

OUR WATER, OUR FUTURE

Saving water is in **our hands**

Saving a little water can make a huge difference. Better still, we can all enjoy our daily activities and save water at the same time. Save 9 litres by showering one minute less. Save 11 litres by using a cup when you brush your teeth. Save 14 litres by washing vegetables with a tub of water instead of a running tap. Every little bit helps. Saving water is in our hands.



**Every drop counts.
Use only what you need.**

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PUB SINGAPORE'S
NATIONAL
WATER AGENCY

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FOREWORD



A Water-Stressed Country

In 2015, the Water Resources Institute (WRI) ranked Singapore as one of the most water-stressed countries in the world. It thinks that, by 2040, Singapore would be one of eight countries in the world most vulnerable to disruptions in water supply.

Water planners in PUB are not in the least surprised by the WRI's conclusion, although I suspect that even a reasonably well-informed Singaporean would find it incredible. Because the notion that our water taps could run dry is just inconceivable to most Singaporeans alive today.

These same Singaporeans would probably be taken aback when told that, for a good five months – from August 2015 to January 2016 – some 600,000 consumers went without water as rationing was imposed in Pasir Gudang and Kota Tinggi. Just 30 km across from the causeway as the

crow flies, these districts in Johor Bahru would have received pretty much the same amount of rain as we did in Singapore. Even so, more than half a million there had to endure the agony of a “one-day-on-two-day-off” scheduled supply for months on end.

The fact that imported water – which can meet half of Singapore's daily demand for drinking water – is under threat and steadily depleting, but has no impact for the Singaporean end consumer is an unappreciated blessing. For sure, this happy outcome is not due to good fortune, but the direct consequence of long careful planning and careful implementation by PUB and other parts of government.

We expect total demand for water to double by 2061, when our remaining water agreement with Malaysia will end. This is water that we do not have now. Water that we will need to find and to treat.

The reader will readily appreciate that Singapore's

continued ability to ensure water security and sustainability guarantees our national survival and economic prosperity. This was the case at independence, as it is now, as it will be in the future.

The simple fact is that there is not enough room on Singapore to collect and store all the water that we need. As such, although right on the equator and in the tropics, Singapore is actually a severely water-challenged country, as the WRI has observed. Fortunately, as long as we remain clear-eyed about our nation's water situation, are able to devise an intelligent strategy and then execute it conscientiously, there should always be enough water. This updated edition of “Our Water, Our Future” explains how.

Our Water Strategy

Singapore's water strategy comes in three parts. First of all, we have to maximise our own yield. And so we strive to collect every drop of



rain that falls on Singapore. This means turning as much of Singapore as possible into a water catchment, and keeping our drains, canals and waterways pristinely clean.

Secondly, we have to think of water as an endlessly reusable resource. In our minds, the H₂O molecule is never lost. Water can always be reclaimed and retreated so that it can be drunk again. PUB is a world leader in this. We reclaim every drop of sewage and turn much of it into potable water again.

And thirdly, because Singapore is surrounded by sea, we can turn seawater into drinking water. And we continue to research better desalination technology to find even cheaper ways of desalting water.

PUB, Singapore's Water Agency

PUB is the national water agency, the sole water utility and the agency responsible for realising Singapore's water strategy. Our mission is a straightforward one. By supplying

good water, reclaiming used water and taming stormwater, PUB officers make everyday life possible. In the PUB, our vision is a Singapore that will always have enough water and for Singaporeans to cherish every drop of water.

A Good Outcome

This "Our Water, Our Future" publication describes, in some detail and in an engaging way, how we manage the water system in Singapore so that we can guarantee everyone in Singapore will have enough clean water, so that wastewater is collected and properly treated, and that stormwater is properly channelled and stored.

It will become quickly apparent to the reader that the future of Singapore's water security lies with desalination and reuse. At the same time, he will also realise that the Singapore water system must forever remain adequate, sustainable and resilient.

This is entirely practicable, as long as we remain coldly realistic about our circumstances and do not shy away from pursuing and employing hard-nosed policies. It will require that we apply our intellect and imagination, researching and testing continuously, and use science and technology to overcome our water challenges. And it will require judicious consumption and increased frugality on the part of Singaporeans and residents.

Then, in this remarkable way, Singapore will be always able to turn what is a disadvantage into strength, and what seemed an unsurmountable vulnerability into endless opportunity.

NG JOO HEE

Chief Executive
PUB, Singapore's National Water Agency

WATER FOR ALL

Turn on a tap at home at any time and you can get all the drinking water that you need. While some countries are struggling to provide enough clean drinking water for their people, Singaporeans have little fear that their homes and workplaces will run dry.

This was not always the case. More than 50 years ago, some of us queued in the streets for water during water rationing caused by prolonged dry spells. At other times, heavy downpours led to widespread flooding that wrecked homes and destroyed lives.

In just a few decades, PUB, Singapore's national water agency, has transformed Singapore's water management by tapping technology and embarking on ambitious engineering projects. We are now in the midst of another evolution.

At first, we took nature's bounty by storing and treating rainwater. Then, we collected the used water that flows into sinks and sewers as we go about our daily lives, and turned it into NEWater, our own brand of ultra-clean, high-grade reclaimed water. Ten years ago, we began building desalination plants, turning seawater into drinking water.

In Singapore's 50 years of independence, we have turned our water vulnerability into a strategic asset. We created the Four National Taps – water from local





catchments, imported water from Malaysia, NEWater and desalinated water – to diversify and strengthen our water supply. Our technology investments gave us NEWater and desalinated water, two weather-resilient sources that saw us through one of Singapore's driest periods in early 2014.

Still, challenges lie ahead. Our weather has become more erratic, with dry spells spanning weeks at a time in recent years. More intense storms at other times threatened to overwhelm our drainage systems. Dry weather in recent years led to record low water levels at the Linggiu Reservoir in Johor, which

Singapore built and operates under the Water Agreement. This could reduce Singapore's ability to draw and use water from the Johor River.

As we produce more water from desalinated seawater and NEWater, our energy needs for these treatment processes are also expected to rise.

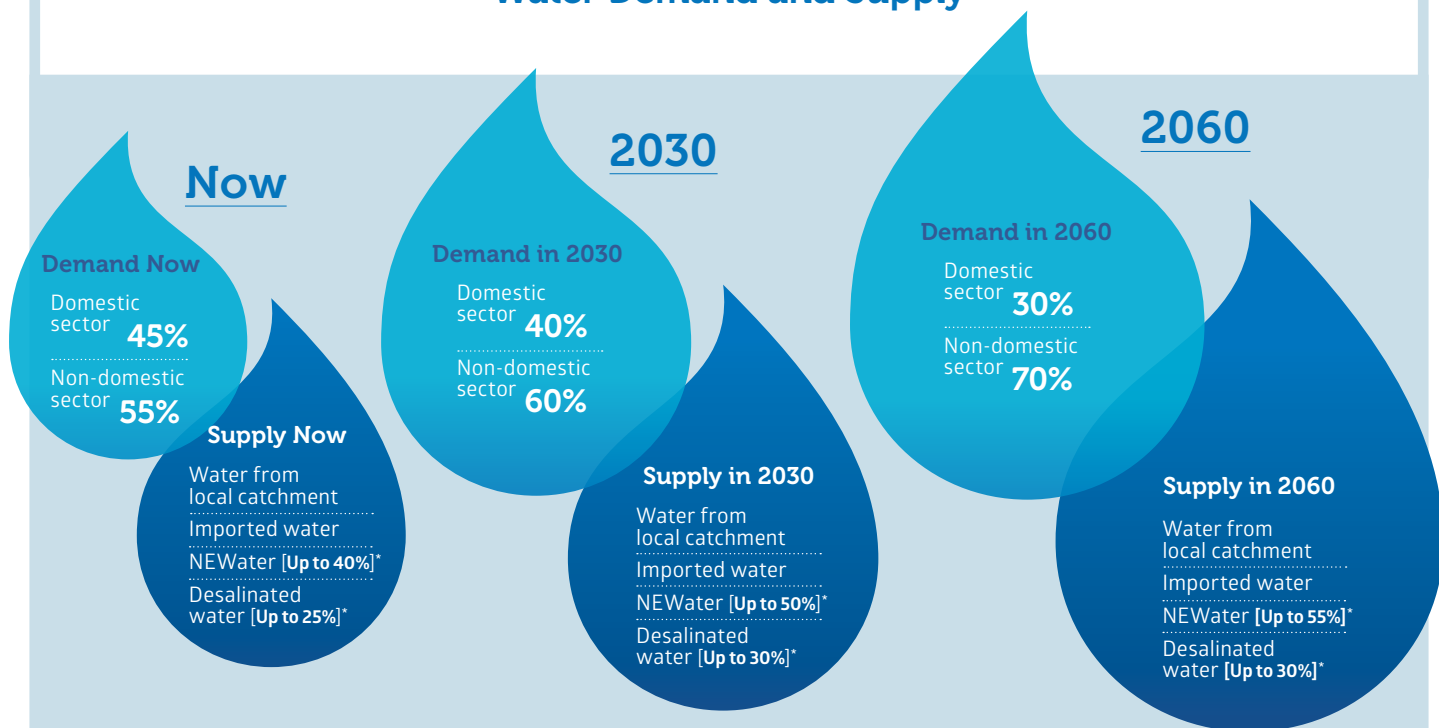
These issues will become more pressing as our population and economy continue to grow. As we forge ahead in the next 50 years, our vision is to ensure that our water supply continues to be robust, sustainable and affordable.



WATER DEMAND: TODAY AND FUTURE

By 2060, Singapore's water use is expected to double from about 430 million gallons a day (mgd) now. We will increase our water recycling and desalination capacity to meet the rising demand. Together, these two sources will supply up to 85% of our future water needs.

Water Demand and Supply



* denotes % of demand



FOUR NATIONAL TAPS

LOCAL WATER CATCHMENTS

With good planning, rain can be a gift. Most rainwater that falls on Singapore is whisked through drains, canals, rivers and ponds to our 17 reservoirs for storage, and then treated to become drinking water. Two-thirds of Singapore is water catchment, making us one of just a few countries in the world to harvest urban stormwater on a large scale for consumption. To prevent contamination, our used water is collected in a separate underground sewerage system.

17
reservoirs
for storage

2/3
of Singapore
is a water
catchment

IMPORTED WATER

Singapore imports water from Johor under the 1962 Water Agreement, which allows Singapore to draw up to 250 mgd from the Johor River until 2061.



NEWATER

Waste not, want not – the idiom is true in water too. 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. The used water is treated and put through microfiltration and reverse osmosis to remove contaminants, bacteria and viruses, and then disinfected with ultraviolet light as an additional barrier.

