# *Appendix 3.7 –*
# *Detailed Calculation of Marine Emission*

# 1 CHINA FERRY TERMINAL

Macau and China Ferries Berthing at China Ferry Terminal

1.1 China Ferry Terminal provides 8 berths for ferry services to Macau and Pearl River Delta China (China). The ferry services are mainly provided by Cotai Water Jet, TurboJet and Chu Kong Passenger Transport Limited. The arrival and departure schedules were reviewed based on TurboJet's website and the latest available online information on Marine Department's website (https://crossboundaryferryservices.mardep.gov.hk/en/) (for the other 2 operators as no available information on their websites), and are presented in **Table 1.1** and **Table 1.2**.

**Table 1.1 Schedule of Ferry Service to and from Macau**

| Hour | Departure | Arrival | Total | Hour | Departure | Arrival | Total |
|---|---|---|---|---|---|---|---|
| **0:00** | 0 | 0 | 0 | **12:00** | 2 | 0 | 2 |
| **1:00** | 0 | 0 | 0 | **13:00** | 0 | 1 | 1 |
| **2:00** | 0 | 0 | 0 | **14:00** | 2 | 1 | 3 |
| **3:00** | 0 | 0 | 0 | **15:00** | 1 | 2 | 3 |
| **4:00** | 0 | 0 | 0 | **16:00** | 0 | 1 | 1 |
| **5:00** | 0 | 0 | 0 | **17:00** | 1 | 2 | 3 |
| **6:00** | 0 | 0 | 0 | **18:00** | 2 | 2 | 4 |
| **7:00** | 1 | 0 | 1 | **19:00** | 0 | 2 | 2 |
| **8:00** | 1 | 0 | 1 | **20:00** | 0 | 1 | 1 |
| **9:00** | 3 | 1 | 4 | **21:00** | 0 | 0 | 0 |
| **10:00** | 2 | 1 | 3 | **22:00** | 0 | 1 | 1 |
| **11:00** | 2 | 2 | 4 | **23:00** | 0 | 0 | 0 |

**Table 1.2 Schedule of Ferry Service to and from China**

| Hour | Departure | Arrival | Total | Hour | Departure | Arrival | Total |
|---|---|---|---|---|---|---|---|
| **0:00** | 0 | 0 | 0 | **12:00** | 1 | 3 | 4 |
| **1:00** | 0 | 0 | 0 | **13:00** | 2 | 1 | 3 |
| **2:00** | 0 | 0 | 0 | **14:00** | 1 | 1 | 2 |
| **3:00** | 0 | 0 | 0 | **15:00** | 2 | 2 | 4 |
| **4:00** | 0 | 0 | 0 | **16:00** | 2 | 0 | 2 |
| **5:00** | 0 | 0 | 0 | **17:00** | 1 | 5 | 6 |
| **6:00** | 0 | 0 | 0 | **18:00** | 4 | 1 | 5 |
| **7:00** | 2 | 0 | 2 | **19:00** | 0 | 2 | 2 |
| **8:00** | 4 | 0 | 4 | **20:00** | 1 | 1 | 2 |
| **9:00** | 1 | 2 | 3 | **21:00** | 0 | 1 | 1 |
| **10:00** | 1 | 3 | 4 | **22:00** | 0 | 0 | 0 |
| **11:00** | 3 | 2 | 5 | **23:00** | 0 | 0 | 0 |

1.2 During hotelling mode, ferries rely on the auxiliary engines to supply electrical needs. Due to the lack of available information, auxiliary engine information for Macau ferries and China ferries were assumed the same except the engine power and the information is summarized in **Table 1.3**. Therefore, the emissions from Macau ferries and China ferries were calculated separately but modelled as a combined emission source at the berths. Emission during hoteling at the berths were modelled as "POINTHOR" sources with AERMOD. Horizontal plume was assumed for the hotelling emission at 6.2mAG, with exit temperature of 773K and stack diameter of 0.7m (with reference to the approved *Expansion of Heliport Facilities at Macau Ferry Terminal EIA Report* (*MFT EIA Report*) [1]) and an exit velocity of 8m/s (with reference to the approved *Sludge Treatment Facilities EIA Report*

[1] Civil Aviation Department. 2005. *Expansion of Heliport Facilities at Macau Ferry Terminal EIA Report*. Prepared by Maunsell Environmental Management Consultants Ltd.

*(STF EIA Report)* [2]). The auxiliary engine information for Macau and China ferries and locations of berths are summarized in **Table 1.3**.

