For discussion
on 19 December 2017

Legislative Council
Panel on Environmental Affairs

Improvement of Water Quality in Hong Kong

PURPOSE

This paper updates Members on the water quality improvement in Hong Kong over the past three decades through a series of actions and programmes including the full commissioning of the Harbour Area Treatment Scheme (HATS) Stage 2A in December 2015, briefs Members on the planned maintenance works by Drainage Services Department (DSD) at the main pumping station of the Stonecutters Island Sewage Treatment Works (SCISTW) under HATS Stage 1 in February 2018 to sustain the long term water quality improvement effort, and seeks Members' views on the initial proposals for further enhancing the quality of coastal waters of Victoria Harbour.

WATER QUALITY IMPROVEMENTS OVER THE PAST 30 YEARS

2. Since the 1980s, the Government has been taking actions to progressively improve Hong Kong's water quality through the implementation of the Sewerage Master Plans (SMPs) in the territory and the enforcement of environmental laws including the Water Pollution Control Ordinance (WPCO). Priorities have been given to protect the gazetted beaches and water gathering grounds, and to provide sewerage and sewage treatment facilities to serve the populated areas around Victoria Harbour and in the New Territories. At present, over 93% of the population in Hong Kong is served by public sewerage facilities, which is among the highest in the world as shown in **Figure 1**. The remaining population relies mainly on private on-site facilities including sewage treatment plants, septic tank and soakaway systems for sewage treatment and disposal.

3. The water quality in Hong Kong has significantly improved over the past three decades. The quality of our marine waters is generally good, with a

relatively high overall Water Quality Objectives (WQOs) compliance rate[1] of 86% recorded in 2016 (see **Figure 2**). Since the commissioning of the advance disinfection facilities (ADF) of HATS in 2010, all 41 gazetted beaches in Hong Kong have achieved the bacteriological WQO (see **Figure 3**) and remain suitable for swimming. In 2016, 18 beaches were rated "Good, Grade 1" while the remaining 23 beaches were graded "Fair, Grade 2" in the annual ranking. The cross-harbour swimming race, resumed since 2011, has been moved to the legendary route in Central Harbour in October this year as a result of further water quality improvement achieved by commissioning of HATS Stage 2A. Detailed information of the marine, river and beach water quality is published in their respective annual reports available on the website[2] of the Environmental Protection Department (EPD).

4. Tolo Harbour is another coastal water body that has shown significant improvement in water quality. Owing to its specific topographic nature, Tolo Harbour is an enclosed water body which had been suffering from serious pollution in the 1970s. To tackle the water pollution problems, the Government implemented the Tolo Harbour Action Plan (THAP) in 1980s, including the implementation of the WPCO and the Livestock Waste Control Scheme (LWCS), the provision of sewerage facilities, upgrading of the Sha Tin and Tai Po Sewage Treatment Works (STWs), and the export of the treated effluent from these two STWs to Victoria Harbour for better dispersive discharge. Since then, the water quality of Tolo Harbour has significantly improved. The nutrients (i.e. nitrogen and phosphorus) levels have greatly reduced and the number of red tides has substantially decreased from the record high of 43 in 1988 to 4 in 2016 (**Figure 4**).

5. Remarkable improvements of river water quality have also been observed over the past 30 years. In terms of the grading based on the Water Quality Index (WQI)[3], 84% of our rivers were graded as "Excellent" or "Good" in 2016, compared with only 26% in 1987 (**Figures 5 and 6**). The remaining few rivers rated "Fair" or "Bad" are mainly located in the Yuen Long and Kam

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[1] The overall WQO compliance rate is calculated based on the individual compliance rates for the four key numeric parameters including dissolved oxygen (DO), total inorganic nitrogen (TIN), unionised ammonia nitrogen (UIA) and *E. coli* bacteria, whichever are applicable to specific Water Control Zones (WCZs). The individual compliance rates for the four key parameters, namely DO, TIN, UIA and *E. coli* bacteria are 93%, 59%, 100% and 100% respectively in 2016.

[2] Annual Marine Water Quality Reports (http://wqrc.epd.gov.hk/en/water-quality/marine-2.aspx); Annual River Water Quality Reports (http://wqrc.epd.gov.hk/en/water-quality/river-2.aspx); and Annual Beach Water Quality Reports (http://www.beachwq.gov.hk/en/report.aspx).

[3] The Water Quality Index (WQI), developed by the Ministry of Transport and Public Works in The Netherlands, uses three key parameters dissolved oxygen, 5-day biochemical oxygen demand, and ammonia-nitrogen to provide a simple and clear index for assessing and rating a river's level of organic pollution and its ability to support aquatic life.

Tin areas where residual pollution load is largely contributed by unsewered villages. The Government is now carrying out a review of the local sewerage programme with a view to developing an action plan to further improve the water quality in the above areas. Options including the provision of sewerage facilities for unsewered villages and possible installation of dry weather flow interceptors (DWFIs) where appropriate. Livestock farms are another key source of pollution in the above areas. In addition to stepping up enforcement effect against illegal discharges, measures to support the livestock farmers to improve their on-farm waste treatment system are being explored. Apart from engineering solution options, the EPD has been collaborating with the Agriculture, Fisheries and Conservation Department (AFCD) in undertaking education programmes and enforcement actions to tackle the pollution problems arising from livestock farms.

6. Shing Mun River was heavily polluted for decades leading to serious local concerns on odour and water pollution in the past few decades. The Government has taken a series of actions to improve its water quality, including the provision of village sewerage and DWFIs, the implementation of the LWCS, and the rectification of expedient connections and bioremediation of river sediments. Shing Mun Main Channel first achieved "Excellent" water quality in 2005 and has maintained this grading since 2008. In 2016, the overall WQOs compliance rate of Shing Mun River was 93%, which was considered satisfactory bearing in mind its main channel is used for secondary contact recreation activities (such as rowing and canoeing in Hong Kong) rather than swimming. We will make reference to the success in Shing Mun River for planning the improvement works for other major rivers, such as Tuen Mun, Yuen Long and Kam Tin Rivers.

HARBOUR AREA TREATMENT SCHEME (HATS)

Developments and Benefits

7. HATS, formerly known as the Strategic Sewage Disposal Scheme (SSDS), was launched in late 1980s to improve the water quality of Victoria Harbour. Being the largest sewerage infrastructure project in Hong Kong, HATS was implemented in two stages (see **Figure 7**). With the gradual commissioning of HATS Stage 1 in December 2001, all sewage generated in Kowloon (from Tsuen Wan to Tseung Kwan O) and Chai Wan and Shau Kei Wan was conveyed to the SCISTW through deep tunnels for chemically-enhanced primary treatment (CEPT).

8. HATS Stage 2A consists of the construction of deep tunnels to collect

the remaining sewage from the Hong Kong Island (i.e. from North Point to Ap Lei Chau) to the expanded SCISTW for centralised treatment. With the commissioning of ADF in March 2010 and the full commissioning of HATS Stage 2A in December 2015, all sewage generated from both sides of Victoria Harbour is now conveyed to the SCISTW for centralised CEPT and disinfection before discharging to the western harbour waters.

9. When comparing the situation in 2016 to that before HATS (1997-2001), the commissioning of HATS has resulted in marked water quality improvement in Victoria Harbour, with an overall 14% increase in dissolved oxygen (DO). There has also been a substantial reduction of pollutants, including a 93% decrease in *E. coli*, 56% decrease in unionised ammonia nitrogen (UIA) and 14% decrease in total inorganic nitrogen (TIN), as shown in **Figure 8**. In 2016, the overall WQOs compliance rate for Victoria Harbour Water Control Zone (VHWCZ)[4] has increased to a historically high rate of 93%, revealing that a satisfactory water quality with the local pollution sources largely reduced. At present, the EPD is conducting a post-project monitoring programme which also covers biological monitoring[5] to assess and ascertain the long-term trend of water quality improvement in Victoria Harbour and neighbouring waters.