NEWater has passed more than 150,000 scientific tests, and is well within drinking water guidelines set by the United States Environmental Protection Agency (USEPA) and the World Health Organization (WHO). It is mainly used in wafer fabrication parks, industrial estates and commercial buildings for cooling and industrial processes.

NEWater can now meet about 40% of Singapore's water needs. During dry months, we also top up reservoirs with NEWater, and further treat the blended water at the waterworks before supplying it to the population. NEWater is the pillar of Singapore's water sustainability, and by 2060, we will expand its capacity to meet up to 55% of our future water needs.

2060

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



DESALINATED WATER

Even if the skies dry up, we can always look to the sea. Desalinated water, or treated seawater, however, is the most energy-intensive of the Four National Taps and so the most expensive to produce. Two desalination plants with a combined capacity of 100 mgd can now meet 25% of Singapore's water needs.

By 2020, we will build three more 30 mgd desalination plants at Tuas, Marina East and Jurong Island to boost our drought resilience. We plan to double our desalination capacity by 2030, and triple it by 2060 to meet up to 30% of our future water needs.

2060

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



NEWATER, NOTHING NEW

NEWater's genesis dates back to the 1970s, when the Singapore government commissioned a study to determine the feasibility of producing reclaimed water. Although the study found it was technically possible, the technology's high cost and unproven reliability then were insurmountable concerns.

By the 1990s, however, membrane technology's cost and performance had improved considerably. Other countries such as the United States were also increasingly using it for water treatment and reclamation.

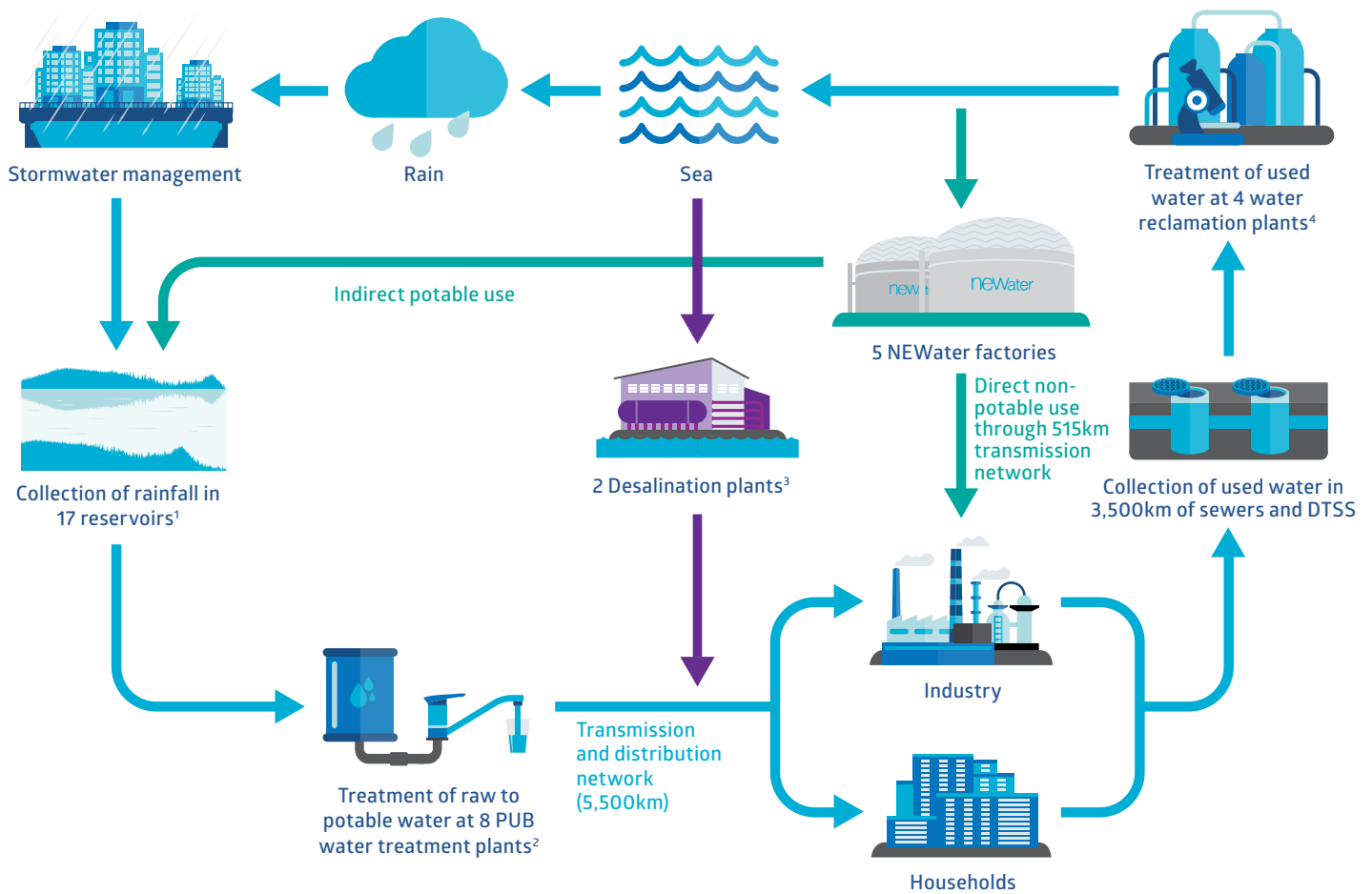
In 1998, PUB set up a team to test the latest proven membrane technology's use in water reclamation for potable purposes. Two years later, it commissioned a full-scale demonstration plant that could produce 10,000 cubic metres (m³) of water daily.

The high-grade, reclaimed water was christened NEWater, and a battery of tests and audits showed it was a safe and sustainable water source.

An international group of experts in engineering, biomedical sciences, chemistry and water technology also found that NEWater's quality was consistently safe and high, and well within the WHO and USEPA's requirements for drinking water. They recommended it for indirect potable use, to be introduced into raw water reservoirs. The blended water undergoes naturalisation and further treatment in conventional waterworks to create drinking water.

In 2003, we launched NEWater with the opening of the first two NEWater plants at Bedok and Kranji, and the NEWater Visitor Centre, a water museum to showcase our journey towards water sustainability. The rest, as they say, is history.

(THE WATER LOOP)



¹ Refers to waterbodies in Singapore

² Includes one water treatment plant in Johor

³ Three more desalination plants will be built by 2020.

⁴ It is envisaged that there will only be 3 water reclamation plants in the long term, with the completion of the Deep Tunnel Sewerage System Phase 2

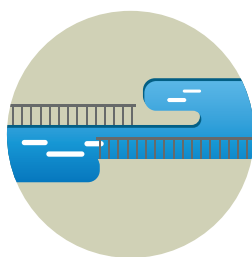
KEY STRATEGIES IN PLACE

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

1

Collect every drop of water

As a city-state with scarce land, we have to make every drop of rain count. Our separate rainwater and used water infrastructure, good land use planning policies and strong environmental controls also protect the collected rainwater from pollution.



2

Reuse water endlessly

Water can always be reclaimed and retreated so it can be used again. PUB is a world leader in this. Recycling water is the most sustainable and cost-effective way to increase our water supply, and it also does so exponentially.

To increase the recycling rate, we will:

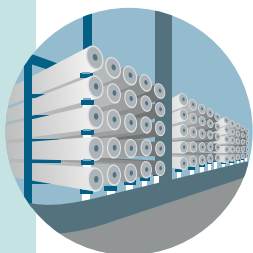
- ➔ Further close the water loop by reclaiming used water from industrial sources for non-potable use. Such water is now treated and discharged to the sea;
- ➔ Increase water recovery from water reclamation and NEWater treatment. The NEWater process currently turns 75% of feed water into NEWater;
- ➔ Reduce losses from PUB's supply by encouraging seafront companies on Jurong Island to use seawater for cooling processes, instead of freshwater.



3

Desalinate more seawater

As an island surrounded by the sea, desalination is a natural option for Singapore, especially when membrane technology has made it economically viable. We will continue investing in research and technology to find better and less expensive ways of desalting seawater.



SCIENCE TO THE RESCUE



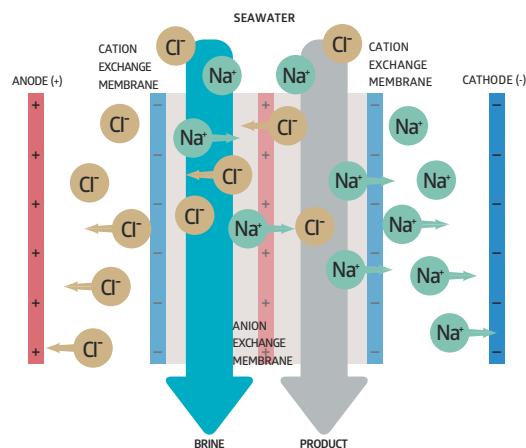
Investing in research and technology unlocked water solutions for Singapore, and that continues to be key. When the public and private sectors work closely, we can develop ways to keep our water supply sustainable and affordable. These are some areas we are exploring:

LOW-ENERGY DESALINATION

Singapore's current desalination method is reverse osmosis, which uses 3.5 kWh/m³. The process pushes seawater through membranes that filter out dissolved salts and minerals, resulting in pure drinking water. If we continue to use this method, however, Singapore's desalination energy use in 2060 will be four times greater compared to now.

Electro-deionisation could reduce desalination's energy use and cost. This method uses an electric field to pull dissolved salts, which have a positive or negative charge, from water. PUB and United States-based Evoqua Water Technologies (formerly Siemens Water) successfully piloted the technology to demonstrate an achievable energy consumption of 1.65 kWh/m³ at a 50 m³/day pilot plant. Plans are in place to further scale up the technology and demonstrate it at a 3,800 m³/day facility in Tuas by the end of 2018.

Another exciting research field is based on biomimicry, or the mimicking of biological processes by which mangrove plants and euryhaline fish extract freshwater from seawater using negligible amounts of energy. PUB's goal is to halve desalination's energy use.



Electro-deionisation uses an electric field to remove dissolved salts (Na⁺Cl⁻) from water, reducing desalination's energy use and cost.

Illustration credit: iStock.com



TAKING A LEAF FROM NATURE

Sometimes, nature knows best. Aquaporins are proteins in living organisms that shuttle water in and out of cells while blocking salts. Biomimetic membranes enhanced by aquaporins could desalinate seawater more efficiently than current technology.

