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ACRONYMS

3P	Private-Public-People
3PN	Private-Public-People Networking
D & B	Design and Build
DBOO	Design-Build-Own-Operate
DTSS	Deep Tunnel Sewerage System
DGP	Development Guide Plan
EDB	Economic Development Board
GST	Goods and Service Tax
HDB	Housing & Development Board
IW	Industry Water
JTC	Jurong Town Corporation
LTA	Land Transport Authority
MBR	Membrane Bioreactor
Mgd	Million Gallon Day
MOE	Ministry of Environment
MOF	Ministry of Finance
MOEWR	Ministry of Environment and Water Resources
NEA	National Environmental Agency
NGO	Non Government Organization
PBU	Public Building Authority
PCD	Pollution Control Department
PPP	Public-Private Partnership
PUB	Public Utilities Board
RIET	Regional Institute of Environmental Technology
RO	Reverse Osmosis
TDB	Trade Development Board
URA	Urban Redevelopment Authority
USEPA	United States Environmental Protection Agency
WBF	Water Borne Fee
WCT	Water Conservation Tax
WHO	World Health Organization

EXECUTIVE SUMMARY

From the 1980s to 1990s Singapore made tremendous efforts to create a comprehensive environmental management system, including water supply, control of river pollution, establishment of well planned industrial estates, and a world class urban sanitation system for the whole island. More recently, the Singapore government has made "sustainable water supply" the main target of water management, and a series of initiatives and actions have been undertaken. Singapore has achieved remarkable progress in water resource management based primarily on urban catchment management and water reuse. Its experience is valuable for other countries and cities facing threats to the quality and quantity of their water supplies. The key points of the Singapore experience are highlighted below:

Political Will. The Singapore government has been an essential force behind the successful water policy, strategy, planning and implementation. The Prime Minister's support for the *Four National Taps Strategy* has enabled the Public Utilities Board (PUB) to conduct a series of water programs;

Institutional Integration. The newly established Ministry of Environment and Water Resources (MOEWR), which has full responsibility for water related affairs, including policy formulation, planning and infrastructure, eliminates administrative barriers in water management and makes implementation effective and efficient.

Integrated Land Use Planning. Singapore has been very effective in integrating land use planning and water management. It prevents water pollution at an early stage, and constitutes one of the most critical factors for successful catchment management. Effective cross-sector coordination among the relevant government agencies in water management ensures success of integration, and reduces inter-sectoral conflict of interest.

Enforcement of Legislation. Strict implementation of legislation such as pollution control is another essential characteristic of water management in Singapore.

Public Education. School education and public campaigns are used as tools to raise public awareness of water policy and programs. These activities boost public support for the government's water policy and initiatives.

Application of Advanced Technology. Singapore pays close attention to development and application of new water technology. Combined with its policies, regulations, planning, and enforcement mechanisms, the application of new technology is an important contributor to Singapore's standing as a world leader in urban water management.

CHAPTER 1
NATIONAL WATER RESOURCE DEVELOPMENT STRATEGY

Singapore is a city state with an area of about 680 square kilometers and a population of 4 million, and has highly developed industrial, business, and financial services. As an essentially urbanized country, but one which lacks natural resources, Singapore is facing a serious shortage of water resources. Its current water demand is about 1.4 million cu meters daily but domestic resources only meet about 50% of that (Baumgarten, 1998). Water resource management becomes, therefore, a strategically important issue for national economic development and public and social life.

From the 1980s to 1990s Singapore made tremendous efforts in (i) establishing a legal and management system for the environment, including water; (ii) conducting pollution control, river cleaning and setting up industrial estates according to land planning; and (iii) building up a world class urban sanitation system including water and sewerage networks and treatment plants covering the whole island. With these institutional instruments and rigorous enforcement of regulations and legislation, Singapore has been referred to as a "Garden City Country".

