate of flow; otherwise workers tend to overuse water.
- Recycle of steam condensates back to the boiler.
- Adoption of counter-current washing where washing is done in 3 or 4 successive compartments. As the wash waters from the last compartment are relatively clean and can be directly recycled to the first compartment.
- Use of closed-circuit cooling systems wherever feasible so that re-circulating waters are not lost in evaporation.
- Adoption of 'dry' cleaning systems wherever possible.
- Recycling of water used for conveying materials.
- Adopt modern 'cleaner' technologies in manufacture that use less water and / or produce less waste in the wastewater.
- Lay out separately the drains carrying wastewaters from different processes, purposefully, so as to make recycle / reuse more feasible, and at lesser cost.
- Create and reward awareness among workmen.

4. Action Plan for Water Conservation

For conservation water in agriculture, industry, municipal and domestic use, a number of schemes are available. Some of the important action plans for water conservation are the following (MOWR, 2008).

- Conservation of surface water resources – create new storages and renovate existing tanks and water bodies.
- Conservation of groundwater resources – increase groundwater recharge and stop groundwater outflows by sub-surface dams, watershed management measures etc.
- Rainwater harvesting – collection and storage of rainwater at the surface or in sub-surface aquifers, before it is lost as surface runoff.
- Protection of water quality – due to increase in environmental pollution, "utilizable water resources" is decreasing; hence protection of existing water resources from pollution is a vital aspect of water conservation.

An important component of water conservation involves minimizing water losses, prevention of water wastage and increasing efficiency in water use. The action plans for conservation in different sectors are different and explained below.

4.1 Irrigation Sector: Some of the important action plans towards the irrigation sectors are the following:

- Performance improvement of irrigation system and water utilization – proper and timely system maintenance; rehabilitation and restoration of damaged / silted system; reduce seepage losses by lining; restoration / provision of appropriate control structures; renovation and modernization of existing irrigation systems; provision of adequate water measuring structure
- Conjunctive use of surface and groundwater – especially in the areas where there is threat of water logging.
- Adopting efficient irrigation systems such as sprinkler and drip irrigation, wherever suitable.
- Preparation of a realistic and scientific system operation plan – based on availability of water and crop water requirement; minimize water logging and water loss.
- Scientific farming – revision of cropping pattern; training of farmers on excess water use; mixed cropping pattern; rotational cropping.
- Rationalization of water rate to make the system self-sustainable; formation of water user associations and transfer of management to them; promote multiple and efficient use of water.

4.2 Domestic and Municipal Sector: Some of the important action plans towards the domestic and municipal sectors are the following:

- Measures towards reduction of conveyance losses; management of supply through proper meter.
- Intermittent domestic water supply to reduce wasteful usage.
- Realization of appropriate water charges for sustainable supply and reduce wastage.
- Creation of awareness to make attitudinal change.
- Modification in design of accessories such as flushing system, taps etc.
- Possibility of recycling and reuse.

4.3 Industrial Sector: Some of the important action plans towards the industrial sectors are the following:

- Modernising of industrial process to reduce water requirement.
- Setting-up of norms for water budgeting.
- Recycling water – especially re-circulating cooling system.
- Proper processing of effluents by industrial units to adhere to the norms for disposal.
- Rational pricing of industrial water requirement to ensure consciousness / action for adopting water saving technologies.

5. Water Conservation Possibilities

It is imperative that users from all sectors of water use, stakeholders including state and central governments, agencies, institutions, organizations, NGOs, municipalities, village panchayats, public-sector undertakings and other agencies providing services to the users, may need to be involved for making integrated and continuous efforts for creating mass awareness towards importance of saving and conservation of water, and duties and responsibilities of individuals as well as organizations and institutions towards judicious and optimal use of water. Some of the possible ways for water conservation in industries and domestic and municipal uses are briefly described below (CWC Report, 2005).

5.1 Industrial Use

Some of the important possibilities for water conservation in industry are:

- Using fogging nozzle to cool product;

- Installing in-line strainers on all spray headers; regular inspection of nozzles for clogging;
- Adjusting pump cooling and water flushing to the minimum required level;
- Determine whether discharge from any one operation can be substituted for the fresh water supply to another operation;
- Choosing conveying system that use water more efficiently;
- Handling waste materials in a dry mode wherever possible;
- Replacing high-volume hoses with high-pressure, low volume cleaning systems; equipping all hoses with spring loaded shutoff nozzles; instruct employees to use hoses only when necessary;
- Replacing worn-out equipments with water-saving models;
- Turning off all flows during shutdowns unless flows are essential for cleanup; adjusting flows in sprays and other lines to meet minimum requirements;
- Sweeping and shovelling may be practiced instead of hosing down the floors, driveways, loading docks, parking areas etc; washing cars / trucks / buses less often;
- Avoiding runoff and making sure that sprinklers are used in gardens / lawns

5.2 Domestic and Municipal Use

- Timely detection and repair of all leaks;
- Minimize use of water for all domestic uses such as bathing, brushing, shaving, washing etc. by various means;
- Avoid water wastage in cooking, drinking, washing floors etc.
- Minimum use of water for watering of lawns and gardens;
- Installation of high-pressure, low volume nozzles on spray washers; installation of float controlled valves on the make-up line; washing vehicles less often;
- Use of recycled water.

In case of big establishments like hotels, large offices and industrial complexes, community centres etc. dual piped water supply may be insisted upon. Under such arrangement, one supply may carry fresh water for drinking, bathing and other human consumptions whereas recycled water from second line may be utilized for flushing of human solid wastes. Similarly, water harvesting through storing of water runoff including rainwater harvesting in all new buildings on plots of 100 sq.m and above may be made mandatory.

6. Role of Water Users' Association (WUA) and Water Audit

Water User's Association is an association of water users, generally prevalent in irrigation sector. It is considered that involvement of farmers in water management will facilitate equitable and judicious allocation of irrigation waters among farmers of head, middle and tail reaches and improve collection of water charges from users. It is felt that with improvement in collection of water charges, irrigation projects may not languish for maintenance for want of funds and in this way overall efficiency of irrigation systems will improve. This will help saving of water and optimum utilization of water.

WUA concept of involvement of users in the distribution and management process may also be extended in domestic and industrial sectors of water use. In domestic sector, WUA can help in finding illegal tapping of water from supply lines, identifying leakages and losses and other illegal activities. Similarly in case of industrial sectors, WUA can identify the cases of illegal discharge of industrial effluents to water bodies and help in conservation of water. WUAs may be duly empowered through legalization to punish the errant water users.

Water audit determines the amount of water lost from a distribution system due to leakage and other reasons such as theft, unauthorized or illegal withdrawals from the system and the cost of such losses to the utility. Comprehensive water audit gives a detailed profile of the distribution system and water users, thereby facilitating easier and effective management of the resources with improved reliability. It helps in correct diagnosis of the problem faced in order to suggest optimum solutions. It is also an effective tool for realistic understanding and assessment of the present performance level and efficiency of the services and the adaptability of the system for future expansion and rectification of faults during modernization.

Elements of water audit include a record of the amount of water produced (total water supply), water delivered to metered users, water delivered to un-metered users, water loss and suggested measures to address water loss. Water audit improves the knowledge and documentation of the distribution system, problem and risk areas and a better understanding of what is happening to the water after it leaves the source point. A water audit report may invariably, contain: a) amount of water earmarked / made available to the service; b) amount of water utilized, both through metered and un-metered supplies; c) water loss and efficiency of the system along with reasons for such water losses; d) suggested measures to check water loss and improve efficiency.

An effective water audit report may be purposeful in detection of leak in distribution system, taking timely action for plugging such leaks and thereby reducing conveyance losses of water and improving efficiency of the system. Water audit of the system should be undertaken at regular interval of time, at least on an annual basis.

Water audit is an important management tool for effective conservation of water. Broadly water audit should be conducted categorically in two systems, resource audit or supply side audit and the other one as consumption audit on demand side. All efforts should be made for improvement of not only water use efficiency and distribution system, but also on the efficient development and management of the source of water.

7. Water Conservation Technologies

7.1 Agricultural water conservation

Ninety percent of agricultural water consumption is used for irrigation and the rest is used for forestry, animal husbandry, fishery and drinking water for rural people and domestic animals. Developing highly efficient water conserving agriculture is a fundamental strategy of the country.

7.1.1 Optimizing water dispatch technology for agriculture

Water resources for agricultural consumption consists of precipitation, surface water, underground water, soil water and return water, briny water and regenerated water that has been treated to bring it up to the water quality standard. By means of engineering measures and non-engineering measures, optimizing various water resources is the basic requirement for realizing planned water consumption, water conservation and enhancing the efficiency of agricultural water consumption. Following are some of the techniques for optimizing water for agriculture.

- Actively develop technology to unify dispatching of water from multiple resources. Greatly popularize various agricultural water-consuming projects control and dispatching methods, use surface water with high efficiency.

- Gradually push forward the controls over the total amount and quota management of agricultural water consumption. Speed up setting the total amount indicators for agricultural water consumption for different regions in different precipitation years, setting irrigation water consumption quotas for different plants under different irrigation methods and conditions. Reasonably adjust the water consumption proportion for farming, forestry, animal husbandry, sideline production and fishery.

- Based on the conditions of local water, soil, sunshine and heat resources, and based on the high efficiency and water conservation principle, crops should be decided by water conditions. Reasonably arrange the crop planting structure and irrigation scales.

- Develop the combined irrigation technology of wells and ditches. Popularize and apply unified adjustment and control technology for surface water and underground water. Advocate dual-irrigation from wells and ditches.

- Develop soil moisture and drought supervision and forecasting technology. Actively research and develop soil moisture, drought supervision instruments and facilities.

7.1.2 Highly efficient water transfer and dispatching technology

Agriculture-use water loss during the process of transfer and dispatching occupies a great proportion of water used. It is the main focus of agricultural water conservation to enhance the efficiency of water transfer.

- Give priority in taking anti-leakage measures to ditches and branch ditches that cause great loss and low-efficiency in water transfer.

Advocate overall anti-leakage to fix ditches that are not required to supplement the irrigation water from wells.

- Develop pipeline water transfer technology. When renovating relatively small volume ditches, low-pressure pipeline water transfer and dispatch technology should be given priority.
- Popularize the adoption of low-cost anti-seepage materials. Advocate the use of cement, stones and other local materials.
- Develop anti-seepage ditch cross sectional scale and structure optimization design technology. Large and medium-sized anti-seepage ditches should adopt non-standard cross sections with sloped or arced bottoms. Small ditches should use the U-shaped cross section. Medium and small-scale ditches should use concrete anti-seepage stone laying.
- Develop and apply real-time irrigation forecasting technology.
- Encourage the research, development and popularization of small water measuring facilities that are highly accurate, low in cost, strong in application, easy of operation, and convenient for managing and maintaining.
- Develop ageing prevention technology for water transfer projects. Actively research technologies of ageing prevention for water transfer constructions, disease diagnosis and corrosion prevention, restoration and leakage-blocking technologies.

7.1.3 Field irrigation technology

Field irrigation is the last sector for enhancing the utilization rate of irrigation water. It is also the basis for water diversion, transfer and dispatch. It is the key part of agricultural water conservation for improving field irrigation technology.

