CHAPTER 5

Development Bureau
Water Supplies Department

Management of flushing water supply

Audit Commission
Hong Kong
30 November 2021

This audit review was carried out under a set of guidelines tabled in the Provisional Legislative Council by the Chairman of the Public Accounts Committee on 11 February 1998. The guidelines were agreed between the Public Accounts Committee and the Director of Audit and accepted by the Government of the Hong Kong Special Administrative Region.

Report No. 77 of the Director of Audit contains 8 Chapters which are available on our website at https://www.aud.gov.hk

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MANAGEMENT OF FLUSHING WATER SUPPLY

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MANAGEMENT OF FLUSHING WATER SUPPLY

Executive Summary

1. Hong Kong is the world's first city to systematically utilise seawater for flushing and, up till now, is one of the few places in the world extensively applying seawater for flushing. The use of seawater, a sustainable water resource, plays an important role in Hong Kong's water resources management. In the late 1950s, seawater flushing was introduced in Hong Kong in view of the then acute shortage of fresh water for potable use and to conserve fresh water. Seawater supply systems were then added one after another, extending the seawater supply network for flushing in Hong Kong.

2. Since 1965, all new buildings have been required to be installed with dual plumbing systems for potable and flushing water. According to the Waterworks Regulations (Cap. 102A), the Water Authority, who is the Director of Water Supplies (for simplicity, the Water Authority is referred to as the Water Supplies Department (WSD) in this Audit Report), may require the use of salt water for flushing. For areas without seawater supply at the moment, as an interim measure, WSD would approve the use of temporary mains fresh water for flushing (TMF). Seawater for flushing is supplied free of charge while the use of fresh water for flushing may be subject to charge depending on usage.

3. WSD is responsible for operation and maintenance of the seawater supply systems (consisting of 42 pumping stations, 54 salt water service reservoirs (SWSRs) and 1,660 kilometres of salt water mains as of March 2021). In 2020-21, the total operating and administration expenses (including depreciation but excluding staff cost) related to flushing water supply was about $976 million. The seawater supply network for flushing currently covers about 85% of the population in Hong Kong. WSD targets at expanding the network coverage of using lower grade water (i.e. seawater and recycled water) for flushing from 85% of the total population to 90% in the long run in order to further reduce the fresh water demand for flushing.

The Audit Commission (Audit) has recently conducted a review to examine WSD's work in managing flushing water supply.

Management of projects for extension of seawater supply network

4. The latest extension of seawater supply network involved two areas, namely Pok Fu Lam and Northwest New Territories. The works for these two areas commenced in August 1996 and February 2008 and were substantially completed in July 2013 and March 2015 respectively. As of June 2021, the total project expenditure was $1,380.9 million. Between 1996 and April 2012, WSD awarded 4 contracts (Contracts A to D) and 9 contracts (Contracts E to M) under the projects for extension of seawater supply network in Pok Fu Lam (Projects A to C) and Northwest New Territories (Projects D and E) respectively. The works under the 13 works contracts were supervised by in-house staff of WSD except Contract D for which a consultant (Consultant X) was engaged to supervise the works (paras. 1.11, 2.2 and 2.3).

5. ***Disputes under Contract D.*** Contract D was a lump sum contract covering the construction of 2 SWSRs and 2 salt water pumping stations (SWPSs), and laying of associated salt water mains in Pok Fu Lam. WSD awarded Contract D to Contractor D in September 2009 at $190.7 million. The works commenced in October 2009 and were substantially completed in July 2013. Consultant X was the Engineer responsible for supervising the contract works. There were disputes under Contract D and counterclaims against Consultant X. In June 2015, Contractor D served a Notice of Arbitration in respect of disputes relating to various claims under Contract D. Before the completion of arbitration hearing, WSD and Contractor D agreed to settle various claims (mainly low-value claims) at a total sum of $3.2 million (paid in October 2015 and December 2019). The disputes then proceeded to arbitration hearing in June 2019 and the Arbitrator issued a Partial Award which covered all the claims except interest and legal costs in December 2019. In October 2020, the Arbitrator issued a Final Award on the terms agreed between WSD and Contractor D. In the event, WSD paid a total of $47.5 million to Contractor D in January and October 2020 to settle all the claims under Contract D. After the Partial Award was issued by the Arbitrator in December 2019, WSD decided to claim against Consultant X. In the event, Consultant X paid to the Government a sum of $13.6 million to settle all the claims under Consultancy X on a "without any

admission of liability or wrongdoing" basis. According to WSD, the disputes under Contract D mainly involved (paras. 2.4 to 2.7, 2.11 and 2.13):

(a) ***Measurement and valuation of formwork.*** Under Contract D, Contractor D was required to carry out certain formwork at two SWPSs in accordance with the formwork requirements stipulated in the contract specification. The Bills of Quantities (BQ) under Contract D specified the firm quantities of classes of formwork finish required. During the tender assessment for Contract D, Consultant X noted that under Contractor D's tender, there were substantially over-priced/under-priced and un-priced BQ items. These items included class F2 formwork finish (substantially over-priced) and class F4 formwork finish (substantially under-priced). Contractor D commenced the formwork in March 2011. The actual quantities of classes F2 and F4 formwork finish provided by Contractor D during the construction stage were found to have substantially deviated from the corresponding firm quantities in BQ. Contractor D and Consultant X had different views on the valuation of formwork (para. 2.8); and

(b) ***Omitted items in BQ.*** The disputes involved whether certain works were omitted items in BQ and their valuation, and the valuation of a number of omitted items agreed between Contractor D and Consultant X (para. 2.10).

6. ***Need to draw lessons from disputes under Contract D.*** Audit noted that: (a) according to the Arbitrator, the disputes under Contract D on measurement and valuation of formwork arose from different interpretations on the application of class of formwork finish and BQ of Contract D did not correctly represent the works shown on the drawings and described in the contract specification. Other major disputes were related to omitted items in BQ (see para. 5(b)). In the event, $13.6 million and $5.9 million were paid to Contractor D to settle these claims respectively (see also para. 5 for WSD's claim against Consultant X); and (b) according to Consultant X, during the course of construction, it certified the interim payments to Contractor D based on the formwork of class F2 standard with the intention to assist Contractor D with its cash flow. According to WSD, interim payments had to be based on the BQ rate for class F2 formwork finish so long as they were applicable according to the terms of contract. Consultant X subsequently adjusted the interim payments to Contractor D to recover the overpaid amount of $8.9 million. In Audit's view, there is scope for WSD to draw lessons from the disputes under Contract D (paras. 2.8, 2.13 and 2.15).

7. ***Scope for enhancing pre-tender site investigations and tree surveys.*** Under Contract J, Contractor J was required to construct a SWPS and carry out associated works. The contract works were substantially completed in late December 2014, about 23 months later than the original completion date of February 2013. According to WSD, extensions of time had been granted except 21 days (subject to liquidated damages). The reasons for granting the extensions of time mainly included: (a) additional works arising from the adverse ground conditions (i.e. marine mud and large boulders found below the original foundation level of the proposed intake culvert) identified during the construction stage, which was at variance with the contract drawings; (b) need for transplantation of 3 trees, which were not shown in the contract drawings, before the construction of SWPS commenced; and (c) substantial increase in the volume of rocks excavated, which significantly raised the construction difficulty. In the event, extensions of time totalling 595.5 days were granted for the above reasons, leading to prolongation costs of $8.7 million as assessed according to the terms of the contract. In October 2021, WSD informed Audit that its manual was recently updated in September 2021 with a view to strengthening the requirements on pre-tender site investigations and a review of the requirements on tree surveys was in progress. In Audit's view, WSD needs to remind its staff to comply with the requirements on pre-tender site investigations in implementing works projects in future. WSD also needs to early complete the review of the requirements on tree surveys with a view to enhancing planning and design work (paras. 2.18, 2.20 and 2.21).

8. ***Need to timely conduct post-completion review.*** According to the Project Administration Handbook for Civil Engineering Works, a post-completion review is a useful project management tool and should be carried out within a reasonable period, say six months, after the substantial completion of a consultancy agreement or a works contract. As a broad guideline, post-completion reviews are generally not warranted for consultancy agreements and works contracts of a project which has a total cost less than $500 million. The total project expenditure of Project E (one of the projects for the extension of seawater supply network in Northwest New Territories) exceeded $500 million (i.e. $798.2 million as of June 2021) and all works were substantially completed in March 2015. However, as of June 2021 (6 years later), WSD had not conducted a post-completion review for the project (paras. 2.26 and 2.27).

9. ***Need to continue to expedite the conversion to seawater flushing.*** The projects for extension of seawater supply network in Pok Fu Lam and Northwest New Territories were completed in July 2013 and March 2015 respectively. However,

Audit noted that, as of June 2021 (i.e. about 8 and 6 years after the completion of the extension projects), WSD had not completed the conversion to seawater flushing in the two areas. Over 80% of TMF accounts in the two areas had not been converted to seawater for flushing. In 2020, a total of 8.2 million cubic metres (Mm^3) of fresh water was still used for flushing in the two areas (or 40% (1.6 Mm^3) and 17% (6.6 Mm^3) of the total volume of flushing water in each respective area). Apart from the two areas, Audit noted that some consumers in other seawater supply zones (i.e. with salt water supply systems available) were still using fresh water for flushing (there were 4,134 such TMF accounts as of June 2021 and 18.8 Mm^3 of fresh water was used for flushing in 2020) (paras. 2.34 and 2.37).

Operation and maintenance of seawater supply systems

10. ***Scope for improving the sampling of flushing water quality at customer ends.*** WSD has laid down standards (i.e. Water Quality Objectives) for flushing water to ensure that the quality of seawater for flushing is acceptable, and set out a key performance measure to ensure that flushing water supplied to customers complies with WSD's Water Quality Objectives. Under the programme for monitoring flushing water quality, samples are taken from monitoring points at SWPSs, SWSRs and customer ends (such as publicly accessible toilets at estate management offices, shopping centres, government buildings and community facilities). According to WSD, for sampling of flushing water quality at customer ends, the selection criteria are based on accessibility and the representativeness of the sampling point with inputs from the regional offices. However, Audit noted that, as of October 2021, WSD had no specific guidelines in this regard. According to WSD, it issued such guidelines in November 2021. Audit also noted that the number of monitoring points at customer ends decreased from 63 in 2018-19 to 55 in 2019-20, and further to 30 in 2020-21. A total of 70 different monitoring points were covered in the three-year period, of which the same 25 (36%) monitoring points had been selected in all three years. While the changes of relevant sampling programmes for flushing water were reported in regular WSD's meetings, the details were not documented (paras. 3.3, 3.4, 3.6 and 3.8).

11. ***Scope for improving handling complaints on seawater supply systems.*** According to WSD, it will provide a substantive reply to a complainant within 30 calendar days as far as practicable. From January 2018 to March 2021, WSD received 2,544 complaints on seawater supply systems. Audit noted that, as of March 2021: (a) the follow-up actions for 2,497 complaints had been completed. There were

68 complaints with data entry problems (e.g. follow-up actions and completion dates for handling the complaints not recorded) in the complaint management system. For 607 (25%) of the remaining 2,429 complaints, WSD took more than 1 month and up to 12 months (averaging 2 months) to complete the follow-up actions after receipt of the complaints; and (b) the follow-up actions for 47 complaints had not been completed, of which 27 (57%) complaints had been received for more than 1 month and up to 9 months (averaging 4 months) (paras. 3.11 and 3.12).

12. ***Improvement works for salt water mains.*** Audit noted the following issues:

(a) ***Scope for improving the selection of salt water mains for improvement works.*** According to WSD, it will assess the risk of water main bursts or leaks taking into account various factors and accord priorities to those water mains assessed with high risk for improvement works so as to reduce the risk of water main bursts and leaks. A scoring system is developed to prioritise all water mains into five ranks (from Rank 1 (the highest risk) to Rank 5 (the lowest risk)). WSD conducted a prioritisation exercise of water mains based on the scoring system in 2016. Audit noted that, as of March 2021 (about five years after the 2016 prioritisation exercise), 2 (67%) of the 3 salt water mains of the highest risk (i.e. Rank 1) and 23 (38%) of the 61 salt water mains of high risk (i.e. Rank 2) had not been selected for improvement works (paras. 3.16 and 3.20); and

(b) ***Improvement works for some salt water main burst hot spots not completed after a long time.*** WSD has outsourced the risk-based improvement works of water mains to contractors. According to WSD, it accords the highest priority to arrange improvement works at hot spots (i.e. locations with repeated water main bursts) to eliminate the risk of water main bursts. WSD identified 44 hot spots of salt water main bursts for which improvement works were required. Audit noted that, as of April 2021, the improvement works for 14 (32%) of the 44 hot spots were still in progress. The works for 13 (93%) of the 14 hot spots had not been completed for more than 2 years and up to 6.5 years (averaging about 4.5 years) after the last burst at the hot spot (para. 3.21).

13. ***Salt water main bursts and leaks.*** Audit noted the following issues:

(a) ***Scope for enhancing the monitoring of repair works for salt water main bursts.*** For water main bursts and leaks, WSD has mainly engaged term contractors to carry out repair works of the water mains. According to the contracts, the contractors should provide adequate labour and/or plant to handle all emergency works, including deploying a specified minimum number of workers for attending to an emergency involving water main burst. From January 2018 to March 2021, there were 105 salt water main burst cases. Audit noted that there were 10 cases with shortfall in contractors' workers by 2 to 5 (ranging from 20% to 63%, averaging 33%) (paras. 3.22 and 3.23); and

(b) ***Scope for improving attendance to salt water main leaks.*** While the number of salt water main leak cases decreased by 3% from 1,876 cases in 2017 to 1,827 cases in 2018, it increased by 10% from 1,827 cases in 2018 to 2,006 cases in 2020. From January 2018 to March 2021, there were 6,193 salt water main leak cases. Audit noted that, for 1,991 (32%) of the 6,193 cases, more than 2 hours and up to 49 days (averaging 22 hours) were taken to close the valve after receipt of report of salt water main leaks. For 217 (4%) of the 6,193 cases, the duration of supply interruption due to salt water main leak was more than 24 hours and up to 7 days (averaging 39 hours) (paras. 3.25 and 3.26).

14. ***Scope for utilising advanced technologies to monitor seawater supply systems.*** From January 2018 to March 2021, most of the salt water main burst and leak cases were identified by the public and not by WSD. Audit notes that WSD has implemented a Water Intelligent Network (including active leakage detection and control measures), which only covers fresh water distribution systems but not seawater supply systems. In Audit's view, WSD needs to explore the feasibility of utilising advanced technologies (such as the Water Intelligent Network) to monitor the seawater supply systems (paras. 3.30 to 3.32).

Other related issues

15. ***Quality Water Supply Scheme for Buildings — Flushing Water (Quality Flushing Water Scheme).*** Audit noted the following issues:

(a) ***Need to keep up efforts to encourage more buildings to participate in Quality Flushing Water Scheme.*** WSD has launched the Quality Flushing Water Scheme since July 2013. The number of buildings participating in the Scheme had been fluctuating since its launch in July 2013 (increasing from 550 buildings in December 2013 to 1,804 buildings in December 2016, decreasing to 1,414 buildings in December 2020, and increasing to 1,949 buildings in September 2021). As of September 2021, only two government buildings participated in the Scheme (paras. 4.2 and 4.5); and

(b) ***Need to complete processing of applications as soon as practicable.*** As of March 2021, WSD had not completed the processing of 176 new applications (involving 876 buildings) and 240 renewal applications (involving 784 buildings) for the Quality Flushing Water Scheme. For the 176 new applications, they had been received by WSD for about 7 months on average. For 104 (59%) of the 176 applications, they had been received for more than 6 months and up to 17 months (averaging about 10 months). For the 240 renewal applications, they had been received by WSD for about 5 months on average. For 90 (38%) of the 240 applications, they had been received for more than 6 months and up to 13 months (averaging about 8 months) (para. 4.9).

16. ***Slow progress of mainlaying works under a project for uprating the existing seawater supply system for Wan Chai.*** According to WSD, for some areas with seawater supply systems, the existing systems may not be able to cope with the increasing seawater demand arising from the existing or planned developments in the areas, and enhancement works to uprate the existing seawater supply system will be required. As of September 2021, an uprating project for the salt water supply system for Wan Chai (Wan Chai uprating project) was still in progress. WSD had awarded four contracts for the project, of which three contracts had been completed. For the remaining contract (Contract Q), WSD awarded it in January 2012 to a contractor (Contractor Q) for mainlaying works at $165.6 million. Audit noted that: (a) as of September 2021 (about 5.7 years after the original contract completion date of January 2016), the works for Contract Q were still not yet completed, mainly due to problems encountered during mainlaying works (e.g. congested and uncharted underground utilities and obstructions affecting trenchless works); and (b) according to WSD, the performance of Contractor Q was unsatisfactory (including persistent slippage of progress, poor planning of works and inadequate resources). In Audit's view, WSD needs to complete the Wan Chai uprating project as soon as practicable and draw on the experience gained in implementing the project (paras. 4.15 to 4.20).

17. ***Need to keep under review the implementation of projects for supply of recycled water.*** According to WSD, it has been actively exploring the use of recycled water (see para. 3 for WSD's related target) by providing a centralised recycled water supply system in those areas where fresh water is being used for flushing and in new development areas (especially in the inland areas) to contain the fresh water demand. It is implementing two projects: (a) constructing a district-based grey water (which is collected from baths, wash-basins, kitchen sinks, etc.) recycling system at the Anderson Road Quarry Development site. The system is anticipated to be completed in 2023; and (b) carrying out works to supply reclaimed water, converted from tertiary treated sewage effluent at the Shek Wu Hui Effluent Polishing Plant, to the Northeast New Territories for non-potable uses (including toilet flushing) in phases. The supply of reclaimed water to Sheung Shui and Fanling will start in 2024. In Audit's view, WSD needs to keep under review the implementation of projects for supply of recycled water (paras. 1.6, 4.27 and 4.29).

