

**THE GOVERNMENT OF THE HONG KONG
SPECIAL ADMINISTRATIVE REGION**

Drainage Services Department

CONTRACT NO. SPW 05/2015

Odour Survey for Sha Tin Cavern Sewage Treatment Works

December 2015

By Odour Research Centre

Faculty of Science and Technology
Technological and Higher Education Institute of Hong Kong
(Member of VTC Group)



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1. Background

A service of odour sampling and olfactometry analysis was required by the Drainage Services Department of Hong Kong Government to determine the odour conditions at the existing Sha Tin Sewage Treatment Works (STSTW) to build up the odour emission inventory for the future relocated STSTW in caverns.

2. Scope of the Work

- provision of all labour, transportation, materials, equipment and tools necessary for the satisfactory completion of the Services as per Technical Requirements within the course of the Services;
- to conduct odour sampling and olfactometry analysis to determine odour emission rates background odour concentration at the odorous source locations of the existing STSTW and nearby representative air sensitive receivers (ASRs);
- in conjunction with the odour sampling, to conduct on-site H₂S measurement at the identified odorous source locations of the existing STSTW and nearby representative ASRs, and near the relocation site to obtain quantitative data on existing odour level during the odour sampling;
to conduct the measurement of TVOC at inlet and outlet points of the deodourizer; and
- preparation and submission of Odour Analysis Report to the Employer's Representative (AECOM Asia Co. Ltd.).

3. Sampling Locations and Frequency

Odour sampling shall be carried out at the odour source locations within the existing STSTW. The sampling shall be conducted at both the inlet and outlet points of the deodourizers (DO) for different facilities as well as the effluent surface / screens surface / sludge surface of the different facilities which are open to the atmosphere. The respective locations are listed below and as shown in Appendix A and Appendix B:

Location of odour sampling at odorous source at STSTW (excluding deodourizers);

- A1 - Inlet Fine Screen
- A2 - SAS Holding Tank
- A3 - Thickened SAS Holding Tank
- A4 - Digested Sludge Holding Tank
- F1 - Inlet Channel
- F2 - Screening Skip
- F3 - Aerated Grit Channel
- F4 - Primary Influent Channel
- F5 - Primary Sedimentation Tank
- F6 - Primary Effluent Channel
- F7 - Aeration Tank (Anoxic Zone)
- F8 - Aeration Tank (Aerobic Zone)
- F9 - Final Sedimentation Tank
- F10 - MLSS Channel
- F11 - Digester Overflow Box
- F12 - Dewatered Sludge Skip

Two sampling events will be conducted for each sampling location on separate days with daytime's temperature measures greater than 30°C (during sampling period) at site.

4. Methodology

4.1. Odour Sampling

- 4.1.1 Odour gas sample at each survey location is collected by a Sampling Device Standard consists of a vacuum container, which is evacuated by a vacuum pump. The sampling point and the standard sampler are connected by a probe.
- 4.1.2 Due to the evacuation in the sampling device, the sample bag, inside the device, sucks in sample air via the probe. During this process, none of its components come into contact with the sample air due to the construction of the sampling device.
- 4.1.3 The only materials, which the odorous air should contact, are stainless steel, borosilicate glass or one of polytetrafluoroethylenes (PTFE). The sample bags are to be manufactured from PTFE, Tedlar if the bags to be reused or from nalophane (NATM) if the sample bags are to be discarded after use.



Odour Sampling System

4.1.4 In order to determine a specific odour emission rate from an area source such as water surface, air sampling can use a “hood” method, whereby a Flux Hood is placed on the odour emission surface of selected locations and a stream of odour-free nitrogen gas from a certified gas cylinder is supplied into the Flux Hood to simulate a sweep wind blowing on the main section of sampling hood. The flow rate of odour-free nitrogen gas is 5 (L/min). The emission rate is then determined by the air flow through the hood and the odour concentration of the exit air. Air samples shall be collected using the above Sampling Device Standard and odour bags. The Flux Hood system is shown below.



