PolyU Technology & Consultancy

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CONSULTANCY SERVICE

FOR

[MOTT MACDONALD HONG KONG LIMITED]

[Expert Review of New Yau Mei Tei Typhoon Shelter (NYMTTS) Odour Source Measurement Stage I]
[P12-0295]

Prepared by:
[Prof. S.C. Lee]

Signed by:

Date: 10/4/2013

1. Scope of the Work

Description	Date
Proposal Submission	7-10 Jan, 2013
1st Site Visit	24 Jan, 2013
2nd Site Visit	1 Feb, 2013
1st On-site sampling	18 Feb, 2013
2nd On-site sampling	20 Feb, 2013

Figure 1 - Schedule for the project

- To conduct odour monitoring work at particular locations after reviewing the HKPC's report
- To measure the odour concentration, odour emission rate, H_2S concentration, VOCs Level, Mercaptans concentration at Grid #30 and Grid #7, where were the closest grids near to the Park Avenue Central Park and the Jordon Road
- To identify the major sources of odour from which odour pollutants (H_2S, VOCs, Mercaptans, or others)
- To determine the main odorants and the main influencing factors based on multi-dimensional analysis (air-bound, water-bound or sediment-bound)

2. Methodology

2.1. Odour sampling

Odour gaseous sample is collected by using an odour sampling system, which includes a battery-operated air pump, a sampling vessel, and an odour bag as shown below. During air sampling, an empty sample bag is placed in the vessel, a rigid plastic container, and the container is then evacuated at a controlled rate and the bag is filled with foul gas.

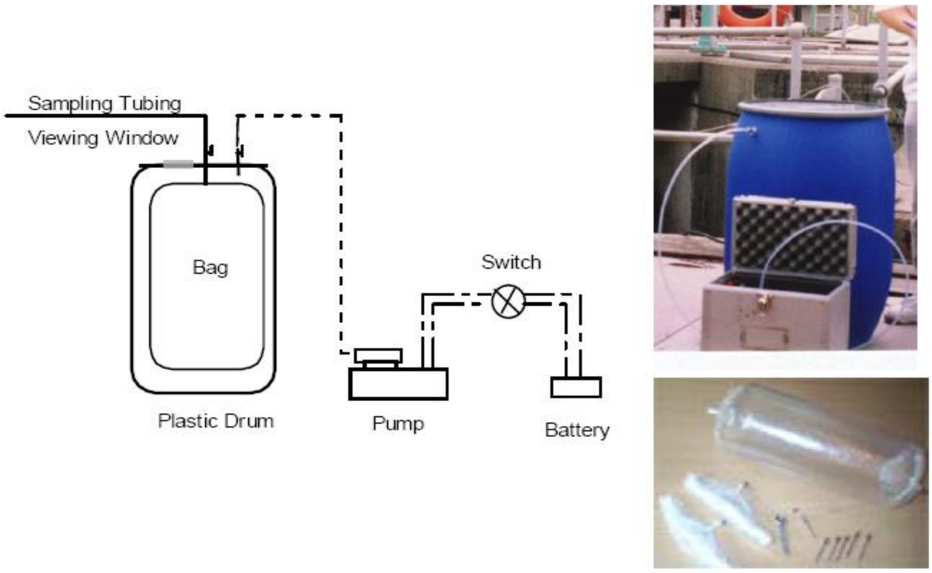


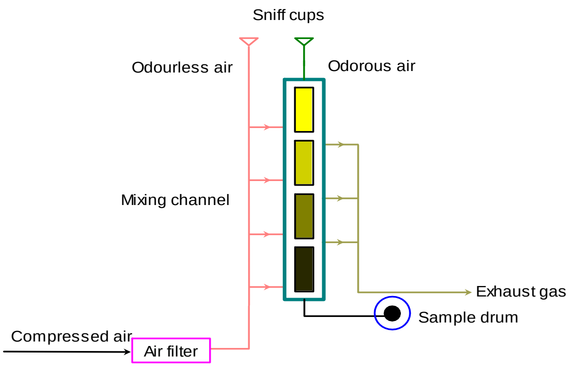
Figure 2 - Sampling equipment of odour sampling

In this technique, all "wetted" parts exposed to the odorous gas are to be composed of stainless steel and Teflon tubing. It is necessary to pre-conditioning the sampling bag, that is the bag is to be partly filled with the odorous sample and then emptied prior to filling the bag for odour testing. 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 NA^{TM} if the sample bags are to be discarded after use. About 60 L of foul gas is collected for each sample.

The QA/QC samples will be collected by sucking the ambient air through a portable gas purifier (Drierite 27068) on the site. It could be also collected by using a "hood" method whereby either a dynamic flux hood or a wind tunnel is placed on the odour emission surface of selected locations, and odour-free air either from a gas cylinder or by passing through an activated carbon filter is blown through it.

2.2. Olfactometry analysis

The odour concentration of a gaseous sample is determined by presentation to a panel of observers, with known acuity to odour, in varying dilutions. The odour concentration is then expressed in multiples of Odour concentration is determined by a Forced-choice Dynamic Olfactometer (Olfacton-n2) in full accordance with the European Standard Method (EN13725). 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 range of measurement including pre-dilution prior to the olfactometry analysis is typically from 10^1 ou/m^3 to 10^7 ou/m^3. one Odour Unit. This analysis technique provides directly comparable data for different odour types, and used for input into dispersion models to determine odour impact in terms of annoyance and abatement efficiency assessments.



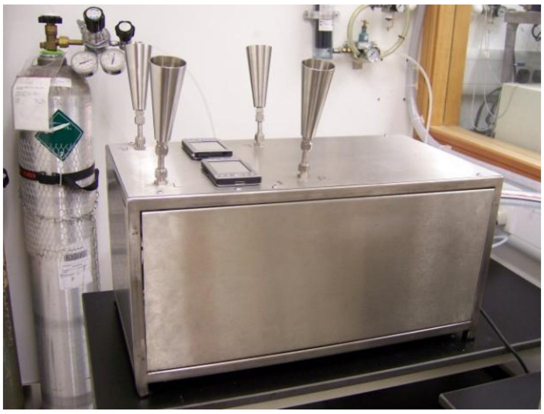


Figure 3 - Olfactormeter (Oldacton-n2) at Odour Lab

2.3. Dynamic Sampling

Gaseous sample is collected using a hood method as a dynamic sampling system, which includes an odour-free air source from a gas cylinder, a dynamic flux chamber and a canister as shown below, in which the flux chamber is placed on the odour emission surface of selected locations and a stream of odour-free air from a certified gas cylinder is supplied into the flux chamber to simulate a parallel wind blowing on the main section of sampling hood. The emission rate is then determined by the air flow through the hood and the odour concentration of the exit air.

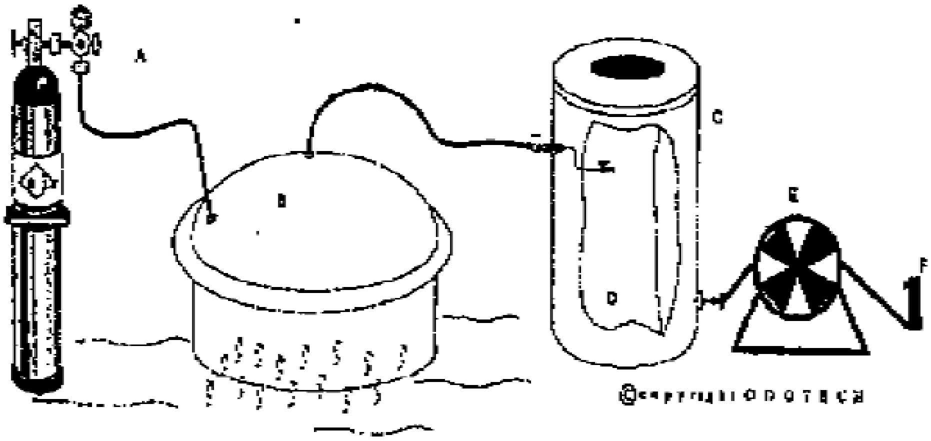


Figure 4 - Operation principle of Dynamic flux chamber

Dynamic flux chamber	
Diameter	0.41m
Effective volume	30L
Flow rate inside hood	3.5L/min
Covered surface area	$(0.41m/2)^2$x3.14=0.132m^2

Table 1- Technical specification of Dynamic flux chamber

2.4. Water and Sediment analysis

Prior to beginning the sampling of the proposed area for chemical and physical characteristics, site-visit is needed to determine the feasibility of conducting sample. Sediment samples were collected with a plastic corer.

Sediment Content in 60-L Odour Bags

Experimental Preparation from Water Samples

2.5. H_2S analysis

Odour gaseous sample is collected on site using the odour sampling system and then transported to our odour laboratory to determine H_2S concentration using a desktop UV fluorenscence H2S analyzer (Teledyne-API Model 101E) with a low detection limit of 1 ppb. The M101E is equipped with an internally mounted low temperature converter which converts H_2S at a closely controlled temperature setting of 315 ℃, leaving other gases unaffected to convert H_2S to SO_2. The resulting concentration for SO_2 is then measured by fluorescence as shown below.

Figure 5 - API Model 101E H2S analyzer

For on-site H_2S measurement, Jerome H_2S Analyzer is available for sampling in STSTW and nearby Air Sensitive Receivers (ASRs). Jerome H_2S Analyzer is a portable instrument and Very low level, selective, and interference free Hydrogen Sulfide measurements are made possible using Jerome's gold film sensor technology. The 631-X is capable of attaining Hydrogen Sulfide measurements at accuracy of ±3 ppb.

Figure 6 - Jerome 631-X portable H2S analyzer

2.6. Mercaptan (CH_3SH) analysis

Air sample will be collected through an air sampling system with air pumps and air bags ,while gaseous CH_3SH concentration would be monitored CH_3SH detector (Detcon DM-100-CH_3SH) in the range of 0.1 – 100ppm/v (±2%).

The CH_3SH concentration in aqueous solution before and after the reactions were determined by the Ellman's reagent method, in which first buffered at pH ~8.0 and then the light absorbance at 412nm was measured using the spectrophotometer after incubation of 15 min.

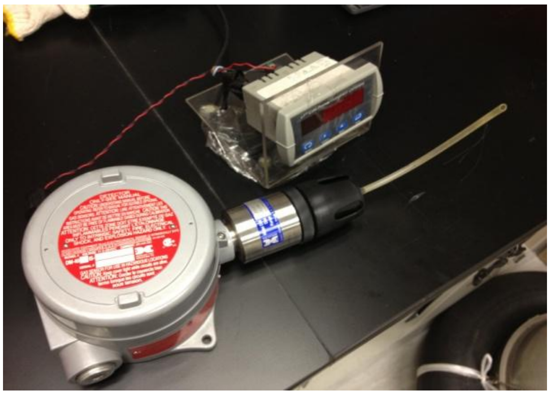


Figure 7 - Detcon DM-100 - CH3SH detector

2.7. VOCs level analysis

Equipment	Air pollutants measured	Photographs
HP Hewlett Packard 5973 Mass Selective Detector	VOC toxic species	

- Sampling and analysis of VOCs are conducted in accordance with the USEPA Method TO-14. The samples are immediately analyzed within 24 hours after sampling. Collected samples are analyzed using a combined cryogenic concentrator (NUTECH 3350A, USA) with gas chromatograph (HP 6891A) fitted with mass selective detector (MSD)MSD (HP 5973). 250 ml of sample is loaded and the target compounds are trapped in the cryogenic concentrator with liquid nitrogen. The analytes are desorbed rapidly from -190 oC to 150 oC.

For GC/MS, a capillary column (Restek RTX-1 column, 60 m × 0.32 mm ID × 0.3 µm) is used with an initial oven temperature of -30 to 80 oC at a rate of 10 oC min-1 and then is raised to 220 oC at a rate of 5 oC min-1. Target VOCs are then identified from the mass spectra and quantified by multipoint calibration. A total of 42 VOC species are identified by the GC/MSD (Gas Chromatography/ Mass Selective Detector) system. The calibration system used TO-14 standard calibration gas (Toxi-Mat-14M Certified Standard, Matheson) at nominal concentrations of 1 ppmv in nitrogen to be diluted with nitrogen using Dynamic Dilution Calibrator-Model 700 (Advanced Pollution Instrumentation, Inc.). A multipoint dynamic calibration (three levels plus zero air) is performed.

3. On-site Sampling

3.1. 16 sampling locations with relevant sampling methods are summarized in Table 2 and also clearly marked in Appendix 1.

Date	Location ID	Location description	Sampling method
18/2/2013	WK30BG	Background at Grid 30	Sampling at ambient air
	WK30AS	Water surface at Grid 30	Sampling with flux hood
	WK30WS	Water sample at Grid 30	Sampling with collected water sampler
	WK30SS	Sediment sample at Grid 30	Sampling with sediment collector
	WK7BG	Background at Grid 7	Sampling at ambient air
	WK7AS	Water surface at Grid 7	Sampling with flux hood
	WK7WS	Water sample at Grid 7	Sampling with collected water sampler
	WK7SS	Sediment sample at Grid 7	Sampling with sediment collector
20/2/2013	WK30BG(2)	Background at Grid 30	Sampling at ambient air
	WK30AS(2)	Water surface at Grid 30	Sampling with flux hood
	WK30WS(2)	Water sample at Grid 30	Sampling with collected water sampler
	WK30SS(2)	Sediment sample at Grid 30	Sampling with sediment collector
	WK7BG(2)	Background at Grid 7	Sampling at ambient air
	WK7AS(2)	Water surface at Grid 7	Sampling with flux hood
	WK7WS(2)	Water sample at Grid 7	Sampling with collected water sampler
	WK7SS(2)	Sediment sample at Grid 7	Sampling with sediment collector

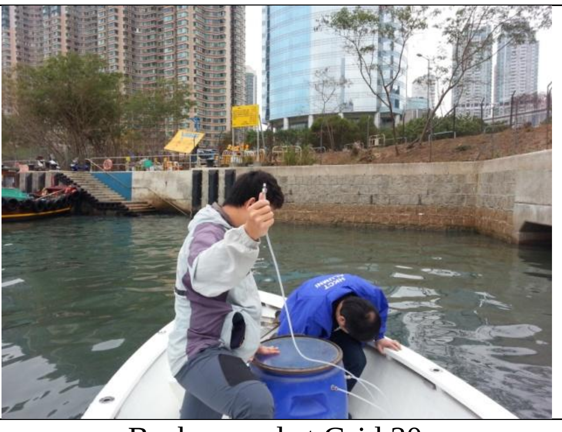
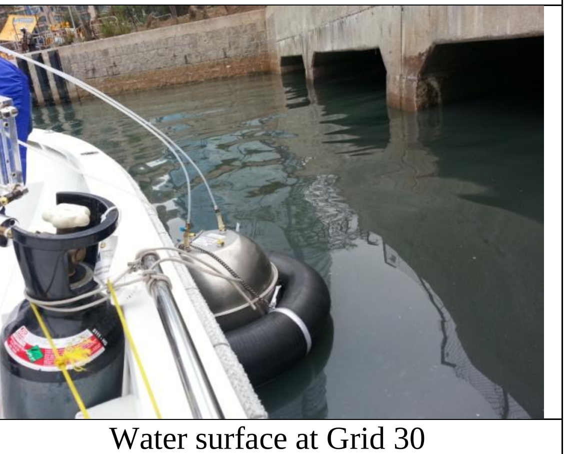
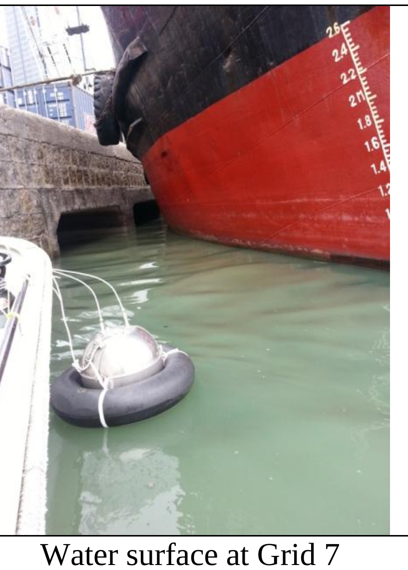
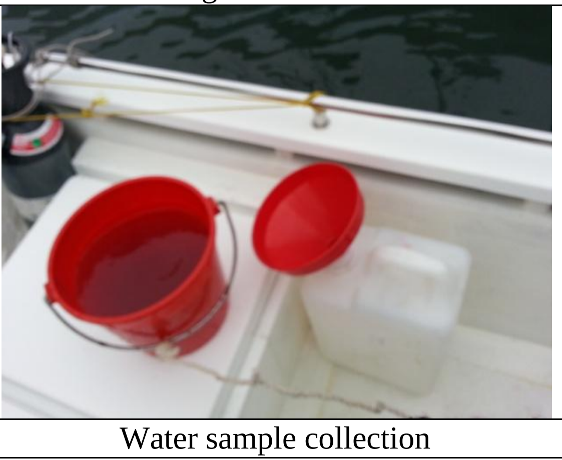
Table 2 - Sampling locations at NYMT Typhoon Shelter

3.2. The odour sampling works were conducted on 18th and 20th February 2013. A total of 16 gaseous samples and 4 VOCs canisters were collected were collected on the site and delivered to the Odour Research Laboratory of PolyU immediately

3.3. During the odour sampling, relevant weather conditions including ambient temperature, relative humidity, wind speed, and wind direction were recorded on the sites for references.

