Tugs - movements in NYMTTS

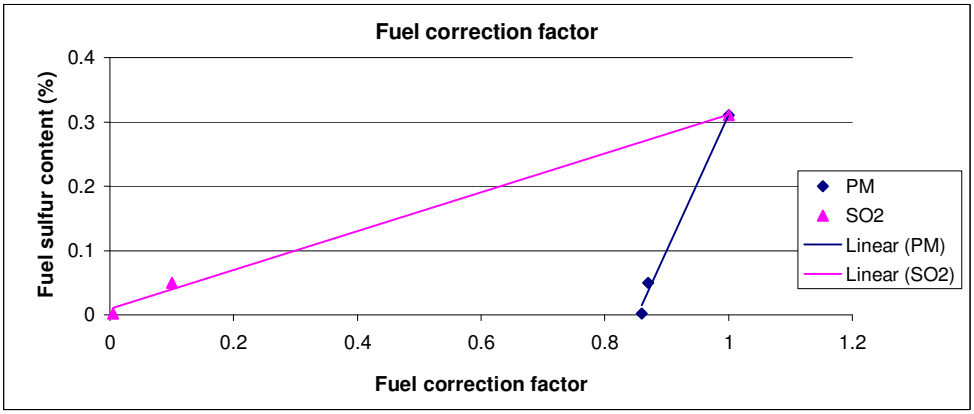
	Unit	Ref		
Vessel Information				
Vessel Type			Tug	(Harbour Craft)
Gross Register Tonnage	**tonnes**	(v)	**218.3**	
Length	**m**	(v)	**28.2**	
Width	**m**	(v)	**8.2**	
Draft	**m**	(v)	**3.0**	
Average Cruising Speed	**knot**	(a)	**8.0**	
Cruise time	**hours**		0.08	*Total distance travelled / Speed*
Engine Information				
Name			Various - Cummins	
Number of engines		(w)	**2**	
Engine capacity	**kW**	(w)	**696**	
Cylinder displacement (total for 12 cylinders)	**l**	(w)	**37.7**	
Load Factor	**Ratio**	(ad)	**0.31**	

Engine type assumed to be Category 1, <3.5 l/cyclinder displacement, Tier 1

Fuel Information				
Fuel consumption	**l/hr**	(w)	**188.4**	
Fuel consumption	**g/kWh**		225.3	*Diesel density(g/l) * Fuel consumption(l/hr) / Engine Capacity(kW)*
Diesel density	**g/l**		**832.0**	
Diesel sulfur content	**ppm**	(ac)	**5000**	

Harbour craft fuel correction factor from offroad diesel fuel (aa)

Fuel	NOx	VOC	CO	SO2	PM	CO2	S %	*Ref for S%*
Diesel, offroad	1	1	1	1	1	1	0.31	(ao)
Diesel, onroad	1	1	1	0.1	0.87	1	0.05	(ap)
Diesel, ultra low sulfur	1	1	1	0.005	0.86	1	0.0015	(ap)
Biodiesel	1.17	0.5	0.65	1	0.68	0.96		
HK light diesel oil				1.63	1.09		0.5	(ac)



Tugs - movements in NYMTTS

Emissions Information					
Emission Factor (Main Engine) - Assume full load	**NOx**	**g/kWh**	(w)	**8.55**	
	PM10	**g/kWh**	(q)	**0.33**	*0.3 (from table 3-5) * 1.09 (Fuel correction factor for PM as above)*
	SO2	**g/kWh**	(ab)	2.25	*Sulfur content (%) * Fuel consumption (g/kWh) * 2 (SO_2:S conversion factor)*
Total Emissions (Manoeurving / Hotelling) (per hour)	**NOx**	**g/s**		1.02	*emission factor (g/kWh) * load factor * engine capacity (kW) * number of engines / 3600 (s/h)*
	PM10	**g/s**		0.04	
	SO2	**g/s**		0.27	
Exhaust Gas Flow (one engine)		**m³/s**	(w)	**2.3**	
Exhaust Gas Temp (Turbine out)		**°C**	(v)	**421.7**	

Route coordinates			**Length**
	833703.93	818666.12	
	834090.28	818434.66	450.38
	834223.51	818447.52	133.84
	834396.70	818666.12	278.89
	834405.58	819039.02	373.01
Total area			37083.71

		Emissions (g/m².s)			
24 hour emissions		NOx	PM10	SO2	
TIME	VESSELS	EMISSION			
0	0	0	0	0	
1	0	0	0	0	*= number of vessels x total emission per vessel x cruise time / total area*
2	0	0	0	0	
3	0	0	0	0	
4	0	0	0	0	
5	0	0	0	0	
6	0	0	0	0	
7	9	2.14E-05	8.18E-07	5.64E-06	
8	9	2.14E-05	8.18E-07	5.64E-06	
9	9	2.14E-05	8.18E-07	5.64E-06	
10	9	2.14E-05	8.18E-07	5.64E-06	
11	9	2.14E-05	8.18E-07	5.64E-06	
12	9	2.14E-05	8.18E-07	5.64E-06	
13	9	2.14E-05	8.18E-07	5.64E-06	
14	9	2.14E-05	8.18E-07	5.64E-06	
15	9	2.14E-05	8.18E-07	5.64E-06	
16	9	2.14E-05	8.18E-07	5.64E-06	
17	9	2.14E-05	8.18E-07	5.64E-06	
18	9	2.14E-05	8.18E-07	5.64E-06	
19	9	2.14E-05	0.0	5.64E-06	
20	9	2.14E-05	8.18E-07	5.64E-06	
21	0	0	0	0	
22	0	0	0	0	
23	0	0	0	0	

Derrick Lighter Barges - NYMTTS

	Unit	Ref		
Vessel Information and Shelter Information				
Vessel Type			Derrick Lighter Barge	(Harbour Craft)
Max length of barge	**m**	(i)	**50**	
Beam	**m**	(j)	**22**	
Draft	**m**	(j)	**5.5**	
Gross Tonnage	**tonnes**	(j)	**1817**	
Length of NYPCWA	**m**		**1240**	*Approximate measurement from plan*
Max number of barges			**20**	*NYPCWA shoreline length / (Barge length + Manuerving length (10m))*
Activity	**hours**		**14**	*Based on NYPCWA operating hours of 0700 - 2100*
	time-in-mode (operation time)		0.25	*Observational dat. Approximately: rigging 10 minutes, usage 5 minutes, unloading 5 minutes*
Lifting Capacity	**tonnes**	(j)	**250**	
Engine Information				
Main Diesel Electric Generator	**kW**	(g)	**314.6**	*average from 250t crane information*
Load	**%**	(u)	**50%**	*Based on the maximum theoretical load of 43% for gantry cranes a similar loading is used. 50% is considered to be conservative based on the reference provided*