Flux Hood Systems

4.2. Olfactometry Analysis

4.2.1 The collected air sample in sample bag should be delivered to Odour Research Centre of THEi and the odour concentration is determined by a Dynamic Olfactometer (TO9) in accordance with the European Standard Method (EN13725).

4.2.2 This European Standard specifies a method for the objective determination of the odour concentration of a gaseous sample using dynamic olfactometry with human assessors and the emission rate of odours emanating from point sources, area sources with outward flow and area sources without outward flow. The primary application is to provide a common basis for evaluation of odour emissions in the member states of the European Union.

4.2.3 This European Standard is applicable to the measurement of odour concentration of pure substances, defined mixtures and undefined mixtures of gaseous odorants in air or nitrogen, using dynamic olfactometry with a panel of human assessors being the sensor. The unit of measurement is the European odour unit per cubic metre: OU_E/m^3 . The odour concentration is measured by determining the dilution factor required to reach the detection threshold. The odour concentration at the detection threshold is by definition $1 OU_E/m^3$. The odour concentration is then expressed in terms of multiples of the detection threshold. The range of measurement is typically from $2^2 OU_E/m^3$ to $2^{17} OU_E/m^3$ (excluding pre-dilution).



Olfactometer TO9

4.3. Determination of Specific Odour Emission Rate

A dynamic flux hood system was employed in this sampling work to collect odour samples from water surface, in which an odour-free gas from a nitrogen gas cylinder was supplied to generate a known air inflow at a fixed flow rate of 5 L/min inside the hood. The specific odour emission rates (SOER) at the area source can be calculated by the following equation:

$$SOER (OU_E/m^2 /s) = \frac{\text{Odour concentration } (OU_E /m^3) \times \text{Air flow rate inside hood } (m^3 /s)}{\text{Covered water surface area } (m^2)}$$

4.4. Quality Control (QA/QC)

During each odour sampling day, one blank sample by purging odour-free nitrogen gas from the certified gas cylinder shall be prepared for a purpose of QA/QC.

4.5. On-site H₂S measurements

The concentration of H₂S is detected on site using Jerome J605 Hydrogen Sulfide Analyzer. The concentration unit is ppb. The detection limit is 3 ppb.



Jerome J605 Hydrogen Sulfide Analyzer

4.6. TVOC measurement

The concentration of TVOC is detected in laboratory using ppbRAE 3000 Portable Handheld VOC Monitor. The concentration unit is ppb. The detection limit is 1 ppb.



ppbRAE 3000 Portable Handheld VOC Monitor

4.7. Quality Assurance

The odour laboratory shall be ventilated to maintain an odour-free environment and to provide fresh air to the panel members.

Each odour testing session shall comprise of at least five qualified panellists. All of the panellists shall be screened beforehand by using a certified n-butanol standard gas. The qualified panellists should have their individual thresholds of n-butanol in the range of 20-80 ppb/v to comply with the requirement of EN13725.

Panel members must not eat or smoke for one hour prior to the testing session. Panel members should not use perfumes, shave lotions or any other fragrant essences before the session. Panel member should not attend a session if he/she has a cold, influenza or any other health problems which will affect his/her nose.

Eating, drinking or smoking is not permitted while a session is in progress. The exception is during the mid-session break when water can be taken. If a lunch break is taken, food can also be eaten at one hour before the session. Smoking is not permitted during any breaks.

Each odour testing session should not last for more than 4 hours, in which at least two breaks (ten minutes each) for olfactometry test shall be taken.

Exposure to direct sunlight shall be avoided for the samples. If any condensate is observed on the inner surface of the air bag, the sample should be discarded.

After sampling, the odour samples should be delivered to an odour laboratory as soon as possible and the odour samples shall be analysed within 24 hours.