10. The implementation of HATS has also enhanced the public enjoyment of Victoria Harbour and the nearby coastal waters. With the ADF put into operation in March 2010, the *E. coli* level in the western part of Victoria Harbour has significantly reduced, and all our gazetted beaches have met the *E. coli* WQO for bathing waters. This has led to the gradual re-opening of all bathing beaches in Tsuen Wan.

11. With the full commissioning of HATS Stage 2A in December 2015, the *E. coli* level in the central harbour area has further reduced by 10 times to an overall annual geometric mean *E. coli* level of around 300 count/100ml in 2016 (i.e. below the WQO of 610 count/100ml for the Secondary Contact Recreation Subzone[6]).

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[4] The overall WQO compliance rate VHWCZ is calculated based on the compliance rates for the key numeric parameters including DO, TIN and UIA applicable to the VHWCZ.

[5] The biological monitoring includes benthic and coral surveys to gauge up-to-date conditions for assessing the impact on and improvements to the ecological resources in Victoria Harbour and neighbouring waters due to the implementation of HATS Stage 2A.

[6] The beneficial uses of Victoria Harbour include mainly navigation and port uses such as anchoring and containers / cargos handling facilities, and typhoon shelters, etc. Hence there is no WQO (annual geometric mean *E. coli* < 610 count / 100mL) of the Secondary Contact Recreation Subzone designated for Victoria Harbour. Nevertheless, we could make reference to this *E. coli* WQO for assessing the improvement made to the water quality and amenity value of the harbour.

Maintenance of HATS Stage 1

12. HATS Stage 1 system has been in round-the-clock operation since its commissioning in December 2001. Like any large-scale sewage treatment plants in Hong Kong or elsewhere, its effectiveness and sustained operation requires suitable maintenance from time to time. Proper and planned maintenance is essential for the effective operation of HATS to sustain the water quality improvement achieved for Victoria Harbour. Without proper and planned maintenance, the sewage treatment system under HATS is highly vulnerable to abrupt disruptions to the plant operation due to equipment failure, resulting in potentially serious suspension of the plant operation with emergency discharges in a much longer duration and larger impact than in the case of a planned maintenance. Based on the overseas[7] and local experiences, planned maintenance is essential and always preferred. Such planned maintenance will be carefully planned, carried out and limited to certain specified time periods in a manner with the least impacts to the environment and human activities.

13. The DSD, which oversees HATS operation, has been providing maintenance to the system to ensure proper system functioning at all times. Among the numerous electrical and mechanical equipment are two large inlet penstocks at the Main Pumping Station No. 1 (MPS1) of the SCISTW installed under HATS Stage 1 that have been operating round the clock continuously for over 16 years without cessation. These penstocks serve as inlet gates at the points where the two sewage conveyance tunnels, one from the Kwai Chung and Tsing Yi Preliminary Treatment Works (PTWs) and the other from the Chai Wan, Shau Kei Wan, Tseung Kwan O, Kwun Tong and To Kwa Wan PTWs, connect to MPS1[8]. The two penstocks are approaching the end of their design life. It is essential for the DSD to carry out proper maintenance and replacement now before there is any technical failure which may lead to irrevocable damage to the HATS systems and long-term adverse impact on the water quality of Victoria Harbour.

14. Knowing the potential risk, the DSD has been very keen to undertake

[7] For instance, there was a planned maintenance of a major sewage treatment plant in New Zealand with screened bypass discharge for six weeks for plant improvement. There were emergency discharges from sewage treatment plants in Sydney of Australia, Toronto of Canada, and Seattle of the US on various occasions, with larger impacts due to screened bypass.

[8] HATS Stage 1 system also includes the North West Kowloon PTW which is connected to the SCISTW separately and thus its normal operation will not be affected by the planned maintenance to MPS1 described here.

maintenance and replacement work of these penstocks like other parts of HATS Stage 1 systems. However, given the unique functions, large scale and deep location of these penstocks, it is impossible to maintain and replace these two penstocks under normal HATS system operation because such maintenance works will require flow stoppage to MPS1, necessitating prolonged screened sewage bypass of around 28 weeks at the aforementioned seven upstream HATS Stage 1 PTWs. To address this issue, the DSD deliberately planned and built under HATS Stage 2A, an additional pumping station - Main Pumping Station No. 2 (MPS2) - among other facilities, and an interconnection tunnel between MPS1 and MPS2. With the benefit of the completion of the structure in January 2017, HATS Stage 1 flows arriving at MPS1 can now be further conveyed to MPS2 for pumping and treatment in the SCISTW. This in turn allows the DSD to trigger the plan to replace the two aforementioned MPS1 penstocks without prolonged screened sewage bypass in the seven upstream HATS Stage 1 PTWs. Nonetheless, short-term bypass of screened sewage at the seven PTWs, the majority of which through the existing submarine outfalls[9], is still necessary to ensure works safety of workers therein and for the necessary setting-up arrangement. Such bypass will not affect the flows relating to the Northwest Kowloon PTW or HATS Stage 2A, which will continue to be treated properly before discharge. During the bypass period, the properly treated sewage will be about 45% whereas the bypassed screened sewage flow will be 55% of the total flow. The short-term bypass is expected to be limited to five occasions, each lasting up to two weeks, in three consecutive dry seasons. Compared to the normal maintenance works without the interconnection tunnel, the duration and scale of this planned screened sewage bypass will be much reduced[10]. The conditions of the penstocks and proposed sequencing of penstock replacement works / sewage bypass are set out at **Annex**.

15. To ensure the proper functioning of the HATS system and reduce the impacts of the maintenance works, we plan to replace the two penstocks in the earliest dry season in accordance with the bypass mechanism as specified in the HATS Discharge Licence. The first bypass episode is scheduled for February 2018, then November 2018, February 2019, November 2019, with the last one scheduled for February 2020. We have deliberately planned to conduct the bypass in dry seasons when the gazetted beaches are less patronised and the

[9] The screened sewage bypass at Kwai Chung PTW will take place through the seawall outfall as its 40-year-old submarine outfall was demolished as part of the dredging works approved by the Finance Committee in 2013 to suit the design sea-bed level of 17.5 m below Chart Datum to enable ultra large container ships to navigate in and out the Kwai Tsing Container Terminals at all tides (see paper PWSC(2013-14)22) . The bypass at the other 6 HATS 1 PTWs will be discharged via existing submarine outfalls.

[10] Before the completion of the interconnection channel under HATS 2A, replacement works will necessitate bypass for about 28 weeks.

sewage flow is on the low side, which would help reduce the volume of screened bypass flow into the Harbour. We will review the implementation arrangement and the effectiveness of the measures after the first bypass to determine any further enhancement measures necessary to minimise the impacts, the detailed arrangements and the exact timing for the second bypass; and will keep reviewing the works arrangement as and when the maintenance works proceed. We will also endeavor to reduce the number of bypass episodes and their duration if and where practicable.

16. The potential water quality impact of the proposed two-week screened sewage bypass has been assessed through detailed water quality modeling by an independent consultant, which indicates that during the five bypass periods, the geometric mean of *E. coli* levels at the identified water sensitive receivers of beaches and fish culture zones are all below 610 count/100ml[11]. The modeling also predicted that the potential impact on water quality would be short-term and reversible, which would resume normal within a few days after each bypass.

17. During each bypass episode, we would closely monitor the water quality, particularly the resulting levels of DO, suspended solids, turbidity, pH and *E. coli*. Daily water quality monitoring will be carried out at sensitive receivers including gazetted beaches, fish culture zones, seawater intakes, coral sites, etc. to gauge the water quality. The most up-to-date monitoring results will be uploaded to the DSD's website on a daily basis or as early as practicable since some analyses like microbial tests[12] might take some time to complete.

18. Detailed contingency plans have been devised to handle various anticipated and unforeseeable situations. For instance, the Water Supplies Department (WSD) will increase disinfectant dosage at sea water intakes and the Leisure and Cultural Services Department (LCSD) will close the affected beaches[13] if needed. The DSD will timely intensify the water quality sampling and analyses at any specific locations of concern identified from the water quality monitoring programme with a view to implementing urgent follow-up actions as appropriate.