Derrick Lighter Barges - NYMTTS

Emissions Information

Emission Factor

			(aah)		*Assume 10,000 hours operating life if operation is 0.25 time-in-mode, 14 hours per day, 6 days perweek then the maximum engine age is assumed to be 10,000 / (0.25 x 14 x 6) ~ 10 years. A conservative assumption that the average fleet age is 10 years has been made*
	NOx	**g/kWh**	(aai)	6.40	
	PM10	**g/kWh**	(aah)	0.20	
	SOx	**g/kWh**	(h)	1.25	*Assume SOx=SO2*
Emissions					
	NOx	**g**	(c)	3523	*Engine capacity(kW) * Load Factor * Emission Rate(g/kWh) * Activity(hour) * Time-in-mode*
	PM10	**g**	(c)	110	
	SO2	**g**	(c)	686	
Total Emissions (per barge)	**NOx**	**g/s**		0.0699	
	PM10	**g/s**		0.0022	
	SO2	**g/s**		0.0136	
Exhaust Temp		**K**		811.28	
		°C		538.1	*Average based on engine spec sheets*
Volumetric Flowrate		**m³/s**		0.9752	*Based on proportional size of exhaust volume for 314.6kW engines (see graph below)*
Effective efflux velocity (to account for horizontal plume)		**m/s**	(y)	**0.001**	
Exhaust Height				8.7	*Based on visual survey (approximately the height of 3 shipping containers)*
Effective stack diameter		**m**		35.24	*= 2 * SQRT ((Volumetric flowrate / Efflux velocity) / pi)*

Barge Stack Coordinates	
834350.61	818456.45
834379.32	818492.61
834401.41	818533.03
834432.32	818571.31
834461.03	818613.85
834489.75	818658.52
834505.20	818726.58
834505.20	818786.14
834505.20	818847.82
834505.20	818913.76
834507.41	818969.06
834503.00	819017.98
834503.00	819077.54
834505.20	819158.36
834500.79	819220.05
834503.00	819281.73
834503.00	819364.68
834503.00	819437.00
834498.58	819502.94
834505.20	819564.62

Derrick Lighter Barges - NYMTTS

Additional Information for emission calculations

			(aq)	(ar)	(as)	(at)
Reference						
Power		**kW**	**150**	**150**	**150**	**150**
Speed		**RPM**	**1800**	**1500**	**1800**	**1800**
Bore			**0.106**	**0.135**	**0.105**	**0.104**
Stroke			**0.127**	**0.15**	**0.127**	**0.132**
Cylinders			**6**	**6**	**6**	**6**
Total displacement (given)			**0.00679**		**0.0066**	
Stroke			4	4	4	4
Air Intake Volume (given)	**V1**	**m³/s**	**0.208**		**0.215**	
Exhaust Temp	**T2**	**°C**	**566.0**		**625.0**	**560**
Exhaust volume (given)	**V2**	**m³/s**	**0.562**		**0.525**	**0.625**
Outlet size		**m**	**0.0980**	0.0980	0.0980	0.0980

			(au)	(av)	(aw)	(ax)
Reference						
Power		**kW**	**40-50**	**50**	**50**	**50**
Speed		**RPM**	**1500**	**1500**	**1800**	**1800**
Bore			**0.106**	**0.135**	**0.086**	**0.102**
Stroke			**0.127**	**0.15**	**0.105**	**0.120**
Cylinders			**4**	**4**	**4**	**4**
Total displacement (given)			**0.0045**		**0.0024**	
Stroke			4	4	4	4
Air Intake Volume (given)	**V1**	**m³/s**	**0.070**		**0.067**	**0.090**
Exhaust Temp	**T2**	**°C**	**487.0**		**496.0**	**468.9**
Exhaust volume (given)	**V2**	**m³/s**	**0.170**		**0.180**	**0.212**
Outlet size		**m**	**0.0980**	0.0744	**0.0508**	0.0744

Derrick Lighter Barges - NYMTTS

Additional Information for emission calculations

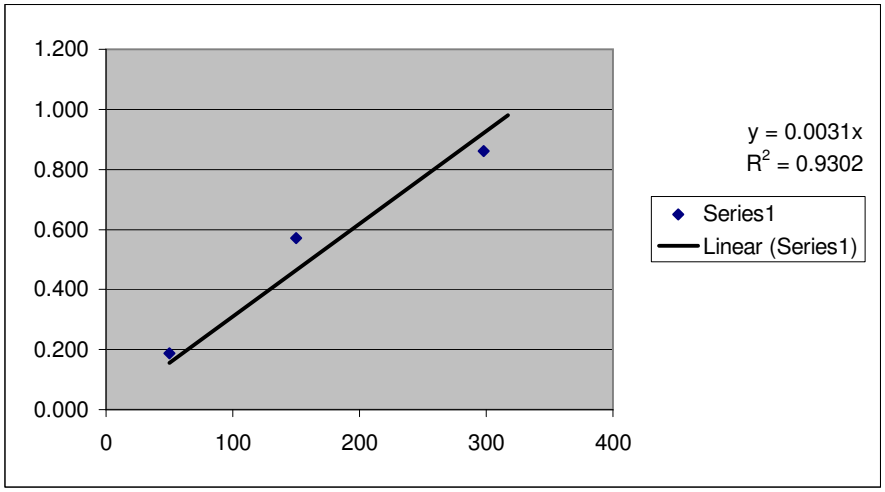
Reference			(aae)	(aad)	(aac)	(aab)
Power			224	247	336	247
Speed			2200	2000	1800	2000
Bore			0.11402	0.122	0.13	0.122
Stroke			0.135	0.15	0.152	0.150
Cylinders			6	6	6	6
Total displacement (given)			0.0083	0.01052	0.0128	0.0105
Stroke			4	4	4	4
Air Intake Volume (given)	**V1**	**m³/s**				
Exhaust Temp	**T2**	**°C**				
Exhaust volume (given)	**V2**	**m³/s**				
Outlet size		**m**				

Reference			(aaa)	(az)	
Power			298	450	
Speed			2100	2100	
Bore			0.125		
Stroke			0.147		
Cylinders			6		
Total displacement (given)					
Stroke			4	4	
Air Intake Volume (given)	**V1**	**m³/s**	0.413		
Exhaust Temp	**T2**	**°C**	564.0		
Exhaust volume (given)	**V2**	**m³/s**	0.862		
Outlet size		**m**			

Derrick Lighter Barges - NYMTTS

Relationship for exhaust volume

Engine size	**kW**	50	150	298
Exhaust volume (given)	**m³/s**	0.187	0.571	0.862



Ocean Passenger Cruise Ship - Ocean Terminal

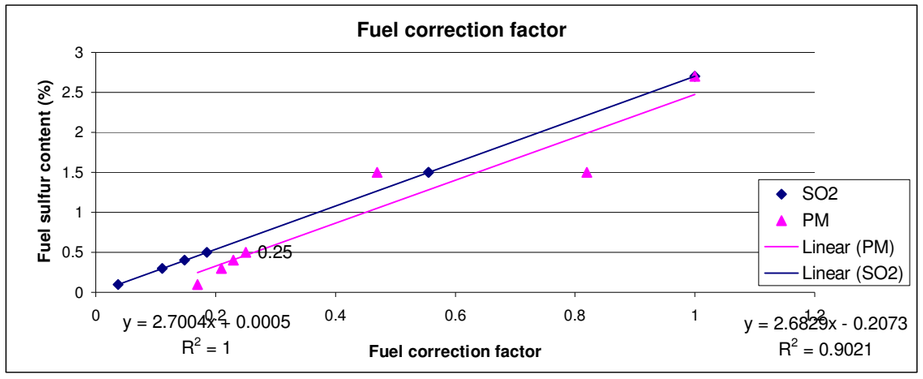
	Unit	Ref			Unit	Ref	
Vessel Information				**Vessel Information**			
Vessel Type			Daytime Ship (40,000 tons) (OGV)				24 hour ship (70,000 tons) (OGV)
Gross Tonnage	**tonnes**	(e)	**40053**		**tonnes**	(t)	**70000**
Length	**m**	(e)	**177.0**		**m**	(t)	**264.3**
Width	**m**	(e)	**29.0**		**m**	(t)	**32.0**
Draft					**m**	(t)	**7.5**
Hotelling Activity	**hours**	(n)	**12** *Regular berth*		**hours**		**24** *Irregular berth*
Fuel Information							
Diesel density	**g/l**		**832.0**				
Diesel sulfur content	**ppm**	(ac)	**28000**				

