Appendix 3-11A

Odour Impact Assessment of
Proposed Interim STP

Appendix 3-11A Odour Impact Assessment of Proposed Interim Sewage Treatment Plant (STP)

Introduction

An interim STP is proposed within the Project Site before the commissioning of proposed public sewer along Yau Pok Road, it is currently envisaged that the interim on-site STP for the proposed development will be a combination of MBR system and RO system downstream. The interim STP will be located within a totally enclosed building of which the MBR and RO system will be located underground. The location of proposed interim STP is shown on the MLP in Figure 2-10 of the EIA report.

The proposed STP will be a small plant serving the Project Site only, and with a design sewage treatment capacity of about 160 m^3/day. Detailed design of the interim STP has yet been carried out, but the exhaust of the totally enclosed interim sewage system will be equipped with odour removal system, e.g. scrubbing system (with an odour removal efficiency of not less than 99.5%). It is expected that the exhaust will be directed away from nearby ASRs including proposed buildings of this Project. During the detailed design stage, the minimisation of odour from STP will be considered further to reduce any localized impact.

Methodology

Odour Assessment Criteria

For odour impact assessment, Annex 4 of EIAO-TM stipulates an odour limit of 5 odour units based on an average time of 5 seconds. This has been adopted in this assessment.

Potential Odour Sources

According to the Engineer, potential odour sources of the proposed STP are identified, which includes the followings:

Preliminary Treatmnet Unit:

- Inlet Chamber
- Equalization Tank cum wet well (compartment 1)
- Equalization Tank (compartment 2)
- Pre-membrane fine screen and screening handling

MBR Treatment Unit:

- Anoxic Tank
- Aerobic / Membrane Tank

Slude Treatment Unit:

- Sludge Holding/ RO Concentration Tank

No. of plants and dimensions of the above equipment are presented in Annex 2, which are also provided by the Engineer for this assessment.

Since there is currently no detailed design of the proposed STP or its layout plan, the exhaust of the above equipment (after treatment by odour removal system) has been assumed to be directed away from nearby ASRs.

Odour Emission Strength and Emission Rate

Assessment on potential odour impact due to operation of the STP has been undertaken by making reference to the published odour emission strength from other similar facilities (e.g. sewage treatment plants managed by the Drainage Services Department (DSD) of Hong Kong SAR Government). Information of odour emission sources and odour strength has been collected for STPs using MBR system, which is comparable to this Project[1] (extracted information is also provided in Annex 1). It was found that the reported odour emission strength, was based on direct measurements at DSD's STPs which represents a worst case scenario.

The same reported odour strength has been adopted in this odour impact assessment. It is considered that the reported odour emission strength would represent a worst case scenario of this Project given that this Project only concerns domestic sewage from proposed 70 houses and club house, and that the concerned odour strength is unlikely to be in the same magnitude as DSD's STPs, which are designed for a much larger treatment capacity. Please refer to Annex 2 for details of the odour emission strength that has been adopted in this assessment and the calculation of mitigated emission rates.

Selection of Representative ASRs

Among the ASRs that have been identified for construction phase air quality assessment of this Project, the worst affected ASRs surrounding the proposed interim STP have been selected for the odour impact assessment. In addition, proposed house of this Project that is nearest to the proposed STP has also been assessed. The location of selected ASRs for odour impact assessment is presented in Figure 1 below.

[1] Approved EIA report namely, "Outlying Islands Sewerage Stage 2 - Upgrading of Cheung Chau Sewage Collection, Treatment and Disposal Facilities (EIA-219/ 2013)", Appendix 3.4 and Section 3.8.