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[11] As the screened sewage bypass will be conducted in the dry season which is the non-bathing season, there is no applicable *E. coli* standard. For ease of reference, the *E. coli* geometric mean level used to determine the suitability of water quality for swimming (i.e. not exceeding 610 count/100 mL) is referenced here.

[12] It normally takes about 48 hours for reports of microbial analysis of *E. coli* samples to become available and hence the information uploaded will be slightly delayed.

[13] The bypass will take place during the non-bathing dry season, thus avoiding the bathing season. While the beaches would normally be opened in April each year after the bypass has been completed, there may still be some swimmers using the beaches in the dry season.

19. We will also put up notices at prominent locations of the gazetted beaches and promenades close to sewage bypass outfalls/points to alert the public. The EPD and DSD will maintain very close liaison with relevant Government departments, including the AFCD, the Electrical and Mechanical Services Department, the Home Affairs Department, the LCSD, the Marine Department and the WSD, throughout each bypass period to ensure that the impacts to the community would be closely monitored, and minimised.

FURTHER ENHANCING QUALITY OF COASTAL WATERS OF VICTORIA HARBOUR

20. At the meeting of Panel on Environmental Affairs on 24 November 2014, Members supported our proposal to conduct a consultancy study to further enhance the quality of coastal waters of Victoria Harbour (LC Paper No. CB(1)245/14-15(05)). We have subsequently appointed a consultant in January 2016 to carry out the study on "Further enhancing quality of coastal waters of Victoria Harbour" (the Study). The consultant was tasked to conduct field surveys, evidence-based reviews and data analyses to develop targeted pollution control measures and engineering solutions to reduce near shore water pollution, as well as to resolve odour and aesthetic problems on both sides of the Harbour.

21. The Study has preliminarily confirmed that the pollution problems along the Harbour were mostly related to discharge of polluted water through storm water outfalls. The Study has so far surveyed about 250 storm water outfalls and 4 000 storm water manholes to map out and isolate the focus areas of pollution. High levels of organic pollutants and *E. coli*, probably attributed to contamination due to misconnections of foul sewers with storm drainage pipes and non-point sources (e.g. leakage from ageing sewers, street activities and cleansing of public places) were observed in about 4% of the manholes surveyed (see **Figure 9**). While the Study will continue to survey more catchments, the information has been shared with relevant Government departments for prompt and parallel follow-up actions.

22. The Study recognised that misconnections which are usually associated with building or public sewer repair and maintenance works would happen from time to time, particularly in the developed coastal areas where there are numerous old buildings with aging sewers and drainage pipes that would undergo repair and maintenance works in coming years. Government departments are working earnestly to identify these misconnections for rectification and prevent them from happening. Nevertheless, this on-going

effort through enforcement and public education would not be able to eliminate their re-occurrence entirely; and non-point source pollution to the storm water systems will continue to affect the coastal water quality. The Study has therefore recommended a number of engineering solutions including the diversion of some of the polluted storm water away from the sensitive residential / recreational harbourfront areas, and the provision of compact and high efficiency DWFIs or gross pollutant traps near the storm water outfalls or at other strategic locations. To take forward these recommendations, the Study has, based on the survey findings, proposed 10 priority areas for implementing DWFIs (see **Figure 10**). With funding approval from the Finance Committee of the Legislative Council in July 2017, we already commenced the construction of DWFIs upstream of some of the outfalls in four of these areas (namely, Tsuen Wan Bay, Cheung Sha Wan, Tai Kok Tsui, and New Yau Ma Tei Typhoon Shelter) this year. We would further engage relevant departments to look into the feasibility of implementing the storm water diversion / compact DWFI options for the outfalls at another two priority areas at Hung Hom and Wan Chai East, and conduct a trial of the gross pollutant trap at Kowloon City in 2018. Whenever we could locate suitable sites, we would implement these solutions in other priority locations as soon as practicable.

23. In parallel, the EPD and the DSD have joined hands in launching a major territorial wide sewer rehabilitation programme to rectify the leakage problem of aged and broken sewers. With funding approval from the Finance Committee of the Legislative Council in July 2017, the rehabilitation works for 2 kilometres (km) of badly worn sewers in Ngau Chi Wan, To Kwa Wan, Shatin and Sai Kung will commence soon. We will submit another two funding applications in 2018 for a $800 million project to overhaul 4.5km of sewage culvert in Tuen Mun and a $400 million project to rehabilitate a further 7km of sewers throughout Hong Kong that are in desperate need of repair. We would also collaborate with local research institutes to develop odour reduction measures for storm water systems and conduct trials on new methods to desilt sediments to minimise their accumulation and contamination by polluted water.

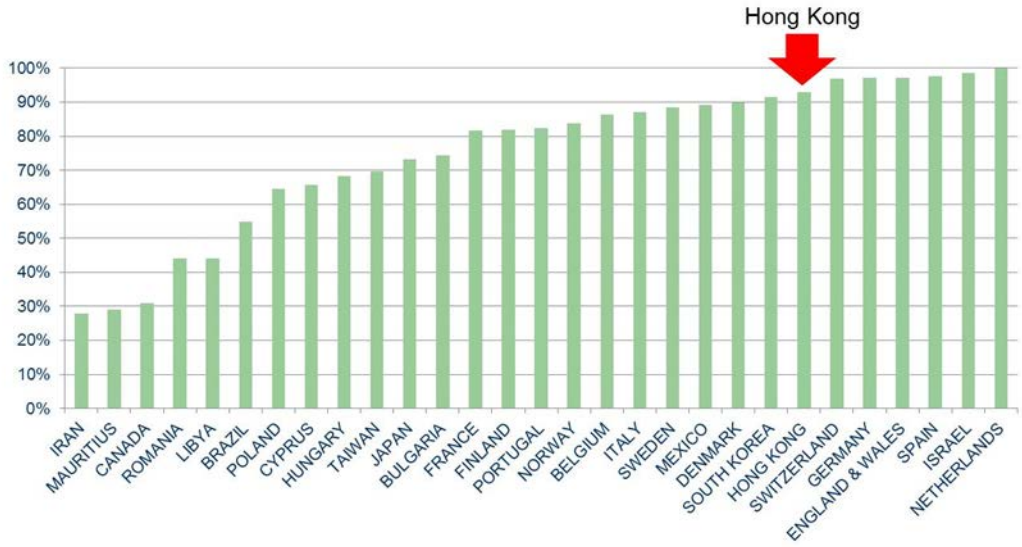
24. We consulted the Advisory Council on the Environment on 4 December 2017. Members recognised the improvements made and proposed measures to further enhance the water quality of Victoria Harbour. They also supported the planned maintenance works at the MPS1 of the SCISTW and suggested the Government proactively and timely disclose the monitoring information on water quality during the bypass periods to the public so that they could become more vigilant. As indicated above, we will disclose timely monitoring information to the public through DSD's website and will also put up prominent notices at relevant locations.

ADVICE SOUGHT

25. Members are invited to note and give views on the progress made in improving the water quality of Victoria Harbour, the planned maintenance works of the main pumping station of the SCISTW under HATS Stage 1, and the initial proposals for further enhancing the quality of coastal waters of Victoria Harbour.