3.4. Some photos about the on-site sampling activities at the Grid 30 and Grid 7 are presented below.

18/2/2013	
	
Background at Grid 30	Water surface at Grid 30
	
Background at Grid 7	Water surface at Grid 7
	
Water sample collection	Sediment sample collection

20/2/1013	
	
Background at Grid 30	Water surface at Grid 30
	
Background at Grid 7	Water surface at Grid 7
	
Water sample collection	Sediment sample collection

4. Laboratory Analysis

4.1. A total of 16 odour samples were transported to the Odour Laboratory of PolyU immediately after the sampling for olfactometry analysis using a forced-choice dynamic olfactometer within 30 hours in accordance with the European Standard Method (EN 13725). Five qualified panelists participated in the odour testing session, which were previously selected through a screening testing by using a 48ppm of certified n-butanol gas as a standard reference.

4.2. 4 VOCs canisters were transported to the Air Laboratory of PolyU after the sampling for chemical speciation using HP Hewlett Packard 5973 Mass Selective Detector

4.3. From the odour concentrations determined by olfactometry, the specific emission rates (SOER) at 24 locations were calculated by the following equation and the final results are shown in Table 2:

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

Where air flow rate inside hood $= 3.5\,\mathrm{L/Min} = 0.0035\,\mathrm{m^3/Min} = 0.000058\,\mathrm{m^3/s}$, and covered surface area $= (0.41/2)^2 \times 3.14 = 0.132\mathrm{m^2}$

4.4. It is assumed that the total odour concentration is contributed by three different sources, sediment, water, or others. It is therefore, the contribution % of water to the overall total odour concentration would be divided the odour concentration (water) by the total sum of the odour concentration. This is roughly estimated from the result of odour concentration, and this may be influenced by many uncertainties.

$$\mathrm{Odour\ Distribution\ (water),\%} = \frac{\mathrm{Odour\ Concentration,ou/m^3\ (water)}}{\mathrm{Total\ odour\ concentration,ou/m^3}}$$

5. Analytical Results (Grid 30)

Description	Date	Time	Temp.	W-speed, m/s	W-D	RH, %	TVOC, ppb	H_2S concentration, ppb	Odour concentration, ou/m^3	Odour emission rate, $ou/m^2/s$	Mercaptans, ppm
Background at Grid 30	18/2	14:01	22.7	0.2	W	74.6	498	<1	229	/	<1
	20/2	11:03	21.1	2	SE	66.7	647	<1	240	/	<1
Air sample on water surface (Hood) at Grid 30	18/2	14:11	25.7	1.7	W	72.3	9159	58.2	2632	1.163	<1
	20/2	11:17	22.7	0.4	SE	59.6	9579	65.6	2168	0.959	<1
Water sample at Grid 30	18/2	14:20	26.3	3.8	W	66.7	1169	<1	1334	/	<1
	20/2	11:23	23.5	1.6	SE	57.8	14500	74.5	2118	/	6.23
Sediment sample at Grid 30	18/2	14:22	26.2	4	W	67.1	929	1.1	299	/	<1
	20/2	11:25	23	0.9	SE	59.2	2569	12.6	463	/	<1

Table 3 - Summary of analytical results (Grid30)

Remark: Time: Sampling time; Temp.: Air temperature; W-S: Wind speed; WD Wind direction; RH: Relative humidity

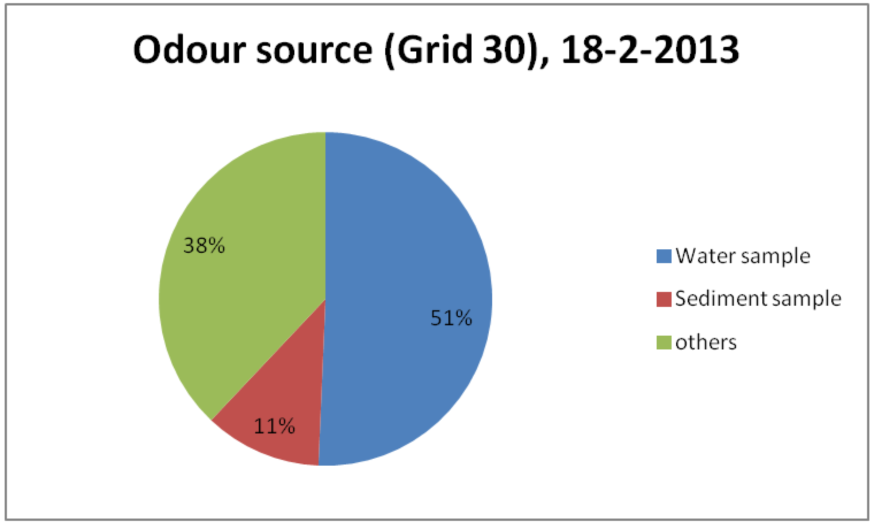
6. Analytical Results (Grid 7)

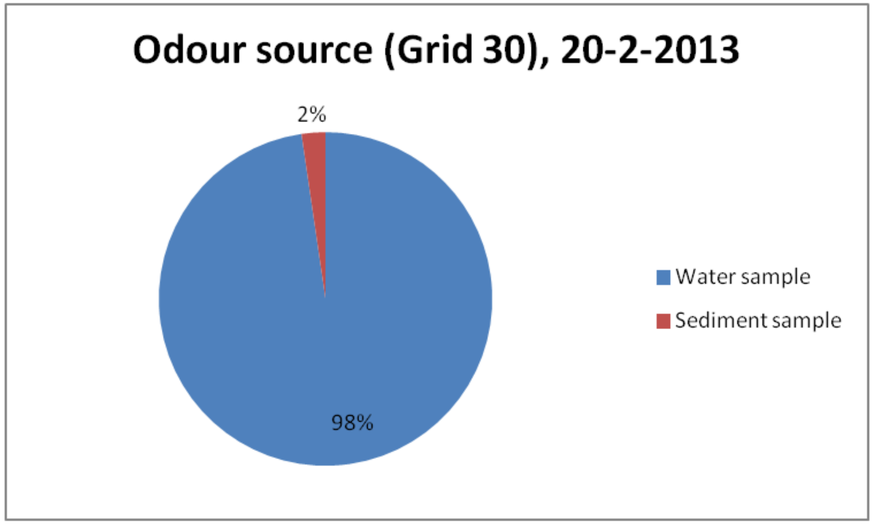
Description	Date	Time	Temp.	W-speed, m/s	W-D	RH, %	TVOC, ppb	H_2S concentration, ppb	Odour concentration, ou/m^3	Odour emission rate, $ou/m^2/s$	Mercaptans, ppm
Background at Grid 7	18/2	14:40	26.2	0.1	W	68.3	412	2.4	98	/	<1
	20/2	11:46	20.2	0.7	SE	63.2	911	<1	389	/	<1
Air sample on water surface (Hood) at Grid 7	18/2	14:58	30.7	2.1	W	56.1	8256	42.5	1722	0.761	<1
	20/2	11:52	23	0.2	SE	57.7	10900	76.1	3373	1.491	8.49
Water sample at Grid 7	18/2	15:18	28.3	0.9	W	60.8	504	3.5	1051	/	<1
	20/2	11:58	24.5	0.6	SE	54.4	11400	64.9	2723	/	2.01
Sediment sample at Grid 7	18/2	15:26	28.4	1.5	W	62.7	535	<1	<10	/	<1
	20/2	12:05	24	0.1	SE	55.4	841	<1	<10	/	<1

Table 4 - Summary of analytical results (Grid7)

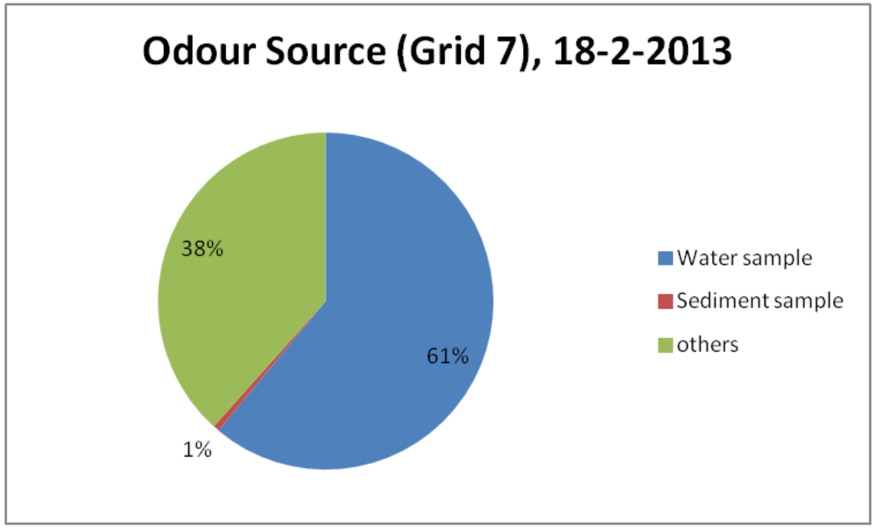
Remark: Time: Sampling time; Temp.: Air temperature; W-S: Wind speed; WD Wind direction; RH: Relative humidity

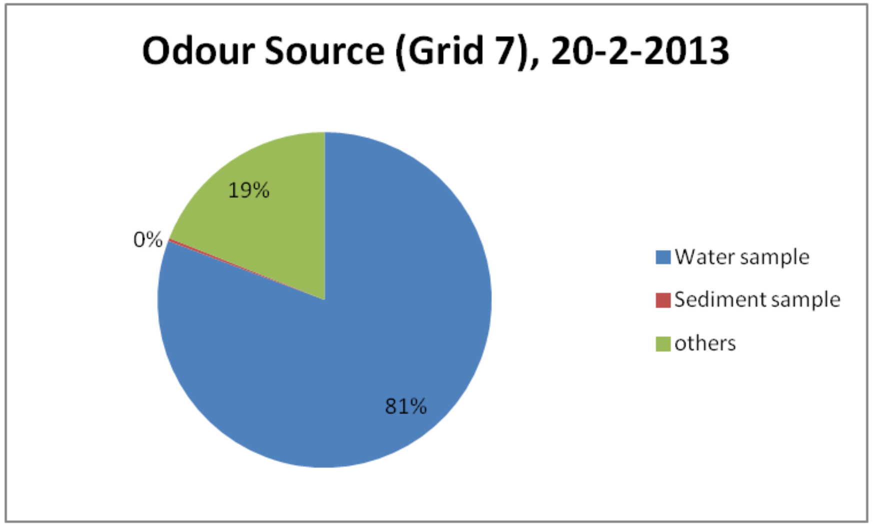
7. Odour distribution (Grid 30)





8. Odour distribution (Grid 7)





9. VOCs Level Analysis (Grid 30)

Data File Name: C:\msdchem\1\DATA\WestKowloonOdourTest\WK35VOC.D
Acquired Date: 18 Feb 2013 21:59
Method Name: C:\msdchem\1\METHODS\121217.M
Sample Name: WK35VOC

Comp #	Compound	RT (min)	Area	Amount	Units	Q-value		
1	Freon-12	5.446	31551	0.009857	ppb	71		0%
2	chorometh	0	0	0	ppb	0		0%
3	Freon-14	6.499	12957	0.001987	ppb	40		0%
4	chloroethe	6.909	699719	0.668625	ppb	79		1%
5	1,3-Butadi	7.307	341795	0.302234	ppb	100		0%
6	Bromomet	8.187	38068	0.023599	ppb	1		0%
7	Ethylchlori	8.701	323595	0.681911	ppb	99		1%
8	Freon-11	10.809	149837	0.036287	ppb	1		0%
9	Acrylonitril	0	0	0	ppb	0		0%
10	1,1-Dichlor	12.271	37185819	14.3111	ppb	100		13%
11	Methylene	0	0	0	ppb	0		0%
12	3-Chloropr	0	0	0	ppb	0		0%
13	Freon-113	0	0	0	ppb	0		0%
14	1,1-Dichlor	0	0	0	ppb	0		0%
15	cis-1,2-Dic	16.563	13021063	4.50804	ppb	77		4%
16	Chloroform	16.981	37011	0.011574	ppb	71		0%
17	1,2-Dichlor	18.162	19087171	8.82985	ppb	98		8%
18	1,1,1-Trich	0	0	0	ppb	0		0%
19	Benzene	0	0	0	ppb	0		0%
20	Carbon Tet	0	0	0	ppb	0		0%
21	1,2-Dichlor	20.339	302814	0.105933	ppb	86		0%
22	Trichloroet	0	0	0	ppb	0		0%
23	cis-1,3-Dic	21.437	1.8E+08	76.1639	ppb	49		67%
24	trans-1,3-D	22.057	652544	0.267216	ppb	87		0%
25	1,1,2-Trich	0	0	0	ppb	0		0%
26	Toluene	22.893	30117	0.005653	ppb	100		0%
27	1.2-Dibrom	23.648	123691	0.034715	ppb	100		0%
28	Tetrachlorc	0	0	0	ppb	0		0%
29	Chlorobenz	0	0	0	ppb	0		0%
30	Ethylbenze	25.667	21015407	3.12588	ppb	95		3%
31	p-Xylene	25.992	49984064	3.60371	ppb	100		3%
32	Styrene	0	0	0	ppb	0		0%
33	o-Xylene	26.835	821047	0.074681	ppb	92		0%
34	1,3,5-Trime	0	0	0	ppb	0		0%
35	1,2,4-Trime	0	0	0	ppb	0		0%
36	4-Ethyltolu	30.039	1528897	0.189407	ppb	59		0%
37	1,3-Dichlor	0	0	0	ppb	0		0%
38	1,2-Dichlor	0	0	0	ppb	0		0%
39	1,4-Dichlor	31.79	683484	0.133782	ppb	7		0%
40	1,2,4-Trich	0	0	0	ppb	0		0%
41	Hexachlorc	0	0	0	ppb	0		0%

Data File Name: C:\msdchem\1\DATA\WestKowloonOdourTest\WK35VOC2.D
Acquired Date: 20 Feb 2013 20:42
Method Name: C:\msdchem\1\METHODS\121217.M
Sample Name: WK35VOC20/2/203

Comp #	Compound	RT (min)	Area	Amount	Units	Q-value		
1	Freon-12	5.463	12756	0.003985	ppb	71		0%
2	chorometh	0	0	0	ppb	0		0%
3	Freon-14	6.4	52908	0.008112	ppb	40		0%
4	chloroethe	6.881	399019	0.381287	ppb	88		1%
5	1,3-Butadi	7.27	268300	0.237246	ppb	100		0%
6	Bromomet	0	0	0	ppb	0		0%
7	Ethylchlori	8.814	5513207	11.618	ppb	88		18%
8	Freon-11	10.76	41642	0.010085	ppb	1		0%
9	Acrylonitril	11.344	21702	0.03642	ppb	100		0%
10	1,1-Dichlor	12.227	7002855	2.69507	ppb	100		4%
11	Methylene	0	0	0	ppb	0		0%
12	3-Chloropr	0	0	0	ppb	0		0%
13	Freon-113	0	0	0	ppb	0		0%
14	1,1-Dichlor	14.972	26551	0.011123	ppb	58		0%
15	cis-1,2-Dic	16.52	8867918	3.07017	ppb	77		5%
16	Chloroform	0	0	0	ppb	0		0%
17	1,2-Dichlor	18.133	7978030	3.69069	ppb	98		6%
18	1,1,1-Trich	0	0	0	ppb	0		0%
19	Benzene	0	0	0	ppb	0		0%
20	Carbon Tet	0	0	0	ppb	0		0%
21	1,2-Dichlor	20.321	369082	0.129116	ppb	25		0%
22	Trichloroet	0	0	0	ppb	0		0%
23	cis-1,3-Dic	21.42	90996505	38.4396	ppb	49		60%
24	trans-1,3-D	0	0	0	ppb	0		0%
25	1,1,2-Trich	0	0	0	ppb	0		0%
26	Toluene	22.894	21571	0.004049	ppb	100		0%
27	1.2-Dibrom	23.618	167050	0.046884	ppb	100		0%
28	Tetrachlorc	0	0	0	ppb	0		0%
29	Chlorobenz	0	0	0	ppb	0		0%
30	Ethylbenze	25.668	10300467	1.53211	ppb	90		2%
31	p-Xylene	25.99	24293517	1.7515	ppb	100		3%
32	Styrene	0	0	0	ppb	0		0%
33	o-Xylene	26.83	287295	0.026132	ppb	52		0%
34	1,3,5-Trime	0	0	0	ppb	0		0%
35	1,2,4-Trime	0	0	0	ppb	0		0%
36	4-Ethyltolu	30.066	839358	0.103984	ppb	98		0%
37	1,3-Dichlor	0	0	0	ppb	0		0%
38	1,2-Dichlor	0	0	0	ppb	0		0%
39	1,4-Dichlor	0	0	0	ppb	0		0%
40	1,2,4-Trich	0	0	0	ppb	0		0%
41	Hexachlorc	0	0	0	ppb	0		0%