Audit recommendations

18. **Audit recommendations are made in the respective sections of this Audit Report. Only the key ones are highlighted in this Executive Summary. Audit has *recommended* that the Director of Water Supplies should:**

Management of projects for extension of seawater supply network

(a) **in implementing works projects in future:**

(i) **remind WSD staff and consultants to critically vet contract documents (e.g. BQ) for ensuring their completeness, accuracy and consistency with one another in accordance with the related guidelines (para. 2.16(a));**

(ii) **in certifying interim payments to contractors, require consultants to pay particular attention to payments involving over-priced/under-priced items when there is substantial change in quantities and report to WSD any irregularities including possible overpayments (para. 2.16(b)); and**

(iii) **remind WSD staff to comply with the requirements on pre-tender site investigations recently updated in September 2021 (para. 2.30(a));**

(b) **early complete the review of the requirements on tree surveys with a view to enhancing planning and design work (para. 2.30(b));**

(c) **complete the post-completion review for Project E as soon as practicable, and remind WSD staff and consultants to conduct post-completion reviews as needed in a timely manner (para. 2.30(c) and (d));**

(d) **continue to expedite the conversion to seawater flushing for consumers in seawater supply zones (including Pok Fu Lam and Northwest New Territories) (para. 2.39(a));**

Operation and maintenance of seawater supply systems

(e) **document more details about the changes of sampling programmes for flushing water (para. 3.13(a));**

(f) **continue to follow up the complaints on seawater supply systems as early as practicable and take measures to ensure that information about the complaints is accurately and timely updated in the complaint management system (para. 3.13(c) and (d));**

(g) **include salt water mains of high risk for implementation of improvement works and continue to take measures to ensure that improvement works of salt water mains are completed as soon as practicable (para. 3.33(a) and (c));**

(h) **take measures to ensure that the contractors comply with the contract requirement of deploying adequate labour to handle emergencies involving salt water main bursts, and attend to salt water main leaks as soon as practicable, balancing all relevant factors (para. 3.33(e) and (f));**

(i) **explore the feasibility of utilising advanced technologies to monitor the seawater supply systems (para. 3.33(h));**

Other related issues

(j) **keep up efforts to encourage more buildings to participate in the Quality Flushing Water Scheme and complete the processing of applications for the Scheme as soon as practicable (para. 4.13(a) and (b));**

(k) **strengthen actions to complete the Wan Chai uprating project as soon as practicable and draw on the experience gained in implementing the project (para. 4.24(a) and (b)); and**

(l) **keep under review the implementation of projects for supply of recycled water (para. 4.32(a)).**

Response from the Government

19. The Director of Water Supplies agrees with the audit recommendations.

PART 1: INTRODUCTION

1.1 This PART describes the background to the audit and outlines the audit objectives and scope.

Background

1.2 According to the Water Supplies Department (WSD), Hong Kong is the world's first city to systematically utilise seawater (Note 1) for flushing and, up till now, is one of the few places in the world (Note 2) extensively applying seawater for flushing. The use of seawater, a sustainable water resource, plays an important role in Hong Kong's water resources management (Note 3).

1.3 In the late 1950s, seawater flushing was introduced in Hong Kong in view of the then acute shortage of fresh water for potable use and to conserve fresh water (Note 4). At the initial stage, seawater was pumped to supply government office buildings and government housing estates only. Since then, seawater supply systems

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Note 1: *The terms "seawater" and "salt water" are used interchangeably in this Audit Report.*

Note 2: *According to WSD, apart from Hong Kong, for example, some places in Marshall Islands and Gibraltar also use seawater for flushing.*

Note 3: *According to WSD, Hong Kong is a coastal city where seawater can be easily accessed and is a reliable natural water resource. Moreover, the treatment of seawater is relatively simple which mainly involves screening by strainers and chlorination for disinfection. Thus, utilising seawater for flushing in Hong Kong is generally a cost-effective and environmental friendly option to replace the precious fresh water for flushing. For 2020-21, the unit production cost of seawater was $4.2 per cubic metre as compared to that for fresh water of $9.8 per cubic metre.*

Note 4: *According to WSD, the seawater flushing supply system was planned in the 1950s and was formally established in 1965. The drought in 1963 and 1964 (with water rationing measures of supplying fresh water to the public for 4 hours every 4 days introduced between June 1963 and May 1964) and the general lack of water resources in the 1960s promoted the widespread use of seawater in Hong Kong. Due to construction of reservoirs of large capacity and water supply from Dongjiang, no water rationing has been imposed since 1982.*

(comprising salt water pumping stations (SWPSs), salt water service reservoirs (SWSRs) and salt water distribution systems — see para. 1.9) were added one after another, extending the seawater supply network for flushing in Hong Kong. The seawater supply systems are completely separated from the potable water supply systems.

Legislative requirements

1.4 According to WSD, since 1965, all new buildings have been required to be installed with dual plumbing systems for potable and flushing water. According to the Building (Standards of Sanitary Fitments, Plumbing, Drainage Works and Latrines) Regulations (Cap. 123I), a system of plumbing shall be provided for the supply of water for flushing purposes to every watercloset fitment, trough watercloset, urinal and slop sink. Every part of any such system of plumbing shall be constructed of material that is suitable for use with salt water.

1.5 According to the Waterworks Regulations (Cap. 102A), the Water Authority, who is the Director of Water Supplies (for simplicity, the Water Authority is referred to as WSD in this Audit Report), may require the use of salt water for flushing. For areas without seawater supply at the moment, as an interim measure, WSD would approve the use of temporary mains fresh water for flushing (TMF). If in a premises fresh water is used for flushing without any written permission of WSD, the occupier and the owner of the premises shall be guilty of an offence under the Waterworks Regulations.

Total Water Management Strategy

1.6 ***2008 Total Water Management Strategy.*** In the 2003 Policy Address, the Government pledged that a Total Water Management (TWM) programme would be implemented as the major initiative to enhance water conservation and water resource protection. In 2008, WSD promulgated the TWM Strategy for the period up to 2030, focusing on water demand and water supply management. Key initiatives relating to flushing water supply included extension of the use of seawater for flushing in order

to save fresh water (Note 5), conducting pilot schemes to provide reclaimed water (produced by further processing treated sewage effluent) for consumers in Sheung Shui and Fanling for toilet flushing and other non-potable uses, and conducting trial schemes of reuse of grey water (collected from baths, wash-basins, kitchen sinks, etc.) and rainwater harvesting for toilet flushing and irrigation for some new public projects.

1.7 ***2019 Total Water Management Strategy.*** In 2019, WSD completed a review of the 2008 TWM Strategy (see para. 1.6) to extend the water demand and supply forecast up to 2040 and update the Strategy. According to WSD, the 2008 TWM Strategy had been overall effective (Note 6). One of the achievements of the key initiatives under the Strategy was extension of the coverage of the seawater supply network for flushing from below 80% to 85% of the total population for further reduction of fresh water demand. According to the updated TWM Strategy in 2019 (Note 7), one of the key initiatives of containing fresh water demand was expansion of use of lower grade water (i.e. seawater and recycled water — Note 8) for non-potable purposes. WSD targets at expanding the network coverage of using lower grade water for flushing from 85% of the total population to 90% in the long run in order to further reduce the fresh water demand for flushing.

Note 5: *Among other initiatives (e.g. publicity and public education programmes for water conservation and the Replacement and Rehabilitation of Water Mains Programme for reduction of mains bursts and water loss), the extension of the use of seawater for flushing contributed to the Government's pledge to reduce the average fresh water per capita consumption by 10% by 2030 at the earliest (using 2016 as the base year) in the Policy Agendas 2017 and 2018.*

Note 6: *According to the review of the 2008 TWM Strategy in 2019, the total fresh water consumption in Hong Kong had been contained at the level of around 1,000 million cubic metres per year from 2009 to 2018 notwithstanding a continuous growth of population at a rate of 0.7% per annum. The 10-year average fresh water per capita consumption dropped from 140 (1999 – 2008) to 133 (2009 – 2018) cubic metres per capita per year after implementation of the Strategy.*

Note 7: *The 2019 TWM Strategy adopted a two-pronged approach, with emphasis on containing fresh water demand growth and building resilience in the fresh water supply catering for extreme effects of climate change with diversified water resources.*

Note 8: *Recycled water comprises reclaimed water (produced by further processing treated sewage effluent), treated grey water (collected from baths, wash-basins, kitchen sinks, etc. and treated for non-potable purposes) and harvested rainwater.*

Seawater supply network and system for flushing

1.8 According to WSD, the seawater supply network for flushing currently covers about 85% of the population in Hong Kong while the remaining 15% are provided with TMF. According to the Waterworks Regulations, seawater for flushing is supplied free of charge while the use of fresh water for flushing may be subject to charge depending on usage (Note 9). In 2020, a total of 394 million cubic metres (Mm^3) of water was used for flushing, of which 331 Mm^3 (84%) was seawater and 63 Mm^3 (16%) was fresh water (Note 10). For the supply of TMF, normally only one meter is installed for a housing estate/individual building(s) instead of individual premises and the charges for flushing supply are billed to the registered consumers (e.g. management office, agent, incorporated owner or development company). In general, the seawater supply network covers Hong Kong Island's coastal areas, Kowloon and the New Territories (excluding some rural areas such as Sai Kung and inland areas such as Sheung Shui and Fanling — Note 11) (see Figure 1). WSD is carrying out works to extend the seawater supply network to Tung Chung and Sha Tin Area 52 for Shui Chuen O (Note 12). It will continue to extend the seawater supply network to other areas whenever it is technically feasible and cost-effective.

Note 9: *The charge rate of fresh water for flushing per flat (per 4-month period) is free of charge for the first 30 cubic metres and $4.58 per cubic metre for the remainder. According to WSD, it has been keeping record of the number of flats of each TMF account for billing purpose.*

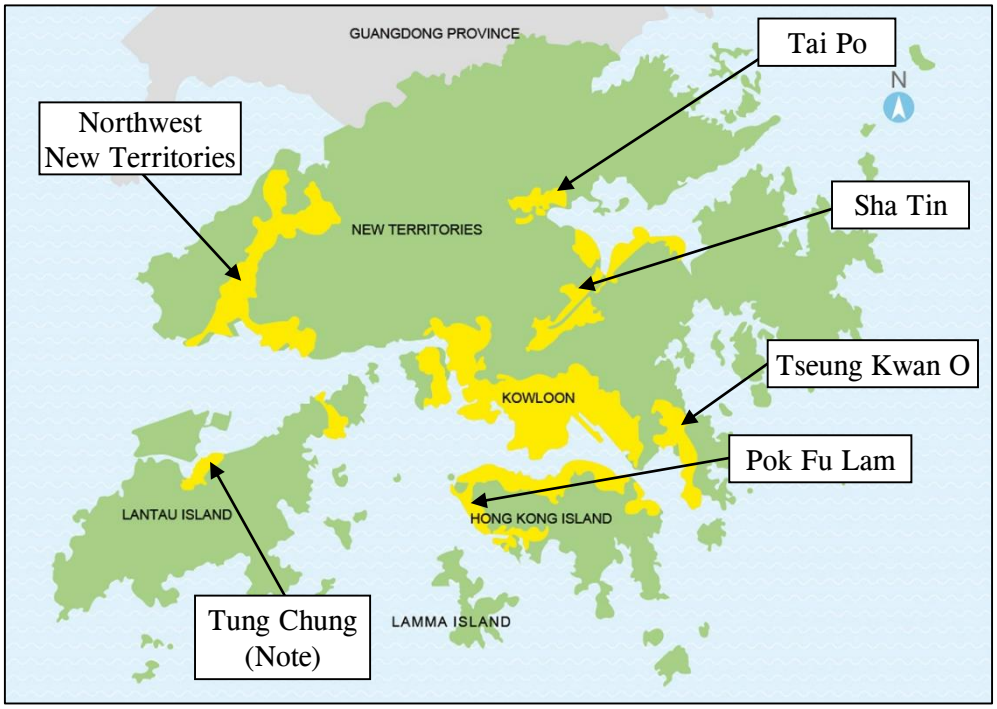
Note 10: *The 63 Mm^3 of TMF accounted for 6.1% of a total of 1,027 Mm^3 of fresh water consumed in Hong Kong in 2020.*

Note 11: *The reasons for not supplying seawater to some areas (e.g. Sai Kung, Sheung Shui, Fanling, the Peak, Southern District and the outlying islands) include their remoteness from the seafront, high altitudes and sparse and scattered population which render seawater supply not technically feasible or not cost-effective.*

Note 12: *The works for the salt water supply system under the Tung Chung New Town Extension project commenced in June 2021 for completion in 2024. The network extension works for Sha Tin Area 52 commenced in August 2021 for completion in August 2025.*

Figure 1

Seawater supply zones in Hong Kong
(June 2021)



Legend: Seawater supply zone

Source: *WSD records*

Note: *Seawater supply in Tung Chung would be commissioned in phases from 2023 onwards.*

Remarks: *As of June 2021, there were 21 seawater supply zones (10 for Hong Kong and Islands Region, 4 for Kowloon Region, 4 for New Territories West Region and 3 for New Territories East Region of WSD) in Hong Kong.*

1.9 As of March 2021, the seawater supply system consisted of 42 pumping stations (Note 13), 54 SWSRs and 1,660 kilometres (km) of salt water mains (Note 14) for supplying seawater to specified areas (see Figure 2). The seawater is

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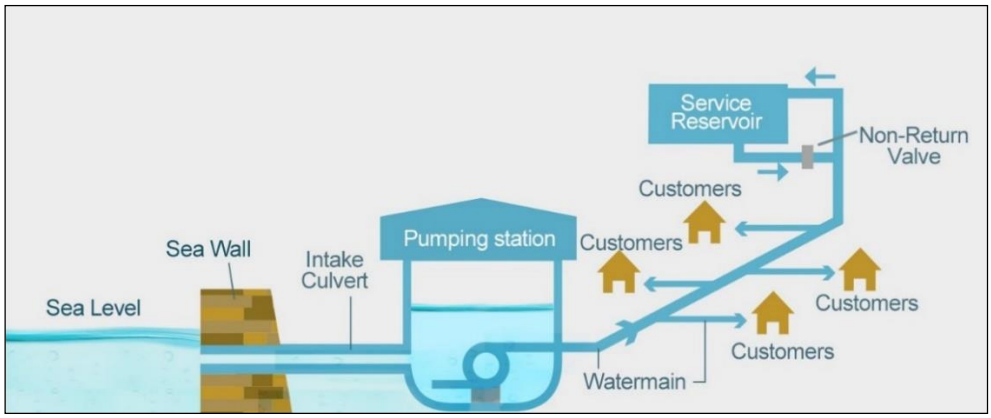
Note 13: *The 42 pumping stations comprised 35 SWPSs (including pump houses) and 7 combined fresh water and salt water pumping stations.*

Note 14: *The salt water mains were with diameter of 20 millimetres to 1,200 millimetres.*

firstly screened by strainers to remove sizeable particles, and then disinfected to ensure the water quality conforming to WSD standard (i.e. Water Quality Objectives for seawater for flushing — see para. 3.3), before being pumped to the consumers with surplus water delivered to and stored at the service reservoirs.

Figure 2

Schematic diagram of a seawater supply system



Source: *WSD records*

Conversion to seawater flushing

1.10 WSD would withdraw the approval to use TMF and require the registered consumers of TMF to use seawater for flushing when the seawater supply has become available. When consumers receive a letter issued by WSD about conversion to seawater flushing, they should employ licensed plumbers to inspect the inside services. If modification works are required, application to WSD is necessary. After inspection/completion of modification works by licensed plumbers, they should apply to WSD for connection to salt water mains. With the required connection fee paid, WSD would schedule the works for pipe connection and seawater supply. According to WSD, pursuant to the Waterworks Regulations, the occupier and owner of a premises shall be guilty of an offence if they contravene the requirement of using seawater for flushing and use fresh water for flushing without any written permission of WSD (see para. 1.5).

Projects for extension of seawater supply network

1.11 The latest extension of seawater supply network involved two areas, namely Pok Fu Lam and Northwest New Territories. The works for these two areas commenced in August 1996 and February 2008 and were substantially completed in July 2013 and March 2015 respectively (see Table 1). The total approved project estimate (APE) for implementing the network extension in these two areas under five projects (Projects A to E) was $1,442.7 million (see Table 2). As of June 2021, $1,380.9 million (96%) of APE totalling $1,442.7 million had been incurred. Of the $1,380.9 million, $1,232.1 million (89%) was related to expenditures for works contracts and the remaining $148.8 million (11%) included resident site staff costs and consultancy fee.

Table 1

Extension of seawater supply network in Pok Fu Lam and Northwest New Territories (August 1996 to March 2015)

Network area	Major works component	Works commenced	Works completed
Pok Fu Lam	• Construction of Wah Fu SWSR, Pok Fu Lam SWSR, Wah Fu SWPS and Telegraph Bay SWPS • Laying of associated salt water mains	August 1996	July 2013
Northwest New Territories (Note)	• Construction of Tan Kwai Tsuen SWSR, Lok On Pai SWPS and an intermediate booster chlorination plant • Laying of associated salt water mains	February 2008	March 2015

Source: *WSD records*

Note: *The area includes Tuen Mun East, Hung Shui Kiu, Tin Shui Wai and Yuen Long Town Centre.*

Table 2

Funding approval for projects for extending seawater supply network (June 1990 to March 2020)

Project	Date	Particulars	Approved amount ($ million)
Salt water supply system for Pok Fu Lam (Note)			
A	June 1990	Advance mainlaying along Victoria Road	7.5
B	June 1995	Mainlaying along Pok Fu Lam Road, Mount Davis Road, Victoria Road, Sandy Bay Road and other minor roads	141.2
C	July 2008	Construction of a salt water supply system to serve Pok Fu Lam area	268.0
	May 2019	Increase in APE to cover additional costs arising from settlement of disputes	15.0
		Total	431.7
Salt water supply system for Northwest New Territories			
D	July 2007	Implementation of the stage 1 works of salt water supply to Northwest New Territories	188.0
	March 2020	Increase in APE to cover additional costs arising from variation of works and contractor's claims	14.6
E	January 2009	Implementation of the remaining works of salt water supply to Northwest New Territories	808.4
		Total	1,011.0
		Overall	1,442.7

Source: *WSD records*

Note: *In November 1992, an item was included in Category D of the Public Works Programme under the Capital Works Reserve Fund at an estimated cost of $1.5 million for laying short sections of salt water mains at road crossings along Pok Fu Lam Road in conjunction with road reconstruction. The mainlaying works were completed in February 1995 and the final expenditure was $0.8 million.*

Operation and maintenance of seawater supply systems

1.12 WSD is responsible for operation and maintenance of the seawater supply systems (consisting of 42 pumping stations, 54 SWSRs and 1,660 km of salt water mains as of March 2021 — see para. 1.9). In 2020-21, the total operating and administration expenses (including depreciation but excluding staff cost) related to flushing water supply was about $976 million.