Environment Bureau
Drainage Services Department
December 2017

Figure 1 International Sewerage Connection Rate



Source of Information: *International Statistics for Water Services*. International Water Association 2014

Figure 2 Compliance Rate of Marine Water Quality Objectives

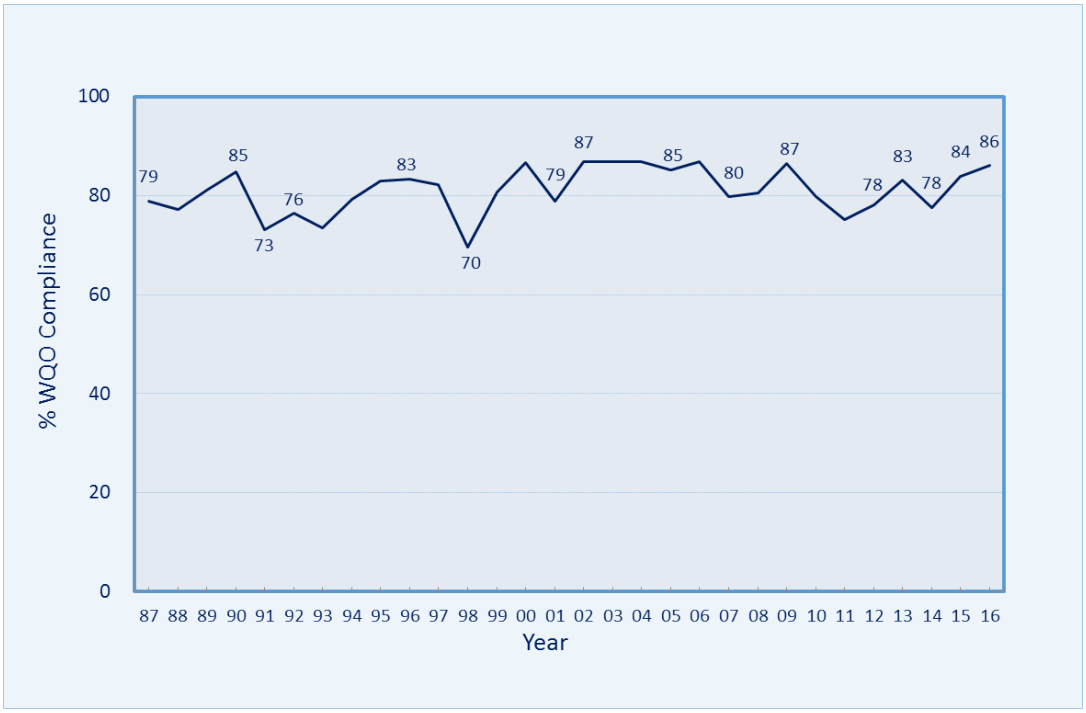


Figure 3 Beach Water Quality (1987 – 2016)

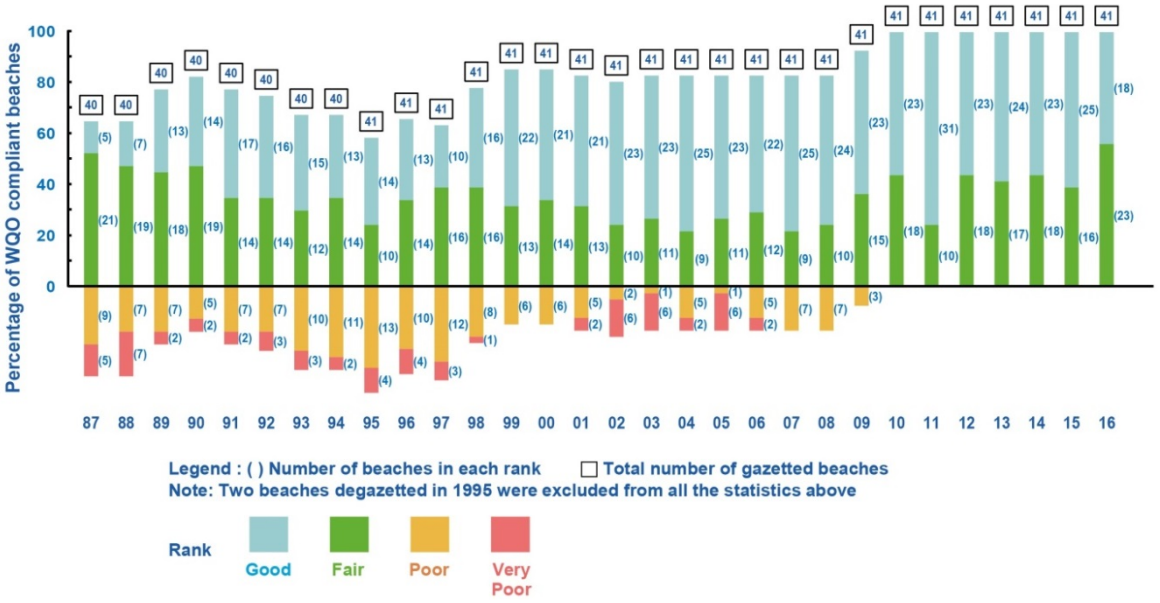


Figure 4 Reductions in total inorganic nitrogen (TIN), orthophosphate phosphorus (PO_4-P) levels and red tide occurrence in Tolo Harbour since the implementation of the Tolo Harbour Action Plan

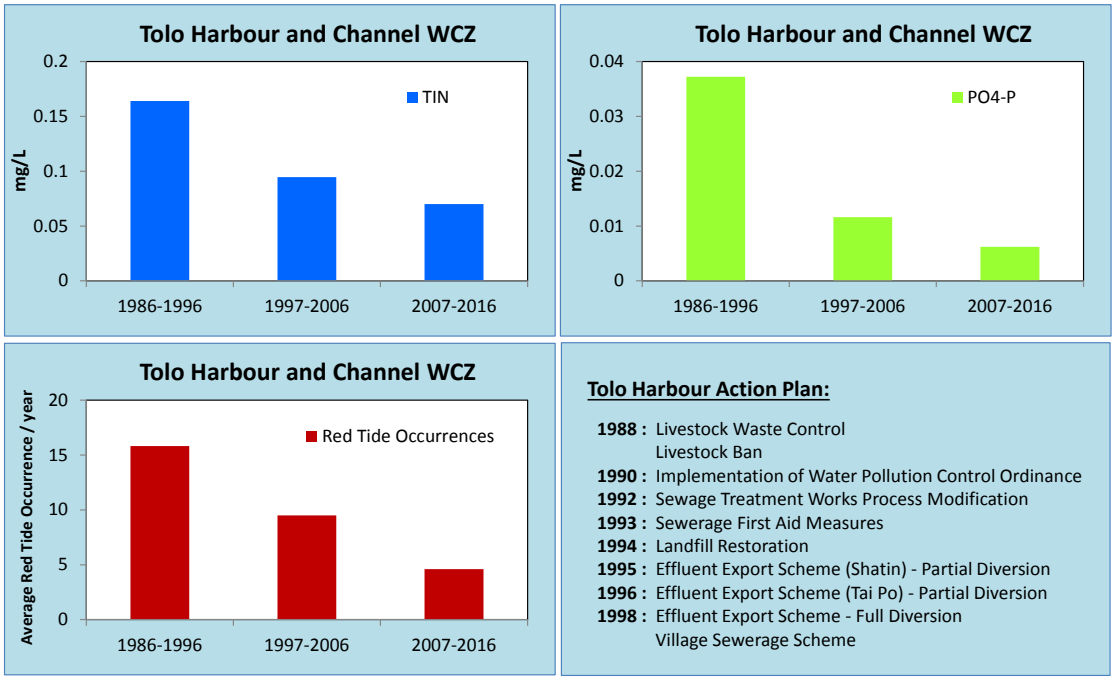


Figure 5 Water Quality Index Gradings of Rivers (1987 – 2016)

