

Appendix 3.7

Calculations of Industrial Emission Rates

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Emission Inventory for Gaseous Pollutant

Source	Source	Type	X	Y	Exit Temperature	Exit velocity	Internal diameter	Stack Height / Release Height	Emission Rate		
									NO _x	SO ₂	RSP
	ID		(m)	(m)	(K)	(m/s)	(m)	(m)	(g/s)	(g/s)	(g/s)
Existing Chimneys	1	POINT	831090	840480	373	10	0.380	52.4	8.933E-02	3.171E-01	8.933E-03
	3	POINT	831180	840480	373	10	0.202	23.0	2.133E-02	7.573E-02	2.133E-03
	4	POINT	831180	840480	373	10	0.202	23.0	3.133E-02	1.112E-01	3.133E-03
	5	POINT	831290	840490	373	10	0.300	17.0	2.133E-02	7.573E-02	2.133E-03
	6	POINT	831370	840490	373	10	0.200	18.0	1.933E-02	6.863E-02	1.933E-03
	8	POINT	832150	840110	673	10	0.280	13.0	2.333E-02	8.283E-02	2.333E-03
	9	POINT	832580	839390	673	10	0.330	21.3	8.133E-02	2.887E-01	8.133E-03
	10	POINT	832670	839880	373	10	0.200	25.0	3.133E-02	1.112E-01	3.133E-03
	11	POINT	833060	839730	477	10	0.280	13.4	5.533E-02	1.964E-01	5.533E-03
	14	POINT	833470	842200	438	10	0.400	7.7	1.733E-02	6.153E-02	1.733E-03
	19	POINT	834800	842780	373	10	0.650	22.0	5.453E-01	1.936E+00	5.453E-02
	22	POINT	834890	842690	478	10	0.540	20.4	3.073E-01	1.091E+00	3.073E-02
	25	POINT	834756	841214	373	10	0.500	10.0	1.333E-01	4.733E-01	1.333E-02
	26	POINT	834122	840743	373	10	0.500	10.0	1.333E-01	4.733E-01	1.333E-02
Wo Hop Shek Crematorium ^[1]	WHS1	POINT	833261	837920	373	10	0.310	30.7	2.100E-01	0.000E+00	2.200E-03
	WHS2	POINT	833262	837922	373	10	0.310	30.7	2.100E-01	0.000E+00	2.200E-03
	WHS3	POINT	833263	837924	373	10	0.310	30.7	2.100E-01	0.000E+00	2.200E-03
	WHS4	POINT	833263	837923	373	10	0.310	30.7	2.100E-01	0.000E+00	2.200E-03
	WHS5	POINT	833263	837921	373	10	0.310	30.7	2.100E-01	0.000E+00	2.200E-03
	WHS6	POINT	833266	837927	373	17.8	0.140	25.7	7.500E-03	0.000E+00	8.056E-03
	WHS7	POINT	833268	837927	373	10	0.310	25.7	2.100E-01	0.000E+00	2.200E-03
	WHS8	POINT	833268	837926	373	10	0.310	25.7	2.100E-01	0.000E+00	2.200E-03
	WHS9	POINT	833268	837924	373	10	0.310	25.7	2.100E-01	0.000E+00	2.200E-03
Northern District Hospital ^[2]	NDH1	POINT	830849	839680	506	6	0.500	64.3	5.808E-02	4.309E-06	1.214E-05
	NDH2	POINT	830850	839680	506	6	0.500	64.3	5.808E-02	4.309E-06	1.214E-05
Proposed Hospital in KTN B2-2 ^[3]	KTN1	POINT	827780	840600	506	6	0.500	64.3	8.228E-02	6.105E-06	1.720E-05
	KTN2	POINT	827781	840600	506	6	0.500	64.3	8.228E-02	6.105E-06	1.720E-05
Shek Wu Hui Sewage Treatment Works Expansion ^[4]	CHP	POINT	830322	841504	373	6	0.779	7	6.157E-02	0.000E+00	8.629E-02
	BGB	POINT	830296	841490	1088	6	1.363	10	1.070E-03	7.732E-03	0.000E+00

Note:

[1] Referenced from the specified process (SP) license registered in March 2011 (No. A0700)

[2] Accounted for the potential growth of nos. of beds (as twice as that in Yr2009 at the Northern District Hospital)

[3] In accordance with the assumption of "2.5 staff per bed" stated in the TR8, the nos. of beds in the proposed Hospital in KTN will be at least 860.