Weighted Fuel Sulfur Content of Residual Oil, Selected years (ai)

	2010-2020		
	Main Eng	**Aux Eng**	**Aux Boiler**
Cruise	2.11%	1.98%	2.07%

Fuel Correction Factors 2011 puget sound report

Fuel	NOx	VOC	CO	SO2	PM	CO2	S %	*Ref for S%*
HFO	1	1	1	1	1	1	2.7	
HFO	1	1	1	0.555	0.82	1	1.5	
MGO	0.94	1	1	0.185	0.25	1	0.5	
MDO	0.94	1	1	0.555	0.47	1	1.5	(ao)
MGO	0.94	1	1	0.037	0.17	1	0.1	(ap)
MGO	0.94	1	1	0.111	0.21	1	0.3	(ap)
MGO	0.94	1	1	0.148	0.23	1	0.4	
Residual Oil - HK (historic avg)				1.04	1.12		2.8	(ac)
Residual Oil - HK AE (2010-2020)				0.73	0.82		1.98	(ai)
Residual Oil - HK AB (2010-2020)				0.77	0.85		2.07	(ai)



Ocean Passenger Cruise Ship - Ocean Terminal

Vessel Type				Daytime Ship (40,000 tons)	(OGV)			24 hour ship (70,000 tons)	(OGV)
Auxiliary Engine Information						**Main Engine Information (no Aux engine info available)**			
Name			(m)	Wartsila 6R32D			(aj)	Wartsila W12V46	
Number of engines			(m)	4			(aj)	5	
Power		kW		2220			(x)	11700	
Bore		m	(o)	0.32			(x)	0.46	
Stroke		m	(o)	0.35			(x)	0.58	
Piston Displacement	given	l/cylinder	(o)	28.2		given	(x)	96.4	
Piston Displacement	calc	m³/cyl		0.0281		calc		0.0964	
Total cylinders			(o)	6			(x)	12	
Total displacement		m³		0.169				1.157	
Total Power		kW	(o)	8880				58500	
Speed		rpm	(o)	720			(x)	514	
Aux Engine/Main Engine Ratio							(f)	0.16	
Aux Engine Power								9360	
Load Factor (Aux Engines)	Hotel	Ratio	(ae)	0.42		Hotel	(ae)	0.42	
Auxiliary Boiler Information						**Auxiliary Boiler Information**			
Name			(m)	Alfa Laval Mission OS			(aj)	SUNROD CPH-8-2	
Number of engines			(m)	2			(aj)	2	
Total Power		kW	(r)	9200					
Load Factor (Aux Boilers)	Hotel	kW	(ag)	1000		Hotel	kW	(ag)	1000
Emissions Information - 40,000						**Emissions Information - 70,000**			
Emission Factor (Aux Engines) (fuel sulfur content of 2.8%)	**NOx**	g/kWh	(l)	12.07		**NOx**	g/kWh	(l)	12.91
	PM10	g/kWh	(b)	1.61		**PM10**	g/kWh	(b)	1.61
	SO2	g/kWh	(b)	13.43		**SO2**	g/kWh	(b)	13.43
Emissions (Auxiliary Engines)	**NOx**	g	(c)	535098		**NOx**	g	(c)	1206703
	PM10	g	(c)	71552		**PM10**	g	(c)	150840
	SO2	g	(c)	595274		**SO2**	g	(c)	1254901
Emission Factor (Aux Boilers) (fuel sulfur content of 2.7%)	**NOx**	g/kWh	(s)	2.10	*No. 6 residual oil (conservative)*	**NOx**	g/kWh	(s)	2.10 *No. 6 residual oil (conservative)*
	PM10	g/kWh	(s)	0.80		**PM10**	g/kWh	(s)	0.80
	SO2	g/kWh	(s)	16.10		**SO2**	g/kWh	(s)	16.10
Emissions (Auxiliary Boilers)	**NOx**	g	(c)	25200		**NOx**	g	(c)	50400
	PM10	g	(c)	9600		**PM10**	g	(c)	19200
	SO2	g	(c)	193200		**SO2**	g	(c)	386400
	[Emission(boiler) + Emission(Aux Engine)] / Hotelling Time					*[Emission(boiler) + Emission(Aux Engine)] / Hotelling Time*			
Total Emissions (Manoeuvring & Hotelling only)	**NOx**	g/s		12.97		**NOx**	g/s		14.55
	PM10	g/s		1.88		**PM10**	g/s		1.97
	SO2 (from literature)	g/s		18.25		**SO2 (from literature)**	g/s		19.00
	SO2 (adjusted)	g/s		7.6	*Assume the same as the adjusted value for 24 hour ship*	**SO2 (adjusted)**	g/s		7.6 *Adjusted accoding to the calibration result*
Input Air (aux engine)		100% kg/s	(o)	4.6			100%		4.8 *Assume exhaust air is proportionally larger according to engine size*
Exhaust gas flow (aux engine) (one engine)		100% kg/s	(o)	4.7			100% kg/s		5.0 *Assume exhaust air is proportionally larger according to engine size*
		85% kg/s	(o)	4.1			85% kg/s		4.3 *Assume exhaust air is proportionally larger according to engine size*
		75% kg/s	(o)	3.7			75% kg/s		3.9 *Assume exhaust air is proportionally larger according to engine size*
		50% kg/s	(o)	2.7			50% kg/s		2.8 *Assume exhaust air is proportionally larger according to engine size*