**Table 1.3 Auxiliary Engine Information and Locations of Berths for Macau and China Ferries**

| Parameters | Unit | Macau Ferry | China Ferry |
|---|---|---|---|
| Coordinates for Berths (Combined for Macau and China Ferries) | - | X-Coordinate | Y-Coordinate |
| | | 835044.8 | 817788.1 |
| | | 835096.7 | 817795.3 |
| | | 835153.9 | 817806.0 |
| | | 835246.6 | 817940.1 |
| | | 835274.1 | 817791.1 |
| | | 835202.2 | 817780.0 |
| | | 835146.7 | 817768.9 |
| | | 835097.6 | 817754.9 |
| Auxiliary Engine Power [1] | kW | 326 | 208 |
| Auxiliary Engine Load Factor [2] | - | 0.45 | |

Notes:

[1] Maximum auxiliary engine power for the Macau and China Ferries from Section 4.2.12 and Section 4.2.13 of *Institute for the Environment, The Hong Kong University of Science & Technology (HKUST): Final Report of Study on Marine Vessels Emission Inventory (MVEIS)* [3]

[2] Table 4-10 of *MVEIS* [3]

1.3 Each ferry was assumed to hotel at the berth for half an hour. The emission factors were referenced to *MVEIS* published by HKUST [3]. All RSP emissions were assumed for FSP as a conservative approach. The emission factors and emission rates for each Macau ferry and China ferry at each berth are presented in **Table 1.4**.

**Table 1.4 Hotelling Emission Information for Macau and China Ferries**

| Parameters | | Unit | Macau Ferry | China Ferry |
|---|---|---|---|---|
| Hotelling Time | | hr | 0.5 | |
| No. of Berths | | - | 8 | |
| Emission Factors of Auxiliary Engine [1] | NOx | g/kWh | 10 | |
| | RSP | g/kWh | 0.31 | |
| Emission Rates for Hotelling for each Ferry at each Berth [2] | NOx | g/s | 2.547E-02 | 1.625E-02 |
| | RSP | g/s | 7.895E-04 | 5.038E-04 |

Notes:

[1] Table 4-17 of *MVEIS* [3]

[2] Emission Rate = Emission Factor x Engine Power x Load Factor x Hotelling Time ÷ No. of Berths ÷ 3600

1.4 Emission rate at each hour was calculated based on the number of Macau and China ferries hotelling at berth, which was assumed as the maximum number of ferries among departure and arrival at each hour. The hourly NOx and RSP emission rates are summarized in **Table 1.5** and **Table 1.6** respectively.

[2] Environmental Protection Department. 2008. *Sludge Treatment Facilities EIA Report*. Prepared by Metcalf & Eddy Ltd.

[3] Institute for the Environment, The Hong Kong University of Science & Technology. 2012. *Final Report of Study on Marine Vessels Emission Inventory*.

**Table 1.5 Hourly NOx Emission Rates during Hotelling**

| Hour | Macau Ferry | | China Ferry | | Total NOx Emission Rate (g/s) |
|---|---|---|---|---|---|
| | No. of Vessels | NOx Emission Rate (g/s) | No. of Vessels | NOx Emission Rate (g/s) | |
| **0:00** | 0 | 0 | 0 | 0 | 0 |
| **1:00** | 0 | 0 | 0 | 0 | 0 |
| **2:00** | 0 | 0 | 0 | 0 | 0 |
| **3:00** | 0 | 0 | 0 | 0 | 0 |
| **4:00** | 0 | 0 | 0 | 0 | 0 |
| **5:00** | 0 | 0 | 0 | 0 | 0 |
| **6:00** | 0 | 0 | 0 | 0 | 0 |
| **7:00** | 1 | 2.547E-02 | 2 | 3.250E-02 | 5.797E-02 |
| **8:00** | 1 | 2.547E-02 | 4 | 6.500E-02 | 9.047E-02 |
| **9:00** | 3 | 7.641E-02 | 2 | 3.250E-02 | 1.089E-01 |
| **10:00** | 2 | 5.094E-02 | 3 | 4.875E-02 | 9.969E-02 |
| **11:00** | 2 | 5.094E-02 | 3 | 4.875E-02 | 9.969E-02 |
| **12:00** | 2 | 5.094E-02 | 3 | 4.875E-02 | 9.969E-02 |
| **13:00** | 1 | 2.547E-02 | 2 | 3.250E-02 | 5.797E-02 |
| **14:00** | 2 | 5.094E-02 | 1 | 1.625E-02 | 6.719E-02 |
| **15:00** | 2 | 5.094E-02 | 2 | 3.250E-02 | 8.344E-02 |
| **16:00** | 1 | 2.547E-02 | 2 | 3.250E-02 | 5.797E-02 |
| **17:00** | 2 | 5.094E-02 | 5 | 8.125E-02 | 1.322E-01 |
| **18:00** | 2 | 5.094E-02 | 4 | 6.500E-02 | 1.159E-01 |
| **19:00** | 2 | 5.094E-02 | 2 | 3.250E-02 | 8.344E-02 |
| **20:00** | 1 | 2.547E-02 | 1 | 1.625E-02 | 4.172E-02 |
| **21:00** | 0 | 0 | 1 | 1.625E-02 | 1.625E-02 |
| **22:00** | 1 | 2.547E-02 | 0 | 0 | 2.547E-02 |
| **23:00** | 0 | 0 | 0 | 0 | 0 |