1.13 WSD will ensure that the quality of flushing water supplied to customers is acceptable. According to WSD, it monitors the flushing water quality by taking samples from SWPSs, SWSRs and customer ends (such as publicly accessible toilets at community facilities).

1.14 WSD is responsible for the management of water supply network (for both fresh and salt water). It has implemented a risk-based water main asset management strategy to maintain the healthiness of the water supply network (for both fresh and salt water) and reduce the risk of water main bursts and leaks. According to WSD, it will assess the risk of water main bursts or leaks taking into account various factors and accord priorities to those water mains assessed with high risk for improvement works. From January 2020 to March 2021, there were 20 salt water main burst cases and 2,484 salt water main leak cases.

Responsible branches of WSD

1.15 The main branches of WSD responsible for the management of flushing water supply are as follows:

(a) the Development Branch is responsible for, among others, planning of flushing water supply and monitoring of quality of flushing water supply;

(b) the New Works Branch is responsible for, among others, planning and management of projects for flushing water supply network; and

(c) the Supply and Distribution (Urban) Branch and the Supply and Distribution (New Territories) Branch are responsible for, among others, operation and maintenance of flushing water supply and distribution systems in urban areas and the New Territories respectively.

An extract of WSD's organisation chart as at 31 March 2021 is at Appendix A.

1.16 As of March 2021, 823 staff (comprising 818 civil servants and 5 non-civil service contract staff) of WSD were involved in management of flushing water supply (Note 15).

Audit review

1.17 In 2015, the Audit Commission (Audit) conducted a review of WSD's management of water supply and demand, the results of which (covering use of reclaimed water and extending the use of seawater for flushing) were included in Chapter 4 of the Director of Audit's Report No. 64 of April 2015.

1.18 In April 2021, Audit commenced a review to examine WSD's work in managing flushing water supply. The audit review has focused on the following areas:

(a) management of projects for extension of seawater supply network (PART 2);

(b) operation and maintenance of seawater supply systems (PART 3); and

(c) other related issues (PART 4).

Audit has found room for improvement in the above areas and has made a number of recommendations to address the issues.

Note 15: *According to WSD, the 823 staff were also involved in management of fresh water supply. It could not provide a breakdown of the staff expenditure incurred solely for management of flushing water supply as no separate staff time records for such work were kept.*

Acknowledgement

1.19 Audit would like to acknowledge with gratitude the full cooperation of the staff of WSD during the course of the audit review.

PART 2: MANAGEMENT OF PROJECTS FOR EXTENSION OF SEAWATER SUPPLY NETWORK

2.1 This PART examines WSD's work in managing the projects for extension of seawater supply network, focusing on:

(a) disputes under Contract D (paras. 2.4 to 2.17);

(b) other project and contract management issues (paras. 2.18 to 2.31); and

(c) conversion to seawater flushing (paras. 2.32 to 2.40).

Implementation of projects for extension of seawater supply network

2.2 Extension of seawater supply network in Pok Fu Lam and Northwest New Territories were mainly implemented under 3 projects (Projects A to C) and 2 projects (Projects D and E) respectively (see Table 2 in para. 1.11). Between 1996 and April 2012, WSD awarded 4 contracts (Contracts A to D) and 9 contracts (Contracts E to M) under the projects for extension of seawater supply network in Pok Fu Lam and Northwest New Territories respectively (see Appendix B). The works under the 13 works contracts were substantially completed between September 1998 and March 2015, which were 1.3 to 34.4 months later than the respective original contract completion dates. According to WSD, extensions of time (due to reasons including inclement weather, revision of mainlaying alignment and unforeseen underground conditions) had been granted to the contractors in accordance with the terms of the contracts for completion of works later than the original contract completion dates. Of the 13 works contracts, full extensions of time had been granted to 8 contracts according to the contractual provisions (i.e. they were completed within the extended contract completion dates) and liquidated damages had been imposed on the contractors of 5 contracts for delays in completion of works later than their respective extended contract completion dates (ranging from 0.1 to 0.9 months) (see Note 1 to Appendix B).

2.3 The works under the 13 contracts were supervised by in-house staff of WSD (Note 16) except Contract D for which a consultant (Consultant X under Consultancy X — Note 17) was engaged to supervise the works. As of June 2021, all contract accounts had been finalised and total contract expenditure of $305.6 million and $1,019.2 million had been incurred for the extension projects in Pok Fu Lam and Northwest New Territories respectively (see Appendix C).

Disputes under Contract D

2.4 Contract D was a lump sum contract (Note 18) covering the construction of 2 SWSRs and 2 SWPSs, and laying of associated salt water mains in Pok Fu Lam. WSD awarded Contract D to Contractor D in September 2009 at $190.7 million. The works commenced in October 2009 and were substantially completed in July 2013 (see Appendix B). Consultant X was the Engineer responsible for supervising the contract works. The accounts for Contract D was finalised in April 2016 and the total contract expenditure was $231.8 million (see Appendix C). There were disputes under Contract D and counterclaims against Consultant X.

Note 16: *According to WSD: (a) the mode of project delivery was determined at the planning stage of projects; and (b) in determining whether consultant(s) or in-house staff were used to implement the projects, consideration was mainly given to the availability of specialist expertise in the department and sufficient in-house manpower resources for carrying out the design, tendering, contract administration and supervision of works.*

Note 17: *In July 2007, WSD awarded Consultancy X to Consultant X for the design and construction supervision work of Contract D's works of the salt water supply system for Pok Fu Lam. Consultancy X was completed in December 2020 and consultancy fees of $6.4 million had been paid to Consultant X.*

Note 18: *Under a lump sum contract, the quantities of various works items are substantially measured firm and the final price to be paid is ascertained by adding to/deducting from the contractor's accepted tender price the value of variations and other specified items (e.g. provisional quantities and contingency items). For Contract D, the quantities in the Bills of Quantities were firm, except that provisional quantities, variation orders, work shown on the Drawings or described in the Specification but not measured in the Bills of Quantities, and errors discovered in firm quantities should be measured.*

2.5 In June 2015, Contractor D served a Notice of Arbitration in respect of disputes relating to various claims under Contract D. To prepare for the arbitration with Contractor D, the Legal Advisory Division (Works) (LAD) of the Development Bureau (DEVB) (as the legal representative for the Government in the arbitration) engaged an external legal team (comprising external solicitors and counsels) between September 2015 and June 2016, and independent quantum and programming experts (Note 19) in January 2016. Before the completion of arbitration hearing, both sides agreed to settle various claims (mainly low-value claims) at a total sum of $3.2 million ($1.5 million was paid in October 2015 and $1.7 million was paid in December 2019).

2.6 In February 2019, WSD sought the approval of the Financial Services and the Treasury Bureau (FSTB) for a strategy and bottom line to negotiate with Contractor D for settlement of disputes under Contract D. Between February and May 2019, WSD and LAD provided all relevant information of the case to FSTB and FSTB granted the approval in May 2019. In the event, WSD and Contractor D were unable to reach a settlement agreement. The disputes then proceeded to arbitration hearing in June 2019. In December 2019, the Arbitrator issued a Partial Award which covered all the claims except interest and legal costs. In January 2020, WSD sought the approval of FSTB for a strategy and bottom line to negotiate with Contractor D on interest and legal costs. After WSD and LAD provided all relevant information of the case in late April 2020, FSTB granted the approval in May 2020. In September 2020, WSD and Contractor D informed the Arbitrator that both parties had come to agree to settle all the claims under Contract D at a full and final settlement amount of $47.5 million. In October 2020, the Arbitrator issued a Final Award on the terms agreed between WSD and Contractor D. WSD paid a total of $47.5 million to Contractor D in January and October 2020.

Note 19: *The quantum and programming experts were engaged to: (a) provide advice and assistance to WSD on the quantum, valuation and programming aspects of the disputes between the parties for the arbitration and for achieving a practical solution or settlement which would be acceptable for both parties; and (b) provide the necessary input and support to the legal team and WSD.*

2.7 According to WSD, the disputes under Contract D mainly involved (Note 20):

(a) measurement and valuation of formwork (see paras. 2.8 and 2.9); and

(b) omitted items in Bills of Quantities (BQ) (see para. 2.10).

Measurement and valuation of formwork

2.8 The salient points relating to the disputes on measurement and valuation of formwork are as follows:

(a) under Contract D, Contractor D was required to carry out certain formwork (Note 21) at the Telegraph Bay SWPS and the Wah Fu SWPS in accordance with the formwork requirements stipulated in the General Specification for Civil Engineering Works (1992 Edition) (hereinafter referred to as the General Specification — Note 22), as follows:

(i) formwork finish of class F2 was specified for "rendered, plastered" and "tiled" surfaces under the category "surfaces to be covered"; and

(ii) formwork finish of class F4 was specified for "internal" surface under the category "buildings";

Note 20: *Apart from the issues under paragraph 2.7(a) and (b), other issues under disputes included assessment of extension of time and the related costs. In the event, the Arbitrator decided the grant of additional extension of time and related costs to Contractor D.*

Note 21: *According to WSD, formwork referred to the temporary mould that was required to be erected for carrying out concreting. There were different classes of formwork and the difference among them was the standard of finish left on the concrete at the end of the casting process.*

Note 22: *The General Specification laid down the quality of materials, the standards of workmanship, the testing methods and the acceptance criteria for civil engineering works undertaken for the Government.*

(b) the BQ under Contract D specified the firm quantities (see Note 18 to para. 2.4) of classes of formwork finish required, including that:

(i) a total of 816 square metres (m^2) of class F2 finish (with BQ rate of \$2,450 per m^2) would be required; and

(ii) a total of 5,928 m^2 of class F4 finish (with BQ rate of \$145 per m^2) would be required;

(c) during the tender assessment for Contract D, Consultant X noted that, under Contractor D's tender, there were substantially over-priced/under-priced and un-priced BQ items. These items included class F2 formwork finish (substantially over-priced) and class F4 formwork finish (substantially under-priced). In August 2009, Consultant X requested Contractor D to confirm whether it would abide by its tender given such BQ items. Contractor D then confirmed that it was prepared to abide by its tender;

(d) Contractor D commenced the formwork in March 2011. The actual quantities of classes F2 and F4 formwork finish provided by Contractor D during the construction stage were found to have substantially deviated from the corresponding firm quantities in BQ (see Table 3);

Table 3

Formwork at pumping stations under Contract D

Class of finish	Firm quantities in BQ (a) (m^2)	Actual quantities provided by Contractor D (b) (m^2)	Variance (c) = (b) - (a) (m^2)
F2	816	6,172	5,356 (656%)
F4	5,928	597	(5,331) (-90%)

Source: WSD records

(e) during the course of construction, Consultant X certified the interim payments to Contractor D based on the formwork of class F2 standard. According to Consultant X, it continuously certified payments for class F2 formwork finish at the BQ rate for class F2 formwork finish with the intention to assist Contractor D with its cash flow. According to WSD, interim payments had to be based on the BQ rate for class F2 formwork finish so long as they were applicable according to the terms of contract. Subsequently, Consultant X adjusted the interim payments to Contractor D during January to May 2014 to recover the overpaid amount of $8.9 million (i.e. difference between valuing class F2 formwork finish at BQ rate of class F2 formwork finish and BQ rate of class F4 formwork finish) from Contractor D;

(f) two variation orders (VOs — Note 23) were issued by Consultant X in December 2011 and April 2012 to revise the class of formwork finish from F2 to F4 for the internal walls and columns of the Telegraph Bay SWPS; and

(g) Contractor D and Consultant X had different views on the valuation of formwork, as follows:

Contractor D's views

(i) Contractor D contended that, according to the contract drawings, internal walls and columns of the pumping stations were primarily plastered or tiled. Class F2 formwork finish (instead of class F4 formwork finish) should thus be provided in accordance with the General Specification of Contract D;

(ii) the mis-allocation of quantities between classes F2 and F4 formwork finish were "errors", which warranted correction and would entitle itself an additional payment amount;

Note 23: *The Engineer shall order any variation to any part of the works that is necessary for the completion of the works. The Engineer shall have the power to order any variation that for any other reason shall in the Engineer's opinion be desirable for or to achieve the satisfactory completion and functioning of the works. The Engineer shall also determine the sum which in his opinion shall be added to or deducted from the contract sum as a result of issuing a VO.*

Consultant X's views

(iii) Consultant X contended that class F4 formwork finish (instead of class F2 formwork finish) should be provided to the internal surfaces of the pumping stations (i.e. buildings) in accordance with the General Specification of Contract D; and

(iv) the deviation in quantities should not be regarded as "errors".

2.9 In the event, the Arbitrator decided in favour of Contractor D and the Government paid $13.6 million to Contractor D for settlement of this claim. According to the Arbitrator:

(a) the dispute between Contractor D and the Government arose from different interpretations on the class of formwork finish to be applied to the internal surfaces of the Telegraph Bay SWPS;

(b) BQ of Contract D did not correctly represent the works shown on the drawings (e.g. the type of surface required) and described in the General Specification (e.g. the formwork finish required);

(c) as Contract D provided that errors discovered in firm quantities should be measured (see Note 18 to para. 2.4), measurement was required in respect of the mis-measured items of formwork;

(d) the enormous disparity in rates between classes F2 and F4 formwork finish included in Contractor D's tender had been noticed by Consultant X at tender stage that the supposedly lesser quality class F2 formwork finish was priced at a very much higher rate than the higher quality class F4 formwork finish (see para. 2.8(c)). While this had been drawn to the attention of Contractor D, no other steps had been taken to avoid a claim situation developing until the issuance of VOs (see para. 2.8(f)); and

(e) Consultant X was motivated by reduction of the cost of works in issuing the VOs. In fact, the use of a higher quality finish (i.e. class F4 formwork finish) would not benefit the project overall.

Omitted items in BQ

2.10 As mentioned in paragraph 2.7(b), the disputes under Contract D also included omitted items in BQ (Note 24). The disputes involved whether certain works were omitted items in BQ and their valuation, and the valuation of a number of omitted items agreed between Contractor D and Consultant X. In the event, following the Arbitrator's decision, the Government paid a total of $5.9 million for settlement of Contractor D's claims. Details of the disputes are set out in Appendix D.

Counterclaim against Consultant X

2.11 After the Partial Award was issued by the Arbitrator in December 2019 (see para. 2.6), based on the advice of an external counsel and the quantum expert, and with the support of LAD, WSD decided to claim against Consultant X. In September 2020, the Government entered into a settlement agreement with Consultant X for full and final settlement of all the claims under Consultancy X at a sum of $13.6 million on a "without any admission of liability or wrongdoing" basis. In October 2020, Consultant X paid the settlement sum to the Government.

Need to draw lessons from disputes under Contract D

2.12 According to the Project Administration Handbook for Civil Engineering Works (hereinafter referred to as the Project Administration Handbook) issued by the Civil Engineering and Development Department:

(a) the documents forming a contract must be scrutinised for comprehensive coverage, accuracy and consistency with one another before tenders are invited. In particular, for a lump sum contract, with a view to eliminating the need for total post contract remeasurement, more pre-tender effort is necessary to produce an advanced detailed design and accurate quantities for the tender; and

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Note 24: *According to WSD, omitted items in BQ should be measured and valued according to the terms of the contract.*

(b) in vetting and certifying interim payments, measurement shall be accurate enough to ensure that there is no large over-payment or under-payment made to the Contractor. In assessing the interim payments, the Engineer should check the correctness of all quantities, that the works is being paid for under the appropriate items, the extension of quantities and rates, and the summation of the amounts shown against each item.

2.13 Audit noted the following:

(a) ***Preparation and checking of contract documents.*** There were disputes under Contract D on measurement and valuation of formwork. According to the Arbitrator, the disputes arose from different interpretations on the application of class of formwork finish and BQ of Contract D did not correctly represent the works shown on the drawings and described in the General Specification (see para. 2.9(a) and (b)). Other major disputes were related to omitted items in BQ (see para. 2.10). In the event, $13.6 million and $5.9 million were paid to Contractor D to settle these claims respectively. Consultant X paid to the Government a sum of $13.6 million to settle all the claims under Consultancy X on a "without any admission of liability or wrongdoing" basis (see para. 2.11); and

(b) ***Certification of interim payments to contractor.*** According to Consultant X, it certified the payments for class F2 formwork finish at the BQ rate for this class under Contract D with the intention to assist Contractor D with its cash flow. According to WSD, interim payments had to be based on the BQ rate for class F2 formwork finish so long as they were applicable according to the terms of contract. Consultant X subsequently adjusted the interim payments to Contractor D to recover the overpaid amount of $8.9 million (see para. 2.8(e)).

2.14 In October 2021, WSD informed Audit that:

(a) it had completed a review on Contract D after its substantial completion in July 2013. In March 2015, following the completion of the review, WSD issued guidance notes which included the requirements of carrying out a pre-tender cross-checking procedure when preparing a BQ; and

(b) in certifying interim payments to contractors, it would require consultants to:

(i) pay particular attention to payments involving over-priced/ under-priced items when there is substantial change in quantities; and

(ii) report to WSD any irregularities including possible overpayments.

2.15 In Audit's view, there is scope for WSD to draw lessons from the disputes under Contract D.

Audit recommendations

2.16 **Audit has *recommended* that the Director of Water Supplies should, in implementing works projects in future (particularly for lump sum contracts):**

(a) **remind WSD staff and consultants to critically vet contract documents (e.g. BQ) for ensuring their completeness, accuracy and consistency with one another in accordance with the related guidelines; and**

(b) **in certifying interim payments to contractors, require consultants to:**

(i) **pay particular attention to payments involving over-priced/ under-priced items when there is substantial change in quantities; and**

(ii) **report to WSD any irregularities including possible overpayments.**

Response from the Government

2.17 The Director of Water Supplies agrees with the audit recommendations.

Other project and contract management issues

Scope for enhancing pre-tender site investigations and tree surveys

2.18 Contract J was a remeasurement contract (Note 25) covering the construction of the Lok On Pai SWPS and associated works. WSD awarded Contract J to Contractor J in January 2010 at $116.9 million and the works commenced in February 2010. Audit noted that the works were substantially completed in late December 2014, about 23 months later than the original completion date of February 2013. According to WSD, extensions of time totalling 671 days (22.1 months) were granted and Contract J was completed 21 days (0.7 months) later than the extended contract completion date of early December 2014 (the delay of 21 days was subject to liquidated damages). The reasons for granting the extensions of time mainly included the following:

(a) ***Adverse ground conditions.*** In constructing the SWPS, Contractor J was required to construct a precast concrete intake culvert (Note 26) at the sea. During the construction stage, Contractor J found that there was marine mud and large boulders below the original foundation level of the proposed intake culvert, which was at variance with the contract drawings. According to WSD:

(i) as the marine mud would affect the stability of the proposed intake culvert, Contractor J was requested to carry out additional works to remove it and to replace by rockfill filter layer in order to provide a firm ground for the proposed intake culvert; and

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Note 25: *Under a remeasurement contract, the costs of works are based on the actual quantities of works done to be remeasured and the prices of different works items as priced by the contractor in BQ according to the contract. BQ, which form part of the tender documents and subsequently the contract documents after the award of a contract, contain estimated quantities of various works items. A tenderer needs to provide a tender price for the relevant BQ items. For the successful tenderer, BQ prices would be used for valuing the actual works performed as remeasured.*

Note 26: *According to WSD, a seawater intake culvert was constructed to extend from the SWPS towards the seabed by removing part of the existing seawall for seawater intake.*

(ii) as part of the works under another section of works had to be constructed on top of the intake culvert which could not be commenced until the completion of the intake culvert construction, the progress of that section was also affected as a consequential effect;

(b) ***Trees not shown in contract drawings.*** In constructing the SWPS, Contractor J identified that 8 trees were not shown in the contract drawings. Of these 8 trees, 3 would obstruct the construction works and were required to be transplanted before the construction commenced; and

(c) ***Excavation of rocks.*** During the excavation works, the quantities of rocks actually excavated were substantially greater than those stated in BQ of Contract J. According to WSD, the actual volume of rocks excavated increased from 760 cubic metres (m^3) to 1,632 m^3 (i.e. an increase of 872 m^3 or 115%), which significantly raised the construction difficulty.