- Scientifically control the irrigation factors affecting water volume into the strips (furrows), water intake and irrigation quotas, and the proportion of water volume changes.
- Greatly popularize water management technology that is based on rice-field dry-wet alternate irrigation. Advocate square fields in rice irrigation areas and adopt rice shallow-wet control irrigation techniques. Advocate the combined technique of rice soaking and

tilling. Develop the technique of rice "three-drought" tillage, drought breeding and rarefaction plant and seedlings tossing.

- Suit the development and applications of sprinkler irrigation technique to local conditions. Actively encourage the application of sprinkler irrigation techniques in commercial crop planting areas, suburban agriculture areas and concentrated scaled management areas.
- Encourage the development of micro-irrigation techniques. Widely popularize micro-sprinkler irrigation and drip irrigation techniques in fruit tree planting areas and in areas where agriculture requires facility support, offers quick returns and earns foreign exchange.

7.1.4 Biological water conservation and agronomic water conservation techniques

Biological measures and agronomic measures can help enhance the utilization rate and production rate of water content so as to save on the volume of irrigation. It is a main water conservation measure for agriculture.

- Encourage research into the application of water/fertilizer coupling techniques. Advocate the reasonable application of a combination of irrigation and manure in terms of times, amounts and methods to adjust the fertilizer with water and apply water and mature together so as to enhance the utilization rate of water and fertilizer.
- Advocate water storage and soil moisture preservation techniques such as deep ploughing and loosening, and biological soil nourishment techniques. Improve the soil structure and enhance the water-storage, water-preserving and water- supplying ability of soil.
- In the areas where the soil is light, the ground has a big slope or the amount of precipitation is not great, actively popularize protective ploughing techniques.
- Develop and apply transpiration and evaporation inhibition techniques.

7.1.5 Precipitation and return water utilization techniques

Enhancing the utilization rate of precipitation and the repeated utilization rate of return water can directly reduce the water volume of irrigation. It is the most basic content of the agricultural water conservation program.

- Popularize the utilization technique of precipitation storage. In drought-resistant crop zones, popularize field leveling techniques and improved ploughing techniques that aim to restore natural precipitation.
- Popularize techniques of utilizing return water for irrigation. Actively develop irrigation-drainage unified management techniques. In areas that have no saline and alkaline threat, prohibit ineffective water receding and low-effective drainage irrigation water management techniques. In areas where the quality of irrigation return water is not up to the standard of irrigation water, actively develop the simple "mixed watering of salty and fresh water" irrigation return water safe utilization technique.

7.1.6 Breeding sector water conservation techniques

Developing breeding sector water conservation techniques, enhancing water consumption efficiency in the breeding sector for forage grass irrigation, animal and domestic fowl drinking water, washing water at animal and domestic fowl breeding sites, temperature reduction water and aquatic products breeding water are all important aspects.

- Speed up the development of drought-resistant (drought-enduring) water conservation quality forage grass species selection and breeding techniques.
- Greatly popularize artificial grassland water conservation irrigation techniques. Popularize grassland water conservation irrigation systems. Adapt the development of grassland irrigation ditch anti-seepage liner and pipeline water-transfer irrigation techniques to local conditions.
- Popularize breeding wastewater treatment and repeated utilization techniques. Popularize breeding wastewater re-use technique after anaerobic treatment and the recycling utilization technique after deep treatment and disinfection for washing sties.

7.1.7 Seasonal Variations and Water Conservation

In India, mainly two crops are practiced by the farmers: Khariff crop during monsoon season and Rabi crop during the post monsoon season. In some places, a third summer crop is also practiced. Hence water conservation should be implemented crop wise. Following are some of the suggestions in this regard.

- For the Khariff crops, as monsoon rainwater and other nearby surface water will be available other than the water supplied through canals, the farmers should be encouraged to use the locally available water.
- Promote conjunctive use of surface water and groundwater for the Rabi and summer crops.
- Provide incentives to the farmers who use groundwater/ other nearby surface water/ conjunctive use practices.
- Provide incentives to the farmers who adopt rainwater harvesting techniques in their farmlands.
- Promote modern technologies in irrigation such as drip irrigation/ sprinkler irrigation by giving subsidies/ incentives.
- Provide incentives to the farmers who adopt scientific farming/ irrigation in their fields and use less water for farming.

7.2 Domestic Water Conservation Technologies

For domestic water conservation, large number of methodologies are available and practiced in many places (*discussed in earlier report*). Here some of the latest available technologies are described for the domestic water conservation.

7.2.1 Low-flow sensored faucets

Faucet aerators are so inexpensive and save so much water and money that they are cost effective in nearly all applications. Low-flow (1.9 lpm) faucet aerators can be especially cost-effective in restrooms and kitchen areas in government housing, hospitals, and office buildings.

7.2.2 Low-flow showerheads

Several models have flow rates of 3.8–5.7 lpm or less. A venturi effect is built into the design; this creates a strong spray pattern at a high velocity and low flow rate. And they are especially appropriate for use in hospitals, recreation areas and centers, and prisons.

7.2.3 Horizontal-axis clothes washers

One of the most effective water-saving mechanisms in clothes washers is a horizontal-axis tub or drum. These kinds of machines can clean as many clothes as comparable vertical-axis or "agitator" washers, but with less water. Manufacturers' estimates of the water savings obtainable with horizontal axis washing machines range from one-third to one-half the water and energy used by conventional, vertical-axis machines.

7.2.4 Low flow urinals, toilets and waterless urinals

Water-saving toilets and urinals are efficient because they either (1) reduce the amount of water available per flush, (2) use compressed air to increase the force of the flush, (3) refine the design of the fixture so more waste is washed away per flush, or (4) are completely redesigned, for example, as a composting toilet or waterless urinal. The fourth option can virtually eliminate the need for water to operate the fixture, though some water is usually required to clean it. According to the Rocky Mountain Institute studies in USA, replacing an older conventional toilet that uses 11.4–18.9 lpf (liters per flush) with a low-flush model can reduce residential water use per capita by 30–83 liters per day, depending on the number of uses. Estimates for savings obtainable with waterless urinals range from about 37,854 –170,344 liters of water per unit each year.

For some of the domestic water conservation technologies discussed above, the price range and installation process in the US market is described in the following table 1.

Table 1: Cost Ranges for Domestic Water Conservation Technologies

Technology	Estimated Installed Approximate Average Cost Range	Approximate Average Installed Price
Low-flow sensored faucets	\$100–\$1,300	\$330
Low-flow showerheads	\$15–\$75	\$31

Pressure-reducing valve		$100
Horizontal-axis clothes washer, residential size	$600–$1,000	$850
Water-efficient dishwasher, residential size	$200–$1,600	$700
Low-flush tank toilets	$150–$1,000	$240
Low-flush flushometer toilets	$300–$800	$450
Low-flow urinals	$300–$800	$450
Waterless urinals	$600–$800	

8. Concluding Remarks

- Water conservation is prime and challenging concern. Due to lack of proper operation and maintenance in irrigation, industry and domestic water distribution system, there is huge loss of water. Hence it is emphasized to improve the operation and maintenance.
- For developing the water resources, age-old traditional water conservation methods need to be judiciously adopted in conjunction with the latest modern conservation technology. Rain water harvesting, revival of traditional water storages, check dams and other similar structures need to be adopted. Building byelaws should be suitably modified to introduce mandatory roof top rain water harvesting.
- In order to conserve water, recycling of wastewater may be incorporated wherever feasible.
- Timely and need based irrigation should be done to minimize loss of water.
- Strategic mass awareness campaign should be conducted regularly to cover all stakeholders, including service providers and consumers, for water conservation in irrigation, domestic and industrial sectors.

ANNEXURE - III

(WATER RECYCLING TECHNOLOGIES AND BULK WATER TARIFF)

Annexure-III: Water Recycling Technologies and Bulk Water Tariff

1. Introduction

Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing and groundwater recharge. Water is sometimes recycled and reused onsite; for example when an industrial facility recycles water used for cooling processes. A common type of recycled water is water that has been reclaimed from municipal wastewater, or sewage.

Through the natural water cycle, the earth has recycled and reused water for millions of years. Water recycling, though, generally refers to projects that use technology to speed up these natural processes. Water recycling is often characterized as “unplanned” or “planned”. A common example of unplanned water recycling occurs when cities draw their water supplies from rivers that receive wastewater upstream from those cities. Water from these rivers has been reused, treated, and piped into the water supply a number of times before the last downstream user withdraws the water. Planned projects are those that are developed with the goal of beneficially reusing a recycled water supply.

The water reuse may be for agricultural purposes, industrial purposes or domestic purposes. For agricultural reuse, the wastewater may need to undergo the usual preliminary, primary and secondary treatment steps, generally undertaken to make the wastewater fit for discharge to the environment. For certain industrial reuse, further treatment called tertiary treatment may have to be employed to remove the more residual pollutants, especially the dissolved and refractory (non-biodegradable) substances and micro-organisms depending on the use contemplated.

2. Types of wastewater reuse

Recycled water is most commonly used for non-potable purposes such as agriculture, landscape, public parks, and golf course irrigation. Other non-potable applications include cooling water for power plants and oil refineries, industrial process water for paper mills, carpet dyers, dust control, construction activities etc. The practice of reuse can be grouped under five major groupings as follows.

1. Reuse of urban wastewater in agriculture and horticulture from sewered areas.
2. Reuse of urban wastewater from polluted nallahs draining unsewered areas.
3. Reuse in industrial and commercial establishments to meet the water shortage.
4. Reuse in industry to meet various other objectives besides relief from water shortage such as 'zero discharge'.
5. Reuse for major urban and community development purposes say for example to augment public water supplies.

3. Stages of Wastewater Treatment

Wastewater treatment systems are characterized by the level of treatment they provide.

a) **Preliminary treatment**: This involves removal of heavy solids like wood, rags and grit. This is usually done by passing the inkling wastewater through a screen with bars 25-50 mm apart.

b) **Primary treatment:** This involves slowing the wastewater down. Generally settlement chambers or sedimentation tanks are used for this purpose. In domestic situation, septic tank can be used as a settlement chamber, which may remove about 30-50 % of the BOD and suspended solids.

c) **Secondary treatment:** This process generally known as biological treatment (use of micro organisms) removes the remaining BOD and suspended solids. During the later stage of secondary treatment, the nitrification process begins. This is when the ammonia present in the waste water is transformed into nitrate.

d) **Tertiary treatment:** Tertiary treatment involves, taking the wastewater through a further biological, physical or chemical steps. This involves further removal of BOD, suspended solids, nitrogen, phosphorous and pathogens. Fig.1 shows the treatment methods in tertiary treatment.

Tertiary treatment for industrial reuse is usually done by using mechanized, physio-chemical processes selected out as given below.

- Activated carbon treatment (powdered or granular)
- Chemical oxidation and other advanced oxidation processes

- Multi-media filtration
- Softening (lime soda or zeolite)
- Demineralization (ion exchange)
- Disinfection (chlorine, hypochlorine, ozone, U-V)
- Membrane processes (microfiltration, ultrafiltration and reverse osmosis).

Generally, the tertiary treatment can also be provided by using ‘natural systems’ of treatment such as ponds, lagoons, constructed wetlands, and such methods where adequate extent of land is available. However other than few agro-industries located in rural areas, land availability is a big problem, thus forcing industries to adopt mechanized methods.