10. VOCs Level Analysis (Grid 7)

Data File Name: C:\msdchem\1\DATA\WestKowloonOdourTest\WK8VOC.D
Acquired Date: 18 Feb 2013 23:00
Method Name: C:\msdchem\1\METHODS\121217.M
Sample Name: WK8VOC

Comp #	Compound	RT (min)	Area	Amount	Units	Q-value		
1	Freon-12	5.294	106052	0.033132	ppb	71		0%
2	chorometh	0	0	0	ppb	0		0%
3	Freon-14	0	0	0	ppb	0		0%
4	chloroethe	6.913	213614	0.204122	ppb	8		0%
5	1,3-Butadi	7.292	141599	0.125209	ppb	100		0%
6	Bromomet	8.366	41706	0.025853	ppb	1		0%
7	Ethylchlori	8.771	4226069	8.90558	ppb	79		18%
8	Freon-11	10.783	316694	0.076695	ppb	20		0%
9	Acrylonitril	0	0	0	ppb	0		0%
10	1,1-Dichlor	12.288	7019128	2.70133	ppb	100		5%
11	Methylene	12.551	160556	0.357607	ppb	1		1%
12	3-Chloropr	0	0	0	ppb	0		0%
13	Freon-113	0	0	0	ppb	0		0%
14	1,1-Dichlor	0	0	0	ppb	0		0%
15	cis-1,2-Dic	16.581	8697027	3.01101	ppb	77		6%
16	Chloroform	16.832	96268	0.030106	ppb	97		0%
17	1,2-Dichlor	18.177	7766232	3.59271	ppb	98		7%
18	1,1,1-Trich	0	0	0	ppb	0		0%
19	Benzene	0	0	0	ppb	0		0%
20	Carbon Tet	0	0	0	ppb	0		0%
21	1,2-Dichlor	20.355	336742	0.117802	ppb	16		0%
22	Trichloroet	0	0	0	ppb	0		0%
23	cis-1,3-Dic	21.452	68651154	29.0003	ppb	50		57%
24	trans-1,3-D	0	0	0	ppb	0		0%
25	1,1,2-Trich	0	0	0	ppb	0		0%
26	Toluene	0	0	0	ppb	0		0%
27	1.2-Dibrom	0	0	0	ppb	0		0%
28	Tetrachlorc	0	0	0	ppb	0		0%
29	Chlorobenz	0	0	0	ppb	0		0%
30	Ethylbenze	25.687	6479598	0.963789	ppb	91		2%
31	p-Xylene	25.999	18521410	1.33534	ppb	100		3%
32	Styrene	26.47	26933	0.00683	ppb	100		0%
33	o-Xylene	26.824	562530	0.051167	ppb	91		0%
34	1,3,5-Trime	0	0	0	ppb	0		0%
35	1,2,4-Trime	0	0	0	ppb	0		0%
36	4-Ethyltolu	30.054	452073	0.056005	ppb	64		0%
37	1,3-Dichlor	0	0	0	ppb	0		0%
38	1,2-Dichlor	0	0	0	ppb	0		0%
39	1,4-Dichlor	31.792	232048	0.04542	ppb	36		0%
40	1,2,4-Trich	0	0	0	ppb	0		0%
41	Hexachlorc	0	0	0	ppb	0		0%

Data File Name: C:\msdchem\1\DATA\WestKowloonOdourTest\WK8VOC2.D
Acquired Date: 20 Feb 2013 19:41
Method Name: C:\msdchem\1\METHODS\121217.M
Sample Name: WK8VOC20/2/203

Comp #	Compound	RT (min)	Area	Amount	Units	Q-value		
1	Freon-12	0	0	0	ppb	0		0%
2	chorometh	0	0	0	ppb	0		0%
3	Freon-14	0	0	0	ppb	0		0%
4	chloroethe	6.916	862015	0.82371	ppb	40		1%
5	1,3-Butadi	7.305	820002	0.725091	ppb	100		0%
6	Bromomet	8.262	74532	0.046202	ppb	63		0%
7	Ethylchlori	8.846	6127653	12.9128	ppb	86		8%
8	Freon-11	10.789	211389	0.051193	ppb	74		0%
9	Acrylonitril	0	0	0	ppb	0		0%
10	1,1-Dichlor	12.265	23580751	9.07513	ppb	100		6%
11	Methylene	12.514	268416	0.597846	ppb	88		0%
12	3-Chloropr	12.8	111187	0	ppb	100		0%
13	Freon-113	0	0	0	ppb	0		0%
14	1,1-Dichlor	0	0	0	ppb	0		0%
15	cis-1,2-Dic	16.536	25283825	8.75354	ppb	77		6%
16	Chloroform	17.032	332619	0.104018	ppb	71		0%
17	1,2-Dichlor	18.138	29221183	13.5179	ppb	98		9%
18	1,1,1-Trich	18.394	73255	0.018325	ppb	1		0%
19	Benzene	0	0	0	ppb	0		0%
20	Carbon Tet	0	0	0	ppb	0		0%
21	1,2-Dichlor	20.327	687797	0.240612	ppb	57		0%
22	Trichloroet	0	0	0	ppb	0		0%
23	cis-1,3-Dic	21.425	2.26E+08	95.5269	ppb	50		63%
24	trans-1,3-D	0	0	0	ppb	0		0%
25	1,1,2-Trich	22.462	40692	0.014834	ppb	1		0%
26	Toluene	22.892	192671	0.036163	ppb	100		0%
27	1.2-Dibrom	23.633	46738	0.013118	ppb	100		0%
28	Tetrachlorc	0	0	0	ppb	0		0%
29	Chlorobenz	0	0	0	ppb	0		0%
30	Ethylbenze	25.666	29518208	4.3906	ppb	94		3%
31	p-Xylene	25.99	74327174	5.35878	ppb	100		4%
32	Styrene	0	0	0	ppb	0		0%
33	o-Xylene	26.83	1351466	0.122927	ppb	88		0%
34	1,3,5-Trime	0	0	0	ppb	0		0%
35	1,2,4-Trime	0	0	0	ppb	0		0%
36	4-Ethyltolu	30.058	2458715	0.304597	ppb	81		0%
37	1,3-Dichlor	30.655	42513	0.011815	ppb	1		0%
38	1,2-Dichlor	0	0	0	ppb	0		0%
39	1,4-Dichlor	0	0	0	ppb	0		0%
40	1,2,4-Trich	0	0	0	ppb	0		0%
41	Hexachlorc	0	0	0	ppb	0		0%

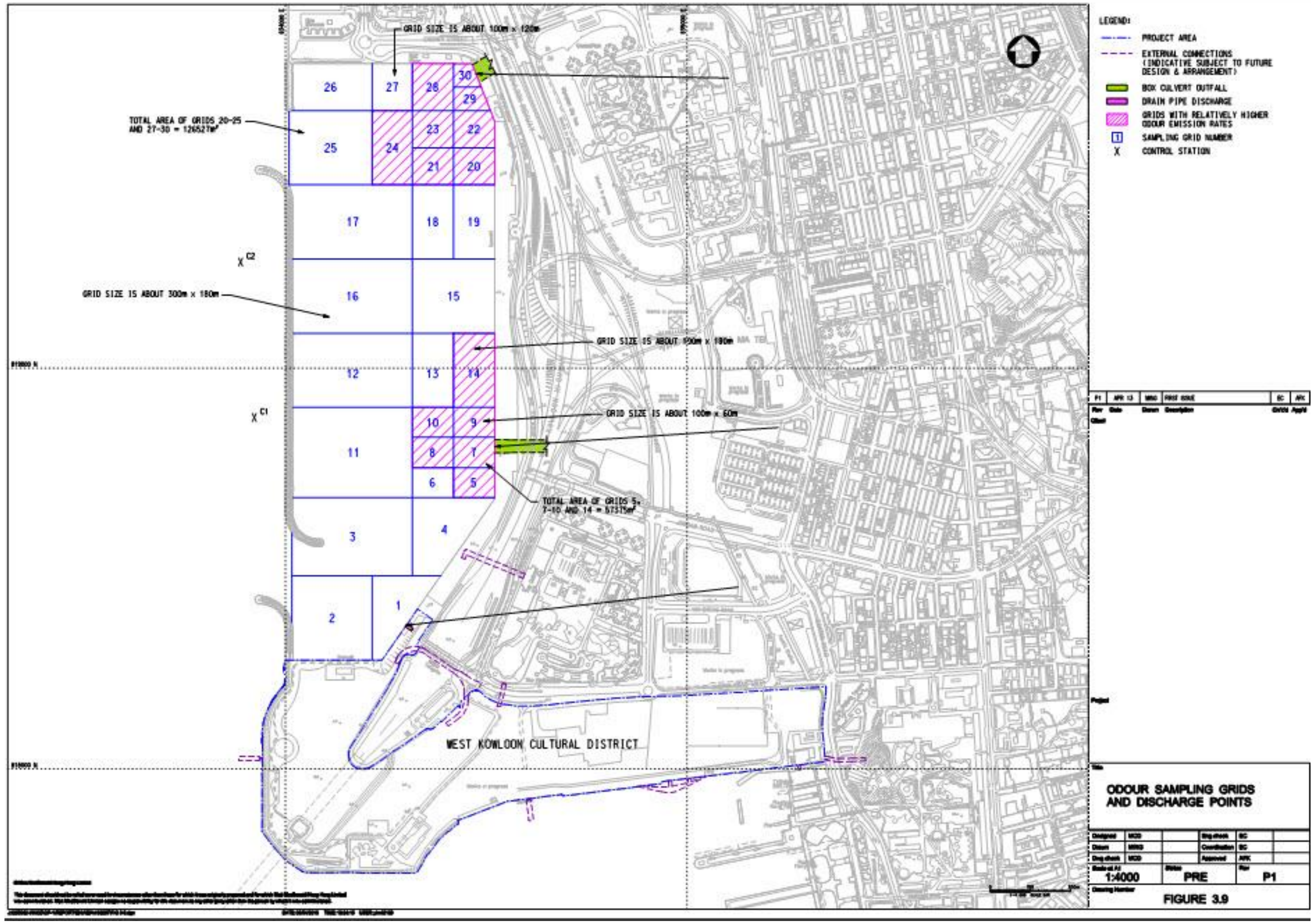
11. Conclusion

Box Culvert Discharge is the key source for the high odour concentration. 1st sampling (18 February, 2013) and 2nd sampling (20 February, 2013) reflected high odour concentration in grid 30 and Grid 7. The highest odour concentration conducted at Grid 30 and Grud 7 is 2632ou/m^3 and 3373 ou/m^3 respectively.

Comparing with the odour concentration from water and sediment, it is over 65% and 72% of odour contributed by water at Grid 30 and Grid 7. The contribution of sediment is about 15% and 1% at Grid 30 and Grid 7

During the sampling, cargo ship from Mainland China parked at Grid 7 released wasted water and rubbish directly to water surface. Other potential odour emission sources identified from the observation include waste generated by cargo ship, “diesel engine” boat, oil and rubbish on the water surface.

Appendix 1: Location Description of grid location



CONSULTANCY SERVICE

FOR

[MOTT MACDONALD HONG KONG LIMITED]

[Expert Review of New Yau Mei Tei Typhoon Shelter (NYMTTS) Odour Source Measurement Stage II]
[P12-0295]

Prepared by:
[Prof. S.C. Lee]

Signed by:

Date: 10/4/2013

1. **Background**

A service was requested by the Mott MacDonald at the meeting with EPD on 4th March, 2013, to conduct a follow-up odour emission study (stage II) at the new Yau Ma Tei Typhoon Shelter (NYMTTS).

2. **Scope of the Work**

Description	Date
Proposal Submission	12-13 Mar, 2013
1st On-site sampling	18 Mar, 2013
2nd On-site sampling	20 Mar, 2013
3rd On-site sampling	22 Mar, 2013

Figure 1 - Schedule for the project

- To conduct odour monitoring work at particular locations
- To collect water and air samples (Sea-base) at particular locations
- To collect background odour concentration (Land-base) at site boundary and proposed area (West Kowloon Cultural District)
- To measure the odour concentration, odour emission rate and ambient background odour concentration
- To submit report

3. Methodology

3.1. <u>Odour sampling</u>

Odour gaseous sample is collected by using an odour sampling system, which includes a battery-operated air pump, a sampling vessel, and an odour bag as shown below. During air sampling, an empty sample bag is placed in the vessel, a rigid plastic container, and the container is then evacuated at a controlled rate and the bag is filled with foul gas.

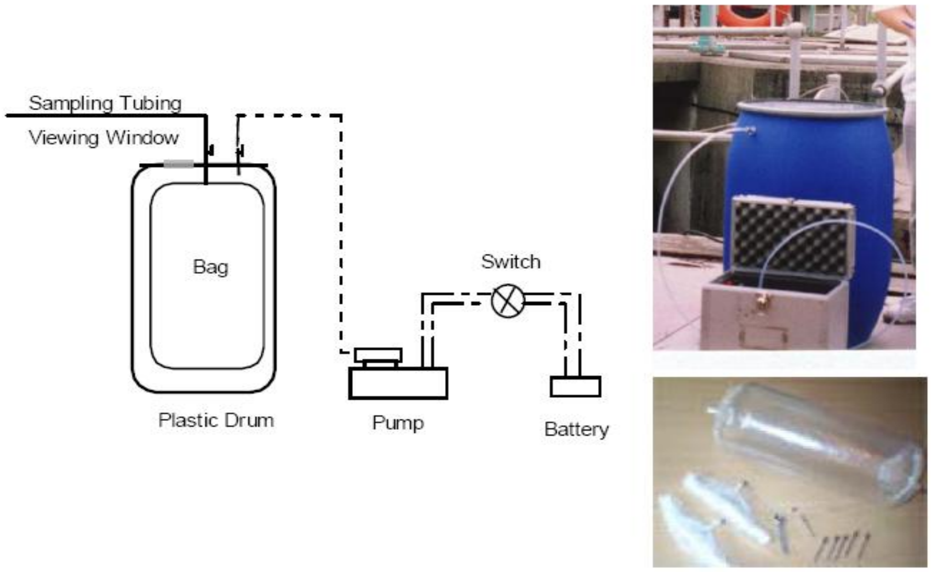


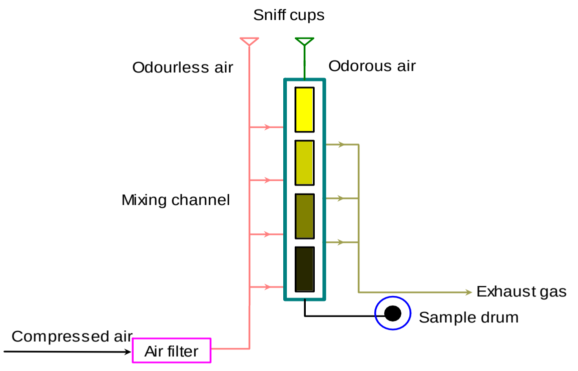
Figure 2 - Sampling equipment of odour sampling

In this technique, all "wetted" parts exposed to the odorous gas are to be composed of stainless steel and Teflon tubing. It is necessary to pre-conditioning the sampling bag, that is the bag is to be partly filled with the odorous sample and then emptied prior to filling the bag for odour testing. 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 NA^{TM} if the sample bags are to be discarded after use. About 60 L of foul gas is collected for each sample.

The QA/QC samples will be collected by sucking the ambient air through a portable gas purifier (Drierite 27068) on the site. It could be also collected by using a "hood" method whereby either a dynamic flux hood or a wind tunnel is placed on the odour emission surface of selected locations, and odour-free air either from a gas cylinder or by passing through an activated carbon filter is blown through it.

3.2. Olfactometry analysis

The odour concentration of a gaseous sample is determined by presentation to a panel of observers, with known acuity to odour, in varying dilutions. The odour concentration is then expressed in multiples of Odour concentration is determined by a Forced-choice Dynamic Olfactometer (Olfacton-n2) in full accordance with the European Standard Method (EN13725). 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 range of measurement including pre-dilution prior to the olfactometry analysis is typically from 10^1 ou/m^3 to 10^7 ou/m^3. one Odour Unit. This analysis technique provides directly comparable data for different odour types, and used for input into dispersion models to determine odour impact in terms of annoyance and abatement efficiency assessments.