In the event, extensions of time totalling 595.5 days were granted for the above reasons, leading to prolongation costs of $8.7 million as assessed according to the terms of the contract.

2.19 According to the Project Administration Handbook:

(a) a properly planned site investigation (including adequate supervision of the ground investigation and laboratory testing) is essential to identify the geotechnical problems of a site and provide sufficient data for safe and economic design and construction; and

(b) the need for tree preservation and tree felling/transplanting to be included in the contract should have been identified during the planning and design stage with necessary approvals obtained.

2.20 In October 2021, WSD informed Audit that:

(a) the WSD Civil Engineering Design Manual was recently updated in September 2021 with a view to strengthening the requirements on

pre-tender site investigations (e.g. sufficient inspection pits should be dug to obtain underground conditions before the alignment is finalised); and

(b) a review of the requirements on tree surveys was in progress.

2.21 In Audit's view, WSD needs to:

(a) in implementing works projects in future, remind its staff to comply with the requirements recently updated in September 2021 on pre-tender site investigations and continue to enhance the requirements with a view to providing better information on site conditions for design and tender purposes; and

(b) early complete the review of the requirements on tree surveys with a view to enhancing planning and design work.

Scope for better ascertaining the presence of underground structures in the vicinity of the works sites at the pre-tender stage

2.22 Under Contract J, Contractor J was required to lay a salt water main in a sleeve pipe in Tuen Mun. Audit examination found that some underground structures were identified during the course of construction, as follows:

(a) according to the original design, the construction of a portion of the pipeline would encounter rock stratum while the rest would be almost free from rock. During the course of construction, due to the obstruction of existing drainage manholes, the original design was regarded as not reasonably feasible unless revised to avoid the manholes (Note 27); and

(b) in order to complete the works, WSD revised the design by lowering the invert level of the pipeline at one pit. As a result, a substantial portion of the pipeline (which should be located above the bedrock according to the

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Note 27: *According to WSD, the depth of pipeline under the original design was underestimated in avoiding the obstruction of existing drainage manholes practicably.*

original design) became embedded inside the rock stratum and more rock excavation was thus required. The substantial increase in quantities of rock excavation significantly increased the construction difficulty.

Contractor J submitted a claim for additional costs due to the increase in quantities of rock excavation. In the event, $5.4 million was paid to Contractor J according to the terms of the contract.

2.23 According to Environment, Transport and Works Bureau Technical Circular (Works) No. 17/2004 on "Impossibility/Unforeseen Ground Conditions/Utility Interference", project officers should investigate the existence of any buried underground structures such as abandoned old seawalls, pile caps, etc. within or in the vicinity of the works site and verify the accuracy of the records of these buried structures.

2.24 In October 2021, WSD informed Audit that the WSD Civil Engineering Design Manual was recently updated in September 2021 with a view to strengthening the requirements on gathering as-built records of underground structures (including abandoned seawalls and piers) that might affect mainlaying works involving deep excavation.

2.25 In Audit's view, in implementing works projects in future, WSD needs to remind its staff to comply with the requirements recently updated in September 2021 on gathering as-built records of underground structures and continue to enhance the requirements with a view to better ascertaining the presence of underground structures in the vicinity of the works sites at the pre-tender stage.

Need to timely conduct post-completion review

2.26 According to the Project Administration Handbook:

(a) a post-completion review is a useful project management tool and shall be conducted upon the substantial completion of a major consultancy agreement or a major works contract on projects under the Public Works Programme;

(b) as a broad guideline, post-completion reviews are generally not warranted for consultancy agreements and works contracts of a project which has a total cost less than $500 million or of a project which does not involve complicated technical and management issues;

(c) indicators that a project involves complicated issues may include project involving a claim of a substantial sum, say over $1 million;

(d) a post-completion review should be carried out within a reasonable period, say six months, after the substantial completion of a consultancy agreement or a works contract. However, in case there are on-going disputes with the service providers, it may be more appropriate to defer the review until the disputes are settled; and

(e) for a project that comprises a number of contracts/consultancy agreements, the project office may elect, in view of the benefit of an overall review, to conduct a single review upon the substantial completion of the last contract.

2.27 The extension of seawater supply network in Northwest New Territories involved two projects (Projects D and E — see Table 2 in para. 1.11). Audit noted that Project E's total project expenditure exceeded $500 million (i.e. $798.2 million as of June 2021). While all works were substantially completed in March 2015 and the supply system was commissioned in the same month, as of June 2021 (six years later), WSD had not conducted a post-completion review for the project.

2.28 In October 2021, WSD informed Audit that:

(a) the post-completion review of Project E was underway and targeted to be completed by the fourth quarter of 2021; and

(b) though post-completion review was not necessary for a project with a total cost less than $500 million (e.g. seawater supply network extension in Pok Fu Lam), WSD completed a review on Contract D under the project and issued relevant guidance notes in March 2015 (see para. 2.14(a)).

2.29 As a post-completion review is a useful project management tool, in Audit's view, WSD needs to:

(a) complete the post-completion review for Project E as soon as practicable; and

(b) remind its staff and consultants to conduct post-completion reviews as needed in a timely manner.

Audit recommendations

2.30 **Audit has *recommended* that the Director of Water Supplies should:**

(a) **in implementing works projects in future, remind WSD staff to comply with the following requirements recently updated in September 2021:**

(i) **the requirements on pre-tender site investigations, and continue to enhance the requirements with a view to providing better information on site conditions for design and tender purposes; and**

(ii) **the requirements on gathering as-built records of underground structures, and continue to enhance the requirements with a view to better ascertaining the presence of underground structures in the vicinity of the works sites at the pre-tender stage;**

(b) **early complete the review of the requirements on tree surveys with a view to enhancing planning and design work;**

(c) **complete the post-completion review for Project E as soon as practicable; and**

(d) **remind WSD staff and consultants to conduct post-completion reviews as needed in a timely manner.**

Response from the Government

2.31 The Director of Water Supplies agrees with the audit recommendations.

Conversion to seawater flushing

2.32 According to WSD, following the completion of projects for extension of seawater supply network in Pok Fu Lam and Northwest New Territories in July 2013 and March 2015 respectively, it had advised the registered consumers in these 2 areas to convert to seawater flushing. The consumers need to employ licensed plumbers to inspect inside services, and apply to WSD for modification works, if needed, and connection to salt water mains. WSD would schedule the works for pipe connection and seawater supply after payment of the required connection fee (see para. 1.10).

2.33 Between August 2013 and November 2017, WSD engaged 3 consultants to provide services in relation to the conversion to seawater flushing (Note 28) in Pok Fu Lam and Northwest New Territories (see Table 4).

Note 28: *Under the consultancies, the consultants were responsible for condition checking of the existing WSD flushing water distribution systems, inspection of the plumbing installations in the communal parts of the buildings concerned, the design and construction supervision work for the area distribution sub-mains and their connections, and handling consumer-related issues for the conversion to seawater flushing.*

Table 4

Consultancy services for conversion to seawater flushing in Pok Fu Lam and Northwest New Territories (June 2021)

Consultancy	Area covered	Completion date	Consultancy fee incurred ($ million)
Y1 (Awarded in August 2013)	• Pok Fu Lam	December 2015	1.0
Y2 (Awarded in March 2015)	• Northwest New Territories (including Yuen Long, Tuen Mun North and Tin Shui Wai)	October 2018	12.7
Y3 (Awarded in November 2017)	• Pok Fu Lam • Northwest New Territories (including Tuen Mun East and Yuen Long)	Being finalised (Note)	4.8
		Total	18.5

Source: *WSD records*

Note: *According to WSD, the provision of services under Consultancy Y3 had been substantially completed in November 2020 and the completion of Consultancy Y3 was anticipated to be certified upon settlement of the final account in end 2021.*

Need to continue to expedite the conversion to seawater flushing

2.34 The projects for extension of seawater supply network in Pok Fu Lam and Northwest New Territories were completed in July 2013 and March 2015 respectively (see para. 1.11). However, Audit noted that, as of June 2021 (i.e. about 8 and 6 years respectively after the completion of the extension projects), WSD had not completed the conversion to seawater flushing in the two areas. Over 80% of TMF accounts (i.e. using fresh water for flushing — Note 29) in the two areas had not been converted to seawater for flushing (see Table 5). In 2020, 60% (2.4 Mm^3) and 83% (31.6 Mm^3) of the total volume of flushing water in Pok Fu Lam and Northwest New Territories were seawater respectively (i.e. saving of a total of 34 Mm^3 of fresh water). On the other hand, a total of 8.2 Mm^3 of fresh water was still used for flushing in the two areas (or 40% (1.6 Mm^3) and 17% (6.6 Mm^3) of the total volume of flushing water in each respective area — see Table 6).

Table 5

Number of TMF accounts in Pok Fu Lam and Northwest New Territories (June 2021)

Area	Number of TMF accounts		
	Converted to seawater flushing (a)	Not yet converted to seawater flushing (b)	Total (c) = (a) + (b)
Pok Fu Lam	56 (17%)	277 (83%)	333 (100%)
Northwest New Territories	635 (16%)	3,446 (84%)	4,081 (100%)

Source: WSD records

Note 29: *According to WSD, upon the approval for the use of TMF by WSD (see para. 1.5), a TMF account would be created in the Customer Care and Billing System maintained by WSD. The data in the System is mainly account-based for billing purpose. Normally, only one meter is installed to record the total consumption of all flats in the same building.*

Table 6

Flushing water consumption in Pok Fu Lam and Northwest New Territories (2016 to 2020)

Type of flushing water	Flushing water consumption				
	2016 (Mm^3)	2017 (Mm^3)	2018 (Mm^3)	2019 (Mm^3)	2020 (Mm^3)
Pok Fu Lam					
Seawater	1.3 (37%)	1.9 (49%)	2.0 (50%)	2.3 (58%)	2.4 (60%)
Fresh water	2.2 (63%)	2.0 (51%)	2.0 (50%)	1.7 (42%)	1.6 (40%)
Total	3.5 (100%)	3.9 (100%)	4.0 (100%)	4.0 (100%)	4.0 (100%)
Northwest New Territories					
Seawater	10.0 (34%)	18.5 (68%)	23.9 (74%)	26.7 (78%)	31.6 (83%)
Fresh water	19.1 (66%)	8.6 (32%)	8.2 (26%)	7.5 (22%)	6.6 (17%)
Total	29.1 (100%)	27.1 (100%)	32.1 (100%)	34.2 (100%)	38.2 (100%)

8.2 Mm^3

Source: *WSD records*

2.35 According to the consultants of Consultancies Y1 and Y2, the major concerns of registered consumers for conversion to seawater flushing and difficulties encountered by WSD to persuade them during the course of conversion work included the following:

(a) the inside services of buildings were required to be modified by the registered consumers prior to conversion. The cost involved depends on the connection works required and the condition of the inside services. In particular, substantial risk might be noted for conversion at aged buildings;

(b) connection fee (depending on the size and length of the water mains) and excavation permit fee for buildings not directly connected to the salt water mains were required to be paid by the registered consumers;

(c) the buildings would be redeveloped shortly;

(d) the buildings did not have management office or Owners' Corporation for coordinating the application and modification works;

(e) there was a lack of motivation to convert to seawater flushing owing to the tariff structure of using fresh water for flushing (i.e. fresh water is provided free of charge for the first 30 m^3 per flat per 4-month period — see Note 9 to para. 1.8);

(f) seawater was perceived to be corrosive to metallic pipes, fittings and pumps, which might cause higher maintenance cost to the plumbing system; and

(g) there were difficulties in laying sub-mains from the existing salt water mains in certain areas, especially for heavily trafficked roads with stringent road opening restrictions and congested underground utilities.

2.36 According to WSD, the conversion work to seawater flushing is time and effort consuming and it has adopted a strategy to accord priority to deal with those TMF accounts with large flushing water consumption first. As a result, for those TMF accounts which have been converted to seawater for flushing, a total of 34 Mm^3 of fresh water had been saved in 2020, representing 60% and 83% of the total volume of flushing water in Pok Fu Lam and Northwest New Territories respectively. Besides, in addressing the concerns of consumers on conversion to seawater flushing, WSD had taken the following proactive measures:

(a) it had redeployed in-house staff resources and created new posts to strengthen the communication with relevant parties (e.g. consumers, district council members, residents' associations and management offices of housing estates) and provided advice and technical support to them on the inspection and modification of internal plumbing systems to facilitate the conversion;

(b) regarding the connection fee (see para. 2.35(b)), since October 2019, registered consumers of buildings not directly connected to the salt water mains might apply to WSD for waiving the connection fee if certain conditions were met (Note 30); and

(c) regarding the tariff structure of using fresh water for flushing (see para. 2.35(e)), in November 2020, DEVB and WSD launched a public consultation on the proposed amendments to the Waterworks Ordinance (Cap. 102), including the introduction of a financial disincentive scheme (Note 31) to those non-compliant registered consumers who refused to convert to seawater for flushing. The consultation period ended in February 2021. As of September 2021, DEVB and WSD were reviewing the consultation results.

2.37 While the salt water supply systems for Pok Fu Lam and Northwest New Territories had been completed 8 and 6 years ago respectively, over 80% of TMF accounts in these two areas had not been converted to seawater flushing and 8.2 Mm^3 of fresh water (i.e. 19% of total flushing water) was used for flushing in 2020 (see Table 6 in para. 2.34). In this connection, apart from the two areas, Audit noted that some consumers in other seawater supply zones (i.e. with salt water supply systems available) were still using fresh water for flushing. According to WSD, there were 4,134 such TMF accounts (excluding those in Pok Fu Lam and Northwest New Territories) as of June 2021 and 18.8 Mm^3 of fresh water was used for flushing in 2020.

Note 30: *According to WSD, the conditions for waiving connection fee included: (a) the subject building's fresh water pipes and TMF pipes were installed and interconnected inside the building lot, and only one common connection pipe for both internal fresh water and TMF systems was extended onto government land for connection; (b) there was evidence showing that a decision had been made by property owners to proceed with the modification works of inside services required for the conversion from TMF to seawater; and (c) the waived connection charge could be offset by saving within five years after conversion of the building from TMF to seawater flushing.*

Note 31: *It was proposed that flushing water consumption of non-compliant registered consumers could be charged at the highest rate for fresh water supply for domestic purposes (i.e. $9.05 per m^3 of consumption presently) without any free allowance.*

2.38 According to WSD:

(a) conversion to seawater flushing was progressed with lower priority as priority had been accorded to tasks of greater imminence or urgency (e.g. maintenance of water supply systems to serve the existing accounts and provision of water supply for new account applications) to ensure public accessibility to safe and quality water supply with continuity; and

(b) with a view to expediting the progress of conversion to seawater flushing over the territory, it has already sought necessary policy support to engage consultants to conduct investigation into the remaining TMF accounts within the seawater supply zones in Hong Kong (Note 32). Based on the results of the investigation, the conversion work for about 200 TMF accounts accorded with top priority will be completed by end 2024 tentatively, and the remaining conversion work will be taken forward in next few years progressively with due considerations to cost and benefit, technical feasibility, etc.

Audit recommendations

2.39 **Audit has *recommended* that the Director of Water Supplies should:**

(a) **continue to expedite the conversion to seawater flushing for consumers in seawater supply zones (including Pok Fu Lam and Northwest New Territories), including taking measures to address the consumers' concerns and difficulties encountered during the course of conversion work;**

(b) **draw on experience gained in Pok Fu Lam and Northwest New Territories with a view to enhancing future conversion work; and**

Note 32: *According to WSD, it started to procure an investigation, design and construction consultancy in end September 2021. It is expected that the consultancy agreement will be awarded and relevant consultancy services will commence in early 2022.*

(c) **complete the review of the results of public consultation on the proposed amendments to the Waterworks Ordinance (including the introduction of a financial disincentive scheme) as early as practicable.**

Response from the Government

2.40 The Director of Water Supplies agrees with the audit recommendations.

PART 3: OPERATION AND MAINTENANCE OF SEAWATER SUPPLY SYSTEMS

3.1 This PART examines WSD's work in operation and maintenance of seawater supply systems, focusing on:

(a) monitoring of flushing water quality and complaint handling (paras. 3.2 to 3.14); and

(b) maintenance of seawater supply systems (paras. 3.15 to 3.34).

Monitoring of flushing water quality and complaint handling

3.2 Most of the SWPSs are located on or near seafronts enabling direct pumping of seawater into the flushing water distribution network. Screens are installed at intake structures to keep debris from entering the pumping stations. Sodium hypochlorite is dosed in the seawater for disinfection before the seawater is supplied to the customers for flushing. The residual chlorine will also help prevent marine growth in the distribution pipes.