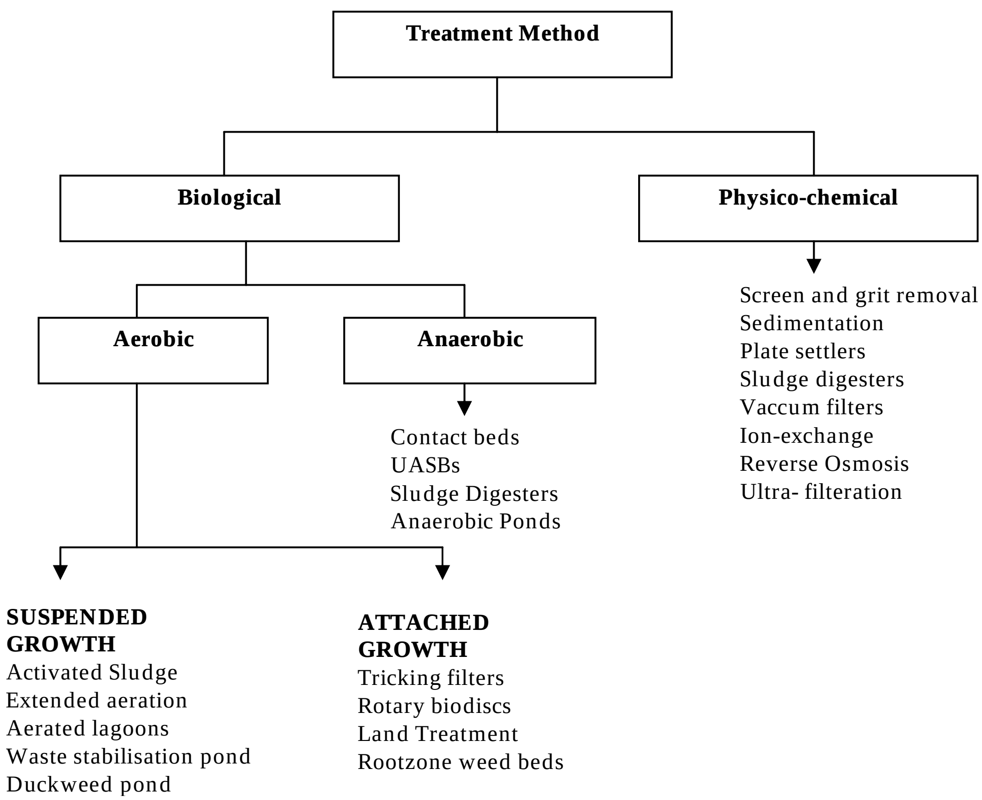

Fig.1: Tertiary treatment methods

The conventional waste water treatment systems using biological processes can remove around 90-95 % BOD (Biological Oxygen demand), COD (Chemical Oxygen Demand), coliforms and sediment solids. When greater removals approaching 99% or more are required, the use of one or more of the above discussed tertiary treatment systems are necessary. Also when substances such as dissolved solids, trace organics, nitrogen, phosphorus etc., may need to be removed, appropriate tertiary systems may be used.

4. Overview of Water Recycling Practices

Water recycling is a growing practice in many regions of the world including USA, Western Europe, Australia, Israel etc. An estimated 13 million m^3/d is reused in USA, which is only a small fraction of the total volume of wastewater generated. Thus out of the 132 million m^3/d, only about 9.7% of wastewater is recycled, suggesting the potential of recycling (USEPA, website). Recycled water use on a volume basis is growing at an estimated 15% per year in the US. All evidences suggest that water recycling will play an expanded role in the water management in the 21st century. In US, at a compound annual growth rate of 15%, the volume of recycled water would amount to 45 million m^3/d by the year 2015.

In many states in the US, agricultural reuse is mandatory wherever tertiary treatment is required before disposal. Similarly for industries, the National Association of Manufactures, USA reported from a survey some years ago that the potential for reuse in industries existed as given in Table 1 (Arcevala and Asolekar, 2007). According to this survey, the scope of reuse lay from 15% to as much as 52% mostly from the direct reuse of cooling waters and wash waters. The survey also reported that over 3000 plants reused their wastewaters and a few plants used municipal sewage after necessary treatment for reuse.

Table 1: Potential for direct reuse in industries in USA (National Association of Manufacturers, USA)

Industry	Water reuse potential (%)
Pulp and paper	52
Chemicals and drugs	35
Automobile	25
Iron and steel	25
Food and beverage	22
Non-ferrous metals	18
Textiles	15

In India, presently water recycling is not so common. However, some of the Industries and Hotels have started to reuse wastewater after suitable treatment. Presently in India, some of the methodologies adopted include (Arcevala and Asolerkar, 2007):

- Plain water conservation
- Reuse without any treatment
- Reuse after treatment using on-site toilet waters and some easily treated industrial wastewaters
- Reuse after treatment using off-site sources of municipal wastewater

A study of the reuse of waste water in India shows that the reuse has achieved in affordable costs and some industries have in fact, saved money by reusing their wastewaters.

5. Reuse in Industries

Generally, the objective of industrial reuse is to meet chronic water supply shortages. In most of the cases, the solution usually starts with simple water conservation (just careful usage) and follows the principle that the greater the extent of reuse one wants, the higher the degree of treatment that will need to be given. The typical strategy followed by most of the industries is as follows:

- Firstly, practice as much conservation of water as possible.
- Secondly, recycle the fraction of waste water which is in relatively good condition and can be recycled back with little or no treatment.
- Thirdly, arrange more 'reuse' after some treatment to make the industry's own wastewater fit for reuse.
- Lastly, if more reuse is needed, get the external sources of wastewater, such as municipal sewage.

6. Review of Water Recycling in India

1) *Direct reuse in Industries without Treatment:* In India, water recycling has first begun in Mumbai in 1964-65, by textile industry, when it was shown that nearly 15-20 % of water can be recycled without any pre-treatment (Arceivala, 1998). The cost of providing direct reuse was relatively small say holding tanks, pumps and pipes. Hence the cost / benefit ratios are fairly high and cost recovery periods is low. The recycling was carried out in as many as 22 mills of Mumbai and later few more industries started recycling.

2) *Reuse in Commercial Buildings Using on-site Sources of Wastewater:* In Mumbai, due to water shortage, many of the large commercial establishments started water recycling in 1970s, by reusing their toilet waters after suitable treatment to produce good quality water to meet cooling system requirements. The Air India Building in Mumbai was the first one to treat the building's toilet waters for reuse as cooling water for centralized air-conditioning system. All over India, about 30 plants of similar type have been built (Arceivala, 1998). A typical treatment scheme for toilet waters for reuse in cooling water make-up is as follows: *Wastewater -> Screening -> Extended aeration -> Chemical dosing + Flocculation -> Sand filtration -> Zeolite softening + acid correction + occasional chlorine shock dose -> make-up water to cooling towers.* The sludge and other wastewaters were returned to the municipal sewer line.
3) *Reuse in Large Industries after Treatment:* In Industries where large volumes of reuse water are required, other than using their own resources, wastewater has to be obtained from off-site sources such as city sewers. This may necessitates complicated treatment systems depending on the nature of the wastewater and reuse proposed. The examples of four large industrial reuse are described in the following sections.
    a. *Oswal Agro (Union Carbide Plant), Chembur, Mumbai:* This was the first tertiary treatment plant to be built in India in 1968-69 for sewage water reclamation with capacity of 5 Mld with a scope to expand to 10 Mld. The raw sewage was obtained from Mumbai Municipal Corporation at a nominal cost. The sewer was considered as a dependable source of water. The treat water was used for cooling purpose (Arceivala, 1998). The treatment scheme include the following: *Wastewater -> Screening -> Grit removal -> Extended aeration -> Chemical dosing + Flocculation -> Sand filtration -> Zeolite softening + acid correction + occasional chlorine shock dose -> make-up water to cooling towers.* The scheme was very economical and the reuse plant met the industry's water requirement for many years until industry itself closed down.
    b. *Rashtriya Chemicals & Fertilizers (RCF) Plant, Chembur, Mumbai:* RCF has a water reuse plant of 23 Mld capacity built in 2000 with a plant cost of Rs. 40 crores. It has a more complicated treatment process including reverse osmosis because the municipal sewage is

more polluted with various industrial wastes. In 2005, the operating cost was Rs. 39 per m^3. With the passage of time and the success of recycling schemes, the Municipal charge levied also became higher at Rs. 6/- of m^3 raw wastewater. The plant in RCF has the following flow sheet (Arceivala and Asolekar, 2007): *Wastewater -> Screening -> Grit removal -> Activated Sludge System -> Clarifier -> Sand Filter -> Pressure Filter-> Cartridge Filters ->Reverse Osmosis -> Degasser to Remove CO2 -> Reuse in Industry.*

c. *Madras Refineries Ltd. & Madras Fertilizers Ltd., Chennai:* Chennai is perennially short of water and due to the heavy shortage of water, Madras Refineries is producing 12 Mld of reusable water and Madras Fertilizer is producing 16 Mld of reusable water since 1991. Here the Chennai Metro Water Board supplies secondary treated sewage (with about 120 mg/L BOD) and the Industries provide the further required treatment depending on their end-use. The treatment include the following: *Secondary Treated Wastewater -> Additional Secondary Biological Treatment -> Chemically Aided Settling + Pressure Filtration + Ammonia Stripping, Carbonation, Clarification, Pressure Filtration-> Chlorination -> Sodium Bisulfite Dosing -> Multimedia Filtration -> Cartridge Filtration ->Reverse Osmosis -> Permeate for Reuse in Industry.* The rejects containing high TDS are disposed to the sea through a submerged outfall. In 1991, the capital cost of MRL was Rs. 24 crores. The operating are reported to be about Rs. 35/- per 1000 litres (against Rs. 60 per 1000 litres for fresh water supplied to Industries). The Metro Water Board charges Rs. 5.20 per 1000 litres to cover the initial treatments.

d. *Vadodara Pilot Plant, Gujarat:* This plant uses highly polluted wastewater from a “effluent disposal channel” into which several industries (such as refineries, fertilizers, petrochemicals) discharge their raw wastes with a capacity of 3 Mld freshwater. The plant shows that at least 75% of wastewater could be made reusable at an operating cost of Rs. 36/ 1000 litres. The flow sheet adopted in the plant include: *Wastewater -> Chem-feeds (Lime, Polyelec, Soda Ash) -> Clarification-> HCl -> Pressure Filtration -> Sodium Biosulfite -> Cartridge Filters ->Reverse Osmosis -> Degasser to Remove* CO_2 *-> for Reuse in Industry.*

7. Benefits of Water Recycling

Recycled water has numerous benefits, including a local dependable water supply that is drought resistant and under local control, reduction of treated wastewater discharge to sensitive or impaired surface waters, reduction of imported water and avoided costs associated with importing water; environmental benefits and that it represents a sustainable water resource. Recycled water can also be used to create or enhance wetlands and riparian habitats. Some of the other specific benefits include:

- Conservation of other resources besides water (e.g. steam recovery because both water and heat are recovered; Chromium removal from leather industry).
- Reuse at little extra cost over that required for pollution abatement.
- Savings on water abstraction costs and on "Cess" charges
- Reduced dependence on vagaries of river flows.
- Gaining tax advantages in arid and designated zones.
- Reduction in effluent discharge volume (even approaching "Zero" discharge).

For example, the following flow sheet for treatment can be used to achieve "zero" discharge in a textile industry, depending on water requirement.