**Table 1.6 Hourly RSP Emission Rates during Hotelling**

| Hour | Macau Ferry | | China Ferry | | Total RSP Emission Rate (g/s) |
|---|---|---|---|---|---|
| | No. of Vessels | RSP Emission Rate (g/s) | No. of Vessels | RSP Emission Rate (g/s) | |
| **0:00** | 0 | 0 | 0 | 0 | 0 |
| **1:00** | 0 | 0 | 0 | 0 | 0 |
| **2:00** | 0 | 0 | 0 | 0 | 0 |
| **3:00** | 0 | 0 | 0 | 0 | 0 |
| **4:00** | 0 | 0 | 0 | 0 | 0 |
| **5:00** | 0 | 0 | 0 | 0 | 0 |
| **6:00** | 0 | 0 | 0 | 0 | 0 |
| **7:00** | 1 | 7.895E-04 | 2 | 1.008E-03 | 1.797E-03 |
| **8:00** | 1 | 7.895E-04 | 4 | 2.015E-03 | 2.805E-03 |
| **9:00** | 3 | 2.369E-03 | 2 | 1.008E-03 | 3.376E-03 |
| **10:00** | 2 | 1.579E-03 | 3 | 1.511E-03 | 3.090E-03 |
| **11:00** | 2 | 1.579E-03 | 3 | 1.511E-03 | 3.090E-03 |
| **12:00** | 2 | 1.579E-03 | 3 | 1.511E-03 | 3.090E-03 |
| **13:00** | 1 | 7.895E-04 | 2 | 1.008E-03 | 1.797E-03 |
| **14:00** | 2 | 1.579E-03 | 1 | 5.038E-04 | 2.083E-03 |
| **15:00** | 2 | 1.579E-03 | 2 | 1.008E-03 | 2.587E-03 |
| **16:00** | 1 | 7.895E-04 | 2 | 1.008E-03 | 1.797E-03 |
| **17:00** | 2 | 1.579E-03 | 5 | 2.519E-03 | 4.098E-03 |
| **18:00** | 2 | 1.579E-03 | 4 | 2.015E-03 | 3.594E-03 |
| **19:00** | 2 | 1.579E-03 | 2 | 1.008E-03 | 2.587E-03 |
| **20:00** | 1 | 7.895E-04 | 1 | 5.038E-04 | 1.293E-03 |
| **21:00** | 0 | 0 | 1 | 5.038E-04 | 5.038E-04 |
| **22:00** | 1 | 7.895E-04 | 0 | 0 | 7.895E-04 |
| **23:00** | 0 | 0 | 0 | 0 | 0 |

Macau and China Ferries Cruising within Victoria Harbour

1.5 During cruising mode, Macau ferries rely on the main engine, while China ferries operate with both main engine and auxiliary engine, with reference to the approved *West Kowloon Cultural District EIA Report* [4]. The maximum designed cruising speeds for Macau ferries and China ferries are 45 knots and 32 knots, respectively, while the maximum allowable cruising speed within Victoria Harbour is 10 knots. As a conservative approach, the load factors for main engines were assumed as the ratio of actual cruising speed in Victoria Harbour to the maximum designed cruising speed. Therefore, the load factors for Macau ferries and China ferries are 0.22 (10/45) and 0.31 (10/32), respectively. The engine information for Macau and China ferries is presented in **Table 1.7**.

**Table 1.7 Engine Information for Macau and China Ferries**

| Parameters | Unit | Macau Ferry | China Ferry |
|---|---|---|---|
| Main Engine Power [1] | kW | 9280 | 5490 |
| Main Engine Speed [2] | rpm | 2000 | 2000 |
| Max. Designed Cruising Speed [2] | knots | 45 | 32 |
| Victoria Harbour Speed Limit [3] | knots | 10 | |
| Main Engine Load Factor [4] | - | 0.22 | 0.31 |
| Auxiliary Engine Power [5] | kW | 326 | 208 |
| Auxiliary Load Factor [6] | - | 0.45 | |

Notes:

[1] Maximum main engine power for the Macau and China Ferries from Sections 4.2.7 and Section 4.2.8 of *MVEIS* [3]

[2] http://www.barcaferry.com/index_c.htm

[3] Schedule 4 of Shipping and Port Control Regulations (CAP 313A), as illustrated in https://www.mardep.gov.hk/en/publication/pdf/hps_speed_limit.pdf

[4] Main Engine Load Factor = Actual Cruising Speed (i.e. 10 knots) ÷ Max. Designed Cruising Speed

[5] Maximum auxiliary engine power for the Macau and China Ferries from Section 4.2.12 and Section 4.2.13 of *MVEIS* [3]

[6] Table 4-10 of *MVEIS* [3]

1.6 Emissions from both Macau and China ferries travelling along the routes were modelled as "AREA" sources with AERMOD with a route width of 30m and exhaust height at 6.2mAG, with reference to the approved *WKCD EIA Report* [4] and *MFT EIA Report* [1], respectively. The locations of the cruising routes are shown in **Table 1.8**.