3.3 ***Flushing water quality.*** WSD has laid down standards (i.e. Water Quality Objectives) for flushing water to ensure that the quality of seawater for flushing is acceptable. The Water Quality Objectives for seawater for flushing comprise nine parameters (e.g. *Escherichia coli*, suspended solids and turbidity — Note 33) to ensure that flushing water conforms chemically and bacteriologically to WSD's Water Quality Objectives. WSD has set out a key performance measure for flushing water quality. Before 2018-19, the key performance measure was "salt water quality — water supplied to customers at the connection points complies with Water Quality

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Note 33: *Apart from these three parameters, the other six parameters are ammoniacal nitrogen, biochemical oxygen demand, colour, dissolved oxygen, synthetic detergents and threshold odour number.*

Objectives set by WSD". Since 2018-19, the measure has been revised (Note 34) to reflect WSD's commitment to the extension of compliance monitoring from connection points (Note 35) to customer ends. The target compliance has also been increased from 96% to 97% since 2019-20. According to WSD, such target had been met in the last five years from 2016-17 to 2020-21.

3.4 ***Programme for monitoring flushing water quality.*** According to WSD, it has implemented a programme for monitoring flushing water quality. Under the programme, samples are taken from monitoring points (Note 36) at SWPSs, SWSRs and customer ends (such as publicly accessible toilets at estate management offices, shopping centres, government buildings and community facilities). WSD plans the programme for monitoring flushing water annually, as follows:

(a) fixed monitoring points are selected for taking samples with specified visiting frequencies (ranging from 2 to 24 times per year (i.e. twice a year to twice a month)); and

(b) during each visit of the monitoring point, flushing water samples will be taken for testing under various parameters (Note 37) to ensure that flushing water complies with WSD's Water Quality Objectives.

Note 34: *The key performance measure was stated as "salt water quality — water supplied to customers complies with Water Quality Objectives set by WSD" in 2018-19 and 2019-20. It was renamed as "flushing water quality — salt water supplied to customers complies with Water Quality Objectives set by WSD" in 2020-21.*

Note 35: *According to WSD, a connection point refers to the location where the inside services of a building are connected to the government water main.*

Note 36: *According to WSD, a monitoring point refers to the location where samples are taken for testing the flushing water quality.*

Note 37: *The flushing water samples are tested under various parameters with different testing frequencies.*

3.5 According to WSD, in 2020-21, flushing water samples were taken from monitoring points at all SWPSs and SWSRs (Note 38) and 30 customer ends. Audit noted that there was scope for improvement in sampling of flushing water quality at customer ends (see paras. 3.6 to 3.8).

Scope for improving the sampling of flushing water quality at customer ends

3.6 According to WSD, for sampling of flushing water quality at customer ends, the selection criteria are based on accessibility and the representativeness of the sampling point with inputs from the regional offices. Regarding the sampling of flushing water quality at customer ends, Audit noted that the number of monitoring points at customer ends decreased from 63 in 2018-19 to 55 in 2019-20, and further to 30 in 2020-21 (Note 39). A total of 70 different monitoring points were covered in the three-year period. Of the 70 monitoring points, the same 25 (36%) monitoring points had been selected in all three years.

3.7 According to WSD:

(a) the effectiveness of the monitoring programme was reviewed periodically. In 2019, WSD commissioned an expert consultant to conduct a review (including making reference to the international practices on flushing water

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Note 38: *According to WSD: (a) of 35 SWPSs in 2020-21: (i) flushing water samples were taken from 21 seafront SWPSs at the intake points and after the chlorination process to monitor the seawater quality; and (ii) the remaining 14 SWPSs were not covered in the sampling programme as they were booster pumping stations (i.e. the intake of seawater for the SWPSs was pumped from other seafront SWPSs which were subject to flushing water sampling); and (b) of 54 SWSRs in 2020-21: (i) flushing water samples were taken from 52 SWSRs; and (ii) samples were not taken from the remaining 2 SWSRs because one SWSR was temporarily closed and for the other SWSR, seawater was transferred to another SWSR (which was subject to flushing water sampling) before delivery to customers.*

Note 39: *According to WSD, flushing water samples were collected from 30 monitoring points at customer ends in 2020-21, including one monitoring point in each seawater supply zone (i.e. 21 monitoring points), an additional monitoring point for each seawater supply zone with output greater than 2,000 million litres per month (i.e. 6 monitoring points) and additional monitoring points identified with inputs from regional offices (i.e. 3 monitoring points).*

supply) on health risks associated with seawater for flushing in Hong Kong. Based on the recommendations of the expert consultant, sufficient level of residual chlorine at SWSRs could be one of the control measures to reduce the health risks to an acceptable level. Therefore, WSD commenced the water quality monitoring at 52 SWSRs from 2020-21 (Note 40) without additional manpower and resources on sampling and testing work. Given that the overall total number of flushing water samples was maintained at around the same level, the number of samples and the monitoring points at customer ends in 2020-21 was reduced; and

(b) it would continue to review the availability of publicly accessible monitoring points in the seawater supply zones. The update and change of relevant sampling programme were discussed and reported in the Group Meeting for Resources Management Matters (Note 41) regularly. More details would be recorded in the minutes of the meeting in the future.

3.8 The key performance measure for flushing water quality is to ensure that the flushing water at customer ends conforms to WSD's Water Quality Objectives (see para. 3.3). Audit noted that:

(a) while WSD's selection criteria for sampling of flushing water quality at customer ends are based on accessibility and the representativeness of the sampling points (see para. 3.6), as of October 2021, it had no specific guidelines in this regard. In November 2021, WSD informed Audit that the detailed guidelines of the sampling programme for flushing water were documented in the Testing Programme for Monitoring of Seawater for Flushing Supply issued on 4 November 2021; and

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Note 40: *According to WSD, flushing water samples were taken from 5 SWSRs in both 2018-19 and 2019-20.*

Note 41: *The Group Meeting for Resources Management Matters, chaired by a Senior Chemist of WSD and with members from WSD's Development Branch, is established to evaluate the suitability and adequacy of the operation system in monitoring water quality.*

(b) the number of monitoring points at customer ends decreased from 63 in 2018-19 to 30 in 2020-21 (see para. 3.6). While the changes of relevant sampling programmes for flushing water were reported in regular WSD's meetings, the details were not documented (e.g. selection of individual monitoring points at customer ends). According to WSD, it would record more details in meeting minutes in the future (see para. 3.7(b)). In Audit's view, WSD needs to document more details in this regard.

Need to continue to share the experience gained in handling the incidents on entry of debris to seawater supply system

3.9 In March 2021, WSD received complaints that dead shrimps were found in the flushing water inside services of two housing estates in Tuen Mun, affecting the supply of seawater for flushing in the estates (Note 42). In the event, after further inspection, WSD found that three housing estates in Tuen Mun were affected. According to WSD:

(a) for the cause of the incident, as seawater for flushing was disinfected with chlorine, it was unlikely that the shrimps could breed and flourish inside the flushing water system. Having reviewed the seawater quality of the intake chamber of the Lok On Pai SWPS, where seawater was extracted for the affected estates, it was noted that the seawater quality in the affected period was better compared with the same period from 2016 to 2020. This might be beneficial for breeding of shrimps and some of them might enter the flushing system together with the seawater;

(b) to prevent recurrence of similar incidents, it had taken various measures at the Lok On Pai SWPS, including desilting at intake chamber (completed in March 2021), adding screens with finer mesh openings at intake chamber (completed in March 2021) and stepping up inspections to the strainers within the pumping stations for early detection of entry of small debris to the seawater supply system (ongoing measure); and

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Note 42: *According to the complaints, the dead shrimps slowed down the seawater flow in the flushing water inside services of the buildings, resulting in insufficient seawater for flushing.*

(c) the incident, which only occurred in the Lok On Pai SWPS supply zone, was a rare incident. Nevertheless, the case and the follow-up actions taken were shared in the Working Group on Improvement of Salt Water Quality (Note 43) in August 2021.

3.10 In Audit's view, WSD needs to continue to share with all parties concerned the experience gained in handling the incidents relating to entry of debris to the seawater supply systems with a view to ensuring the flushing water quality meeting its Water Quality Objectives.

Scope for improving handling complaints on seawater supply systems

3.11 According to WSD:

(a) upon receipt of a complaint, it will send an acknowledgement of receipt of the complaint to the complainant no later than ten calendar days upon receipt of the complaint; and

(b) it will conduct investigation, take follow-up action (e.g. arrange site inspection and conduct the rectification works) and provide a substantive reply to the complainant within 30 calendar days as far as practicable. The complaint will be monitored and recorded under a complaint management system. Regular management reports of the complaints will be sent to the supervisory staff for monitoring.

3.12 From January 2018 to March 2021 (i.e. 39 months), WSD received 2,544 complaints on seawater supply systems, including 1,109 (44%) complaints related to no or poor flushing water supply, 664 (26%) complaints related to inside service leak or burst, and 354 (14%) complaints related to flushing water quality. Audit noted that there was scope for improvement, as follows:

Note 43: *The Working Group on Improvement of Salt Water Quality, chaired by an Assistant Director of WSD and with members from WSD's Development Branch, Supply and Distribution Branches, New Works Branch and Mechanical and Electrical Branch, is established to monitor the quality of seawater for flushing.*

(a) ***Long time taken to complete the follow-up actions on some complaints.*** According to the complaint management system, of the 2,544 complaints on seawater supply system, as of March 2021:

(i) the follow-up actions for 2,497 (98% of 2,544) complaints had been completed. Except 68 complaints with data entry problems (see (b) below), for 607 (25%) of the remaining 2,429 complaints, WSD took more than 1 month and up to 12 months (averaging 2 months) to complete the follow-up actions after receipt of the complaints; and

(ii) the follow-up actions for 47 complaints had not been completed, of which 27 (57%) complaints had been received for more than 1 month and up to 9 months (averaging 4 months).

In October 2021, WSD informed Audit that, for 318 (52%) of the 607 complaints (see (i) above) and 12 (44%) of the 27 complaints (see (ii) above), the cases were related to seepage or inside service burst and leak (Note 44) for which private parties were involved and a longer handling time was normally required to liaise with concerned parties (e.g. the premises owners/tenants and District Council members). In Audit's view, WSD needs to continue to follow up the complaints on seawater supply systems as early as practicable; and

(b) ***Need to improve record keeping of complaint information.*** Audit noted that 68 complaints had data entry problems in the complaint management system as of March 2021 (see (a)(i) above), as follows:

(i) the completion dates for handling 6 complaints were earlier than the complaint receipt dates. In October 2021, WSD informed Audit that, after further checking, these were due to typographical errors,

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Note 44: *Excluding the cases related to seepage or inside service burst and leak, for the remaining: (a) 289 (48%) of the 607 complaints (see para. 3.12(a)(i)), WSD took more than 1 month and up to 8 months (averaging 2 months) to complete the follow-up actions after receipt of the complaints; and (b) 15 (56%) of the 27 complaints (see para. 3.12(a)(ii)), they had been received for more than 1 month and up to 8 months (averaging 4 months) but follow-up actions had not been completed.*

and there was no case with completion date earlier than the complaint receipt date; and

(ii) the follow-up actions and the completion dates for handling 62 cases were not recorded. According to WSD, follow-up actions had been taken but not inputted into the system. In October 2021, WSD informed Audit that the records for 45 of the 62 cases had been subsequently updated in the system, and the details for the remaining 17 cases could not be traced.

In Audit's view, WSD needs to take measures to ensure that information about complaints on seawater supply systems is accurately and timely updated in the complaint management system.

Audit recommendations

3.13 **Audit has *recommended* that the Director of Water Supplies should:**

(a) **document more details about the changes of sampling programmes for flushing water;**

(b) **continue to share with all parties concerned the experience gained in handling the incidents relating to entry of debris to the seawater supply systems with a view to ensuring the flushing water quality meeting WSD's Water Quality Objectives;**

(c) **continue to follow up the complaints on seawater supply systems as early as practicable; and**

(d) **take measures to ensure that information about complaints on seawater supply systems is accurately and timely updated in the complaint management system.**

Response from the Government

3.14 The Director of Water Supplies agrees with the audit recommendations.

Maintenance of seawater supply systems

3.15 WSD is responsible for maintenance of the seawater supply systems for flushing, including salt water mains, SWPSs and SWSRs (Note 45). According to WSD, various measures have been implemented to maintain the healthiness of the seawater supply network and reduce water loss (see paras. 3.16 to 3.18).

3.16 ***Improvement works of salt water mains.*** Since late 2017, WSD has implemented a risk-based water main asset management strategy to maintain the healthiness of the water supply network (for both fresh and salt water) and reduce the risk of water main bursts and leaks. According to WSD, it will assess the risk of water main bursts or leaks taking into account various factors and accord priorities to those water mains assessed with high risk for improvement works, including replacement and rehabilitation, so as to reduce the risk of water main bursts and leaks. According to WSD, to prioritise the water mains for risk-based improvement works:

(a) a scoring system is developed to prioritise all water mains into five ranks (from Rank 1 (the highest risk) to Rank 5 (the lowest risk)), taking into account:

(i) the probability of failure (e.g. ages and materials of water mains (Note 46), past records of bursts or leaks and surrounding condition); and

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Note 45: *As of March 2021, there were 35 SWPSs and 54 SWSRs. According to WSD: (a) of the 35 SWPSs, 19 SWPSs were day-manned and inspection was carried out daily. For the remaining 16 unmanned SWPSs, inspection was carried out at least once a week; (b) for the 54 SWSRs, WSD carried out regular inspection on a monthly basis; and (c) there was no incident/non-compliance report for the inspections carried out for SWPSs and SWSRs in 2019 and 2020.*

Note 46: *According to WSD, the expected service lives of salt water mains range from 20 to 70 years, depending on the pipe materials and ground environment.*

(ii) the consequence of bursts or leaks (e.g. number of consumers, impact to traffic and impact to adjacent features);

(b) the regional offices of WSD will, from time to time, review and provide comments and suggestions on the water mains for improvement works; and

(c) the Risk-based Improvement Works Prioritisation Committee (Note 47) is established to monitor, prioritise and endorse the water mains for improvement works.

3.17 ***Repair of salt water main bursts and leaks.*** According to WSD, an incident is classified as a water main burst when there is an immediate need to isolate water supply under certain circumstances (Note 48). Water main leak incidents refer to other events for which an immediate isolation of water supply is not normally required. WSD has set two performance pledges with time targets in handling salt water main bursts (Note 49). The numbers of salt water main bursts and leaks from January 2017 to March 2021 are shown in Table 7.

Note 47: *The Risk-based Improvement Works Prioritisation Committee, chaired by an Assistant Director of WSD and with members from WSD's New Works Branch and Supply and Distribution Branches, was established in April 2018 to monitor the progress of works items approved, prioritise or re-prioritise these items as necessary, and consider and endorse new items of additional works requested by regional offices.*

Note 48: *According to WSD, the circumstances include: (a) the outflow of water is significant in quantity; (b) the velocity of water escaping from the faulty main is high; and (c) there is an imminent danger of flooding the area and/or causing significant traffic disruption.*

Note 49: *The two performance pledges are: (a) "time after receipt of report of burst main for valve closure to enable repair works to start", with targets of 80% within 1 hour and 15 minutes for pipe diameter up to 300 millimetres, and 80% within 2 hours for pipe diameter above 300 millimetres to 600 millimetres; and (b) "duration of supply interruption due to salt water main burst", with target of 75% within 24 hours. According to WSD, the target for the first performance pledge for salt water mains was achieved in the past three years from 2017-18 to 2019-20 and that for the second performance pledge (introduced in 2019-20) was achieved in 2019-20.*

Table 7

Number of salt water main bursts and leaks
(January 2017 to March 2021)

Year	No. of salt water main bursts	No. of salt water main leaks
2017	52	1,876
2018	58	1,827
2019	27	1,882
2020	17	2,006
2021 (up to March)	3	478

Source: WSD records

3.18 ***Leak detection of salt water mains.*** According to WSD, water main bursts and some visible leaks are usually noticeable and will be reported by various parties (e.g. the public and WSD's maintenance staff). To tackle water main leaks, WSD has carried out routine leak detection on water mains (for both fresh and salt water) to identify and locate any leak in the water mains for repairs at an early stage in order to reduce the water loss and to prevent the leaks from developing into bursts. The leak detection work includes sounding and visual inspections of the water mains, associated valves and fittings, leakage tests by noise loggers and leakage surveys by leak noise correlators.

Scope for improving the selection of salt water mains for improvement works

3.19 According to WSD:

(a) the risk-based water main asset management strategy is to accord priorities to those water mains (for both fresh and salt water) assessed with relatively higher risk for improvement works in order to minimise the chance of occurrence and consequence of pipe failure; and

(b) implementation of improvement works will depend on the manpower and funding resources available amongst other work priorities as well as other implications and technical feasibility including disturbance to traffic and the public.

3.20 WSD conducted a prioritisation exercise of water mains based on the scoring system (see para. 3.16(a)) in 2016. As of March 2021, after taking into account the priority list (compiled based on the scoring system) and the comments provided by the regional offices, 1,227 salt water mains (with a total length of about 39.1 km) had been selected for improvement works. Audit noted that there was scope for improvement, as follows:

(a) ***Some salt water mains classified as high risk under the scoring system not selected for improvement works.*** According to WSD's prioritisation exercise (based on the scoring system) in 2016, 3 salt water mains were classified as the highest risk (i.e. Rank 1) and 61 salt water mains as high risk (i.e. Rank 2) (see para. 3.16(a)). However, Audit noted that as of March 2021 (about five years later), 2 (67%) of the 3 salt water mains of the highest risk and 23 (38%) of the 61 salt water mains of high risk had not been selected for improvement works. In July and October 2021, WSD informed Audit that owing to practical difficulties (including traffic impact, interface issue, site constraints and the outbreak of coronavirus disease (COVID-19)), longer time was required for planning of the improvement works for these salt water mains. The objective of the risk-based improvement works is to reduce the risk of water main bursts and leaks (see para. 3.16). In Audit's view, WSD needs to include salt water mains of high risk for implementation of improvement works with a view to reducing the risk of main bursts and leaks as far as practicable; and

(b) ***Scope for reviewing salt water main burst cases.*** From January 2018 to March 2021 (i.e. 39 months), there were 105 salt water main burst cases. According to WSD, 73 (70%) of the 105 salt water main burst cases (Note 50) were caused by corrosion of water mains. Audit noted that, of the 73 cases, the salt water mains for 68 (93%) cases had not been identified

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Note 50: *Of the 105 salt water main burst cases, 73 (70%) cases were caused by corrosion of water mains, 14 (13%) cases by external disturbances (e.g. damaged by others) and the remaining 18 (17%) cases by other factors.*

as high risk and therefore had not been selected for improvement works. Of the 68 cases, 19 (28%) cases were major emergency incidents of main bursts where emergency announcement via the radio was made for the incidents (Note 51). In October and November 2021, WSD informed Audit that:

(i) there had been an overall improving trend (i.e. decreasing number of main bursts per year) with the continuous effort of replacement of water mains. The salt water mains with burst cases were not necessarily those previously identified as high risk (e.g. no past failure record and low failure consequence) under the prioritisation exercise, which was carried out based on the information available at the time of the prioritisation exercise prior to some bursts. All the 68 cases were not accorded with high consequence of failure; and

(ii) any failure case would be studied and opportunity would be taken for considering enhancement to the risk assessment. While no particular enhancement on the risk assessment had been proposed arising from the 68 cases concerned, if the criteria of hot spots (see para. 3.21(a)) were met, the relevant water mains would be accorded with priority for earlier improvement, which was a supplement to the risk assessment exercise.