Textile wastewater -> Chemical Dosing + Clarifier -> Aeration-> Tube-settlers -> Pre-treatment + Cartridge Filter -> Reverse Osmosis -> Recycle to Process.

8. Methods of Treating Wastewater

8.1 Conventional way of Treating Wastewater

The conventional treatment methodologies are suitable for small scale wastewater treatment such as domestic / hotels / small scale industries etc. Following are some of the commonly used technologies for small scale wastewater treatment.

a) *Cesspools (Containment, decentralized)*: A cess pool is a big tank of at least 18 cubic metres. It has an inlet but no outlet. Cesspools do not treat wastewater, but simply store it until it is removed by a sludge tanker. In places where the location is unsuitable for discharging effluent and where no stream or river course is available, cesspools are the main conventional solutions. Due to the environmental pollution especially to groundwater, cesspools are not preferred in the urban environment.

b) *Septic tanks (primary treatment, decentralized):* Unlike cesspools, septic tanks have both an inlet and outlet. They are much smaller because they retain only the amount of sewage generated in a day. Septic tanks are suitable for small scale waste water treatment and they can be adopted for domestic/ hotels sewage treatment. Septic tanks provide primary treatment and so should be followed by a soak pit or leach field.

c) *Leach fields (Secondary, tertiary and dispersal– centralized/ decentralized):* A leach field is the last stage of a conventional treatment system. It is usually preceded by a septic tank and this combination is often referred to as a 'septic tank system'. A leach field is a series of perforated pipes, surrounded by gravel, that run in underground trenches. With a well designed leach field in suitable soil, the wastewater is thoroughly cleaned by passing it through a one-metre thick layer of soil.

d) *Waste stabilization ponds (all stages possible, centralized/ decentralized):* These are also known as solar ponds, settlement ponds, lagoons or sewage ponds. It may be with a small anaerobic pond in the beginning, followed by larger aerobic ponds. These ponds are placed in tandem with reed beds, making system more attractive. For this type of system, a large surface area is required to ensure sufficient treatment.

e) *Constructed wetlands (centralized/ decentralized):* These are human made wetlands, developed in areas where they do not occur naturally. Treatment of wastewater in wetlands is a relatively recent technology. The constructed wetlands can be designed to closely imitate the treatment functions that occur in a natural wetland ecosystem. They operate on ambient solar energy and require low external energy input.

f) *Duckweed pond (centralized/ decentralized):* Duckweed is a green coloured small plants which grows in sewage holding ponds. The weeds feed on the organic elements in the wastewater for growth. A duckweed-based sewage treatment plant could often be in the form of a single pond, which may be used for the treatment of low-strength community wastewater. It function as an anaerobic pond except in the top layer where aerobic conditions prevail. The duckweeds create an environment for treatment, but contribute very little directly to removal of BOD. Duckweeds help in removing nutrients and heavy metals by absorbing nitrogen, phosphorous, sulphur and trace elements.

g) *Trickling filters (secondary treatment, decentralized):* Trickling filters are always preceded by a primary settlement stage, usually a septic tank, and followed by a humus tank. They are also known as percolating filters, biological filters and filter beds. A trickling filter is a container, usually filled with blast furnace clinker or stones, called as media. Sewage is distributed over the surface of this media and drains freely to the base. The method is relatively robust, tolerant of peak loadings and does not require power, if a fall is available.

8.2 Improvised way of Treating Wastewater

a) *Decentralized Wastewater Treatment Systems (DEWATS):* DEWATS is based on different natural treatment techniques, put together in different combinations according to need. In this method, the reed bed system acts as a secondary treatment unit, which is preceded by baffled reactor where most of the treatment takes place. In the DEWATS, both anaerobic and aerobic techniques are applied. Its applications are based on four basic treatment modules, which are combined according to specific requirements. The modules are: i) pre-treatment and sedimentation in settlement tank or in septic tank; ii) secondary anaerobic treatment in baffled reactors; iii) post-treatment aerobic/ anaerobic treatment in reed bed system; iv) post treatment aerobic treatment in ponds. In India, DEWATS is practiced by the Auroville Centre for Scientific Research (CSR), Pondicherry.

b) *Soil biotechnology (SBT):* SBT involves removal of organics by adsorption followed by biological degradation (conversion to CO_2) and oxygen supply by natural aeration. The suspended solids are removed by filtration as the wastewater travels in the soil media. Dissolved solids are removed by filtration and biodegradation. The under drain serves as a liquid hold up media and additives provide sites for chemical and biological transformation. The SBT requires low operation and maintenance costs. This technology was developed by Prof. Shankar of IIT Bombay.

c) *Soil aquifer treatment (SAT):* The process of purifying and reclaiming water by allowing it to pass through the soil and aquifer is referred as SAT. In SAT systems, the soil layer above the aquifer acts as a natural filter that removes the pollutants and other impurities from the wastewater by physical, chemical and biological processes, as it moves down to the groundwater.

d) *Rotary biological contactors:* Also called bio disks, these hold a series of high surface area plastic discs, mounted on a horizontal shaft driven slowly by a motor a bio film develops on the surface of the disks which dip into the sewage. As they turn, the bio film is exposed to air, providing oxygen for aerobic degradation of the sewage.

e) *Activated sludge package plants:* These units make use of several processes commonly used in large-scale municipal treatment works. It involves blowing air bubbles through the incoming sewage. The oxygen is rapidly used to degrade organic matter and this process creates a slurry which contains micro organisms in the most rapid phase of growth, and ideal for sewage breakdown.

8.3 Additives for treating wastewater

a) *Biosanitiser:* The idea of treating wastewater using biosanitizer or biocatalyst was developed by Dr. Udai S. Bhawalakr at IIT Bombay, in 1996. The biocatalyst included two products namely Vermi++, and Sujala. As claimed by the inventor, these products are for one time use, once incorporated in the system; they stay inside the treatment unit and treat the wastewater. This is used for small scale water recycling such as domestic/ hotels where the water from kitchen, bathroom and toilet can be cleaned and recycled for gardening or irrigation purpose. The technology is very cheap with approximately Rs. 400/- for one time, say for a family of 5 members.

b) *Effective micro organisms (EM):* It denotes a liquid mixture of several micro organisms in a molasses based medium. It was developed by Prof. Tero Higa, Ryukyus University, Japan in 1982. EM contains micro organisms which are mostly used in food processing like lactobacilli. The product in the market is a liquid in a one-litre bottle costing approximately Rs. 200/-. It is to be activated with the help of a sugar solution. One litre of EM solution can treat upto 200,000 litres of effluent depending on the effluent. This technology is used by many industries including rubber, textile, tanneries etc.

c) *Bioclean:* It involves treating the industrial effluent using naturally occurring bacteria in soil. Each gramme of the product contains up to four billion microbes and there are up to 76 different strains of bacteria in each

Bioclean product. These microbes increase the efficiency of treatment plants without the need for increasing its capacity. This technology is developed and promoted by Organica Biotech, a Mumbai based company.

8.4 Modern technologies for treating wastewater

a) Upflow anaerobic sludge blanket reactor (UASBR): This technology is manufactured by Naik Environmental Engineers, Mumbai. The treatment plant is shop assembled and it is a skid mounted package unit and requires minimal civil construction works. A sludge blanket cultured in the lower portion of the UASBR very effectively traps suspended and dissolved organic matter. The Rotating Biodisc Contactor (RBC), which is the second unit in the series, takes the atmospheric oxygen. An attached growth anoxic reactor is built into the upper portion of the UASBR for conversion of nitrites and nitrates into nitrogen gas. The entire operation is simple and the system once stabilized, can be left to itself without much human intervention. The treated water may be used for irrigation purpose, depending on the nature of the waste water. This system is used by many small scale industries in India now.

b) Cyclic activated sludge process (c-tech): The c-tech is a cyclic activated wastewater treatment process whereby carbon oxidation, nitrification, denitrification and bio-phosphorous removal are carried out simultaneously. This technology ensures that all the effluent processes like equalization, aeration, settling and decanting are carried out in a single tank. Most importantly the system treats the effluent to a level specified by authorities for irrigation or discharge into open water sources like rivers. The treated effluent has the characteristics such as BOD< 30 mg/l, COD<150 mg/l and ammonia nitrate less than 5mg/l etc. The system is marked by Ion Exchange company in India and used by many small scale industries. The technology is automatic and found to be economical.

c) Submerged aerobic fixed film process (SAFF): The SAFF reactor comprise PVC fill media that facilitate attached fixed film growth of the micro organisms. The aerobic environment in the SAFF reactor is achieved by using fine bubble diffused aeration. After some time, the treated wastewater overflows into a clarifier where the sludge and treated water separate. The clarifier consists of specially designed tubular synthetic media with the property of enhanced settling rate and hence reduced size of the unit over a conventional clarifier. The settled sludge passes on to an aerobic sludge digestor-cum-thickner. The clarified water is then let to the chlorinated contact tank. The chlorinated water is further filtered in pressure filter to remove suspended matter. This ensures complete and safe effluent having zero BOD and suspended solids less than 5mg/l. The treated water can be used for the make up water in cooling towers and for horticulture.

d) Fluidised bioreactor (FAB): The FAB reactor is based on the concept of suspended growth as well as attached growth processes. The media has a specific gravity less than that of water. Hydraulic currents set by aeration facilitate fluidisation of the media. The advantages of the system include: no moving parts, wide treatment range (25 – 20,000 cub.m/ day), no sludge recycling required and totally closed system for small capacities. The technology is ideal for treating the sewage from municipalities, hotels, hospitals, IT parks and commercial complexes.

9. Membrane Processes

Membranes are semi-permeable materials designed to separate particulate, colloidal and dissolved substances from liquid solutes. Essentially, they allow substances smaller than the membrane pores to flow through, while holding back substances larger than the pores.

The use of membrane technologies in wastewater was earlier mainly limited to reverse osmosis. Due to the development in polymer chemistry in the last few years, a variety of membranes are now available including “membrane bioreactors”. In many countries such as US and European countries, more stringent public water supply requirement make the use of membrane processes, increasingly necessary. Moreover, the membrane technologies are being increasingly considered where reuse of the treated wastewater is envisaged. Membranes are produced from a wide variety of materials such as cellulose acetate, polyamides, polysulfones, polypropylene, nylon, polyvinyl alcohol etc. They are manufactured to remove down to the smallest desired material which is normally stated as molecular weight cut-off. The four most common configurations are: tubular, plate and frame, spiral wound and hollow fibre. Of these, the hollow membranes are the most commonly used in water recycling, because they have the highest membrane surface area for a given footprint. Membrane replacement is generally required every 3-5 years.

Membrane systems are generally all pressure systems and for wastewater treatment, they are divided into four classifications depending on their pore size and molecular weight cut-off as: Microfiltration, Ultrafiltration, Nanofiltration and Reverse Osmosis.

Microfiltration (MF): MF membranes (pores > 50 nm (nano-metre)) are the least expensive membranes and have been used in wastewater treatment for turbidity removal, solids separation after biological treatment, as in Membrane Bioreactors (MBRs), removal of helminth ova, other organisms etc. Operation pressures are generally below 350 kPa. Their flux rates average between 400-1600 $L/m^2/d$. They are often used in MBRs for producing recycled water for non-potable purposes.