**Table 1.8 Locations of Cruising Routes for Macau and China Ferries**

| Macau Ferries | | China Ferries | |
|---|---|---|---|
| X-Coordinate | Y-Coordinate | X-Coordinate | Y-Coordinate |
| 834934.0 | 817748.9 | 833726.1 | 818674.7 |
| 834747.5 | 817688.9 | 833730.6 | 818529.0 |
| 834578.8 | 817628.8 | 833735.0 | 818374.7 |
| 834361.2 | 817560.3 | 833730.6 | 818207.5 |
| 834161.3 | 817487.4 | 833735.0 | 818018.9 |
| 833974.8 | 817423.1 | 833735.0 | 817877.4 |
| | | 833735.0 | 817693.1 |
| | | 833735.0 | 817547.4 |
| | | 833814.9 | 817440.3 |
| | | 833863.8 | 817384.5 |
| | | 834010.4 | 817431.7 |
| | | 834179.1 | 817491.7 |
| | | 834347.9 | 817547.4 |
| | | 834516.6 | 817611.7 |
| | | 834707.6 | 817676.0 |

[4] West Kowloon Cultural District Authority. 2013. *West Kowloon Cultural District Environmental Impact Assessment Report*. Prepared by Mott MacDonald.

1.7 The emission factors were reference to the emission limits for Tier 1 engines as stated in *MARPOL 73/78 Annex VI Regulation for the Prevention of Air Pollution from Ships* and *MVEIS* [3]. All RSP emissions were assumed for FSP as a conservative approach. The emission factors and emission rates for each ferry movement are calculated in **Table 1.9**.

**Table 1.9 Emission Information for each Ferry Movement**

| Parameters | | Unit | Macau Ferry | China Ferry |
|---|---|---|---|---|
| Distance Travelled | | m | 1106.78 | 2434.70 |
| Cruising Time [1] | | hr | 0.06 | 0.13 |
| Area of Route | | $m^2$ | 33203.18 | 73040.93 |
| Emission Factors of Main Engine | NOx [2] | g/kWh | 9.8 | |
| | RSP [3] | g/kWh | 0.31 | |
| Emission Rates of Main Engine for each Ferry Movement [4] | NOx | $g/m^2/s$ | 1.010E-05 | 8.406E-06 |
| | RSP | $g/m^2/s$ | 3.196E-07 | 2.659E-07 |
| Emission Factors of Auxiliary Engine [3] | NOx | g/kWh | 10 | |
| | RSP | g/kWh | 0.31 | |
| Emission Rates of Auxiliary Engine for each Ferry Movement [4] | NOx | $g/m^2/s$ | N.A. | 4.680E-07 |
| | RSP | $g/m^2/s$ | N.A. | 1.451E-08 |
| Total Emission Rates for each Ferry Movement [5] | NOx | $g/m^2/s$ | 1.010E-05 | 8.874E-06 |
| | RSP | $g/m^2/s$ | 3.196E-07 | 2.804E-07 |

Notes:

[1] Cruising Time = Distance Travelled ÷ Max. Allowable Cruising Speed in Victoria Harbour

[2] Emission limit for Tier 1 engines stated in *MARPOL 73/78 Annex VI Regulation for the Prevention of Air Pollution from Ships* from http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-(NOx)-%E2%80%93-Regulation-13.aspx

[3] Table 4-17 of *MVEIS* [3]

[4] Emission Rate = Emission Factor x Engine Power x Load Factor x Cruising Time ÷ Area of Route ÷ 3600
Macau ferries rely on main engine only during cruising mode, with reference to the approved *WKCD EIA Report* [4].

[5] Total Cruising Emission Rate = Emission Rate of Main Engine + Emission Rate of Auxiliary Engine (China ferries only)

1.8 Emission rates for each hour were calculated based on the total number of vessels arriving and departing China Ferry Terminal. The hourly emission rates for Macau and China ferries are presented in **Table 1.10** and **Table 1.11**, respectively.