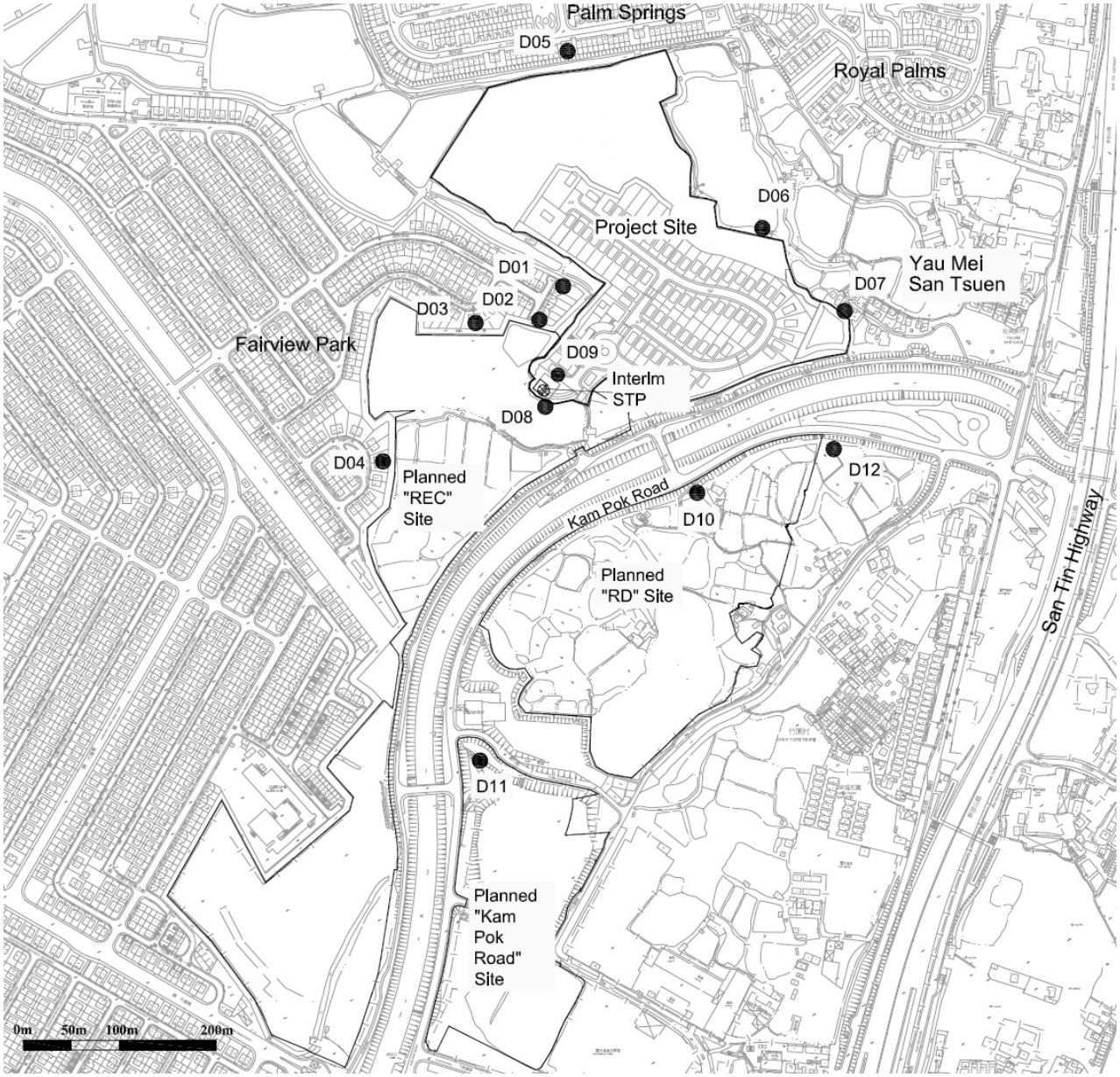

Figure 1 Locations of Representative ASRs Selected for Odour Impact Assessment

Air Dispersion Model

The odour impact from STP was modelled using the software "Industrial Source Complex Short Term (ISCST)" developed by Trinity Consultants Incorporated. The ISCST model is based on the principle of Gaussian dispersion and is widely accepted by authorities worldwide including the Hong Kong Environmental Protection Department (EPD) and the United States Environmental Protection Agency (USEPA). The odour emission sources were modelled as point source.

The proposed development falls within grid(20,40) in PATH system, thus meteorological data derived using MM5 model (grid(20,40)) has been adopted for the assessment.

Conversion of 1-hour Average to 5-second Average

The ISCST3 model output for 1-hour average concentration is converted into 5-second average to enable a direct comparison with the above-mentioned odour criteria.

