



PUB SINGAPORE'S
NATIONAL
WATER AGENCY



WHO WE ARE

PUB is Singapore's National Water Agency. Three thousand five hundred people work in PUB, most of them in engineering roles. As an integrated water utility, PUB is responsible for providing good water, reclaiming used water and taming stormwater in Singapore.



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THE PUB STORY

1961

First water agreement allowing Singapore to draw water from areas in Johor for 50 years.



1976

A new emblem was unveiled.



2001

PUB was reconstituted to become a full-fledged water agency and transferred from the Ministry of Trade and Industry to the Ministry of the Environment.



2009

Opening of Changi Water Reclamation Plant, the heart of Deep Tunnel Sewerage System (Phase 1)

2016

Singapore Water Academy opened.



1962

Second water agreement allowing Singapore to draw up to 250 million gallons (mgd) of water a day from Johor River till 2061.

1963

Public Utilities Board (PUB) was set up as a statutory board to coordinate the supply of electricity, piped gas and water.

1965

Both water agreements are guaranteed by Malaysia in the Separation Agreement, which is registered with the United Nations.

1977

Singapore River clean-up launched by the 1st Prime Minister of Singapore, Mr Lee Kuan Yew.

1980s

The century-old night soil bucket system was phased out and replaced with the on-site sanitation system islandwide.

1987

Singapore River clean-up completed.

1990

Supplement to 1962 Agreement signed allowing Singapore to build the Linggiu Dam to increase the yield of Johor River.

1991

Water Conservation Tax introduced.

1994

Linggiu Reservoir built upstream of the Johor River.

1995

PUB's electricity and piped gas undertakings were corporatised to Singapore Power Ltd.

1997 – 2000

The Government increased water prices progressively over a period of four years.

2002

NEWater was introduced to the public at Singapore's 37th National Day Parade.

2003

Official opening of Bedok and Kranji NEWater Plants.

2004

Ministry of the Environment was renamed Ministry of the Environment and Water Resources to reflect its full scope of work.

2005

- First desalination plant at Tuas commissioned.
- PUB was rebranded to PUB, Singapore's national water agency. A tagline was introduced: Water for All: Conserve, Value, Enjoy.

2006

Launch of the Active, Beautiful, Clean Waters Programme

2007

PUB won the Stockholm Industry Water Prize.

2008

- Inaugural edition of Singapore International Water Week.
- Opening of Marina Barrage.

2010

Marina Reservoir commissioned.

2011

- Punggol and Serangoon Reservoirs commissioned.
- Expiry of the 1961 Water Agreement.

2013

- PUB celebrated its 50th anniversary.
- Opening of Tuaspring Desalination Plant.

2017

- BEWG-UESH NEWater Plant operational.
- Singapore's 3rd desalination plant opens.
- Water prices increased progressively over a period of two years.

ENGINEERED FOR SUCCESS

PUB is entrusted with two very valuable resources – water and people. Just as we aim to capture every drop of water, we seek to maximise the potential of every one of our employees.

We do this by providing a supportive work environment and carving out challenging roles that enable our people to shine.

While we depend on people with diverse skills, engineering is our core competency. We are an interesting organisation because of the variety of work involved, the large scale of our projects and use of cutting-edge technology. And our work makes a difference to people's lives and the environment, both in Singapore and beyond.

Engineering for Sustainability

One vital role our engineers play is in equipping our country to cope with climate change. Besides managing water demand, PUB's plans and policies aim to ensure enough water even in extreme drought. We also work towards reducing the risk of flooding due to more intense rainfall or rising sea levels as well as minimising disruptions to our tap water and used water services.

In addition, we are helping to cut carbon emissions. We do this not only by maximising energy efficiency in our water treatment processes but also by generating electricity through them. To help Singapore harness solar energy, we are working with other government agencies to install solar panels at our facilities and deploy floating solar farms on our reservoirs.