**Table 1.10 Hourly Emission Rates for Macau Ferries during Cruising**

| Hour | No. of Vessels | NOx Emission Rate (g/s) | RSP Emission Rate (g/s) |
|---|---|---|---|
| **0:00** | 0 | 0 | 0 |
| **1:00** | 0 | 0 | 0 |
| **2:00** | 0 | 0 | 0 |
| **3:00** | 0 | 0 | 0 |
| **4:00** | 0 | 0 | 0 |
| **5:00** | 0 | 0 | 0 |
| **6:00** | 0 | 0 | 0 |
| **7:00** | 1 | 1.010E-05 | 3.196E-07 |
| **8:00** | 1 | 1.010E-05 | 3.196E-07 |
| **9:00** | 4 | 4.042E-05 | 1.278E-06 |
| **10:00** | 3 | 3.031E-05 | 9.589E-07 |
| **11:00** | 4 | 4.042E-05 | 1.278E-06 |
| **12:00** | 2 | 2.021E-05 | 6.392E-07 |
| **13:00** | 1 | 1.010E-05 | 3.196E-07 |
| **14:00** | 3 | 3.031E-05 | 9.589E-07 |
| **15:00** | 3 | 3.031E-05 | 9.589E-07 |
| **16:00** | 1 | 1.010E-05 | 3.196E-07 |

| Hour | No. of Vessels | NOx Emission Rate (g/s) | RSP Emission Rate (g/s) |
|---|---|---|---|
| **17:00** | 3 | 3.031E-05 | 9.589E-07 |
| **18:00** | 4 | 4.042E-05 | 1.278E-06 |
| **19:00** | 2 | 2.021E-05 | 6.392E-07 |
| **20:00** | 1 | 1.010E-05 | 3.196E-07 |
| **21:00** | 0 | 0 | 0 |
| **22:00** | 1 | 1.010E-05 | 3.196E-07 |
| **23:00** | 0 | 0 | 0 |

**Table 1.11 Hourly Emission Rates for China Ferries during Cruising**

| Hour | No. of Vessels | NOx Emission Rate (g/s) | RSP Emission Rate (g/s) |
|---|---|---|---|
| **0:00** | 0 | 0 | 0 |
| **1:00** | 0 | 0 | 0 |
| **2:00** | 0 | 0 | 0 |
| **3:00** | 0 | 0 | 0 |
| **4:00** | 0 | 0 | 0 |
| **5:00** | 0 | 0 | 0 |
| **6:00** | 0 | 0 | 0 |
| **7:00** | 2 | 1.775E-05 | 5.608E-07 |
| **8:00** | 4 | 3.550E-05 | 1.122E-06 |
| **9:00** | 3 | 2.662E-05 | 8.412E-07 |
| **10:00** | 4 | 3.550E-05 | 1.122E-06 |
| **11:00** | 5 | 4.437E-05 | 1.402E-06 |
| **12:00** | 4 | 3.550E-05 | 1.122E-06 |
| **13:00** | 3 | 2.662E-05 | 8.412E-07 |
| **14:00** | 2 | 1.775E-05 | 5.608E-07 |
| **15:00** | 4 | 3.550E-05 | 1.122E-06 |
| **16:00** | 2 | 1.775E-05 | 5.608E-07 |
| **17:00** | 6 | 5.324E-05 | 1.682E-06 |
| **18:00** | 5 | 4.437E-05 | 1.402E-06 |
| **19:00** | 2 | 1.775E-05 | 5.608E-07 |
| **20:00** | 2 | 1.775E-05 | 5.608E-07 |
| **21:00** | 1 | 8.874E-06 | 2.804E-07 |
| **22:00** | 0 | 0 | 0 |
| **23:00** | 0 | 0 | 0 |

# 2 NEW YAU MA TEI PUBLIC CARGO WORKING AREA (NYPCWA)

Derrick Lighter Barges Loading and Unloading at NYPCWA

2.1 The NYPCWA is located at the shoreline of New Yau Ma Tei Typhoon Shelter (NYMTTS). It mainly serves the purpose of loading and unloading cargos with the use of derrick lighter barges. The shoreline is approximately 1,250 metres long. With reference to the Merchant Shipping (Local Vessels) (Typhoon Shelters) Regulation (CAP 548E), the maximum permitted length for local vessels in NYMTTS is 50 metres. With the assumption of 5 metres at bow and stern for maneuvering purpose, the maximum number of vessels operating simultaneously is 20 (shoreline length divided by sum of vessel and maneuvering length). The NYPCWA is under operation from 07:00 to 21:00 daily.

2.2 During loading and unloading, auxiliary engines of the derrick lighter barges support the lifting operations. Emissions from derrick lighter barges during loading and unloading were modelled as "POINT" sources with AERMOD. Vertical plume was assumed for the hotelling emission at a height of 11mAG, with exit temperature of 588K and stack diameter of 0.2m with reference to the approved *West New Territories (WENT) Landfill Extensions – Feasibility Study EIA Report* [5] and an exit velocity of 8m/s (with reference to the approved *STF EIA Report* [2]. The auxiliary engine information for derrick lighter barges and locations of the berths are shown in **Table 2.1**.