The 1-hour average odour concentration is first converted to 3-minute average by the power law relationship which is related to the stability classes. For stability class A to F, multiplying factors of 2.23, 2.23, 1.7, 1.38, 1.31 and 1.31 respectively were applied. The 3-minutes averages were further converted to 5-second averages by applying a multiplying factor of 10 for those hours with atmospheric stability classes A to B, and a factor of 5 for those hours with stability classes C to F. The same conversation factors have widely been adopted in other DSD's projects [1].

Stability Class	**Conversation Factor (from 1-hour to 5 seconds)**
A	22.3
B	22.3
C	8.5
D	6.9
E	6.55
F	6.55

Remark: The above conversation factors have been input to the ISCST model using the "Stability Category" option in the model in order to specify emission rate factors for each stability class.

Assessment Results

The odour assessment results are presented in the below table. According to the results, the predicted mitigated 5-seconds odour unit due to operation of the proposed STP would be well below the odour criteria, and no adverse odour impact is therefore anticipated.

It shall be noted that the below odour assessment results are presented by adopting a very conservative odour emission strength from other projects for the purpose of a worst case scenario. Given the scale of this Project (70 houses) and that the proposed STP will be underground, it is anticipated that the actual odour emission strength from the STP would be lower. During the detailed design stage, minimisation of odour will be considered further to reduce any localized impact.

Table 1 Predicted Mitigated 5-Seconds Odour Unit at ASRs

ASR ID	**Description**	**Height, m above ground level**	**Mitigated 5-second Odour Unit**
D01	Fairview Park	1.5m / 4.5m/ 7.5m	0.1 / 0.1 / 0.3
D02	Fairview Park	1.5m / 4.5m/ 7.5m	0.2 / 0.4 / 0.6
D03	Fairview Park	1.5m / 4.5m/ 7.5m	0.1 / 0.2 / 0.3
D04	Fairview Park	1.5m / 4.5m/ 7.5m	0.1 / 0.1 / 0.1
D05	Palm Springs	1.5m / 4.5m/ 7.5m	0 / 0 / 0.1
D06	Yau Mei San Tsuen village house	1.5m / 4.5m/ 7.5m	0.1 / 0.1 / 0.1
D07	Yau Mei San Tsuen village house	1.5m / 4.5m/ 7.5m	0 / 0 / 0
D08	Planned REC Site *	1.5m / -/ -	1.2 / - / -
D09	Proposed building of this Project	1.5m / 4.5m/ 7.5m	1.5 / 2.4 / 3
D10	Planned RD Site	1.5m / 4.5m/ 7.5m	0.1 / 0.1 / 0.1
D11	Planned Kam Pok Road Site	1.5m / 4.5m/ 7.5m	0 / 0 / 0
D12	Fairview Park	1.5m / 4.5m/ 7.5m	0 / 0 / 0
Max. Odour Level			**3** (or 60% of odour criteria)
Odour Criteria			**5**

Remark: * According to the published "REC Site' EIA report, landscape area was proposed at northern portion of that project. Thus, 1.5m above ground level was adopted in the assessment.

Annex 1

(Extracted Odour Emission Strength Information from Similar STP Projects)

2. PROJECT DESCRIPTION

2.1 Location and Description of the Project

2.1.1 The works for this Project in Cheung Chau mainly comprises the following items and as shown in Layout Plan of **Figure 2.1**:

(a) Upgrading of the existing Cheung Chau STW;

(b) Upgrading of the existing Pak She SPS by increasing the pumping capacity; and

(c) Sewers works in Cheung Chau including upgrading/rehabilitation of the existing sewers at Cheung Chau and provision of new sewers to unsewered areas/villages including Tai Kwai Wan San Tsuen, Pak She San Tsuen, Nam She Tong, Fa Peng, Chi Ma Hang, Round Table Villages, Tai Shek Hau and Sin Yan Tseng, Tai Tsoi Yuen Kui, Ko Shan Tsuen and Lung Tsai Tsuen.

Sewage Treatment Works

2.1.2 Existing Cheung Chau STW is located at the western side of the Cheung Kwai Estate. It is currently a primary treatment works with design capacity of 4,000 m^3/d. Upon completion of the Project, it will be increased to a capacity of 9,800 m^3/d with secondary treatment level. A Membrane-bioreactor (MBR) type sewage treatment plant will be adopted.