According to the implementation programme, the intake year for this proposed hospital is Yr 2029.

[4] The exit temperature of biogas burner (flare) and boiler are referenced to approved EIA *Development of a Biodiesel Plant at Tseung Kwan O Industrial Estate* (AEIAR-131/2009).

The exit temperature of CHP is assumed the same as the boiler due to their similar nature.

Calculations of Emission Factor for Existing Chimneys

Fuel Oil Combustion

Emission factor based on Section 1.3 of AP-42, USEPA

NO _x Emission Factor =	20 lb / 10 ³ gal [ref. AP-42 Table 1.3-1] 2.4 kg / 10 ³ L [multiplied by 0.12 to convert from lb / 10 ³ gal to kg / 10 ³ L]
SO ₂ Emission Factor =	142S lb / 10 ³ gal [ref. AP-42 Table 1.3-1] 71 lb / 10 ³ gal [S is Weight % of Sulfur content in Oil; Maximum sulphur content is 0.5%] 8.52 kg / 10 ³ L [multiplied by 0.12 to convert from lb / 10 ³ gal to kg / 10 ³ L]
RSP Emission Factor =	2 lb / 10 ³ gal [ref. AP-42 Table 1.3-1] 0.24 kg / 10 ³ L [multiplied by 0.12 to convert from lb / 10 ³ gal to kg / 10 ³ L]

Summary of Emission Rates

Chimney ID	Fuel usage	NO _x	SO ₂	RSP
	L/hr	g/s	g/s	g/s
1	134	0.089	0.317	0.009
3	32	0.021	0.076	0.002
4	47	0.031	0.111	0.003
5	32	0.021	0.076	0.002
6	29	0.019	0.069	0.002
8	35	0.023	0.083	0.002
9	122	0.081	0.289	0.008
10	47	0.031	0.111	0.003
11	83	0.055	0.196	0.006
14	26	0.017	0.062	0.002
19	818	0.545	1.936	0.055
22	461	0.307	1.091	0.031
25	200	0.133	0.473	0.013
26	200	0.133	0.473	0.013

Calculations of Emission Factor for North District Hospital

Towngas Combustion

Emission factor based on Section 1.4 of AP-42, USEPA

NO _x Emission Factor =	220 mg / kWh	[ref. (AEIAR 142/2009) Provision of a Poultry Slaughtering Centre in Sheung Shui]
Towngas Consumption =	1,247,742 m ³ per year 0.040 m ³ per second	[provided by Hospital Authority, 2009]
Towngas Consumption =	1,247,742 unit 6,837 MJ per hour 1,901 kWh per hour 1 kWh per second	[provided by Hospital Authority, 2009] [1 unit = 48 MJ] [1 MJ = 0.278 kWh]

Fuel Oil Combustion

Emission factor based on Section 1.3 of AP-42, USEPA

SO ₂ Emission Factor =	142S lb / 10 ³ gal 0.71 lb / 10 ³ gal 0.0852 kg / 10 ³ L	[ref. AP-42 Table 1.3-1] [S is Weight % of Sulfur content in Oil; Maximum sulphur content of ultra low sulfur diesel (ULSD) is 0.005%] [multiplied by 0.12 to convert from lb / 10 ³ gal to kg / 10 ³ L]
RSP Emission Factor =	2 lb / 10 ³ gal 0.24 kg / 10 ³ L	[ref. AP-42 Table 1.3-1] [multiplied by 0.12 to convert from lb / 10 ³ gal to kg / 10 ³ L]
Fuel Oil Consumption =	3190 L per year 0.0001 L per second	[provided by Hospital Authority, 2009]

Total Emission Rate

Nos. of Bed:	607	[ref. Hospital Authority Statistical Report, 2009-2010]
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Adopted Emission Rate for Each Stack (two stacks):

NO _x Emission :	5.81E-02 g / s
SO ₂ Emission :	4.31E-06 g / s
RSP Emission :	1.21E-05 g / s