Chong Mien Ling

Deputy Director,
Technology Department

“Working in a leading utility is exciting because there’s sometimes no precedent to follow. I was able to develop system-level thinking through valuable exposure and involvement in various parts of the water supply system and PUB’s post-graduate scholarship enabled me to earn my Masters of Science overseas. I was also grateful for the opportunity to be seconded to the World Health Organization where I helped various countries implement safer water management frameworks, an experience I found extremely gratifying both personally and professionally.”

Er. Lai Kah Cheong

Chief Engineer,
Water Supply (Network) Department

“From planning and design, actual construction of infrastructure to operation and maintenance of facilities, we get to do it all. My current job centres on ensuring the delivery of good quality potable water 24/7 through a network of pipelines that spans 5,500km. After 17 years in PUB, my work as an engineer still keeps me engaged and I am excited to find that there is still much to learn.”

Cheng Geok Ling

Deputy Director, Sustainability Office
(Active, Beautiful, Clean Waters Programme)

“My team works with other public agencies and private developers to promote the ABC Waters concept. It makes me proud and happy to see the public enjoying the recreational space along the waterways and waterbodies that have been enhanced under the programme. It is also heartening to see the public making efforts to keep our waters clean while enjoying these spaces.”

Pratheipa Rajendram

Principal Engineer, Drainage Planning,
Catchment and Waterways Department

“PUB has taught me much more than school has – I’ve progressively updated my technical knowledge and learned the important skill of customer management. I tell my team members that understanding what the customer expects of PUB and to deliver it on time, is one of the most important skills of public relations.”