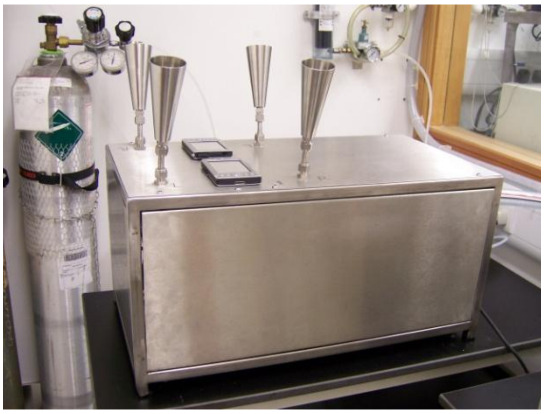


Figure 3 - Olfactormeter (Oldacton-n2) at Odour Lab

3.3. Dynamic Sampling

Gaseous sample is collected using a hood method as a dynamic sampling system, which includes an odour-free air source from a gas cylinder, a dynamic flux chamber and a canister as shown below, in which the flux chamber is placed on the odour emission surface of selected locations and a stream of odour-free air from a certified gas cylinder is supplied into the flux chamber to simulate a parallel wind blowing on the main section of sampling hood. The emission rate is then determined by the air flow through the hood and the odour concentration of the exit air.

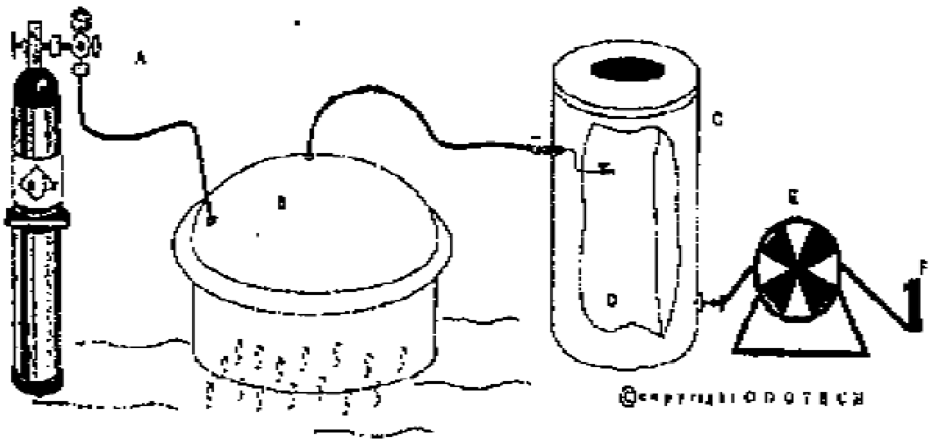


Figure 4 - Operation principle of Dynamic flux chamber

Dynamic flux chamber	
Diameter	0.41m
Effective volume	30L
Flow rate inside hood	3.5L/min
Covered surface area	$(0.41m/2)^2x3.14=0.132m^2$

Table 1- Technical specification of Dynamic flux chamber

3.4. Water analysis

Prior to beginning the sampling of the proposed area for chemical and physical characteristics, site-visit is needed to determine the feasibility of conducting sample.

Figure 5 - Preparation for water sample analysis

3.5. Odour sampling with activated carbon technology

To determine an odour emission rate from an area surface source, air sampling can use a "hood" method as shown in Figure 6, whereby a wind tunnel is placed on the odour emission surface of selected locations, passing through an activated carbon filter is blown through it. The emission rate is then determined by the air flow through the hood and the odour concentration of the exit air.

Figure 6 - Wind Tunnel connected with Activated Carbon

Wind Tunnel	
Flow Velocity, m/s	5.5 m/s
Covered surface area	0.8m(L)×0.4m(W)=0.32m^2

4. On-site Sampling

4.1. 42 sampling locations with relevant sampling methods are summarized in Table 2 and also clearly marked in Appendix 1.

Date	Location ID	Location description	Sampling method
18/3/2013	Gird26Air	Water surface at Grid 26	Sampling with flux hood
	Grid28Air	Water surface at Grid 28	Sampling with flux hood
	Grid25Air	Water surface at Grid 25	Sampling with flux hood
	Grid22Air	Water surface at Grid 22	Sampling with flux hood
	Grid21Air	Water surface at Grid 21	Sampling with flux hood
	Grid21Water	Water sample at Grid 21	Sampling with water sampler
	Grid20Air	Water surface at Grid 20	Sampling with flux hood
	Grid5Air	Water surface at Grid 5	Sampling with flux hood
	Grid9Air	Water surface at Grid 9	Sampling with flux hood
	Grid9Water	Water sample at Grid 9	Sampling with water sampler
	Grid17Air (control point)	Water surface at Grid 17	Sampling with flux hood
	Grid11Air (control point)	Water surface at Grid 11	Sampling with flux hood
	PierCP	Background air at Pier	Sampling at ambient air
	WKCDCP	Background air at West Kowloon Cultural District	Sampling at ambient air
20/3/2013	Grid27Air	Water surface at Grid 27	Sampling with flux hood
	Grid27Water	Water sample at Grid 27	Sampling with water sampler
	Grid30Air	Water surface at Grid 30	Sampling with flux hood
	Grid30Water	Water sample at Grid 30	Sampling with water sampler

	Grid24Air	Water surface at Grid 24	Sampling with flux hood
	Grid23Air	Water surface at Grid 23	Sampling with flux hood
	Grid23Water	Water sample at Grid 23	Sampling with water sampler
	Grid30(AC)	Water surface at Grid 30	Sampling with Activated carbon and wind tunnel
	Grid23(AC)	Water surface at Grid 23	Sampling with Activated carbon and wind tunnel
	Grid27(AC)	Water surface at Grid 27	Sampling with Activated carbon and wind tunnel
	Grid17Air (control point)	Water surface at Grid 17	Sampling with Activated carbon and wind tunnel
	Grid11Air (control point)	Water surface at Grid 11	Sampling with flux hood
	PierCP	Background air at Pier	Sampling at ambient air
	WKCDCP	Background air at West Kowloon Cultural District	Sampling at ambient air
22/3/2013	Grid7Air	Water surface at Grid 7	Sampling with flux hood
	Grid7Water	Water sample at Grid 7	Sampling with water sampler
	Grid8Air	Water surface at Grid 8	Sampling with flux hood
	Grid10Air	Water surface at Grid 10	Sampling with flux hood
	Grid10Water	Water sample at Grid 10	Sampling with water sampler
	Grid14Air	Water surface at Grid 14	Sampling with flux hood
	Grid14Water	Water sample at Grid 14	Sampling with water sampler
	Grid14(AC)	Water surface at Grid 14	Sampling with Activated carbon and wind tunnel

	Grid7(AC)	Water surface at Grid 7	Sampling with Activated carbon and wind tunnel
	Grid10(AC)	Water surface at Grid 10	Sampling with Activated carbon and wind tunnel
	Grid17Air (control point)	Water surface at Grid 17	Sampling with Activated carbon and wind tunnel
	Grid11Air (control point)	Water surface at Grid 11	Sampling with flux hood
	PierCP	Background air at Pier	Sampling at ambient air
	WKCDCP	Background air at West Kowloon Cultural District	Sampling at ambient air

Table 2 - Sampling locations at NYMT Typhoon Shelter

4.2. The odour sampling works were conducted on 18th, 20th and 22nd March 2013. A total of 42 gaseous samples and 3 QA/QC samples were collected were collected on the site and delivered to the Odour Research Laboratory of PolyU immediately

4.3. During the odour sampling, relevant weather conditions including ambient temperature, relative humidity, wind speed, and wind direction were recorded on the sites for references.

4.4. Some photos about the on-site sampling activities are presented below.

18/3/2013

Water surface at Grid 26

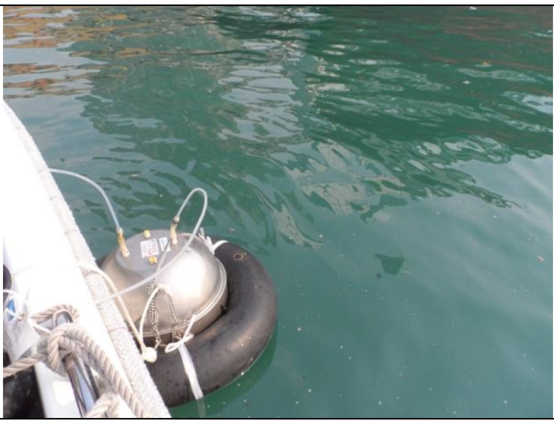
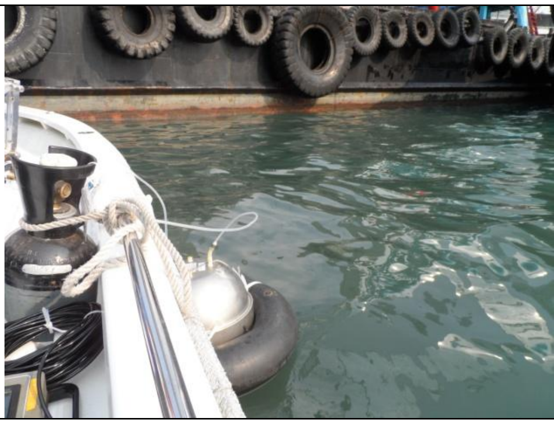
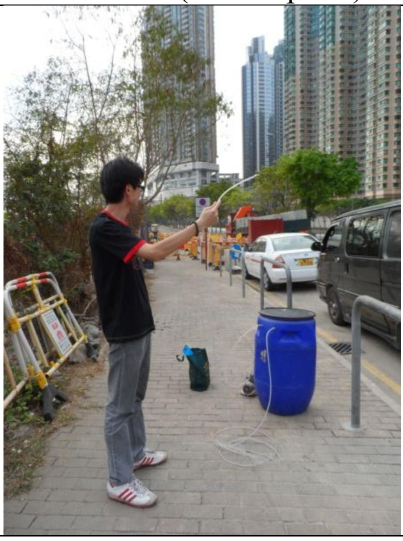
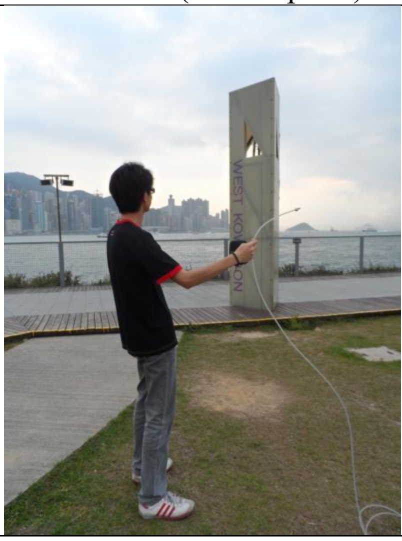
Water surface at Grid 28

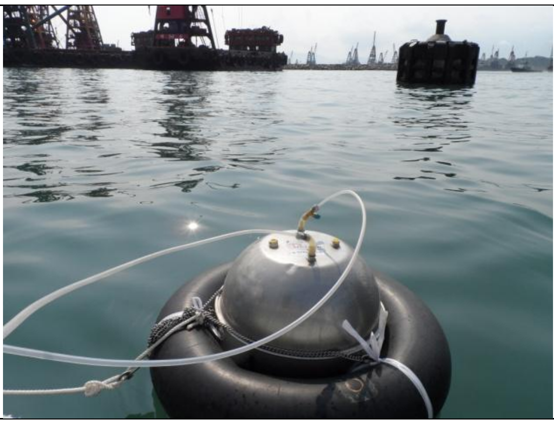
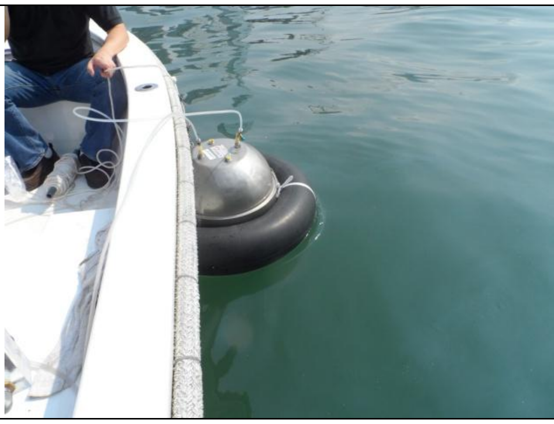
Water surface at Grid 25

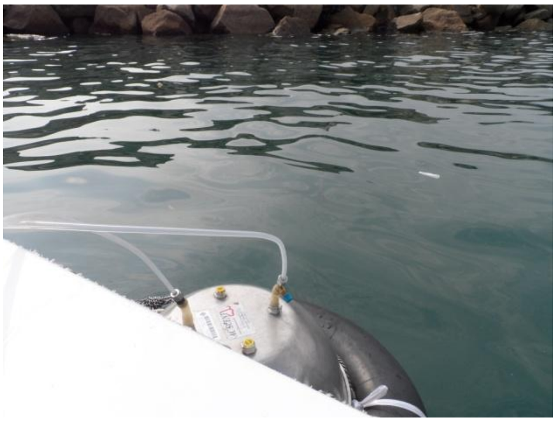
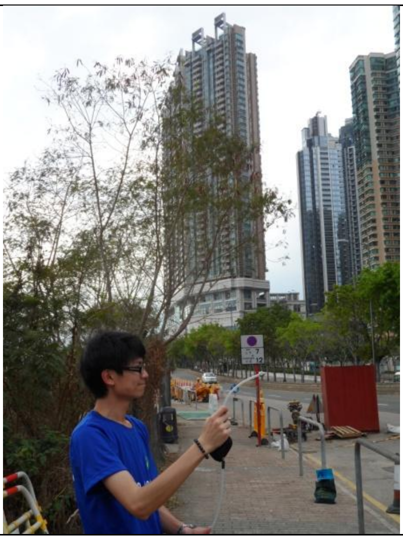
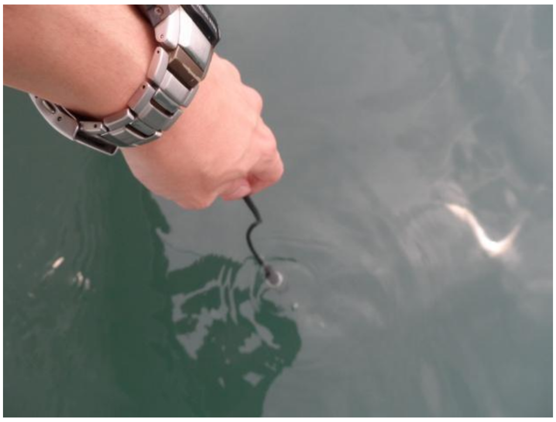
Water surface at Grid 22

Water surface at Grid 21

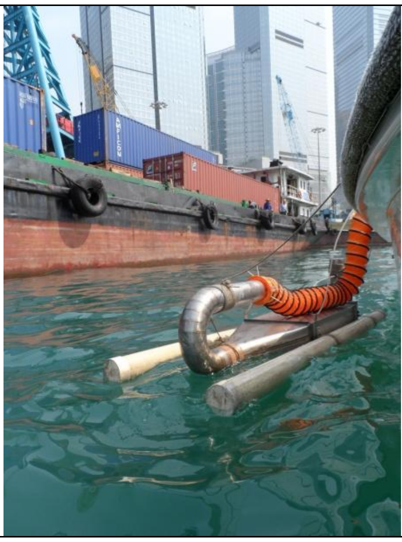
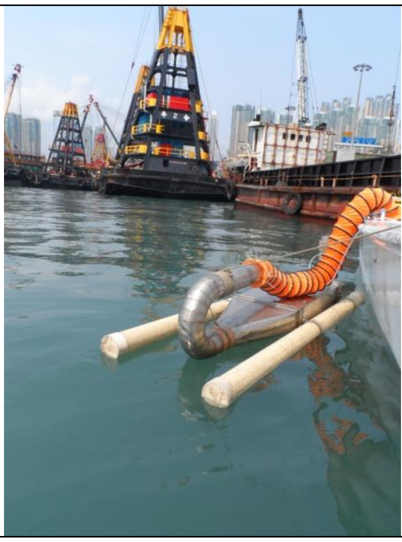
Water surface at Grid 20

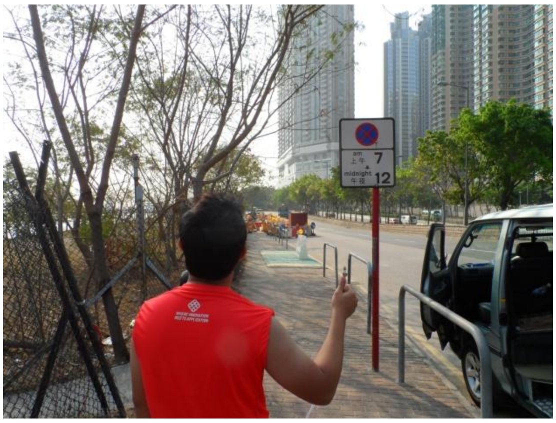
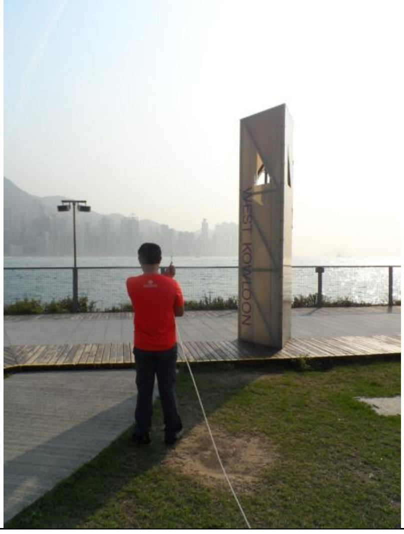
	
Water surface at Grid 5	Water surface at Grid 9
	
Grid17Air (control point)	Grid11Air (control point)
	
Background air at Pier	Background air at West Kowloon Cultural District

20/3/1013	
	
Water surface at Grid 27	Water surface at Grid 30
	
Water surface at Grid 24	Water surface at Grid 23
	
Water surface at Grid 30 (with Activated Carbon)	Water surface at Grid 23 (with Activated Carbon)

	
Water surface at Grid 27 (with Activated Carbon)	Grid17Air (control point)
	
Grid11Air (control point)	Background air at Pier
	
Background air at West Kowloon Cultural District	Water Temperature analysis

22/3/2013	
	
Water surface at Grid 7	Water surface at Grid 8
	
Water surface at Grid 10	Water surface at Grid 14

	
Water surface at Grid 14 (with Activated Carbon)	Water surface at Grid 7 (with Activated Carbon)
	
Water surface at Grid 10 (with Activated Carbon)	Grid17Air (control point)

	
Grid11Air (control point)	Background air at Pier
	
Background air at West Kowloon Cultural District	Sampling boat

5. Laboratory Analysis

5.1. A total of 42 odour samples were transported to the Odour Laboratory of PolyU immediately after the sampling for olfactometry analysis using a forced-choice dynamic olfactometer within 30 hours in accordance with the European Standard Method (EN 13725). Five qualified panelists participated in the odour testing session, which were previously selected through a screening testing by using a 48ppm of certified n-butanol gas as a standard reference.

