

# Water Management in Singapore

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**ABSTRACT** *Water has become an issue of national security for most countries of the world, Singapore being one of them because of its dependence on imports of water from Malaysia. In order to reduce its dependence on external sources, this city–state has developed and implemented extremely efficient demand and supply management practices. In addition to imports of water and land reclamation, this strategy is a combination of rainfall storage, desalination and very sophisticated technology for recycling used water. As the paper analyses, Singapore has successfully managed to find the right balances between water quantity and water quality considerations; water supply and water demand management; public sector and private sector participation; efficiency and equity considerations; strategic national interest and economic efficiency; and strengthening internal capacities and reliance on external sources.*

## Introduction

Singapore is a city-state with an area of about 700 km<sup>2</sup>, a population of approximately 4.4 million people, and an annual growth of 1.9%. Total fertility rates have declined from 1.7 in 1996 to 1.4 in 2001. The population growth of Singapore between 1980 and 2005 is shown in Figure 1.

The average GDP growth of 7.7% per year during the last decade has resulted in economic prosperity, which has been translated into steady improvements in the socio-economic conditions of the country.

One of the main concerns of the government has been how to provide clean water to the population, which currently consumes about 1.36 billion litres of water per day. Singapore is considered to be a water-scarce country not because of lack of rainfall (2400 mm/year), but because of the limited amount of land area where rainfall can be stored. Singapore imports its entitlement of water from the neighbouring Johor state of Malaysia, under long-term agreements signed in 1961 and 1962 when Singapore was still a self-governing British colony. Under these agreements, Singapore can transfer water from Johor for a price of less than 1 cent per 1000 gallons until the years 2011 and 2061, respectively. The water from Johor is imported through three large pipelines across the 2 km causeway that separates the two countries.

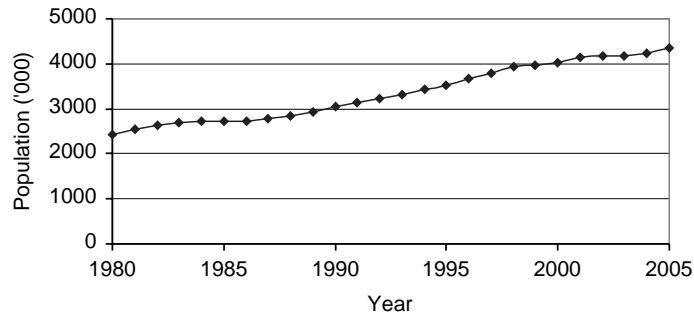
In August 1965, Singapore became an independent country. The Constitution of Malaysia was amended on 9 August 1965. Under clause 14, this amendment stipulated that:

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**Figure 1.** Total population of Singapore, 1980–2005

14. The Government of Singapore shall guarantee that the Public Utilities Board of Singapore shall on and after Singapore Day abide by the terms and conditions of the Water Agreements dated 1st September 1961, and 29th September 1962, entered into between the City Council of Singapore and the Government of the State of Johor.

The Government of Malaysia shall guarantee that the Government of the State of Johor will on and after the Singapore Day also abide by the terms and conditions of the said two Water Agreements.

The long-term security of water was an important consideration for Singapore when it became a newly independent nation. Accordingly, it made a special effort to register the Separation Agreement in the United Nations Charter Secretariat Office in June 1966.

The two countries have been negotiating the possible extension of the water agreement. The results thus far have not been encouraging since the two countries are still far apart in terms of their national requirements. Singapore would like to ensure its long-term water security by having a treaty that will provide it with the stipulated quantity of water well beyond the year 2061. In contrast, the main Malaysian demand has been for a much higher price of water, which has varied from 15 to 20 times the current price. While Singapore has said that it has no problem paying a higher price for the water it imports from Johor, its main concern has been how the price revision will be decided, and not the concept of a higher price *per se*.

Because of this continuing stalemate, Singapore has developed a new plan for increasing water security and self-sufficiency during the post 2011-period, with increasingly more efficient water management, including the formulation and implementation of new water-related policies, heavy investments in desalination and extensive reuse of wastewater, and catchment management and other similar actions.