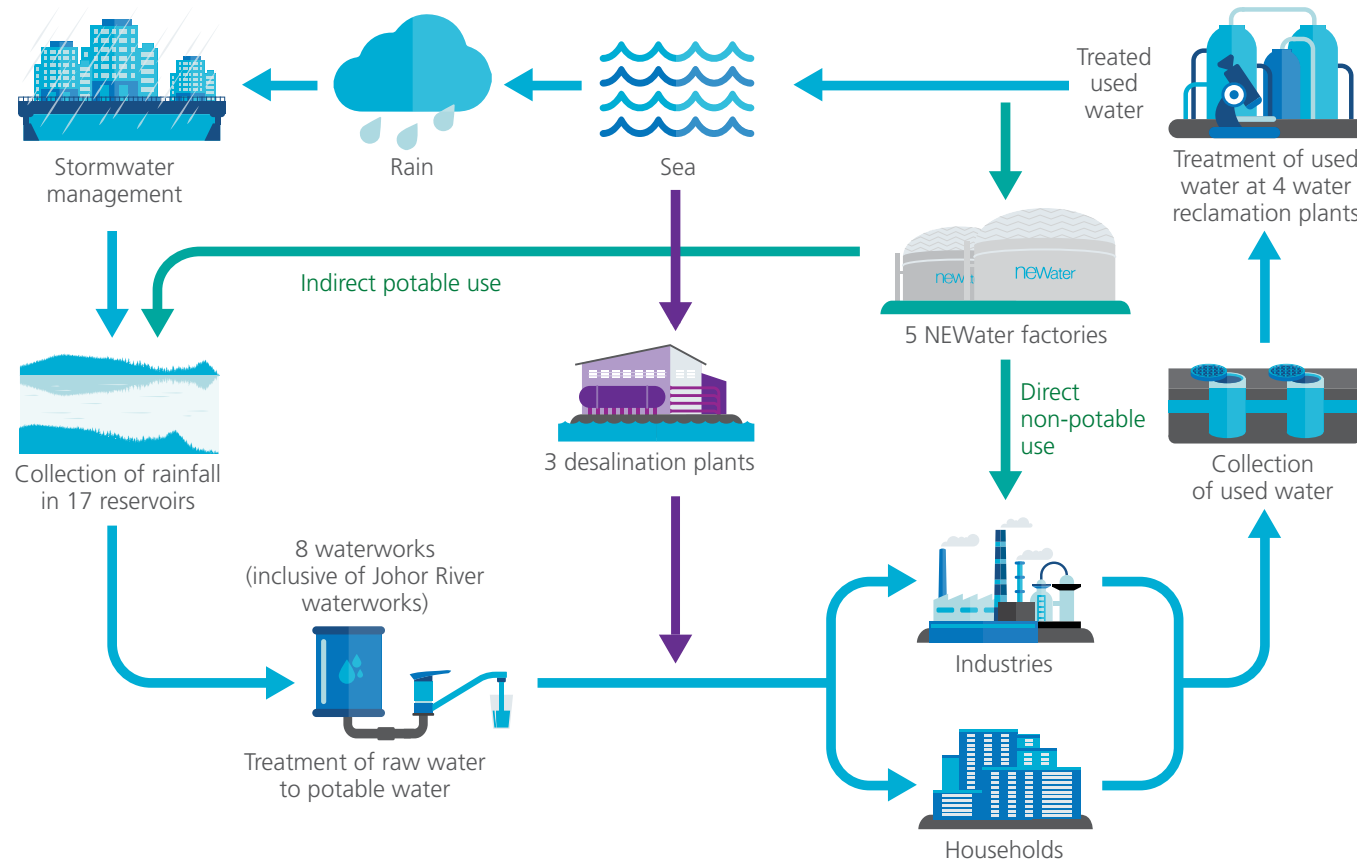
SUPPLYING GOOD WATER

THE WATER LOOP

Water is not just essential for every life, it also makes commerce and industry possible. PUB's job is to ensure that Singapore has an adequate and safe supply of water.

Although it rains often in Singapore, we do not have the space to capture and to store all of the rainfall that would be required to satisfy our daily demand for water. As such, although situated in the tropics, Singapore is one of the most water-stressed countries in the world.

To have enough water, PUB has to "close the water loop". In the process, we constantly recycle and reuse wastewater, and also desalinate seawater, in order to supplement natural sources.



KEY STRATEGIES IN PLACE

Singapore's water policies have evolved over the years as the focus shifted from survival to sustainability. Our holistic approach to water management can be distilled into three key strategies:

1. Capture every drop of water

As a city-state with scarce land, we have to make every drop of rain count.



1

2. Reuse water endlessly

Water can always be reclaimed and retreated so that it can be used again.



2

3. Desalinate seawater

As an island surrounded by the sea, desalination is a viable and attractive option for Singapore.



3

WATER QUALITY

Singapore has one of the world's highest quality water supply. Our tap water is well within the World Health Organization drinking water guidelines. It is suitable for drinking directly from the tap without any further filtration.

Sampling and Monitoring Programme

PUB has established a comprehensive and robust sampling and monitoring

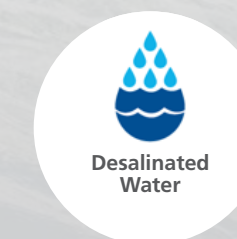
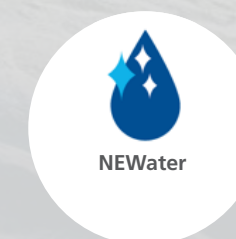
programme to ensure high water quality from source to tap. Water samples are collected from reservoirs, waterworks and distribution systems and tested daily in our laboratories. Online sensors also monitor water quality at each stage of the treatment process and service reservoirs.

Over 400,000 tests are conducted annually on the physical, organic, inorganic, radiological and microbiological parameters of our water supply.

WATER SUPPLY AND DEMAND

By 2060, Singapore's water use is expected to double from the current 430 million gallons per day (mgd).

We plan to increase our recycling and desalination capacity to meet this future demand.



FOUR NATIONAL TAPS: RAIN

1 Water from Local Catchment

Most of the rain that falls on Singapore is whisked through drains, canals, rivers and ponds to our 17 reservoirs for storage. Two-thirds of Singapore is now a water catchment, making us one of just a few countries in the world to harvest urban stormwater on a large scale for potable consumption.

PUB continues to explore ways to maximise our rainwater collection yield and strives to collect every drop of water that falls on Singapore.