5.2. From the odour concentrations determined by olfactometry, the specific emission rates (SOER) at 24 locations were calculated by the following equation and the final results are shown in Table 2:

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

Where air flow rate inside hood $= 3.5\,\mathrm{L/Min} = 0.0035\,\mathrm{m^3/Min} = 0.000058\,\mathrm{m^3/s}$, and covered surface area $= (0.41/2)^2 \times 3.14 = 0.132\mathrm{m}^2$ (for the dynamic flux chamber); $0.8 \times 0.4 = 0.32\mathrm{m}^2$ (for wind tunnel)

5.3. It is assumed that the total odour concentration is contributed by three different sources, sediment, water, or others. It is therefore, the contribution % of water to the overall total odour concentration would be divided the odour concentration (water) by the total sum of the odour concentration. This is roughly estimated from the result of odour concentration, and this may be influenced by many uncertainties.

$$\mathrm{Odour\ Distribution\ (water),\%} = \frac{\mathrm{Odour\ Concentration,ou/m^3\ (water)}}{\mathrm{Total\ odour\ concentration,ou/m^3}}$$

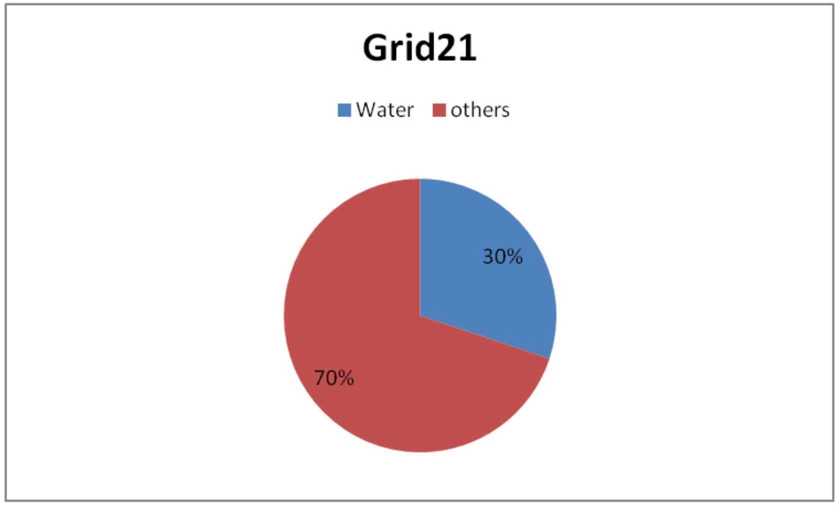
6. Analytical Results (18/3/2013)

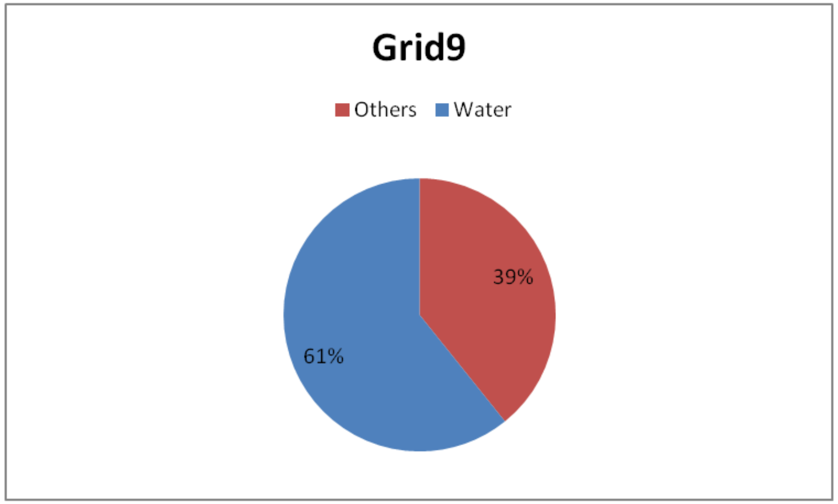
ID	Time	Temperature		W-speed, m/s	W-D	RH, %	Odour concentration, ou/m^3	Odour emission rate, ou/m^2/s
		Ambient	Water					
Gird26Air	15:37	31.6	20.4	0.9	W	58.2	<10	<0.004
Grid28Air	14:39	26.9	20.4	2.9	W	80.9	256	0.113
Grid25Air	15:29	31.8	20.4	7.1	W	58.4	<10	<0.004
Grid22Air	14:53	29.2	20.4	0.3	W	58.4	276	0.122
Grid21Air	15:01	29.5	20.1	1.6	W	63.3	83	0.037
Grid21Water	15:03	29.6	20.1	0.2	W	64.6	25	n/a
Grid20Air	15:10	27.5	20.4	3.5	W	70.3	244	0.108
Grid5Air	16:01	30.6	19.7	2.6	W	60.6	2007	0.997
Grid9Air	15:53	33.1	20.6	0.1	W	57.8	321	0.142
Grid9Water	15:54	32.2	20.6	0.2	W	57.9	195	n/a
QA/QC	14:29	29.8	n/a	2.1	W	76.4	<10	<0.004
Grid17Air	15:20	28.8	20.3	0.8	W	65.8	<10	<0.004
Grid11Air	16:12	29.7	20.2	0.3	W	63.6	81	0.036
PierCP	16:31	28.9	n/a	0.1	W	66.5	<10	n/a
WKCDCP	17:07	27.5	n/a	3.8	NW	71.1	<10	n/a

Table 3 - Summary of analytical results (18/3/2013)

Remark: Time: Sampling time; Temp.: Air temperature; W-S: Wind speed; WD Wind direction; RH: Relative humidity

7. Odour Distribution (18/3/2013)





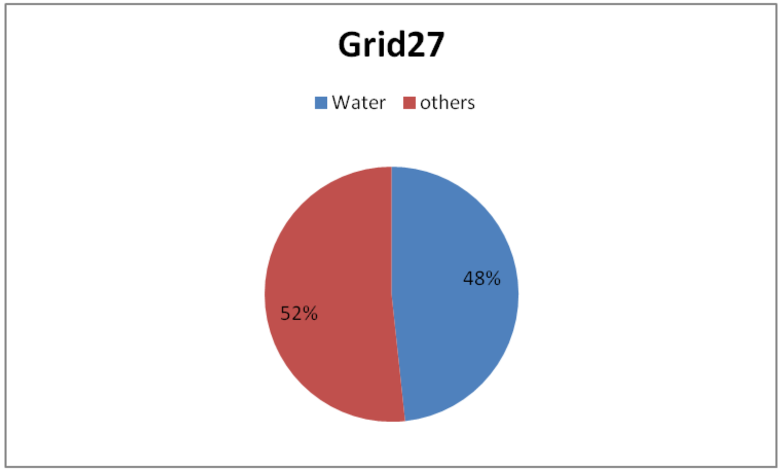
8. Analytical Results (20/3/2013)

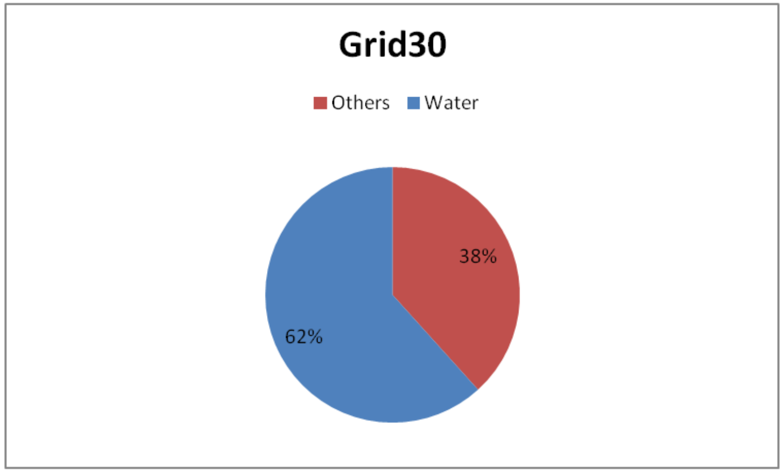
ID	Time	Temperature		W-speed, m/s	W-D	RH, %	Odour concentration, ou/m^3	Odour emission rate, ou/m^2/s
		Ambient	Water					
Grid27Air	14:54	39.9	21.0	6.8	W	44.3	118	0.052
Grid27Water	14:55	40.1	20.9	7.4	W	44.2	57	n/a
Grid30Air	14:36	39.6	20.9	5.8	W	45.5	1613	0.713
Grid30Water	14:39	34.4	21.1	1.8	W	52.9	995	n/a
Grid24Air	15:02	39.7	21.3	6.9	W	49.7	79	0.035
Grid23Air	14:46	37.8	21.3	4.8	W	45.6	1879	0.83
Grid23Water	14:48	39.1	21.2	3.1	W	45.2	684	n/a
QA/QC	13:43	37.1	n/a	1.1	W	50.4	<10	<0.004
Grid17Air	15:21	37.4	21.2	1.7	NW	51.9	64	0.0283
Grid11Air	15:13	38.5	20.9	3.5	W	45.6	57	0.0252
PierCP	15:41	36.3	n/a	0.1	W	52.4	<10	n/a
WKCDCP	16:04	30.9	n/a	0.8	NW	59.8	<10	n/a

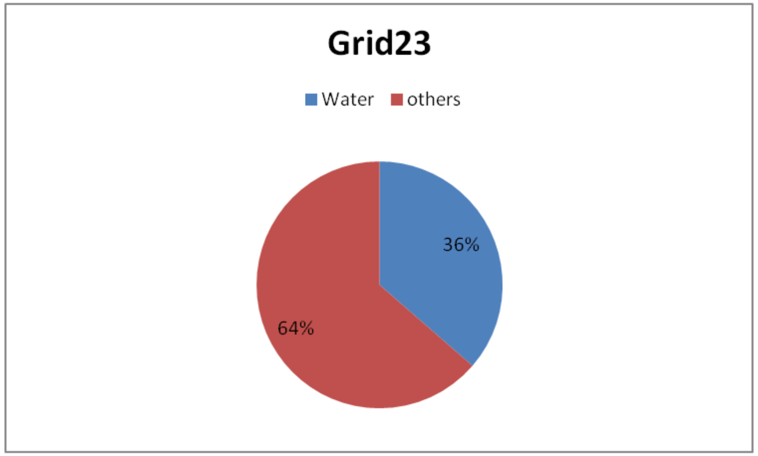
Table 4 - Summary of analytical results (20/3/2013)

Remark: Time: Sampling time; Temp.: Air temperature; W-S: Wind speed; WD Wind direction; RH: Relative humidity

9. Odour Distribution (20/3/2013)







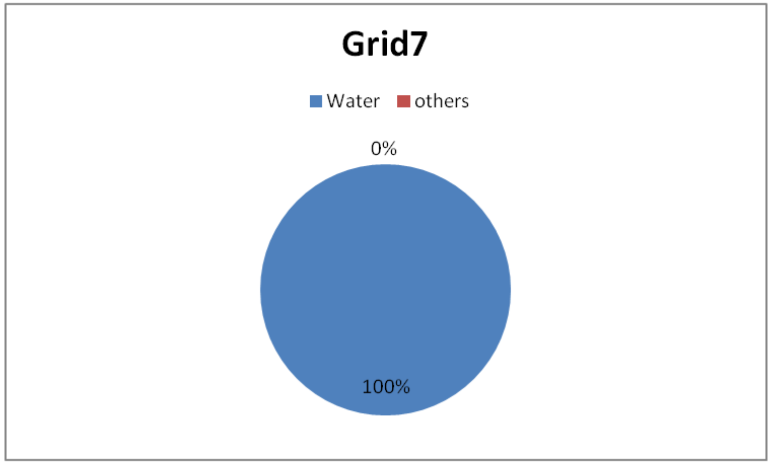
10. Analytical Results (22/3/2013)

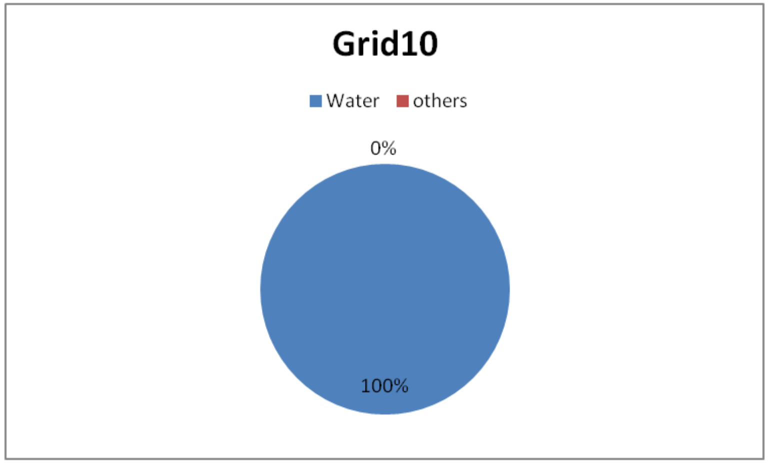
ID	Time	Temperature		W-speed, m/s	W-D	RH, %	Odour concentration, ou/m^3	Odour emission rate, ou/m^2/s
		Ambient	Water					
Grid7Air	15:09	33.4	20.3	1.8	W	50.4	658	0.291
Grid7Water	15:10	33.6	20.2	1.9	W	51.1	918	n/a
Grid8Air	15:17	39.8	20.3	1.7	W	44.7	62	0.027
Grid10Air	15:01	39.2	20.8	0.2	W	42.2	65	0.029
Grid10Water	15:02	38.7	20.7	0.3	W	43.8	262	n/a
Grid14Air	14:51	35.9	20.7	1.3	W	47.9	49	0.022
Grid14Water	14:52	39.3	20.7	3.1	W	43.3	217	n/a
QA/QC	13:57	36.7	n/a	2.1	W	49.2	<10	<0.004
Grid14Air	15:37	36.6	20.5	0.1	W	47.2	<10	<0.004
Grid11Air	15:27	37.1	20.7	0.8	W	45.7	33	0.015
PierCP	15:59	32.7	n/a	0.1	W	54.3	<10	n/a
WKCDCP	16:19	31.8	n/a	1.1	NW	55.8	<10	n/a

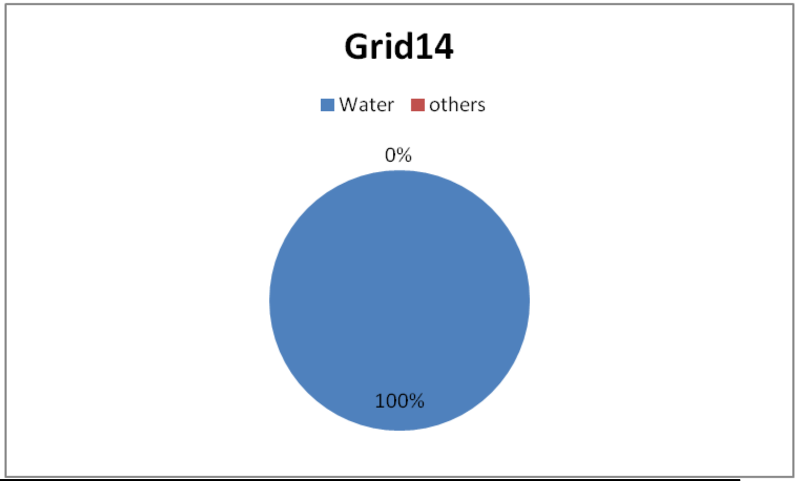
Table 5 - Summary of analytical results (22/3/2013)

