NOTE FOR PUBLIC WORKS SUBCOMMITTEE OF FINANCE COMMITTEE

Supplementary information on 340DS - Port Shelter sewerage stage 3 – Sai Kung Area 4 and Mang Kung Uk sewerage

INTRODUCTION

In considering the paper referenced PWSC(2005-06)31 on the above project on 23 November 2005, the Public Works Subcommittee (PWSC) requested the Administration to –

(a) provide supplementary information to account for any discrepancy between the computer modeling predictions in planning for the Stonecutters Island Sewage Treatment Works (SCISTW), and the actual impact of the SCISTW on the water quality of the Tsuen Wan beaches;

(b) provide information on computer modeling used for assessing the impact of the sewerage and associated facilities in Sai Kung on the water quality and that adopted for the SCISTW;

(c) report the *E. coli* level in the surrounding marine waters and beaches after the completion of the project; and

(d) provide the Administration's information paper on the project to the Sai Kung District Council (SKDC) for SKDC Members' comments before the relevant FC meeting.

THE ADMINISTRATION'S RESPONSE

Comparison between Water Quality Predictions and Actual Impact for SCISTW

2. The SCISTW was built as part of the sewerage facilities under the Harbour Area Treatment Scheme (HATS) Stage 1. It is now providing chemical

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treatment for 1.4 million m^3/day i.e. 75% of the sewage generated from both sides of Victoria Harbour. Treated effluent is discharged via an outfall at the western harbour without disinfection. When the scheme was first introduced, water quality assessments were conducted using the "Water Quality and Hydraulic Models" (WAHMO) computer model suite in 1996. This model suite was considered to be the best water quality assessment tool available to the Government at the time.

3. Taking the harbour as a whole, the predicted water quality impacts of the SCISTW discharge are broadly in line with the actual observed outcome. The water quality at the eastern end of the harbour and at the beaches to the east of the harbour (e.g. Rocky Bay) has improved significantly, as predicted. At the western end of the harbour, in the general vicinity of the outfall, the model predicted that there would be some deterioration in water quality due to the concentration of the treated effluent in this area, before full dilution and dispersion by the tidal currents could take effect. This expected deterioration was judged to be acceptable at that time, particularly having regard to the originally planned temporary nature of the outfall.

4. However, stronger than predicted bacterial (*E. coli*) influence from the SCISTW discharge was experienced at the Tsuen Wan beaches after the full implementation of the HATS Stage 1. The average predicted *E. coli* level at these beaches resulting from the SCISTW discharge was less than 30% that of the actual observed level, as detailed in Enclosure 1. The discrepancy was mainly due to the technological limitations of the mathematical water quality model. The model could not satisfactorily deal with the complexities of the water movements in narrow channels of fine geographical scale, such as those found in the vicinity of the Tsuen Wan beaches.

Water quality computer modeling for the Sai Kung sewerage proposals

5. At the PWSC Meeting on 23 November 2005, Members raised concerns as to the accuracy of the water quality models deployed for assessment of the water quality implications of the projected future increased sewage flow from the Sai Kung Sewage Treatment works (SKSTW).

6. We employed different mathematical computer models in the HATS Stage 1 EIA and the Sai Kung sewerage project. In the HATS Stage 1 EIA which was completed in 1996, the WAHMO model suite was used. On the other hand, the much more advanced "Delft3D" model, developed by the world-renowned Delft Hydraulics in the Netherlands, was used to assess the potential water quality impacts from the SKSTW.

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7. Although WAHMO was the best water quality assessment tool available to the government in the 1990s, it was developed two decades ago and did not provide the capability and flexibility of modern numerical model codes. For instance, the WAHMO model was a simplified two-layer, two-dimensional water quality model which could not take into account the vertical water circulation (a critical element in hydrodynamics). Moreover, the model had limitations in simulating the complex water movement in localized areas ch as regions in the vicinity of the Tsuen Wan beaches where there are several narrow channels through which the water may flow. This led to the under-estimation of the impacts from the HATS Stage 1 effluent on the Tsuen Wan beaches.