In Audit's view, WSD needs to continue to review salt water main burst cases with a view to enhancing the risk assessment relating to selection of salt water mains for improvement works.

Note 51: *According to WSD guidelines, for major emergency incidents of main bursts (e.g. serious supply interruption affecting large population, and incidents likely generating wide media coverage or great public concern), emergency announcement through the radio and other press media should be made so as to keep the public promptly informed of the incidents.*

Scope for enhancing the improvement works of salt water mains

3.21 WSD has outsourced the risk-based improvement works of water mains to contractors. In November 2017 and January 2018, WSD awarded two contracts for implementation of the improvement works (Note 52) with completion dates in May 2021 and August 2021 (Note 53). Audit noted the following issues:

(a) ***Improvement works for some salt water main burst hot spots not completed after a long time.*** Main burst hot spots refer to locations with repeated water main bursts (Note 54). According to WSD, it accords the highest priority to arrange improvement works at hot spots to eliminate the risk of water main bursts. WSD identified 44 hot spots of salt water main bursts for which improvement works were required. Audit noted that, as of April 2021, the improvement works for 30 hot spots had been completed and the works for 14 (32%) hot spots were still in progress. The works for 13 (93%) of the 14 hot spots had not been completed for more than 2 years and up to 6.5 years (averaging about 4.5 years) after the last burst at the hot spot. In October 2021, WSD informed Audit that the progress of the improvement works would depend on the site conditions and other constraints. In Audit's view, WSD needs to continue to take measures to ensure that improvement works at salt water main burst hot spots are completed as soon as practicable;

(b) ***Some improvement works for salt water mains not completed a long time after their target completion dates.*** Under the contracts, WSD will issue works orders (including commencement dates and completion dates) to the contractors to carry out the improvement works of salt water mains.

Note 52: *The two contracts were awarded to two contractors for implementation of the risk-based improvement works for both fresh and salt water mains, with a total contract sum of $830.2 million for improvement works for about 82 km of water mains. According to WSD, the corresponding contract sum and pipe length for improvement works of salt water mains were about $190 million and 20 km.*

Note 53: *The contract periods were from November 2017 to May 2021 and from February 2018 to August 2021.*

Note 54: *According to WSD, a hot spot refers to a location where at least two bursts (other than damage or suspected damage cases) of water mains (in diameter of 150 millimetres or above) occurred in two years within a road section in 400 metres length.*

According to WSD, a total of 207 works orders were issued for the improvement works of the 1,227 salt water mains (see para. 3.20). As of August 2021, of the 207 works orders, the works for 187 (90%) works orders had been completed and the works for 20 (10%) works orders had not been completed (being 25 to 212 days (averaging 52 days) later than their original completion dates) (Note 55). Audit considers that WSD needs to continue to take measures to ensure that improvement works of salt water mains are completed as soon as practicable; and

(c) ***Need to keep under review the development of computerised system in monitoring progress of improvement works.*** Audit noted that WSD had maintained the information of improvement works of salt water mains in spreadsheets. However, information on the salt water mains included in each works order was not consolidated into a centralised information platform and management information (e.g. highlights of overdue works orders) was not readily available. In October 2021, WSD informed Audit that:

(i) it monitored the progress of improvement works in the individual works orders under the respective contracts monthly and as required; and

(ii) it had included the development of a Task Order Management System in the new risk-based improvement contracts commencing in late September 2021 with expected commissioning in January 2022 at the earliest. The System would be a workflow enabled application system to facilitate digital processing of required forms and records with one centralised database system for monitoring programme and progress of works summary/records.

In Audit's view, WSD needs to keep under review the development of the computerised system for maintaining details of improvement works of salt water mains with a view to facilitating monitoring of progress of works.

Note 55: *According to WSD, as of October 2021, extension of completion date was being assessed for these works orders according to the contract terms and would be granted if applicable.*

Scope for enhancing the monitoring of repair works for salt water main bursts

3.22 For water main bursts and leaks, WSD has mainly engaged term contractors (Note 56) to carry out repair works of the water mains. According to the contracts, the contractors should provide adequate labour and/or plant to handle all emergency works, including deploying a specified minimum number of workers (ranging from 3 to 14 workers — Note 57) for attending to an emergency involving water main burst.

3.23 WSD maintains the details of all water main burst and leak cases (e.g. date and time, location, estimated volume of water loss and labour force of contractor) in a computerised Maintenance Works Management System (MWMS). From January 2018 to March 2021 (i.e. 39 months), there were 105 salt water main burst cases, resulting in a total estimated seawater loss of 46,184 m^3. Based on MWMS records, Audit noted 12 cases which did not meet the contract requirement on minimum number of contractors' workers and referred them to WSD for examination. In October 2021, WSD informed Audit that, after further checking, there was typographical error in inputting the number of contractors' workers in MWMS for 3 cases (see also para. 3.28(a)) and 2 of them met the minimum contract requirement after correction. As a result, there were 10 cases with shortfall in contractors' workers by 2 to 5 (ranging from 20% to 63%, averaging 33%). According to WSD, the non-compliance would be reflected in the contractors' performance reports.

3.24 In Audit's view, WSD needs to take measures to ensure that the contractors comply with the contract requirement of deploying adequate labour to handle emergencies involving salt water main bursts.

Note 56: *As of March 2021, WSD had awarded five term contracts for waterworks, with scope of works including maintenance and repair of water mains and waterworks installation, road reinstatement associated with these works and construction of minor works.*

Note 57: *According to the contracts, the minimum number of workers depends on the size of the burst main and whether the burst is located within carriageway.*

Scope for improving attendance to salt water main leaks

3.25 The number of salt water main burst cases decreased by 67% from 52 cases in 2017 to 17 cases in 2020 (see Table 7 in para. 3.17). On the other hand, while the number of salt water main leak cases decreased by 3% from 1,876 cases in 2017 to 1,827 cases in 2018, it increased by 10% from 1,827 cases in 2018 to 2,006 cases in 2020. According to MWMS records, from January 2018 to March 2021 (i.e. 39 months), there were 6,193 salt water main leak cases, resulting in a total estimated seawater loss of 271,934 m^3.

3.26 Audit noted that:

(a) according to MWMS records, for 1,991 (32%) of the 6,193 cases, more than 2 hours and up to 49 days (averaging 22 hours) were taken to close the valve after receipt of report of salt water main leaks. In October 2021, WSD informed Audit that:

  (i) the long time taken in isolation of seawater supply was due to priority given to other urgent cases (642 cases or 32%), minimisation of disturbance to customers (492 cases or 25%), operation need/site constraints (434 cases or 22%), site obstructed by others/traffic arrangement or leaks located in private land (104 cases or 5%), and other miscellaneous reasons (319 cases or 16%); and

  (ii) for the case taking 49 days to close the valve after receipt of report of salt water main leak, the delay was due to site obstructed by others. Excluding the 104 cases obstructed by others, for the remaining 1,887 cases, more than 2 hours and up to 35 days (averaging 21 hours) were taken to close the valve after receipt of report of salt water main leaks;

(b) according to MWMS records, for 217 (4%) of the 6,193 cases, the duration of supply interruption due to salt water main leak was more than 24 hours and up to 42 days (according to WSD, the duration should be more than 24 hours and up to 7 days (averaging 39 hours — see (ii) below)). In October and November 2021, WSD informed Audit that:

(i) the longer duration of seawater supply interruption was due to utility and other site constraints; and

(ii) for the case with supply interruption for 42 days, after further checking, the completion date of repair works was wrongly inputted into MWMS due to typographical error and the correct duration of supply interruption should be 12 days (Note 58) (see also para. 3.28(a)). Notwithstanding this, as some closed valves were re-opened after confirming the salt water main leak location, the actual duration of supply interruption for the case should be 27.75 hours. As a result, for the 217 cases (see (b) above), the duration of supply interruption due to salt water main leak was more than 24 hours and up to 7 days (averaging 39 hours); and

(c) according to WSD, for the attendance to salt water main leaks, it would balance all relevant factors (e.g. consequence of late attendance against immediate disruption to the public).

3.27 In Audit's view, WSD needs to attend to salt water main leaks (e.g. closing the valve after receipt of report of salt water main leaks and completing the repair works) as soon as practicable, balancing all relevant factors (e.g. consequence of late attendance against immediate disruption to the public — see para. 3.26(c)).

Scope for improving the record keeping of salt water main bursts and leaks

3.28 WSD maintains the details of all water main burst and leak cases in MWMS. Audit noted that there was scope for enhancing the accuracy and completeness of information in MWMS, as follows:

Note 58: *As MWMS had not maintained a field for duration of supply interruption, the duration was measured from seawater supply isolation to completion of repair works.*

(a) some information was wrongly inputted into MWMS due to typographical error, including the number of contractors' workers for attending to emergency involving salt water main burst (see para. 3.23) and the completion date of repair works for salt water main leak (see para. 3.26(b)(ii)); and

(b) the estimated seawater loss for one salt water main leak case should be 4,079 m^3 instead of 45,315 m^3 as recorded in MWMS. Besides, for 13 salt water main leak cases, the field in MWMS for estimated seawater loss was left blank. In November 2021, WSD informed Audit that the estimated seawater loss for the 13 cases was minimal and not measurable.

3.29 In Audit's view, WSD needs to take measures to ensure that accurate and complete information on salt water main bursts and leaks is properly recorded in MWMS for monitoring purpose.

Scope for utilising advanced technologies to monitor seawater supply systems

3.30 According to WSD, water main bursts are usually noticeable and will be reported by various parties (e.g. the public and WSD's maintenance staff), and it has carried out routine leak detection (including sounding and visual inspections — Note 59) on water mains to identify leaks in the water mains (see para. 3.18). Audit noted that from January 2018 to March 2021, most of the salt water main burst and leak cases were identified by the public and not by WSD (Note 60).

Note 59: *According to WSD, it conducted 933 sounding and visual inspections of salt water mains and identified 88 salt water main leaks in 2020-21.*

Note 60: *According to MWMS records: (a) of the 105 salt water main burst cases, 103 (98%) cases were identified by the public and 2 (2%) cases by WSD's inspection; and (b) of the 6,193 salt water main leak cases, 5,745 (93%) cases were identified by the public and 448 (7%) cases by WSD's inspection and leak detection. According to WSD, the salt water main leak cases identified by the public were visible cases while those identified by WSD's inspection and leak detection were mostly invisible cases.*

3.31 In this connection, Audit notes that WSD has implemented a Water Intelligent Network to maintain the healthiness of the fresh water distribution network and monitor water loss. According to WSD, the essence of the Water Intelligent Network is continuous monitoring of network performance in a holistic manner by utilising advanced technologies (Note 61). One of the measures under the Water Intelligent Network is active leakage detection and control through the usage of the monitoring and sensing equipment installed in the network.

3.32 Audit noted that the Water Intelligent Network only covers fresh water distribution systems but not seawater supply systems. In Audit's view, WSD needs to explore the feasibility of utilising advanced technologies (such as the Water Intelligent Network) to monitor the seawater supply systems (e.g. active leakage detection of salt water mains).

Audit recommendations

3.33 **Audit has *recommended* that the Director of Water Supplies should:**

(a) **include salt water mains of high risk for implementation of improvement works with a view to reducing the risk of main bursts and leaks as far as practicable;**

(b) **continue to review salt water main burst cases with a view to enhancing the risk assessment relating to selection of salt water mains for improvement works;**

(c) **continue to take measures to ensure that improvement works of salt water mains (including those at salt water main burst hot spots) are completed as soon as practicable;**

Note 61: *According to WSD, under the Water Intelligent Network, the fresh water distribution network is divided into about 2,400 discrete District Metering Areas of manageable sizes with monitoring and sensing equipment installed in each area. The Water Intelligent Network enables determination of the priorities of the District Metering Areas and the most effective means to tackle the water loss in individual District Metering Areas under the four pillars of network management (i.e. reprovisioning of aged water mains, quality and speedy repairs to water main leaks and bursts, active leakage detection and control, and pressure management) in an integrated and coordinated manner.*

(d) **keep under review the development of the computerised system for maintaining details of improvement works of salt water mains with a view to facilitating monitoring of progress of works;**

(e) **take measures to ensure that the contractors comply with the contract requirement of deploying adequate labour to handle emergencies involving salt water main bursts;**

(f) **attend to salt water main leaks (e.g. closing the valve after receipt of report of salt water main leaks and completing the repair works) as soon as practicable, balancing all relevant factors (e.g. consequence of late attendance against immediate disruption to the public);**

(g) **take measures to ensure that accurate and complete information on salt water main bursts and leaks is properly recorded in MWMS for monitoring purpose; and**

(h) **explore the feasibility of utilising advanced technologies (such as the Water Intelligent Network) to monitor the seawater supply systems (e.g. active leakage detection of salt water mains).**

Response from the Government

3.34 The Director of Water Supplies agrees with the audit recommendations.

PART 4: OTHER RELATED ISSUES

4.1 This PART examines WSD's work in other related issues, focusing on:

(a) Quality Water Supply Scheme for Buildings — Flushing Water (paras. 4.2 to 4.14);

(b) uprating of seawater supply systems (paras. 4.15 to 4.25); and

(c) supply and use of recycled water (paras. 4.26 to 4.34).

Quality Water Supply Scheme for Buildings — Flushing Water

4.2 WSD has launched the "Quality Water Supply Scheme for Buildings — Flushing Water" (hereinafter referred to as Quality Flushing Water Scheme) since July 2013 (Note 62). According to WSD, the objectives of the Scheme include:

(a) strengthening the capability of building management agents to achieve value-added performance in meeting the expectation of consumers with respect to the reliability of flushing system;

(b) giving recognition to those building management agents who can demonstrate consistent compliance of the prescribed criteria under the Scheme;

(c) assisting the owners and building management agents in conducting self-assessments on plumbing conditions and to identity areas for necessary maintenance; and

(d) minimising the failure frequency of inside services of flushing system.

Note 62: *The Scheme was previously known as "Flushing Water Plumbing Quality Maintenance Recognition Scheme", which was renamed to the current name in March 2015.*

Other related issues

4.3 Participation of the Quality Flushing Water Scheme is voluntary and free of charge. The target groups to join the Scheme are the property owners and management agents of buildings. Applicants are required to submit applications to WSD. The applications will be assessed according to the following criteria:

(a) the plumbing systems should be inspected at least once every three months by qualified persons (such as licensed plumbers, building services engineers and building surveyors) and are found to be in good condition. All defects identified in the inspections should be promptly rectified by qualified persons; and

(b) the flushing water tanks should be cleansed at least once every six months.

4.4 Successful buildings will be awarded certificates (Note 63) in recognition of their proper maintenance of the flushing water plumbing systems. The names of the buildings, the owners' corporations and management agents are shown on the certificates to commend their contributions. The certificates or their copies could be displayed in those awarded buildings, stationeries and promotional materials.

Note 63: *The certificates are classified into three grades according to the length of the continuous participation (i.e. no break of more than three months) in the Quality Flushing Water Scheme, as follows:*

Type of certificate	***Length of continuous participation***	***Validity***
Blue - new application	*Less than 3 years*	*1 year*
Blue - renewal	*Less than 3 years*	*2 years*
Silver - renewal	*3 years or more but less than 5 years*	*2 years*
Gold - renewal	*5 years or more*	*2 years*

Renewal applications submitted later than three months after the expiry date of the last certificates will be considered as new applications and the validity periods of such new certificates will be reset to one year, starting from the new approval dates.

Need to keep up efforts to encourage more buildings to participate in Quality Flushing Water Scheme

4.5 Audit noted that:

(a) the number of buildings participating in the Quality Flushing Water Scheme had been fluctuating since its launch in July 2013 (increasing from 550 buildings in December 2013 to 1,804 buildings in December 2016, decreasing to 1,414 buildings in December 2020, and increasing to 1,949 buildings in September 2021 — see Table 8); and

(b) nearly all participating buildings were private buildings. As at 30 September 2021, only two government buildings (under WSD) participated in the Scheme.

Table 8

Number of buildings participating in Quality Flushing Water Scheme (December 2013 to September 2021)

Date	No. of buildings
31 December 2013 (Note)	550
31 December 2014	1,358
31 December 2015	1,803
31 December 2016	1,804
31 December 2017	1,775
31 December 2018	1,724
31 December 2019	1,611
31 December 2020	1,414
30 September 2021	1,949

Source: WSD records

Note: The Quality Flushing Water Scheme was launched in July 2013.

Other related issues

4.6 According to WSD:

(a) despite the slight drop in number in the period 2017 to 2019, the number of buildings applying for the Quality Flushing Water Scheme regained the rising momentum in 2020. As at 31 December 2020, 1,414 buildings participated in the Scheme and 1,193 buildings were with applications submitted and under processing by WSD. As at 30 September 2021, 1,949 buildings participated in the Scheme, and property owners and management agents of 237 and 292 buildings had submitted new and renewal applications respectively which were being processed by WSD. Given the increasing trend of applications for the Scheme since 2020, WSD considered that its recent promotion efforts had been proven effective, as follows:

(i) it held one certificate presentation ceremony in 2016 and one seminar in 2017 for the Quality Flushing Water Scheme. From January 2018 to March 2021, it had taken the opportunity to encourage participants in seminars for Quality Water Supply Scheme for Buildings — Fresh Water (Management System) (QMS) (Note 64) to join the Quality Flushing Water Scheme; and

(ii) promotion leaflet on the Quality Flushing Water Scheme had been attached to the letter to successful applicants of QMS (or earlier scheme for fresh water quality) with a reminder added in the letter to encourage the buildings under their management to join the Quality Flushing Water Scheme since 2016;

(b) as government buildings were normally administered by robust maintenance system with reliable mechanism in handling routine tasks and emergencies situations, the Quality Flushing Water Scheme and QMS primarily focused on strengthening the capability of private property owners and management agents to maintain their internal plumbing system. Nevertheless, DEVB formulated a new policy in July 2020 to implement Water Safety Plan for Buildings at all government buildings in order to take the lead in the participation in QMS. WSD had also taken this opportunity to encourage the concerned government buildings for participation in the

Note 64: *According to WSD, from 2018 to 2020, it held 6 to 19 seminars annually for QMS.*

Quality Flushing Water Scheme at the same time with a view to showing the benefits of proper management and maintenance of the inside services of flushing system to private property owners and management agents (Note 65); and

(c) when the certificates of the participating buildings nearly expire (the validity period of the certificates is one to two years — see Note 63 to para. 4.4), WSD would call the applicants by phone and remind them for renewal.