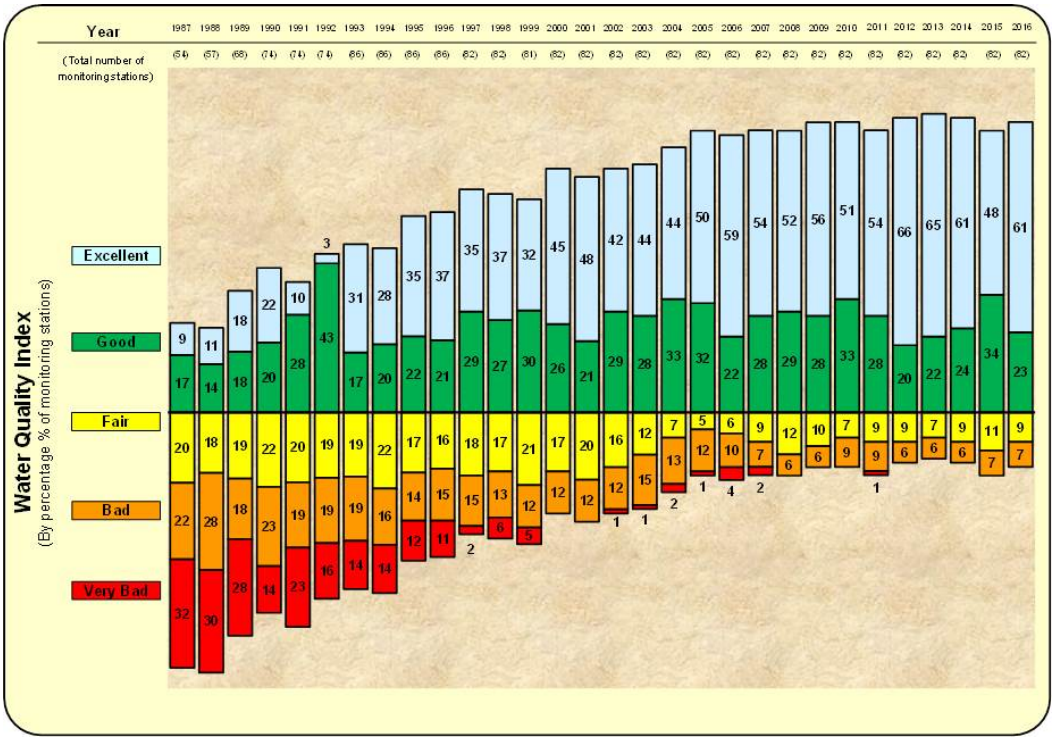


Figure 6a Water Quality Index Grading of Rivers in 2016

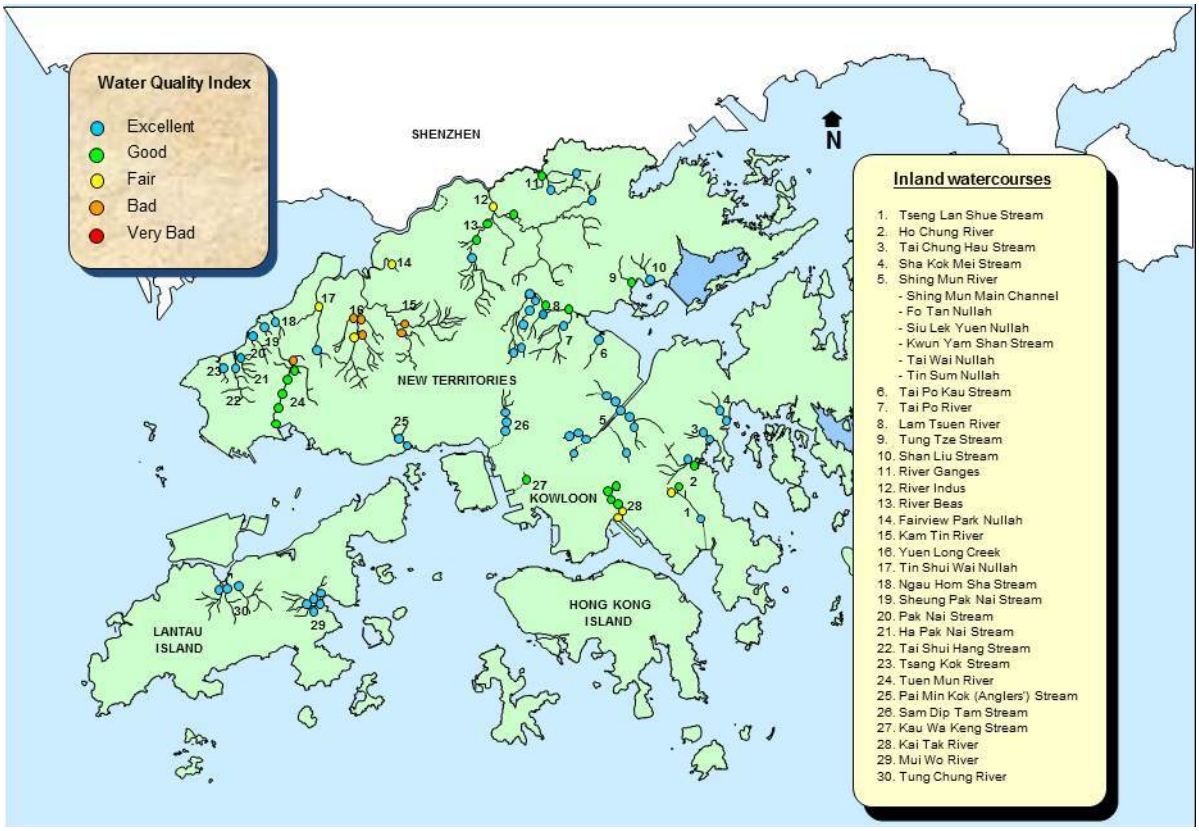


Figure 6b Water Quality Index Gradings of Rivers in 1987

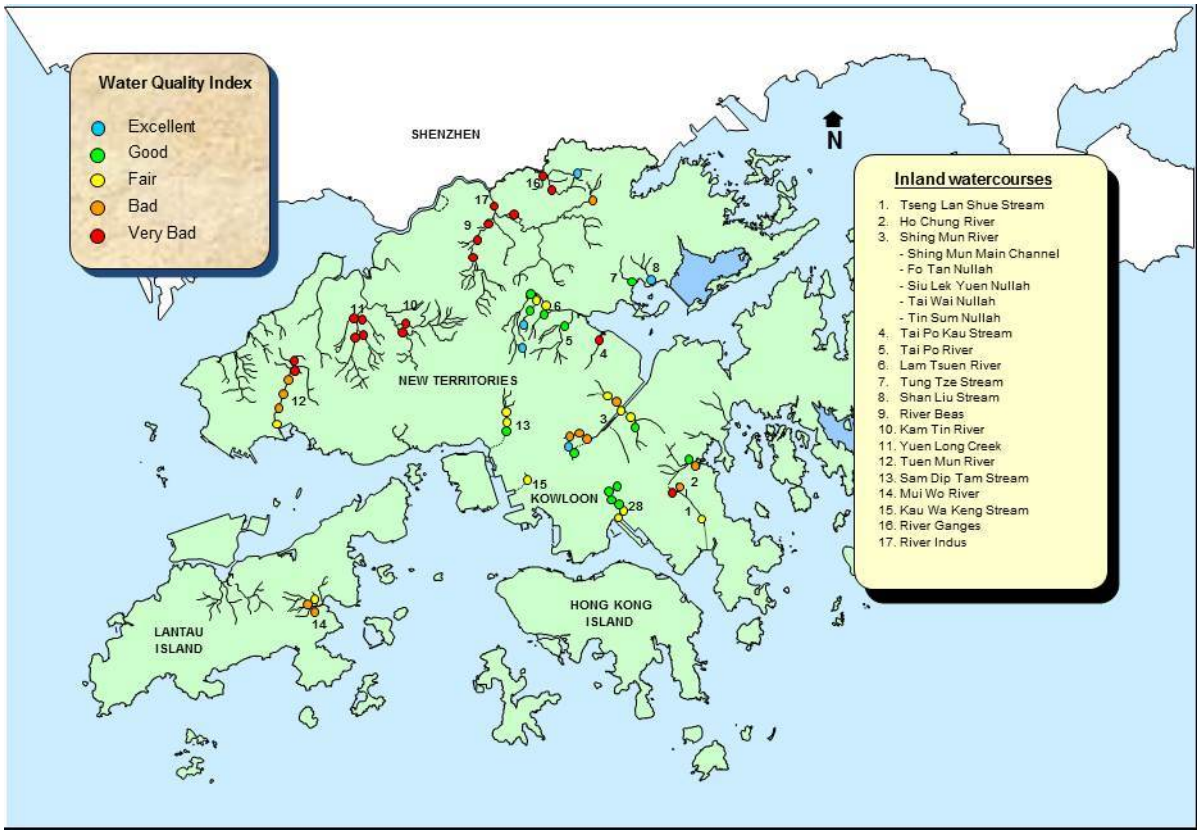


Figure 7 Harbour Area Treatment Scheme

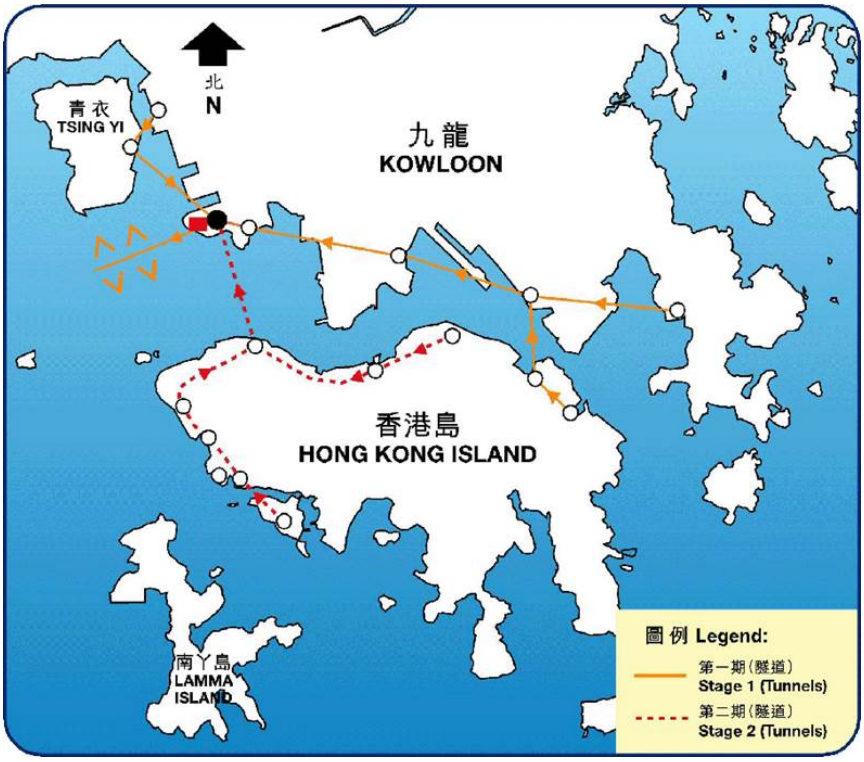
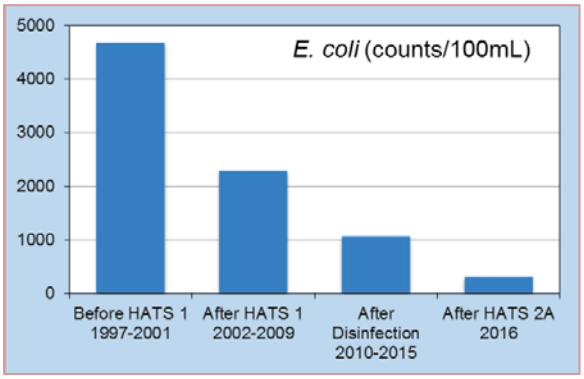
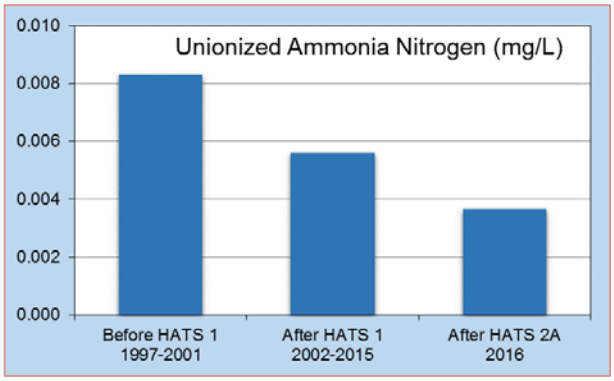


