MODERNISING HONG KONG'S WATER MANAGEMENT POLICY PART II

EXECUTIVE SUMMARY

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WYNG FOUNDATION

SUSTAINABLE WATER INFRASTRUCTURE: TOWARDS A DIVERSIFIED WATER SUPPLY

Since the late 1960s, a combination of local yield, water imported from the Dongjiang River Basin, and seawater for flushing has formed the backbone of the Hong Kong water supply. Over this period, the volume of Dongjiang water has increased steadily every year. Hong Kong now imports 70-80% of its total freshwater supply from the Dongjiang River Basin, under an agreement with Mainland Chinese authorities.

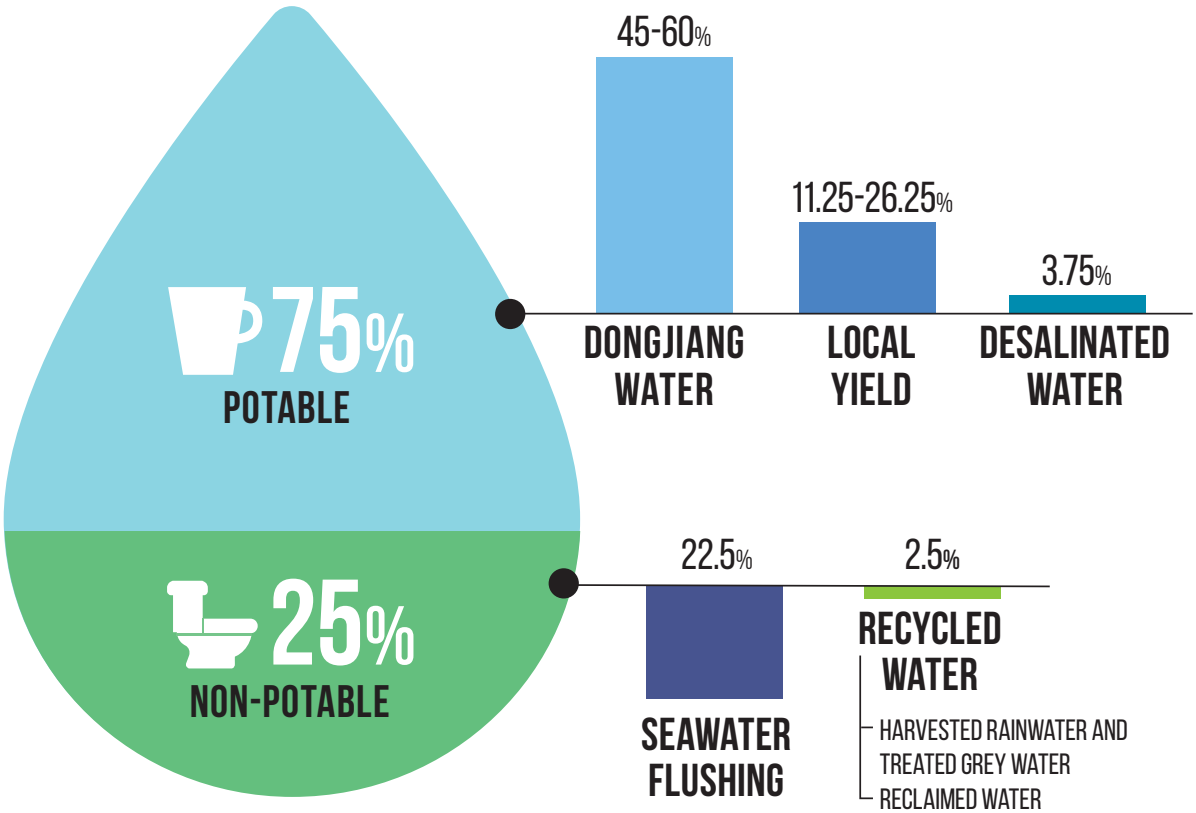
Importing Dongjiang water is a costly option for Hong Kong's water security. Water prices have continued to increase annually, and are only set to become more expensive due to increasing competition from higher priority uses, such as maintaining the ecological function of rivers and generating hydropower. WSD has also expressed concern over potential increases in demand for water from rapidly growing cities along the Dongjiang. Other uses of the river, including the support of greater river traffic, increase competition for water resources.