**Table 2.1 Auxiliary Engine Information for Derrick Lighter Barges and Locations of Berths**

| Parameters | Unit | Derrick Lighter Barge | |
|---|---|---|---|
| | | X-Coordinate | Y-Coordinate |
| Coordinates for the Berths | - | 834355.6 | 818461.5 |
| | | 834379.3 | 818492.6 |
| | | 834401.4 | 818533.0 |
| | | 834432.3 | 818571.3 |
| | | 834461.0 | 818613.9 |
| | | 834489.8 | 818658.5 |
| | | 834505.2 | 818726.6 |
| | | 834505.2 | 818786.1 |
| | | 834505.2 | 818847.8 |
| | | 834505.2 | 818913.8 |
| | | 834505.2 | 818969.1 |
| | | 834505.2 | 819018.0 |
| | | 834505.2 | 819077.5 |
| | | 834505.2 | 819158.4 |
| | | 834505.2 | 819220.1 |
| | | 834505.2 | 819281.7 |
| | | 834505.2 | 819364.7 |
| | | 834505.2 | 819437.0 |
| | | 834505.2 | 819502.9 |
| | | 834505.2 | 819564.6 |
| Auxiliary Engine Power [1] | kW | 116 | |
| Auxiliary Engine Load Factor [2] | - | 0.43 | |

Notes:
[1] Table 4-6 of MVEIS [3]
[2] Table 4-10 of MVEIS [3].

2.3 With reference to the approved *WKCD EIA Report* [4], the barges operate around 5 minutes out of every operation period of 20 minutes. Therefore, 0.25 (5/20) was adopted as an

[5] Environmental Protection Department. 2009. *West New Territories (WENT) Landfill Extensions – Feasibility Study EIA Report*. Prepared by Ove Arup & Partners Hong Kong Ltd.

activity factor. All RSP emissions were assumed for FSP as a conservative approach. The emission factors and emission rates for each derrick lighter barge for loading and unloading at NYPCWA are summarized in **Table 2.2**.

**Table 2.2 Emission Information for each Barge during Loading and Unloading**

| **Parameters** | | **Unit** | **Derrick Lighter Barge** |
|---|---|---|---|
| Activity Factor [1] | | - | 0.25 |
| Emission Factors of Main Engine [2] | NOx | g/kWh | 10.0 |
| | RSP | g/kWh | 0.4 |
| Emission Rates for Loading and Unloading per Barge [4] | NOx | g/s | 3.464E-02 |
| | RSP | g/s | 1.386E-03 |

Notes:

[1] With reference to the approved *WKCD EIA Report* [4], the derrick lighter barges operate for around 5 minutes out of every operation period of 20 minutes. Therefore, 0.25 (5/20) was adopted as an activity factor.

[2] Table 4-16 of *MVEIS* [3]

[3] Emission Rate = Emission Factor x Engine Power x Load Factor x Activity Factor ÷ 3600

# 3 NEW YAU MA TEI TPYHOON SHELTER (NYMTTS)

Tug Movement at NYMTTS

3.1 With reference to the approved *WKCD EIA Report* [4], there are about 130 small craft movements both entering and leaving the NYMTTS, similar to the findings of site survey of a maximum of 9 numbers per hour as presented in **Annex B**. All small crafts were assumed to be tugs and the operation period was assumed the same as that of NYPCWA, i.e. 07:00 to 21:00 daily.

3.2 Within NYMTTS, tugs cruise with main engine and auxiliary engine at a max. speed of 5 knots according to the Schedule 4 of CAP 313A. Emissions from tugs cruising at NYMTTS were modelled as "AREA" sources with AERMOD with a route width of 30m with reference to the approved *WKCD EIA Report* [4] and an exhaust height of 4mAG based on observation [7]. The engine information for tugs and the locations of the cruising route are summarized in **Table 3.1** below.

**Table 3.1 Engine Information for Tugs and Locations of Cruising Route**

| Parameters | Unit | Tug | |
|---|---|---|---|
| | | X-Coordinate | Y-Coordinate |
| Coordinates for Cruising Route | - | 833704.9 | 818666.9 |
| | | 833796.5 | 818611.6 |
| | | 833903.5 | 818549.0 |
| | | 833976.0 | 818504.7 |
| | | 834094.4 | 818434.7 |
| | | 834228.1 | 818445.7 |
| | | 834316.0 | 818567.4 |
| | | 834400.0 | 818666.9 |
| | | 834403.8 | 818840.2 |
| Main Engine Power [1] | kW | 629 | |
| Main Engine Load Factor [2] [3] | - | 0.30 | |
| Auxiliary Engine Power [4] | kW | 33.4 | |
| Auxiliary Engine Load Factor [2] [5] | - | 0.43 | |

Notes:

[1] Weighted main engine power based on Table 4-4 and Table 4-5 of *MVEIS* [3].