8. The model now used in the Sai Kung sewerage project is based on a regional model (the Update Model) set up using the Delft3D model suite. It capitalizes on the advances in computer technology and the environmental data and experience accumulated over the past 15 years. The Update Model was rigorously set up and extensively calibrated and verified with more than 10 years of field monitoring data. It is a very sophisticated software tool which allows the full three-dimensional circulation of the Hong Kong and surrounding waters to be simulated. The model not only takes into account the complex hydrodynamic and transport processes, but also all the relevant physical-chemical-biological interactions in the water body, rendering the modelling results more reliable and accurate than those predictions made previously using the WAHMO model suite.

Consultation with the Sai Kung District Council

9. We provided an information paper (Enclosure 2) on the water quality assessment arising from the proposed project to the SKDC and consulted the SKDC Food and Environmental Hygiene Committee at its meeting on 15 December 2005. We also provided a detailed briefing for the interested DC members on the water quality modelling aspects on 30 December 2005. Some DC members raised concerns similar to those raised by PWSC in relation to the modeling work as well as the potential environmental impact arising from the discharge from SKSTW. They also suggested us to consider extending the outfall to deeper waters when the upgrading of SKSTW is required in future. We agreed to take this into account during the planning stage of the upgrading of the SKSTW. Having considered the materials we presented, the SKDC re-confirmed their support for the implementation of the proposed works.

10. In view of the high quality of the effluent from the SKSTW, we do not expect the marine water quality of Port Shelter to be adversely affected by the discharge. In fact, the latest marine monitoring data has demonstrated that the *E. coli* level in the marine water in the vicinity is below 10 per 100 mL. Given the

fact that the beaches are at least 1 km away from the outfall location, it is unlikely that they would be affected by the outfall discharge. Nevertheless, we will continue to monitor the water quality in the surrounding marine waters and the beaches and report the measurements to the Legislative Council after the completion of the project.

Environment, Transport and Works Bureau
January 2006

Comparison of Water Quality Predictions and Actual Impact for SCISTW

The SCISTW was built as part of the sewerage facilities under the Harbour Area Treatment Scheme (HATS) Stage 1. It now treats 1.4 million m^3/day of sewage from urban Kowloon, Tseung Kwan O, and Kwai Tsing, and from Chai Wan and Shaukeiwan on Hong Kong Island. Treated effluent is discharged via an outfall at the western harbour. The original scheme for HATS was to provide chemical treatment to all of the HATS sewage at SCISTW, followed by the transfer of the effluent to the southeast of Lamma Island for disposal in deep off-shore waters. The outfall at the western harbour was thus planned for interim use only under the original scheme.

2. The predicted *E.coli* levels at the Tsuen Wan beaches due to HATS 1, using the WAHMO model suite and the actual observed levels, are tabulated in Table 1. The average results for the wet season (May to September)[1] in terms of *E. coli* were about 119 counts/100mL and 436 counts/100mL, based respectively on model predictions, and calculations using field measurements taken from 2002 to 2004. The model-predicted average bacteria outcome was therefore found to be about 27% of the field data-based outcome, and under-predicted the impact of the effluent discharged from the SCISTW.

Table 1 – Comparison of model-predicted results and calculations based on field measurements in the wet season from May to September (all units in counts of *E. coli*/100mL)

	***E.coli* level at Tsuen Wan Beaches**
Model predicted HATS-related influence for 2006	**119**
Summary of Field Measurements: ● No impact from HATS Stage 1(average of year 2000 to 2001 data) [A] ● With impact from HATS Stage 1(average of year 2002 to 2004 data) [B]	 349 785
Average influence due to HATS Stage 1 = [B] - [A]	**436**

