EXECUTIVE SUMMARY

Introduction

S1 The Harbour Area Treatment Scheme (HATS) system consist of two mega-sized sewage conveyance systems (SCS) conveying effluent collected from preliminary treatment works (PTWs) to the Stonecutters Island Sewage Treatment Works (SCISTW) through a network of interconnected sewage tunnels. Septicity of sewage becomes a major concern for such system as septic sewage will not only bring odour issues, but also corrosion problems to the concrete structures.

S2 According to the agreed proposal, the Sewer Process Mathematical Model (SPMM) developed by the Prof. Guang-Hao Chen of Hong Kong University of Science and Technology (HKUST) and Prof. Feng Jiang of South China Normal University (SCNU) will be adopted for this study with proper modification to suit the HATS SCS.

S3 The overall objective of this study is:

- Construction, calibration, and validation of the SPMM for simulation of sulphide generation along the HATS SCS Stage 1;
- Construction of SPMM for the HSTS SCS Stage 2A based on the calibrated parameters from HATS SCS Stage 1 for the prediction of sulphide generation in the future operation;
- Model-based assessment of septicity control measures for the HATS SCS.

Sampling and Testing

S4 Overall 4 phases of onsite sampling and testing had been conducted in HATS 1 and 2A PTWs and SCISTW to capture the quality of sewage at the entrance and exit of HATS tunnels. Continuous gas phase monitoring was carried out in the headspace of wet well of the Main Pumping Station No.1 (MPS1) in the SCISTW. Instant flowrate inside the HATS SCS would also be used as model inputs which allow the SPMM to better suit the dynamic sewer network.

- Phase 1A - Background sampling at SCISTW. The results were used for basic evaluation of the model conditions and help optimizing the sampling procedures for key parameters;
- Phase 1B - Background sampling at Kwun Tong PTW. Aiming at determine the air intake the hydrogen sulphide release rate in the vortex shaft;
- Phase 1C - Gas phase monitoring in the headspace of MPS1 in SCISTW.
- Phase 3 - Intensive sampling at HATS Stage 1 PTWs, Kwun Tong Pumping Station and MPS1 in parallel for 7 days. The results were used for model calibration and verification of HATS Stage 1
- Phase 4 - Provisional sampling at HATS Stage 2A PTWs and MPS2 in parallel for 48 hours. The results were used for prediction of sulphide generation condition in HATS Stage 2A tunnel in the future.

Model Calibration and Verification

S5 With reference to the sampling and testing results of HATS Stage 1, the SPMM was calibrated and verified:-

- The simulated average Dissolved Sulphide (DS) concentration in the wet well of SCISTW MPS No.1 is 1.94 mgS/L and the $H_2S(g)$ concentration in the headspace of the wet well is 219 ppm under the sewage temperature of 28.7 ℃.
- The model was also simulated the sulphide generation under ultimate flowrate which is 1.44 times of the existing flowrate. The sulphide production can be reduced by 12% compared to the value under current flow.
- The most critical factor for sulphide generation is temperature that the sulphide generate in summer is nearly 3 times of winter.

S6 Due to the unformed biofilm in the sewage tunnel and unstable flow condition during the sampling and testing of HATS Stage 2A, the modelling results cannot be verified with the detected gas phase concentration in MPS2. Therefore, the simulation was mainly target at predicting the sulphide generation in HATS 2 SCS when the biofilm is fully developed and the hydraulic condition is stable.

- The DS concentration in the wet well of SCISTW MPS No.2 is 1.81 mgS/L and the $H_2S(g)$ concentration is 39 and 71 ppm with or without forced ventilation (3 ACH) under the sewage temperature of 23.2 ℃.
- Under ultimate flow situation, the sulphide production can be reduced by 31% compared to the value under current flow.
- The sulphide production in summer is 4 times higher than winter.

Mitigation Measures

S7 Multiple case studies concerning the mitigation measures are evaluated by SPMM. Based on the simulation results in HATS SCS Stage 1,

- To Kwa Wan (TKW) PTW was displayed to be the optimal chemical dosing location;
- The solely chemical dosing of $Ca(NO_3)_2$ is impractical to control the $H_2S(g)$ concentration in MPS1 below 20 ppm even combined with forced ventilation;
- The solely chemical dosing of NaOH is capable of reducing the $H_2S(g)$ in MPS1 below 20 ppm when the sewage pH raised to 8.5. However, dosing NaOH cannot reduce the DS concentration that the septicity problem may still be outstanding after the sewage enter the CEPT process and cause additional consumption on the coagulant.
- The combination dosage of $Ca(NO_3)_2$ and NaOH is more cost effective compared to individual chemical dosing and capable of achieving both liquid and gas phase control targets.

Table S1 - Simulated Chemical Consumption in HATS SCS Stage 1

Scenarios	Scenario 1 (1)		Scenario 2 (2)	
DS control target in MPS1	< 1.5 mgS/L			
H_2S(g) control target in MPS1	< 20 ppm			
Sewage Temperature	27 ℃ (3)			
Chemical Form	50% solution			
	$Ca(NO_3)_2$	NaOH	$Ca(NO_3)_2$	NaOH
Consumption (m^3/d)	28.5	23.3	28.5	14.7

Note:
(1) Dosing $Ca(NO_3)_2$ and NaOH at TKW PTW;
(2) Dosing $Ca(NO_3)_2$ and NaOH at TKW PTW, combined with forced ventilation in SCISTW MPS1 at ACH of 5.
(3) The chemical consumption is adjusted to the annually average sewage temperature of SCISTW (27℃).

S8 Based on the case study in HATS SCS Stage 2A:

- The optimal chemical dosing locations are indicated to be Sai Ying Pun Junction Shaft and Central PTW;
- The solely chemical dosing of $Ca(NO_3)_2$ is capable of reducing the H_2S(g) concentration in MPS2 below 20 ppm, but the chemical consumption would be tremendous;
- The solely chemical dosing of NaOH cannot reduce or inhibit the sulphide generation in the tunnel. The combination dosage of $Ca(NO_3)_2$ and NaOH would be a more comprehensive and cost effective method.

Table S2 - Simulated Chemical Consumption in HATS SCS Stage 2A

DS control target in MPS2	< 1.5 mgS/L	
H_2S(g) control target in MPS2	< 20 ppm	
Sewage Temperature	27 ℃ (1)	
Chemical Form	50% solution	
	$Ca(NO_3)_2$	NaOH
Consumption (m^3/d)	34 m^3/d	3.5 m^3/d

Note:
(1) The chemical consumption is adjusted to the annually average sewage temperature of SCISTW (27℃).