Figure 8 Reduction of *E. coli*, unionised ammonia nitrogen and total inorganic nitrogen levels in Victoria Harbour as brought by the progressive implementation of HATS





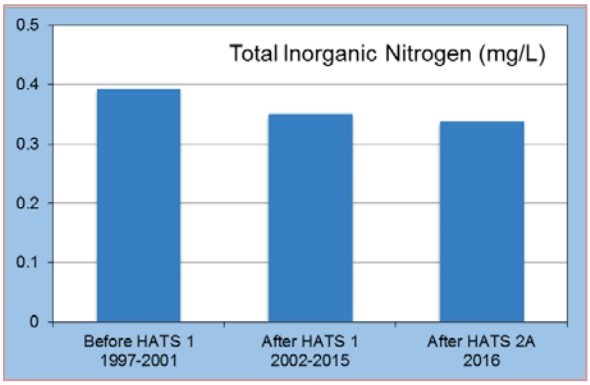


Figure 9 Distribution of storm water manholes with high levels of organic pollutants and *E.coli*

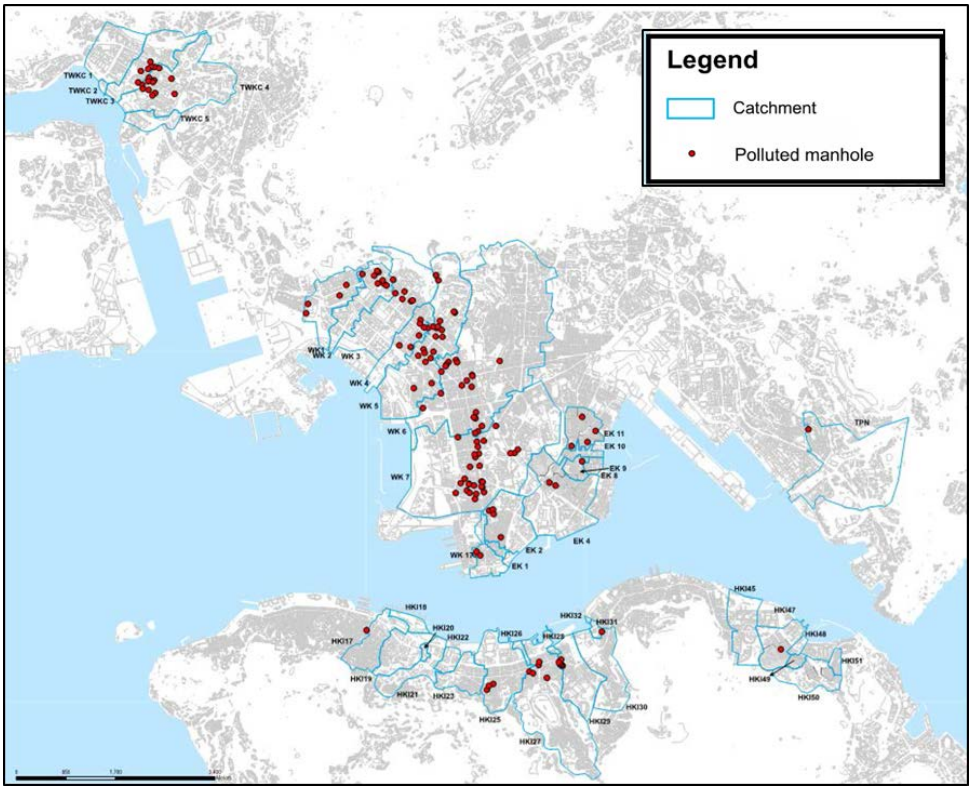
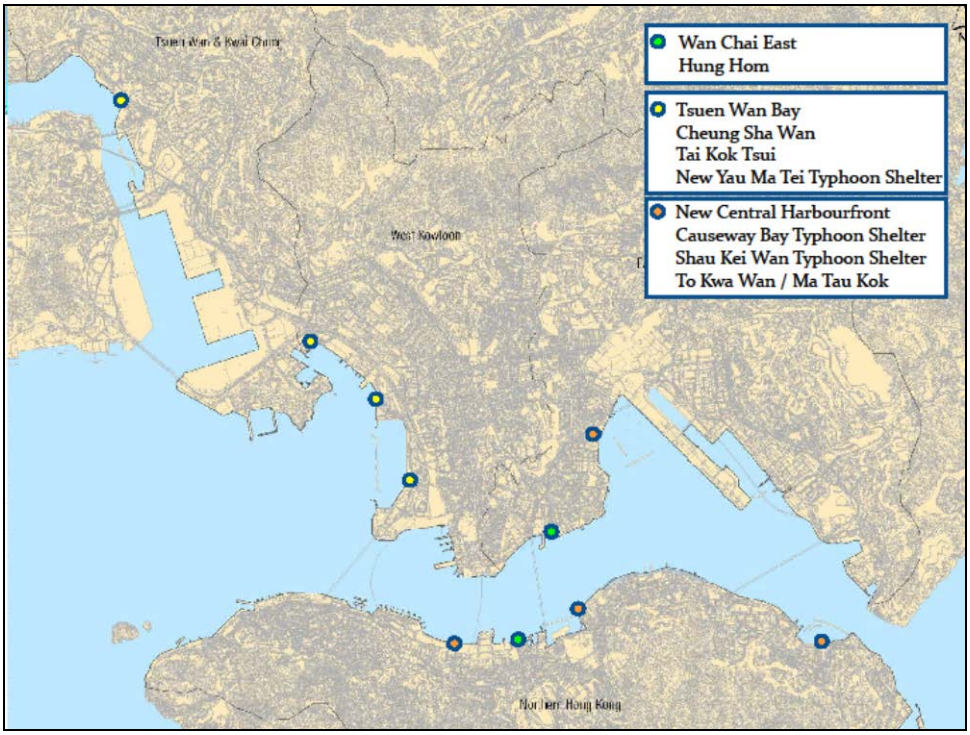