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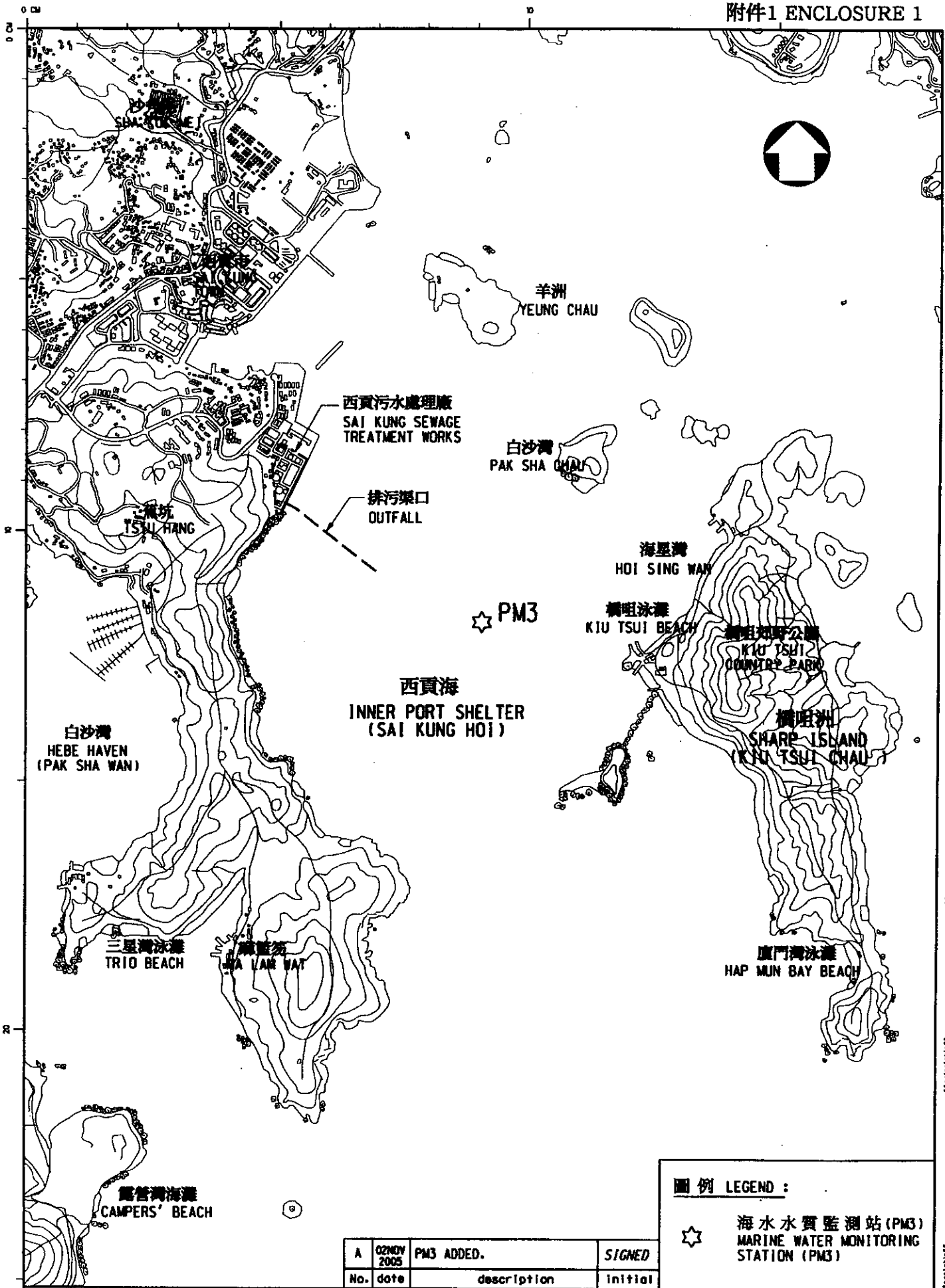
[1] The wet season in Hong Kong is taken to be from May to September, and constitutes a major part of the local bathing season. Water quality modeling was conducted for the wet season, since it had to take into account heavy summer rainfall which had implications for the hydrodynamics of the water body being modeled.