2.1.3 Conventional secondary sewage treatment generally involves the biological degradation of organic content in the influent followed by secondary sedimentation to settle out the sludge from the aqueous activated sludge solution. Rather than employing sedimentation, an MBR system passes the aqueous activated sludge solution through membrane filtration to separate water from the sludge. The MBR systems can operate at a considerably higher mixed liquor suspended solids concentration and provide an effective and reliable barrier, therefore MBR system has smaller footprint, superior effluent quality and less sludge production over the conventional process. All the MBR modules will be placed in MBR tanks, which are covered and installed indoor.

2.1.4 The STW upgrading works will include construction of new treatment facilities and also effluent reuse facilities to reuse portion of the treated effluent for non-potable uses within STW. All the upgrading works will be constructed within the existing site boundary of Cheung Chau STW. Proposed general layout of the Cheung Chau STW and the Schematic Flow Diagram are shown in **Figure 2.2** and **Figure 2.4**, respectively.

Sewage Pumping Station

2.1.5 Existing Pak She SPS was commissioned in 1984 and is located at the junction of Pak She Praya Road and Ping Chong Road, opposite to the Cheung Chau Fire Station. It is currently equipped with three screw pumps (two duty and one standby) with existing pumping capacity of 29,376 m^3/d (340 L/s). Upon completion of the Project, it will be increased to a capacity of 42,336 m^3/d (490 L/s).

2.1.6 The upgrading works of Pak She SPS mainly include replacement of pumps with higher pumping capacity and other Electrical and Mechanical (E&M) equipments, minor modification of existing pump troughs. Dual power supply or standby power sources, and deodourizing units will be provided to the upgraded Pak She SPS.

2.1.7 There is an existing 750mm dia. emergency bypass at the Pak She SPS currently connected to the Cheung Chau typhoon shelter. Under this Project, the emergency

3.8.4 The General Layout Plan of the Cheung Chau STW (**Figure 2.2**) shows the locations of these potential odour sources.

Pak She Sewage Pumping Station

3.8.5 Potential odour sources identified in the SPS mainly include the wet well, screw pump and screening area as shown in **Figure 3.54**.

Emissions Rates

3.8.6 The odour emission rates from Preliminary Treatment Unit and Sludge Treatment Unit of the Cheung Chau STW, and the Pak She SPS were referenced to the odour emission rates provided in the approved EIA of Harbour Area Treatment Scheme (HATS) Stage 2A (Appendix 3-2) (Register No. AEIAR-121/2008).

3.8.7 Odour measurement of air collected from an operative MBR sewage treatment facility in Hong Kong was conducted for estimating the odour emissions data of the aerobic MBR tank of the MBR treatment unit of the upgraded Cheung Chau STW. MBR Sewage Treatment Facility at Lo Wu Correctional Institution (LWCISTP) was chosen due to similar sewage condition and also using same MBR treatment facility. The correction of changes of surface flow rate under operation scenario of LWCISTP and Cheung Chau Sewage Treatment Works was adopted before the air modelling assessment. Details of the odour measurements at LWCISTP and the calculations of the odour emission rates are provided in **Appendix 3.4**.

Meteorological Data and Assumptions

3.8.8 Meteorological data from Cheung Chau Automatic Weather Station provided by the Hong Kong Observatory for the year 2010 was used for the dispersion model. .

Selected ASR for Dispersion Modelling Assessment

3.8.9 All ASRs selected and described in **Table 3.4** were used for the operational phase odour assessment. In addition, for odour concentration contour plots, assessment grid points were also included to cover the assessment area within 500 m from the Cheung Chau STW and Pak She SPS.

Conversion of 1-Hour Average to 5-Second Average

3.8.10 Odour impact assessment is based on a 5-second average level. Conversion of the ISCST3 modelled output from 1-hour average concentration to 5-second average is needed. The 1-hour average odour concentration is first converted to 3-minute average by the power law relationship which is related to the stability classes. For stability class A to F, multiplying factors of 2.23, 2.23, 1.7, 1.38, 1.31 and 1.31 respectively were applied. The 3-minutes averages were further converted to 5-second averages by applying a multiplying factor of 10 for those hours with atmospheric stability classes A to B, and a factor of 5 for those hours with stability classes C to F. This has made reference to the Guidelines for Choice of Models and Model Parameters in Air Quality Assessment.