From the later 1990s until the present the government has set "sustainable water supply" as the main target of water strategy, and for this a series of initiatives and actions have been taken, and the country has achieved remarkable progress in water resource management. Currently, its urban catchment area covers 50% of the island, and by the end of 2006 reused water will account for about 12% of its water supply. To achieve this, several ambitious programs are being undertaken.

The Singapore Green Plan 2012 (MOEWR, 2006), states that to "ensure the sustainability of clean water supply" is the core of water policy in Singapore. The Ministry of Environment and Water Resource (MOEWR) further defines the core Strategies for Sustainability as below (MOEWR, 2005):

- Enhance robustness and resilience of water supply sources
- Develop effective water demand management strategies
- Build up a vibrant water industry
- Encourage greater private sector participation
- Study and explore alternative policies, technologies and strategies to ensure long-term sustainability of Singapore's water supply.

Singapore has been active in diversifying its water sources with its *Four National Taps Strategy* (MOEWR, 2006). The first tap is the supply of water from local catchments. This consists of an integrated system of reservoirs and an extensive drainage system to channel storm water into the reservoirs.

The second tap – imported water from Johor – supplements Singapore's needs. So does the third tap – NEWater, which is drinking water-quality water produced by further purification of the secondary effluent. The fourth tap is desalinated water. Increasing the portions of the first, third and fourth Taps is the target and challenge.

CHAPTER 2
INSTITUTIONS AND POLICY INSTRUMENTS

Institutional Reform

Institutional reform to allocate all water related administrations under one umbrella is a key component of Singapore's water resource management. In the past water supply and sewage treatment were managed separately by different institutions in Singapore. The Public Utilities Board (PUB) was responsible for water resources and supply, while the Ministry of Environment (MOE) was responsible for sewage treatment and the sewerage system. To implement an integrated water resource management strategy, the Ministry of MOEWR, which replaced the previous MOE, was formed on 1 July 2002. The PUB became part of the MOEWR and was restructured. The new PUB's responsibilities have been extended and now include sewage treatment and reuse, flood control and sewer system in addition to water resources and supply. PUB is now the major institution responsible for comprehensive water related affairs in Singapore (Box 1). The new water institutions in Singapore provide favorable conditions for integrated water management and have largely wiped away administrative barriers which exist in many other countries.

Regulations

Singapore has a comprehensive environmental legislative system and, more importantly, strict implementation. Important water resource-related regulations include (RIET, 2004):

- Environmental Pollution Control Act (Cap.94) (2002). The Act sets allowable limits for liquid effluent discharge to sewers and waterways including temperature, BOD, COD, total suspended solids, total dissolved solids, pH value, and 28 different chemicals;
- Environmental Public Health (Toxic Industrial Waste) Regulations. These list the categories of toxic industrial wastes subject to specific legislated controls;
- Sewerage and Drainage Act (Cap.294) (2001). Under this legislation, PUB is empowered to be responsible for matters related to drainage systems.
- Public Utilities Act (2002) (Cap. 261). It stipulates the responsibilities of PUB;
- Public Utilities (Water Supply) Regulations; and
- Public Utilities (Central Water Catchment and Catchment Area Parks) Regulations.

Public Utilities (Water Supply) Regulations stipulate that "No supply of water, except with the consent of the Board, be given otherwise than through a meter". The same regulations also stipulate that "No person shall install, or cause or permit to be or to remain installed… any water fitting in any premises which is not fitted with such water saving devices as may be stipulated by the authorized officer". These regulations make water metering and water saving devices mandatory in Singapore.