Institutionally, Public Utilities Board (PUB) currently manages the entire water cycle of Singapore. Earlier, PUB was responsible for managing potable water, electricity and gas. On 1 April 2001, the responsibilities for sewerage and drainage were transferred to PUB from the Ministry of the Environment. This transfer allowed PUB to develop and implement a holistic policy, which included protection and expansion of water sources, stormwater management, desalination, demand management, community-driven programmes, catchment management, outsourcing to private sector specific activities which

are not core to its mission, and public education and awareness programmes. The country is now fully sewered to collect all wastewater, and has constructed separate drainage and sewerage systems to facilitate wastewater reuse on an extensive scale.

### **Overall Approach**

A main reason as to why Singapore has been very successful in managing its water and wastewater is because of its concurrent emphasis on supply and demand management, wastewater and stormwater management, institutional effectiveness and creating an enabling environment, which includes a strong political will, effective legal and regulatory frameworks and an experienced and motivated workforce. The Singapore example indicates that it is unrealistic to expect the existence of an efficient water management institution in a country, in the midst of other similar mediocre management institutions, be they for energy, agriculture or industry. Water management institution in a country can only be as efficient as its management of other development sectors. The current implicit global assumption that water management institutions can be improved unilaterally when other development sectors remain somewhat inefficient is simply not a viable proposition.

### *Supply Management*

Singapore is one of the very few countries that looks at its supply sources in their totality. In addition to importing water from Johor, it has made a determined attempt to protect its water sources (both in terms of quantity and quality on a long-term basis), expand its available sources by desalination and reuse of wastewater and stormwater (Lee & Nazarudeen, 1996), and use technological developments to increase water availability, improve water quality management and steadily lower production and management costs. At present, PUB has an in-house Centre for Advanced Water Technology, with about 50 expert staff members who provide it with the necessary research and development support.

Over the years, there has been an increasing emphasis on catchment management. Protected catchment areas are well demarcated and gazetted (Appan, 2003), and no pollution-causing activities are allowed in such protected areas. In land-scarce Singapore, protected catchment classification covers less than 5% of the area.

The Trade Effluent Regulations of 1976 promulgated the idea of partly protected catchments, where wastewater discharges to streams require prior treatment. The effluents must have an acceptable water quality that has been defined. While many other developing countries have similar requirements, the main difference is that, in Singapore, these regulations are strictly implemented. For example, when wastes from pig farms became a major source of water contamination, the Cattle Act was legislated to restrict the rearing of cattle to certain areas in the interest of public health. This also protects the water catchments from animal wastes generated from the cattle farms. At present, half of the land area of Singapore is considered to be protected and partly protected catchment. This ratio is expected to increase to two-thirds by 2009.

Desalination is becoming an important component for augmenting and diversifying available national water sources. In late 2005, the Tuas Desalination Plant, the first municipal-scale seawater desalination plant, was opened at a cost of S\$200 million. Designed and constructed by a local water company, it is the first designed, built, owned and operated desalination plant in the nation. The process used is reverse osmosis and it

has a capacity of 30 mgd (million gallons per day). The cost of the desalinated water during its first year of operation is S\$0.78/m<sup>3</sup> (Lee, 2005).

Faced with the strategic issue of water security, Singapore considered the possibility of recycling wastewater (or used water) as early as the 1970s. It opted for proper treatment of its effluents, instead of discharging them to the sea. However, the first experimental recycling plant was closed in 1975 because it proved to be uneconomical and unreliable: the technology was simply not available three decades ago to make such a plant practical.

In 1998, PUB and the Ministry of the Environment formulated a reclamation study. The prototype plant, located on a site downstream of the Bedok Water Reclamation Plant, started functioning in May 2000, and produced 10 000 m<sup>3</sup> of water per day. The reclaimed water from this plant was monitored regularly over a period of two years, when an expert panel gave it a clean bill of health in terms of quality and reliability (Lee, 2005).

The quality of water produced by the Bedok Water Reclamation Plant was found not only to be better than the water supplied by PUB but also met the water quality standards of the Environmental Protection Agency of the United States and the World Health Organisation (PUB, 2002, in Lee, 2005).

The water supply is thus also being increased through the collection, treatment and reuse of wastewater. Investments in 2003 were of the order of S\$116 million (PUB, 2003). During the period 2002–04 the amount of wastewater that was treated has increased from 1.315 to 1.369 MCM/day (Ministry of the Environment and Water Resources, 2005).