Ultrafiltration (UF): UF membranes (pore sizes 2-50 nm) have been used in wastewater treatment for many of the same applications as MF membranes except that UF systems give a better separation of finer colloids, bacteria, viruses etc. They are also used in MBRs to separate bio solids after activated sludge process. Operating pressures vary from 350-690 kPa and flux rates vary from 400-600 $L/m^2/d$.

Nanofiltration (NF): In NF membranes, the pores should be less than 2 nm. The pressures vary between 520-1400 kPa and flux rates vary from 200-800 $L/m^2/d$. They are used in water purification for potable purpose and can remove viruses. They are often used to treat waters pre-treated by microinfiltration or ultrainfiltration to produce waters for indirect potable reuse applications such as groundwater injection.

Reverse Osmosis (RO): In RO systems, the membranes have pores < 2nm and have the lowest molecular weight cut-off. They require a relatively high operating pressures of > 1400 kPa and flux rates vary from 300 – 500 $L/m^2/d$. They are used in desalination operations to remove ionic species from solution. They also remove sodium, nitrates, sulphates, heavy metals etc. RO can be used in further treating of waters pre-treated by MF and UF to produce waters of high quality for indirect reuse applications.

10. Modern Technologies for Recycling by Industries

As discussed above, a number of technologies are available for wastewater treatment. However the modern technologies used by Industries for recycling of wastewater include: Combined biological and physico-chemical methods (conventional), Ultrafiltration technology, Membrane Bioreactor (MBR), Reverse Osmosis (RO) and Ultraviolet (UV) disinfections. A brief description of these modern technologies and there uses are discussed in the following sections.

10.1 Combined Biological & Physico-Chemical Method

A combination of biological and physico-chemical methods has to be used where a high quality of reusable water has to be produced. The biological treatment methods generally include activated sludge method or one of its modifications. The effluent is further treated by physico-chemical methods such as activated carbon, multi media filtration, zeolite softening, pH correction etc. The flow sheet of a typical combined biological and physico chemical method (conventional method) include the following:

Wastewater -> *Biological Treatment (activated sludge + clarification and sludge return)* -> *Alum dosing* -> *Clarification* -> *Sand Filtration* -> *Softening* -> *Chlorination* -> *Reuse.*

The typical flowsheet for a conventional treatment with Combined Biological & Physico-chemical method is shown in Fig.2.

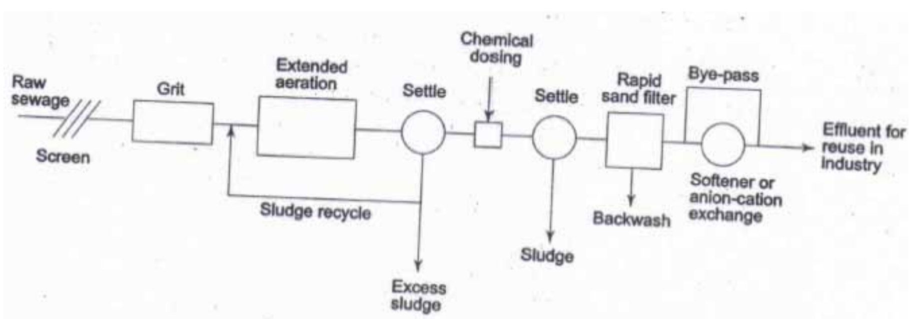

Fig.2: Typical Flow sheet of combined biological and physico-chemical for non-potable reuse.

10.2 Ultrafiltration Technology

Ultrafiltration is nowadays used in conjunction with biological treatment to give a very high quality water for reuse. Biological treatment along with ultrafiltration simplifies the flowsheet by replacing all the clarification, sand filtration and other units. This gives a much reduced footprint and simplicity in operation. It provides a more positive means of solid-liquid separation by preventing any loss of solids in the effluent, and therefore allowing a high concentration of biomass (MLSS) to be built up in the reactor. This gives a longer time for the bio solids (SRT) which enables a more complete bio-degradation to occur. With ultrafiltration, complete disinfection as well as removal of micro-pollutants are achieved which is particularly useful for recycling. A simplified flow sheet with ultrafiltration would be as follows.

Wastewater -> Preliminary Screening, Grit removal, oil separation -> Activated Sludge, Extended Aeration -> Ultrafiltration module -> Permeate to Storage -> Water Recycled for use -> Solids Recycled Back to Reactor.

The typical flowsheet with ultrafiltration is shown in Fig.3.

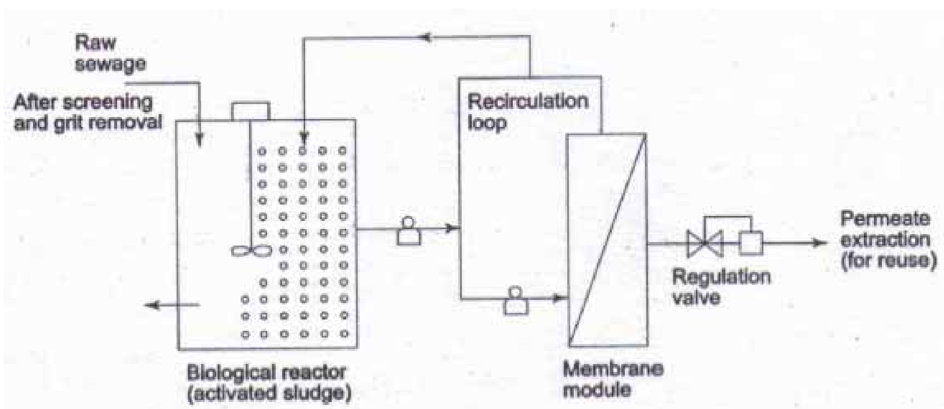

Fig.3 Typical Flow sheet of biological treatment with ultrafiltration unit

10.3 Membrane Bioreactor (MBR)

Membrane bioreactor is designed to produce high quality treated water from wastewater. It is available in standard and customized modules to treat domestic sewage and industrial effluent. The characteristics of the MBR process is the use of revolutionary submerged membranes in the biological process water tank. Some MBRs incorporate the MF system (e.g., Kubota, Mitsubishi, US filter, Siemens) while some others (e.g., Zenon) incorporates the UF system. MBR using UF system give a better final water quality than those using MF system.

Compared to the conventional system discussed in section 10.1, MBR required only one fourth space. The typical flow chart for MBR include:

Wastewater -> Biological Treatment (aeration only) + MF or UF -> Reusable water

The use of microfiltration or ultrafiltration systems has simplified the flow sheet by replacing all the clarification, sand filtration and other units. The membrane is used instead of the clarifier to separate the solids from the liquid so effectively that sand filtration and other steps become unnecessary and the foot-print of the plant is greatly reduced. The membrane step provides a positive means of liquid-solid separation after biological treatment by preventing any loss of biological solids in the effluent and therefore allowing a high concentration of biomass to be held in the reactor. Longer solids retention time is obtained which enables more complete bio-degradation of pollutants to occur. Sludge production is thus reduced. With MBR, complete disinfection of wastewater can be achieved, together with removal of micro-pollutants, which is particularly useful for reuse applications. Cleaning of MBR is done in two steps: first is called 'maintenance cleaning' and is done automatically every 10-15 minutes to manage membrane fouling and minimize permeability decline and this is done automatically. The second is called 'recovery cleaning' and is done once in a few months using chemicals to restore permeability. Fig. 4 shows a typical schematic of a MBR system. Fig. 5 shows a typical module of MBR.

MBRs are increasingly being used in USA, Europe, Japan and Australia to give tertiary treatment to municipal sewage and industrial wastewater to produce high quality effluents for reuse of water. The capacity of MBR may vary from 5 Ml/d to 45 Ml/d.

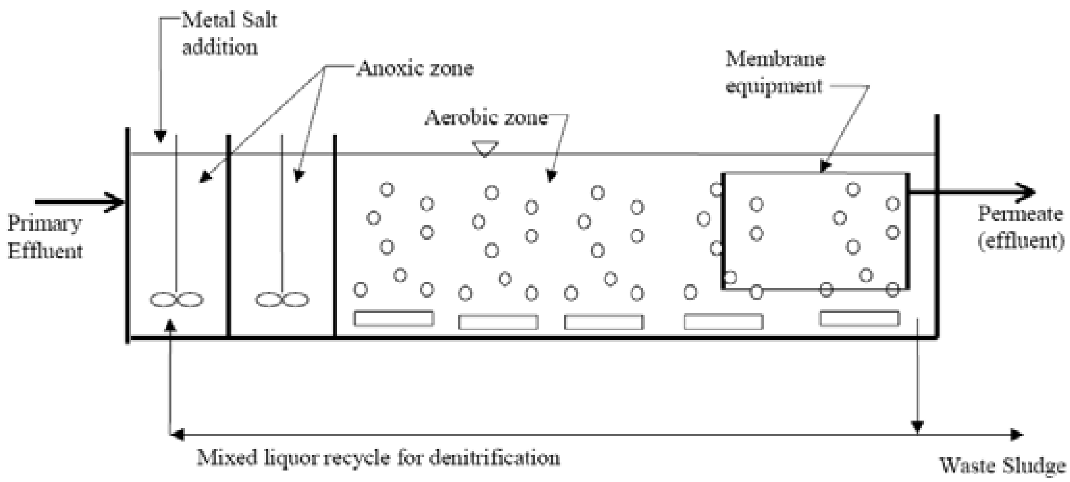

Fig.4 Typical schematic for MBR System

In India, Zenon has installed MBR in Bangalore to treat municipal wastewater for reuse in 2005. Other manufacturers also supply similar MBR units. Ion Exchange, Mumbai, India, supply MBRs with MF or UF according to requirements of industries or domestic users. Various studies on MBRs show that the cost of the system can be recovered in less than 3 years.

Fig.5 Typical MBR module

10.4 Reverse Osmosis (RO) System for Water Recycling

Reverse Osmosis is generally required where microfiltration and ultrafiltration are not adequate for the purpose. Generally, MF and UF are often used to give pre-treatment to wastewaters to prepare them for application to RO system. The RO can give adequate treatment to pre-treated wastewaters to make them fit for reuse in high-pressure boilers and for various non-potable uses/ reuses in industry. RO units are really required where Total Dissolved Solids (TDS) are to be reduced. Their use in treating brackish waters and sea waters is well known. The flow sheet for RO is as follows.

Wastewater -> Conventional pre-treatment -> Pre-treatment by UF -> Reverse Osmosis system -> Permeate aerate / stabilized as necessary -> Reusable water

For RO system, the membranes are made from cellulose acetate or polyamides or other materials and have flux rates and operating pressures as mentioned earlier in section 9. Due to high pressure in RO, special manufacturing techniques are to be adopted and manufacturers ascertain the extent of pre-treatment. The power requirement in RO is about 10 kWh / cub.m.

In India, a large number of RO systems are being installed at various parts of the country for last 25 years. Most of these plants produce feed water for high-pressure boilers while few of them produce water for reuse, where so called "zero" discharge is required.

10.5 Ultraviolet (UV) Disinfection

Disinfection is considered to be the primary mechanism for the inactivation / destruction of pathogenic organisms. It is important that wastewater be adequately treated prior to disinfection in order for any disinfectant to be effective. An Ultraviolet (UV) disinfection system transfers electromagnetic energy from a mercury arc lamp to an organism's genetic material (DNA & RNA) and destroys the cell's ability to reproduce. The effectiveness of a UV disinfection system depends on the characteristics of the wastewater, the intensity of UV radiation, the amount of time the micro organisms are exposed to radiation, and the reactor configuration. For any one treatment plant, disinfection success is directly related to the concentration of colloidal and particulate constituents in the wastewater.