Despite the fact that most Hong Kong citizens use seawater to flush the toilet, Hong Kong's per capita freshwater use is around 21% higher than the global average of 110 litres per day.[1] When all water uses are taken, it is clear that Hong Kong needs to find alternative sources of water. In order to secure supply beyond 2030, the Water Supplies Department (WSD)'s Total Water Management (TWM) strategy 2019 includes the addition of desalinated and recycled water to our water portfolio (see the figure below).

This research analyses both the efficacy of current water resources and the potential of WSD's proposed new water sources in the local context of Hong Kong. It comprises a brief background on the current sources and water use in Hong Kong, evaluations of the potential of each of the current and proposed sources based on a set of criteria, which includes sustainability, and strategic recommendations based on this analysis.

Diversification of Water Resources in 2019 Total Water Management Strategy

Source: WSD, 2019



LOCAL YIELD

Rainwater accounts for approximately 30% of Hong Kong's total freshwater each year.[2] Approximately 50% of total annual rainfall lands in the current catchment area, but only about 10% of that total is collected since most rainfall volume is concentrated in a short period of time, making it difficult to collect and store.

Rainwater is stored in a series of 17 reservoirs across Hong Kong Island and the Kowloon Peninsula. Without an efficient raw water transfer tunnel, the reservoirs overflow during periods of heavy rainfall. According to WSD records, an annual average of 19.8 million m^3 was lost between 2009 and 2014. The Inter-reservoirs Transfer Scheme (IRTS), a combined project with the Drainage Services Department (DSD), aims to help alleviate some of the overflow by diverting about 3.4 million m^3 a year from Kowloon Byewash Reservoir to Lower Shing Mun Reservoir, which is enough to supply water to about 68,000 people.[3,4] WSD has estimated the cost of this project at about HK$20 per m^3 – about five times the current price of HK$4.2[5] for local freshwater – and serves dual purposes of flood control and increasing local yield, according to WSD.[6]

The majority of water catchment areas are located in country parks, which provides additional protection against development under the Country Parks Ordinance, but also makes the expansion or modification of reservoirs much more complicated due to potential environmental impact.

While the expansion of storage for additional Dongjiang water would be useful, it would also be expensive: WSD has cited costs of over HK$20 per m^3 to increase capacity. A review of the literature surrounding shape modification of large storage reservoirs finds this to be a non-viable option, as the scale and cost of modifications generally have a payback period of over 250 years.[7] Additionally, it would not significantly increase the reliability of supply in the face of climate change, as it does not reduce Hong Kong's overall dependence on natural flows.