Ocean Passenger Cruise Ship - Ocean Terminal

Calibration for SO2 emissions for 24-hour ship based on monitored data

Date of monitoring	16-Feb-12	04-Nov-11	20-Jan-12	03-Mar-12	20-Jan-12	15-Feb-12	
Cruise Ship at Ocean Terminal	Arcadia	Explorer	Costa Classica	Costa Classica	Costa Classica	Azamara Quest	
Hour	22:00:00	21:00:00	02:00:00	02:00:00	03:00:00	08:00:00	
wind direction measured at EPD WKCD met station	101.17	109.29	124.25	109.88	105.52	110.29	
wind speed (m/s)	2.6345	2.1747	3.0181	3.3197	3.2700	2.6875	
PG stability class (from HKO, Kings Park)	6	6	6	6	6	6	
Mixing height (m)	348.7 - 422.3	702.3 - 1252	643.2 - 692	461.1 - 65536	643.2 - 692	273.4 - 362.7	
Temp (℃) (from WKCD)	16.24	27.14	17.83	20.63	17.34	21.07	
Temp (K) (from WKCD)	289.4	300.3	291.0	293.8	290.5	294.2	
SO2 Measured at EPD WKCD monitoring station	37.45	35.75	33.42	32.74	32.00	31.46	
Average background SO2 concentration (Central, Central/Western, Mong Kok, Sham Shui Po)	11.75	15.25	7.25	4.00	6.00	5.25	
Measured value at WKCD due to ship (excluding average background SO2)	25.70	20.50	26.17	28.74	26.00	26.21	
Max modelled concentration at 1200m for notional emission of 16 g/s	61.17	72.55	54.45	50.27	50.86	60.22	
Max modelled concentration at 1300m for notional emission of 16 g/s	57.96	68.89	51.49	47.47	48.04	57.04	
Max modelled concentration at 1400m for notional emission of 16 g/s	54.84	65.30	48.65	44.79	45.34	53.95	
Average modelled conc (µg/m³) (based on notional emission of 16 g/s)	57.99	68.91	51.53	47.51	48.08	57.07	
Average conc based on emission rate of 19 g/s as calcualted from literature)	68.85	81.82	61.18	56.41	57.08	67.76	AVERAGE
Average scaling factor for 19 g/s = 0.40	0.37	0.25	0.43	0.51	0.46	0.39	0.40

70,000 ton ship emissions from literature **19.00 g/s**

The emissions for the 70,000 ton ship are therefore 19.00 x 0.40 = 7.6 g/s

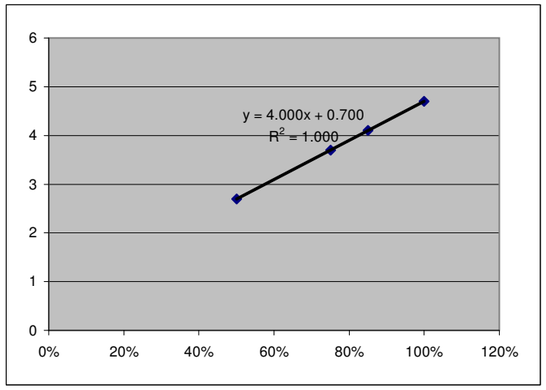
To prevent over-estimation of the SO2 emissions from the ships berthing at the Ocean Terminal, a calibration exercise was performed with reference to the on-site SO2 data recorded at the EPD's WKCD monitoring station (see Section 3.4.1). Historic berthing timetable at the Ocean Terminal during the monitoring period of the WKCD monitoring station (i.e., from Sep 2011 to Aug 2012) was identified. As there are many day-time marine traffic emission sources (e.g., Star Ferries, China ferries, Macau ferries, recreational and cargo vessels) during day-time, the calibration exercise was carried out only for night-tme periods between 9pm and 8am when the 24-hour ship alone is berthed at the Ocean Terminal (the day-time ship is at cruise during night-time) and the emissions from fast ferries and other marine traffic are minimal.

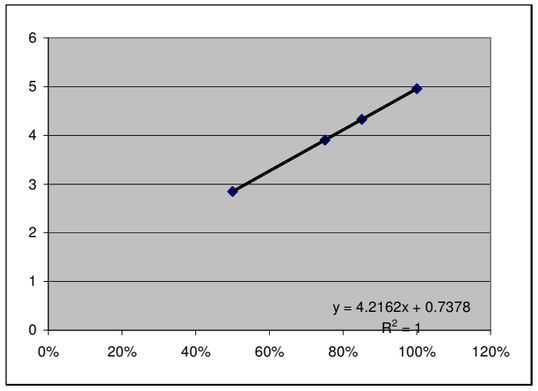
Based on the emission rates as referenced in the "HK Inventory" and the meteorological data as recorded at the WKCD monitoring station during the monitoring period, the hourly SO2 concentrations at the monitoring station due to emissions from only the 24-hour ship berthing at the Ocean Terminal were modelled by using ISCST3. The modelling results so obtained were then filtered to identify only those results that correspond to the worst-case wind directions, (i.e., blowing directly toward the WKCD monitoring station from the Ocean Terminal or wind directions: 100° to 130°), the night-time hours (i.e., 9pm to 8am) and the worst-case atmospheric conditions (i.e., stable atmospheric conditions).

With this filtering exercise, the maximum hourly concentration as recorded at the WKCD monitoring station was compared with the maximum hourly concentration as predicted by the ISCST3 model (with the emission rates as referenced in the "HK Inventory") in order to obtain the ratio of maximum monitoring result to maximum model result. The SO2 emission rates for the 24-hour ship were then adjusted by this ratio, which is found to be 0.40:1. Therefore, the SO2 emission rate for the 24-hour ship was adjusted by a factor of 0.40 in the model run so as to provide more realistic estimates of the maximum SO2 concentrations at the ASRs. The SO2 emission rate for the day-time ship, which is smaller in tonnage than the 24-hour ship, is conservatively assumed to be the same as the adjusted emission rate for the 24-hour ship.

Ocean Passenger Cruise Ship - Ocean Terminal

Vessel Type	Daytime Ship (40,000 tons)	(OGV)	24 hour ship (70,000 tons)	(OGV)





Exhaust flow at load factor		42%	**kg/s**		2.364		42% **kg/s**	2.49 *Assume exhaust air is proportionally larger according to engine size*
Molecular Weight of air			**g/mole**		**28.97**		**g/mole**	**28.97**
Molecular weight of fuel	**C14H30**		**g/mole**		198.4	**C14H30**	**g/mole**	198.4
Mole Air in exhaust (per second)			**mole/s**		81.6		**mole**	86.0
Mole fuel in exhaust (per second)			**mole/s**		0.254		**mole**	0.267
PV=nRT								
Pressure	**P**		**kPa**		101.3 *Assume Standard Pressure*	**P**	**kPa**	101.3 *Assume Standard Pressure*
Total Mole	**n**				81.9	**n**		86.3
Exhaust Temperature (after turbocharg	**Tm**		**K**	(o)	**586.2**	**Tm**	**K** (o)	**586.2** *Assume as for 40,000ton ship as no information available*
Exhaust Temperature	**Te**		**K**	(ah)	**448.2** *Passes through boiler*	**Te**	**K** (ah)	**448.2** *Passes through boiler*
Universal gas constant	**R**		**J/K/mol**		8.314	**R**	**J/K/mol**	8.314
Volumetric flow (exhaust)	**at 313℃**		**L/s**		3938.0	**at 313℃**	**L/s**	4150.8 *Assume as for 40,000ton ship as no information available*
	at 175℃				3010.9	**at 175℃**		3173.6
Volumetric flow (exhaust)			**m³/s**		3.01		**m³/s**	3.17
Exhaust diameter			**m**	(o)	**0.6**		**m** (o)	**0.6**
Efflux velocity			**m/s**		10.65		**m/s**	11.22
Note four engines so 4 exhaust of 600mm, 10.6m/s etc						**Assume four engines so 4 exhaust of 600mm, 11.2m/s etc**		
Emissions (Manoeuvring & Hotelling only) per stack	**NOx**		**g/s**		3.24	**NOx**	**g/s**	3.64
	PM10		**g/s**		0.47	**PM10**	**g/s**	0.49
	SO2		**g/s**		1.90	**SO2**	**g/s**	1.90
Stack coordinate			**m**		835175.41 817276.31		**m**	835170.51 817393.30