Box 1: Structure of PUB

Major Departments and the Duties of Public Utilities Board (PUB) Singapore

Department	Main Duty
Water Supply	Production of public water and reused water, which is produced from treated secondary effluent and collective systems in Singapore. The reused water is sent for industry and indirect discharge into the reservoirs after advanced treatment of the secondary effluent.
Water Reclamation	Treatment and reclamation of water from municipal sewage and sewer systems. Treatment plants have been updated for production of the reused water, a new water resource in Singapore.
Catchment and Waterways	Planning, management, construction and maintenance of catchment, reservoir, drainage systems, flood control and discharge of rain water.
3PN (Private-Public-People Networking)	Private participation in water infrastructure. To make investment more efficient several water plants were built by private-public partnership mode although the government has a financial surplus.
Policy and Planning	Planning and development of water resource policy and pricing.
Best Sources	Exploration and identification of opportunities to outsource PUB's work based on cost-effectiveness.
Technology and Water Quality	Planning, evaluation, testing and budget management for new technology and projects. Water quality is a new area for the department.

Source: http://www.pub.gov.sg/home/index.aspx

The Public Utilities (Central Water Catchment and Catchment Area Parks) Regulations stipulate that prior approval is needed to "draw water from any reservoirs and streams". These regulations indicate that water in Singapore is in the public domain. The government intervenes in water issues through administration and regulation in the public interest

Integrated Land Use Planning

Integrating land use planning with water resource management is an important feature of Singapore's water management. The Singapore Land Authority ACT (Cap.301) (2002), which provides a legal basis for the coherence of water resource and land management, stipulates that land use planning must be conducted for the allocation and disposal of State land or grant of any State title to any person or public authority, and for technical co-operation and exchange in the area of land survey and land resource administration and management with other persons and organizations. The Urban Redevelopment Authority (URA) plays a leading and active role in national planning and industrial estate development, where water is an important element.

In addition to the URA, other government agencies participate in water management. For example, rainwater collection is facilitated by close liaison with several government bodies, including the URA, the

Housing & Development Board (HDB), National Environmental Agency (NEA), Jurong Town Corporation (JTC) and Land Transport Authority (LTA) although the PUB takes the overall responsibility. Notable features of such coordinated planning and various measures implemented are: (a) judicious planning of land use to exclude polluting activities, principally industrial, from the stormwater catchments; (b) redesign of HDB refuse bin collection centers and refuse chutes to minimize spillage; (c) strict enforcement of anti-pollution laws and regulations; and (d) incorporation of the main components of the collection system such as diversion structures and holding ponds into the main drainage network. Compliance with drainage requirements is necessary before planning approval is granted by URA (Lim, 2005).

Economic Instruments

A huge public investment has been made in water and water-related infrastructure, including upgrading and rehabilitation as well as building new facilities and plants. Water collection and sewer systems now cover almost the whole island. Drinking water meets international standards. Six sewage treatment plants handle all the sewage collected from domestic and industrial sources.

*Water Tariff System***.** Demand management is implemented with various economic instruments to reduce water consumption in Singapore. As shown in Table 1 an increasing block rate water tariff structure is used. An increase in fees up to S$ 1.4 /m3 is collected when the amount of water used exceeds 40 m3/month. A Water Conservation Tax is levied by the Government to reinforce the water conservation message. Sanitary Appliance Fees and Waterborne Fees are statutory charges payable to the Public Utilities Board (PUB) under the Sanitary Appliances and Water Charges Regulations to offset the cost of treating used water and for the maintenance and extension of the public sewerage system. However, it appears that the costs of household sewage collection and disposal remain subsidized from general revenues.

Table 1: Water Tariffs in Singapore [1]

Tariff Category	Consumption Block (m^3 per month)	Tariff (cents /m^3)	Water Conservation Tax (% of tariff)	Waterborne Fee (cents /m^3)	Sanitary Appliance Fee
Domestic	1 to 40	117	30	30	$3/- per chargeable fitting per month
	Above 40	140	45	30	
Non-domestic	All units	117	30	60	
Shipping	All units	192	30	-	-

Table 2 lists the prices of NEWater and Industrial Water (IW), which is non-potable reused water (grey water). To encourage water reuse, the Water Conservation Tax is not applied to NEWater and Industrial Water (IW).