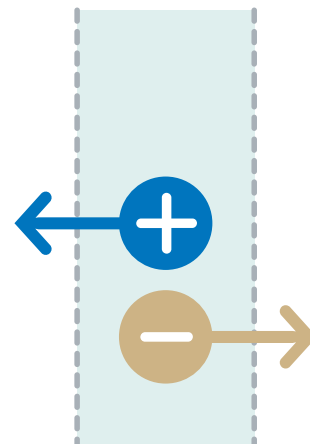
Nanyang Technological University's Singapore Membrane Technology Centre was among the world's first to create prototypes of a durable and aquaporin-based membrane for water reuse and desalination. The scientists' invention outdid commercial reverse osmosis membranes for brackish water and seawater, and they are now refining their work.

A new research area called synthetic water channels could also improve water separation and purification. Inspired by natural proteins such as aquaporins, they could be more stable and scalable since they are completely artificial and hence easier to manufacture and integrate into engineering systems. PUB awarded three proposals on this new research area in 2016.

IMPROVING NEWATER RECOVERY

We produce NEWater by putting treated used water through microfiltration, reverse osmosis and ultraviolet light (MF-RO-UV). Our three-stage process is one of the most efficient ways to recycle used water and has a recovery rate of 75%, but the goal is a sustainable 90% rate.

Electrodialysis reversal-reverse osmosis (EDR-RO) could be an alternative. Similar to electro-deionisation, it uses an electric field to remove charged pollutants from used water. PUB, the National University of Singapore (NUS) and United States-based GE Water and Process Technologies are currently piloting an EDR-RO system at the Ulu Pandan Water Reclamation Plant.



AUTOMATION AND ROBOTICS

From sensors to artificial swans, robotics and automated systems can help us minimise human error and redeploy manpower to more productive tasks. In the 1980s, PUB developed a long-term computerisation plan for its systems. It has since completed many automation projects, and is working on more.

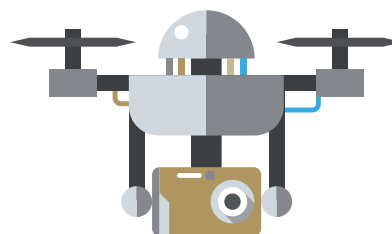
Robots that can cope with different tunnel conditions and an unmanned aerial vehicle (UAV) system are being developed to inspect and maintain the Deep Tunnel Sewerage System. We have also installed about 1,000 sensors and 20 flow gauges in sewer manholes island-wide to detect potential sewer and overflow problems.

About 320 sensors help us to monitor the water quality and pressure in the water supply distribution network in real-time. This Smart Water Grid, developed by PUB and local firm Visenti,

has been deployed in our potable water networks and PUB is planning to expand the system to cover our NEWater network. The system provides decision support tools that will help in network management, and allows early detection of network occurrences, enhancing PUB's

operations and the efficiency of water supply to consumers.

PUB's other projects include the NUSwan, a robotic swan developed with NUS to monitor our reservoirs' water quality, and UAVs for security surveillance at plants and reservoirs.



The NUSwan helps to monitor water quality in our reservoirs.

Illustration credit: iStock.com

Image credit: NUS

REDUCING ENERGY IN USED WATER TREATMENT

If we can minimise the energy needed to treat used water and recover more energy from the process, the treatment could use only as much energy as it generates. For instance, biogas produced from used water treatment can be harvested to generate power and offset the treatment's energy cost.

Other methods are promising. An upflow anaerobic sludge blanket (UASB) uses microorganisms to break down organic particles in used water. Unlike some processes, it does not require oxygen, so there is no need for energy-intensive aeration. It also produces biogas.

Anaerobic membrane bio-reactors (AnMBR) and anaerobic ammonium oxidation (Anammox) also avoid using oxygen and could generate more biogas.

In 2014, PUB opened a 1 mgd demonstration plant at the Jurong Water Reclamation Plant to test UASB-MBR technologies that could recycle industries' used water and use less energy.



UASB-MBR demonstration plant at the Jurong Water Reclamation Plant.



WHEN WASTE IS POWER

People aren't the only ones who work better with some food in them. In 2015, Singapore announced its first co-digestion plant. It will process used water sludge and food waste to produce more biogas for electricity generation. PUB's water reclamation plants now break down the sludge to produce biogas, but adding food waste to the mix could create more biogas due to food's higher calorific value.

The demonstration plant, a collaboration between PUB and Canada-based energy firm Anaergia, can treat 40 tonnes of combined food waste and used water sludge, and does not use oxygen to convert them into biogas, saving energy. Used water treatment plants could become energy self-sufficient with the help of this technology. If successful, it could be deployed at the future Tuas Water Reclamation Plant and the National Environment Agency's Integrated Waste Management Facility.

Illustration credit: iStock.com



Image credit: JTC

INDUSTRIAL WATER SOLUTIONS

By 2060, homes will make up just 30% of Singapore's water demand, with the non-domestic sector accounting for the rest. Managing industrial water use is thus a priority, especially as Singapore also hosts water-intensive businesses like petrochemicals, electronics and pharmaceuticals.

By understanding the water needs of various industries in Singapore, we can promote innovative technologies and water audits to help them make their facilities and manufacturing processes more water-efficient. When firms reduce their water footprint, use alternative water sources such as seawater, and maximise their water recovery by reclaiming waste streams, they make every drop of water count and reduce their water costs too.

2060
Non-domestic sector
will make up
70%
of Singapore's
water demand

USING SEAWATER FOR COOLING PURPOSES

About one-tenth of Singapore's water demand now comes from Jurong Island, which is home to more than 100 petroleum, petrochemical, specialty chemical and supporting companies that use 40 million gallons of water daily. However, a large portion of water supplied to industries is lost to the atmosphere from cooling processes, which reduces the amount that can be collected for reuse. PUB has completed a feasibility study on the use of seawater to meet future cooling demand. We are working with agencies such as JTC Corporation and the Economic Development Board to promote the use of seawater for cooling purposes on Jurong Island.

Firms can also do more to boost their water efficiency. By attending water-related networking events and seminars, they can learn about best practices, and existing, new and emerging technologies that can reduce their water needs. These platforms include the annual Industrial Water Solutions Forum and the Industrial Water Solutions Seminar Series.

Two exemplary companies on Jurong Island have stood out for their water-saving efforts. The Singapore Refining Company (SRC) started building an Effluent Treatment Recycling Plant in 2015 to produce NEWater-grade water for non-potable use. The project was completed in 2016, and helps the company to reduce its NEWater use by up to 2,000 m³/day.

The Petrochemical Corporation of Singapore's (PCS) trade effluent recycling and reuse project will also reduce its NEWater use by 1,200 m³/day when completed by early 2018. These treatment and recycling projects' success will instill confidence in the technologies and processes, and encourage other firms to adopt them.



Image credit: JTC



A COMMUNITY OF CO-CREATORS



In Singapore, water is no longer just a resource – it’s also an economic asset. With water and environment technologies identified as a key growth industry in 2006, \$670 million in public funds was secured to foster technologies and create a thriving research community in Singapore over 15 years.

Today, Singapore has 180 water companies and more than 20 water research centres. These include home-grown firms that can compete overseas, having built a track record in producing NEWater and desalinated water for PUB under Design-Build-Own-and-Operate arrangements. The private and public sectors collaborate on R&D projects, firms can test their technologies at PUB’s facilities under actual site conditions, and there is a comprehensive plan to commercialise good ideas.

Products, technologies and solutions developed in Singapore have applications worldwide, especially in the light of urbanisation and weather changes. Solutions to complex issues require collaboration among researchers, industry, governments, policy-makers and utilities. With this in mind, Singapore organises the Singapore International Water Week (SIWW), a global platform for sharing and co-creating water solutions.

Comprising the Water Leaders Summit, Water Convention, Water Expo and Business Forums, the SIWW culminates in the presentation of the Lee Kuan Yew Water Prize, a prestigious international award to recognise outstanding contributions in solving global water issues.

For more information on SIWW, please visit www.siww.com.sg.

**Singapore,
the Global Hydrohub**

180 companies
More than **20** research centres

IN THE PIPELINE



Securing a steady supply of clean water is just the first step. Subsequent steps include getting it to homes, offices and factories, and collecting used water back for recycling. This requires an extensive and reliable network of pipes, sewers, and other infrastructure.

To keep ahead of Singapore's needs, PUB looks to the future to plan its major infrastructure. In the next 15 years, we will build new plants, upgrade existing ones and expand the water distribution and used water collection networks.

With new and cutting-edge technologies, we can curb rising costs, reduce desalination's energy use, recover more energy from water treatment and boost our water recycling rate. We have identified and started several key projects for Singapore's future.