After this successful demonstration, PUB decided to collect, treat and reuse wastewater at an extensive scale, a step that very few countries have taken. At present, with a 100% sewer connection, all wastewater is collected and treated. Wastewater is reclaimed after secondary treatment by means of advanced dual-membrane and ultraviolet technologies. NEWater is used for industrial and commercial purposes, even though quality wise it is safe to drink. Since its purity is higher than tap water, it is ideal for certain types of industrial manufacturing processes, like semiconductors which require ultrapure water. It is thus economical for such plants to use NEWater since no additional treatment is necessary to improve water quality. With more industries using NEWater, water saved is being used for domestic purposes.

A small amount of NEWater (2 mgd in 2002 and 5 mgd in 2005, or about 1% of the daily consumption of the country) is blended with raw water in the reservoirs, which is then treated for domestic use. It is expected that, by 2011, Singapore will produce 65 mgd of NEWater annually, 10 mgd (2.5% of water consumption) for indirect domestic use, and 55 mgd for industrial and commercial use (PUB, 2003, in Lee, 2005).

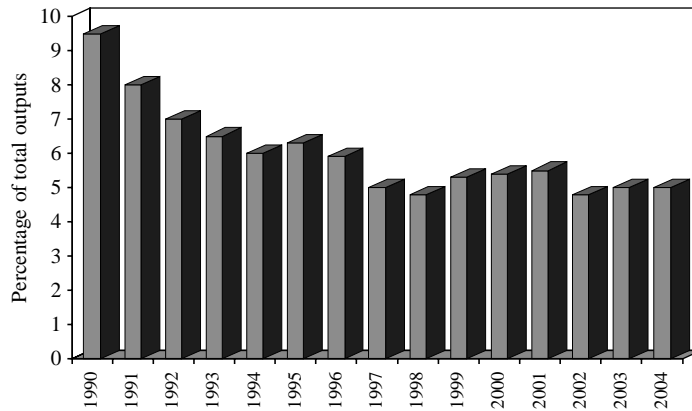
There are currently three plants producing NEWater at Seletar, Bedok and Kranji. These plants have a total capacity of 20 mgd and will provide water to the north–eastern, eastern and northern parts of Singapore, respectively. The distribution network for NEWater includes 100 km of pipelines. PUB has recently awarded another PPP project to construct the country's largest NEWater factory at Ulu Pandan, with a capacity of 25 mgd (Khoo, 2005). This plant will supply water to the western part and central business district of Singapore. Once this plant is operational, the overall production of NEWater will represent more than 10% of the total water demand per day. The overall acceptance of this recycled ultra-pure water has been high. By 2011, NEWater is expected to meet 15% of Singapore's water needs. The number of customers of NEWater, as well as some statistical information, are shown in Table 1.

**Table 1.** Summary of statistical information 1995–2004

	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995
Employees at the end of the year	3125	3232	3333	3426	2143	2116	2163	2138	2190	2219
<i>Customers (Number of accounts at the end of each year)</i>										
Water	1 173 434	1 153 195	1 129 815	1 108 255	1 063 331	1 049 438	1 013 495	974 467	942 925	910 712
NEWater	51	24	–	–	–	–	–	–	–	–
Used water	1 173 462	1 153 196	1 129 792	1 108 232	–	–	–	–	–	–
Domestic Water Consumption (lpcd)	162	165	165	165	165	165	166	170	170	172
Number of accounts served per PUB employee at the end of the year	376	357	339	324	496	496	468	456	431	NA
<i>Capital expenditure</i>										
Water	95.8	214.8	88.0	115.6	144.0	197.4	108.7	84.0	50.5	43.7
NEWater	58.4	89.6	96.5	12.8	–	–	–	–	–	–

*Notes:* In 1995 PUB was restructured to be in charge of only water supply. Previously PUB handled supply of gas and electricity in addition to water. In 2001, PUB took over the drainage and sewerage departments from what was then the Ministry of the Environment.

*Source:* Modified from PUB, 2004 Annual Report.



**Figure 2.** Unaccounted for water, Singapore, 1990–2004

The first year tender price for NEWater from the Ulu pandan plant was S\$0.30/m<sup>3</sup>, which is significantly less than the cost of desalinated water. The selling price of NEWater is S\$1.15/m<sup>3</sup>, which covers production, transmission and distribution costs. Because the production cost of NEWater is less than that of desalinated water, future water demands plan to be covered with more NEWater rather than with construction of desalination plants.

The supply of water is further expanded by reducing unaccounted for water (UFW), which is defined as actual water loss due to leaks, and apparent water loss arising from meter inaccuracies. Unlike other South and Southeast Asian countries, Singapore simply does not have any illegal connections to its water supply systems.