Fast Ferries - China Ferry Terminal

		Unit	Ref		
Vessel Information					
Vessel Type				Fast Ferry	(Harbour Craft)
Draft		**m**	(a)	**1.2**	
Actual Cruise Speed	(in harbour)	**knots**	(aag)	**10.0**	
Activity - Cruise (China ferries)		**hours**		0.13	
Activity - Cruise (Macau ferries)		**hours**		0.06	
Activity - Hotel		**hours**		0.50	
Auxiliary Engine Information (Average)					
Name					
Number of engines			(ay)	2.0	*Average all ferries*
Average Auxiliary Engine Capacity		**kW**	(ay)	96.9	*Average all ferries*
Average Total Auxiliary Engine Capacity		**kW**		194	
Speed		**RPM**	(ay)	1500.0	*Average all ferries*
Phase	2 or 4 stroke			4	
Load Factor (Aux Engines)	**Cruise**		(ak)	**0.45**	
	Hotel		(ak)	**0.45**	
Fuel type			(ac)	**Light Diesel Oil**	
Main Engine Information - Macau					
Total Maximum Main Engine Power		**kW**	(ay)	**9280.00**	
Maximum design speed		**knots**	(ay)	**45.00**	
Victoria Harbour speed limit		**knots**	(aag)	**10.00**	
Load Factor (Main Engines)	**Macau**	**Cruise**	(am)	0.222	*Mechanical Power =Force x Velocity* *Assume Force is constant* *∴ load factor is proportional to speed* *LF = 10 / 45*
Fuel type			(ac)	**Light Diesel Oil**	
Main Engine Information - China					
Maximum Main Engine Power		**kW**	(ay)	**5490.00**	
Maximum design speed		**knots**	(ay)	**32.00**	
Victoria Harbour speed limit		**knots**	(aag)	**10.00**	
Load Factor (Main Engines)	**China**	**Cruise**	(al)	0.313	*Mechanical Power =Force x Velocity* *Assume Force is constant* *∴ load factor is proportional to speed* *LF = 10 / 45*
Fuel type			(ac)	**Light Diesel Oil**	

Fast Ferries - China Ferry Terminal

Emissions Information - Macau (weighted average)

Emission Factor (Aux Engines)	**NOx**	**g/kWh**	(af)	**10.00**
	PM10	**g/kWh**	(af)	**0.31**
	SO2	**g/kWh**	(af)	**2.12**
Average weighted Emissions (Aux Engines) - Cruise	**NOx**	**g/s**	(c)	0.00
	PM10	**g/s**	(c)	0.00
	SO2	**g/s**	(c)	0.00
Emissions (Aux Engines) - Hotel	**NOx**	**g/s**	(c)	0.24
	PM10	**g/s**	(c)	0.01
	SO2	**g/s**	(c)	0.05
Emission Factor (Main Engines) - Cruise	**NOx**	**g/kWh**	(l),(ay)	**9.80**
	PM10	**g/kWh**	(af)	**0.31**
	SO2	**g/kWh**	(af)	**2.08**
Emissions (Main Engines) - Cruise	**NOx**	**g/s**	(c)	5.61
	PM10	**g/s**	(c)	0.18
	SO2	**g/s**	(c)	1.19
Total Emissions - Cruise	**NOx**	**g/s**	(c)	5.61
	PM10	**g/s**	(c)	0.18
	SO2	**g/s**	(c)	1.19

Fast Ferries - China Ferry Terminal

Emissions Information - China

Emission Factor (Aux Engines)	**NOx**	**g/kWh**	(af)	**10.00**	
	PM10	**g/kWh**	(af)	**0.31**	
	SO2	**g/kWh**	(af)	**2.12**	
Emissions (Aux Engines) - Cruise	**NOx**	**g/s**	(c)	0.24	
	PM10	**g/s**	(c)	0.01	
	SO2	**g/s**	(c)	0.05	
Emissions (Aux Engines) - Hotel	**NOx**	**g/s**	(c)	0.24	
	PM10	**g/s**	(c)	0.01	
	SO2	**g/s**	(c)	0.1	
Emission Factor (Main Engines) - Cruise	**NOx**	**g/kWh**	(l)	**9.80**	
	PM10	**g/kWh**	(af)	**0.31**	
	SO2	**g/kWh**	(af)	**2.08**	
Emissions (Main Engines) - Cruise	**NOx**	**g/s**	(c)	4.67	
	PM10	**g/s**	(c)	0.15	
	SO2	**g/s**	(c)	0.99	
Total Emissions - Cruise	**NOx**	**g/s**	(c)	4.91	
	PM10	**g/s**	(c)	0.16	
	SO2	**g/s**	(c)	1.04	

Exhaust Information (for berthing)

Engine Size (displacement)	**m³**		0.007	
	CID	(p)	425.5	*=0.007*39.37^3*
Intake Airflow	**CFM**	(p)	**554.0**	*=((Engine Size (CID)*Engine Speed (RPM))/3456)*Volumetric efficiency*
Volumetric Efficiency		(p)	**3**	
Manifold Flow	**CFM**	(p)	**1395.2**	*=((900+460)/540)*Intake Airflow (CFM)*
	m³/s		0.66	*=Manifold Flow (CFM) * 0.02832 / 60*
Manifold temp	**°C**	(p)	537.8	*As referenced*
Exhaust Temp	**°C**	(an)	274.2	*Average of engine information as referenced*
	K		**547.3**	
Exhaust flow Diesel (total)	**m³/s**		0.67	*=Manifold Flow (m³/s) * number of engines * Exhaust Temp / Manifold Temp*
Exhaust Height	**mPd**		1.3	

Fast Ferries - China Ferry Terminal

Additional Information for emission calculations

			(aq)	(ar)	(as)	(at)
Reference						
Power		**kW**	**150**	**150**	**150**	**150**
Speed		**RPM**	**1800**	**1500**	**1800**	**1800**
Bore			**0.106**	**0.135**	**0.105**	**0.104**
Stroke			**0.127**	**0.15**	**0.127**	**0.132**
Cylinders			**6**	**6**	**6**	**6**
Total displacement (calc)		**m³**	0.0067	0.0129	0.0066	0.0067
Total displacement (given)			**0.00679**		**0.0066**	
Stroke			4	4	4	4
Air Intake Volume (calc)	**V0**	**m³/s**	0.102	0.226	0.099	0.101
Air Intake Volume (given)	**V1**	**m³/s**	**0.208**		**0.215**	
Air Intake Temp (calc)	**T1**	**℃**	200.5	235.5	256.0	250.0
Exhaust Temp	**T2**	**℃**	**566.0**	583.7	**625.0**	**560**
PV=nRT						
Exhaust volume (calc)			0.588	0.561	0.525	0.226
Exhaust volume (given)	**V2**	**m³/s**	**0.562**		**0.525**	**0.625**
Outlet size		**m**	**0.0980**	0.0980	0.0980	0.0980