Regular calibrations of the olfactometer should be performed to check the accuracy and repeatability of its dilution settings and to establish its calibration history. The calibration should be regularly performed using sulfur hexafluoride as a tracer gas and a sulfur hexafluoride monitor.

5. Odour Sampling and Olfactometry Measurement

5.1. Sampling Activities

5.1.1 Two sampling events were conducted at identified odour source and representative air sensitive receiver of twenty one locations respectively on 15 and 17 July 2015 with daytime's temperature measures greater than 30°C (during sampling period) at site. The sampling locations are shown in Table 1 and Appendix A and C.

5.1.2 On the effluent surface / screens surface / sludge surface of the different facilities at twelve locations, the odour sample was taken from the surface using the Flux Hood, where a stream of odour-free nitrogen gas from a certified gas cylinder is supplied into the Flux Hood to simulate parallel winds blowing on the main section of sampling hood at a fixed flow rate of 5 L/min and the outlet gas from the Flux Hood was taken as odour samples.

5.1.3 At the four odour source locations and the five nearest representative air sensitive receivers, the ambient air was collected as odour samples.

5.1.4 During the sampling period, the concentration of H₂S was detected on site at twenty-one locations using Jerome J605 Hydrogen Sulfide Analyzer.

5.1.5 During the odour sampling, relevant weather conditions including ambient temperature, relative humidity, wind speed, and wind direction were recorded on the sites for references. The data are shown in Table 1. The operation status of different unit/tanks at STSTW during sampling period are referred to Appendix D.

5.1.6 In every sampling day, one blank sample by purging odour-free nitrogen gas from the certified gas cylinder was also prepared for a purpose of QA/QC.

5.1.7 A total of forty-four gas samples on 15 and 17 July 2015 were collected and immediately transported to the Odour Research Centre of THEi after the sampling.

5.2. Additional Sampling Activities at Deodourizer

5.2.1 Two sampling events were conducted at inlet and outlet points of the deodourizer of twelve locations respectively on 13 and 17 November 2015. The sampling locations are shown in Table 2 and Appendix B.

5.2.2 During the odour sampling, relevant weather conditions including ambient temperature, relative humidity, wind speed, and wind direction were recorded on the sites for references. The data are shown in Table 2.

5.2.3 In every sampling day, one blank sample by purging odour-free nitrogen gas from the certified gas cylinder was also prepared for a purpose of QA/QC.

5.2.4 A total of fifty gas samples on 13 and 17 November 2015 were collected and immediately transported to the Odour Research Centre of THEi after the sampling.

5.2.5 The concentrations of H₂S and TVOC were detected in laboratory using Jerome J605 Hydrogen Sulfide Analyzer and ppbRAE 3000 Portable Handheld VOC Monitor.

5.3. Olfactometry Analysis

Olfactometry analysis was conducted within 24 hours after the sampling work using a dynamic olfactometer in accordance with the European Standard Method (EN13725). Five qualified panellists participated in the odour testing session, who were previously selected through a set of screening tests using a certified n-butanol gas (60 ppm/v) as a standard reference.

5.4. Determination of Specific Odour Emission Rate

From the odour concentrations determined by olfactometry, the specific odour emission rates (SOER) at twelve sampling locations (F1 – F12) were calculated by the following equation and the final results are shown in Table 1:

$$\text{SOER (OU}_E\text{/m}^2\text{/s)} = \frac{\text{Odour concentration (OU}_E\text{/m}^3\text{)} \times \text{Air flow rate inside hood (m}^3\text{/s)}}{\text{Covered water surface area (m}^2\text{)}}$$

Where air flow rate inside hood = 5.0 (L/min) x 10⁻³ / 60 = 8.33 x 10⁻⁵ (m³/s), and covered surface area = 0.2 (m) x 0.2 (m) x 3.14 = 0.126 m².

5.5. Survey Results

Summary of sampling condition and results for odour sampling and olfactometry measurement are shown in Table 1 and Table 2.