As shown in Figure 2, in 1990, unaccounted for water (UFW) was 9.5% of the total water production (Khoo, 2005). Even at this level, it would still be considered to be one of the best examples in the world at the present time. However, PUB has managed to lower the UFW consistently to around 5% in recent years. This is a level that no other country can match at present. In comparison, in England and Wales, the only region in the world which has privatized its water more than a decade ago, the best any of its private sector companies have managed to achieve is more than twice the level of Singapore. Similarly, UFW in most Asian urban centres now range between 40 and 60%.

### *Demand Management*

Concurrent to the diversification and expansion of water sources, PUB has put in place a well-thought out and comprehensive demand management policy. It is useful to review the progress of water tariffs for water during the period 1997–2000. The progressive tariff structure used from 1997 to the present is shown in Table 2.

Before 1 July 1997, the first 20 m<sup>3</sup> of domestic consumption for each household was charged at S\$0.56/m<sup>3</sup>. The next block of 20–40 m<sup>3</sup> was charged at S\$0.80/m<sup>3</sup>. For consumption of more than 40 m<sup>3</sup>/month and non-domestic consumption, it was S\$1.17/m<sup>3</sup>.

Effective from 1 July 2000, domestic consumption of up to 40 m<sup>3</sup>/month and non-domestic uses were charged at a uniform rate of S\$1.17/m<sup>3</sup>. For domestic consumption of more than 40 m<sup>3</sup>/month, the tariff became S\$1.40/m<sup>3</sup>, which is higher than non-domestic consumption. The earlier cheaper block rate for the first 20 m<sup>3</sup> of domestic consumption was eliminated.

**Table 2. Water Tariffs, 1997–2006**

Tariff category	Consumption block (m <sup>3</sup> per month)	Before 1 July 1997			Effective 1 July 1997			Effective 1 July 2000		
		Tariff (¢/m <sup>3</sup> )	WCT (%)	WBF (¢/m <sup>3</sup> )	Tariff (¢/m <sup>3</sup> )	WCT (%)	WBF (¢/m <sup>3</sup> )	Tariff (¢/m <sup>3</sup> )	WCT(%)	WBF (¢/m <sup>3</sup> )
Domestic	1 to 20	56	0	10	73	10	15			
	20 to 40	80	15	10	90	20	15			
	Above 40	117	15	10	121	25	15			
Non-domestic	All units	117	20	22	117	25	32			
Shipping	All units	207	20	–	199	25	–			
Tariff category	Consumption block (m <sup>3</sup> per month)	Effective 1 July 1998			Effective 1 July 1999			Effective 1 July 2000		
		Tariff (¢/m <sup>3</sup> )	WCT (%)	WBF (¢/m <sup>3</sup> )	Tariff (¢/m <sup>3</sup> )	WCT (%)	WBF (¢/m <sup>3</sup> )	Tariff (¢/m <sup>3</sup> )	WCT(%)	WBF (¢/m <sup>3</sup> )
Domestic	1 to 20	87	20	20	103	25	25	117	30	30
	20 to 40	98	25	20	106	30	25	117	30	30
	Above 40	124	35	20	133	40	25	140	45	30
Non-domestic	All units	117	25	42	117	30	51	117	30	60
Shipping	All units	199	25	–	192	30	–	192	30	–

*Notes:* Water Conservation Tax (WCT) levied by the government to reinforce the water conservation message. Water Borne Fee (WBF) and Sanitary Appliance Fee (SAF): Statutory charges prescribed under the Statutory Appliances and Water Charges Regulations to offset the cost of treating used water and for the maintenance and extension of the public sewerage system. SAF is S\$3 per sanitary fitting per month. WBF and SAF charges are inclusive of goods and services tax. *Source:* PUB (2005) personal communication.

**Table 3.** Average monthly consumption and bills per household, 1995, 2000, 2004

Item	1995	2000	2004
Average monthly consumption, m <sup>3</sup>	21.7	20.5	19.3
Average monthly bill, inclusive of all taxes	S\$14.50	S\$31.00	S\$29.40

Source: PUB (2005); personal communication.

In addition, the water conservation tax (WCT) that is levied by the government to reinforce the water conservation message, was 0% for the first 20 m<sup>3</sup>/month consumption prior to 1 July 1997. For consumption over 20 m<sup>3</sup>/month, WCT was set at 15%. Non-domestic users paid a WCT levy of 20%.