17

Reservoirs

2/3

of Singapore's land area is a water catchment

2 Imported Water

Singapore imports water from Johor under the 1962 Water Agreement, which allows Singapore to draw up to 250 million gallons per day (mgd) from Johor River until 2061.

MacRitchie Reservoir

Box Story:

A Marvel at Marina Bay

Scenic leisure attraction, flood alleviation tool, vital water source, Marina Barrage – a dam built across the Marina Channel creating a reservoir in downtown Singapore – is all of these.

Marina Barrage separates the bay from the sea. It is an important piece of PUB's arsenal to alleviate flooding in low-lying parts of the city. During heavy rain, its nine crest gates or seven powerful pumps can be activated to release excess stormwater into the sea. As a result, the water level in the reservoir can be kept constant, making it ideal for activities like kayaking and dragon-boating.



Canoeing at Marina Reservoir

A dam built across the 350-metre wide Marina Channel



FOUR NATIONAL TAPS: REUSE AND DESALINATION

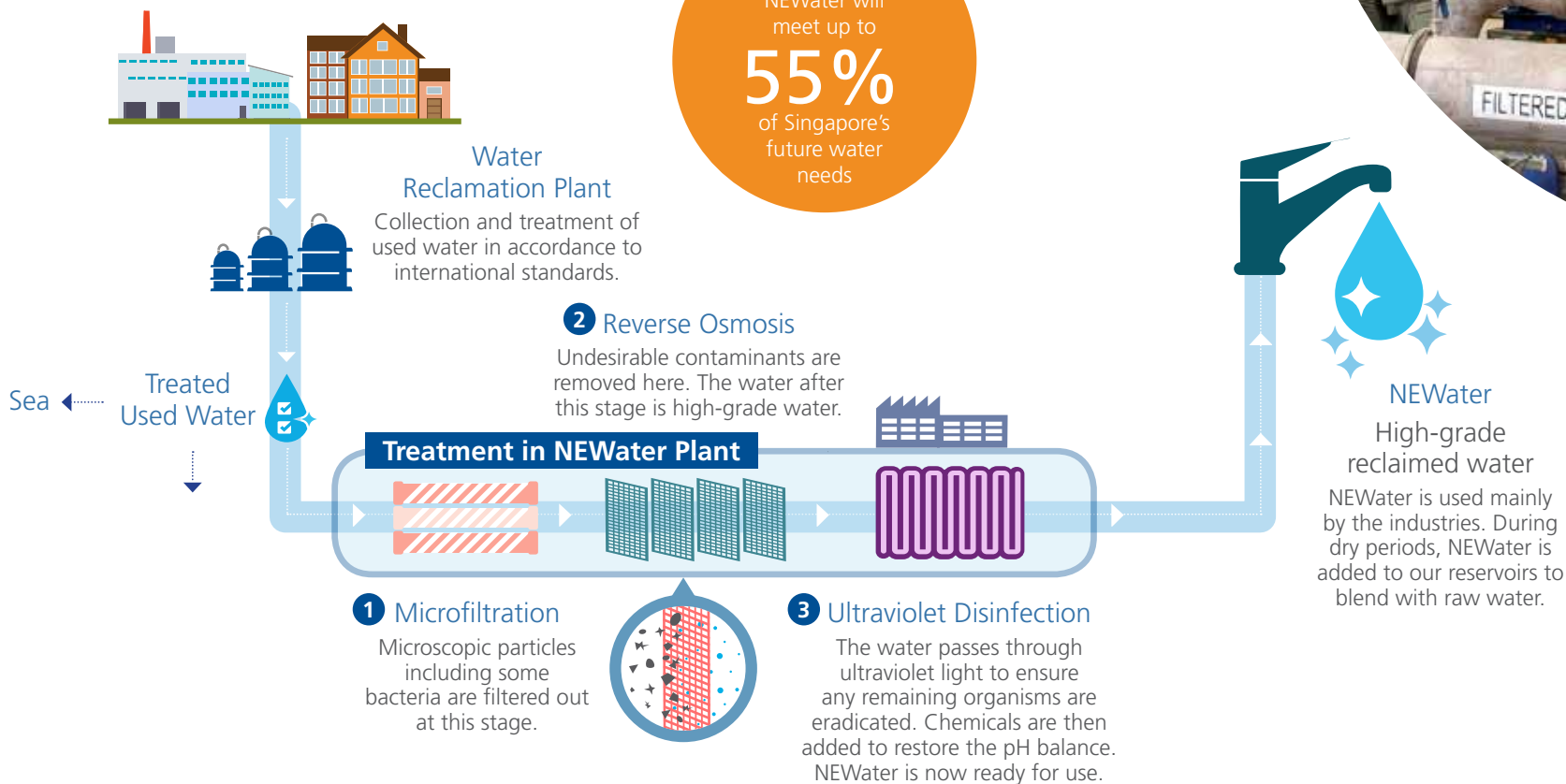
3 NEWater