Remark: Time: Sampling time; Temp.: Air temperature; W-S: Wind speed; WD Wind direction; RH: Relative humidity

11. Odour Distribution (22/3/2013)







12. Analytical Results (Activated Carbon)

ID	Date	Time	Temperature		W-speed, m/s	W-D	RH, %	Odour concentration, ou/m^3	Odour emission rate, ou/m^2/s
			Ambient	Water					
Grid27(AC)	20/3/2013	13:56	30.1	20.9	1.8	W	76.1	252	7.650
Grid30(AC)	20/3/2013	14:16	38.7	20.6	2.8	W	48.2	1748	53.065
Grid23(AC)	20/3/2013	14:07	37.7	21.0	2.2	W	56.8	2086	63.326
Grid7(AC)	22/3/2013	14:29	40.9	20.1	0.4	W	40.7	1544	46.872
Grid10(AC)	22/3/2013	14:18	40.3	20.4	0.9	W	42.3	1108	33.636
Grid14(AC)	22/3/2013	14:07	38.3	20.4	1.8	W	49.5	1163	35.306

Table 6 - Summary of analytical results (Activated Carbon)

Remark: Time: Sampling time; Temp.: Air temperature; W-S: Wind speed; WD Wind direction; RH: Relative humidity

13. Comparison of N_2 and ambient air as carrying air

Grid No.	Odour Concentration (nitrogen gas) (ou/m^3) [A]	Odour Concentration (activated carbon) (ou/m^3) [B]	Ratio of [B] to [A]	Odour Emission Rate (nitrogen gas) ($ou/m^2/s$) [C]	Odour Emission Rate (activated carbon) ($ou/m^2/s$) [D]	Ratio of [D] to [C]
7	658	1544	2.35	0.291	46.872	161.07
10	65	1108	17.05	0.029	33.636	1159.86
14	49	1163	23.72	0.022	35.306	1604.82
23	1613	1748	1.08	0.713	53.065	74.42
27	118	252	2.14	0.052	7.65	147.12
30	1879	2086	1.11	0.83	63.326	76.3

Table 7 - Comparison of Odour Results Obtained by Using Nitrogen Gas and Air through Activated Carbon as Carrier Gas

According to past experience, the sampling result (odour concentration and odour emission rate) conducted by activated carbon filter is easily influenced by certain external factors, such as high ambient air odour level, surrounding human activities, etc. Odour Research Lab at PolyU had changed to use nitrogen gas rather than activated carbon filter as the primary sampling equipments since 2010. During the sampling at Grid 10 and 14, a large amount of diesel gas was emitted by the nearby cargo ship. This is likely to increase the ambient air odour level. The value of odour emission rate is affected not only by the carrying gases, by also affected by other factors, like the flow velocity, cross section area of the sampling hood, etc.

14. Conclusion

42 samples conducted at 18 grids between 18th and 22nd March, 2013 (Grid#26, Grid#28, Grid#25, Grid#22, Grid#21, Grid#20, Grid#5, Grid#9, Grid#27, Grid#30, Grid#24, Grid#23, Grid#7, Grid#8, Grid#10, Grid#14, Grid#17 and Grid#11). The highest odour concentration was 2007ou/m^3 from air sample conducted at Grid 5 on 18th March, 2013. The second-highest odour concentration was 1879ou/m^3 from air sample conducted at Grid 23 on 20th March, 2013. The third-highest odour concentration was 1613ou/m^3 from water sample conducted at Grid 30 on 20th March, 2013.

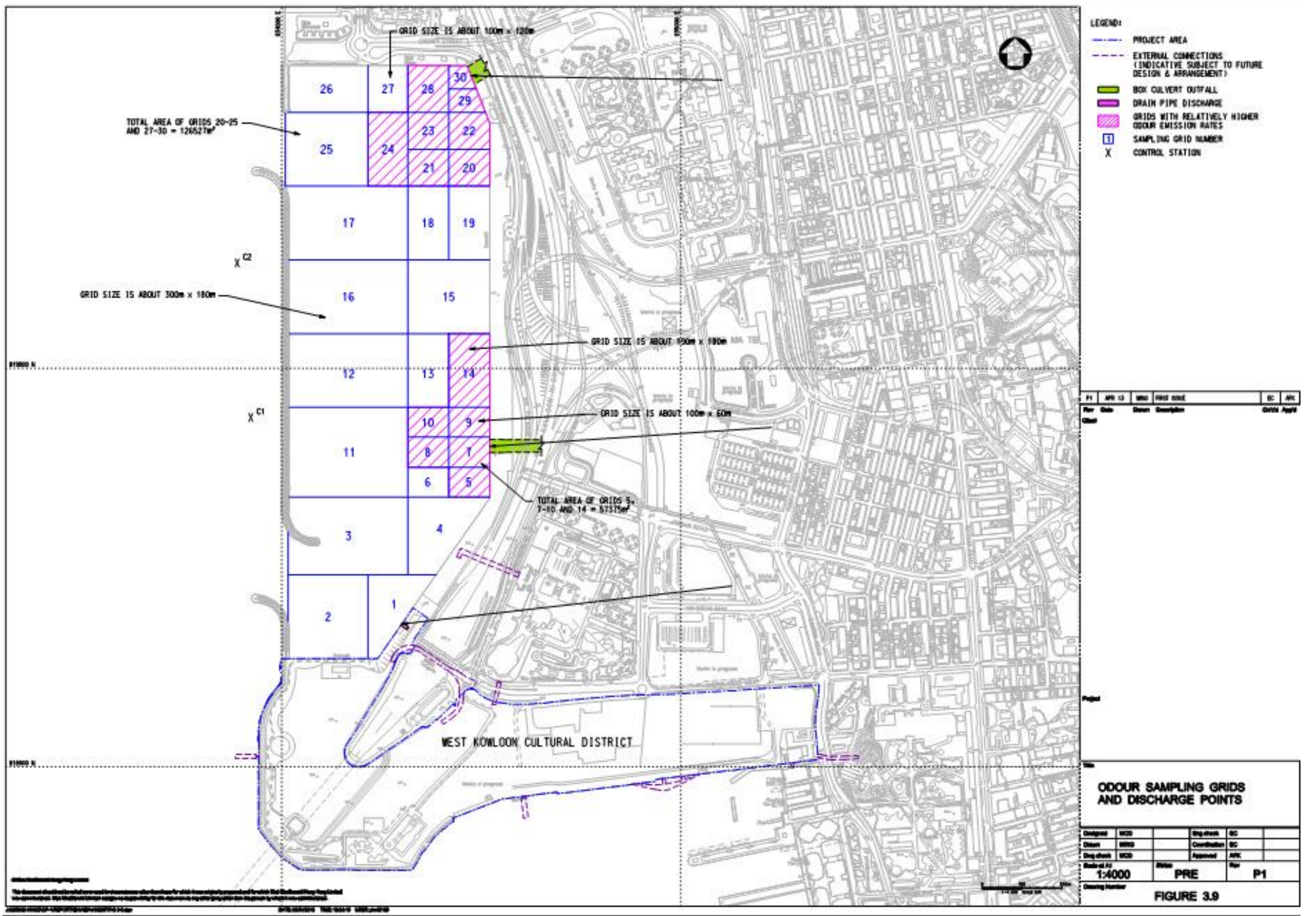
A total of 6 samples conducted at the pier (Cherry Street near to grid 30) and West Kowloon Cultural District (WKCD) between 18th and 22nd March, 2013. All the tested result indicated that the odour concentrations from the land-based area are below 10ou/m^3

Average ambient temperature is 34.2 ℃, average water temperature is 20.6℃. Temperature readings were not taken in the shade. Relatively High recorded temperature is likely to be caused by solar reflections of water surface and/or land surface. Ambient temperature may also affected by the heat from engine, generator and nearby loading / unloading cango ships.

Comparing with using Nitrogen Gas (N_2) and Air through Activated Carbon (AC) as Carrier Gas, the ratio of odour concentration conducted by two different sampling methods is between 1.08 and 23.72, whereas the ratio of odour emission rates are between 74.4 and 1604.82.

During the sampling on 22nd March, 2013, cargo ship from Mainland China parked at Grid 7 was loading / unloading the cargos and releasing a huge amount of diesel gas. Other potential odour emission sources identified from the observation include waste generated by cargo ship, “diesel engine” boat, oil and rubbish on the water surface.

Appendix 1: Location Description of grid location



Odour Source Monitoring for New Yau Ma Tei Typhoon Shelter

for

Mott MacDonald Hong Kong Limited

Submitted by

Hong Kong Productivity Council
Environmental Management Division

(Revision No. 0)

Quality Index

Date	Reference No.	Prepared by	Endorsed by
18 September 2012	40163555_Mott MacDonald\2878_001(R0)	POON Ka Wo	CHAU Kam Man, Grant

TABLE OF CONTENTS

1. INTRODUCTION

The client, Mott MacDonald Hong Kong, commissioned Hong Kong Productivity Council (HKPC) to conduct an odour monitoring work at the new Yau Ma Tei Typhoon Shelter (NYMTTS) in August 2011 by taking odour emission measurement from the identified odorous sea surface in the shelter. Subsequently, upon receipt of comment from Environmental Protection Department of HKSAR Government, this project is initiated by the client to commission HKPC again to conduct further odour measurements at identified odorous sources at the shelter, which together with the previous results will provide sufficient information for quantifying the odour strengths of the identified odorous sources at the shelter.

This project was to measure the odour emission rates and hydrogen sulfide (H_2S) level at identified odorous sources of the NYMTTS. A 2-day survey was carried out at 14:30 – 19:05 and 14:30 – 18:15 on 21 August 2012 and 22 August 2012 during the ebb tide period to collect air samples for laboratory analysis. Besides, field measurements of hydrogen sulphide, odour intensity detection, odour hedonic, odour quality determination, and weather conditions etc were also conducted during the survey. Details of the findings and the laboratory results are presented in this report.

2. SURVEY METHODOLOGY

2.1 Survey Schedule

The survey consisted of 2 rounds of sampling trips at the NYMTTS, and the work schedule is shown in the table below.

Table 2.1: Schedule for the sampling trip on 21 & 22 August 2012

Date	Time	Survey Type	Location
21 August 2012	14:30 – 19:05	Sampling Trip	NYMTTS Sea Surface
22 August 2012	14:30 – 18:15	Sampling Trip	NYMTTS Sea Surface

2.2 Sampling Trip

2.2.1 Sampling Grid

To facilitate the sampling works, the NYMTTS was divided into 30 grids as shown in **Figure 2.1**. Basically, the proposed number and the grid size were referenced to the odour investigation for the Kwun Tong Typhoon Shelter in the EIA report for Kai Tak Development Engineering Study (EIA-157/2008). However, the result of the last odour assessment in August 2011 indicated the higher odour intensity was detected at the 2 locations near the sewage outfall. Thus, denser grid was set for the areas near the 2 box culvert outlets, of which one was near the Park Avenue Central Park and another was near the Jordon Road. Besides, two additional stations (Control 1 & 2) were assigned outside the NYMTTS for quality control purpose. The highlighted grids in Figure 2.2 showed higher odour emission rates detected in 2011.

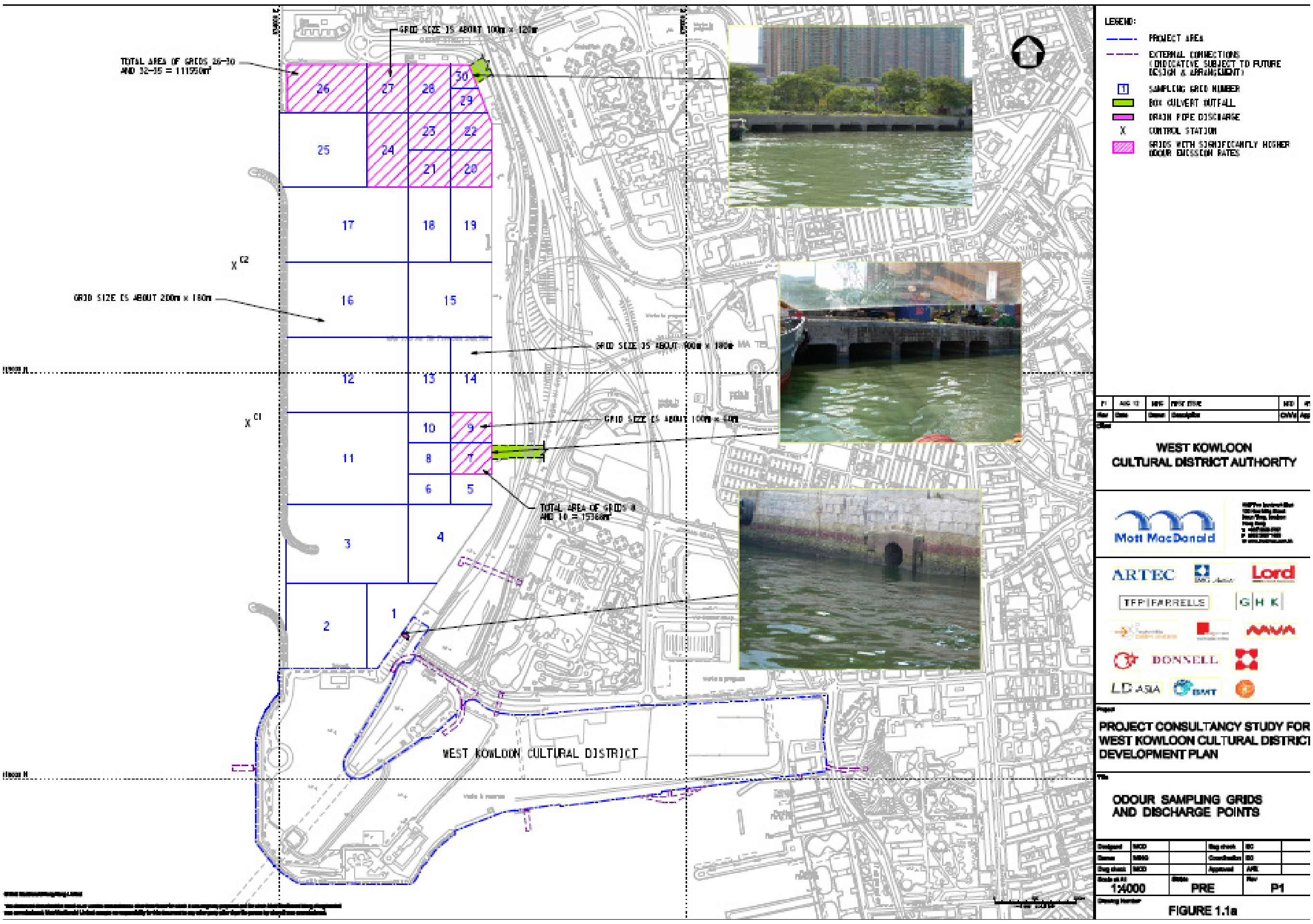


Figure 2.1: Design of sampling grids

The sampling work was conducted on 2 consecutive days, and the grid locations involved in each sampling trip are shown in **Table 2.2** below. In order to capture the worst scenario of odour emissions, the site works were performed during the ebb tide period according to the Hong Kong Observatory's tidal chart **(Annex A)**.

Table 2.2: Schedule for the sampling trip on 21 & 22 August 2012

Date	Time	Grid Location
21 August 2012	14:30 – 19:05	15 to 30 & Control 2
22 August 2012	14:30 – 18:15	1 to 14 & Control 1

2.2.2 Determination of Odour Emission Rate (OER) of the NYMTTS

At each grid, three (3) air samples from the water surface were collected via a floating ventilated sampling hood (FCSH) in couple with a lung sampler. The volumetric flow rate of the FCSH was $10.4m^3/(m^2 \cdot h)$ in compliance with the specification of the VDI3880 standard in Germany. On-site measurements of H_2S, odour intensity, hedonic tone, ambient temperature, relative humidity, wind direction and wind speed were conducted during the sampling, while the duration of odour episodes, odour characteristics, and possible odour generation sources were also recorded.

The collected air samples were delivered to HKPC EPI laboratory for testing the odour concentration. The odour emission rate (OER) at each grid surface area can be calculated by the following equation:

OER ($OU/m^2/s$) = Odour concentration (OU/m^3) x Volumetric sampling flow rate ($m^3/m^2/s$)

2.3 Field Measurement

2.3.1 On-site Measuring Equipment

The equipment items adopted for field measurement, sampling and odour measurement are summarized in **Table 2.3**. The calibration record for Jerome 631-X portable hydrogen sulphide analyzer is shown in **Annex B**.