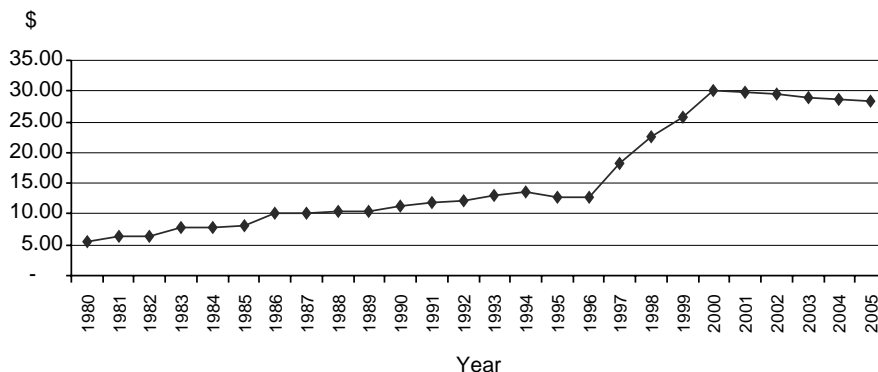
Effective 1 July 2000, WCT was increased to 30% of the tariff for the first 40 m<sup>3</sup>/month for domestic consumers and all consumption for non-domestic consumers. However, domestic consumers pay 45% WCT, when their water consumption exceeds 40 m<sup>3</sup>/month. In other words, there is now a financial disincentive for higher water consumption by the households.

Similarly, water-borne fee (WBF), a statutory charge prescribed to offset the cost of treating used water and for the maintenance and extension of the public sewerage system, was S\$0.10/m<sup>3</sup> for all domestic consumption prior to 1 July 1997. Effective 1 July 2000, WBF was increased to S\$0.30/m<sup>3</sup> for all domestic consumption. Impacts of these tariff increases on the consumers can be seen in Table 3.

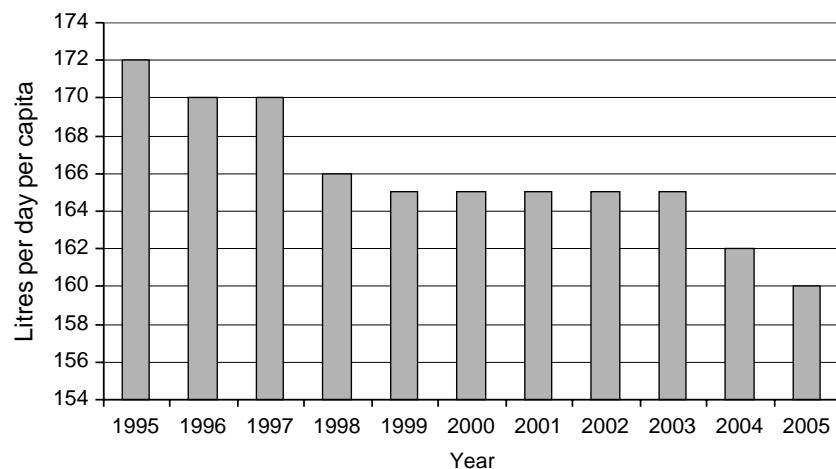
Average monthly household consumption steadily declined during the period 1995–2004 (Table 3, Figure 3). The consumption in 2004 was 11% less than in 1995. During the same period, the average monthly bill has more than doubled.

Figure 4 shows the domestic water consumption per capita per day over the period 1995–2005. It shows a steady decline in per capita consumption because of the implementation of demand management practices, from 172 lpcd in 1995 to 160 lpcd in 2005.

These statistics indicate that the new tariffs had a notable impact on the behaviour of the consumers, and have turned out to be an effective instrument for demand management. This is a positive development since the annual water demands in Singapore increased steadily, from 403 million m<sup>3</sup> in 1995 to 454 million m<sup>3</sup> in 2000. The demand management policies introduced have resulted in the lowering of this demand, which declined to 440 million m<sup>3</sup> in 2004.

**Figure 3.** Average monthly bill, inclusive of all taxes (in S\$) 1980–2005





**Figure 4.** Domestic water consumption, 1995–2005

In terms of equity, the government provides specially targeted help for lower-income families. Households living in 1- and 2-room flats receive higher rebates during difficult economic times. For hardship cases, affected households are eligible to receive social financial assistance from the Ministry of Community Development, Youth and Sports.