The main components of a UV disinfection system are mercury lamps, a reactor, and ballasts. The source of UV radiation is either the low-pressure or medium pressure mercury arc lamp with low or high intensities. The optimum wavelength to effectively inactivate micro organisms is in the range of 250 to 270 nm. The intensity of the radiation emitted by the lamp dissipates as the distance from the lamp increases. There are two types of UV disinfection reactor configurations that exist: contact types and non-contact types. In both types, wastewater can flow either perpendicular or parallel to the lamps. Fig. 6 shows two UV contact reactors with submerged lamps placed parallel and perpendicular to the direction of the wastewater flow. Flap gates or weirs are used to control the level of the wastewater.

Some of the advantages of UV disinfection include: it is effective at inactivating most viruses, spores and cysts; UV disinfection is a physical process rather than a chemical disinfectant; there is no residual effect that can be harmful to humans or aquatic life; it is user friendly, needs short contact time and required less space than other methods. The disadvantages include: pre-treatment required; low dosage may not be effective and turbidity and suspended solids may make UV disinfection ineffective. Siemens, Germany offers a wide range of UV disinfection system for wastewater recycling.

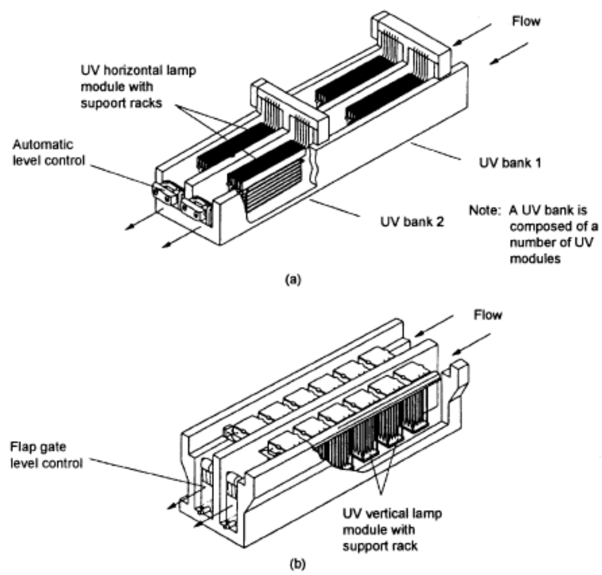

Fig. 6: UV Contact reactors configuration with submerged lams places parallel and perpendicular to the direction of flow

11. Water Recycling Modern Technologies – Feasibility, Costs and comparison

11.1. Conventional Technologies

1) Conventional Wastewater Treatment (activated sludge process):

a) Area requirement in sq.m per mld (daily flow): 400 to 1000 (depending on size)
b) Capital investment per mld – Rs. 23 – 60 Lakhs/- (depending on size)
c) Operation and maintenance cost per cum – Rs. 0.40 to 2.5/- (approx.)
d) Technical Feasibility – Applicable for recycling of both 'grey' and 'black' municipal/ domestic wastewater.
e) Implementing Agency: Different components by different agencies
f) Case study examples: Large number of cases implemented – (e.g. Textile Mills in Mumbai; Air India Building, Mumbai; treated water used for reuse).

2) DEWATS (Decentralized Wastewater Treatment Systems):

g) Area requirement in sq.m per cum (cubic meter) (daily flow):10 to 12
h) Capital investment per cum – Rs. 25,000 - 50,000/-
i) Operation and maintenance cost (annual) – Rs. 1000/- (approx.)
j) Technical Feasibility – Applicable for recycling of both 'grey' and 'black' municipal/ domestic wastewater.
k) Implementing Agency: Centre for Scientific Research, Pondicherry
l) Case study examples: About 50 cases implemented – (e.g. Arvind Eye Hospital, Pondicherry – investment: Rs. 1.2 Crores; Capacity about 300 Cum/day; treated water used for irrigation).

3. Cyclic Activated Sludge Process (c-tech):

a) Area requirement in sq.m per Mld : about 50% conventional sewage treatment plants.
b) Capital investment per cum – Rs. 10,000 - 20,000/-
c) Operation and maintenance cost per cum – about 50% conventional sewage treatment plants.
d) Technical Feasibility – Applicable for recycling of domestic/ industrial wastewater.

e) Implementing Agency: Ion Exchange India
f) Case study example: (e.g. Manav Breweries, Ghaziabad, First in India – investment: Rs. 1 Crore; Capacity about 1200 Cum / day in four cycles of six hours each per day; treated water used for irrigation / discharged to streams).

11.2. Modern Technologies

1) Reverse Osmosis:

a) Area requirement in sq.m per cum (cubic meter) (daily flow): depends on total capacity
b) Capital investment: Rs 8 to 20 / lpd (Capacity>500,000 lpd)
c) Operation and maintenance cost per cum – Rs 10-20/- (approx.)
d) Technical Feasibility – Applicable for recycling of all types of wastewater including brackish and sea waters.
e) Implementing Agency: Various agencies supplying membrane technologies, as mentioned below.
f) Case study examples: Large number of examples – (e.g. RCF Chembur, Mumbai – investment: Rs. 40 Crores in 1998; Capacity about 23 Million liters / day; treated water used for all industrial use).

2) Ultrafiltration:

a) Area requirement in sq.m per cum (cubic meter) (daily flow): depends on total capacity
b) Capital investment: Rs 10 to Rs 20 / lpd (depending on the total Capacity)
c) Operation and maintenance cost per cum – Rs. 5 - 10/- (approx.)
d) Technical Feasibility – Applicable for recycling of all types of wastewater for industrial reuse.
e) Implementing Agency: Various agencies supplying membrane technologies, as mentioned below.
f) Case study examples: Large number of examples all over the world.

Note: BARC Mumbai also recently developed an ultrafiltration technique for water recycling (Head, Technology Transfer & Collaboration Division, BHABHA ATOMIC RESEARCH CENTRE, TROMBAY, MUMBAI - 400 085).

3) Membrane Bioreactor (MBR)

a) Area requirement in sq.m per cum (cubic meter) (daily flow): depends on total capacity
b) Capital investment: Rs 15 to Rs 35/ lpd (depending on the total Capacity)
c) Operation and maintenance cost per cum – Rs.15 -25 /- (approx.)
d) Technical Feasibility – Biological treatment with membrane separation; Exceptional treatment efficiency with reduced foot print; Applicable for recycling of all types of wastewater for industrial reuse with high quality output.
e) Implementing Agency: Various agencies supplying membrane technologies, as mentioned below.
f) Case study examples: Large number of examples all over the world – (e.g.Nordkanal, Germany with 45 Ml/d; Bangalore Development Authority, Bangalore).

4) UV Disinfection:

a) Area requirement in sq.m per cum (cubic meter) (daily flow): depends on total capacity
b) Capital investment: Rs 5 to Rs 10 / lpd (depending on the total Capacity)
c) Operation and maintenance cost per cum – Rs. 2 - 5/- (approx.) (this does not include the costs of other treatments)
d) Technical Feasibility – Powerful disinfection solution without chemicals; Applicable for recycling of all types of wastewater for industrial reuse with high quality output.
e) Implementing Agency: Siemens, Germany, Hatch Mott MacDonald, USA etc.
f) Case study examples: Large number of examples all over the world.

A comparison between the methods are given in Table 1.

Table 1: Comparison of technologies for wastewater treatment & water recycling

Recycling Method	Technical feasibility	Cost	Remarks
Convent-ional	Side effects due to chemicals; more time for treatment; high water quality difficult to achieve	Based on chemical and power cost; Capital investment per mld: Rs. 23 – 60 Lakhs/- (depending on size); Operation and maintenance (O&M) cost per cum – Rs. 0.40 to 2.5/- (approx.)	Larger area requirement; huge conveyance & power consumption costs; water may not be of high quality for reuse in industry
DEWATS	Applicable for recycling of both 'grey' and 'black' municipal/ domestic wastewater	Capital investment per cum – Rs. 25,000 - 50,000/-; Annual O &M cost – Rs. 1000/- (approx.)	Less dependent on electricity; space requirement more; water quality better than of conventional
c-tech	Applicable for recycling of domestic/ industrial wastewater	Capital investment per cum – Rs. 10,000 - 20,000/-; O& M – 50% of conventional; system	Less energy requirement; less space; water quality better than of conventional
Ultrafiltr-ation	Adaptable for high turbidity industrial water; Applicable for recycling of all types of wastewater for industrial reuse; Good quality of water for reuse	Capital investment: Rs 10 to Rs 20 / lpd; O & M Rs. 5 - 10/- (approx.)	Eco-friendly as no chemicals are used 97% water recovery; high quality water for reuse

MBR	Biological treatment with membrane separation; Exceptional treatment efficiency with reduced foot print;	Capital investment: Rs 15 to Rs 35/ lpd ; O & M: Rs.15 -25 /- (approx.)	No side effects, no need of chemicals; high quality water for reuse
RO	Feasible for bulk quantities of water; Applicable for recycling of all types of wastewater including brackish and sea waters.	Capital investment: Rs 8 to 20 /lpd (Capacity>500,000 lpd) O & M costs: Rs 10-20/- (approx.)	Recovery of salts for reuse; Savings are more than operating costs; 93% water recovery; high quality water for reuse
UV Disinfection	UV water treatment technology 99.99% of all pathogens in water without the addition of chemicals or harmful side effects	Capital investment: Rs 5 to Rs 10 / lpd (depending on the total Capacity); O &M : Rs. 2 - 5/- (approx.) (this does not include the costs of other treatments)	Increase in lamp life and decrease in energy consumption using modern methods; high quality water

11.3 Agencies for Water Recycling Installation

1. VA TECH WABAG LTD, India

HEAD OFFICE : VA TECH WABAG LIMITED

\# 11, Murray's Gate Road Alwarpet, CHENNAI - 600 018, TAMILNADU , INDIA

Phone : 91 + 44 + 42232323 **FAX :** 91 + 44 +42232324

Email : wabag@bdwt.com

Regional Office - Pune

VA TECH WABAG LIMITED

Bhakti Plaza, 2nd Floor, Near Aundh Police Chowki, Auundhgao, Pune – 411007

Phone: 020-66424900 / 66424901, **Fax** : 020-66424949
Offerings:

- Reverse Osmosis
- Ultra filtration
- Micro filtration
- Membrane Bio reactor

Technology References
Indian Oil Corporation Ltd., Panipat

- Six -stream recycling plant
- Capacity of 150 m3/hr/stream
- Based on Ultra filtration and Reverse osmosis technology
- One of world's largest plant with 90% recovery
- Automatic PLC based

Indian Oil Corporation Ltd, Naptha Cracker Project, Panipat

- Complex naptha cracker effluent recycled
- Capacity -1 x 900 m3/hr
- Based on Ultra filtration and Reverse osmosis technology in combination with solid contact clarification and resin based processes
- Automatic PLC based

Travancore Titanium Products Limited (TTPL), Trivandrum

- Neutralization cum effluent recycle plant for a highly acidic waste with heavy metal contaminants
- Capacity 6000 m3/day
- Based on microfiltration and reverse osmosis in combination with chemical treatment
- Gypsum is obtained as a by product and is worthy of commercial use
- Semiautomatic PLC based