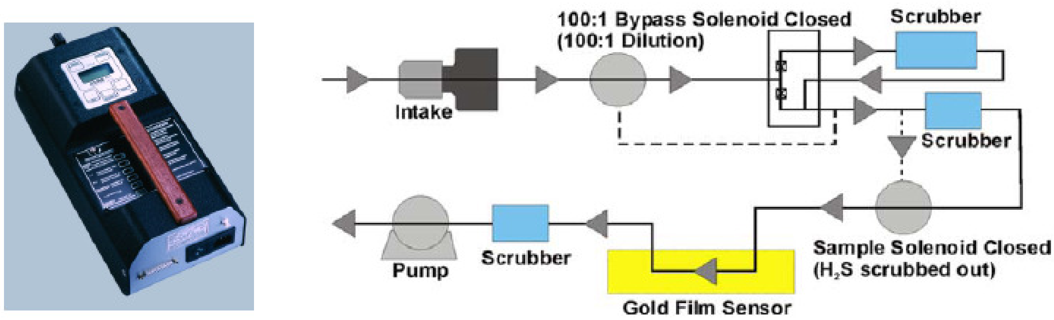
Table 2.3 Equipment for Odour Survey

Description	Equipment	Model
On-site hydrogen sulphide measurement	Portable hydrogen sulphide analyzer	Jerome 631-X
Laboratory hydrogen sulphide measurement	Desktop UV fluorescence H_2S analyzer	Teledyn API Model 101E
Air sample collection	Odour sampler	Ecoma
	Sampling bags	Nalophan NA, PET (8L)
	Floating ventilated sampling hood	Ecoma
Odour concentration measurement	Dynamic olfactometer	Model TO9, Ecoma
Temperature, relative humidity, wind direction and wind speed measurement	Weather tracker	Kestrel 4500
GPS Tracking and Navigation	A handheld GPS	Garmin eTrex Vista HCx

2.3.2 In-situ Measurement Method

Hydrogen sulphide

H_2S concentration was measured with a portable H_2S analyzer (Jerome 631-X) **(Figure 2.2)** at each monitoring location for 10 minutes at 5-minute intervals[1]. The analyzer was able to measure hydrogen sulphide concentration in the range of 1 ppbv to 50ppmv, and the sensitivity was 0.003ppmv hydrogen sulphide.



Jerome 631-X H_2S analyzer

Figure 2.2: Jerome 631-X portable H_2S analyzer

The specification of the analyzer was shown in **Table 2.4** below.

Table 2.4 Specification of Jerome 631-X portable H_2S analyzer

Items	Values
Range	3ppb to 50 ppm
Accuracy	±3ppb (at 50ppb)
Flow rate	0.15L/min
Working temperature	0 – 40°C

Odour intensity

The odour strength in term of odour intensity at the monitoring location was determined by 5 odour monitoring team members in accordance with the classification in **Table 2.5**.

Table 2.5 Classification of Odour Intensity

[1] If the concentration of hydrogen sulphide measured by the portable H_2S monitor is < 3ppb, a grab sample would

Intensity number	Intensity	Description
4	Extreme	Severe odour
3	Strong	Identifiable odour, strong
2	Moderate	Identifiable odour, moderate
1	Slight	Identifiable odour, slight
0	Not detected	No odour perceived or an odour so weak that it cannot be easily characterized or described

Hedonic Tone Test

Hedonic tone was an evaluation of relatively pleasant or unpleasant senses of the odour samples. Five field members indicated their perceived hedonic tone at each determination as a value from the five points hedonic tone scale (**Table 2.6**).

Table 2.6 Classification of Hedonic Tone Test

Hedonic tone	Description
0	Neutral odour / no odour
-1	Mildly unpleasant
-2	Moderately unpleasant
-3	Unpleasant
-4	Offensive

Ambient temperature, relative humidity, wind direction and wind speed

Meteorological measurement on the ambient temperature, relative humidity, wind speed, and wind direction were conducted with a Kestrel weather tracker **(Photo 2.1)** during the sampling trip.

be collected for laboratory analysis using another H_2S analyzer with detection limit of 1ppb.

Photo 2.1 Kestrel weather tracker

2.3.3 Field Sampling

Air sample was collected with an odour sampler **(Photo 2.2)** via a ventilated sampling hood **(Photo 2.3)** at suction rate of 0.45L/s (i.e. to fill the 8L sampling bag in about 18 seconds) by adopting the lung principle. The sampling bag **(Photo 2.4)** is made of polyethyleneterephthalate (PET, Nalophan) which is one of the approved materials in compliance with BS EN13725:2003. **Photo 2.5** shows the method of air sample collection from water surface by using the ventilated sampling hood. At each sampling grid, 3 replicate samples each with about 24L (3 x 8L) of sample air was collected for laboratory analysis.

 **Photo 2.2 Odour Sampler**	 **Photo 2.3 Ventilated sampling hood**

Photo 2.4 Sampling bag

Photo 2.5 Sampling in water surface

2.4 Laboratory Analysis

Laboratory H_2S Analysis

For any airborne H_2S concentration lower than 3ppb, the collected air samples were delivered to laboratory for H_2S analysis by using a desktop UV fluorescence H_2S analyzer (Teledyn API Model 101E) **(Photo 2.6)** to confirm the H_2S concentration.

Photo 2.6 TeledynAPI Model 101E desktop UV fluorescence H_2S analyzer

Laboratory analysis by dynamic olfactometry, BS EN13725

The odour samples were delivered to HKPC's odour research laboratory for dynamic olfactometry analysis. The odour analysis was conducted by 4 qualified panelists with a forced-choice olfactometer within 24 hours after sample collection. The olfactometer was an apparatus that automatically presents an odorous sample at different dilution accomplished with odour-free air to the panelists. The odour concentration was determined according to the dilution factor required to reach the detection threshold of each panelist. **Photo 2.7** shows 4 certified panelists to determine the odour concentration of a sample.

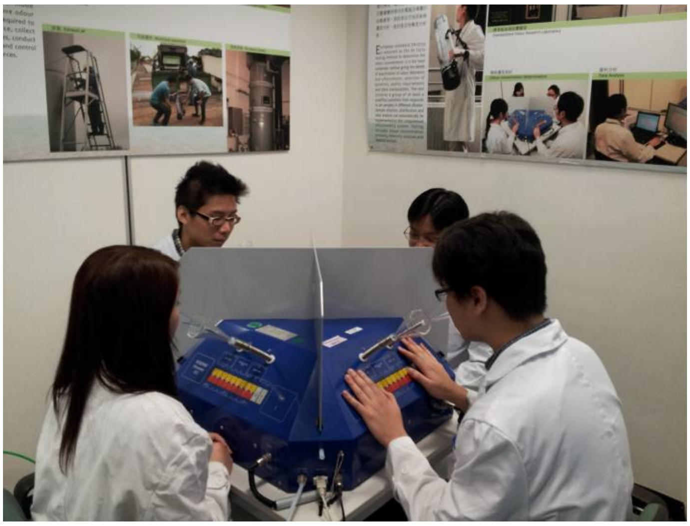


Photo 2.7 Four qualified panelists were measuring the odour concentration of a sample

2.5 Field Logs and Meteorological Conditions

The safety and contingency plan for sampling work are enclosed in **Annex C**. A "Field Record for Odour Episode" record sheet was available for the field staff to record the required information during sampling and measurement. The survey team maintained the field log for all survey works, and the field log records are enclosed in **Annex D**.

The information for odour evaluation included:

- ✓ Time
- ✓ Location
- ✓ GPS location
- ✓ The prevailing weather condition
- ✓ Temperature
- ✓ Relative humidity
- ✓ Wind direction
- ✓ Wind speed
- ✓ Possible source of odour
- ✓ Perceived intensity of the odour
- ✓ Hedonic test
- ✓ Duration of odour episodes
- ✓ Odour characteristics (e.g. sewage or rotten-egg smell, etc)
- ✓ Observed activities would be the possible of odour
- ✓ On-site H_2S measurement

Meteorological measurements including ambient temperature, relative humidity, wind speed, and wind direction were also recorded in the field record log sheet.

2.6 QA/QC Requirement

2.6.1 The QA/QC for field sampling and laboratory analysis of this project followed with standard method BS EN13725:2003. The certified records of the panelists were shown in **Annex E**. Details of the QA/QC of this project were summarized in **Annex F**

3. ON-SITE OBSERVATIONS AND TEST RESULTS

3.1 Sampling Trip Findings

3.1.1 Locations for Odour Evaluation

The actual sampling location of each grid is showed in **Table 3.1**. Since there were a lot of barges and boats travelling in the NYMTTS, all measurements and sampling activities were carried out at the centre of each grid as possible.

Table 3.1 Summary of GPS locations

Grid no.	GPS Location	
	N	E
1	818400.326	834254.488
2	818338.8	834108.5
3	818606.451	834125.7
4	818551.075	834331.753
5	818702.209	834485.9
6	818704.878	834394.711
7	818784.815	834506.431
8	818783.48	834401.95
9	818825.325	834505.817
10	818824.249	834399.173
11	818798.898	834194.108
12	818990.913	834183.006
13	819009.4	834406.3
14	818994.0	834500.7
15	819132.415	834466.389
16	819169.309	834168.708
17	819379.28	834167.602
18	819374.806	834373.257
19	819366.045	834485.975
20	819482.556	834483.842
21	819484.765	834377.718
22	819581.424	834483.854
23	819612.24	834371.02
24	819612.252	834276.024

Grid no.	GPS Location	
	N	**E**
25	819607.935	834121.286
26	819711.252	834112.422
27	819706.82	834265.012
28	819714.448	834372.165
29	819678.224	834488.278
30	819745.203	834462.339
Control 1	818825.4	833942.1
Control 2	819218.843	833915.575

3.1.2 In-situ H_2S Measurement, Odour Evaluation and Sampling Results

During sampling, our sniffing team processed the following activities at each sampling grid:-

- ✓ on-site measurement of ambient hydrogen sulphide **(Photo 3.1)**, sample bags hydrogen sulphide **(Photo 3.2)**, odour intensity, hedonic tone **(Photo 3.3)**, ambient temperature, relative humidity, wind direction, and wind speed **(Photo 3.4)**, GPS recording **(Photo 3.5)**
- ✓ odour characteristics determination including the odour quality, duration of the odour episode and the observed possible sources **(Photo 3.6)**.
- ✓ air samples collection through a floating ventilated sampling hood located at the water surface of the grid **(Photo 3.7 – 3.10)**

Details of the sampling procedure were attached in **Annex F**, and the results of the in-situ measurement were summarized in **Table 3.2 & 3.3**.

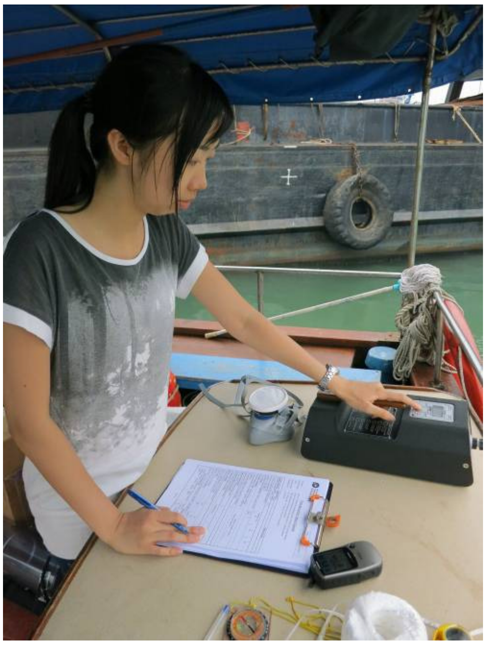
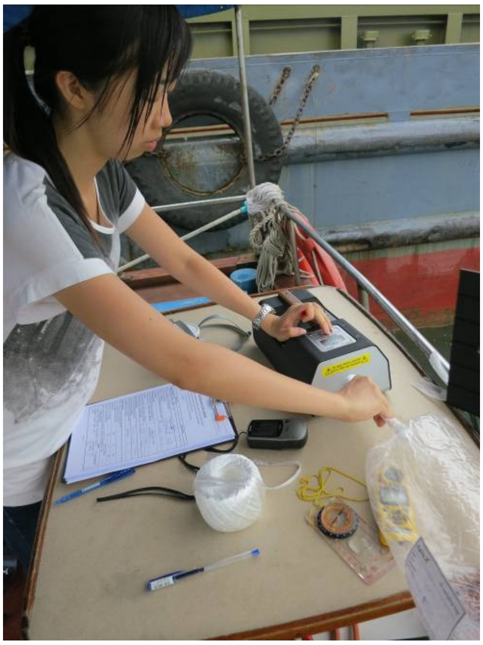
 **Photo 3.1 In-situ ambient H_2S measurement**	 **Photo 3.2 In-situ sample bags H_2S measurement**
 **Photo 3.3 Odour intensity and hedonic tone measurement**	 **Photo 3.4 Meteorological observations recording**

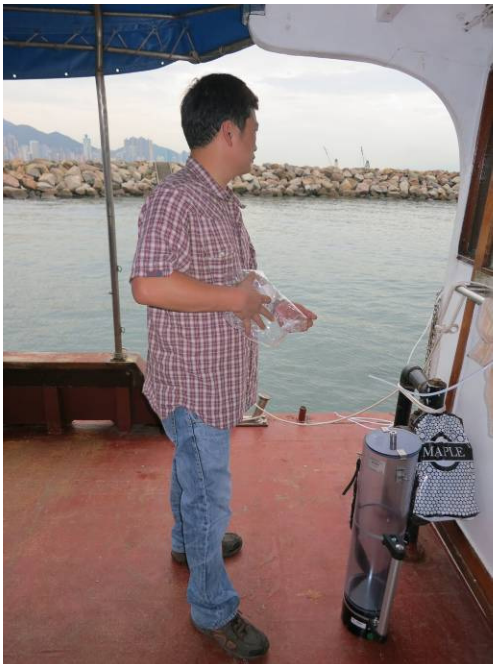
 **Photo 3.5 GPS recording**	 **Photo 3.6 Odour data recording**
 **Photo 3.7 Floating ventilated sampling hood on the sea surface**	 **Photo 3.8 Pre-washing sampling bag**

 **Photo 3.9 Sample was collected at the sea surface**	 **Photo 3.10 Three samples were collected at each grids**

The ambient H_2S levels in the NYMTTS were detected from 0.004 up to 1.37ppm and the H_2S levels at the seawater surface was ranged from 0.004 up to 15.33ppm. In general, higher H_2S level was detected when the measurement location was getting closer to the box culvert discharge points. Besides smell of rotten-egg and seawater were dominant near the box culvert. However, the sniffing team also perceived diesel smell at some grids, which might be generated from engines **(Photo 3.11 - 3.12)** of the boats in the shelter.

The results of hedonic tone test near the box culverts were found from -2 to -4, representing a moderately unpleasant to offensive situation. The offensive smell might trigger complaints near the NYMTTS.

During the monitoring period, some rubbish was found near the box culvert discharge point which was near the Jordon Road (**Photo 3.13 – 3.15**). Besides, oil was also found on the seawater surface **(Photo 3.16**). Moreover, there was a backhoe clearing sludge over the box culvert discharge point near the Park Avenue Central Park (**Photo 3.17**). Furthermore, there was a lot of loading activities at the boundary of the NYMTTS. The parked loading cargo ships exhausted dark smoke **(Photo 3.18**).