Calculations of Emission Factor for the Proposed Hospital in KTN B2-2

In accordance with the assumption of "2.5 staff per bed" stated in the TR8,
the nos. of beds in the proposed Hospital in KTN will be at least: 860 beds

Adopted Emission Rate for Each Stack (assuming two stacks with reference to the North District Hospital):

NO _x Emission :	8.23E-02 g / s
SO ₂ Emission :	6.11E-06 g / s
RSP Emission :	1.72E-05 g / s

Projection of Biogas Consumption at Full Capacity of the Shek Wu Hui Sewage Treatment Works Expansion

According to the Outline Design Report of SWHSTW Further Expansion - Phase 1 and 2 (Final)(July 2012), the design criteria of daily biogas production is 12712 m³/day at sewage flow 170000m³/day.

The latest design of SWHSTW Expansion is with sewage flow 190000m³/day.
Assume the biogas production is directly proportional to the sewage treated,
the projected biogas production

$$\begin{aligned} &= 12712 \times (190000/170000) \\ &= 14207.53 \text{ m}^3/\text{day} \\ &= 591.98 \text{ m}^3/\text{hr} \end{aligned}$$

Based on the biogas usage data (From Aug 2011 to Dec 2012) from DSD,

The biogas production (From Aug 2011 to Dec 2012)	=	2139116 m ³
Biogas used for combined heat and power generator (CHP) (From Aug 2011 to Dec 2012)	=	1892230 m ³
Biogas used for hot boiler (From Aug 2011 to Dec 2012)	=	63746 m ³
Biogas used for biogas burner (BGB) (From Aug 2011 to Dec 2012)	=	183140 m ³

Percentage of biogas used for CHP	=	88.46 %
Percentage of biogas used for hot boiler	=	2.98 %
Percentage of biogas used for biogas burner	=	8.56 %

Assume the percentages of biogas used in different devices of the SWHSTW Expansion are the same as the existing SWHSTW
Since there are only CHP and biogas burner in the SWHSTW Expansion layout plan, the biogas used for hot boiler will be assumed to be used by CHP.

Therefore, the biogas usage of different devices in SWHSTW Expansion:

$$\begin{aligned} \text{Biogas used for CHP in SHWSTW Expansion:} &= 591.98 \times (88.46+2.98)/100 \\ &= 541.307 \text{ m}^3/\text{hr} \end{aligned}$$

$$\begin{aligned} \text{Biogas used for biogas burner in SHWSTW Expansion:} &= 591.98 \times 8.56/100 \\ &= 50.674 \text{ m}^3/\text{hr} \end{aligned}$$

Detailed Calculation of NO₂, RSP and SO₂ Emission from CHP and Biogas burner at SWHSTW Expansion

Estimated biogas used in the CHP	=	541.307	m ³ /hr
Estimated biogas to be flared in biogas burner	=	50.674	m ³ /hr

NO_x Emission

By considering the similar chemical content of landfill gas and biogas generated from sewage treatment works, and their emission control devices, the emission factor of Table 4.4 of USEPA Air Emission from Municipal Solid Waste Landfills - Background Information for Proposed Standards and Guidelines, March 1991 (EPA-450/3-90-011a) are adopted for biogas

Secondary NO _x emission from gas turbine (CHP)	=	26.4	lb/MM scf LFG
Secondary NO _x emission from enclosed flare (Biogas burner)	=	4.9	lb/MM scf LFG

Unit Conservation:	=	1	MM scf
	=	1000000	scf
	=	28316.847	scm
* scf = Standard Cubic Foot; scm = Standard Cubic Meter			
	=	1	lb/MM scf
	=	453.600	g/MM scf
	=	0.016	g/scm

Therefore,

Secondary NO _x emission from gas turbine (CHP)	=	26.4	lb/MM scf LFG
	=	0.423	g/scm

Secondary NO _x emission from enclosed flare/incinerator (Flare System)	=	4.9	lb/MM scf LFG
	=	0.078	g/scm