2. Delta Technologies
Contact: Mr. Shankar, 101, Ranjeet Towers, Dilsukhnagar, : Hyderabad

Phone: 040-55468278; Fax: 040-55468378; email: deltatechnik@yahoo.co.in; Mobile: 9948171469; http://www.deltaionexchange.net
Available technologies: UV disinfection and Reverse Osmosis plants

3. *Unicom Skytech Ltd.*
ddress : 8, Arab House, 12th Khetwadi, Lane, Mumbai – 400004 ,
Tel. (022) 23883469 / 23898787; Fax : (022) 23880226
Email : response@unicom.co.in , ultraguard@vsnl.com
WebSite: www.unicom.co.in
Available technologies: Standard and Customised Models for specific customer need are available from 60 liters per hour to 3 lakh liters per hour.(UV disinfection and Filters)

4. *Veolia water solutions and technologies, France*
Available technologies: MBR and Ultraviolet Disinfection; Range of flow rates**:** 2 to more than 60m^3/hr; UV-Star™ - Ultraviolet Disinfection (Separate Brochure available) ; UV-Star™ provides final disinfection for both domestic and industrial effluent prior to discharge into the natural environment. Flow rates from 100 m^3/hr to several thousand m^3/hr

Other Agencies supplying Membrane Technologies in India and worldwide:

a) Ion Exchange India, Ionics USA
b) Siemens, Germany
c) Nu-Chem, USA
d) Thermax, USA,
e) Memberatek
f) Pall (Asahi), Australia and USA
g) KOCH Membrane Systems – PURON Submerged Membranes, Germany
h) NORIT Membrane Technology, The Netherlands.
i) Kubota Systems, Japan, Germany & Netherlands
j) Mitsubishi, Japan
k) Zenon Environmental (ZeeWeed), USA, Canada, Europe (500 tp 19,000 m^3/d).
l) US Filter
m) Dynatec Systems, USA
n) Microfilt India, Vikhroli, Mumbai for Ultrafiltration.

12. Water Tariff Rebate Mechanism for Industries

As discussed earlier, there are large number modern water recycling technologies available in market. If any of these technologies are implemented by Industries, depending on the type of Industry, characteristics of effluent, investments possibilities, good amount of wastewater can be recycled and reused, as demonstrated by few Industries.

Regarding any water tariff rebate for Industries opting for water recycling, there is no known case studies / published works are available in literature. It may be possible that if some incentives are provided for water recycling, more Industries may come forward for wastewater recycling and reuse.

Hence while formulating the bulk water tariff for Industries, rebates should be provided for quantum of water recycled and not for water being supplied. Say for example, let an Industry is taking 'x' units of water per day for its use from the main supply and it produces 'y' units of wastewater (effluent) after all process. If the Industry is treating wastewater and make 'z' units of water per day for 'reuse', then a rebate may be given for the 'z' units of water from the 'x' units supplied. The Industry may declare about the units of water it recycles for 'reuse' on monthly wise and some agencies may check whether it is correct on a regular basis.

The rebate may be on a percentage wise on the tariff imposed on the Industry for the water supplied. Say for example, the percentage rebate may vary from 10 to 20% depending on the percentage reuse by the concerned Industry.

Notes:

1. It may be noted that the installation and operation and maintenance costs mentioned are approximated based on the available installed plants. However the real costs of installation, operation and maintenance depends on the manufacturer, the site, the capacity of the plant, the characteristics of the wastewater to be treated, the primary treatment given and the quality of water required for reuse.
2. As per the available information, there are no fixed mandatory norms by MPCB for water recycling/ water reuse by Industries. If any Industry is presently recycling or reusing the water, it is on their own interest either due to less availability of water or cost saving by reuse.

3. To work out a suitable rebate mechanism suitable, more discussion with the concerned officials may be required.

13. Concluding Remarks

Water recycling has proven to be effective and successful in creating a new and reliable water supply, while not compromising public health, especially in industries. Non-potable reuse is widely accepted practice that will grow. Advances in wastewater treatment technology and health studies of indirect potable reuse have led many to predict that planned reuse will become more common. The treatment of wastewater for reuse and the installation of distribution systems can be initially expensive, however can be sustainable and cost effective in the long term.

Other than the conventional treatment processes discussed, the modern technologies such as filtration technologies, membrane bioreactors, reverse osmosis and UV disinfection are the most promising technologies for the water recycling. These technologies are under further development. As water demands and environmental needs grow, water recycling will play a greater role in our overall water supply.

ANNEXURE - IV
(WATER RATES FOR NON IRRIGATION (INDUSTRIAL AND DRINKING) PURPOSE)

Annexure IV – Water Rates for Non Irrigation (Industrial and Drinking) purpose

Present water rates with effect from April 1, 2007, in Maharashtra, for industrial use where water is used as raw material, industrial use where water use is incidental and for drinking purpose, as per Government Resolution No. WTR 2006/ (396/03)-IM (P) in July 31, 2006 are presented Table 1, Table 1 and Table 3 respectively.

Table 1: Water Rates for water supply by Water Resources Department to industrial use where water is used as raw material (e.g., cold drinks, breweries, mineral water or similar use for drinking purposes)

	Type of use	**Water Rates (Rs./10,000 litre)**
A)	If dam is constructed across the river	
1	From the reservoir	190
2	From the Canal (by gravity or lift)/river on downstream of the dam and if there is no storage tank as per yardsticks	480
3	If water using agency has constructed the dam with their own expenses / cost of construction given by user in proportion of water use.	70
B)	If there is no dam on upstream op point from where water is lifted from river	
	From river	70

Table 2: Water Rates for water supply by Water Resources Department to Industrial use (except drinking purpose etc.)

	Type of use	**Water Rates (Rs./10,000 litre)**
A)	If dam is constructed across the river	
1	From the reservoir	38
2	From the Canal (by gravity or lift) / river on downstream of the dam and if there is no storage tank as per yardsticks	95
3	If water using agency has constructed the dam with their own expenses / cost of construction given by user in proportion of water use.	13
B)	If there is no dam on upstream op point from where water is lifted from river	
	From river	13

Table 3: Water Rates for water supply by Water Resources Department for Domestic Use

	Type of Use	**Water Rates (Rs./ 10,000 litre)**
A)	If dam is constructed across the river	
1	From the reservoir	1.70
2	From the Canal (by gravity or lift) / river on downstream of the dam and if there is no storage tank as per yardsticks	6.60
3	If water using agency has constructed the dam with their own expenses / cost of construction given by user in proportion of water use.	1.50
B)	If there is no dam on upstream op point from where water is lifted from river	
	From river	1.50

ANNEXURE - V

(WATER RATES FOR IRRIGATION PURPOSE (CANAL FLOW WATER CHARGE, SERVICE CHARGE FOR LIFT IRRIGATION, WATER RATES FOR WATER SUPPLIED ON VOLUMETRIC BASIS AND WATER RATES FOR PRIVATE LIFT IRRIGATION SCHEMES))

Annexure V – Water Rates for Irrigation purpose (Canal flow water charge, service charges for lift irrigation, water rates for water supplied on volumetric basis and water rates for private lift irrigation schemes)

1. Water Rates for canal flow water

Present water rates in Maharashtra for canal flow water use by different crops under different seasons with effect form July 01, 2003, as per Government Resolution No. Water Rates 1001/ (5/2001)-IM (Policy) in September 13, 2001 are presented in below given Table 1:

Table 1: Water Rates for canal flow use by different crops under different seasons

Sr. No.	Name of Crop of Season	Water Rates (Rs./hectare)
A)	**Kharif season**	
1	Kharif seasonals (including hybrid), Kharif rice (on contract)	238
2	Kharif rice (on demand), Kharif groundnut hybrid seeds and kharif support crops	476
3	Advanced watering (in kharif season for rabi crops)	119
B)	**Rabi crops**	
4	Rabi seasonals (excluding wheat and groundnut)	357
5	Rabi wheat	476
6	Kharif and rabi cotton, rabi groundnut, rabi-HW rice, hybrid seeds and rabi support crops	724
7	Late watering (given for kharif crops in rabi seasons	119
C)	**Hot weather seasons**	
8	Hot weather seasonals	724
9	HW groundnut, HW cotton (from April 1)	1438
10	HW cotton (from March 1)	1924
11	Advanced watering (1 watering given in Hot weather season)	357
12	Late watering (1 watering given in HW for rabi crops)	178
D)	**Two seasonal crops**	
13	Two seasonals e.g. Tur, Potato etc	

	In Kharif & Rabi	357
	In rabi and hot weather	605
E)	**Perennials (flow)**	
14	Sugarcane and Banana	6297
F)	**Other perennials (flow)**	
15	Fruit crops, lucerne etc.	6297
16	Sugarbeet (excluding advance and late irrigation given), rabi vegetables	1081
17	Kharif vegetables	724
18	Hot weather vegetables	2697
19	Onion in kharif and rabi seasons, Onion in kharif and rabi seasons given with one late irrigation	1805
20	Onion in Kharif and rabi seasons and in HW season given more than one irrigation	2519
21	Onion in rabi and HW seasons	2876
G)	**Extended (flow)**	
22	Adsali upto December for every month	
	Kharif	307
	Rabi	526
23	Adsali in January	1259
24	Adsali in February	1368
25	Adsali in March	2380
26	Adsali in April	2955
27	Suru upto February for every month	526
28	Suru in March	1805
29	Suru in April	2092
H)	**Crop block rates (flow)**	
30	Sugarcane block 1 : 4	2073
31	Fruit block	6297
32	Garden block	2449
33	Garden seasonal block	2628
34	Three seasonal block, two seasonal block	902
35	Rabi block	635
I)	**Perennials (Drip and Sprinkler)**	
36	Sugarcane and banana	4205

J)	**Other perennials (Drip and Sprinkler)**	
37	Fruit crops, lucerne etc.	4205
38	Sugarbeet (excluding advanced and late irrigation given)	724
39	Kharif vegetables	476
40	Rabi vegetables	724
41	Hot weather vegetables	1805
42	Onion in kharif and Rabi seasons	1200
43	Onion in kharif and Rabi seasons given with one late irrigation	1319
44	Onion in kharif and Rabi seasons given more than one irrigation	1686
45	Onion in Rabi and HW seasons	1924
K)	**Extended irrigation (Drip and Sprinkler)**	
46	Adsali upto December for every month	
	Kharif	208
	Rabi	347
47	Adsali in January	843
48	Adsali in February	912
49	Adsali in March	1587
50	Adsali in April	1963
51	Suru upto February for every month	347
52	Suru in March	1200
53	Suru in April	1398
L)	**Crop block rates (drip and sprinkler)**	
54	Sugarcane block 1: 4	1388
55	Fruit block	4205
56	Garden block	1636
57	Garden seasonal block	1755
58	Three seasonal block, two seasonal block	605
59	Rabi block	426
N)	**Water rates for sewage water**	
60	Sugarcane	11701
61	Other perennials	9897
62	Kharif seasonals	476
63	Rabi seasonals	724

64	Wheat	1021
65	Hot weather crops, rice (follow on)	1805
66	Cotton, groundnut	2519

2. Service charges for lift irrigation

Present Service charges for lift Irrigation schemes below 30m and above 30m, with effect form July 01, 2003 under jurisdiction of Irrigation Department and Irrigation Development Corporation as per Government Resolution No. Water Rates 1001/ (5/2001)-IM (Policy) in September 13, 2001 are presented in Table 2 and Table 3 respectively.