The current tariff structure used by PUB has several distinct advantages, among which are the following:

- There is no ‘lifeline’ tariff that is used in many countries with the rationale that water for the poor should be subsidized since they cannot afford to pay high tariffs for an essential requirement for human survival. The main disadvantage of such a lifeline tariff is that it also subsidizes water consumers who can afford to pay for the quantity of water they actually consume.
- The poor who cannot afford to pay for the current water tariffs receive a targeted subsidy. This is a much more efficient policy in socio-economic terms, instead of providing subsidized water to all for the first 20–30 m<sup>3</sup> of water consumed by all households, irrespective of their economic conditions.
- The current domestic tariff of water consumption up to 40 m<sup>3</sup>/month/household is identical to the non-domestic tariff. Both are set at S\$1.17/m<sup>3</sup>. In other words, commercial and industrial users do not subsidize domestic users, which is often the case for numerous countries.
- The tariff structure penalizes all those households who use more than 40 m<sup>3</sup> of water per month. They pay the highest rates, S\$1.40 m<sup>3</sup>, for consumption above this level. This rate is higher than the commercial and the industrial rates, and is a somewhat unusual feature compared to the existing norm.
- Water conservation tax (WCT) is 30% of the tariff for all consumers, except for domestic households who use more than 40 m<sup>3</sup>/month. The WCT on consumption of each unit higher than 40 m<sup>3</sup>/month increases by 50%, from 30% to 45%, which must be having perceptible impacts on household behaviour in terms of water conservation and overall demand management.

- Water-borne fee (WBF) is used to offset the cost of treating wastewater and for the maintenance and extension of the public sewerage system. It is set at S\$0.30 m<sup>3</sup>/s for all domestic consumption. For non-domestic consumption, this fee is doubled, S\$0.60/m<sup>3</sup>, presumably because it is more difficult and expensive to treat non-domestic wastewater.
- A Sanitary Appliance Fee (SAF) is also levied per sanitary fitting per month. It is currently set at S\$3.00 per fitting.
- There are two components to water tariff. A major component of the overall revenue collected through water tariffs accrue to the PUB recovering all operation and for considering maintenance costs and new investments. However, revenue from WCT accrues to the government and not to PUB.

### **Overall Governance**

The overall governance of the water supply and wastewater management systems in Singapore is exemplary in terms of its performance, transparency and accountability. There is much that both the developed and developing world can learn from the PUB experience. Only some selected critical issues will be discussed herein.

#### *Human Resources*

An institution can only be as efficient as its management and the staff that work for it, and the overall social, political and legal environment within which it operates. In terms of human resources, PUB has some unique features in terms of management that makes it stand out among its other Asian counterparts.

In the vast majority of the Asian water utilities, service providers mostly have a limited say on staff recruitment and staff remuneration. Consequently, the utilities are rife with following types of problems:

- Staff, including senior managers, are often selected because of their political connections, rather than their management abilities or technical skills.
- Managers often do not have the skill to manage, even if they had autonomy and authority to manage, which often they do not.
- Water utilities are overstaffed, primarily because of political interference and nepotism. Unions are very strong and generally well-connected politically. Accordingly, downsizing is a difficult task because of strong union opposition and explicit or implicit political support. Overstaffing ensures low productivity and low staff morale.
- Utilities are not allowed to pay their professional staff members the going market rates for remuneration, which sometimes could be 2–3 times higher. This means that they are unable to attract and retain right calibre of staff. Many staff moonlight to obtain extra income, and corruption is rife in nearly all levels.
- Utilities are dominated by engineers, and the career structure available for other disciplines like accountants, administrators, social scientists, information technologist, etc. is somewhat limited. This is another disincentive for non-engineers to join.
- Poor management, overstaffing and promotions because of seniority or political connections ensure that it is very difficult to recruit good staff, and if some do

join, it is equally difficult to retain them because of lack of job satisfaction, poor working environment and absence of incentives for good performance.

PUB has overcome the above and other related constraints through a competitive remuneration, incentives and benefits package. The salary and benefit package is generally benchmarked against the Civil Service, which, in turn, benchmarks against the prevailing market. It provides strong performance incentives that are commensurate with the prevailing pay packages for the private sector. In addition, its pro-family policies, commitment to train its staff for their professional and personal development, and rewarding good performers, ensure good organizational performance and development. Consequently, its overall performance has become undoubtedly one of the best in the world.