			(au)	(av)	(aw)	(ax)
Reference						
Power		**kW**	**40-50**	**50**	**50**	**50**
Speed		**RPM**	**1500**	**1500**	**1800**	**1800**
Bore			**0.106**	**0.135**	**0.086**	**0.102**
Stroke			**0.127**	**0.15**	**0.105**	**0.120**
Cylinders			**4**	**4**	**4**	**4**
Total displacement (calc)		**m³**	0.0045	0.0086	0.0024	0.0039
Total displacement (given)			**0.0045**		**0.0024**	
Stroke			4	4	4	4
Air Intake Volume (calc)	**V0**	**m³/s**	0.056	0.165	0.036	0.059
Air Intake Volume (given)	**V1**	**m³/s**	**0.070**		**0.067**	**0.090**
Air Intake Temp (calc)	**T1**	**℃**	200.5	194.5	183.7	199.4
Exhaust Temp	**T2**	**℃**	**487.0**	484.0	**496.0**	**468.9**
PV=nRT						
Exhaust volume (calc)			0.170	0.412	0.180	0.212
Exhaust volume (given)	**V2**	**m³/s**	**0.170**		**0.180**	**0.212**
Outlet size		**m**	**0.0980**	0.0744	**0.0508**	0.0744

Fast Ferries - China Ferry Terminal

Additional Information for emission calculations

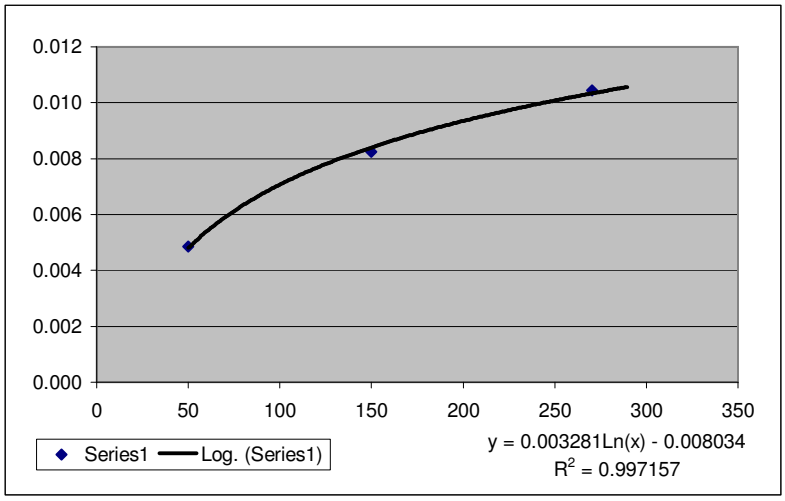
			(aae)	(aad)	(aac)	(aab)
Reference						
Power			**224**	**247**	**336**	**247**
Speed			**2200**	**2000**	**1800**	**2000**
Bore			**0.11402**	**0.122**	**0.13**	**0.122**
Stroke			**0.135**	**0.15**	**0.152**	**0.150**
Cylinders			**6**	**6**	**6**	**6**
Total displacement (calc)		**m³**	0.0083	0.0105	0.0121	0.0105
Total displacement (given)			**0.0083**	**0.01052**	**0.0128**	**0.0105**
						same as K
Stroke			4	4	4	4
Air Intake Volume (calc)	**V0**	**m³/s**	0.152	0.175	0.191	0.175
Air Intake Volume (given)	**V1**	**m³/s**				
Air Intake Temp (calc)	**T1**	**°C**				
Exhaust Temp	**T2**	**°C**				
PV=nRT						
Exhaust volume (calc)						
Exhaust volume (given)	**V2**	**m³/s**				
Outlet size		**m**				

			(aaa)	(az)
Reference				
Power			**298**	**450**
Speed			**2100**	**2100**
Bore			**0.125**	
Stroke			**0.147**	
Cylinders			**6**	
Total displacement (calc)		**m³**	0.0108	
Total displacement (given)				
Stroke			4	4
Air Intake Volume (calc)	**V0**	**m³/s**	0.189	
Air Intake Volume (given)	**V1**	**m³/s**	**0.413**	
Air Intake Temp (calc)	**T1**	**°C**	270.2	
Exhaust Temp	**T2**	**°C**	**564.0**	
PV=nRT				
Exhaust volume (calc)			0.862	
Exhaust volume (given)	**V2**	**m³/s**	**0.862**	
Outlet size		**m**		

Fast Ferries - China Ferry Terminal

Relationship for engine displacement

Engine size	**kW**	50	150	270.4
Displacement	**m³**	0.005	0.008	0.010



Fast Ferries - China Ferry Terminal

Berth Point Source Information

Stack coordinates	835044.77	817788.12
	835096.67	817795.28
	835153.94	817806.02
	835246.64	817940.13
	835274.11	817791.10
	835202.23	817780.00
	835146.71	817768.89
	835097.62	817754.87

Effective efflux velocity (to account for horizontal plume)	**m/s**	(y)	**0.001**	
Effective stack diameter for one stack	**m**		29.24	*=SQRT ((4 * Exhaust Flow Diesel / Efflux Velocity (0.001)) / pi)*

24 hour emissions		NOx	g/s (per hour) PM10	SO2	
TIME	VESSELS	EMISSION			
0	0	0	0	0	*emmision rate x activity*
1	0	0	0	0	
2	0	0	0	0	
3	0	0	0	0	
4	0	0.000	0.00000	0.0000	
5	0	0	0	0	
6	0	0	0	0	
7	5	0.606	0.019	0.128	
8	14	1.696	0.053	0.359	
9	6	0.727	0.023	0.154	
10	8	0.969	0.030	0.205	
11	6	0.727	0.023	0.154	
12	3	0.363	0.011	0.077	
13	7	0.848	0.026	0.180	
14	3	0.363	0.011	0.077	
15	8	0.969	0.030	0.205	
16	5	0.606	0.019	0.128	
17	3	0.363	0.011	0.077	
18	7	0.848	0.026	0.180	
19	6	0.727	0.023	0.154	
20	3	0.363	0.011	0.077	
21	2	0.242	0.008	0.051	
22	1	0.121	0.004	0.026	
23	0	0	0	0	

Fast Ferries - China Ferry Terminal

Macau Cruise Area Source Information

Route coordinates	833886.00	817401.67	**Length**	**Width**	
	834934.04	817757.43	1106.77	30	
Total area			33203.18		

		Emissions (g/m^2.s)			
24 hour emissions		NOx	PM10	SO2	
TIME	VESSELS	EMISSION			
multiply scheduled ferries by two to account for inbound and outbound journeys					
0	0	0	0	0	
1	0	0	0	0	
2	0	0.00E+00	0.00E+00	0.00E+00	*= number of vessels x total emission per vessel x (cruise time for total length) / (total area for total length)*
3	0	0	0	0	
4	0	0	0	0	
5	0	0	0	0	
6	0	0	0	0	
7	4	4.042E-05	1.28E-06	8.58E-06	
8	6	6.062E-05	1.92E-06	1.29E-05	
9	6	6.062E-05	1.92E-06	1.29E-05	
10	6	6.062E-05	1.92E-06	1.29E-05	
11	6	6.062E-05	1.92E-06	1.29E-05	
12	4	4.042E-05	1.28E-06	8.58E-06	
13	6	6.062E-05	1.92E-06	1.29E-05	
14	4	4.042E-05	1.28E-06	8.58E-06	
15	4	4.042E-05	1.28E-06	8.58E-06	
16	4	4.042E-05	1.28E-06	8.58E-06	
17	4	4.042E-05	1.28E-06	8.58E-06	
18	4	4.042E-05	1.28E-06	8.58E-06	
19	10	1.010E-04	3.20E-06	2.14E-05	
20	4	4.042E-05	1.28E-06	8.58E-06	
21	4	4.042E-05	1.28E-06	8.58E-06	
22	2	2.021E-05	6.39E-07	4.29E-06	
23	0	0	0	0	