DONGJIANG WATER

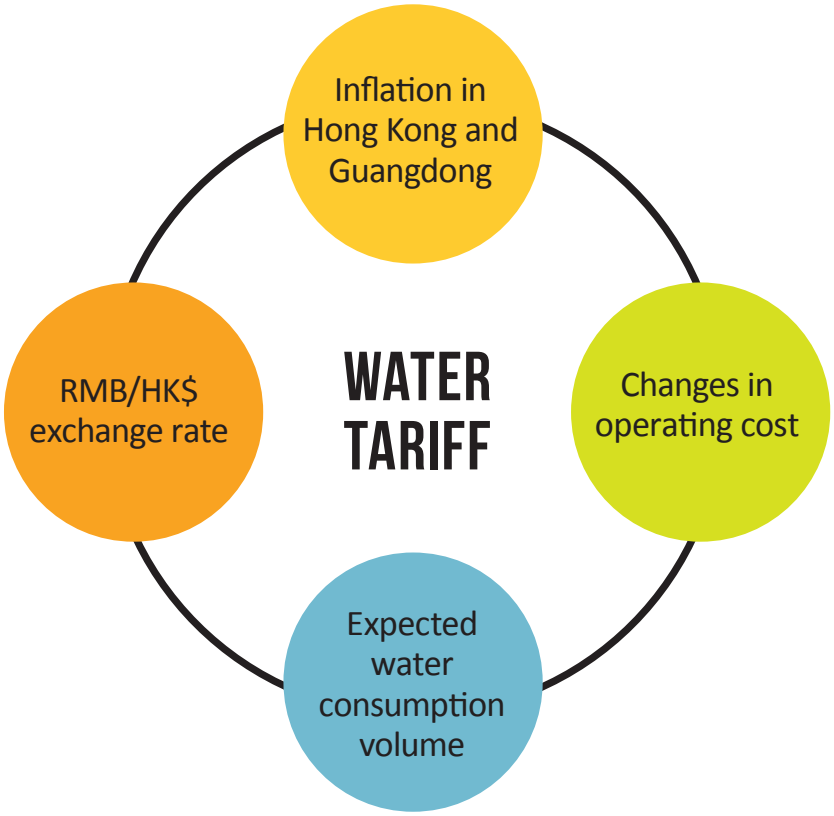
Dongjiang water now accounts for up to 80% of Hong Kong's total freshwater supply, and makes up the bulk of WSD's spending.[8]

The agreement on the supply of Dongjiang water, affected by factors involving water consumption volume and operation cost, has changed over the years, usually to modify the supply ceiling. The most recent significant change occurred in 2006, with the adoption of the 'lump sum deal' model. This change in terms guaranteed Hong Kong 820 million m^3 a year, regardless of drought conditions in the Pearl River Delta. Of this volume, we typically use about 640 million m^3 based on a 10-year average: the full amount was only used in 2011.[9] Additionally, the new agreement allows WSD to accept only the amount of water it needs in each period, by taking into account local reservoir positions, expected demand and predicted rainfall conditions. As a result of importing only the amount of water needed in lieu of being required to accept a fixed amount, medium-sized reservoirs, such as Tai Lam Chung, have been less subject to overflows, and adjusting the timing of purchases has made it possible for additional local yield to be stored. Additionally, when reservoir overflows do occur, according to WSD, it is now only local water that is lost, making overflows less costly. While this may seem like a good deal, it does have some drawbacks.

Hong Kong is required to pay the full amount stipulated in the agreement, regardless of how much water it actually uses, meaning the true cost of the water is actually higher than that listed in the purchase agreement. Since WSD has frozen water charges since February 1995, only about 30% of its income comes from tariffs, while the rest is covered by subsidies (i.e. contribution on rates).

As demand for water in Hong Kong continues to grow, and without significant alternative sources of supply, Hong Kong will inevitably rely increasingly on Dongjiang water. Hong Kong can consider renegotiating the nature of its agreement with the Guangdong authorities to safeguard the interests of Hong Kong, particularly regarding cost. There are certain forms a new deal could take to maintain stability of Dongjiang water prices over the years, or set a lower fixed portion with a variable portion available as needed, which could even be charged at a higher price to encourage conservation efforts. There are still potential savings here, as Hong Kong would only need to pay for what it used, instead of the full bulk rate paid now. There are also benefits available to the Pearl River Delta here, as moving Hong Kong away from dependence on this water frees it up for other cities in the Delta like Shenzhen, which are facing severe future water shortages.

Factors for Consideration in Contract Renewal Negotiation



Since Dongjiang water makes up the single largest portion of annual costs, it is becoming an impediment to growth in research and investment in alternative technologies. With the user-pay principle unable to be realised as discussed in our sister report, "Conservation and Consumption: Towards a Water-Smart Hong Kong", Dongjiang water has put WSD in constant deficit. Without any of its own internal funds, WSD cannot conduct any research or undertake any projects unless it receives additional funds from the Hong Kong Legislative Council (LegCo), which already grants it nearly HK$7 billion a year in subsidies.