The NEWater process recycles our treated used water into ultra-clean, high-grade reclaimed water, cushioning our water supply against dry weather and moving Singapore towards water sustainability. Through a stringent 3-step process using advanced membrane technologies and ultraviolet disinfection, NEWater is ultra-clean and safe to drink. NEWater has passed more than 150,000 quality scientific tests and is well within drinking water guidelines set by the World Health Organization.

Because of its high purity, NEWater is mainly used in wafer fabrication plants, industrial estates and commercial buildings for cooling and industrial processes. During dry periods, NEWater is added to our reservoirs to blend with raw water.

Today, there are five NEWater plants supplying up to 40% of Singapore's water needs. By 2060, NEWater is expected to meet up to 55% of our future water needs.

2060
NEWater will meet up to
55%
of Singapore's future water needs



SingSpring Desalination Plant

2060
Desalinated Water will meet up to
30%
of Singapore's future water needs

4 Desalinated Water

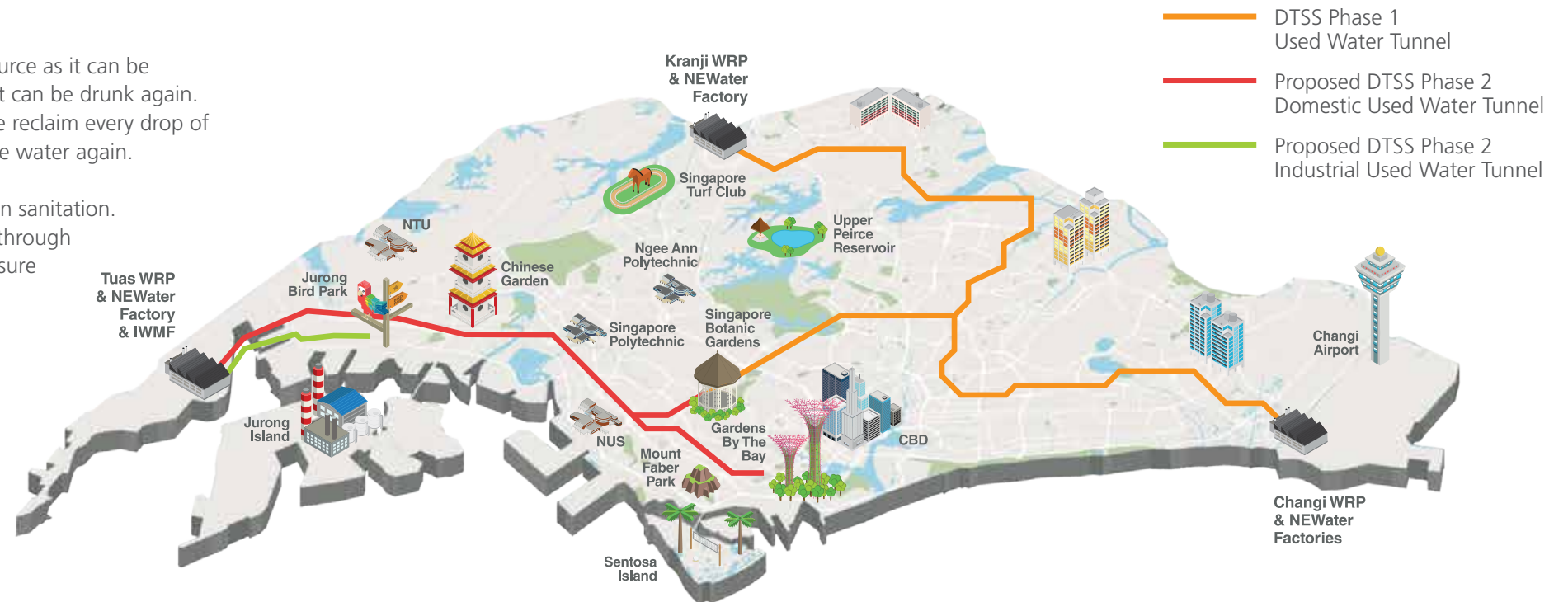
As Singapore is surrounded by sea, PUB has turned seawater into drinking water. And we continue to research better desalination technology to find even cheaper ways of desalting water.