Table 2: NEWater and Industrial Water Tariffs [2]

Tariff Category	Consumption Block (m^3 per month)	Tariff (cents/m^3)	WCT (% of tariff)	WBF (cents/m^3)
NEWater	All units	115	-	-
Industrial Water	All units	43	-	-

[1] From: http://www.pub.gov.sg/info_center/IcFfWaterTariffs.aspx?l1=4&l2=22&l3=27.

[2] From: http://www.pub.gov.sg/info_center/IcFfWaterTariffs.aspx?l1=4&l2=22&l3=27.

Several tax incentive schemes to encourage water recycling and water saving projects are administered by the Economic Development Board (EDB), the Trade Development Board (TDB) and the Ministry of Finance (MOF) under the Economic Expansion Incentives (Relief from Income Tax) Act and the Income Tax Act (RIET, 2004). Tax exemption is granted on a portion of income based on a specified percentage (not exceeding 100 percent) of fixed capital expenditure incurred for certain projects or activities that reduce the consumption of potable water (Baumgarten, 1998).

Penalties. Singapore is rigorous in its application of fines to enforce regulatory measures. For water pollution the maximum fine for violating the acceptable effluent limits is S$ 50,000 for the first conviction and a maximum penalty of S$100,000 for second and subsequent convictions (RIET, 2004).

Private Investment. To pursue more effective investment and promote the local water industry, encouragement of private participation in urban sanitation infrastructure has become Singapore government policy. Two NEWater Factories (see below) were delivered through the conventional "design to build (D&B)" delivery concept. This involves consultants to develop the detailed design of the NEWater factories, followed by contractors to build the NEWater factories in accordance with the design. To leverage the innovation of the private sector and enhance the synergy of the design and construction processes, the third NEWater factory was designed and built by a local contractor. In Jan 2005, PUB entered into a 20-year NEWater agreement with a local private company. Under the agreement, the company will design, build, own and operate (DBOO) the NEWater Factory and sell NEWater and Industry water to the PUB. In 2003, the PUB awarded a contract for the supply of 136,380 m3/day (30 mgd) of desalinated water on the Design-Build-Own-Operate (DBOO) scheme to another local private company (Koh et al., 2005).

Public Awareness

Public awareness about environment, especially water matters, is developed in Singapore through three major avenues, namely specialized campaigns, the education system and the "Clean and Green Week." The first campaign, "Keep Singapore Clean," focuses on building public awareness about environment and water management. Often, a campaign will precede introduction of an environmental or public health law, which is then followed up with strict enforcement. Schools are important conveyors of environmental information. Since 1990, Singapore has held a Clean and Green Week with a different theme each year (Leitmann, 2000).

CHAPTER 3
ACHIEVEMENTS AND TARGETS

Significant progress has been achieved in obtaining more water from the three National Water Taps i.e. domestic catchment, NEWater and desalination. This section will briefly review catchment management, water reuse and applications of new technologies.

Catchment Management and Enlargement

Catchment Management. Watershed conservation is vitally important to ensure water quality in the reservoirs, especially considering most of the catchment is located in urban areas of Singapore. Because of close coordination between land use planning and water catchment activities, including implementation of stringent anti-pollution measures and broad–based actions such as setting of green belts in the periphery of reservoirs, water catchment now accounts for about 50% of the land area of Singapore. Given a unique scheme to implement urban stormwater pond collection systems the raw water from these urbanized catchments have very low levels of heavy metals and low coliform counts as compared to raw water from largely forested catchments (Lee et al., 1996; Lim, 2005).

Enlargement of Catchment. In addition to managing the existing catchment, enlargement of the water catchment in Singapore's limited land is another of many efforts. One of the key pillars of the local water supply blueprint is the Marina Barrier Program (Tan, 2004) (Box 2). It is expected that upon completion of this program there will be an increase in the supply of water by about 10 per cent of current water needs, and the effective catchment area in Singapore will be increased from the current 50% to two thirds of the total land area.