In order to control costs and ensure it can continue to maintain a secure and economical water supply for its citizens, Hong Kong must develop alternatives to lessen its reliance on Dongjiang water. Additionally, Dongjiang water is still susceptible to changes in natural flow, and in the event of a severe drought, there is always the potential for a shortfall, regardless of what the agreement guarantees. While it will unlikely be economically practical for Hong Kong not to purchase water, a reduction in this reliance will increase the overall resilience of the water supply mix in the face of population and economic growth, competition in the PRD on water resources and global climate change.

SEAWATER FLUSHING

Hong Kong is one of the few coastal cities that maintains a dual-reticulation, or separated, plumbing system to deliver both fresh and seawater. The latter is used for toilet flushing. For the last 60 years, this system has been integral in ensuring Hong Kong's water security by offsetting a significant proportion of freshwater use. The economics of its further expansion and future use are, however, less clear.

WSD decided to begin supplying seawater free of charge in 1972 to increase adoption. While it did not directly charge for the seawater, due to the inability to meter its use, the Department intended to recover system costs indirectly through the drinking water tariff. Despite initial difficulties in convincing people to adopt seawater flushing, WSD's policy and pricing efforts have resulted in seawater being supplied to approximately 85% of the population for flushing, as of 2017, accounting for 22% of the total water supply.[10] This supply comes a relatively low average unit cost when compared to that of freshwater (a blend of Dongjiang water and local yield) at HK$16.6 per m^3. Daily per capita flushing water consumption has increased continuously in the last decade.

Studies have found that the two most important factors determining whether seawater flushing is economical are population density and distance from the coast. The population density should exceed 3,000 people per km^2, and the seawater should be pumped less than 30 km, or even less if the elevation is high. As Hong Kong continues to develop and its population migrate into less dense areas away from the coast, the factors that made the system cost-effective will begin to diminish.

WSD has begun to address this issue by looking into alternative flushing water supplies for areas far from the coast, such as the New Territories, where the use of seawater flushing is economically inefficient compared to those of freshwater and other alternatives such as harvested rainwater and reclaimed water. These alternatives also provide WSD with more flexibility, as they can be leveraged to cover non-potable demand beyond flushing.

As Hong Kong adopts more green building standards, with special regard to dual flush toilets, the overall demand for flushing water will begin to decrease. WSD estimates that on average, Hong Kong residents used 92.3 litres per day for flushing their toilets in 2016, based on both seawater and freshwater usage. If Hong Kong adopts a level of technology equivalent to that of Singapore[11] or Macau[12], which use 28.8 and 35 litres per day respectively, WSD would only need to supply approximately 100 million m^3 of seawater for flushing to seawater end users. At this rate, the unit cost of seawater flushing would potentially be as high as HK$7.87, due to the increasing proportion of capital cost in each unit. That would make other alternatives more cost-effective for WSD, not to mention the external impacts, such as those on building owners who would no longer have to worry about the increased corrosion of their appliances resulting from seawater, which are not typically considered in these analyses.

RECYCLED WATER

WSD is looking into increasing the network coverage of lower grade water by expanding the use of seawater flushing and recycled water, comprising harvested rainwater, treated grey water and reclaimed water, for non-potable purposes.

Harvested rainwater and treated grey water

Harvested rainwater is the rainwater collected from surfaces such as roofs and stored for future use, whereas grey water is the water collected from showers, kitchen sinks and laundry machines etc. that can then be treated for use. By mid-2019, rainwater harvesting or grey water recycling systems have been installed in new buildings as part of approximately 100 government projects, which is in line with the government's green building policies.[13] The new development of the Anderson Road Quarry Site, which will be discussed in section 5.1, plans to use a combination of rainwater harvesting and grey water recycling systems, installed and managed by WSD, to offset freshwater usage for flushing.