Standard Conditions (US standard):	=	60	F ⁰
	=	15.6	C ⁰
	=	288.6	K

Assume Biogas at typical ambient temperature:	=	25	C ⁰
	=	298	K

By Ideal gas law, V1/V2 = T1/T2.	=	1	m ³ at 25 °C
	=	0.968	scm

Estimated Biogas used in gas turbine (CHP) at Proposed SWHSTW Expansion	=	541.307	m ³ /hr
	=	524.151	scm/hr
	=	0.146	scm/s
NO _x Emission Rate	=	0.062	g/s

Estimated Biogas used in biogas burner (BGB) at Proposed SWHSTW Expansion	=	50.674	m ³ /hr
	=	49.068	scm/hr
	=	0.014	scm/s
NO _x Emission Rate	=	0.001	g/s

RSP Emission

Similarly, with reference to Table 4.4 of USEPA Air Emission from Municipal Solid Waste Landfills - Background Information for Proposed Standards and Guideline. March 1991 (EPA-450/3-90-011a):

Secondary PM(RSP) emission from gas turbine (CHP)	=	37.0	lb/MM scf LFG
	=	0.593	g/scm
Secondary PM(RSP) emission from enclosed flare (Biogas burner)	=	Negligible	lb/MM scf LFG

Estimated Biogas used in gas turbine (CHP) at Proposed SWHSTW Expansion	=	541.307	m ³ /hr
	=	524.151	scm/hr
	=	0.146	scm/s
RSP Emission Rate	=	0.086	g/s

Estimated Biogas used in biogas burner (BGB) at Proposed SWHSTW Expansion	=		
RSP Emission Rate	=	Negligible	g/s

SO₂ Emission

Assume of the sulphur in the biogas is converted to SO₂ in the emission. According to DSD, the typical concentration of H₂S in biogas is 210 ppm.

H ₂ S concentration in biogas	=	210	ppm
Molecular weight (MW) of H ₂ S	=	34	
Molecular volume of air	=	22.414	L/mol
Concentration of H ₂ S in biogas at 25°C	=	210 ppm X MW / (22.414 x 298/273)/1000)	
	=	0.292	g/m ³
Molecular ratio of H ₂ S to SO ₂ (2 H ₂ S + 3 O ₂ → 2 SO ₂ + 2 H ₂ O)	=	1:1	
Molecular weight of SO ₂	=	64	
Mass of SO ₂ in emission	=	0.549	g/m ³

According to the Outline Design Report of SWHSTW Further Expansion - Phase 1 and 2 (Final)(July 2012), the biogas will be desulphurized before being utilized by CHP, therefore

Estimated Biogas used in gas turbine (CHP) at Proposed SWHSTW Expansion	=		
SO ₂ Emission Rate	=	Negligible	g/s

Estimated Biogas used in biogas burner (BGB) at Proposed SWHSTW Expansion	=	50.7	m ³ /hr
SO ₂ Emission Rate	=	0.008	g/s



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BY FAX

Quality Effective Health Care

North District Hospital, 9 Po Kin Road, Sheung Shui, NT

[Tel. No. : 2683 7893; Fax No. : 2683 8383]

Our Ref. : ADM/E8.1

1 September 2010

ARUP

[Attn. Mr. Davis LEE] (Fax: 2683 8383)
(Total 6 pages)

Dear Mr. LEE,

Request for Fuel Consumption Data of NDH

I refer to your letter dated 23 August 2010 regarding the captioned and would like to append the information below:

- Location and height of chimney
Please refer to annex 1 & 2; and
Height of chimney is around 64.25 metres.
- Types and quantity of fuel used
1,247,742 unit of town gas and 3,190 litres of ultra low sulphur diesel oil were used for boilers and emergency generators in FY 09/10
- Temporal profile of the emission
Please refer to annex 5, 6 and 7.