Inter-transfer Project. Under this on-going project pipe connections amongst the reservoirs are being built up aiming to maximize the storage capacity. Previously, water had to be pumped out to sea from some reservoirs, while the storage capacity was not fully utilized in other reservoirs. The new linkage under construction will allow excess water from one reservoir to be channeled to another, thus increasing yield.

Augmentation of Water Supply from Unconventional Sources

NEWater Program. The PUB started to test the production of NEWater (treated wastewater) in 1998. Currently, there are three NEWater factories with a combined production capacity of 96,000 cu meters per day. At the end 2006, the biggest NEWater Factory in Singapore with production capacity of 116,000 cu meters per day will be completed. There will then be a capacity of about 200,000 cu meters per day of NEWater, corresponding to about 13% of the daily water supply. The treated wastewater becomes a new water resource, which closes the water loop. The NEWater application in Singapore is the largest in non-potable wastewater reuse in the world, and marks a milestone in the development of water reuse. The target is to supply

Box 2: Marina Barrier Program

The Marina catchment is the largest water catchment in Singapore. This program spans an area of 10,000 hectares or one-sixth the size of Singapore. To develop this catchment into a water catchment the Marina Barrage, which is a tidal barrier 350m wide located at the southern tip of Singapore, will keep seawater out of the Marina Basin. A new reservoir with a body of water with a surface area of 240 hectares located in the urban area is under construction and will be completed in 2007.

The concept is that through natural flushing from monsoons over time the saline water originally in the Basin will be gradually displaced and turned into a body of freshwater. This body of freshwater will augment the local sources from water catchments, which is the first of the four National Taps. The resulting body of freshwater would then serve as a reservoir to boost Singapore's water supply. Because the barrage would allow the water level in the basin to be maintained, it would also help to control flooding of low-lying areas in the city centre, an occasional occurrence when heavy rains coincide with high tides.

The success of this project requires Public-Private-People involvement to keep the basin clean and beautiful for enjoyment. The Marina catchment encompasses some of the most densely populated and urbanized areas. From anywhere within the catchment, a piece of litter thrown carelessly into the drains or waterways will eventually find its way to Marina Reservoir, thereby dirtying the very body of water meant for all Singaporeans to enjoy. Also playing an important role in maintaining the cleanliness of Marina Reservoir are the construction sites in the Marina catchment. It is important for construction sites to implement effective earth control measures to ensure that the water discharged from these sites into the drains or waterways does not remain silty or muddy. If allowed to enter Marina Reservoir, the silty or muddy water will dirty the water body and turn it brownish, rendering it aesthetically unpleasing for people to enjoy the pristine water body and the vast varieties of water activities.

Source: PUB (2004).

250,000 cu meters per day of NEWater for direct non-potable use, or 15% of the Singapore water supply, by the year 2011. To launch such a potentially controversial product due to the nature of its source, and make it acceptable by Singaporeans in such a short span of time requires a careful plan, and a well-timed and properly coordinated public communications strategy (Box 3).

Currently, the bulk of the NEWater is supplied to the wafer fabrication plants. A small amount of NEWater, about 18,000 cu meters per day is being pumped into raw water reservoirs for planned indirect potable use. The volume of discharge into reservoirs is expected to gradually increase to 45,000 cu meters per day by 2011.

To enhance public understanding of NEWater, the PUB has embarked on an intensive public education program on NEWater, and advertisements, posters and leaflets have been produced. Briefings and exhibitions have been held to spread the NEWater message. The NEWater Visitor Centre has been open since Feb 2003 for the public to see the use of leading-edge membrane technology and ultra-violet disinfection in the production of NEWater.

Box 3: NEWater Program

In 2000, a full-scale demonstration plant to produce NEWater with a capacity of 10,000 cubic meters per day was commissioned to undertake extensive tests on the quality of reclaimed water and the technical capability and operational reliability of the membrane technology to recover good quality water from treated effluent of a municipal activated sludge wastewater treatment plant. At same time a pilot-scale plant with the same process to use NEWater as feed water producing ultra-pure water as in a wafer factory, was set up to verify the feasibility of using NEWater in the wafer industry.