Based on studies carried out across Australia, the cost of rainwater harvesting is highly variable and will most likely be greater than other low-cost alternatives on the Hong Kong market.[14] A study carried out in Hong Kong found that a typical rooftop harvesting system was only able to provide 25% of the water required for washing machines in a high-rise building.[15] It found that a minimum catchment area of 900 m^2 would be necessary for the system to be financially viable, with an ideal catchment of about 2,000 m^2 for a typical Hong Kong residential building. This amount of space would make harvesting generally unattractive and potentially impractical for a typical private building.

While the use of rainwater harvesting is limited by the high costs associated with land and limited available space, the ability to collect runoff in urban areas would be beneficial for reducing flash flooding during periods of high rainfall. The expansion of reservoirs and harvesting would be of greater benefit as a way of preventing flooding than as a means to support drinking water supply, as their reliance on natural flows does little to increase overall resilience in times of drought.

If WSD and DSD can work closely together, it would be possible to divert rainfall during periods in which flooding has historically been problematic, thereby reducing the impact and damage caused by these events over time. By combining the value of flood prevention with water resources, projects that were considered too expensive may become economically viable.

Reclaimed water

Reclaimed water is essentially wastewater that has been treated to standards consistent with local water quality regulations. It is becoming an increasingly common water resource around the globe, particularly for potable use. In Hong Kong, it can be used to offset freshwater demand, similar to current use of seawater for flushing.

While treating reclaimed water to potable standards would not be practical or economically viable in Hong Kong, it can compete with freshwater supply alternatives such as desalinated water and Dongjiang water for a range of non-potable uses. Due to a wide range of potential applications, freshwater demand can be partially offset, particularly in the non-domestic sectors. However wide-scale implementation will face challenges in both public acceptance and the development of necessary infrastructure and institutional knowledge.

DSD has already launched a pilot scheme to gain experience and determine the feasibility of reclaimed water use in Hong Kong. Commissioned in 2006, the Ngong Ping Sewage Treatment Works (Ngong Ping STW) on Lantau Island became both the first tertiary treatment works and reclaimed water facility to operate in Hong Kong. The plant provides sewage treatment for approximately 40,000 residents and tourists, delivering 140 m^3 per day of reclaimed water for irrigation, fish rearing and toilet flushing.[16] According to DSD, Ngong Ping STW makes use of advanced chemical, biological, filtering and disinfection processes to ensure that the reclaimed water provided is purified, odourless and safe for a wide range of non-potable uses.

DSD also commissioned 11 additional small-scale water reclamation trial plants in 2010.[17] Based on the results of these pilot tests, DSD found that plants that received non-saline wastewater that had undergone secondary treatment required less energy and chemical input, while the plants that received saline effluent following primary treatment required significantly more energy, at times on a par with desalination.

For Hong Kong, the adoption of reclaimed water for flushing and other non-potable uses, in particular in the New Territories, makes sense from both an economic perspective and for environmental resilience. However, the overall ability to harness this resource outside of these areas, to replace freshwater flushing or for provision to the industrial and commercial sectors, is hampered by the presence of seawater in the wastewater stream, which makes reclamation difficult and expensive. Additionally, the majority of Hong Kong's wastewater treatment plants rated as preliminary, primary, or minor secondary, which do not produce treated water of a suitable quality for reuse. Further, the wastewater streams treated at these plants are brackish, meaning the potential applications of reclaimed water are limited without significant capital investment or operational expenses on the part of DSD.

Based on WSD estimates, reclaimed water can be provided for non-potable uses in Hong Kong for about HK$6.5 per m^3, making it 35% cheaper than the current cost of Dongjiang water, in addition to being a drought-resilient resource. By investing in technologies that will make it possible to harvest and supply this water for a wide range of non-potable uses, Hong Kong can secure a low-cost water resource that is drought-resilient and provides environmental benefits in terms of both reduced energy usage and improved local water quality.