Fast Ferries - China Ferry Terminal

China Cruise Area Source Information

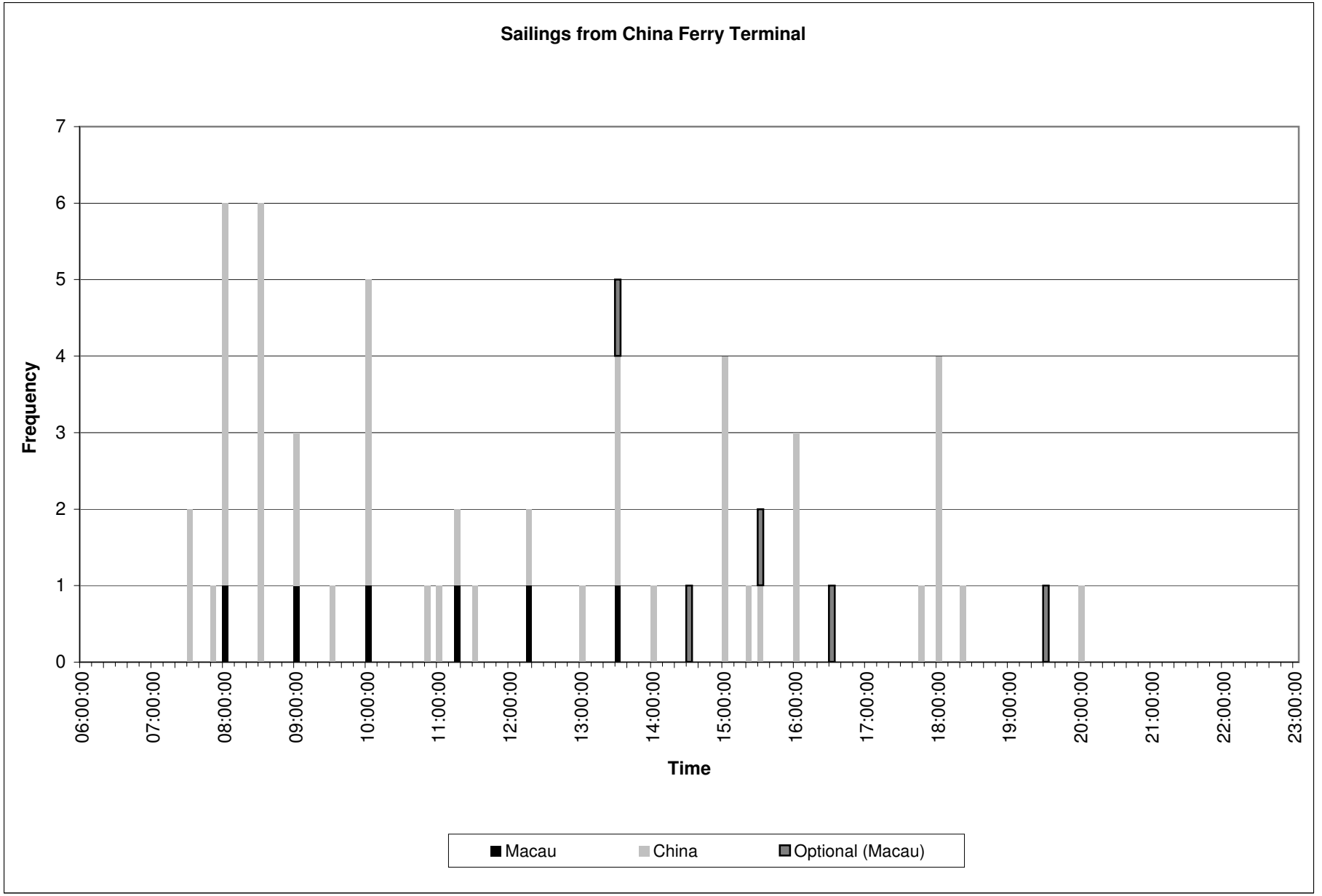
Route coordinates	833730.57	818678.97	**Length**	
	833726.13	817628.84	1050.14	
	833886.00	817401.67	277.79	
	834934.04	817757.43	1106.77	
Total area			73040.93	

		Emissions (g/m^2.s)			
24 hour emissions		NOx	PM10	SO2	
TIME	VESSELS	EMISSION			
multiply scheduled ferries by two to account for inbound and outbound journeys					
0	0	0	0	0	
1	0	0	0	0	
2	0	0.00E+00	0.00E+00	0.00E+00	*= number of vessels x total emission per vessel x (cruise time for total length) / (total area for total length)*
3	0	0	0	0	
4	0	0	0	0	
5	0	0	0	0	
6	0	0	0	0	
7	6	5.31E-05	1.68E-06	1.13E-05	
8	22	1.95E-04	6.15E-06	4.13E-05	
9	6	5.31E-05	1.68E-06	1.13E-05	
10	10	8.84E-05	2.79E-06	1.88E-05	
11	6	5.31E-05	1.68E-06	1.13E-05	
12	2	1.77E-05	5.59E-07	3.75E-06	
13	8	7.07E-05	2.24E-06	1.50E-05	
14	2	1.77E-05	5.59E-07	3.75E-06	
15	12	1.06E-04	3.35E-06	2.25E-05	
16	6	5.31E-05	1.68E-06	1.13E-05	
17	2	1.77E-05	5.59E-07	3.75E-06	
18	10	8.84E-05	2.79E-06	1.88E-05	
19	2	1.77E-05	5.59E-07	3.75E-06	
20	2	1.77E-05	5.59E-07	3.75E-06	
21	0	0	0	0	
22	0	0	0	0	
23	0	0	0	0	