No.	date	description	initial
A	02NOV 2005	PM3 ADDED.	SIGNED

圖例 LEGEND :

☆ 海水水質監測站(PM3)
MARINE WATER MONITORING STATION (PM3)

圖則名稱 drawing title

西貢污水處理廠位置圖
LOCATION PLAN OF SAI KUNG SEWAGE TREATMENT WORKS

繪畫 drawn	SIGNED	Y. K. FAN	日期 date 28OCT05
核對 checked	SIGNED	S. C. CHIU	日期 date 28OCT05
批核 approved	SIGNED	T. Y. YUEN	日期 date 28OCT05

部門 office 污水工程部
SEWERAGE PROJECTS DIVISION

圖則編號 drawing no. DDN/340DS/0008A

比例 scale 1 : 20 000

香港特別行政區政府渠務署
DRAINAGE SERVICES DEPARTMENT
GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION

For Discussion

Sai Kung District Council
Food and Environmental Hygiene Committee

4340DS "Port Shelter Sewerage Stage 3 – Sai Kung Area 4 Sewerage"
Information Note on Water Quality Assessment

PURPOSE

We consulted the Sai Kung District Council on the proposal to provide trunk sewerage for Sai Kung Area 4 on 6 June 2005 and Members supported the proposal. During the discussion at the meeting on 23 November 2005, the Legislative Council Public Works Sub-committee while supporting the project requested the Administration to consult the Sai Kung District Council again on the project regarding the potential water quality impact arising from the projected future increase in the volume of treated effluent to be discharged to Port Shelter. This paper provides salient information on water quality assessment for Members' consideration.

THE PROPOSAL

2. Located on the northern side of Sai Kung town centre, Sai Kung Area 4 covers 37 hectares in area and has a population of about 200. The existing developments, which include a school, an electricity substation, a police station, a community centre, car parks and public leisure facilities, generate sewage of about 50 cubic metres per day (m^3/day). In future, Sai Kung Area 4 will be developed for residential, commercial, cultural, recreational and tourism-related uses (including a hotel), with an ultimate population of about 6 800, which will generate sewage of about 3 750 m^3/day.

3. The sewage generated in Sai Kung Area 4 is now conveyed to the Sai Kung sewage treatment works (SKSTW) by the existing sewerage serving Sai Kung town. The existing sewerage is handling a flow of about 8 000 m^3/day, which is approximately 90% of its design capacity. Therefore it does not have sufficient capacity to handle additional sewage arising from the planned developments. Due to site constraints, and to avoid disruption to the operation of the existing sewers, we propose to construct a separate sewerage system including a sewage pumping station, twin rising mains and trunk sewers with a capacity of 7 500 m^3/day to cater for all existing and future developments in Sai Kung Area 4, and the planned future expansion of the sewerage network to serve the environs up to

Tai Mong Tsai. The proposed sewerage system, which will collect sewage from the unsewered areas to SKSTW for proper treatment before disposal, will improve the water quality of Port Shelter in the long run and this will be beneficial to the long term development and environment of Sai Kung.

LEGISLATIVE COUNCIL'S CONCERN

4. The proposal was discussed at the Legislative Council Panel on Environmental Affairs on 24 October 2005. The Panel generally supported the item but requested the Administration to provide supplementary information on the water quality assessment, in particular the potential increase in *E. coli* level in the surrounding marine waters and at the beaches, arising from the projected future increase in the volume of treated effluent to be discharged to Port Shelter. The Administration subsequently provided the information note **(Appendix 1)**.

5. The potential water quality impact was discussed again at the Legislative Council Public Works Sub-committee (PWSC) meeting on 23 November 2005. The PWSC asked that the Sai Kung District Council be advised on the findings **(Appendix 1)** with regard to the possible impact of the projected future increase in the volume of treated effluent which will materialise later as a result of the development activity in the district. The PWSC's concern was to ensure the water quality modeling was reasonably accurate and there would be no situation similar to the Harbour Area Treatment Scheme (HATS) Stage 1 when the Tsuen Wan beaches were affected by the increase in the treated sewage effluent.