ARUP				
Reply Ref.:	25278	File No. 3.99, 8.99		
Action Required:	By Date			
Received - 1 SEP 2010 16/14				
Initis.	DL	SC	CMNL	LFM
Action	/	/	/	/
Info.	/	/	/	/
Copy	/	/	/	/

Yours sincerely,

(Edwin LO)

for General Manager (Admin. Services)
North District Hospital

cc CEDD [Attn. Mr. Joseph LO] (Fax: 2693 2918)

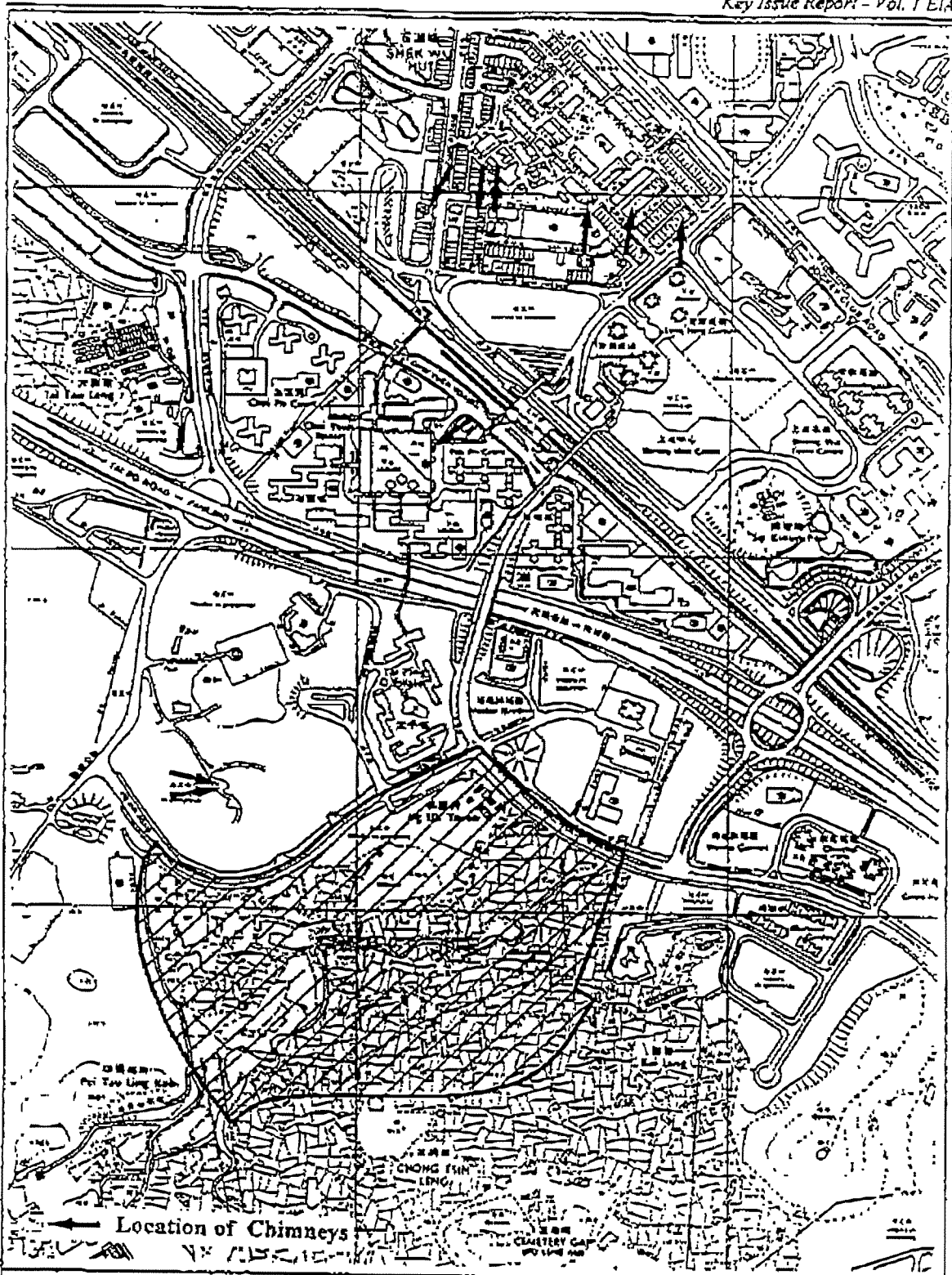
PlanD [Attn. Ms. April KUN] (Fax: 2522 8524)



醫院管理局
HOSPITAL
AUTHORITY

Annex 1

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Formation and Servicing in Area 36, Fanling
Key Issue Report - Vol. 1 EIA