Table 1. Summary of sampling condition and results for odour survey

Sample ID	Sampling Location	Date	Time	Sampling Method	Ambient Temp. °C	Humidity %	Wind Direction	Wind Speed m/s	H ₂ S (ppb) On Site	OC OU _E /m ³	SOER OU _E /m ² ·s
F9	Final Sedimentation Tank	15-7-2015	9:15	FH	31.4	72.9	NE	0.5	< 3.00	38	0.025
F10	MLSS Channel	15-7-2015	9:35	FH	33.0	69.2	NE	0.1	< 3.00	26	0.017
F12	Dewatered Sludge Skip	15-7-2015	10:02	FH	32.4	70.3	NE	0.2	< 3.00	1722	1.14
A4	Digested Sludge Holding Tank	15-7-2015	10:26	A	31.9	71.0	NE	0.1	4.49	2896	
F11	Digester Overflow Box	15-7-2015	10:50	FH	33.9	69.0	E	1.7	< 3.00	1218	0.81
F8	Aeration Tank (Aerobic Zone)	15-7-2015	11:20	FH	34.7	68.4	E	1.5	29.5	107	0.071
F7	Aeration Tank (Anoxic Zone)	15-7-2015	11:34	FH	35.2	67.8	E	0.8	157	152	0.10
F6	Primary Effluent Channel	15-7-2015	11:49	FH	35.5	67.5	E	0.4	1033	6888	4.55
F5	Primary Sedimentation Tank	15-7-2015	12:04	FH	35.8	67.3	E	0.9	322	4096	2.71
F4	Primary Influent Channel	15-7-2015	12:21	FH	36.2	66.9	E	0.3	141	4870	3.22
F2	Screening Skip	15-7-2015	12:53	FH	32.5	70.2	E	0.4	37.6	5792	3.83
F1	Inlet Channel	15-7-2015	13:26	FH	33.8	69.0	E-SE	0.2	128	8191	5.42
F3	Aerated Grit Channel	15-7-2015	13:57	FH	31.4	72.7	E-SE	0.3	121	3444	2.28
A2	SAS Holding Tank	15-7-2015	14:30	A	31.2	72.8	E-SE	0.1	< 3.00	1024	
A3	Thickened SAS Holding Tank	15-7-2015	14:40	A	31.5	72.6	E-SE	0.1	< 3.00	512	
A1	Inlet Fine Screen	15-7-2015	15:00	A	33.2	69.1	E-SE	0.5	1185	6653	
	Marine North Division Headquarter	15-7-2015	10:54	A	32.7	70.0	S	0.9	4.25	7	
	Seaview Villa	15-7-2015	15:20	A	32.4	70.2	SW	0.2	< 3.00	< 4	
	Kam Tai Court	15-7-2015	15:40	A	32.0	70.6	SW	0.8	< 3.00	< 4	
	Chevalier Garden	15-7-2015	16:00	A	31.7	71.2	S	1.4	< 3.00	< 4	
	Sha Tin Fishermen's New Village	15-7-2015	16:15	A	31.2	73.0	SE	1.7	< 3.00	< 4	
	QA/QC	15-7-2015	14:10							< 4	