A comprehensive water sampling and analysis program was implemented and the quality of the NEWater benchmarked against World Health Organization (WHO) Drinking Water Guidelines and the United States Environmental Protection Agency (USEPA) Drinking Water Standards. Leading advanced water testing laboratories of local and foreign institutions were engaged to carry out extensive and comprehensive physical, chemical and microbiological test analyses of the water at various stages of the production process over a 2 year period. Chemical parameters of emerging concerns were also included. In all, some 190 parameters and over 30,000 analyses were carried out during this period.

An international panel of experts comprising renowned local and foreign experts in engineering, biomedical science, chemistry and water technology was formed to provide independent advice on the water reclamation study and to evaluate the suitability of NEWater as a source of water for potable use. The test results and the plant operation were regularly audited and reviewed by the Panel. The Expert Panel concluded that NEWater is consistently of high quality, well within the requirements of the USEPA and WHO standards for drinking water. It is safe as a source of water. The Panel also recommended indirect potable use by introducing NEWater into raw water reservoirs.

The NEWater studies have confirmed that extremely high quality reclaimed water can be reliably and consistently produced by the NEWater Factory. PUB hence embarked on a program for the large scale production and supply of NEWater directly to industries and commercial sector for direct non-potable use. PUB officers visited potential clients, studying industry needs and concerns. Government leaders took actions to boost the NEWater program through meeting with industry and drinking NEWater in public occasions, etc. A NEWater centre was established for demonstration and public education purposes. Economic incentives such as low price and tax reduction, etc. help with implementation of the program. A series of contracts between the PUB and industrial clients for NEWater supply have been signed.

Source: Lim, (2005)

Desalination. The first desalination plant using reverse osmosis (RO) technology and with a capacity 136,380 cu meters per day (30 mgd) was commissioned in September 2005. This seawater plant is one of the first and largest of such facilities in the region.

At the Forefront of Technology

Water Saving. Due to strict enforcement of the regulations, water usage is 100% metered in Singapore and installation of water saving devices such as water saving toilets and water taps are carried out throughout the island. An important implication of these regulations is that all apartments in an apartment block are individually metered, as well as a bulk meter for the apartment block as a whole.

Water audits are undertaken to ensure appropriate water consumption. Leakage prevention is conducted through a rehabilitation program on a regular basis. The proportion of leakage, or unaccounted for water, dropped from the previous 11.2 to 6.2 percent (Ng et al., 1997), which is the lowest in the world.

Membrane Technology. Membrane filtration coupled with enhanced coagulation has been applied in the Chesnut Water Works with a capacity of 273,000 cu meters per day (60 mgd) in 2003 - the largest of its type in the world at the time. Following completion of the pilot-scale experiment, a full-scale demonstration project of a Membrane Bioreactor (MBR) to treat sewage for reuse purpose is under construction. Its design capacity is 23,000 cu meters per day, the largest in Asia so far.

Deep Tunnel Sewerage System (DTSS). This system consists of two cross-island deep tunnels and two new, large water reclamation plants located at the eastern and western ends of the island. The deep tunnels will intercept used water from the existing sewers and channel it to the water reclamation plants. The effluent from the plants will be discharged into the Straits of Singapore through sea outfall pipes. When the system is fully completed, it will gradually replace the existing sewerage infrastructures (water reclamation plants and pumping stations) located island-wide. The first phase of the DTSS will initially treat 800,000 cu meters per day (176 mgd) of wastewater, and is expected to be completed in 2008. The compact and covered plant can ultimately be expanded to a capacity of 2,400,000 cu meters per day (528 mgd) (Nicholson et al., 2005).