Photo 3.11 Diesel smell from other ships

Photo 3.12 Diesel smell from other ships

Photo 3.13 Rubbish on the seawater surface

Photo 3.14 Rubbish on the seawater surface

Photo 3.15 Rubbish on the seawater surface

Photo 3.16 Oil on the seawater surface

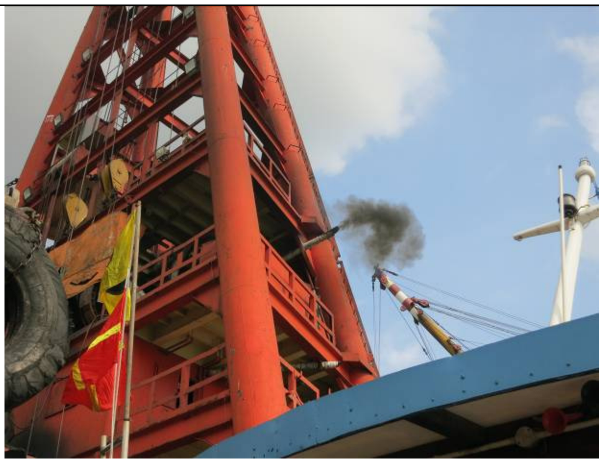
	
Photo 3.17 Backhoe for dredging/clearing mud/sludge over box culvert discharge point	**Photo 3.18 Exhausted smoke from the loading cargo ship**

Table 3.2 Summary of the sampling information and weather conditions

Date	Log Sheet No.	Grid	Sample Collected (Y / N)	Sampling Completed Time			Sample I.D.			GPS Location		Weather Conditions				
				#1	#2	#3	#1	#2	#3	N	E	Prevailing condition	Temp.(℃)	Rel. Humidity (%)	Wind Direction	Wind Speed (m/s)
20120822	O-20120822-1	1	Y	14:30:10	14:32:05	14:34:20	20120822143010-1	20120822143205-2	20120822143420-3	818400.326	834254.488	Sunny	30.1	78.2	E	1.5
20120822	O-20120822-2	2	Y	14:43:40	14:45:35	14:47:30	20120822144340-1	20120822144535-2	20120822144730-3	818338.8	834108.5	Sunny	30.4	77.4	E	0.5
20120822	O-20120822-3	3	Y	14:57:20	14:59:35	15:06:34	20120822145720-1	20120822145935-2	20120822150634-3	818606.451	834125.7	Sunny	30.1	80.0	E	2
20120822	O-20120822-4	4	Y	15:14:45	15:16:30	15:18:45	20120822151445-1	20120822151630-2	20120822151845-3	818551.075	834331.753	Sunny	30.2	79.7	E	1.2
20120822	O-20120822-8	5	Y	16:20:30	16:22:40	16:25:40	20120822162030-1	20120822162240-2	20120822162540-3	818702.209	834485.9	Sunny	30.4	80.4	E	1.0
20120822	O-20120822-9	6	Y	16:35:30	16:37:40	16:39:40	20120822163530-1	20120822163740-2	20120822163940-3	818704.878	834394.711	Sunny	30.7	80.7	E	0.4
20120822	O-20120822-14	7	Y	17:50:50	17:52:50	17:54:50	20120822175050-1	20120822175250-2	20120822175450-3	818784.815	834506.431	Sunny	30.2	80.9	NE	1.5
20120822	O-20120822-10	8	Y	16:50:15	16:52:15	16:54:10	20120822165015-1	20120822165215-2	20120822165410-3	818783.48	834401.95	Sunny	30.3	80.4	E	0.4
20120822	O-20120822-13	9	Y	17:37:30	17:39:30	17:41:30	20120822173730-1	20120822173930-2	20120822174130-3	818825.325	834505.817	Sunny	30.4	80.2	E	0.4
20120822	O-20120822-11	10	Y	17:05:50	17:07:50	17:09:00	20120822170550-1	20120822170750-2	20120822170900-3	818824.249	834399.173	Sunny	30.3	80.3	E	2.1
20120822	O-20120822-5	11	Y	15:36:05	15:38:10	15:40:20	20120822153605-1	20120822153810-2	20120822154020-3	818798.898	834194.108	Sunny	30.3	76.3	E	0.5
20120822	O-20120822-6	12	Y	15:45:30	15:47:45	15:50:20	20120822154530-1	20120822154745-2	20120822155020-3	818990.913	834183.006	Sunny	30.1	80.2	E	1.2
20120822	O-20120822-7	13	Y	16:04:40	16:06:50	16:09:30	20120822160440-1	20120822160650-2	20120822160930-3	819009.4	834406.3	Sunny	30.3	77.7	E	0.4
20120822	O-20120822-12	14	Y	17:20:20	17:22:20	17:24:20	20120822172020-1	20120822172220-2	20120822172420-3	818994.0	834500.7	Sunny	30.5	80.1	E	0.8
20120821	O-20120821-1	15	Y	14:32:25	14:34:25	14:36:45	20120821143225-1	20120821143425-2	20120821143645-3	819132.415	834466.389	Sunny	31.0	80.8	E	1.3
20120821	O-20120821-2	16	Y	14:50:45	14:51:50	14:53:45	20120821145045-1	20120821145150-2	20120821145345-3	819169.309	834168.708	Sunny	31.0	76.2	E	0.7
20120821	O-20120821-3	17	Y	15:04:35	15:06:35	15:08:30	20120821150435-1	20120821150635-2	20120821150830-3	819379.28	834167.602	Sunny	31.8	82.2	E	1.4
20120821	O-20120821-4	18	Y	15:18:50	15:20:50	15:22:50	20120821151850-1	20120821150635-2	20120821152250-3	819374.806	834373.257	Sunny	31.3	83.6	E	1.6
20120821	O-20120821-5	19	Y	15:32:05	15:34:05	15:36:10	20120821153205-1	20120821153405-2	20120821153610-3	819366.045	834485.975	Sunny	31.4	79.1	SE	1.0
20120821	O-20120821-6	20	Y	15:47:35	15:49:46	15:51:50	20120821154735-1	20120821154946-2	20120821155150-3	819482.556	834483.842	Sunny	30.8	86.7	E	2.2
20120821	O-20120821-7	21	Y	16:14:45	16:17:05	16:19:05	20120821161445-1	20120821161705-2	20120821161905-3	819484.765	834377.718	Sunny	30.7	85.1	E	3.6

Date	Log Sheet No.	Grid	Sample Collected (Y / N)	Sampling Completed Time			Sample I.D.			GPS Location		Weather Conditions				
				#1	#2	#3	#1	#2	#3	N	E	Prevailing condition	Temp.(℃)	Rel. Humidity (%)	Wind Direction	Wind Speed (m/s)
20120821	O-20120821-8	22	Y	16:30:20	16:33:30	16:35:40	20120821163020-1	20120821163330-2	20120821163540-3	819581.424	834483.854	Sunny	31.7	75.2	E	0.6
20120821	O-20120821-9	23	Y	16:47:40	16:49:46	16:51:40	20120821164740-1	20120821164946-2	20120821165140-3	819612.24	834371.02	Sunny	30.6	78.0	E	2.1
20120821	O-20120821-10	24	Y	16:59:40	17:01:40	17:03:40	20120821165940-1	20120821170140-2	20120821170340-3	819612.252	834276.024	Sunny	30.6	81.0	E	3.0
20120821	O-20120821-11	25	Y	17:12:40	17:14:45	17:16:58	20120821171240-1	20120821171445-2	20120821171658-3	819607.935	834121.286	Sunny	31.3	78.7	E	1.0
20120821	O-20120821-12	26	Y	17:27:40	17:29:45	17:31:56	20120821172740-1	20120821172945-2	20120821173156-3	819711.252	834112.422	Sunny	30.8	78.0	E	1.5
20120821	O-20120821-13	27	Y	17:58:50	18:00:16	18:02:20	20120821175850-1	20120821180016-2	20120821180220-3	819706.82	834265.012	Sunny	30.1	79.3	E	0.7
20120821	O-20120821-14	28	Y	18:15:20	18:17:50	18:19:50	20120821181520-1	20120821181750-2	20120821181950-3	819714.448	834372.165	Sunny	30.1	78.9	E	3.5
20120821	O-20120821-15	29	Y	18:29:40	18:31:45	18:33:40	20120821182940-1	20120821183145-2	20120821183340-3	819678.224	834488.278	Sunny	30.3	81.8	E	2.6
20120821	O-20120821-16	30	Y	18:40:05	18:42:05	18:44:10	20120821184005-1	20120821184205-2	20120821184410-3	819745.203	834462.339	Sunny	30.1	81.5	E	1.6
20120822	O-20120822-15	Control 1	Y	18:06:05	18:08:10	18:10:10	20120822180605-1	20120822180810-2	20120822181010-3	818825.4	833942.1	Sunny	30.1	80.4	E	0.5
20120821	O-20120821-17	Control 2	Y	18:58:10	19:00:10	19:02:10	20120821185810-1	20120821190010-2	20120821190210-3	819218.843	833915.575	Sunny	30.1	82.0	E	1.5

Table 3.3 Summary of the odour characteristics

Date	Log Sheet No.	Grid	On-site ambient H2S (ppm)				Possible Source of Odour	Odour Intensity (filed perception by individual panelist)				Odour Hedonic (filed perception by individual panelist)				Perceived Odour Duration	Odour Quality
			0 min	in 5 mins	in 10 mins	Average		PK	TS	KW	Median	PK	TS	KW	Median2		
20120822	O-20120822-1	1	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120822	O-20120822-2	2	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120822	O-20120822-3	3	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120822	O-20120822-4	4	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120822	O-20120822-8	5	0.16	0.15	0.15	0.153	Box Culvert Discharge	2	2	2	2	-2	-3	-2	-2	Continuous	Sewage/Sewage odour - Rotten egg
20120822	O-20120822-9	6	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120822	O-20120822-14	7	1.3	1.4	1.4	1.367	Box Culvert Discharge	3	3	4	3	-4	-3	-4	-4	Continuous	Sewage/Sewage odour - Rotten egg
20120822	O-20120822-10	8	0.021	0.023	0.022	0.022	Box Culvert Discharge	1	1	1	1	-1	-1	-1	-1	Continuous	Sewage/Sewage odour - Rotten egg, Seawater
20120822	O-20120822-13	9	0.56	0.58	0.55	0.563	Box Culvert Discharge	3	3	3	3	-3	-3	-3	-3	Continuous	Sewage/Sewage odour - Rotten egg
20120822	O-20120822-11	10	0.12	0.11	0.12	0.117	Box Culvert Discharge	2	1	2	2	-1	-1	-1	-1	Continuous	Sewage/Sewage odour - Rotten egg
20120822	O-20120822-5	11	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120822	O-20120822-6	12	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120822	O-20120822-7	13	0.003	0.004	0.004	0.004	Diesel from ships nearby	1	1	1	1	0	-1	-1	-1	Continuous	Inflammable materials odour
20120822	O-20120822-12	14	0.019	0.017	0.019	0.018	Box Culvert Discharge	1	1	1	1	-1	-1	-1	-1	Continuous	Sewage/Sewage odour - Rotten egg, Seawater
20120821	O-20120821-1	15	<0.003	<0.003	<0.003	<0.003	Diesel from ships nearby	1	1	1	1	-1	-1	-1	-1	Intermit	Inflammable materials odour
20120821	O-20120821-2	16	<0.003	<0.003	<0.003	<0.003	Diesel from ships nearby	1	1	1	1	0	-1	-1	-1	Intermit	Inflammable materials odour
20120821	O-20120821-3	17	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120821	O-20120821-4	18	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water

Date	Log Sheet No.	Grid	On-site ambient H2S (ppm)				Possible Source of Odour	Odour Intensity (filed perception by individual panelist)				Odour Hedonic (filed perception by individual panelist)				Perceived Odour Duration	Odour Quality
			0 min	in 5 mins	in 10 mins	Average		PK	TS	KW	Median	PK	TS	KW	Median2		
20120821	O-20120821-5	19	<0.003	<0.003	<0.003	<0.003	Diesel from ships nearby	1	1	1	1	-1	-1	-1	-1	Intermit	Inflammable materials odour
20120821	O-20120821-6	20	0.063	0.062	0.063	0.063	Box Culvert Discharge, Sea water	1	1	1	1	-1	-1	-2	-1	Intermit	Sewage/Sewage odour - Rotten egg, Seawater
20120821	O-20120821-7	21	0.038	0.040	0.041	0.040	Box Culvert Discharge, Sea water	1	1	1	1	-1	-1	-1	-1	Intermit	Sewage/Sewage odour - Rotten egg, Seawater
20120821	O-20120821-8	22	0.42	0.43	0.45	0.433	Box Culvert Discharge	2	2	2	2	-2	-2	-2	-2	Intermit	Sewage/Sewage odour - Rotten egg, Seawater
20120821	O-20120821-9	23	0.39	0.40	0.40	0.397	Box Culvert Discharge	2	2	2	2	-2	-2	-2	-2	Continuous	Sewage/Sewage odour - Rotten egg
20120821	O-20120821-10	24	0.037	0.038	0.038	0.038	Box Culvert Discharge	1	1	1	1	-1	-1	-1	-1	Intermit	Sewage/Sewage odour - Rotten egg, Seawater
20120821	O-20120821-11	25	0.004	0.005	0.004	0.004	Box Culvert Discharge, Sea water	1	1	1	1	0	-1	-1	-1	Intermit	Sewage/Sewage odour - Rotten egg, Seawater
20120821	O-20120821-12	26	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120821	O-20120821-13	27	0.006	0.005	0.006	0.006	Box Culvert Discharge	1	1	1	1	-1	-1	-1	-1	Intermit	Sewage/Sewage odour - Rotten egg, Seawater
20120821	O-20120821-14	28	0.400	0.41	0.4	0.403	Box Culvert Discharge	2	2	2	2	-2	-2	-2	-2	Intermit	Sewage/Sewage odour - Rotten egg
20120821	O-20120821-15	29	1	0.98	0.97	0.983	Box Culvert Discharge	3	3	3	3	-3	-3	-3	-3	Continuous	Sewage/Sewage odour - Rotten egg
20120821	O-20120821-16	30	1.3	1.2	1.3	1.267	Box Culvert Discharge	3	3	4	3	-4	-3	-4	-4	Continuous	Sewage/Sewage odour - Rotten egg
20120822	O-20120822-15	Control 1	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water
20120821	O-20120821-17	Control 2	<0.003	<0.003	<0.003	<0.003	Sea water	1	1	1	1	0	0	0	0	Continuous	Sea water

3.1.3 <u>In-situ Marine Water Measurement</u>

As requested by the client, the marine water monitoring data provided by the client was included in this report and attached in **Annex G**.

3.2 Determination of Odour Emission Rate

3.2.1 <u>H_2S Measurement, Odour Concentration Determination and Odour Emission Rate Calculation</u>

All the collected samples were delivered to HKPC's Environmental and Product Innovation Laboratory accredited under Hong Kong Laboratory Accreditation Scheme (HOKLAS) to determine the odour concentration by using dynamic olfactometry according to the European Standard Method BS EN13725:2003. For samples after collection with the hydrogen sulphide concentration below 3ppb, a UV florescence analyzer was employed to confirm the result. The odour concentration determination and H_2S measurements were conducted within 24 hours after the collection of samples. The laboratory results summarized in **Table 3.6** demonstrated that the seawater near the box culverts had a higher odour emission. On the other hand, higher odour emission might cause higher H_2S concentration in the ambient. The Control 1 and 2 as the control points of this survey were detected the lowest odour emission, which may be referred as the odour background of the NYMTTS.

Table 3.6: Summarized analytical results for H_2S measurement, odour concentration and odour emission rate

		On-site H_2S in seawater surface - sample bags (ppm)				Odour concentration (Tested in Lab)	Odour emission rate
Date	**Grid**	**1**	**2**	**3**	**Avg**	**(OU/m^3)**	**(OU/m^2/s)**
20120822	1	<0.001	<0.001	<0.001	<0.001	11	0.032
20120822	2	<0.001	<0.001	<0.001	<0.001	11	0.032
20120822	3	<0.001	<0.001	<0.001	<0.001	11	0.032
20120822	4	<0.001	<0.001	<0.001	<0.001	11	0.032
20120822	5	1.2	1.3	1.2	1.233	5,793	17
20120822	6	<0.001	<0.001	<0.001	<0.001	11	0.032
20120822	7	15	16	15	15.333	73,562	213
20120822	8	1.6	1.5	1.5	1.533	7,298	21
20120822	9	2.0	2.1	2.2	2.100	11,585	33
20120822	10	0.82	0.81	0.84	0.823	5,161	15
20120822	11	<0.001	<0.001	<0.001	<0.001	11	0.032
20120822	12	<0.001	<0.001	<0.001	<0.001	11	0.032
20120822	13	0.059	0.061	0.060	0.060	181	0.52
20120822	14	0.25	0.21	0.23	0.230	1,824	5.3
20120821	15	<0.001	<0.001	<0.001	<0.001	11	0.032
20120821	16	<0.001	<0.001	<0.001	<0.001	11	0.032
20120821	17	<0.001	<0.001	<0.001	<0.001	11	0.032
20120821	18	<0.001	<0.001	<0.001	<0.001	11	0.032
20120821	19	<0.001	<0.001	<0.001	<0.001	11	0.032
20120821	20	1.3	1.4	1.3	1.333	4,598	13
20120821	21	0.40	0.42	0.42	0.413	3,649	11
20120821	22	1.4	1.4	1.3	1.367	5,793	17
20120821	23	4.16	4.23	4.19	4.193	13,004	38
20120821	24	0.28	0.28	0.27	0.277	1,824	5.3
20120821	25	0.19	0.18	0.17	0.180	813	2.3
20120821	26	0.003	0.004	0.004	0.004	57	0.16
20120821	27	0.026	0.027	0.025	0.026	128	0.37
20120821	28	0.36	0.36	0.38	0.367	2,896	8.4
20120821	29	9.7	9.4	9.8	9.633	29,193	84
20120821	30	14	13	14	13.667	69,433	201
20120822	Control 1	<0.001	<0.001	<0.001	<0.001	11	0.032
20120821	Control 2	<0.001	<0.001	<0.001	<0.001	11	0.032

4. LIMITATION OF MEASUREMENT

The results obtained in this odour emission measurement are only representative of the odour and pollutant concentrations at the measurement locations during the specified measurement periods. The results should not be used to extrapolate for odour emission levels in other conditions.

Environmental Management Division
Hong Kong Productivity Council

18 September 2012