Demand

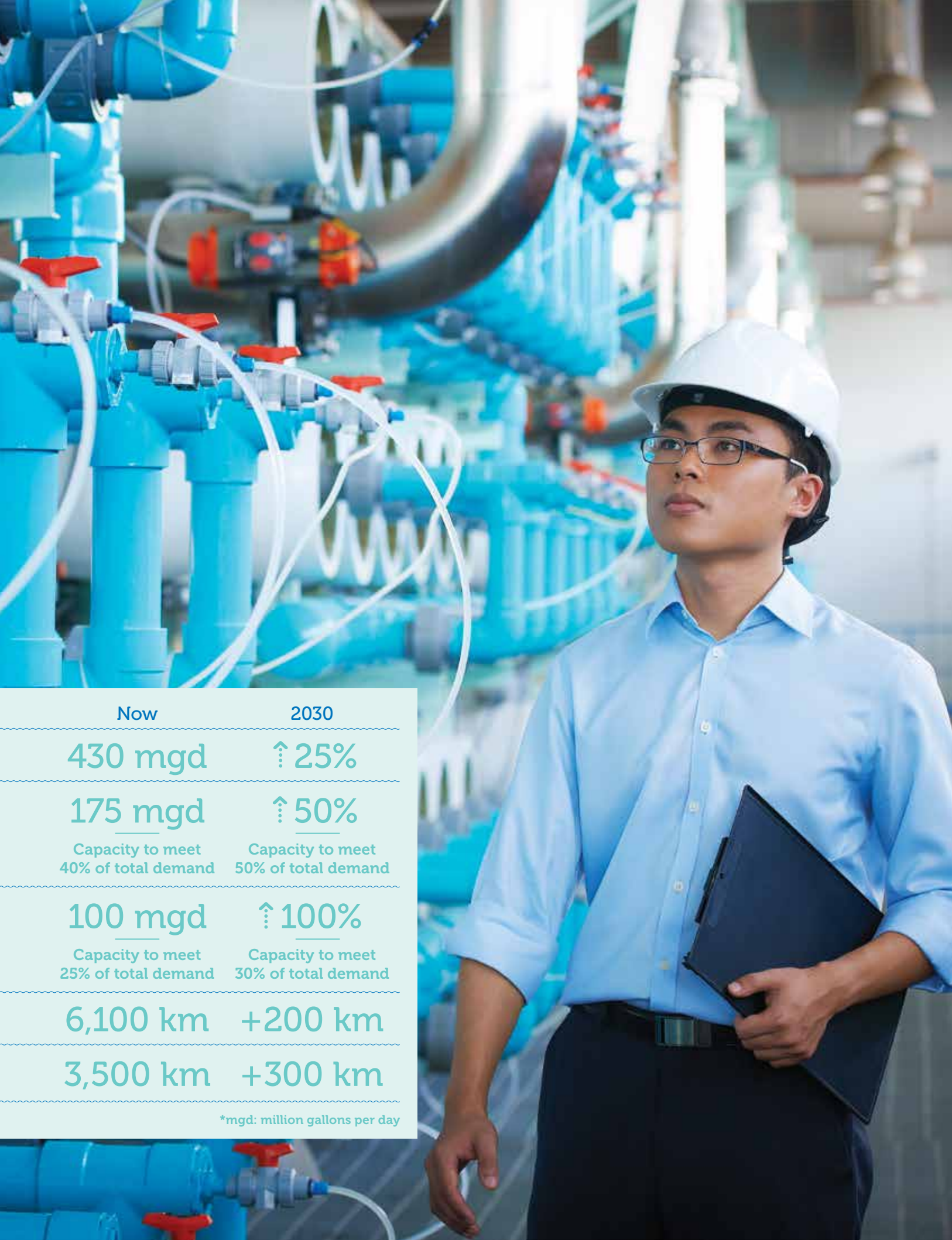
NEWater

Desalination

Pipelines

Sewers





Now	2030
430 mgd	↑ 25%
175 mgd	↑ 50%
Capacity to meet 40% of total demand	Capacity to meet 50% of total demand
100 mgd	↑ 100%
Capacity to meet 25% of total demand	Capacity to meet 30% of total demand
6,100 km	+200 km
3,500 km	+300 km

*mgd: million gallons per day

DEEP TUNNEL SEWERAGE SYSTEM

By 2025, whenever you flush the toilet, take a shower or wash the dishes, the used water will flow into our underground network of tunnel sewers and be channelled by gravity to one of three coastal water reclamation plants (WRPs) for treatment.

This underground superhighway for used water will streamline how Singapore collects, treats and disposes, or reclaims used water, freeing up precious land for higher value uses. When it is completed, the Deep Tunnel Sewerage System (DTSS) will shrink the land occupied by used water infrastructure by 50%.

The engineering marvel, conceived in the 1990s as a long-term solution to Singapore's used water needs, has won several

prestigious awards, including Water Project of the Year at the 2009 Global Water Awards and the ASEAN Outstanding Engineering Achievement Award 2005.

Its construction spans two phases. Phase 1, completed in 2008, included the 48 km-long North and Spur Tunnels, 60 km of link sewers, the Changi WRP in the east, and deep sea outfall pipes to serve Singapore's central and eastern parts.



Above: The Influent Pumping Station located 60 m below ground at the Changi Water Reclamation Plant, implemented under DTSS Phase 1.



Once DTSS is completed

50%

less land

will be occupied by used water infrastructure

Integrating DTSS Phases 1 and 2



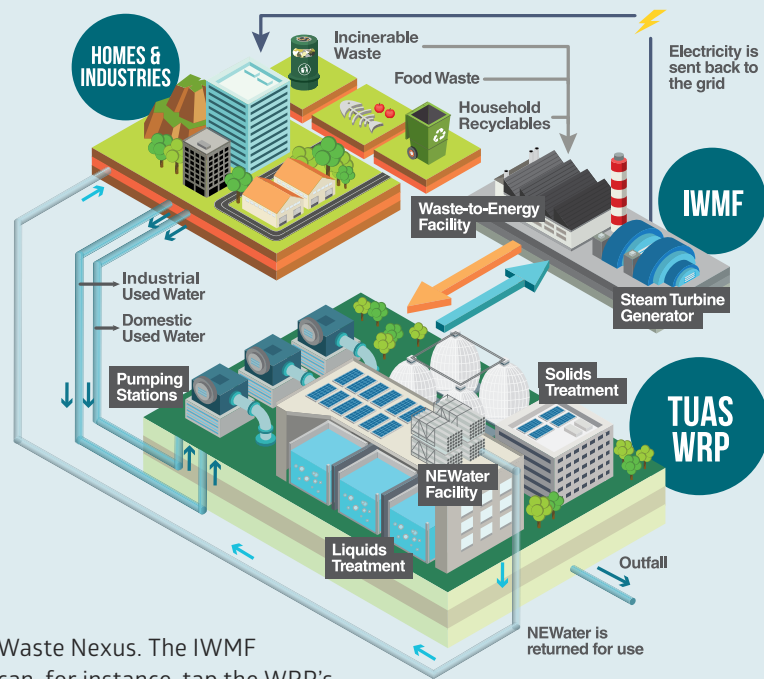
Phase 2, to complete by 2025, extends the system to western Singapore, including the downtown area and upcoming developments such as Tengah Town. After its 40 km of tunnels and 60 km of link sewers are completed, we will progressively decommission the Ulu Pandan and Jurong WRPs and intermediate pumping stations to make way for other developments.

The DTSS is also an opportunity to reinvent Singapore's WRPs. The Changi WRP is one-third the size of a conventional WRP and does not need a buffer zone because its treatment modules are fully covered. Two NEWater factories are also built on its rooftop to maximise the land use.

The new, compact Tuas WRP in Phase 2 will have even more advanced features to improve energy efficiency and reduce waste, and be highly automated to minimise manpower needs.

In another first, the National Environment Agency will site its Integrated Waste Management Facility (IWMF) next to the Tuas WRP to harness potential synergies and reap the benefits of a Water-Energy-

Harnessing synergies from the co-location of Tuas WRP with the IWMF



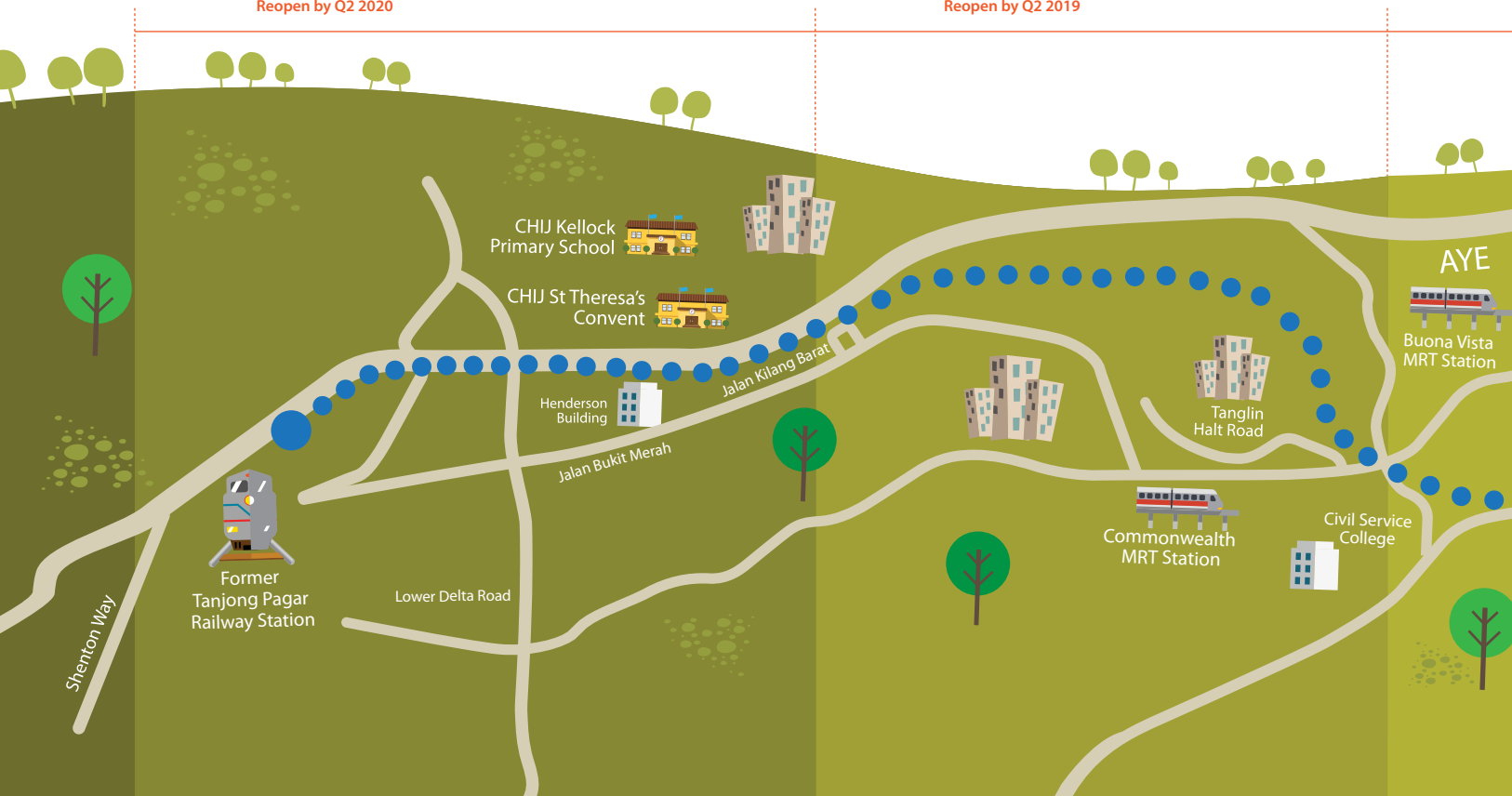
Waste Nexus. The IWMF can, for instance, tap the WRP's treated used water for its processes, and supply food waste to help generate more biogas and electricity.

With the DTSS, every drop of our used water can be collected, treated and further purified into NEWater.

MURNANE PIPELINE

Jalan Kilang Barat to Former Tanjong Pagar Railway Station
Closed from Q3 2016
Reopen by Q2 2020

Commonwealth Ave to Jalan Kilang Barat
Closed from Q3 2016
Reopen by Q2 2019



With new homes and offices in Marina South and Marina East, and the redevelopment of the Tanjong Pagar and Keppel areas, the city area's water demand could double by 2060. To meet long term city demand, PUB is laying a new trunk pipeline from the Murnane Service Reservoir in central Singapore to the city. Its construction will span 2016 to 2020.

About half of the 22 km pipeline will go under the southern half of the Rail Corridor. After that stretch is completed, the ground's surface will be maintained as a contiguous green space for all to enjoy.