### *Corruption*

Corruption is endemic in most Asian utilities. However, it is not an issue at PUB, which emphasizes staff integrity as a key organizational requirement. It has taken measures to prevent corruption by staff training on Code of Governance and Code of Conduct, effective internal control processes, regular audits and strong and immediate sanctions against those who may prove to be corrupt. Staff members are required to make annual declarations, which include Declaration of Assets and Investments and Declaration of Non-indebtedness.

Complaints of corruption are promptly investigated and reported to Singapore's Corrupt Practices Investigation Bureau. PUB is a part of the overall Singapore milieu where there are strong anti-corruption laws at the national level with appropriate sanctions that are regularly implemented. In addition, in recent decades, the government has consistently shown its strong political will to curb all forms of corruption, and take firm actions against all and any form of corruption (see <http://www.cpib.org.sg/aboutus.htm>).

With a good remuneration package, functional institution, and a strong anti-corruption culture, corruption is not an issue at PUB.

### *Autonomy*

Absence of autonomy is one of the most fundamental problems that affect most utilities of the Asian developing countries. This, in turn, creates a series of second order problems and constraints that further erode the efficiency of the utilities to perform their tasks efficiently and in a timely manner.

A fundamental problem in most Asian cities has been that the process of setting tariffs is primarily controlled by the elected officials, who mostly resist increases because of perceived vested interests. Low levels of tariffs cannot have any impact in terms of managing demands. In fact, low levels of tariffs are not compatible with metering, especially as the cost of metering and processing the resulting information may be higher than the revenue metering can generate. The problem is further accentuated by low levels of tariff collection. Furthermore, politicians have preferred to keep domestic water prices artificially low, and subsidize it with much higher tariffs from commercial and industrial consumers. For example, according to a World Bank study, in India, domestic consumers used 90% of the water, but accounted for only 20% of the revenues (ADB, 2003). Domestic consumers were thus heavily cross-subsidized by commercial and industrial water users.

In contrast, PUB has a high level of autonomy and solid political and public support, which have allowed it to increase water tariffs in progressive steps between 1997 and 2000 (see Table 1). This increase not only has reduced the average monthly household water demand but also has increased the income of PUB, which has enabled it to generate funds not only for good and timely operation and maintenance of the existing system but also for investments for future activities. Water tariffs have not been raised since July 2000.

Such an approach has enabled PUB to fund its new capex investments over the years from its own income and internal reserves. In 2005, for the first time, PUB tapped the commercial market for S\$400 million bond issue. Under the Public Utilities Act, the responsible Minister for the Environment and Water Resources had to approve the borrowing. The budgeted capex for the year 2005 was nearly S\$200 million.

Because of lack of autonomy, political interferences, and other associated reasons, internal cash generation of water utilities in developing countries to finance water supply and sanitation has steadily declined: from 34% in 1988, to 10% in 1991 and only 8% in 1998. Thus, the overall situation has been 'lose-lose' for all the activities. The Singapore experience indicates that given autonomy and other appropriate enabling environmental conditions, the utilities are able to be not only financially viable but also perform their tasks efficiently.

Unlike many other similar Asian utilities, the PUB has extensively used the private sector where it did not have special competence or competitive advantage in order to strive for the lowest cost alternative. Earlier, the use of the private sector for desalination and wastewater reclamation was noted. In addition, specific activities are often outsourced to private sector companies. According to the Asian Development Bank (November 2005), some S\$2.7 billion of water-related activities were outsourced over the 'last four years', and another S\$900 million will be outsourced during 'the next two years' to improve the water services.

### *Overall Performance*

No matter which performance indicators are used, PUB invariably appears in the top 5% of all the urban water utilities of the world in terms of its performance. Only a few of these indicators will be noted below:

- 100% of population have access to drinking water and sanitation.
- The entire water supply system, from water works to consumers, is 100% metered.
- Unaccounted for water as a percentage of total production was 5.18% in 2004.
- The number of accounts served per PUB employee was 376 in 2004 (Figure 5).
- Monthly bill collection efficiency: 99% in 2004.
- Monthly bill collection in terms of days of sales outstanding was 35 days in 2004.

The above analysis indicates that PUB has initiated numerous innovative approaches to manage the total water cycle in Singapore. Many of these approaches can be adopted by developed and developing countries to improve their water management systems. If the MDGs that relate to water are to be reached, the example of Singapore needs to be seriously considered for adoption by developing countries concerned and the donor community, after appropriate modifications.