[2] Speed limit of 5 knots for typhoon shelter, according to Schedule 4 of CAP 313A, as illustrated in https://www.mardep.gov.hk/en/publication/pdf/hps_speed_limit.pdf. Maneuvering mode was assumed.

[3] Table 4-7 of *MVEIS* [3]

[4] Weighted main engine power based on Table 4-4 and Table 4-6 of *MVEIS* [3].

[5] Table 4-10 of *MVEIS* [3]

3.3 The emission factors were referenced to *MVEIS* published by HKUST [3]. All RSP emissions were assumed for FSP as a conservative approach. The emission factors and emission rates for tug movement is presented in **Table 3.2** below.

**Table 3.2 Emission Information for Tug Movement**

| Parameters | | Unit | Tug |
|---|---|---|---|
| Distance Travelled | | m | 1236.12 |
| Average Cruising Speed [1] | | knots | 5 |
| | | km/hr | 9.3 |
| Cruising Time [2] | | hr | 0.13 |
| Area of Route | | $m^2$ | 37083.71 |
| No. of Vessels [3] | | per day | 130 |
| | | per hour | 9.3 |
| | NOx | g/kWh | 13.2 |

[7] The typical funnel location (where exhaust is released) of a tug is illustrated in: https://inspirationaltechnology.in/ship-parts-and-their-function/machines/

| Parameters | | Unit | Tug |
|---|---|---|---|
| Emission Factors of Main Engine [4] | RSP | g/kWh | 0.72 |
| Emission Factors of Auxiliary Engine [4] | NOx | g/kWh | 10.0 |
| | RSP | g/kWh | 0.40 |
| Emission Rates of Main Engine [5] | NOx | $g/m^2/s$ | 2.311E-05 |
| | RSP | $g/m^2/s$ | 1.261E-06 |
| Emission Rates of Auxiliary Engine [5] | NOx | $g/m^2/s$ | 1.333E-06 |
| | RSP | $g/m^2/s$ | 5.331E-08 |
| Total Emission Rates for Tug Movement [6] | NOx | $g/m^2/s$ | 2.444E-05 |
| | RSP | $g/m^2/s$ | 1.314E-06 |

Notes:

[1] Speed limit of 5 knots for typhoon shelter, according to Schedule 4 of CAP 313A.

[2] Cruising Time = Distance Travelled ÷ Average Cruising Speed

[3] Reference to the approved *WKCD EIA Report* [4], which is similar to the findings of site survey of 8-9 numbers per hour.

[4] Table 4-16 of *MVEIS* [3]

[5] Emission Rate = Emission Factor x Engine Power x Load Factor x Cruising Time x No. of Vessels ÷ Area of Route ÷ 3600

[6] Total Emission Rate = Emission Rate of Main Engine + Emission Rate of Auxiliary Engine

# 4 OCEAN TERMINAL

4.1.1.1 There are 2 berths for cruises at Ocean Terminal. One of them is reserved for a 40,000-ton local cruise, Star Pisces, while another berth is for international cruises. According to the cruise schedule on Ocean Terminal's website (http://www.oceanterminal.com.hk/en/schedule.php?cid=1&y=2019&m=3&f=t#CruiseSchedule), Queen Victoria, a 90,000-ton cruise is the largest cruise to the terminal with a length of 294m. Therefore, Queen Victoria was considered representative among the visiting cruises and selected for the assessment as a reasonable and conservative assumption. The auxiliary engine and boiler information is summarized in **Table 4.1**.

**Table 4.1 Auxiliary Engine and Auxiliary Boiler Information for Star Pisces and Queen Victoria**

| Parameters | Unit | Star Pisces | Queen Victoria |
|---|---|---|---|
| Name of Auxiliary / Main Engine | - | Wartsila 6R32D [1] | Sulzer 16ZA40S and 12ZA40S [2] |
| No. of Auxiliary / Main Engine | - | 4 [1] | 4 and 2 [2] |
| Power for each Engine | kW | 2220 [3] | 11520 and 8640 [4] |
| Total Main Engine Power | - | - | 63360 |
| Auxiliary Engine to Main Engine Power Ratio [5] | - | - | 0.278 |
| Total Auxiliary Engine Power | kW | 8880 | 17614 |
| Load Factor for Hotelling [6] | - | 0.416 | |
| Engine Speed | rpm | 720 [3] | 500 [4] [7] |
| Passenger Carrying Capacity | - | 1859 [8] | 3015 [9] |
| Auxiliary Boiler Power / Load for Hotelling [10] | kW | 869 | 1000 |

Notes:

[1] http://matkustajalaivat2.com/cruiseships/starcruises/starpisces1990/Technical.htm

[2] Auxiliary engine of Queen Victoria is not available. Reference was made to the main engine from http://www.nedcruise.info/eersteeng.htm.