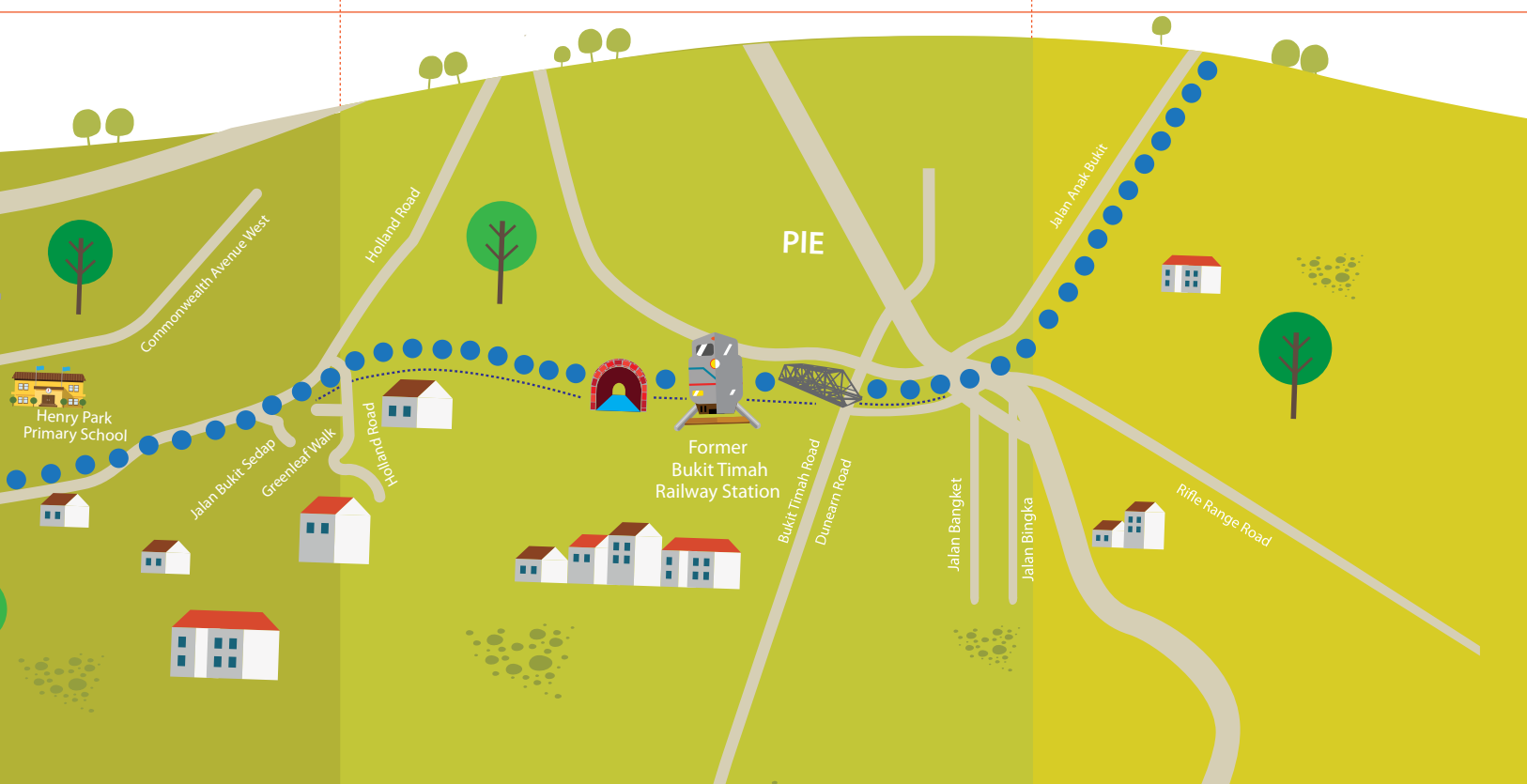
Legend

- Rail Corridor
- Railway Station
- Commercial Buildings
- Residences
- School
- MRT Station
- Businesses
- Historic Brick Drain
- Steel Truss Bridge
- Access Provided

Holland Rd to Commonwealth Ave
 Closed from Q2 2016
 Reopen by Q2 2018

PIE / Jalan Anak Bukit to Holland Rd
 Closed from Q1 2017 (Access Provided)
 Reopen by Q2 2019

After PIE/ Anak Bukit Flyover
 (Not affected by pipeline project)





NEWATER AND DESALINATION PLANTS



When Singapore's rainfall dried up for weeks at a time in early 2014, we plugged the shortfall by producing more NEWater and desalinated water. These alternative water sources will tide us over potentially worse dry spells in future.

To strengthen our water security and drought resilience, we will continue to build up NEWater and desalination capacities.

The second NEWater factory in Changi was completed in 2016, and

the 50 mgd plant is our fifth overall. We will also build a Tuas NEWater factory as part of DTSS Phase 2 by 2025.

Three new 30 mgd desalination plants will be completed by 2020, in Tuas, Marina East and Jurong Island.

We expect desalination and NEWater to supply up to 85% of our water needs by 2060.



Left: NEWater storage tank



Below: Reverse osmosis membranes at the NEWater factory



A PLANT FOR ALL SEASONS

Come rain or shine, Singapore's upcoming desalination plant in Marina East will have plenty to do. The 30 mgd plant can treat fresh water from the nearby Marina Reservoir. In addition, it can purify seawater to help meet the water demand in Singapore's city area and eastern parts.

Once the plant – Singapore's fourth desalination plant – is completed, we will have a total of 160 mgd of desalination capacity. This will go a long way towards meeting the country's water needs, which is about 430 mgd now and projected to double by 2060. Parts of the facility will also be opened to the public, creating more spaces for recreation.



Above: Tuaspring Desalination Plant



Left: Ultrafiltration membranes at the Tuaspring Desalination Plant

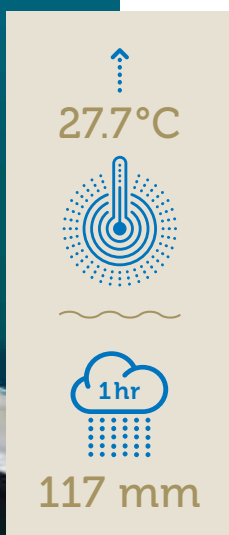


Top and bottom: Artist's impressions of the upcoming Keppel Marina East Desalination Plant.



KEEPING SINGAPORE SUSTAINABLE AND RESILIENT

Look to the future and Singapore's weather could become more extreme. In just the past few years, we've been drenched by more frequent and intense rains, some of which caused flash floods. We've also endured two record-breaking dry spells from January to March 2014.



Extrême floods and droughts have lashed the planet and pose a critical challenge for governments and populations. Like other countries, Singapore has to manage the risks of such weather extremities and ensure there is enough water for everyone.

Long-term records show that Singapore has become hotter and more prone to heavier storms:

between 1972 and 2014, its annual average temperature rose from 26.6°C to 27.7°C. While the maximum rainfall recorded in one hour here in 1980 was 96 mm, by 2012, it was 117 mm.

To prepare Singapore for further weather changes in the long run, we have begun to assess the impacts of climate change on our water services, and will implement adaptation measures.

FORECASTING THE FUTURE

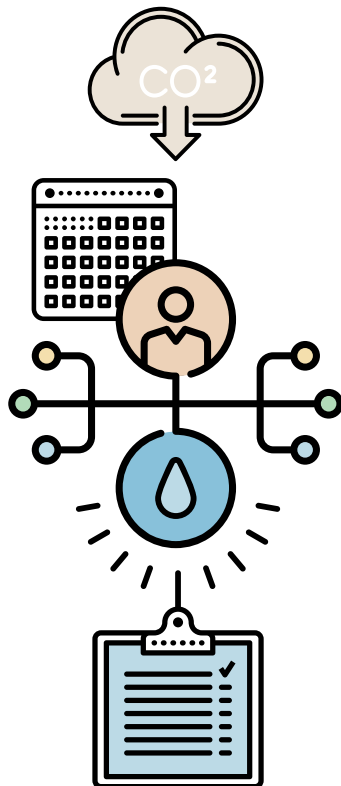
In 2013, the Meteorological Service Singapore established the Centre for Climate Research Singapore (CCRS) to strengthen in-house capability in climate science and climate modelling. The CCRS also translates global climate change findings into their implications for Singapore.

In 2015, the CCRS, in collaboration with the United Kingdom's Met Office Hadley Centre, projected how the climate of Singapore and its surrounding region might change from now until the end of the century, under Phase 1 of the 2nd National Climate Change Study.

The projections show that Singapore is set to become hotter and experience more extreme downpours and dry spells if global emissions remain unchecked. Phase 2 of the study started in 2014 and examines the potential climate change impact on Singapore, including on our water resources and drainage, biodiversity and greenery, buildings, and network infrastructure. The findings will guide government agencies as they prepare Singapore to meet climate change's challenges.



PREPARING FOR THE FUTURE



Knowing what the future might hold is only half the battle. Climate change adaptation plans take time to implement, so Singapore has started early in its preparations.

The Inter-Ministerial Committee on Climate Change was established in 2007 to coordinate climate change policies. PUB, as the lead agency for

water resources and drainage, has crafted plans to help ensure enough water for all even during extreme droughts, reduce our flood risks from more intense rainfall events and rising sea levels, and minimise disruptions to water and used water services.



SECURING THE WATER SUPPLY

Over the years, Singapore's Four National Taps strategy has created a robust, diversified and sustainable water supply. NEWater and desalination, two of the taps introduced in 2003 and 2005 respectively, are not dependent on rainfall and boost our resilience against dry weather.

Today, we have five NEWater plants and two desalination plants. Together, they can supply more than half of our water demand. PUB will continue to build ahead of demand for our water security. By 2020, we will have three new 30 mgd desalination plants in Tuas, Marina East and Jurong Island. By 2060, NEWater and desalinated water will be able to meet up to 85% of our water needs.

2060

NEWater and desalinated water will meet up to **85%** of Singapore's water needs

REDUCING FLOOD RISKS

As Singapore becomes more urbanised and downpours become more frequent and intense, our flood risks will increase. Our holistic "Source-Pathway-Receptor" approach to stormwater management reduces the risks 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").

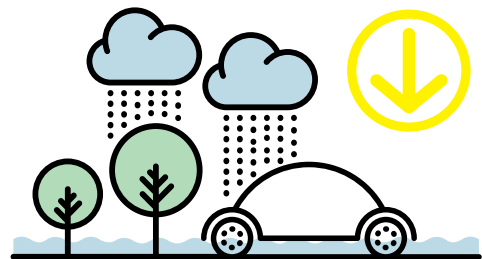
Since 2014, new developments and redevelopments 0.2 hectares or larger in size must have on-site measures, such as detention tanks, green roofs and bio-retention swales, to slow down the flow of peak runoff from these "Sources" into the public drainage system.

We will also continue to widen and deepen Singapore's waterways, and look into constructing centralised detention tanks and diversion canals, to boost the capacity of the "Pathways" that channel stormwater to our reservoirs or to the sea.