Table 2: Service Charges for lift Irrigation schemes below 30m under jurisdiction of Irrigation Department and Irrigation Development Corporation

Sr. No.	Season and crop name	Water Rates (Rs./hectare)
1	**Two seasonal crops**	
1	Tur	476
2	Turmeric / chilies	664
3	LS cotton and groundnut (hot weather & kharif)	1200
2	**Perennial crops (flow)**	
1	Sugarcane / Banana	5405
2	Other perennial crops	3729
3	Extended cane and banana (rate for one watering)	178.5
3	**Perennial crops (drip)**	
1	Sugarcane / Banana	3600
2	Other perennial crops	2489
3	Extended cane and banana (rate for one watering)	119
4	**Kharif crops**	
1	Rice	357
2	Other food grain and fodder crops	297
3	Other cash crops	416
5	**Rabi crops**	
1	Wheat	357
2	Other food grain and fodder crops	297
3	Other cash crops	416

6	**Hot weather crops**	
1	Hot weather food grains / hybrid jowar	724
2	Cash crops	1200
3	Follow on hot weather rice	902
7	**Vegetables**	
1	Kharif	535
2	Rabi crops	846
3	Hot weather	1200
8	**Advanced and late weathering (each watering)**	
1	Food grain crops	99.2
2	Cash crops	128.9

Table 3: Service Charges for lift Irrigation schemes above 30m under jurisdiction of Irrigation Department and Irrigation Development Corporation

Sr. No.	Season and crop name	Water Rates (Rs./hectare)
1	**Two seasonal crops**	
1	Tur	496
2	Turmeric / chilies	685
3	LS cotton and groundnut (hot weather & kharif)	1439
2	**Perennial crops (flow)**	
1	Sugarcane / Banana	6531
2	Other perennial crops	4546
3	Extended cane and banana (rate for one watering)	228
3	**Perennial crops (drip)**	
1	Sugarcane / Banana	4357
2	Other perennial crops	3027
3	Extended cane and banana (rate for one watering)	149
4	**Kharif crops**	
1	Rice	526
2	Other food grain and fodder crops	298
3	Other cash crops	417
5	**Rabi crops**	
1	Wheat	665

2	Other food grain and fodder crops	397
3	Other cash crops	844
6	**Hot weather crops**	
1	Cash crops	1439
2	Follow on hot weather rice	168
7	**Vegetables**	
1	Kharif	556
2	Rabi crops	844
3	Hot weather	1439
8	**Advanced and late weathering (each watering)**	
1	Food grain crops	99.2
2	Cash crops	128.9

3. Water rates for water supplied on volumetric basis

Present water rates/ royalty rates for water supplied on volumetric basis from canals/reservoir from funds of water users with effect form July 01, 2003, as per Government Resolution No. Water Rates 1001/ (5/2001)-IM (Policy) in September 13, 2001 are presented in below given Table 4.

Table 4: Water rates/ royalty charges for water supplied on volumetric basis from canals/ from reservoir constructed from funds of water users

Sr. No.	Location	Rs./1000 m
1	**From canal at minor head (water rates)**	
1	Kharif	47.6
2	Rabi	71.4
3	Hot weather	144.8
2	**From canal at outlet (water rates)**	
1	Kharif	53.6
2	Rabi	79.4
3	Hot weather	158.7
3	**Reservoir constructed by water users (royalty charges)**	
	For all seasons	23.8

4. Water rates for private lift irrigation schemes

Present water rates for lift irrigation schemes with effect from July 1, 2002 as per Government Resolution No. Water Rates 1001/ (5/2001)-IM (Policy) in September 13, 2001 for water use of private life irrigation scheme are presented in Table 5 and water rates for water use by private lift irrigation schemes on Kolhapur type weir and lift from river course for sugarcane irrigation is presented in Table 6 under the same Government Resolution.

Table 5: Water rates for lift irrigation schemes from 01-07-2002 for water use of private lift irrigation scheme

Sr. No.	Locatoin of lift Irrigation	Rs./ha
	Canal	
	Kharif Crops	75
	Rabi crops	110
	Hot weather Crops	220
	Sugarcane and Banana	
	Flow	1645
	Drip irrigation	1095
	Other perennials	
	Flow	1090
	Drip	730
	Reservoir/ dam/ elevated bandana	
	Kharif Crops	35
	Rabi crops	55
	Hot weather Crops	110
	Sugarcane and Banana	
	Flow	825
	Drip irrigation	555
	Other perennials	
	Flow	550
	Drip	365
	Within boundaries of command area in back water areas of river bandharas where dam water in not released	

	Kharif Crops	30
	Rabi crops	30
	Hot weather Crops	55
	Sugarcane and Banana	
	Flow	410
	Drip irrigation	280
	Other perennials	
	Flow	280
	Drip	180
	First bandhara in river/ nalla or lift irrigation from beyond dam, diversion bandhara in khariff	
	Kharif Crops	nil
	Rabi crops	20
	Hot weather Crops	20
	Sugarcane and Banana	
	Flow	135
	Drip irrigation	80
	Other perennials	
	Flow	90
	Drip	60

Table 6: Water rates for water use by private lift irrigation schemes on Kalhapur type weir, lift from river course for sugarcane irrigation including extended (from planting till harvesting)

Sr. No.	Location of River lift	Water Rates Rs./ha
1	**Notified river where water is released for the entire year from dam reservoir**	
1	Flow	1030
2	Drip	680
2	**River where Kolhapur type weirs are there but water is not released from dam reservoirs**	
1	Flow	720
2	Drip	475
3	**From rivers where the benefit of storage is not available**	
1	Flow	170
2	Drip	110

ANNEXURE - VI

(M & R NORMS PROPOSED BY WALMI)

Annexure VI – M & R Norms proposed by WALMI

Following are the proposed norms for Repair and Maintenance developed by Water and Land Management Institute (WALMI), Aurangabad based on study of pilot projects spread over Maharashtra. (Letter reference WALMI/ENGG/M&R Norms/484/2008 dated May 2, 2008)

Norms for Maintenance and Repairs proposed by WALMI

	Basic			
1	**Norms**			
	1.1	**Head Works**		
		Rs.	11000	Per Million m^3 of Design Live Storage **Subject to** :-Provisions for M&R of gates shall be additional as suggested by Chief Engineer, Mechanical, Nasik :-Irrespective of good or bad year
	1.2	**Canal Works**		
	(a)	Rs.	380	Per Hectare of actual irrigated area **Subject to** :-Actual irrigated area as per average of last 3 years :-Perennials, Other Perennials and Two Seasonals counted once :-Area irrigated on wells not to be considered :- In a project, if steps for levying 50% of water fees on the kharif crops are taken and guarantee of supply of water provided, kharif irrigation may be included in the irrigated area.
	(b)	Rs.	190	Per Hectare of balance area **Subject to** :- Balance Area = CCA (Culturable Command Area)- Actual area irrigated

Total amount worked out as per (a) & (b) above may further be allocated component wise as given below

(c)	40%	Main / Branch Canal
	25%	Distributaries
	35%	Minors

1.3 K.T Weir (Kolhapur Type Weir)

(a)	Rs.	2300	Per Sq. Meter of gate area for K.T Weir **with** reservoir backup
(b)	Rs.	1450	Per Sq. Meter of gate area for K.T Weir **without** reservoir backup

1.4 Government Lift Irrigation Scheme (LIS)

(a)	-	Electricity charges & maintenance of pump house & rising mains : As per actuals
(b)	-	For Canals of LIS as per item 1.2 above

1.5 Storage Tanks

Refer item 1.1 above

2 Adjustment for specific conditions

(i.e. increase over & above basic norms, if and as applicable)

2.1 Age of the Project

7.50%	Age 35 to 70 years
15%	Age above 70 years

Subject to

If any modernization or rehabilitation of the concerned component has been carried out within last 35 years, then additional provisions indicated above shall not be admissible

2.2 Black Cotton Soils

(Applicable if dominant soil type (percentage >50%) of the project is B.C soils)

Add to basic norms worked out as per 1.2 (c) above		Project	Add in respect to
-		Major	Minors only
	100%	Medium	Distributaries & Minors only
	100%	Minor	Main / Branch Canal, Distributory Minors

2.3 Project Situated in Hilly Areas/ High Rainfall Zone

(Average rainfall > 2000 mm / year)

Add 100% to Basic Norms on all components of the project, i.e.

:- Add 100% to the amount worked out as per item 1.1 for Head Works (Not applicable is dam is fully masonry / concrete dam)

:-Add 100 % to the amount worked out as per item 1.2 (c) for Main / Branch Canal, Distributaries & Minors

Note : Item 2.2 & 2.3 not applicable to KT Weir

ANNEXURE - VII

(FINANCIAL IMPLICATIONS OF M & R NORMS PROPOSED BY WALMI AT STATE LEVEL)

Annexure VII – Financial implications of M & R Norms proposed by WALMI at State level

Following are the financial implication of the norms for Repair and Maintenance developed by Water and Land Management Institute (WALMI), Aurangabad. (Letter reference WALMI/ENGG/M&R Norms/484/2008 dated May 2, 2008). These implications do not include establishment charges, special repairs, emergency maintenance and extension & improvement.

A.	**Head Works**		
1)	Total live storage of completed state sector irrigation projects (Mm^3)	:	29531
2)	basis M&R Norms for head works excluding Gates (Rs/Mm^3)	:	11000
3)	Annual basic M&R grants for head-works excluding gate (Rs. Million) (3) = [(1) * (2)]	:	324.8
4)	Add 30% for M&R of Gates of head-works (Rs. Million) (4) = [(3) * 0.30]	:	97.44
5)	Annual basis M&R grants for head-works including gates (Rs. Million) (5) = [(3) + (4)]	:	422.24
6)	Add 16% for adjustments in respect of age factor, BC soils, hilly area/ high rainfall zone (Rs. Million) [Note: same is assumed to be applicable at State level] (6) = [(5) * 0.16]	:	67.56
7)	Total annual M&R grants for head-works (Rs. Million) (7) = [(5) + (6)]	:	489.80

B.	**Canals**		
1)	Irrigation potential created (L. ha)*	:	41.32
2)	Culturable command area (Lakh .ha) (41.32 * 1.45)	:	59.91
3)	Area actually irrigated (L. ha)*	:	18.35
4)	Balance area (L.ha) (4) = [(2) –(3)]	:	41.56

5) Basis M&R norms for canals

5(a) : Rs. 380 / ha of actual irrigated area

5(b) : Rs. 190 / ha of balance area

6) Annual M&R grants for canals (Rs. Million)

6(a) = (3) * Rs. 380 / ha	: 697.30
6(b) = (4) * Rs. 190 / ha	: 789.60
Total 6(a) + 6(b)	:1486.90
7) ADD 16% for adjustments (Rs. Million)	: 237.90
(Please refer note at sr. no. A-6)	
[(7) = Rs. 1486.90 * 0.16]	
8) Total annual M&R grants for canals (Rs. Million)	:1724.80
[(8) = 1486.90 + 237.90]	

As per Irrigation Status Report, September 2007

C. Project

Rs. 489.80 (head-works) + Rs. 1724.80 (Canals) = Rs. 2214.60 Million

=Rs. 221.46 Crores

i.e. =Rs. 369.65 / ha of CCA

say Rs. 370 / ha of CCA