Event 2												
Sample ID	Sampling Location	Date	Time	Sampling Method	Ambient Temp. °C	Humidity %	Wind Direction	Wind Speed m/s	H ₂ S (ppb) On Site	OC OU _E /m ³	SOER OU _E /m ² .s	
F9	Final Sedimentation Tank	17-7-2015	9:06	FH	30.8	78.3	SW	0.5	< 3.00	45	0.030	
F10	MLSS Channel	17-7-2015	9:24	FH	31.2	77.7	SW	0.4	< 3.00	31	0.020	
F12	Dewatered Sludge Skip	17-7-2015	13:26	FH	33.0	68.9	SW	0.1	4.42	1261	0.83	
A4	Digested Sludge Holding Tank	17-7-2015	13:46	A	31.3	71.4	SW	0.1	6.86	2195		
F11	Digester Overflow Box	17-7-2015	9:57	FH	32.5	70.7	SW	0.2	7.74	1911	1.26	
F8	Aeration Tank (Aerobic Zone)	17-7-2015	10:26	FH	32.8	70.6	SW	0.9	94.9	76	0.050	
F7	Aeration Tank (Anoxic Zone)	17-7-2015	10:41	FH	33.1	70.2	SW	0.1	116	208	0.14	
F6	Primary Effluent Channel	17-7-2015	10:59	FH	33.5	69.4	SW	1.3	263	7298	4.82	
F5	Primary Sedimentation Tank	17-7-2015	11:14	FH	33.8	68.7	S-SW	1.8	227	4390	2.90	
F4	Primary Influent Channel	17-7-2015	11:33	FH	34.3	68.2	S-SW	1.0	154	5160	3.41	
F2	Screening Skip	17-7-2015	12:00	FH	33.6	68.5	S-SW	0.1	9.61	1625	1.07	
F1	Inlet Channel	17-7-2015	12:32	FH	34.9	67.8	S	0.4	3438	7796	5.15	
F3	Aerated Grit Channel	17-7-2015	12:49	FH	35.4	66.5	S	0.2	1178	4096	2.71	
A2	SAS Holding Tank	17-7-2015	14:14	A	31.7	71.0	SW	0.1	118.5	955		
A3	Thickened SAS Holding Tank	17-7-2015	14:21	A	31.4	71.5	SW	0.1	9.98	549		
A1	Inlet Fine Screen	17-7-2015	13:10	A	35.2	66.8	SW	0.1	567	7643		
	Marine North Division Headquarter	17-7-2015	14:38	A	32.0	70.8	SW	0.3	< 3.00	9		
	Seaview Villa.	17-7-2015	14:52	A	32.6	70.4	SW	0.4	< 3.00	< 4		
	Kam Tai Court	17-7-2015	15:10	A	32.9	70.3	S	0.7	< 3.00	< 4		
	Chevalier Garden	17-7-2015	15:19	A	34.2	68.4	S	0.8	< 3.00	< 4		
	Sha Tin Fishermen's New Village	17-7-2015	15:30	A	32.1	70.7	SW	0.3	< 3.00	< 4		
	QA/QC	17-7-2015	13:40									

Remark: A: Ambient sampling; FH: Flux hood method; OC: Odour concentration; SOER: Specific odour emission rate;

5.6. Site Photos

During the sampling, relevant photos were taken at the all sampling locations and are shown below:



A1 - Inlet Fine Screen



A2 - SAS Holding Tank



A3 - Thickened SAS Holding Tank



A4 - Digested Sludge Holding Tank



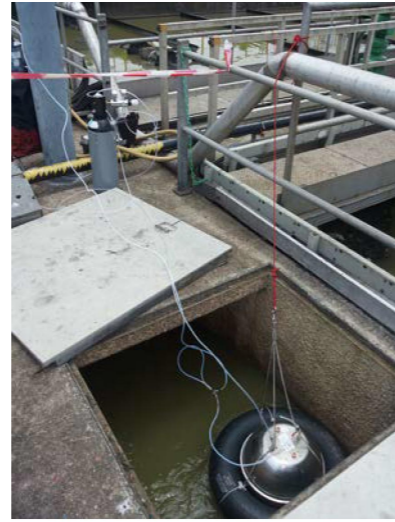
F1 - Inlet Channel



F2 - Screening Skip



F3 - Aerated Grit Channel



F4 - Primary Influent Channel



F9 - Final Sedimentation Tank



F10 - MLSS Channel



F5 - Primary Sedimentation Tank



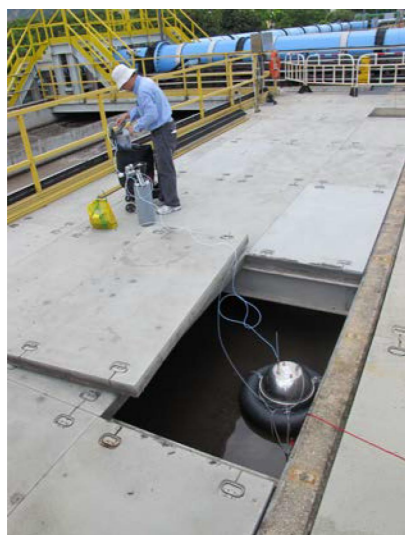
F6 - Primary Effluent Channel



F11 - Digester Overflow Box



F12 - Dewatered Sludge Skip



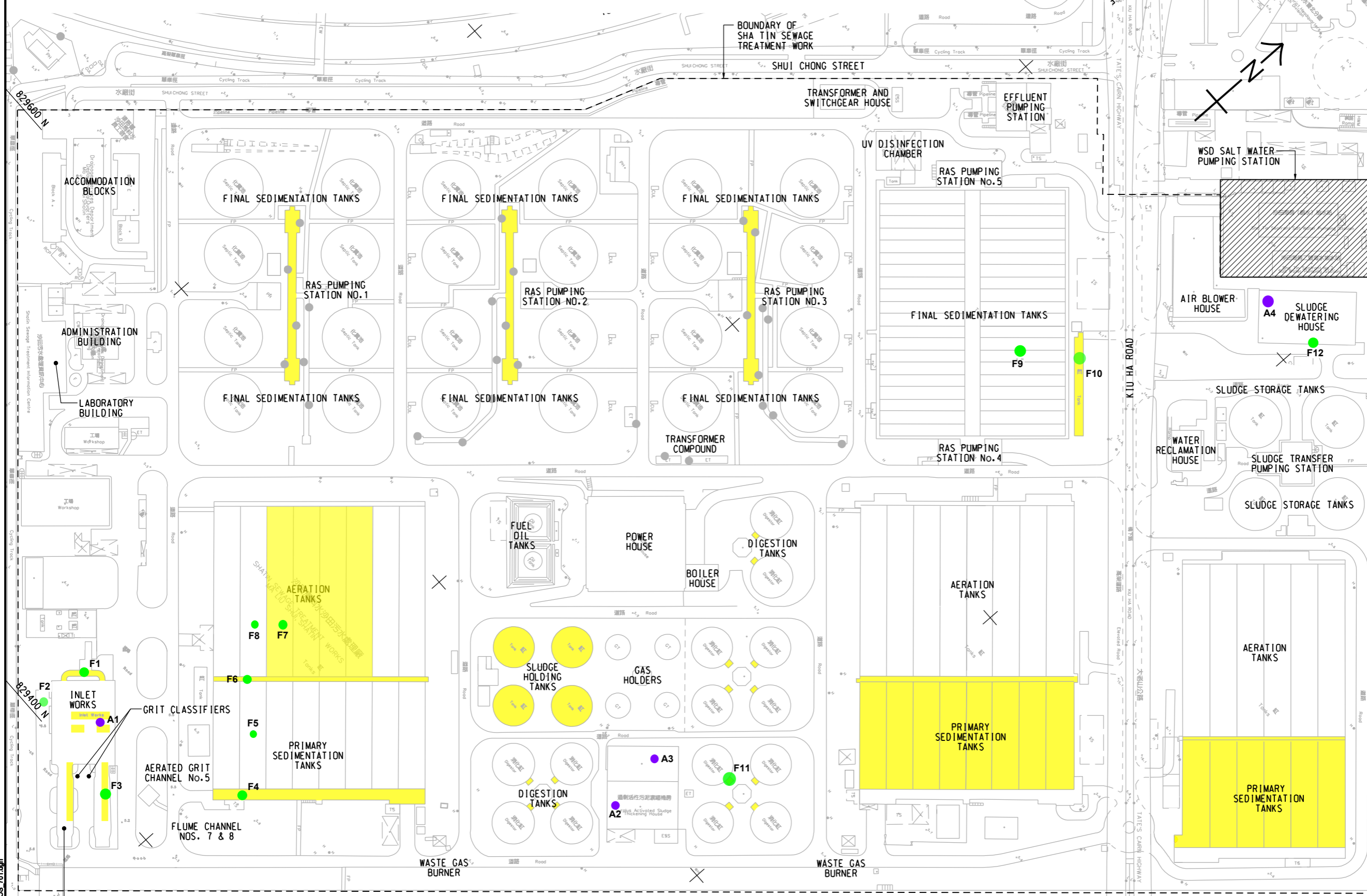
F7 - Aeration Tank (Anoxic Zone)