Figure 10 Location of priority areas for implementing DWFIs



Annex

Penstock Replacement Works in Main Pumping Station No. 1 of the Stonecutters Island Sewage Treatment Works under HATS Stage 1

Location of the Two Penstocks

Main Pumping Station No.1 (MPS1), including the two penstocks to be replaced, has been in use since 2001. The wet well of MPS1 is a very large structure with an internal dimension of 50 metres (m) in diameter and 45m in height. The penstocks are situated 34m below ground level, and of considerable size – one of 4.4m(H) x 2.6m(W); and the other of 4.2m(H) x 1.4m(W). They are located at the points where sewage enters MPS1, one on the side of the deep tunnel from the To Kwa Wan, Kwun Tong, Tseung Kwan O, Shau Kei Wan, Chai Wan Preliminary Treatment Works (PTWs), and the other on the side of the deep tunnel from Tsing Yi and Kwai Chung PTWs (see **Figure A**).

Present Conditions of the Two Penstocks

2. Completion of the interconnection tunnel between MPS1 and Main Pumping Station No. 2 (MPS2) in January 2017 allows the sewage level in MPS1 to be drawn down to permit closed-circuit television (CCTV) inspection of the top part of the two penstocks of MPS1. The survey was conducted in March 2017 and revealed that the two penstocks and their supporting spindles are corroding very severely and have serious operation problem with possible breakdown. If the penstocks drop shut due to spindles failure, screened sewage from the HATS Stage 1 catchment entering the MPS1 will be stopped immediately. This will in turn lead to unplanned and prolonged bypass of screened sewage into Victoria Harbour at the seven upstream Preliminary Treatment Works (PTWs) at Kwai Chung, Tsing Yi, Chai Wan, Shau Kei Wan, Tseung Kwan O, Kwun Tong, and To Kwa Wan.

Works Sequence for Penstock Replacement and Schedule of Sewage Bypass

3. Access to the two penstocks, located at a considerable depth of 34m from ground level, has to be gained via the wet well of MPS1 which, after the incoming sewage is bypassed, will be a deep confined space hitherto filled with sewage, necessitating comprehensive safety measures before and throughout the implementation of any works inside.

4. The penstock replacement works are scheduled to take place in dry seasons. On works safety grounds and taking into account equipment manufacturing time, the works will comprise a number of steps, during which screened sewage bypass at the aforementioned seven upstream PTWs will be required in five occasions, each lasting up to two weeks. Detailed works sequencing of the penstocks replacement works is tabulated below (**Table 1**). The discharge locations are shown in the **Figure A**.

5. Maintenance works mainly comprise three steps. Step 1 is for man entry for temporary stabilization of the existing penstocks and detailed survey of the existing conditions for the production of two temporary bulkheads, one for each penstock. Step 2 is for man entry for removal of the existing penstocks. Such works will take an estimated duration of up to 12 weeks. To allow them to proceed without prolonged screened sewage bypass, temporary bulkheads have to be installed before the works proceed at the beginning of the dry season (i.e. November 2018), after which HATS Stage 1 sewage arriving at MPS1 will be conveyed onwards by an interconnection tunnel to MPS2 for pumping and treatment (see **Figure B**). After completion of the penstock removal works close to the end of the dry season (i.e. February 2019), the temporary bulkheads will be removed in preparation for the wet season. With such temporary bulkhead arrangement, screened sewage bypass in this Step will be limited to two episodes of durations up to two weeks each. Step 3 involves essentially the same works process as Step 2 except that it is for the installation of the new penstocks, which will be completed in February 2020.

Table 1 Works Sequence for Penstock Replacement at MPS1

Step	Start time	Activity and Purpose	Sewage flows from the 7 HATS Stage 1 PTWs [1]		Reference Figures
1	February 2018	• Install temporary support to the existing penstocks • Conduct detailed survey for temporary bulkhead production	Bypass (2 weeks)		Figure C
2A	Early November 2018	• Install temporary bulkheads to seal off MPS1	Bypass (2 weeks)		Figure D
2B	Mid November 2018	• Remove existing penstocks		Handled by MPS2 [2] (12 weeks)	Figure D
2C	Mid February 2019	• Remove temporary bulkheads • MPS1 resume normal functioning	Bypass (2 weeks)		Figure D
3A	Early November 2019	• Install temporary bulkheads to seal off MPS1	Bypass (2 weeks)		Figure E
3B	Mid November 2019	• Install new penstocks		Handled by MPS2 [2] (12 weeks)	Figure E
3C	Mid February 2020	• Remove temporary bulkheads • MPS1 resume normal functioning	Bypass (2 weeks)		Figure E

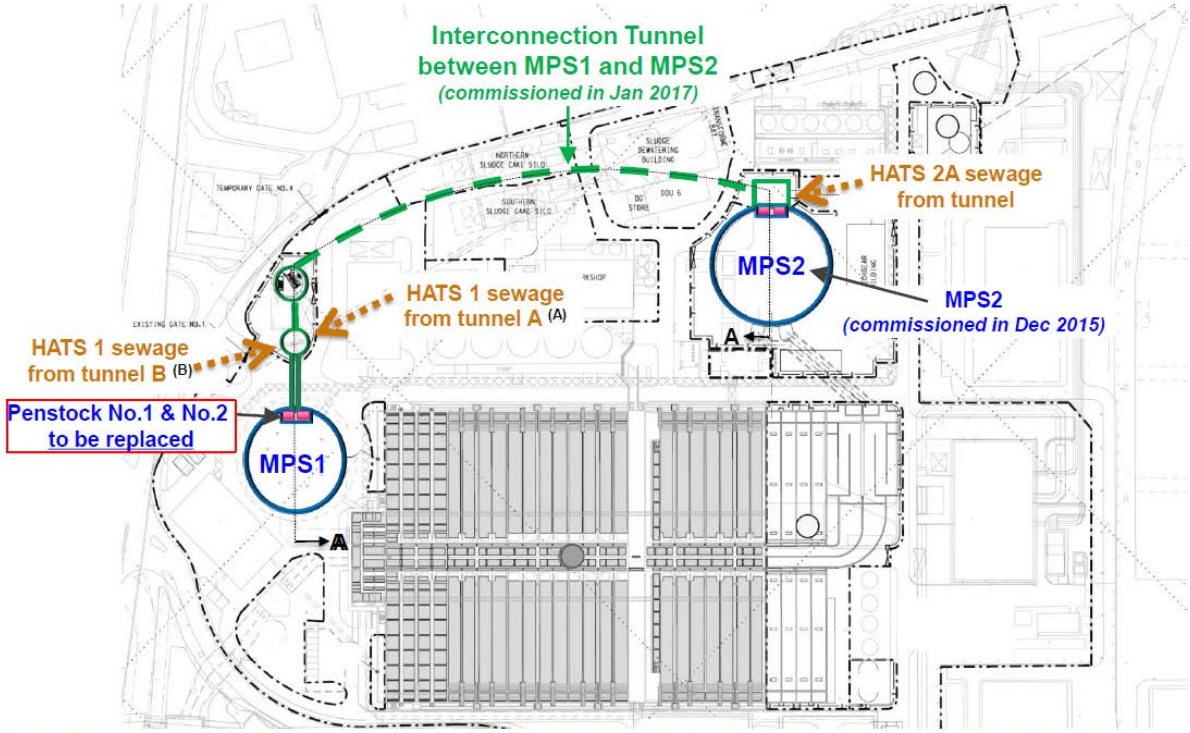
[1] The seven PTWs are Kwai Chung, Tsing Yi, Chai Wan, Shau Kei Wan, Tseung Kwan O, Kwun Tong and To Kwa Wan PTWs