TITLE : Location of the Identified Chimneys in the vicinity of Area 36

PROJECT : Formation and Servicing in Area 36, Fanling
Key Issue Report -Vol. 1 EIA

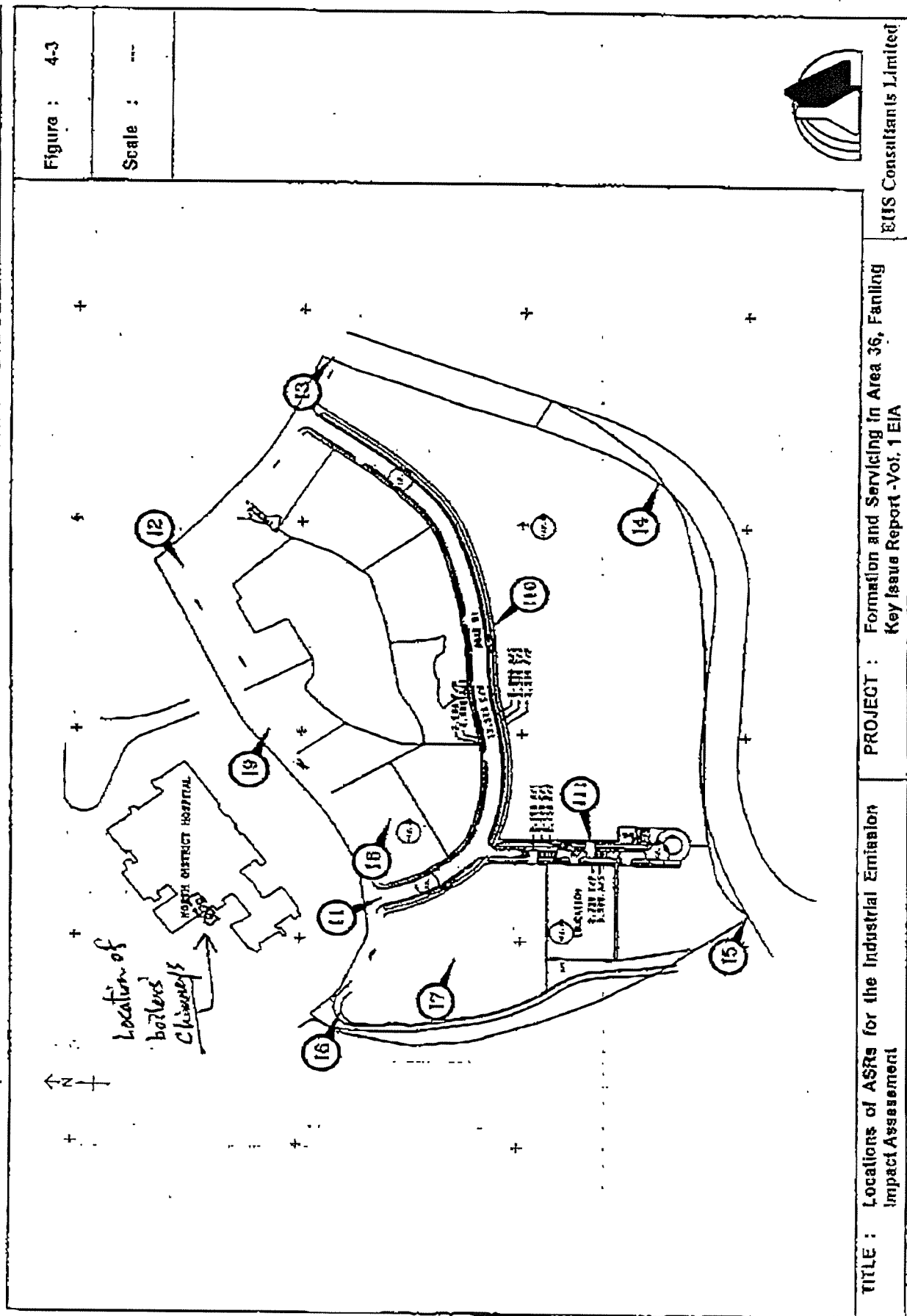
Figure : 4-2

Scale :