3.9 Prediction of Odour Impact

Unmitigated Scenario

3.9.1 It should be noted that deodourizing units will be installed at the Cheung Chau STW and Pak She SPS. Thus, the "unmitigated scenario" prediction results, assuming no deodourizing units, are presented for comparison only. The predicted unmitigated cumulative odour levels at the selected ASRs are summarized in **Table 3.10**. The

*The followings are directly extracted from the Section 8.5 and Appendix 3.4 of the "**Outlying Islands Sewerage Stage 2 - Upgrading of Cheung Chau Sewage Collection, Treatment and Disposal Facilities (EIA-219/ 2013)**"*

Room 1 - Preliminary Treatment Unit

Source ID				Total Surface Area (m^2)	Emission rates (ou/m^2/s))	Emission rates(ou/s)	Total original emission (ou/s)	99% removal efficiency (ou/s)	No. of emission points	Emission rate for each emission points (without Deodorzation unit)	Emission rate for each emission points (with Deodorzation unit)
S1	Inlet Works										
	L(m)	=	8.1								
	W(m)	=	2.4								
	No. of units	=	1 (+1 standy)								
				19.4	8.79	170.8776					
S2	Coarse Screen										
	L(m)	=	4								
	W(m)	=	3.65								
	No. of units	=	1 (+1 standy)								
				14.6	8.79	128.3340					
S3	Distribution Tank										
	L(m)	=	14								
	W(m)	=	8								
	No. of units	=	1								
				112.0	8.79	984.4800					
S4	Fine Screen and Grit Chambers										
	L(m)	=	11.45								
	W(m)	=	8.33								
	No. of units	=	1								
				95.4	8.79	838.3770					
S5	Storm Tank										
	L(m)	=	20								
	W(m)	=	10								
	No. of units	=	1 (+1 standy)								
				200.0	8.79	1758.0000	5047.3261	50.473261	5	1009.465223	10.09465223
S6	Flow Distribution Tank										
	L(m)	=	6.26								
	W(m)	=	2.5								
	No. of units	=	1								
				15.7	8.79	137.5635					
S7	1-2mm Fine Screen Channel										
	L(m)	=	6.26								
	W(m)	=	6.88								
	No. of units	=	1								
				43.1	8.79	378.5748					
S8	Wet Well Before MBR Tank										
	L(m)	=	6.26								
	W(m)	=	2.5								
	No. of units	=	1								
				15.7	8.79	137.5635					
S9	Pump House										
	L(m)	=	6.15								
	W(m)	=	9.5								
	No. of units	=	1 (+1 standy)								
				58.4	8.79	513.5558					

*The followings are directly extracted from the Section 8.5 and Appendix 3.4 of the "**Outlying Islands Sewerage Stage 2 - Upgrading of Cheung Chau Sewage Collection, Treatment and Disposal Facilities (EIA-219/ 2013)**"*

Room 2 - Treatment Unit

Source ID			Total Surface Area (m^2)	Emission rates (ou/m^2/s))	Emission rates(ou/s)	Total original emission (ou/s)	99% removal efficiency (ou/s)	No. of emission points	Emission rate for each emission points (without Deodorzation unit)	Emission rate for each emission points (with Deodorzation unit)
S1	Anoxic Tank									
	L(m)	=	8.56							
	W(m)	=	4.25							
	No. of units	=	6 (+2 standy)							
			218..	8.79	1918.6812					
S2	Aerobic MBR Tank									
	L(m)	=	12.24			1953.2376	19.532376	6	325.5395989	3.255395989
	W(m)	=	4.25							
	No. of units	=	6 (+2 standy)							
			312..	0.11	34.5564					
	V(ACPH)	=	15		from engineer)					
	Total emission area (m^2)	=	12.8		from engineer)					
	Exhaust exit velocity Velocit	=	2.5		from engineer)					