Currently, two desalination plants with a combined capacity of 100 mgd can meet up to 25% of Singapore's current water needs. A third plant in Tuas will be ready by end 2017. The fourth, in Marina East and the fifth in Jurong Island will be completed by 2020.

RECLAIMING USED WATER

Water is an endlessly reusable resource as it can be reclaimed and retreated so that it can be drunk again. As a world leader in this area, we reclaim every drop of used water and turn much of it into potable water again.

Today, Singapore is 100% served by modern sanitation. By maintaining 3,500 km of public sewers through systematic rehabilitation, we are able to ensure efficient collection, treatment, disposal and reclamation of used water.



Anaerobic Digesters located at Changi Water Reclamation Plant, implemented under DTSS Phase 1.



BUILD AN UNDERGROUND WONDER

Singapore's Deep Tunnel Sewerage System (DTSS) is a marvel of modern engineering, allowing the collection of a whole country's worth of used water efficiently. It is also a good example of how science and technology combined can enable us to do large scale used water collection and recycling, thus ensuring the sustainability of NEWater.

DEEP TUNNEL SEWERAGE SYSTEM

*Box
Story:*

DTSS Phase 1

Phase 1 of the DTSS was completed in 2008. It consists of a 48 km-long sewer tunnel running from Kranji to Changi, and Changi Water Reclamation Plant (WRP), which treats some 900,000 m³ (202 mgd) of used water per day. There are also 60 km of link sewers and two 5 km-long deep sea outfall pipes.

DTSS Phase 2

Phase 2 of DTSS is scheduled for completion in 2025. It will add another 40 km of deep tunnels, 60 km of link sewers and a new WRP in Tuas. The co-location of Tuas WRP with National Environment Agency's waste-to-energy facility marks Singapore's first initiative to integrate used water and solid waste treatment processes. Through this, we will be able to maximise energy and resource recovery, benefiting both facilities.

Benefits

By 2025, all used water collected from homes and industries will be channelled by gravity through DTSS to one of three coastal WRPs for treatment. This underground system offers multi-fold benefits:

1. Create synergies: maximise both energy and resource recovery and minimise land footprint
2. Optimise land use
3. Safeguard environmental protection
4. Ensure NEWater sustainability



Woo Lai Lynn

Deputy Director,
DTSS 2 Department

“Working closely with my team, we determine the size and route of all 100 km of tunnels and sewers in the Deep Tunnel Sewerage System Phase 2 project, and decide on the necessary features to be incorporated and suitable materials to be used. I find the geotechnical aspects of my work most interesting, including deep excavations, tunnelling and pipe-jacking. There are very few employers in Singapore that can provide this unique opportunity to work deep underground.”