DESALINATED WATER

Desalinated water is currently planned to contribute 5% of projected total freshwater demand beginning in 2023, on a stand-by basis. It is important to take into account how the technology for this alternative water resource fits in with Hong Kong's other goals. These include the Hong Kong 2030+ Plan, which calls not just for an adequate water supply, but for a "smart, green and resilient infrastructure that should be well-integrated for better synergy and land efficiency."[18]

In spite of its drought-resilient nature, desalination is energy-intensive and potentially environmentally damaging. This high energy intensity makes desalination costly and can lead to significant increases in carbon emissions if the fuel mix used to produce this energy comes from coal or fossil fuels. For these reasons, its large-scale use is not advisable in Hong Kong. Considering that Hong Kong is looking for solutions that are climate-resilient and green, this strategy of producing 5% or more of fresh water from desalination is counter-productive to those goals.

While Hong Kong lacks local water resources, its access to Dongjiang water from Guangdong is currently cheaper than desalination and may remain so under future purchase agreements. Furthermore, water reclamation presents a similarly drought-resilient water source that can produce high-quality water with less energy and at a lower cost. When viewed in this context, it is difficult to support the advocacy by LegCo and WSD for significant investment in desalination.

That is not to say that desalination will never be a practical option. There are several technologies under development, such as electro-desalination which is being pilot tested in Singapore, that have the potential to lower the energy requirements of desalination, but they are still operating at the lab or pilot level and have yet to be proven on the scale needed to be commercially viable. The use of renewable energy could also make desalination more attractive by offsetting both energy costs and associated emissions. However, until these technologies become available, desalination will remain impractical for Hong Kong, as it would prove costly for its residents.

CONCLUSION AND RECOMMENDATIONS

WSD has put forward plans to increase the water supply through the introduction of desalinated water, reclaimed water, harvested rainwater and treated grey water. Together, these will constitute approximately 6.3% of Hong Kong's total water resources, and among them only desalinated water will be potable, with the potential to contribute up to 5% of total freshwater demand in the future. The current plans are not aggressive or ambitious enough to lower Hong Kong's reliance on natural flows, nor do they appear to increase the long-term resilience of the system in the face of climate change.

In addition to the recommendations put forth in this report's sister paper, "Conservation and Consumption: Towards a Water-Smart Hong Kong", with regard to improving demand management through proper pricing, increased conservation efforts and education, Civic Exchange would like to make the following suggestions for improving the deployment of different types of water sources, based on these criteria:

1 CLIMATE RESILIENCE

2 WATER SUSTAINABILITY

3 TECHNICAL FEASIBILITY

4 PUBLIC ACCEPTANCE

5 POTENTIAL FOR EXPANSION

WATER RESOURCE SNAPSHOT

	CURRENT AVERAGE UNIT PRICE	CLIMATE RESILIENCE	ADAPTABILITY
POTABLE			
LOCAL YIELD	HK$4.20	LOW	LOW
DONGJIANG WATER	HK$10.13	HIGH*	LOW
DESALINATED WATER	HK$12.00-HK$13.00	HIGH	LOW-MEDIUM**
NON-POTABLE			
HARVESTED RAINWATER	HK$2.86-HK$231.00	LOW	LOW
TREATED GREYWATER	HK$1.50-HK$16.00	HIGH	HIGH
RECLAIMED WATER	HK$6.50	HIGH	HIGH
FLUSHING ONLY			
SEAWATER FLUSHING	HK$4.26	HIGH	LOW

* Guaranteed by purchase agreement. However, as the Dongjiang is subjected to the same set of weather patterns as local yields, the rating would be the same as Local Yield in the absence of this guarantee or during an extended drought period.