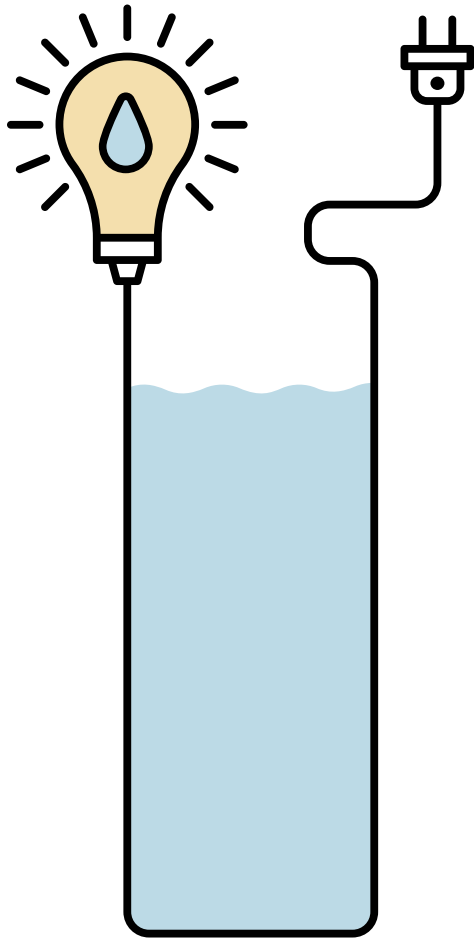
As part of the "Receptor" measures, developments must meet minimum platform and crest level requirements to prevent them from being flooded. This could entail raising ground levels and installing flood barriers.

In 2011, the minimum land reclamation level of all newly reclaimed land was raised from 3 m to 4 m above the mean sea level to protect our coastal areas against increased flood risks arising from sea level rise and storm surges. The Government is also studying Singapore's long term coastal protection needs.

The Building and Construction Authority (BCA) has commissioned a Coastal Adaptation Study. The study will identify measures to safeguard Singapore against coastal inundation. PUB will work with BCA to study and raise the level of protection at our coastal installations, including reservoir structures, treatment plants and pumping stations, to prevent disruption to our water and used water services.



MAXIMISING ENERGY EFFICIENCY



With Singapore's water demand expected to double by 2060 compared to today, our energy needs will increase as we rely more on desalinated water and NEWater. To manage the increase in energy use, we are:



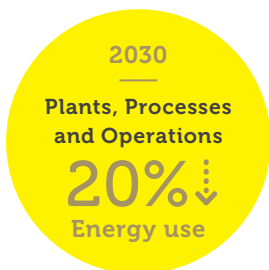
- 1 Reducing our energy needs from treatment processes. PUB develops and installs new technologies at every opportunity to minimise our energy use from existing and new treatment processes.



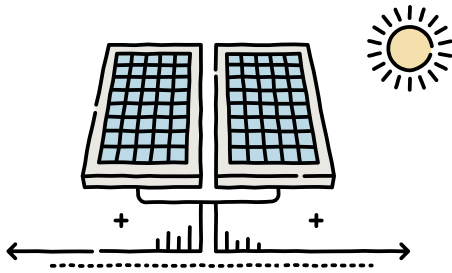
- 2 Increasing our energy production and recovery. When treating used water, PUB recovers biogas which can be used to generate electricity. PUB is also harnessing solar power at its installations to reduce their reliance on the power grid.



- 3 Managing water demand. While PUB works to trim our overall energy consumption, the community must continue, and do more, to conserve water.



These efforts will also reduce Singapore's carbon emissions and change the country into a smart energy economy. We aim to reduce our plants, processes and operations' energy use by 20% compared to business-as-usual levels by 2030, through energy-efficient technologies, solar power and better infrastructure planning.



MAXIMISING SOLAR ENERGY

Solar energy is clean, renewable, and lessens our dependence on the national grid and imported energy. As part of our efforts to harness solar energy, we have installed a 1 MWp system at the Choa Chu Kang Waterworks.

We will also deploy solar panels with a total capacity of 1.13MWp at the Changi Water Reclamation Plant, Bedok Waterworks and WaterHub under the SolarNova programme. The programme, led by the Economic Development Board (EDB) and

Housing Development Board (HDB), aims to boost solar energy use in Singapore by promoting and aggregating demand for it across government agencies.

Our reservoirs, with their open surface area, offer another opportunity for harnessing solar energy. We are studying the feasibility of deploying solar panels on the reservoirs' surfaces. The study will assess how many solar panels can be installed and the associated economic implications.



FLOATING SOLAR POWER

Tapping the sun's boundless energy and our reservoirs' vast surface area, floating solar farms could be an alternative energy source for Singapore. PUB has installed a pilot floating solar system on Tengeh Reservoir that covers 1 hectare and generates up to 1 GWh of electricity each year.

The project is led by EDB in close partnership with PUB, and managed by the National University of Singapore's Solar Energy Research Institute of Singapore (SERIS). As part of the pilot, PUB also conducts studies to measure its effect on the reservoir's evaporation, biodiversity and water quality.



Left: Solar panels at the Choa Chu Kang Waterworks



WATER AND A LIVEABLE CITY

Singapore's transformation from engineered city to environmental model over the past 50 years is just the start of the story.

17
reservoirs
8,000 km
of
waterways

With 17 reservoirs and about 8,000 km of waterways across more than 700 sq km of land, we have a rich opportunity to forge a blue network of beautiful streams, rivers and lakes.

By integrating the waterways with parks and gardens, and harmonising our water features with the built environment, we can create new community and recreational

spaces, and make Singapore an even better place for people to live, work and play.

In the long run, such efforts will aid Singapore's environmental sustainability and economy, as blue skies, green spaces and clean waters are a strong draw for people and investments. They will also be key to maintaining our city-state as a green gem in Asia's urban jungle.

A WATER SCA

You protect what you love: when people enjoy and appreciate our reservoirs and waterways, they are more likely to care for them and keep them clean. In 2006, we launched the Active, Beautiful, Clean Waters (ABC Waters) Programme to revamp our blue spaces from just functional assets to also beautiful spots for people to bond and have fun.

More than 100 locations across Singapore have been identified as potential ABC Waters sites to be implemented by 2030, and 36 sites have been opened by December 2017. Recently opened projects include Kallang River (Upper Boon Keng to Sims Avenue) and Pang Sua Pond.

Most projects integrate ABC Waters design features – green features such as rain gardens – to detain rainwater and

treat it before it is discharged into our waterways. Examples include those at Rochor Canal, Yishun Pond, Sungei Tampines and Kallang River @ Bishan-Ang Mo Kio Park.

Over the next five years, the community can look forward to the completion of more ABC Waters projects, including Sungei Pandan Kechil, Kallang River (Bishan Road to Braddell Road), Sungei Pinang and Serangoon Reservoir. These will enrich the living environment in the heartlands and the experience of connectivity along the waterways. We will also review the ABC Waters Master Plan periodically to identify other potential sites and take into consideration other agencies' development plans.

You can chip in too, by joining groups such as the Waterways Watch Society during their clean-up sessions or caring for our water spaces in other ways. Several schools have adopted ABC Waters sites and help to keep them pristine.

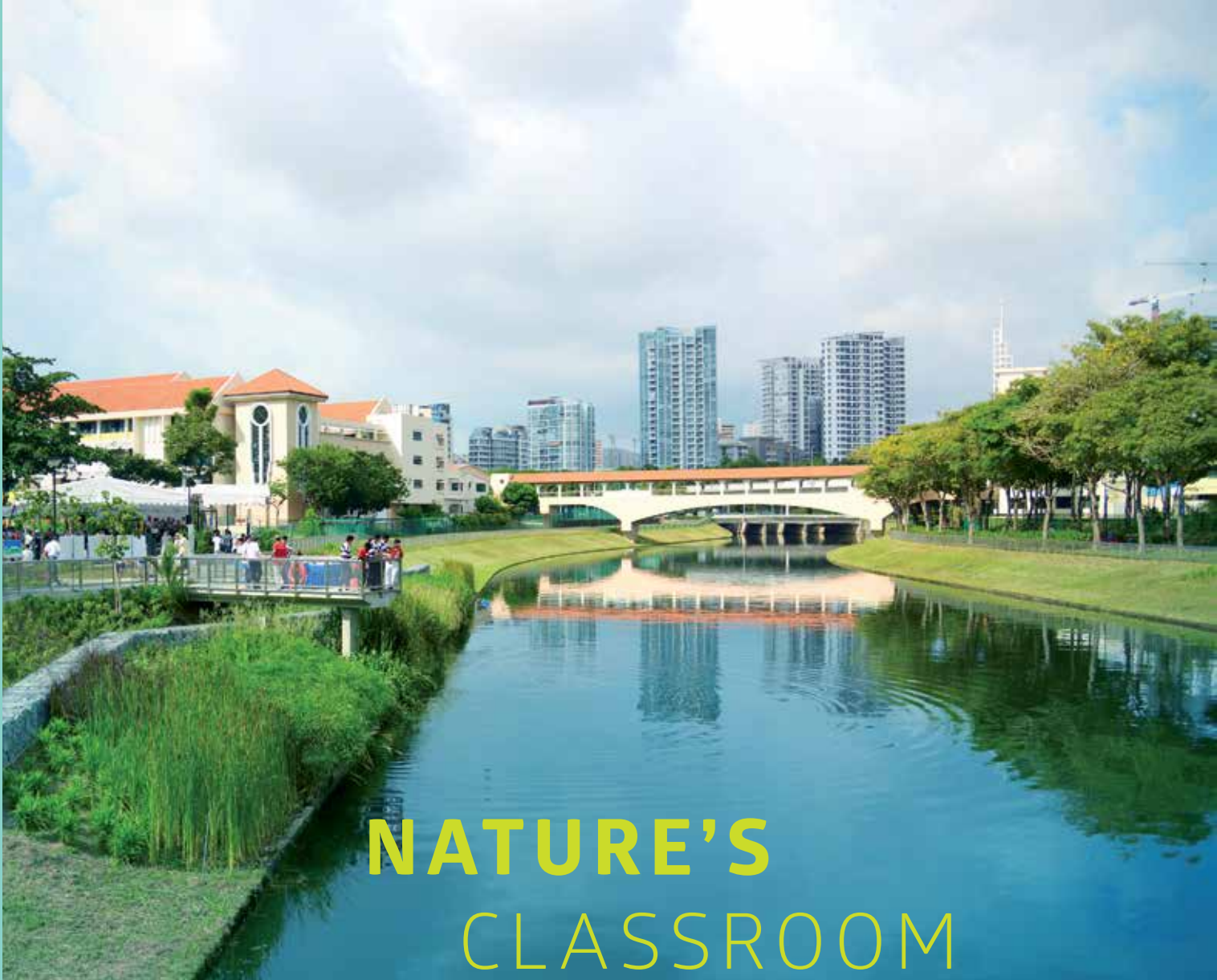

36
ABC Waters
sites
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100
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2030