(a)	BMT data from Jennifer Yue 04/05/2012
(b)	Table 2-16: Auxiliary Engine Emission Factors, g/kWh - *USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories* Assume worst case so SSD (slow speed diesel) engine with RO (residual oil) fuel type
(c)	Page 2-1, section 2.1 - *USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*
(d)	http://cotaijet.com.mo/content/vessel-information http://www.austal.com/Resources/Deliveries/0b9e4bc1-65bf-ebc1-211c-a99d14682d12/Austal_48_311_to_320___350_to_353_web.pdf
(e)	http://www.starcruises.com/en/home/ships/star-pisces/introduction.aspx
(f)	Table 3-13: Estimated average vessel ratio of Auxiliary Engines / Main Engines by ship type - *EMEP/EEA emission inventory guidebook 2011*
(g)	www.globalsecurity.org/military/systems/ship/bd.htm
(h)	Table 3.3-1. Emission Factors for uncontrolled gasoline and diesel industrial engines - USEPA AP42 Section 3.3
(i)	Schedule L.N. 66 of 2010 Cap 548E - Merchant shipping (local vessels) (typhoon shelters) regulation
(j)	http://wisemate9.en.ec21.com/Derrick_Lighter_with_Lifting_Capacity--3435524_3468810.html http://www.bonnyfair.com.hk/deliveries.htm
(k)	http://pdf.nauticexpo.com/pdf/mtu-friedrichshafen/mtu-diesel-engines-8v-12v-16v-4000-m70-for-vessels-with-high-load-factors-1b/31379-19452.html
(l)	MARPOL Annex VI, Chpt 3,Reg 13.3.2 Reg 413M http://www.legislation.gov.hk/blis_pdf.nsf/6799165D2FEE3FA94825755E0033E532/5FC416D2F9038CBB482575EF00059F2A?OpenDocument&bt=0
(m)	https://exchange.dnv.com/exchange/main.aspx?extool=vessel&subview=machinerysummary&vesselid=15641
(n)	http://www.starcruises.com/media/206207/SPC0005_tariff_1112_EN_intl.pdf
(o)	http://www.brownsequipment.com/files/item_files/files/12338.pdf http://www.scribd.com/doc/35255987/Wartsila-Vasa-32-Project-Guide http://www.maritimeequipment.com/ShowAd.aspx?id=106918 http://raflucgr.ra.funpic.de/toppage46.htm http://dec.alaska.gov/air/ap/docs/AQ0433TVP02dper.pdf http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=14&ved=0CE4QFjADOAo&url=http%3A%2F%2Fwww.digitalwavepublishing.com%2Fpdfs%2FNWM%2Fmaritimereporter%2F198601%2F&ei=vlMGUNb3LKrf4QSjvlifCQ&usg=AFQjCNF6gddAvC_NQHxy71bVvQffI9MV8g&sig2=yuFw40cD5j9B883pmboaNg http://www.marinedigital.com/en/mall/Equipment/index2.asp?menu_code=EquipmentSaleView&gubun=S1&GoodsNo=S11100060&Ucategory=1&list_url=Page=4%5Egubun=S1%5EEquipmentName=%5EMaker=%5EModel=%5EPostedYear=%5EPostedMonth=%5EPostedDay=%5ERegisterYN=Y%5EUcategory=1%5EFcategory=1%5EScategory=%5ETcategory=%5EOrderMethod=%5EOrderMethod2= http://www.equipmatching.com/used_equipment/5/75/193435.php
(p)	http://www.asia.donaldson.com/en/exhaust/support/datalibrary/1053747.pdf
(q)	Table 3-5:Harbour Craft Emission Factors - *USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*
(r)	http://www.aalborg-industries.com/marine_solutions/documents/MISSION_OS_datasheet_FEB08.pdf
(s)	Table 3-29 OGV Boiler Emission Factors (g/kWh) - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*
(t)	http://www.royalcaribbean.com/findacruise/ships/class/ship/home.do?shipClassCode=VI&shipCode=LG&br=R
(u)	http://www.polb.com/civica/filebank/blobdload.asp?BlobID=6915

(v)	www.maritimesales.com/AT11.htm www.maritimesales.com/AT13.htm www.maritimesales.com/AT15.htm
(w)	http://marine.cummins.com/
(x)	Wartsila - Project guide Wartsila 46 2007
(y)	http://www.epa.gov/scram001/7thconf/aermod/aermod_implmtn_guide_19March2009.pdf
(z)	http://www.exhaustvideos.com/faq/how-to-calculate-muffler-size-pipe-diameter/
(aa)	Table 4.8: Fuel Correction Factors - *Starcrest: Puget Sound Maritime Air Emission Inventory (April 2007)*
(ab)	p.272 eqn - *Starcrest: Puget Sound Maritime Air Emission Inventory (April 2007)*
(ac)	para.4. - *Legislative Council Panel on Environmental Affairs, Controlling Emissions from Vessels (21 December 2011)*
(ad)	Table 3-4: Load Factors for Harbour Craft (Port of Los Angeles and Long Beach) - *USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*
(ae)	Table 3-21 Adapted Auxiliary Engine Load Factors for OGVs except FCCV - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*
(af)	Table 4-17 ME and AE emission Factors (g/kWh) for Macau and PRD Ferry - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*
(ag)	Table 3-23 Adapted Auxiliary Boiler Energy Defaults (kW) for OGV - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*
(ah)	Table 2-17: Auxiliary Boiler Energy Defaults, kW - *USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories* www.steamesteem.com/?boilers/exhaust-gas-boilers www.polishcimac.pl/Papers1/2012/019.pdf
(ai)	Table 10-6 Weighted Fuel Sulphur Content of Residual Oil, Selected Year - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*
(aj)	https://exchange.dnv.com/exchange/main.aspx?extool=vessel&subview=machinerysummary&vesselid=18204
(ak)	Table 4-10 Auxiliary Engine Load Factors of RTVs, Macau and PRD Ferry - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*
(al)	Table 4-9 Main Engine Load Factors of PRD Ferry - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*
(am)	Table 4-8 Main Engine Load Factors of Macau Ferry - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*
(an)	Cooper, D. A., 2000. Exhaust emissions from high speed passenger ferries. Atmospheric Environment 35 (2001), 4189-4200
(ao)	p.272 para.2 - *Starcrest: Puget Sound Maritime Air Emission Inventory (April 2007)*
(ap)	p.A3 "Diesel" - *Starcrest: Puget Sound Maritime Air Emission Inventory (April 2007)*
(aq)	http://www.kohlerpower.com/onlinecatalog/pdf/g5210.pdf
(ar)	http://www.china-dieselgenerator.com/product.php?name=150kw_generator
(as)	http://www.cat.com/cda/files/256118/7/LEHE5521-01.pdf
(at)	http://www.powertechengines.com/MQP-DataSheets/MQP150IV_Rev_0.pdf
(au)	http://www.kohlerpower.com/onlinecatalog/pdf/g5205.pdf
(av)	http://www.china-dieselgenerator.com/product.php?name=50KW_generator
(aw)	www.generac.com/SpecSheets/0184480SBY.pdf
(ax)	http://www2.generatorjoe.net/html/cumm/CUIN-050D312.pdf
(ay)	http://www.barcaferry.com/index_c.htm
(az)	http://www.liebherr.com/AT/en-GB/products_at.wfw/id-3666-0/measure-metric/tab-2280_1477
(aaa)	http://www.bigge.com/crane-charts/crawler-crane-charts/999_Product_Guide.pdf http://www.cmdmarine.com/Products/Recreational%20Inboard/QSM11/fr20049.pdf
(aab)	http://www.bigge.com/crane-charts/crawler-crane-charts/Kobelco-7250-2F_spec.pdf
(aac)	http://www.bigge.com/crane-charts/crawler-crane-charts/Link-Belt-LS278H-Specifications.pdf
(aad)	http://www.bigge.com/crane-charts/crawler-crane-charts/CK2500-II.pdf
(aae)	http://www.bigge.com/crane-charts/crawler-crane-charts/HC230-LC.pdf
(aaf)	Paragraph 4.2.8 - *Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory*

(aag)	http://www.mardep.gov.hk/en/publication/pressrel/pr2k0629.html
(aah)	http://www.dieselnet.com/standards/us/nonroad.php
	Table 1 225 <= kW <450 - Tier 1
(aai)	http://www.emergencypower.com/
	http://www.boatsafe.com/nauticalknowhow/enginelife.htm


Sailings from China Ferry Terminal
Frequency
0
1
2
3
4
5
6
7
06:00:00
07:00:00
08:00:00
09:00:00
10:00:00
11:00:00
12:00:00
13:00:00
14:00:00
15:00:00
16:00:00
17:00:00
18:00:00
19:00:00
20:00:00
21:00:00
22:00:00
23:00:00
Time
Macau
China
Optional (Macau)