** As Hong Kong will continue to phase down coal for electricity generation and use more natural gas and increase non-fossil fuel sources, the climate-related shortcomings of energy-intensive water resources will gradually decrease. Advances in energy storage systems will also make the use of renewable energy more practicable over time.

1. Set an ambitious vision for the deployment of reclaimed water in non-potable uses

Currently, WSD plans to deploy just 2.5% of recycled water, which includes reclaimed water as well as harvested rainwater and treated grey water, for non-potable uses, with no further breakdown of these uses due to the relative insignificance of this source. We propose a more ambitious vision of 20% should be set to cover non-potable uses, including freshwater flushing (7.9%) and the demands of the construction and industrial sectors (2.2% and 6.1% of total water demand, respectively). In other words, the 20% of reclaimed water represents savings of 197 million m^3 or the freshwater usage of the entire government establishments and flushing sector. This seemingly ambitious vision of 20% can be achieved through efforts to increase public acceptance and the development of necessary infrastructure and institutional knowledge to deliver it.

Replacement of freshwater flushing with reclaimed water in existing areas and future new town developments makes sense from both a logistical and an economic perspective, as it is too expensive to supply them with seawater, due to the cost of transmission.

2. Reconsider the necessary conditions for deploying desalination as a backup option of freshwater supply

While WSD has regarded desalination as a strategic water resource which is not susceptible to the impacts of climate change and could provide Hong Kong with a drought-proof source of water, we must consider the overall impacts of the technology when deciding how much to invest in it. Producing our water through desalination has the potential to substantially increase associated electricity demand, particularly once distribution is considered, which will lead to corresponding increases in greenhouse gas emissions, exacerbating climate change effects such as droughts in the future. Further, the potential impacts of desalination on the water supply could be more easily and cheaply met with improved conservation and policy efforts, such as the suggestions put forth in our sister paper, “Conservation and Consumption: Towards a Water-Smart Hong Kong”.

Beyond the climate change links, researchers have become increasingly concerned with impacts on marine biodiversity and ecosystems linked to desalination operations. Sourcing freshwater using methods that are less energy-intensive and have less impact on the environment, in conjunction with adherence to strict water conservation measures, is preferable for both economic and environmental reasons in most situations.

3. Develop a closer partnership between WSD and DSD

In the Local Yield and Harvested Rainwater sections, we discuss how reservoir balancing and additional harvesting are inefficient methods for increasing Hong Kong's water resources due to their high cost. However, when benefits associated with reduced flooding are considered, the economics of these projects is impacted significantly. When WSD and DSD work together to develop shared solutions, these external benefits can be considered in tandem with benefits to water supply, making projects that are traditionally considered too expensive from the perspective of either department more cost-effective. This approach would also be more in line with the goals put forward in the Hong Kong 2030+ strategy, which considers the city's blue infrastructure in a more holistic way.

4. Increase granularity and transparency of data to improve water supply planning

Currently, seawater flushing is entirely unmetered while freshwater flushing is only metered at the building level. This makes it difficult to accurately determine usage and leakage within the system accurately, as the number of users of each type is unknown. Information provided to users at the household level is therefore incomplete, as this usage must be estimated. Further complicating matters is the lack of timely access to this information, as water bills are only generated once every four months, which makes it difficult for users to quickly notice and respond to leaks, or receive positive feedback about conservation efforts.

Upgrading the network to include broad coverage of smart meters is needed not only to inform WSD how much water is used, but also to increase the awareness of end users, as well as to encourage conservation and accelerate responses to leakages. As long as this data is unavailable, it will be impossible to determine the true efficiency of the system and to compare it with potential alternatives. Billing systems could also be redesigned to include more accurate information and allow for usage comparisons across local areas and with the city average. While the conservation benefits of access to usage data are described in our sister paper, "Conservation and Consumption: Towards a Water-Smart Hong Kong", it would also allow WSD to assess more accurately the volume of flushing water used and would better highlight the economics of seawater flushing versus its alternatives going forward.

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