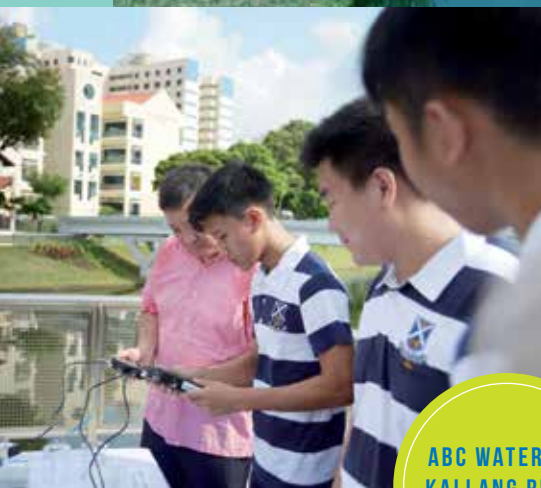


PE OF OASES





NATURE'S CLASSROOM



ABC WATERS @
KALLANG RIVER
(POTONG PASIR)

Our waterways can also be learning spots. Completed in 2015, a 400-metre stretch of the Kallang River between Potong Pasir Avenue 1 and St. Andrew's Junior School was converted into a beautiful waterway with new community spaces, including a plaza that can be used for events and outdoor lessons.

The open green space near the school was turned into an outdoor classroom where students can appreciate how ABC Waters design features such as rain gardens use plants' natural cleansing properties to improve the quality of rainwater runoff.

Shifting the "classroom" outdoors piques and sustains

students' interest as they learn about water and nature in a real-life setting. St. Andrew's Village, which comprises St. Andrew's Junior School, Secondary School and Junior College, is developing a community learning trail at ABC Waters @ Kallang River (Potong Pasir). They will also raise, among the Potong Pasir community, awareness of the importance of taking care of our waterways.

PUB is also working with schools to incorporate rain gardens within their compounds, providing students with an outdoor educational tool within the school setting.



A 480-metre long boardwalk over Pang Sua Pond has become a community focal point as it seamlessly connects residents to facilities in the vicinity such as the Senja-Cashew Community Club, 3G Wellness Centre and the Bukit Panjang Neighbourhood 5 Park. The ABC Waters project also boasts of the second-largest manmade floating wetland in Singapore, slightly bigger than the size of an Olympic swimming pool. They serve to cleanse the water naturally in this stormwater collection pond, while enriching the landscape and providing a biologically diverse ecosystem that supports a thriving community of plant and animal life.

To bring people closer to water, there is a new performance stage with seating at its promenade and viewing decks that present spectacular views of the tranquil and picturesque pond.

BOND BY THE POND





ABC WATERS @
KALLANG RIVER
(BISHAN ROAD TO
BRADDELL ROAD)

GO WITH THE FLOW

ABC Waters projects are sometimes carried out with drainage improvement works. The Kallang River from Bishan Road to Braddell Road will be widened and deepened at certain stretches to cater to more intense storms. Its transformation will also include nature-inspired designs over four stretches.

The canal wall will be greened with planters and creepers, and a 410-metre stretch of the river will meander around planter islands in the channel. The river will then widen and pass over a series of cascades into a permanent water body. Cantilevered decks along this 910-metre stretch will bring residents closer to water. A community deck and seats will be added, and ABC Waters design features such as a rain garden will be integrated to cleanse rainwater runoff before it enters the waterway. PUB and the National Parks Board will also develop the Kallang Linear Park along the river, between Bishan Stadium and Blk 165 Bishan Street 13.



A COMMUNITY EFFORT

ABC Waters can be a way of life. Developers, contractors, landscape architects, and engineers in both the private and public sectors are encouraged to adopt ABC Waters design concepts in their developments.

Developers can incorporate ABC Waters design features when designing their drainage systems to help detain and treat rainwater runoff before it is discharged into our waterways. When more developments implement such features, we can create a more holistic and sustainable system to manage our rainwater runoff.

To encourage public agencies and the private sector to adopt ABC Waters concepts within their developments, PUB introduced these initiatives:



ABC Waters Professional Programme

- > PUB, together with public agencies and professional bodies, have organised courses, seminars, talks and more to develop expertise on ABC Waters designs.
- > The ABC Waters Professional Programme trains industry professionals to design, implement and maintain the ABC Waters design features. These professionals must be engaged by developers/owners when implementing ABC Waters design features.

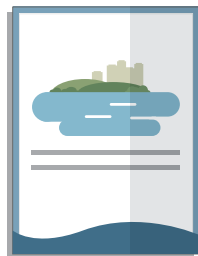


ABC Waters Design Guidelines and Engineering Procedures for ABC Waters Design Features

This publication shows developers and industry professionals how to include environmentally sustainable green features or ABC Waters design features in their developments. It is available on PUB's website and is periodically updated.

ABC Waters Certification Scheme

Launched in 2010, the scheme recognises public agencies and private developers who implement ABC Waters design features in their developments.



Besides promoting ABC Waters concepts, PUB continues to research and develop more innovative ABC Waters design features that suit the Singapore context and facilitate catchment-wide implementation.

OUR WATER FUTURE

While we are working hard to expand the supply, we will also require everyone's help to keep our water use sustainable and efficient.

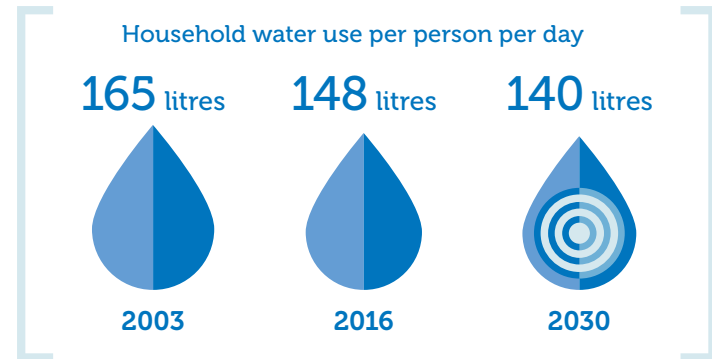




MANAGING WATER DEMAND

Singaporeans are clearly up for the challenge: between 2003 and 2016, households cut their water use per person per day from 165 litres to 148 litres. Our long term goal is 140 litres by 2030.

PUB works with communities to improve their water consumption habits. We adopt a multi-pronged approach: pricing water to reflect its scarcity value; mandating water efficiency standards; and encouraging water conservation practices.



PRICING

We have priced water to encourage people not to waste it. The price not only reflects the full cost of its production and supply, but also includes a Water Conservation Tax to underline the message that every drop of water is precious and everyone must help to conserve this resource.



SETTING THE RIGHT PRICE

In Singapore, water is priced to reflect its scarcity value, given our constrained circumstances. The price takes into account the entire national water system's costs, including those of rainwater collection, reservoir management, NEWater production, desalination, raw water treatment, the island-wide network of pipes to distribute the treated water and the extensive sewers to collect used water so it can be recycled and reused. The price of potable water also reflects the higher costs of producing water from the next available sources, specifically NEWater and desalinated water. Still, the average household's water bill remains a small percentage of its income.

MANDATORY MEASURES

Over the years, advances in technology have led to appliances and fittings that help conserve water. We have mandated measures to ensure households and industries use water efficiently. These include maximum allowable flow rates for taps and mixers, and maximum allowable flushing capacities for flushing cisterns and urinal flush valves. Under the Water Efficiency Labelling Scheme (WELS), water efficiency labels are also required for the sale of taps, mixers, urinals, urinal flush valves, clothes washing machines and other items.

In April 2017, a 4-tick label for washing machines was introduced to encourage the use of more water-efficient appliances. Taps and mixers with 0-ticks were phased out so that only those with 1-tick or more can be sold and supplied. PUB will be extending MWELS to include dishwashers from Oct 2018. From April 2019, PUB will also mandate the sales, supply and installation of minimum 2-tick water fittings in all new and existing premises undergoing renovation.



MAKING AN INFORMED CHOICE

Singaporeans know a good deal when they see one. Sales of water-efficient washing machines shot up here after PUB introduced the Mandatory Water Efficiency Labeling Scheme (WELS) in 2009.

Under this scheme, suppliers are required to list the water efficiency of their water fittings and appliances on displays, packaging, advertisements and other publicity materials, so consumers can make more informed choices. Labelling is required for taps, mixers, urinal flush valves, waterless urinals, dual-flush low-capacity flushing cisterns and clothes washing machines.

Based on a market survey in 2015, the market share of 3-tick models has increased from 37% in 2011 to 86% in 2015. This reflects an increased consumer preference for more water-efficient washing machines.

ENCOURAGING WATER CONSERVATION PRACTICES

Since we are much more likely to use water judiciously when we appreciate the need and know how to do so, PUB works with different stakeholders to design targeted programmes to encourage water conservation.

UNDERSTANDING HOUSEHOLD BEHAVIOUR AND WATER USE

How can real-time information about their water use help households to use less water?

A study by PUB and NUS in 2016 found that providing real-time information on the amount of water used during showers and setting conservation goals had helped households reduce water consumption. A smart shower device attached to the showerhead shows real-time information on the amount of water used, animation, as well as ratings ranging from “very good” to “too much”. By the end of the study, households achieved water savings of about 20 percent, or approximately five litres of water per person per day. PUB will be deploying these devices in some 10,000 new homes to validate its effect in conserving water during showers. This can potentially help households save about 3% of their monthly water bills.

PUB will continue to carry out studies to better understand water usage patterns and habits, as well as what motivates people to save water. This will help us design and implement targeted programmes to encourage water conservation.

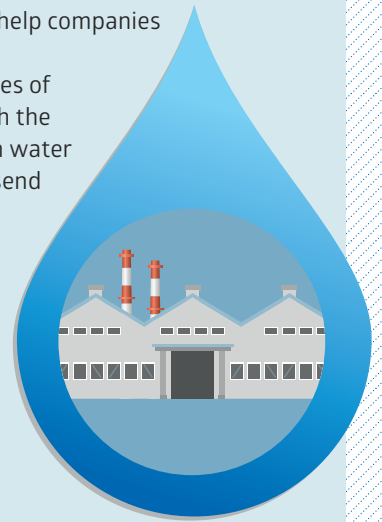
ENCOURAGING WATER CONSERVATION IN THE NON-DOMESTIC SECTOR

From January 2015, large non-domestic water users that consume 60,000 m³ or more a year are required to install private meters, and submit their Water Efficiency Management Plans (WEMP) to PUB annually.