F8 - Aeration Tank (Aerobic Zone)

Appendix A: Location of odour sampling at odourous source at STSTW (excluding deodorizers)

ISO A1 594mm x 841mm
 Approved:
 Checked:
 Designer:
 Project Management Initials:
 Pld File by: ZHILZ 2015/4/1
 PATH P:\PROJECTS\60334056\Drawing\REPORTS\OS_701.dgn



AECOM

PROJECT
 ODOUR SURVEY FOR SHA TIN CAVERN SEWAGE TREATMENT WORKS

CLIENT
 渠務署
 Drainage Services Department

CONSULTANT
 AECOM Asia Company Ltd.
 www.aecom.com

SUB-CONSULTANTS
 丹戎士打有限公司

ISSUE/REVISION

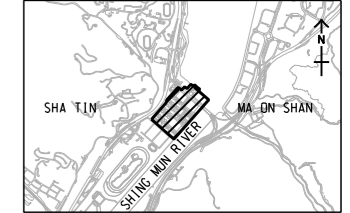
NO.	DATE	DESCRIPTION	CHK.

STATUS
 核准

SCALE
 比例: A1 1:1000

DIMENSION UNIT
 尺寸單位: METRES

KEY PLAN A1 1:50000



- LEGEND:**
- COVERED SURFACE
 - Flux Hood Sampling Location
 - Ambient Air Sampling Location
- TENTATIVE SAMPLING LOCATIONS:**
- Ambient Air Sampling Location**
 - A1 - Inlet Fine Screen
 - A2 - SAS Holding Tank
 - A3 - Thickened SAS Holding Tank
 - A4 - Digested Sludge Holding Tank
 - Flux Hood Sampling Location**
 - F1 - Inlet Channel
 - F2 - Screening Skip
 - F3 - Aerated Grit Channel
 - F4 - Primary Influent Channel
 - F5 - Primary Sedimentation Tank
 - F6 - Primary Effluent Channel
 - F7 - Aeration Tank (Anoxic Zone)
 - F8 - Aeration Tank (Aerobic Zone)
 - F9 - Final Sedimentation Tank
 - F10 - MLSS Channel
 - F11 - Digester Overflow Box
 - F12 - Dewatered Sludge Skip

Note: Exact sampling locations to be confirmed on site

PROJECT NO.
 項目編號: 60334056

CONTRACT NO.
 合約編號: SPW 05/2015

SHEET TITLE
 圖紙名稱: REVISED LOCATIONS FOR ODOUR SURVEY FOR SHA TIN CAVERN SEWAGE TREATMENT WORKS

SHEET NUMBER
 圖紙編號: Appendix B

Appendix B: Operation status of different unit/tanks at STSTW during sampling period