Vijay Das

Head (Water Systems Unit)

The entire water loop is a system that requires active management. My current role gives me the opportunity to coordinate joint operations and reviews across the water loop to enhance system resilience, which includes overseeing the 24/7 PUB Operations Centre. The benefit of having both network and plant operations has helped in my current role and I continue to look forward daily to a journey of innovation and learning in PUB which never ends.

Mohammad Idaly Bin Mamat

Senior Engineer,
Water Reclamation (Network) Department

“I am part of a team, which operates and maintains the sewerage network in Singapore to collect and treat used water for reclamation effectively and reliably. As Singaporeans, we have all been primed on the importance of water conservation, but we give little thought to water once it goes down the sewer. My job is to ensure it travels safely, uninterrupted and does not contaminate our water courses and reservoirs.”

Anne Marie Ang

Senior Engineer, Tuas Water Reclamation Plant, DTSS 2 Department

“Used water treatment has developed from being a means to reduce pollution from waste discharge to a means of recovering resources such as energy, heat, etc. from waste. Used water also has a very special role in Singapore as it contains one of the most important resources to us – water, which we recover in the form of NEWater. Singapore is a water-scarce tropical island with little to no natural resources, this makes engineering solutions for water reclamation even more meaningful.”



TAMING STORMWATER

An average of about 2,330 mm of rain falls on Singapore annually. On occasions, a high amount of rain, equivalent to a month's worth, can fall within just a few hours, defeating our drains and canals in the process.

Our holistic "Source-Pathway-Receptor" approach to stormwater management enhances flood protection not just along drains and canals ("Pathways") that convey stormwater, but also in areas that generate runoff ("Source") and areas where floodwaters may flow to ("Receptors").



Source:
Areas where rain falls



Pathway:
Channels that runoff flows through



Receptor:
Where floodwaters may flow to

Stamford Diversion Canal and Detention Tank

To boost flood protection in the Stamford Canal's catchment, which covers the Orchard Road area, a new 2 km diversion canal and 38,000 m³ detention tank are being constructed. Upon completion in 2018, stormwater that falls in one-third of this catchment will flow into a new diversion canal towards Singapore River instead of Stamford Canal. A detention tank, when completed in 2017, will momentarily hold stormwater surplus from Holland Road drains and release it after the storm.



Alexandra Canal – A short stretch of the open waterway was decked over to create an interesting water cascade.

A CITY OF GARDENS AND WATER

With 17 reservoirs and about 8,000 km of waterways across about 710 sq km of land, we have a rich opportunity to create a blue network of beautiful streams, rivers and lakes.

Since 2006, the Active, Beautiful, Clean Waters (ABC Waters) Programme has helped to draw people closer to water so

that they can better cherish our waters and keep our drains and canals clean.

- 36 ABC Waters sites – completed by March 2017
- 100 potential locations identified for implementation by 2030



Kallang River @ Bishan-Ang Mo Kio Park



MacRitchie Reservoir

Box Story:

A Naturalised River

Kallang River, the longest river in Singapore, connects Lower Peirce Reservoir to Marina Reservoir. As a crucial stormwater pathway with her own flood plain in Bishan-Ang Mo Kio Park, that stretch of the Kallang River is now able to provide more flood protection. A flagship ABC Waters project, the former bare, utilitarian canal has been transformed into a naturalised river filled with life.



CONSERVING AS A WAY OF LIFE

The commitment and participation of the community is instrumental in achieving a sustainable level of water consumption and managing the impact of water on the environment. PUB leverages on mandatory measures, water pricing and facilitation to optimise the use of every drop of water.

By reducing water consumption at home and at work, we can stretch our limited water resources that much further.