This information will help us to better understand how specific industries use water, so that we can develop more targeted conservation measures, and benchmarks for the different sectors. In consultation with the stakeholders, PUB has documented the design and operations of water-efficient buildings into a ‘Best Practice Guide for Water Efficiency - Buildings’ to give the people involved in water management a good knowledge of the design, maintenance and operation of a water-efficient building. We will continue to study the data to develop water efficiency benchmarks and guidelines of good practices for different sectors.

PUB has also published a Technical Reference for Water Conservation in Cooling Towers to help companies better manage water cooling needs.

In addition, to improve the capabilities of practitioners and equip organisations with the relevant technical knowledge and skills on water efficiency, large water users will need to send one of their WEMP Representatives to attend a 3-day Water Efficiency Manager Course to be certified as Water Efficiency Managers from 2019. Organisations can also tap on the Water Efficiency Fund to implement projects to improve their water efficiency. These can include feasibility studies, water audits, recycling efforts or use of alternative sources of water, and community-wide conservation programmes.



WATER EFFICIENCY AWARDS

The Water Efficiency Awards (WEA) is a biennial award which recognizes the top water efficiency performers in the respective sectors. With data from the WEMP, a Water Efficiency Index (WEI) or recycling rate is computed for each organisation. The best performers in each sector refer to premises with the lowest WEI, or industrial plants with the highest recycling rates. In 2017, 27 award recipients from seven sectors (Office, Retail, Hotel, Wafer Fabrication, Refinery, School and Estate) were acknowledged for their outstanding efforts in using water efficiently in their operations.



WATER EFFICIENCY AWARDS RECIPIENT: CARLTON CITY HOTEL

Located in the central business district, Carlton City Hotel Singapore is a 29-storey hotel with 386 guest rooms. In the last two years, Carlton City Hotel has seen a drop of about 4,233m³ in water consumption. Currently, their WEI index of 0.58 m³/occupied guest room/day is within the top 10th percentile. As part of the hotel's sustainability initiatives, Carlton City Hotel Singapore closely monitors its water consumption and has a remote monitoring system, coupled with a prompt maintenance regime, to prevent possible water wastage. The hotel adopted 3-tick MWELS fittings in their guestrooms and common area toilets in their efforts to conserve water. They also actively educate guests and staff on the importance of water conservation by placing water conservation posters all around the premises. Guests are also encouraged to avoid frequent change of linens and towels thus saving water used for laundry. In addition, the hotel recovers AHU condensate and reuses it for the cooling towers.



CAMPAIGNING FOR AWARENESS

Start them young and you'll keep them going – the earlier people adopt water-saving habits, the more likely they are to practise them throughout their lives.

We worked with the Ministry of Education (MOE) to include water conservation topics in the Primary 3 Social Studies syllabus. The "Time-to-Save" programme, introduced in 2013, is aligned to MOE's Primary 3 Social Studies syllabus and creates awareness of the need to cherish and conserve water to protect the environment.

PUB's water hero, Water Wally, and other characters such as Professor Save and Water Waster also call out water-wasting behaviours and highlight good water-saving habits in a skit that includes a "shower dance" to promote the message of keeping showers to under 5 minutes in a fun manner.

As a follow-up activity, participating students are given a timer and an activity booklet to track their shower timings for a week.

SAVING WATER WITH EVERY FLUSH

The Water Closet Replacement Project was launched in June 2017 to help households living in older HDB flats that are on community assistance save water by replacing their non-water efficient 9-litre water closets with more water-efficient ones. Non-water efficient wash basin taps and kitchen sink taps are replaced at the same time. Households that benefit from the project can save up to 5 litres of water per full flush, and save up to 10% of their monthly water usage. Up to 7,000 families are expected to benefit from this project, which will be completed over the next three years.

SHARING OWNERSHIP

Many people in Singapore have started water-related activities and programmes, inspiring an ever-widening circle of 'Friends of Water'. Private firm Pratt & Whitney teamed up with the Waterways Watch Society to implement school outreach programmes that teach students about water and environmental issues.

PUB has also partnered schools, firms and non-government groups to create ABC Waters Learning Trails that raise awareness of the ABC Waters concept and sites, and groom the next generation of water advocates. About 107,500 participants from schools and members of the public have experienced the trails at our waterways and reservoirs. This programme also complements interdisciplinary school subjects such as Geography and Sciences.

Our other programmes also encourage the public and private sectors and people to share ownership of our water.



About
107,500
students and members
of the public
have experienced the ABC Waters
learning trails at our waterways
and reservoirs

NEWATER VISITOR CENTRE

With a fully-functioning NEWater factory on site, visitors can witness the operation of advanced membranes and ultraviolet technologies used to make the ultra-clean NEWater. The centre's interactive games and multimedia exhibits on a wide range of water-related topics make it a hands-on, immersive edutainment experience.





FRIENDS OF WATER

Many people and organisations have helped spread the water message and contributed to keeping our water supply sustainable. As its name suggests, Friends of Water is a way for us to recognise such efforts. These Friends have adopted our waterways and reservoirs, developed their own water-centric programmes, or even gone beyond to become water stewards and advocates in their communities.

WATERMARK AWARD

Introduced in 2007, the Watermark Award aims to inspire and encourage Singaporeans to take ownership of our water resources and contribute towards Singapore's water sustainability.

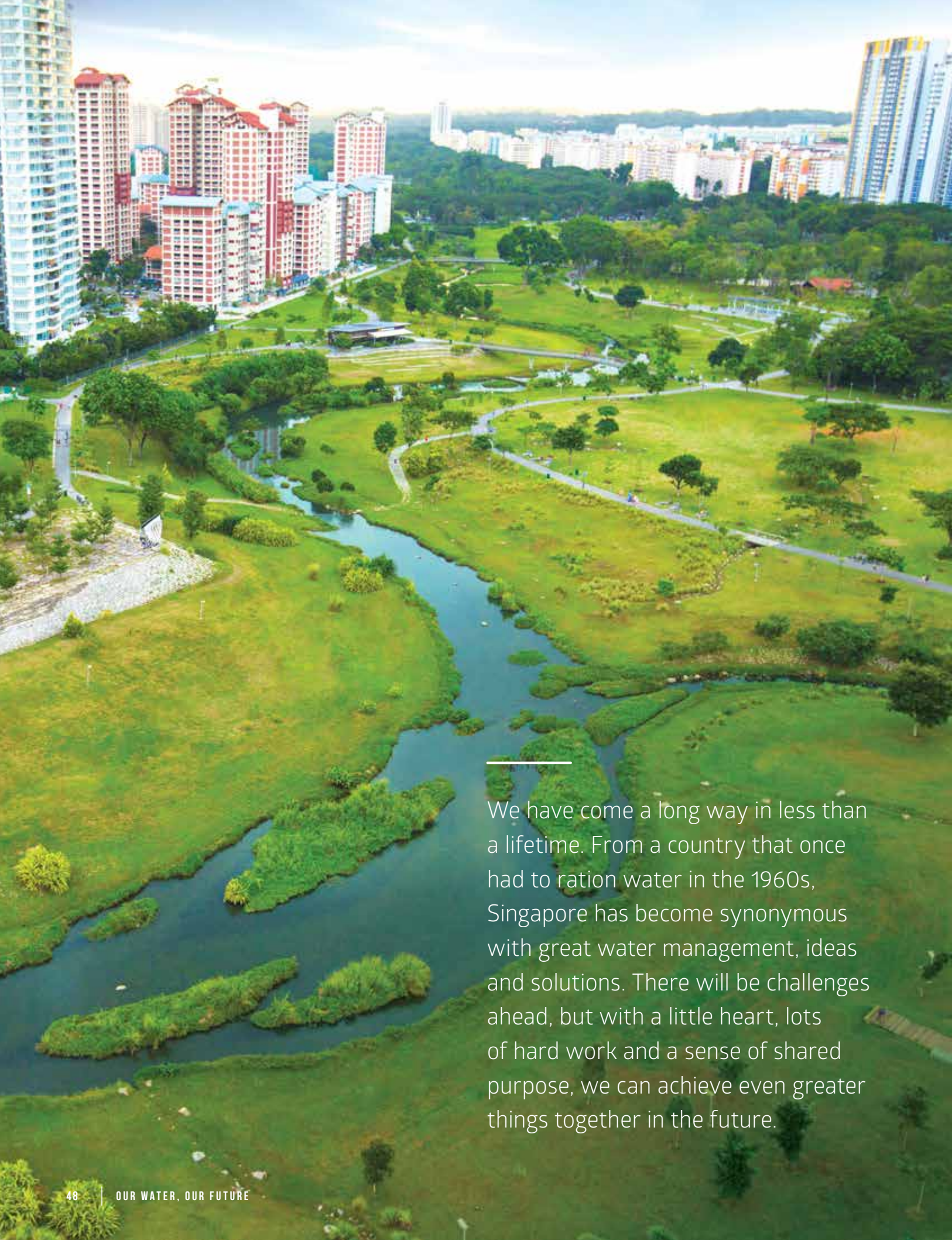
Aero-engine company Pratt & Whitney is a strong advocate for environment sustainability, in particular, promoting efficient water use in their organization. It has invested in water reduction technologies and water saving devices to cut down usage. It introduced vacuum distillation at four facilities to help reduce and manage water waste by removing harmful substances from waste water and allowing the treated water to flow back into the water system.

In 2016, Pratt & Whitney decreased water usage across its Singapore operations by 8% or over 2.7 million gallons.

Pratt & Whitney's initiatives also include community activities to raise awareness of water conservation among employees and local schools. It has developed educational materials while employees take on the role of teachers to share information on saving water.

Pratt & Whitney was awarded the Watermark Award in 2017.





We have come a long way in less than a lifetime. From a country that once had to ration water in the 1960s, Singapore has become synonymous with great water management, ideas and solutions. There will be challenges ahead, but with a little heart, lots of hard work and a sense of shared purpose, we can achieve even greater things together in the future.

5 tips to **SAVE** \approx **140** litres a day



Showers

10-min shower **90l**

5-min shower **45l**



Brushing your teeth

Tap running for 2 minutes **12l**

Using a mug **0.5l**



Flushing the toilet

4 full flushes per day **18l**

2 full flushes, 2 half flushes **15l**



Dish washing

Washing under a running tap for 5 minutes **40l**

Filled sink/container **12l**



Washing machine

4 ticks



Water. It is nature's gift to life, for without it nothing is possible.

Play a part in making every drop count.

Take ownership of this precious resource: use water wisely, keep our waterways clean, and have fun in it.

Together we can continue to enjoy active, beautiful and clean waters.