4.7 Regarding the Quality Flushing Water Scheme, Audit noted that:

(a) the number of buildings participating in the Scheme had been fluctuating since its launch in July 2013. The number of buildings had been increasing up to 2016 and then decreased. After decreasing from 1,804 buildings in 2016 to 1,414 buildings in 2020, it recently increased to 1,949 buildings as of September 2021 (see para. 4.5(a)); and

(b) while WSD had taken the opportunity to encourage government buildings for participation in the Scheme at the same time when a new policy on QMS was formulated in July 2020 (see para. 4.6(b)), only two government buildings participated in the Scheme as of September 2021 (see para. 4.5(b)).

In Audit's view, WSD needs to keep up efforts to encourage more buildings to participate in the Quality Flushing Water Scheme with a view to enhancing management and maintenance of their plumbing systems.

Note 65: *According to WSD, it had set targets for government buildings to join QMS and was encouraging these government buildings for participation in the Quality Flushing Water Scheme in conjunction with application with QMS. While providing technical support for carrying out water safety risk assessment at the concerned buildings to formulate the Water Safety Plan for Buildings, WSD also promoted the Quality Flushing Water Scheme to the responsible government bureaux/departments.*

Other related issues

Need to complete processing of applications as soon as practicable

4.8 Upon receiving an application for the Quality Flushing Water Scheme, WSD will process the application according to the information provided by the applicant and award certificates for buildings that satisfy the assessment criteria. According to WSD:

(a) for cases with insufficient supporting documents provided by the applicants, it will provide written comments to the applicants requesting submission of the required documents or clarification; and

(b) it will continue to process the cases only when the required information is received for applications involving insufficient information. The time required for processing an application is affected by the quality of the submission provided by the applicant.

4.9 Audit noted that, as of March 2021, WSD had not completed the processing of 176 new applications (involving 876 buildings — Note 66) and 240 renewal applications (involving 784 buildings), as follows:

(a) the 176 new applications had been received by WSD for about 7 months on average. For 104 (59%) of the 176 applications, they had been received for more than 6 months and up to 17 months (averaging about 10 months); and

(b) the 240 renewal applications had been received by WSD for about 5 months on average. For 90 (38%) of the 240 applications, they had been received for more than 6 months and up to 13 months (averaging about 8 months).

4.10 In October 2021, WSD informed Audit that:

(a) the progress of processing the applications had been affected by the special working arrangements due to the COVID-19 epidemic in 2020 and early

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Note 66: *An application may include more than one building.*

2021, which resulted in some backlog cases including those due to late return of revised submissions;

(b) for the 176 new applications and 240 renewal applications mentioned in paragraph 4.9:

(i) comments on 37 new applications and 33 renewal applications had been issued to the applicants in March 2021; and

(ii) of the total 416 (i.e. 176 + 240) applications, 302 were backlog cases (involving 1,193 buildings) carried forward from 2020. The remaining 114 applications were received from January to March 2021, of which 97% of the applications were processed within six months with written comments issued to the applicants and the remaining 3% were processed within seven months; and

(c) it had reviewed the number of applications under processing as at 30 September 2021 and found that the situation had been greatly improved as compared with the status as at 31 March 2021. The number of new and renewal applications under processing were reduced to 65 (involving 237 buildings) and 84 (involving 292 buildings) respectively as at 30 September 2021.

4.11 In Audit's view, WSD needs to complete the processing of applications for the Quality Flushing Water Scheme as soon as practicable. In this connection, Audit noted that WSD had not set time target for completion of processing of applications (e.g. straight-forward applications and issuance of the first-round comments) for the Scheme. There is merit for WSD to consider setting such time target.

Scope for improvement in administrative issues

4.12 Audit noted that there was scope for improvement in the administration of the Quality Flushing Water Scheme, as follows:

(a) ***Need to regularly update the names of participating buildings and add information on type of certificates awarded on WSD website.*** According to WSD guidelines, WSD should publish the names of participating

buildings under the Quality Flushing Water Scheme on its website at regular intervals. Audit noted that as at 2 September 2021, only a list of participating buildings as of July 2019 (i.e. two years ago) was published on WSD website. The information in this list may be outdated as there were changes in the number of participating buildings between 2019 and 2021 (see Table 8 in para. 4.5). In October 2021, WSD informed Audit that the list of participating buildings was not updated in 2020 and early 2021 as there had been some backlog cases as a result of the special working arrangement due to the COVID-19 epidemic, and updating the list at that time would not reflect the actual situation on the application of the Quality Flushing Water Scheme and would mislead the public. WSD had subsequently updated the list in mid-September 2021 after progressively clearing the backlog cases. However, Audit noted that the list only showed the names of buildings (1,194 in total) participating in the Scheme as of June 2021 without indicating the type of certificates (i.e. Blue, Silver or Gold — see Note 63 to para. 4.4) awarded to the buildings. In Audit's view, WSD needs to regularly update the names of participating buildings and add information on the type of certificates awarded under the Quality Flushing Water Scheme on its website; and

(b) ***Need to timely update guidelines of Quality Flushing Water Scheme.*** According to WSD, it will randomly select applications under the Quality Flushing Water Scheme and conduct visual inspection of the communal plumbing system for auditing purpose. WSD conducted a review on its audit inspection system for the Scheme in early 2018. After the review, WSD determined that its audit inspection would be conducted after award of the certificates and before their expiry (Note 67), and the target percentage of audit inspection would be raised from 2.5% to 4% of applications. However, as of September 2021, WSD had not updated its guidelines of the Quality Flushing Water Scheme (which was issued in August 2013) to incorporate the revised WSD audit inspection procedures. In October 2021, WSD informed Audit that new guidelines on the audit inspection incorporating the revised procedures were issued on 12 October 2021. In Audit's view, WSD needs to timely update its guidelines to incorporate revised procedures in future.

Note 67: *According to WSD, before the 2018 review, WSD's audit inspection was conducted before award of the certificates.*

Audit recommendations

4.13 **Audit has *recommended* that the Director of Water Supplies should:**

(a) **keep up efforts to encourage more buildings to participate in the Quality Flushing Water Scheme with a view to enhancing management and maintenance of their plumbing systems;**

(b) **complete the processing of applications for the Quality Flushing Water Scheme as soon as practicable;**

(c) **consider setting time target for completion of processing of applications for the Quality Flushing Water Scheme;**

(d) **regularly update the names of participating buildings and add information on the type of certificates awarded under the Quality Flushing Water Scheme on WSD website; and**

(e) **timely update WSD guidelines of the Quality Flushing Water Scheme to incorporate revised procedures in future.**

Response from the Government

4.14 The Director of Water Supplies agrees with the audit recommendations.

Uprating of seawater supply systems

4.15 According to WSD, for some areas with seawater supply systems, the existing systems may not be able to cope with the increasing seawater demand arising from the existing or planned developments in the areas. The shortfall in seawater supply will be met by fresh water as a temporary measure. Enhancement works to uprate the existing seawater supply system will be required for meeting the anticipated shortfall in such areas (Note 68).

Note 68: *According to WSD, based on its regular monitoring as at end 2020, there was no shortfall of seawater supply in any of the existing salt water supply zones.*

Other related issues

4.16 Over the past ten years, two projects for uprating the seawater supply systems for Sha Tin and Chai Wan were substantially completed (in August 2012 and May 2021 respectively). As of September 2021, there was an uprating project still in progress, namely the salt water supply system for Wan Chai (hereinafter referred to as Wan Chai uprating project). The works for this project commenced over ten years ago in August 2010 and the project details were as follows:

(a) the Wan Chai uprating project aims to enhance the existing salt water supply system for Wan Chai, Causeway Bay and Happy Valley, and to extend the system to provide seawater to Bowen Road areas in mid-levels, Central for flushing (Note 69). The uprating works mainly included laying of water mains, construction of a SWSR and a SWPS. In July 2009, the Finance Committee of the Legislative Council (LegCo) approved an APE of $271.1 million for the uprating works; and

(b) WSD awarded four works contracts (Contracts N to Q) between August 2010 and May 2015 for the uprating works. The works for three contracts (Contracts N, O and P) were substantially completed by May 2017 and their accounts were finalised by September 2019. The remaining works contract (Contract Q) was still in progress as of September 2021. The total contract expenditure of the four works contracts funded under the Wan Chai uprating project was about $246 million as of March 2021. The progress and expenditure of Contracts N to Q were shown in Appendices E and F respectively.

Note 69: *In June 2009, in seeking funding approval for the Wan Chai uprating project, DEVB informed the Public Works Subcommittee of the Finance Committee of the Legislative Council that: (a) the current demand in the areas of Wan Chai uprating project was about 38,900 m^3 per day while the capacity of the existing salt water supply system was only about 33,000 m^3 per day, and the shortfall of 5,900 m^3 salt water supply was being met by fresh water as a temporary measure; and (b) the demand was anticipated to increase to 42,300 m^3 per day upon completion of planned developments in the areas and the shortfall would increase to 9,300 m^3 if no improvement works were implemented.*

Slow progress of mainlaying works under Contract Q

4.17 Under the Wan Chai uprating project, WSD awarded Contract Q to a contractor (Contractor Q) in January 2012 for mainlaying works at $165.6 million. Contract Q was a remeasurement contract (see Note 25 to para. 2.18). Audit noted that, as of September 2021 (about 5.7 years after the original contract completion date of January 2016), the works for Contract Q were still not yet completed.

4.18 In October 2021, WSD informed Audit that:

(a) as of September 2021, extension of time of 1,482 days (about 4.1 years) was granted (further extension of time was being assessed) and the completion date of Contract Q was extended to 8 February 2020. Accordingly, as of September 2021, Contract Q was about 1.6 years behind the extended contract completion date;

(b) apart from inclement weather, the completion of the works later than the original contract completion date was mainly due to congested and uncharted underground utilities and obstructions affecting trenchless works, unanticipated shallow rock level in trench excavation, stringent requirements on road opening hours and excavation permit for works in urban areas with dense population and heavy traffic, social unrest in 2019 and outbreak of the COVID-19;

(c) in around May 2019, 94% of the works under Contract Q had been completed. As of October 2021, the works were not yet completed due to unanticipated site difficulties hindering the completion of the last section of the water mains for supplying seawater for flushing to premises at Kennedy Road; and

(d) the reprovisioned Wan Chai SWPS had been completed and commissioned since April 2014. With its commissioning, the capacity of seawater supply for the areas of Wan Chai uprating project had been increased from 33,000 m^3 per day to 58,000 m^3 per day to fully cater for the flushing

demands. There was no major shortfall of salt water supply in the concerned system (Note 70).

4.19 In this connection, according to WSD, the performance of Contractor Q was unsatisfactory, as follows:

(a) from January 2016 (original contract completion date) to August 2021 (i.e. 68 months), WSD had issued 81 warning letters to Contractor Q for unsatisfactory performance of the works under Contract Q. The unsatisfactory performance included persistent slippage of progress, poor planning of works, inadequate resources and poor performance on general obligations (such as non-compliance of excavation permits);

(b) WSD had issued three adverse performance reports to Contractor Q, with one issued for the quarter ending February 2014 (with rating of very poor on aspects of "progress" and "general obligations"), another one issued for the quarter ending May 2019 (with rating of very poor on aspects of "progress", "organisation" and "resources"), and the remaining one issued for the quarter ending August 2021 (with rating of very poor on aspects of "progress", "general obligations" and "resources"); and

(c) WSD had conducted two reviews on actions on Contractor Q for poor progress of Contract Q in 2016 and 2019 respectively. Both reviews concluded to allow Contractor Q to complete the remaining works (Note 71).

Note 70: *According to WSD, as the works at Kennedy Road were not yet completed as of October 2021, the flushing demand at Kennedy Road was met by fresh water as a temporary measure, which had a minor effect (accounting for about 1.5% of the actual total flushing demand in the areas of Wan Chai uprating project as in 2020) on the use of fresh water for flushing.*

Note 71: *According to Contract Q, WSD may expel the contractor if WSD is in the opinion that the contractor fails to comply with certain conditions, such as failing to proceed with the works with due diligence or was persistently in breach of any of the obligations under the contract despite previous written warnings. According to the reviews conducted by WSD in: (a) 2016: the performance of Contractor Q did not fully satisfy the conditions as stipulated in the contract for expelling the contractor; and (b) 2019: as extra time and government staff cost would be required for a new contractor to take up the contract and the works were already 94% completed, it was concluded to allow Contractor Q to complete the remaining works.*

4.20 In Audit's view, WSD needs to:

(a) strengthen actions to complete the Wan Chai uprating project as soon as practicable; and

(b) draw on the experience gained in implementing the project with a view to improving the management of future waterworks projects, including exploring measures to address the problems encountered in mainlaying works (see para. 4.18(b)) and monitoring closely the contractor's performance.

Substantial increase in actual quantities for earthworks under Contract N

4.21 Under the Wan Chai uprating project, WSD awarded Contract N to a contractor (Contractor N) in July 2010 for construction of Bowen Drive SWPS and Magazine Gap Road SWSR, demolition of a decommissioned fresh water service reservoir and the associated works at $53.5 million. Contract N was a remeasurement contract. The works commenced in August 2010 and were substantially completed in October 2013. The accounts were finalised in December 2017. The actual expenditure of Contract N was $83.6 million (i.e. an increase of $30.1 million (56%) over the original contract sum of $53.5 million). Audit noted that there was substantial increase in actual quantities for excavation and disposal works (ranging from 6 to 51 times) over the original BQ quantities, leading to a cost increase of $31.4 million (see Table 9).

Table 9

Substantial increase in actual quantity over BQ quantity under Contract N (December 2017)

BQ item	BQ quantity (a) (m^3)	Actual quantity (b) (m^3)	Increase in quantity (c) = (b) − (a) (m^3)	BQ rate (d) ($/m^3$)	Increase in amount (e) = (c) × (d) ($ million)
Excavation for structures of SWPS and SWSR					
Item A (Note 1)	60	3,098	3,038 (5063%)	5,000	15.2
Item B (Note 1)	130	899	769 (592%)	5,000	3.8
Item C (Note 1)	10	280	270 (2700%)	6,000	1.6
				Subtotal	20.6
Disposal of materials					
Item D (Note 2)	80	2,238	2,158 (2698%)	5,000	10.8
				Total	31.4

Source: WSD records

Note 1: Items A, B and C were related to excavation for structures (material other than rock or artificial hard material) with respective maximum depth: (a) exceeding 9 metres but not exceeding 12 metres; (b) exceeding 3 metres but not exceeding 6 metres; and (c) exceeding 6 metres but not exceeding 9 metres.

Note 2: Item D was related to "Disposal of material other than rock or artificial hard material, in tips provided by the Employer".

4.22 According to WSD:

(a) the increase in quantities was due to excavation for the structures of SWPS and SWSR that could not be anticipated in the tendering stage. Under Contract N, large quantities of excavation and disposal of earthworks were envisaged but the actual quantities were susceptible to variations in existing ground profile. The changes in quantities were mainly due to the fact that the quantities for excavation for structures at deeper range were underestimated while the quantities for excavation for structures at shallower range were overestimated; and

(b) WSD's guidelines were updated in March 2015 to enhance the estimation of BQ quantities in relation to earthworks (see para. 2.14(a)).

4.23 In Audit's view, WSD needs to remind its staff to follow the guidelines in estimation of BQ quantities of earthworks (particularly for different depth ranges) in implementing works projects in future.

Audit recommendations

4.24 **Audit has *recommended* that the Director of Water Supplies should:**

(a) **strengthen actions to complete the Wan Chai uprating project as soon as practicable;**

(b) **draw on the experience gained in implementing the Wan Chai uprating project with a view to improving the management of future waterworks projects, including exploring measures to address the problems encountered in mainlaying works and monitoring closely the contractor's performance; and**

(c) **remind WSD staff to follow the guidelines in estimation of BQ quantities of earthworks (particularly for different depth ranges) in implementing works projects in future.**

Response from the Government

4.25 The Director of Water Supplies agrees with the audit recommendations.

Supply and use of recycled water

4.26 According to TWM Strategy in 2019, WSD targets at expanding the network coverage of using lower grade water (i.e. seawater and recycled water (including treated grey water and reclaimed water — see Note 8 to para. 1.7)) for flushing from 85% to 90% of the total population in the long run in order to further reduce the fresh water demand for flushing. According to WSD:

(a) technical feasibility and cost effectiveness are the prime considerations when determining the type of lower grade water to be supplied to individual areas for flushing; and

(b) recycled water (apart from for toilet flushing) can also be used for other non-potable uses (such as irrigation, street cleaning and car washing) while seawater is limited to flushing only. Moreover, use of recycled water is generally more favourable from environmental protection perspective as it can minimise impacts to the environment by reducing the amount of sewage discharged to the receiving water.

Need to keep under review the implementation of projects for supply of recycled water

4.27 According to WSD, it has been actively exploring the use of recycled water by providing a centralised recycled water supply system in those areas where fresh water is being used for flushing and in new development areas (especially in the inland areas) to contain the fresh water demand. The following projects are being implemented:

(a) ***Grey water recycling system.*** WSD is constructing a district-based grey water recycling system at the Anderson Road Quarry Development site in order to treat grey water collected at the development area and supply the treated grey water for flushing and other non-potable purposes within the area (Note 72). The system is anticipated to be completed in 2023; and

(b) ***Supply system of reclaimed water.*** WSD is carrying out works to supply reclaimed water, converted from tertiary treated sewage effluent at the Shek Wu Hui Effluent Polishing Plant (Note 73), to the Northeast New Territories for non-potable uses (including toilet flushing) in phases. The

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Note 72: *In September 2020, WSD awarded a works contract for the construction of a grey water treatment plant (with a daily treatment capacity of 3,300 m^3) in Anderson Road Quarry Development site at $333 million.*

Note 73: *In May 2019, the Finance Committee of LegCo approved an APE of $11,972.8 million for increasing the treatment capacity and upgrading the sewage treatment level of the existing Shek Wu Hui Sewage Treatment Works to tertiary standard for conversion into a Shek Wu Hui Effluent Polishing Plant.*

supply of reclaimed water to Sheung Shui and Fanling will start in 2024 (Note 74). The supply will be extended to Kwu Tung North and Fanling North New Development Areas in pace with their development programmes.