WATER QUALITY ASSESSMENT

6. The proposed project would increase the sewerage capacity for flows to SKSTW from 10 000 to about 18 000 m^3/day. It is planned to maintain the same high level of treatment at SKSTW and to discharge the treated effluent via a submarine outfall at about 15 metres deep and 500 metres offshore.

7. A state-of-the-art mathematical computer model, Delft3D (developed by Delft Hydraulics of the Netherlands), was used to assess the potential impacts on the quality of the Port Shelter waters. The particulars of the Delfts3D model used for the Sai Kung sewerage project in comparison with the WAHMO model used for the HATS Stage 1 are shown in **Appendix 2.**

8. The information note **(Appendix 1)** provided to Legislative Council shows that –

(a) the effluent from SKSTW is of high quality, with an average *E. coli* level of 2 per 100 mL;

(b) the marine water quality is good, with an average *E. coli* level of 2 per 100 mL in the vicinity of the outfall from SKSTW;

(c) the water quality of the three closest beaches, namely Kiu Tsui Beach, Hap Mun Bay Beach and Trio Beach, is good. In 2004, they were all graded as Category 1 beaches, with average *E. coli* levels of 17, 3 and 2 per 100 mL respectively; and

(d) the water quality modeling results indicate that the general marine water quality in Port Shelter will continue to be good with an E. coli level of less than 10 per 100 mL.

9. There is a huge difference between the Sai Kung sewerage project and the HATS Stage 1 project. HATS Stage 1 involves the discharge of 1.4 million m^3/day of undisinfected sewage with an *E. coli* level of about 5 million/100ml. On the other hand, for Sai Kung, the discharge will increase from 10 000 to only 18 000 m^3/day. The treated effluent will be disinfected by ultraviolet light to an average *E. coli* standard of 100 per 100 mL, i.e. the same high level of treatment as currently applied at SKSTW. Thus, the total loading of *E. coli* from HATS on Victoria Harbour is over 3 million times the projected loading from SKSTW on Port Shelter.

CONCLUSION

10. Both the water quality monitoring results and the mathematical computer modeling results indicate that the water quality in Port Shelter is extremely good and will continue to be so in the future. Given the high level of treatment to be provided, there is no indication that the increase in sewage flow would result in any deterioration of water quality in Port Shelter. Nevertheless, to keep Members up to date of the developments, we will report on the water quality monitoring results once the proposed sewerage project has been completed.

ADVICE SOUGHT

11. Members are requested to reaffirm their support, in the light of the additional information now provided, the Government's proposal to provide the trunk sewerage to serve Sai Kung Area 4 to meet the future development needs.

Environmental Protection Department
Drainage Services Department
December 2005

Appendix 1

For information

Legislative Council
Panel on Environmental Affairs

4340DS "Port Shelter sewerage stage 3 –
Sai Kung Area 4 and Mang Kung Uk sewerage"

Supplementary Information Note on Water Quality Assessment

PURPOSE

During the discussion on the proposal to provide trunk sewerage for Sai Kung Area 4 at the Legislative Council Panel on Environmental Affairs meeting on 24 October 2005, Members requested the Administration to provide supplementary information on the water quality assessment, in particular the potential increase in *E. coli* level in the surrounding marine waters and at the beaches, arising from the increase in sewage flows in Port Shelter. This paper provides the required details.

WATER QUALITY ASSESSMENT

The Existing Environmental Condition of Port Shelter

2. The water quality in Port Shelter is amongst the best in Hong Kong. Since 1989, it has been declared for secondary contact recreational uses with a water quality objective (WQO) for *E. coli* of less than 610 per 100 millilitres (mL). There are six gazetted beaches in Port Shelter with an *E. coli* WQO of less than 180 per 100 mL. The Environmental Protection Department takes routine seawater samples from ten marine monitoring stations and the beaches to monitor the water quality in Port Shelter. The monitoring data in 2004 indicated that –

(a) the marine water quality is good, with an average *E. coli* level at PM3, the marine monitoring station closest to the outfall from Sai Kung Sewage Treatment Works (SKSTW), of 2 per 100 mL; and

(b) the water quality of the three closest beaches, namely Kiu Tsui Beach, Hap Mun Bay Beach and Trio Beach, is good. In 2004 they were all graded as Category 1 beaches, with average *E. coli* levels of 17, 3 and 2 per 100 mL respectively.