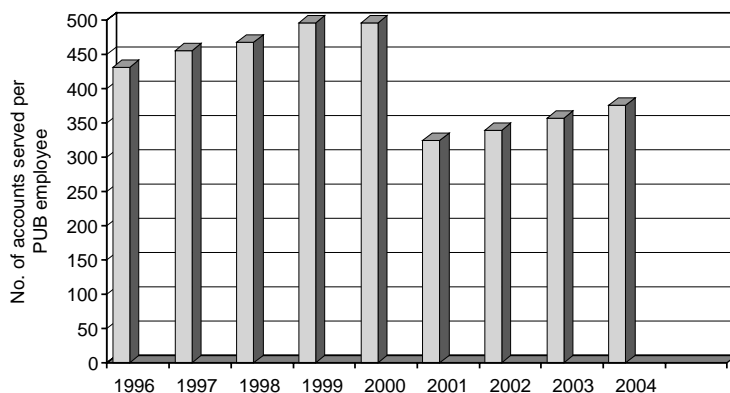


Figure 5. Number of accounts served per PUB employee, 1996–2004

### Concluding Remarks

Viewed from any perspective, any objective analysis has to conclude that water supply and wastewater management practices in recent years in Singapore have been exemplary. Water demand management practices are unquestionably one of the best, if not the best, from any developed or developing countries, irrespective of whether a public or private sector institution is managing the water services. Singapore has successfully managed to find the right balances between:

- water quantity and water quality considerations;
- water supply and water demand management;
- public sector and private sector participation;
- efficiency and equity considerations;
- strategic national interest and economic efficiency; and
- strengthening internal capacities and reliance on external sources.

In other words, the country has successfully implemented what most water professionals have been preaching in recent years.

By ensuring efficient use of its limited water resources through economic instruments, adopting the latest technological development to produce ‘new’ sources of water, enhancing storage capacities by proper catchment management, practicing water conservation measures, and ensuring concurrent consideration of social, economic and environmental factors, Singapore has reached a level of holistic water management that other urban centres will do well to emulate.

### Acknowledgements

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### References

- Appan, A. (2003) A total approach to water quality management in partly-protected catchments. Paper presented at The Singapore Experience, International Workshop on Management and Conservation of Urban Lakes, Hyderabad, India, 16–18 June.

- Asian Development Bank (2003) *Asian Water Supplies: Reaching the Poor* (Manila: ADB).
- Asian Development Bank (2005) Country Water Action: Singapore. Technology turns Water Weakness to Strength, November.
- Cattle Act, Republic of Singapore. Available at [http://app.nea.gov.sg/cms/htdocs/category\\_sub.asp?cid=181](http://app.nea.gov.sg/cms/htdocs/category_sub.asp?cid=181)
- Khoo Teng Chye (2005) Water resources management in Singapore. Paper presented at Second Asian Water Forum, Bali, Indonesia, 29 August–3 September.
- Lee, M. F. & Nazarudeen, H. (1996) Collection of urban storm water for potable water supply in Singapore, *Water Quality International*, May/June, pp. 36–40.
- Lee Poh Onn, (2005) Water management issues in Singapore, paper presented at Water in Mainland Southeast Asia, 29 November–2 December, Siem Reap Cambodia, conference organized by the International Institute for Asian Studies (IIAS), Netherlands, and the Centre for Khmer Studies (CKS), Cambodia.
- Malaysia, Act of Parliament No. 53 of 1965, Constitution of Malaysia (Singapore Amendment) Act, 1965: An Act to amend the Constitution of Malaysia and the Malaysia Act, 9 August, 1965.
- Ministry of the Environment and Water Resources (2006) Key Environmental Statistics 2005, Singapore.
- Public Utilities Board (2002) Annual Report, Singapore.
- Public Utilities Board (2003) Annual Report, Singapore.
- Public Utilities Board (2004) Annual Report, Singapore.
- The Johore River Water Agreement between the Johore State Government and City Council of Singapore signed on 29 September 1962. Available at <http://www.channelnewsasia.com/cna/Parliament/relations/documents.htm>
- The Tebrau and Soudai Rivers Agreement between the Government of the State of Johore and the City Council of the State of Singapore signed on 1 September 1962. Available at <http://www.channelnewsasia.com/cna/parliament/relations/documents.htm>
- Tortajada, C. (2006) Singapore: an exemplary case for urban water management, prepared for the 2006 Human Development Report.
- Trade Effluents Regulations (1976) Water Pollution Control and Drainage Act, Act 29/75, Pub. No. SLS 29/76, Republic of Singapore.