Sample ID	Sampling Location	Date	Time	Sewage/Sludge Temperature (°C)	Flow Speed (m/s)	Capacity of the units/ tanks (m ³)	Operation status of the units/ tanks
F9	Final Sedimentation Tank No.32	15-7-2015	9:15	Unknown	Unknown		Operation
F10	MLSS Channel (at Final Sedimentation Tank No.32)	15-7-2015	9:35	Unknown	Unknown	N.A.	Operation
F12	Dewatered Sludge Skip	15-7-2015	10:02	N.A.	Unknown	N.A.	Operation
A4	Digested Sludge Holding Tank	15-7-2015	10:26	Unknown	Unknown	11.5 m high	Operation
F11	Digester Overflow Box No.5	15-7-2015	10:50	Unknown	Unknown	Unknown	Operation
F8	Aeration Tank No.8 (Aerobic Zone)	15-7-2015	11:20	Unknown	SS flow is 141 l/s , RAS flow is 143 l/s		Operation
F7	Aeration Tank No.8 (Anoxic Zone)	15-7-2015	11:34	Unknown	SS flow is 141 l/s , RAS flow is 143 l/s		Operation
F6	Primary Effluent Channel (towards Aeration Tank No.8)	15-7-2015	11:49	Unknown	Unknown	Unknown	Operation
F5	Primary Sedimentation Tank No.8	15-7-2015	12:04	Unknown	Unknown	Unknown	Operation
F4	Primary Influent Channel (at Primary Sedimentation Tank No.8)	15-7-2015	12:21	Unknown	Unknown	Unknown	Operation
F2	Screening Skip	15-7-2015	12:53	N.A.	Unknown	Unknown	Operation
F1	Inlet Channel	15-7-2015	13:26	Unknown	2207 l/s	N.A.	Operation
F3	Aerated Grit Channel No.1	15-7-2015	13:57	Unknown	Unknown	Unknown	Standby
A2	SAS Holding Tank	15-7-2015	14:30	Unknown	Unknown		Operation
A3	Thickened SAS Holding Tank No.5	15-7-2015	14:40	Unknown	Unknown	1.464m3	Operation
A1	Inlet Fine Screen No.2	15-7-2015	15:00	N.A.	Unknown	N.A.	Operation
F9	Final Sedimentation Tank No.32	17-7-2015	9:06	Unknown	Unknown		Operation
F10	MLSS Channel (at Final Sedimentation Tank No.32)	17-7-2015	9:24	Unknown	Unknown	N.A.	Operation
F12	Dewatered Sludge Skip	17-7-2015	13:26	N.A.	Unknown	N.A.	Operation
A4	Digested Sludge Holding Tank	17-7-2015	13:46	Unknown	Unknown	11.2 m high	Operation
F11	Digester Overflow Box No.5	17-7-2015	9:57	Unknown	Unknown	Unknown	Standby
F8	Aeration Tank No.8 (Aerobic Zone)	17-7-2015	10:26	Unknown	SS flow is 199 l/s , RAS flow is 245 l/s		Operation
F7	Aeration Tank No.8 (Anoxic Zone)	17-7-2015	10:41	Unknown	SS flow is 199 l/s , RAS flow is 245 l/s		Operation
F6	Primary Effluent Channel (towards Aeration Tank No.8)	17-7-2015	10:59	Unknown	Unknown	Unknown	Operation
F5	Primary Sedimentation Tank No.8	17-7-2015	11:14	Unknown	Unknown	Unknown	Operation
F4	Primary Influent Channel (at Primary Sedimentation Tank No.8)	17-7-2015	11:33	Unknown	Unknown	Unknown	Operation
F2	Screening Skip	17-7-2015	12:00	N.A.	Unknown	Unknown	Operation
F1	Inlet Channel	17-7-2015	12:32	Unknown	3002 l/s	N.A.	Operation
F3	Aerated Grit Channel No.1	17-7-2015	12:49	Unknown	Unknown	Unknown	Standby
A2	SAS Holding Tank	17-7-2015	14:14	Unknown	Unknown	11.3 m high	Operation
A3	Thickened SAS Holding Tank No.5	17-7-2015	14:21	Unknown	Unknown	1.5m3	Operation
A1	Inlet Fine Screen No.2	17-7-2015	13:10	N.A.	Unknown	N.A.	Operation
	Remark: The operation data were provided by STSTW.						