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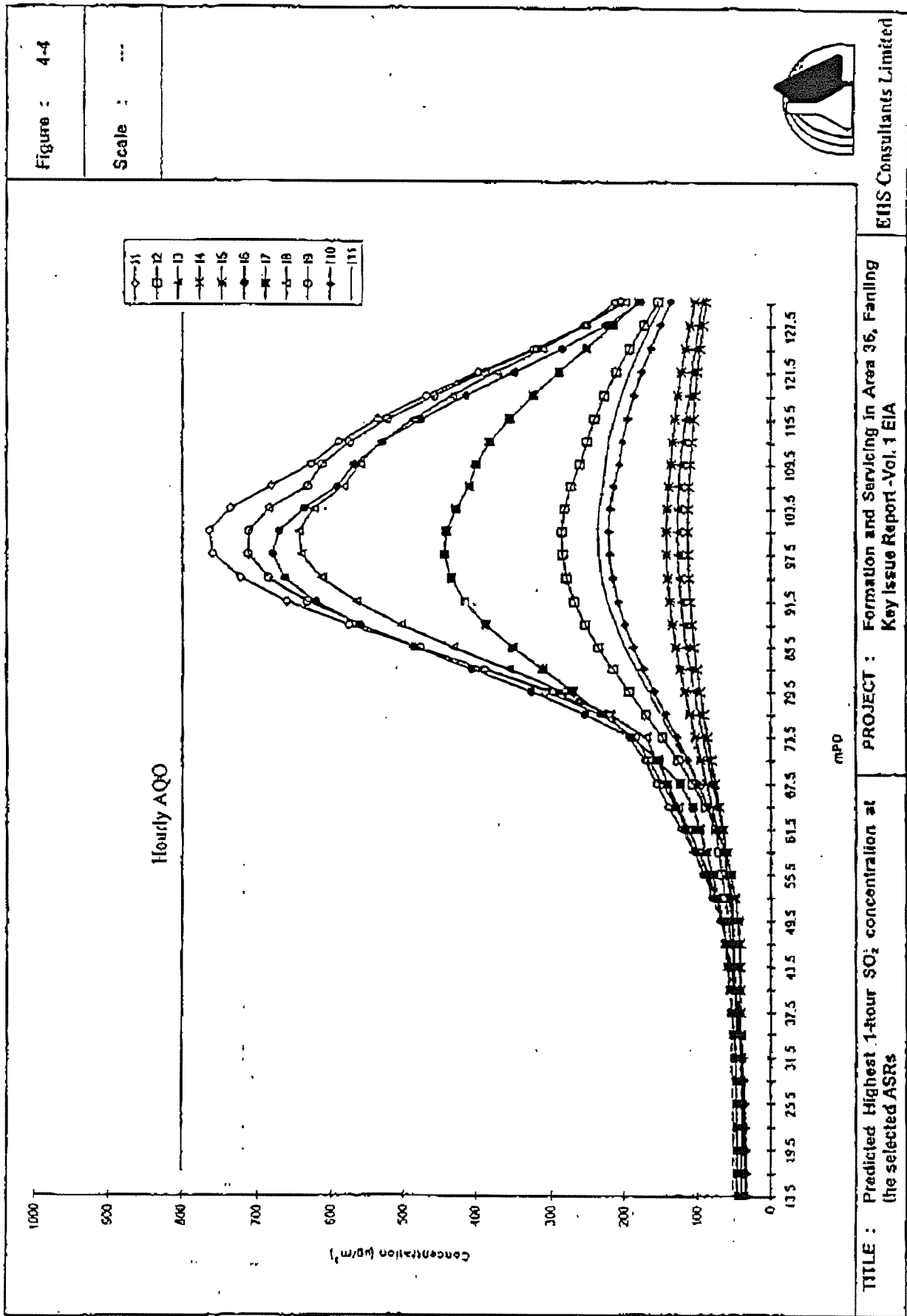
Annex 2