4.28 According to WSD, its supply of recycled water will require legislative amendments to the Waterworks Ordinance and the Waterworks Regulations. According to DEVB and WSD, they are now working on the preparation work for the relevant legislative amendments. The target is to introduce the amendment bill to LegCo in early 2023 for enactment by early 2024.

4.29 Given the benefits of using recycled water for non-potable uses (including flushing — see para. 4.26(b)), in Audit's view, WSD needs to:

(a) keep under review the implementation of projects for supply of recycled water with a view to ensuring their timely completion; and

(b) in collaboration with DEVB, keep track of the work relating to the legislative amendments for supply of recycled water with a view to meeting the target legislative time.

Need to encourage the installation of on-site water recycling systems

4.30 In Hong Kong, with the growing awareness of water conservation and environmental protection, on-site water recycling systems may be implemented in new and existing buildings (Note 75). The use of recycled water for non-potable uses (including flushing) in government buildings and private buildings is as follows:

Note 74: *In May 2021, the Finance Committee of LegCo approved an APE of $1,255.5 million for the construction of Shek Wu Hui water reclamation plant (with a daily capacity of 73,000 m^3) and laying of the associated water mains to supply reclaimed water to Sheung Shui and Fanling.*

Note 75: *According to WSD, the Waterworks Ordinance and the Waterworks Regulations are for control of water supplied by WSD, and no legislative amendment to these Ordinance and Regulations is required for on-site water recycling systems.*

Other related issues

(a) ***Government buildings.*** According to WSD, the Government has led by example in adopting grey water recycling and rainwater harvesting systems by promulgating internal guidelines (Note 76) for installing these water recycling facilities in government buildings as far as practicable. As of March 2021, 115 government buildings were equipped with these systems, of which 13 buildings used the water from such systems for toilet flushing. According to WSD, for the government buildings which have adopted water recycling systems, it follows up to liaise with the Green Managers of relevant government bureaux/departments to keep track of the amount of water reused and remind the government bureaux/departments from time to time to continue the operation of the water recycling systems; and

(b) ***Private buildings.*** WSD has collaborated with the Hong Kong Green Building Council to promote adoption of recycled water in private buildings through the Building Environmental Assessment Method (BEAM) Plus (Note 77). Buildings with grey water recycling system or rainwater harvesting system will be eligible for credits under BEAM Plus to encourage private developers to provide these facilities in lieu of using fresh water for non-potable uses. According to WSD, it provides technical support in formulating the provisions of BEAM Plus Assessment Tools.

4.31 In Audit's view, to conserve fresh water, WSD needs to:

(a) in collaboration with DEVB, keep up efforts to encourage the installation of on-site water recycling systems in government buildings and private buildings for non-potable uses (including toilet flushing); and

(b) continue to follow up with the Green Managers of the government bureaux/departments regarding the operation of water recycling systems of the government buildings under their purview.

Note 76: *The guidelines were promulgated in a joint DEVB and Environment Bureau Technical Circular on Green Government Buildings issued in April 2015.*

Note 77: *BEAM Plus is a comprehensive environmental assessment tool for buildings. It defines the best practice criteria for a range of sustainability issues across the life-cycle (e.g. design and construction) of buildings and projects. Based on the credit achievement where the standard or defined performance criteria are satisfied, the project will be graded Platinum, Gold, Silver or Bronze to reflect the overall performance.*

Audit recommendations

4.32 **Audit has *recommended* that the Director of Water Supplies should:**

(a) **keep under review the implementation of projects for supply of recycled water with a view to ensuring their timely completion;**

(b) **in collaboration with the Secretary for Development, keep track of the work relating to the legislative amendments for supply of recycled water with a view to meeting the target legislative time;**

(c) **in collaboration with the Secretary for Development, keep up efforts to encourage the installation of on-site water recycling systems in government buildings and private buildings for non-potable uses (including toilet flushing); and**

(d) **continue to follow up with the Green Managers of the government bureaux/departments regarding the operation of water recycling systems of the government buildings under their purview.**

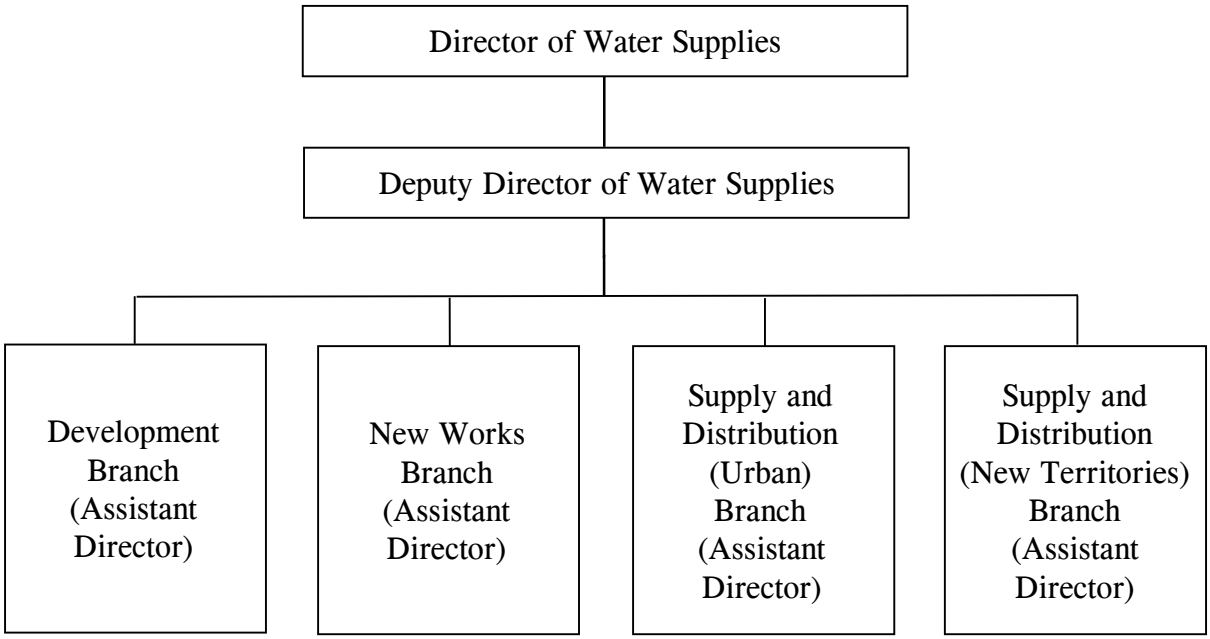
Response from the Government

4.33 The Director of Water Supplies agrees with the audit recommendations.

4.34 The Secretary for Development agrees with the audit recommendations in paragraph 4.32(b) and (c).

Appendix A
(para. 1.15 refers)

Water Supplies Department: Organisation chart (extract) (31 March 2021)



Source: *WSD records*

Appendix B
(paras. 2.2 and 2.4 refer)

Contracts A to M under projects for extension of seawater supply network in Pok Fu Lam and Northwest New Territories (June 2021)

Contract	Commencement date	Original contract completion date	Substantial completion date	No. of months later than original contract completion date (Note 1)
Salt water supply system for Pok Fu Lam (Note 2)				
A	27.8.1996	18.1.1998	22.9.1998	8.1
B	1.4.1997	21.12.1998	1.12.1999	11.3
C	22.11.2001	20.1.2004	7.1.2005	11.6
D	12.10.2009	11.10.2012	31.7.2013	9.6
Salt water supply system for Northwest New Territories (Note 3)				
E	25.2.2008	27.8.2010	15.1.2011	4.6
F	2.10.2008	1.10.2011	23.6.2014	32.7
G	21.5.2009	19.5.2012	31.3.2015	34.4
H	15.7.2009	13.7.2012	6.8.2013	12.8
I	11.1.2010	11.10.2012	12.11.2013	13.1
J	9.2.2010	7.2.2013	31.12.2014	22.8
K	24.2.2010	24.8.2013	22.12.2014	15.9
L	27.7.2010	12.12.2012	17.10.2014	22.2
M	16.5.2012	8.8.2013	17.9.2013	1.3

Source: *WSD records*

Note 1: *According to WSD, for all the 13 contracts, extensions of time (due to reasons including inclement weather, revision of mainlaying alignment and unforeseen underground conditions) had been granted to the contractors in accordance with the terms of the contracts for completion of works later than the original contract completion dates. Of the 13 contracts: (a) full extensions of time had been granted to 8 contracts (Contracts C, E, F, G, I, K, L and M) according to the contractual provisions (i.e. they were completed within the extended contract completion dates); and (b) liquidated damages had been imposed on the contractors of 5 contracts (Contracts A, B, D, H and J) for the delays in completion of works later than their respective extended contract completion dates (of 11 September 1998, 5 November 1999, 18 July 2013, 2 August 2013 and 10 December 2014). The delays subject to liquidated damages were: (i) 11 days (0.4 months) under Contract A; (ii) 26 days (0.9 months) under Contract B; (iii) 13 days (0.4 months) under Contract D; (iv) 4 days (0.1 months) under Contract H; and (v) 21 days (0.7 months) under Contract J.*

Note 2: *For the salt water supply system for Pok Fu Lam: (a) Contract A was under Projects A and B; (b) Contracts B and C were under Project B; and (c) Contract D was under Project C.*

Note 3: *For the salt water supply system for Northwest New Territories: (a) Contracts E and F were under Project D; (b) Contracts G, H, I, K, L and M were under Project E; and (c) Contract J was under Projects D and E.*

Appendix C
(paras. 2.3 and 2.4 refer)

Contract expenditure of salt water supply systems for Pok Fu Lam and Northwest New Territories (June 2021)

Contract	Original contract sum (a) ($ million)	Total contract expenditure (b) ($ million)	Increase/(decrease) (c) = (b) − (a) ($ million)	Increase/ (decrease) in price fluctuation adjustment (Note 1) (d) ($ million)	Increase/ (decrease) after price fluctuation adjustment (e) = (c) − (d) ($ million)
Salt water supply system for Pok Fu Lam					
A	23.9	20.1	(3.8) (-15.9%)	(Note 2)	(Note 2)
B	30.4	19.6	(10.8) (-35.5%)	(Note 2)	(Note 2)
C	34.9	34.1	(0.8) (-2.3%)	(2.3) (-6.6%)	1.5
D	190.7	231.8	41.1 (21.6%)	19.9 (10.4%)	21.2
Total	279.9	305.6	25.7 (9.2%)	N/A	N/A
Salt water supply system for Northwest New Territories					
E	35.5	48.4	12.9 (36.3%)	0.6 (1.7%)	12.3
F	131.1	160.7	29.6 (22.6%)	11.7 (8.9%)	17.9
G	133.9	178.1	44.2 (33.0%)	16.2 (12.1%)	28.0
H	88.8	95.2	6.4 (7.2%)	6.5 (7.3%)	(0.1)
I	92.9	108.0	15.1 (16.3%)	6.7 (7.2%)	8.4
J	116.9	165.6	48.7 (41.7%)	15.7 (13.4%)	33.0
K	131.8	188.2	56.4 (42.8%)	24.2 (18.4%)	32.2
L	64.3	64.5	0.2 (0.3%)	—	0.2
M	10.9	10.5	(0.4) (-3.7%)	—	(0.4)
Total	806.1	1,019.2	213.1 (26.4%)	81.6 (10.1%)	131.5 (16.3%)
Overall	1,086.0	1,324.8 (Note 3)	238.8 (22.0%)	N/A	N/A

Source: *WSD records*

Note 1: *The original contract sums of Contracts C to K included provisions for price fluctuation adjustments. Contracts L and M did not include a provision for price fluctuation adjustments.*

Note 2: *According to WSD, the documents and records of Contracts A and B had been disposed of in accordance with its record retention policy and the relevant information could not be retrieved.*

Note 3: *The funding for the expenditure of $1,324.8 million included: (a) $1,232.1 million funded under the project votes of Projects A to E (see para. 1.11); and (b) $92.7 million funded under other project votes related to fresh water supplies and combined fresh/salt water supplies controlled by WSD. The contracts under Projects A to E are shown in Notes 2 and 3 to Appendix B.*

Appendix D
(para. 2.10 refers)

Disputes related to omitted items in Bills of Quantities under Contract D

(a) ***Joints for pipes/pipe fittings (settlement of $3.2 million).*** The salient points of the disputes are as follows:

(i) Contractor D and Consultant X agreed that there were 22 omitted items in BQ for certain joints for pipes (ductile iron and steel) and steel pipe fittings;

(ii) Contractor D contended that there were similar works items in BQ and the valuation of the omitted items should be based on the rates of similar works items in BQ;

(iii) Consultant X contended that the valuation should not be based on the BQ rates contended by Contractor D as the BQ rates concerned were for electrical and mechanical works but not civil works. As there was no similar item available in BQ, reference was made to relevant rates taken from other WSD contracts; and

(iv) in the event, the Arbitrator decided in favour of Contractor D and the Government paid $3.2 million to Contractor D for settlement of this claim;

(b) ***Excavation for structures (settlement of $2.1 million).*** The salient points of the disputes are as follows:

(i) Contractor D contended that there were four omitted items in BQ related to the excavation for structures at certain depth ranges;

(ii) Consultant X contended that only two of the four were omitted items;

(iii) Contractor D and Consultant X had different views on the rates of the two omitted items mentioned in (ii); and

(iv) in the event, the Arbitrator accepted the interpretation of two omitted items by Consultant X and adopted the rates suggested by the quantum expert engaged by Contractor D for the two omitted items. The Government paid $2.1 million to Contractor D for settlement of this claim; and

(c) ***Slope protection works (settlement of $0.6 million).*** The salient points of the disputes are as follows:

(i) under Contract D, Contractor D was required to carry out excavation works at Pok Fu Lam SWSR, and design and construct the related lateral support (including slope protection works);

(ii) Contractor D contended that deep excavation had been carried out at Pok Fu Lam SWSR and the related slope protection works (related to three omitted items) should be qualified for separate pricing in BQ. The slope protection works were specifically referenced on the contract drawings and approval had been obtained from Consultant X before the works were executed;

(iii) Consultant X contended that the excavation at Pok Fu Lam SWSR was not deep but only site formation was required. The slope protection works were not an omitted item in BQ as the costs had been included in other priced rates in BQ; and

(iv) in the event, the Arbitrator decided in favour of Contractor D and the Government paid $0.6 million to Contractor D for settlement of this claim.

Source: WSD records

Appendix E
(para. 4.16(b) refers)

Progress of contracts under Wan Chai uprating project (March 2021)

Contract (Note 1)	Commencement date	Original contract completion date	Substantial completion date	No. of days later than original contract completion date
N	18.8.2010	20.4.2013	21.10.2013	184 (Note 2)
O	3.1.2012	21.4.2014	29.7.2014	99 (Note 2)
P	20.5.2015	16.2.2017	31.5.2017	104 (Note 2)
Q	20.1.2012	18.1.2016	In progress	1,899 (Note 3)

Source: WSD records

Note 1: The major works under Contracts N to Q were as follows:

Contract	***Major works***
N	*Construction of Bowen Drive SWPS and Magazine Gap Road SWSR*
O	*Supply and installation of mechanical and electrical equipment at Bowen Drive SWPS and Magazine Gap Road SWSR*
P	*Mainlaying works at Magazine Gap and civil engineering works at Sheung Shui, Tai Po Tau, Ma On Shan and Tseung Kwan O*
Q	*Mainlaying works for Wan Chai uprating project and replacement and rehabilitation of fresh water mains*

Note 2: According to WSD, for Contracts N, O and P, their accounts were finalised in December 2017, August 2015 and September 2019 respectively. Full extensions of time were granted (e.g. due to inclement weather) to these contracts (i.e. they were completed within the extended contract completion dates).

Note 3: For Contract Q, as the construction works were in progress, the duration of 1,899 days showed the position as of March 2021, and the total extension of time and liquidated damages (if any) to be granted/imposed were under assessment. According to WSD, as of September 2021: (a) extension of time of 1,482 days (about 4.1 years) was granted (further extension of time was being assessed) and the completion date of Contract Q was extended to 8 February 2020; and (b) Contract Q was 600 days (about 1.6 years) behind the extended contract completion date.

Appendix F
(para. 4.16(b) refers)

Contract expenditure of Wan Chai uprating project (March 2021)

Contract	Original contract sum (a) ($ million)	Actual expenditure (b) ($ million)	Increase/ (decrease) (c) = (b) − (a) ($ million)	Increase/ (decrease) in price fluctuation adjustment (d) ($ million)	Increase/ (decrease) after price fluctuation adjustment (e) = (c) − (d) ($ million)
N	53.5	83.6	30.1 (56.3%)	5.7 (10.7%)	24.4
O	17.0	15.9	(1.1) (-6.5%)	—	(1.1)
P	30.0	21.4	(8.6) (-28.7%)	(0.1) (-0.3%)	(8.5)
Q	165.6	185.7 (Note 1)	(Note 1)	(Note 1)	(Note 1)
Total	266.1	306.6 (Note 2)	N/A	N/A	N/A

Source: *WSD records*

Note 1: *For Contract Q, the construction works were in progress and the accounts were not yet finalised as of March 2021. The actual expenditure showed the position up to March 2021.*

Note 2: *Of the $306.6 million, $246 million was related to the Wan Chai uprating project and $60.6 million was related to works under other WSD projects and funded under the projects concerned.*

Acronyms and abbreviations

APE	Approved project estimate
Audit	Audit Commission
BEAM	Building Environmental Assessment Method
BQ	Bills of Quantities
DEVB	Development Bureau
FSTB	Financial Services and the Treasury Bureau
km	Kilometres
LAD	Legal Advisory Division (Works)
LegCo	Legislative Council
m^2	Square metres
m^3	Cubic metres
Mm^3	Million cubic metres
MWMS	Maintenance Works Management System
QMS	Quality Water Supply Scheme for Buildings — Fresh Water (Management System)
SWPS	Salt water pumping station
SWSR	Salt water service reservoir
TMF	Temporary mains fresh water for flushing
TWM	Total Water Management
VO	Variation order
WSD	Water Supplies Department