Room 3 - Sludge Treatment Unit

Source ID			Total Surface Area (m^2)	Emission rates (ou/m^2/s))	Emission rates(ou/s)	Total original emission (ou/s)	99% removal efficiency (ou/s)	No. of emission points	Emission rate for each emission points (without Deodorzation unit)	Emission rate for each emission points (with Deodorzation unit)
S1	Sludge Holding Tank (Pre-thickener)									
	Diameter(m)	=	6.2							
	No. of units	=	2 (+1 standy)							
	Area (m^2)	=	60.381411	60..	26.4	1595.2769				
S2	Sludge Digester									
	L(m)	=	6.1							
	W(m)	=	6.1							
	No. of units	=	4 (+1 standy)							
	Area (m^2)	=	148.84	148..	26.4	3932.3528				
S3	Sludge Holding Tank (Post-digester)									
	Diameter(m)	=	4.5							
	No. of units	=	2 (+1 standy)			7239.8736	72.398736	2	3619.936781	36.19936781
	Area (m^2)	=	31.808626	31..	26.4	840.3839				
S4	Sludge Dewatering House									
	L(m)	=	5.5							
	W(m)	=	2							
	No. of units	=	3							
	Area (m^2)	=	33	33..	26.4	871.8600				
	V(ACPH)	=	15		(from engineer)					
	Total emission area (m^2)	=	3.5		(from engineer)					
	Exhaust exit velocity Velocit	=	2.5		(from engineer)					

Annex 2

(Odour Emission Strength and Calculated Odour Emission Rate of this Project)

Annex 2-1 Calculation of Odour Emission Factors

Source *			Total Surface Area, m2	Emission Rate, OU/m^2/s **	Emission Rate, OU/s	Total Emission (Unmitigated), OU/s	Removal efficiency, %	Total Emission (Mitigated), OU/s
			A	B	C = A x B	D	E	E)
Preliminary Treatment Unit								
S1	Inlet Chamber							
	L(m)	2						
	W(m)	2						
	No. of Units	1	4	8.79	35.16	2259.03	99.5%	11.30
S2	Equalization Tank cum Wet Well (compartment 1)							
	L(m)	4.5						
	W(m)	4						
	No. of Units	1	18	8.79	158.22			
S3	Equalization Tank (compartment 2)							
	L(m)	15						
	W(m)	15						
	No. of Units	1	225	8.79	1977.75			
S4	Pre-membrane Fine Screen and Screenings Handling							
	L(m)	5						
	W(m)	2						
	No. of Units	1	10	8.79	87.90			
MBR Treatment Unit								
S5	MBR - Anoxic Tank							
	L(m)	2.5						
	W(m)	2						
	No. of Units	1	5	8.79	43.95	45.71	99.5%	0.23
S6	MBR - Aerobic / Membrane Tank							
	L(m)	4						
	W(m)	2						
	No. of Units	2	16	0.11	1.76			
Sludge Treatment Unit								
S7	Sludge Holding/ RO Concentration Tank							
	L(m)	5						
	W(m)	4						
	No. of Units	1	20	26.4	528.00	528.00	99.5%	2.64

Remark:

* The above nos. and dimensions of treatment units are based on similar plant provided by the Engineer, which is considered adequate for the proposed interim sewage treatment. The exact no. and dimensions of equipment to be used are subject to detailed design.

** The above odour emission strength is based on measured odour level from operative MBR facility in Hong Kong by DSD in approved EIA projects, which is considered equivalent to this Project which is also a MBR system. Approved EIA report namely, "Outlying Islands Sewerage Stage 2 - Upgrading of Cheung Chau Sewage Collection, Treatment and Disposal Facilities (EIA-219/ 2013)", Appendix 3.4.

Annex 2-2 Modeling Input of Odour Emision Source

ID	Description	X-coordinate	Y-coordinate	Ground mPD	Emission Rate (unmitigated) *	Emission Rate (Mitigated) *	Emission Height (m)	Temp. (K)	Exit Velocity (m/s)	Diameter
S1 to S4	Preliminary Treatment Unit	823475.7	837799.9	5.5	2259.03	11.30	3	303.15	2.5	1.75
S5 to S6	MBR Treatment Unit	823475.7	837799.9	5.5	45.71	0.23	3	303.15	2.5	1.75
S7	Sludge Treatment Unit	823475.7	837799.9	5.5	528.00	2.64	3	303.15	2.5	1.75

Remark:

* Based on calculated emission rate presented in table Annex 2-1.

The above information is based on the Engineer, and is subject to detailed design.