Annex 5

Formation and Servicing in Area 36, Fanning
Key Issue Report - Vol. 1 EIA

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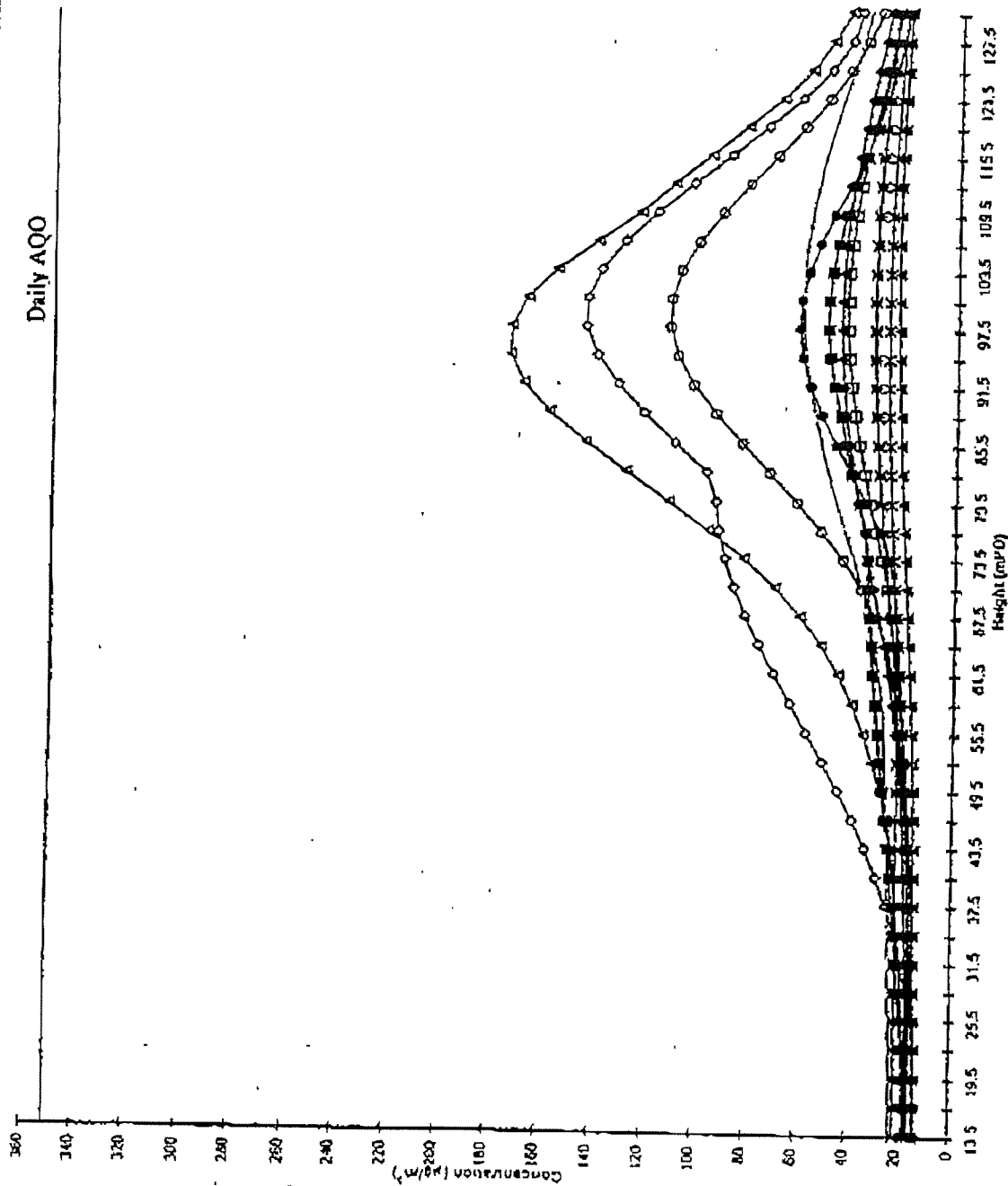
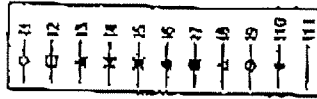
Annex

... and Servicing in Area 36, Fanning
Key Issue Report - Vol. 1 EIA

Daily AQO

Figure : 4-5

Scale : ---



TITLE : Predicted Daily Average SO_2 concentration at the selected ASRs

PROJECT : Formation and Servicing in Area 36, Fanning
Key Issue Report -Vol. 1 EIA

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