New Targets

Singapore has set new water management targets, scheduled to be achieved by 2012, as follows: (MOEWR, 2006):

- Increase catchment areas from 50% to 67% of Singapore's land surface (by 2009).
- Increase supply of water from non-conventional sources, such as desalination and water reclamation, to at least 25% of Singapore's water demand.
- Ensure that water quality continues to meet international standards.
- Reduce per capita domestic water consumption to 155 liters/day..
- Partner the 3P sectors to generate greater awareness of the importance of conserving, valuing and enjoying water and develop a sense of shared ownership of our water resources.

With regard to the latter point, the government realizes the importance of a wider and deeper involvement of public and industry in water management. PUB is entering a new phase to involve the 3P (People, Private, Public) sectors in the management of Singapore's water resources. This 3P approach is embodied in PUB's new tagline – Water for All: Conserve, Value, Enjoy (PUB, 2004). Also, to promote domestic capacity in water technology the Singapore government has selected environment and water as one of the three areas of its national research and development plan in the next five years.

CHAPTER 4
CONCLUDING REMARKS

Singapore has now developed an outstanding urban sanitation infrastructure. The key water institution – the PUB - has comprehensive responsibilities for all water-related affairs, and formulates the national water resource development strategy with clearly defined tasks and timeframe with the strong political will and support from the government. Integrated land use planning and strict enforcement of regulations, combined with a well educated population provide essential conditions for effective and efficient water pollution control and urban catchment management, ensure good water quality, and make catchment enlargement possible. Private investment is increasingly participating in the water utilities business, which further improves the investment efficiency and promotes the capacity of the local water industry.

As a water-scarce city state, Singapore's experience is somewhat unique. Nevertheless, many of the measures it has taken to achieve its remarkable progress in water management do offer useful lessons even for large countries such as China and other cities. In terms of cross-sector and cross-agency coordination, integration of land use planning and water management, enforcement of legislation, and carefully planned and determined implementation of water programs, the Singapore experience shows that public ownership of a water and sewerage utility – in this case the PUB - can be as efficient as any private operation if the enabling conditions are in place.

REFERENCES

Baumgarten B. (1998) The Singapore Environmental Market: Asia's Hub, RIET and the Strategist, Singapore.

Koh S. T and Ong H. H. (2005) Ulu Pandan NEWater – Design Build Own and Operate (DBOO) Project, 1st IWA-ASPIRE (Asia Pacific Regional Group) Conference, July 10-15, 2005, Singapore.

Lee M. F. and Nazarudeen H. (1996) Collection of Urban Stormwater for Potable Water Supply in Singapore. Water Quality International, June, 1996, London.

Leitmann J. (2000) Integrating the Environment in Urban Development: Singapore as a Model of Good Practice, Working Paper Series No.7, The World Bank. Washington DC.

Lim C. H. (2005) Urban Stormwater Collection Systems for Potable Use, 1st IWA-ASPIRE (Asia Pacific Regional Group) Conference, July 10-15, 2005, Singapore.

Ng K. H. and Foo Y. K. (1997) Unaccounted-for Water: Singapore's Experience. J. Water SRT-Aqua. 46(5), pp: 242-251.

Nicholson G. A., Tan N. C. and Tan C. H. (2005) Changi Water Reclamation Plant --- Overview and Implementation, 1st IWA-ASPIRE (Asia Pacific Regional Group) Conference, July 10-15, 2005, Singapore.

MOEWR (2005) Water Strategy in Singapore, (http://www.pub.gov.sg).

MOEWR (2006) The Singapore Green Plan 2012, 2006 edition, (http://www.pub.gov.sg).

RIET (2004) Handbook on Singapore Environmental Laws, Singapore.

PUB (2004) Annual Report, (https://www.pub.gov.sg/annualreport2004/download /financial statements.pdf).

Tan Gee Paw (2004) After the NEWater, There are New Challenges, in: PUB Annual Report 2004, (http://www.pub.gov.sg/annualreport2004/Future_NewChallenge.html).