[2] Flows arriving at MPS1 will be conveyed onwards by the interconnection tunnel to MPS2 for pumping and subsequent treatment.

Figure A Proposed Two-week Sewage Bypass at Seven PTWs of HATS Stage 1

Submarine Outfall Discharge Point	Distance from coast	Depth below sea level
Tsing Yi	200m	17m
To Kwa Wan	950m	12.5m
Kwun Tong	1200m	16m
Shau Kei Wan	400m	41m
Tseung Kwan O	900m from TKO 400m from Chai Wan	19.5m
Chai Wan	500m	15.5m

Figure B MPS1, MPS2 and the Interconnection Tunnel in the SCISTW



Note: (A) Sewage from Chai Wan PTW, Shau Kei Wan PTW, Tseung Kwan O PTW, Kwun Tong PTW and To Kwa Wan PTW

(B) Sewage from Kwai Chung PTW and Tsing Yi PTW

Figure C Works Sequence – Step 1 (Feb 2018)

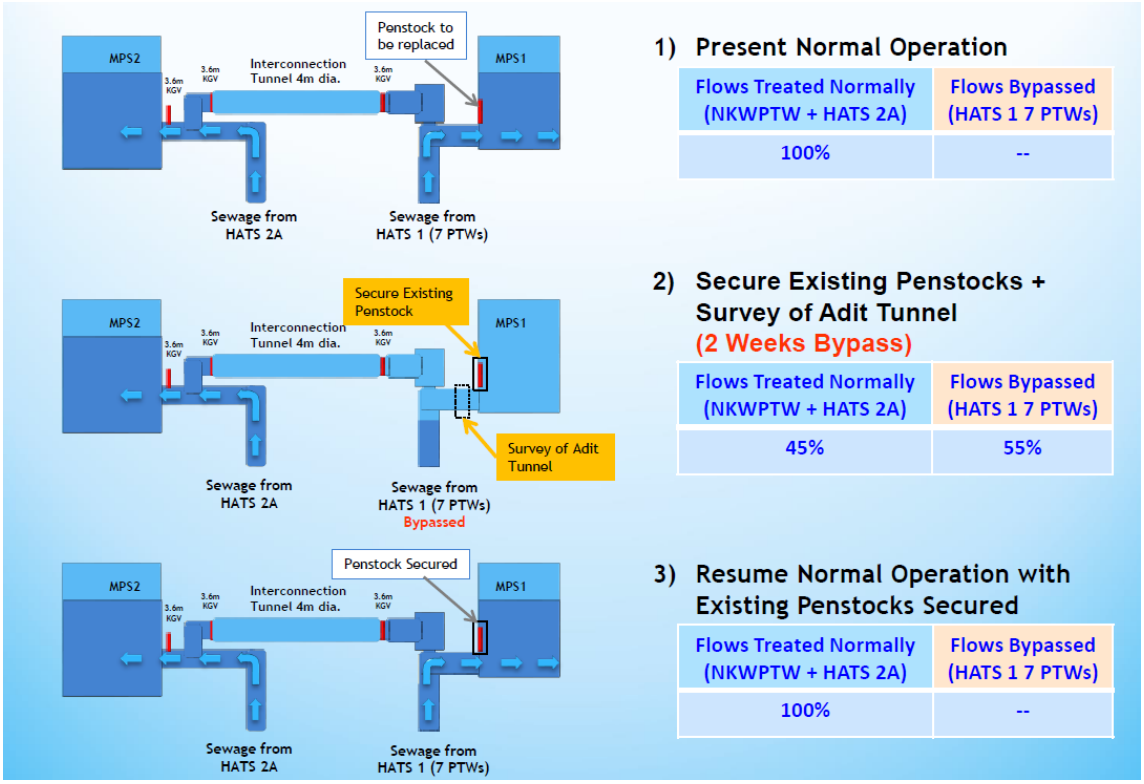


Figure D Works Sequence – Step 2 (2018/19 Dry Season)

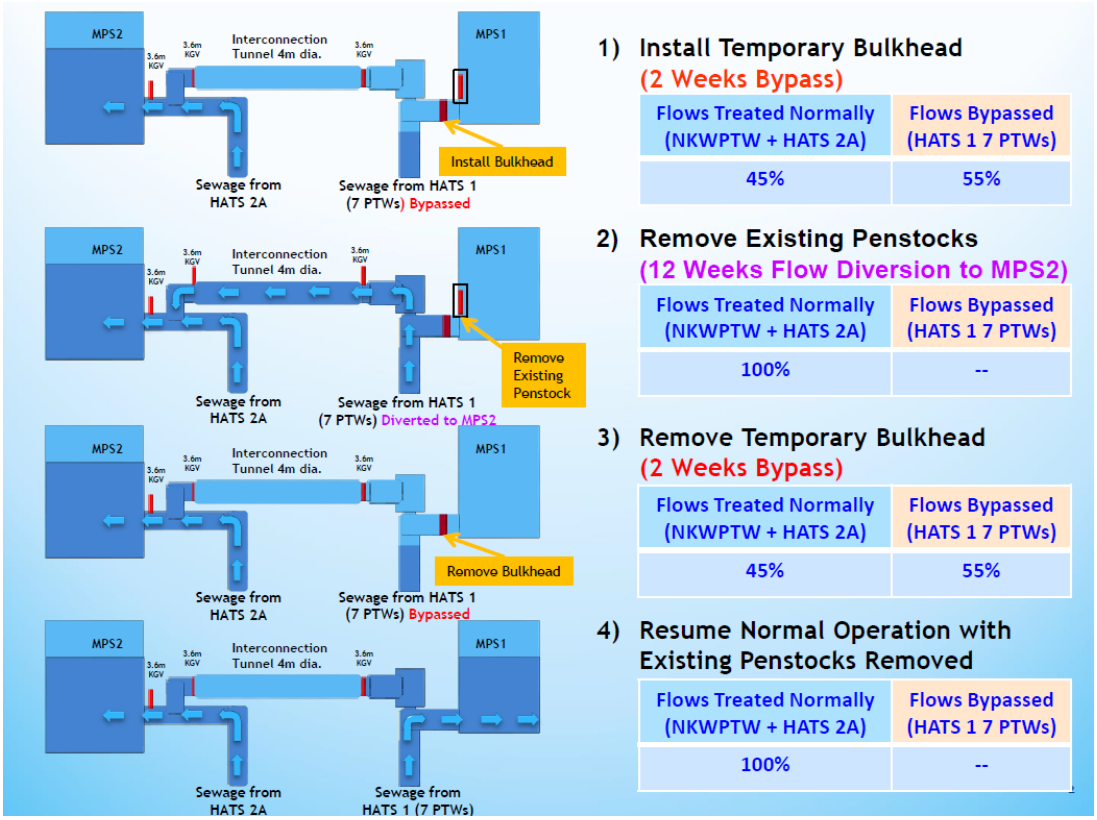


Figure E Works Sequence – Step 3 (2019/20 Dry Season)