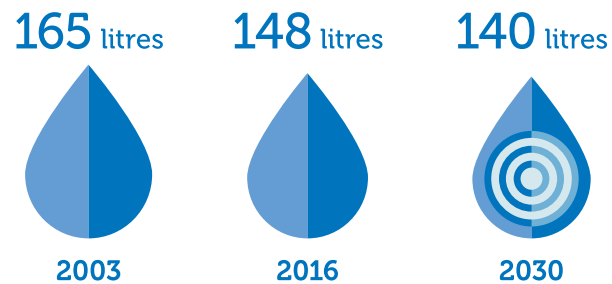
To encourage efficient water usage in every corner of the community, PUB runs a wide range of conservation programmes and initiatives. Besides on-going awareness campaigns, PUB operates, among others, the Water

Efficiency Management Plan Scheme for large water users, and the Mandatory Water Efficiency Labelling Scheme for water appliances including washing machines.



Tampines North Primary School inculcates water conservation habits in students.

Household water use per person per day



Nee Soon South Clean and Green Committee encourages residents to adopt water saving habits during house visits.

Box Story:

Recognising Water Champions

Introduced in 2007, the Watermark Awards aim to inspire individuals and organisations (private sector companies, grassroots, educational institutions, public agencies and non-governmental organisations) to take ownership of our water resources and contribute towards Singapore's water sustainability.

INVESTING IN RESEARCH & TECHNOLOGY

An important goal of water research and development in Singapore is to safeguard the production and delivery of high-quality water to consumers, as well as to ensure the effective and efficient collection and reclamation of used water. As desalination and water reuse are key to Singapore's water sustainability, PUB is on the constant lookout for new ways of doing things and innovations that can let us produce water in a cheaper and more effective manner.

PUB drives water research in Singapore to achieve the following:

1. Increase water resources
2. Reduce cost of production
3. Improve quality and security



Solar PV testbed at Tengeh Reservoir.



Ceramic membrane technology is one of the latest technological breakthroughs in membrane technology.

Low-energy Desalination

Desalination may be weather-resistant but it does require more energy to treat seawater and make it drinkable as compared to rainwater. Working with collaborators, PUB is ready to demonstrate electro-deionisation – the use of a new separation technology – as a far more energy-efficient way of taking salt out of seawater.



CREATING A GLOBAL HYDROHUB

Our Research & Development activities not only create new knowledge but also position Singapore as a world leader in water husbandry.

Singapore International Water Week

The biennial Singapore International Water Week (SIWW) is a leading platform for global water industry players to

showcase innovations, share policy developments, and form partnerships in research and development. The SIWW welcomes the world's top leaders in the water sector, from government, utilities, international organisations, industry and academia. And it offers an unprecedented networking opportunity to interact and confer with high officials, heads of industry and opinion makers.

A COMMUNITY OF CO-CREATORS

With water and environment technologies identified as a key growth industry, S\$670 million in public funds was secured to foster technologies and create a thriving research community in Singapore. Today, Singapore has 180 water companies and more than 20 water research centres.



Young Water Leaders Summit conducted at Singapore International Water Week 2016.

TRAINING FOR PROGRESS



Singapore Water Academy

PUB Foundation Programme

Appropriate and effective training leads directly to higher productivity. The formation of the Singapore Water Academy situates all water-utility-related training in one place and, in the process, seeds a centre of excellence for professional education within the Singapore water industry.

The Singapore Water Academy plans, designs, delivers, places and coordinates all training and development within PUB. It also offers specialised programmes for the local and international water professionals.



Singapore Water Management Series Week

Programmes offered by the Academy include:

Singapore Water Management



Business Leadership and Governance



Engineering and Operations



Technology Translation



Customised Programmes



KEY FACTS

AS OF JUNE 2017

Water Demand	430 mgd
Reservoirs	17 reservoirs
Network of rivers, canals and drains	8,000 km
NEWater capacity	175 mgd Capacity to meet 40% of total demand
Desalination capacity	100 mgd Capacity to meet 25% of total demand
Waterworks	8 (inclusive of Johor River Waterworks)
Desalination Plants	2 (A 3 rd plant is expected to be ready by end-2017.)
NEWater Plants	5
Water Reclamation Plants	4
Property, Plant and Equipment as at 31 March 2017	S\$7.1 billion