Effluent Discharge from Sai Kung Sewage Treatment Works

3. Sewage generated in Sai Kung town is currently collected and conveyed to the SKSTW for treatment before disposal via a submarine outfall into the Port Shelter waters. SKSTW is a secondary sewage treatment works with nutrient removal and ultraviolet disinfection. The effluent standard for *E. coli* is 100 per 100 mL as a monthly geometric mean, with an additional requirement of not more than 1,500 per 100 mL for 95% of the time. In 2004, the average sewage flow to SKSTW was around 10,000 m^3/day. Following UV disinfection, the average *E. coli* level in the effluent was 2 per 100 mL.

Water Quality Assessment for the Increased Sewage Flow

4. The proposed project would increase the sewerage capacity for flows to SKSTW to 18,000 m^3/day. It is planned to maintain the same high level of treatment at SKSTW and to discharge the treated effluent via a submarine outfall at about 15 metres deep and 500 metres offshore, as shown in **Enclosure 1**.

5. Mathematical computer models were used to predict the potential impacts on the quality of the Port Shelter waters. The modeling results indicated that within a downstream distance of less than 10 metres from the outfall, the effluent will be diluted by 100 times on average. The modeling results also indicated that even with the worst case scenario of 1,500 *E. coli* per 100 mL discharged from SKSTW, there will be no material impact on the water quality in Port Shelter. The *E. coli* concentration in the surrounding marine water would remain below 10 counts per 100 ml and the beach water quality will remain unaffected by the effluent discharge from SKSTW.

CONCLUSION

6. Both the water quality monitoring results and the modeling results indicate that the water quality in Port Shelter is good and will continue to be good in the future. Given the high level of treatment to be provided, there is no indication that the increase in sewage flow would result in any deterioration of water quality in Port Shelter.

Environmental Protection Department
Drainage Services Department
November 2005

Appendix 2

WATER QUALITY MODELS

The mathematical computer models used in HATS Stage 1 and that for Sai Kung sewerage project were different. In the HATS Stage 1 EIA which was completed in 1996, the "Water Quality and Hydraulic Models" (WAHMO) modelling suite was used. On the other hand, the much more advanced state-of-the-art "Delft3D" model, developed by the world-renowned Delft Hydraulics in the Netherlands, was used to assess the potential water quality impacts from the SKSTW.

Although WAHMO was the best water quality assessment tool available to the government at that time, it was developed two decades ago and did not provide the capability and flexibility of modern numerical model codes. For instance, the WAHMO model was a simplified two dimensional water quality model which could not take into account the vertical water circulation (a critical element in hydrodynamics). Moreover, the model had limitations in simulating the complex water movement in localized areas such as regions in the vicinity of the Tsuen Wan beaches where there are several narrow channels through which the water may flow. This led to the under-prediction of impacts from the HATS Stage 1 effluent on the Tsuen Wan beaches. This old model has been superseded by more accurate formulations that capitalize on the advances in computer technology and the environmental data and experience we have accumulated over the past 15 years.

The model now used in the Sai Kung sewerage project is based on a regional model (the Update Model) set up using the Delft3D model suite. The Update Model was rigorously set up and extensively calibrated and verified with more than 10 years of field monitoring data. It is a very sophisticated software tool which allows the full three dimensional circulation of the Hong Kong and surrounding waters to be simulated. The model not only takes into account the complex hydrodynamic and transport processes, but also all the relevant physical-chemical-biological interactions in the concerned water body, rendering the modelling results more reliable and accurate than those predictions made previously using the WAHMO model.