[3] https://www.scribd.com/doc/35255987/Wartsila-Vasa-32-Project-Guide

[4] http://www.cheapower.com/photos/000270f.pdf and https://www.motorship.com/news101/industry-news/confidence-confirmed-by-further-orders

[5] Table 3-20 of *MVEIS* [3]

[6] Table 3-21 of *MVEIS* [3]

[7] Auxiliary engine of Queen Victoria is not available. A lower engine speed among the 2 main engines (500rpm and 514rpm) was assumed as a conservative approach.

[8] https://www.ctshk.com/english/special/ship/syxh-jj.htm

[9] https://www.ship-technology.com/projects/cunardqueen

[10] Table 3-23 of *MVEIS* [3]

4.2 Based on the engine manual of Wartsila 6R32D, the air flow at load factor of 41.6% for Star Pisces was estimated by interpolation according to the load factor. Due to the lack of auxiliary engine information for Queen Victoria, the exhaust gas flow of Queen Victoria was interpolated from Star Pisces according to the auxiliary engine power. The exhaust gas flows for both cruises are presented in **Table 4.2**. The emission parameters are calculated and summarized in **Table 4.3**.

**Table 4.2 Exhaust Air Flow Information of Star Pisces and Queen Victoria**

| Load Factor | Exhaust Gas Flow (kg/s) | |
|---|---|---|
| | Star Pisces | Queen Victoria |
| 100% | 4.7 | 9.3 |
| 85% | 4.1 | 8.1 |
| 75% | 3.7 | 7.3 |
| 50% | 2.7 | 5.4 |
| 41.6% | **2.4** | **4.7** |

**Table 4.3 Exhaust Parameters of Star Pisces and Queen Victoria**

| Parameters | Unit | Star Pisces | Queen Victoria |
|---|---|---|---|
| No. of Stack | - | 4 [1] | 4 [2] |
| Exhaust Gas Flow | kg/s | 2.4 | 4.7 |
| Exhaust Diameter | m | 0.6 [3] | 0.6 [2] |
| Input Air for Auxiliary Engine | kg/s | 4.60 [3] | 9.12 [4] |
| Molecular Weight of Air | g/mol | 28.97 | |
| Molecular Weight of Fuel (C14H30) | g/mol | 198.39 | |
| No. of Moles of Exhaust Air per sec | mol/s | 81.6 | 161.9 |
| No. of Moles of Exhaust Fuel per sec | mol/s | 0.254 | 0.503 |
| Total No. of Moles of Exhaust | mol | 81.86 | 162.37 |
| Standard Pressure | kPa | 101.3 | |
| Exhaust Temperature [3] | K | 448.2 | |
| Exhaust Air Flow [5] | $m^3/s$ | 3.01 | 5.97 |
| Exhaust Velocity [6] | m/s | 10.65 | 21.12 |

Notes:

[1] 4 Engines so 4 exhaust stacks.

[2] Due to the lack of auxiliary engine information of Queen Victoria, it was assumed the same as Star Pisces.

[3] Reference to the approved *WKCD EIA Report* [4]

[4] Interpolation from Star Pisces by engine power due to the lack of auxiliary engine information of Queen Victoria.

[5] By ideal gas law: PV = nRT

[6] Exhaust Velocity = Exhaust Air Flow ÷ ((Exhaust Diameter ÷ 2)$^2$ x π)

[7] Emission at 50mAG according to the approved *WKCD EIA Report* [4].

4.3 According to the cruise schedule on Ocean Terminal's website, Star Pisces berths at Ocean Terminal from 08:00 to 19:30 from Monday to Friday and from 11:00 to 19:30 during weekends. Berthing period from 08:00 and 20:00 was assumed as a conservative approach. Since the international cruises might berth there overnight, 24 hours of berthing period for Queen Victoria was assumed in the assessment. The cruise schedule from Year 2019 to 2022 has been reviewed. It was found that the number of days in a year with international cruise visiting Ocean Terminal would be ranged from 36 (Year 2022) to 61 (Year 2019), which is in line with the estimated growth rate being capped at 2019 in the Table 10-1 of *MVEIS*. Therefore, 24 hours of berthing every day over a year was assumed as a conservative approach for short-term air quality impact assessment, while 24 hours of berthing for the 1464 hours (61 days and 24 hours per day) with the highest pollutant concentrations over a year was assumed as a reasonable assumption for long-term air quality impact assessment. The emission factors were referenced to the emission limits as stated in *MARPOL 73/78 Annex VI Regulation for the Prevention of Air Pollution from Ships* and *MVEIS* [3]. All RSP emissions were assumed for FSP as a conservative approach. The emission information is summarized in **Table 4.4**.

**Table 4.4 Hotelling Emission Information for Cruises**

| Parameters | | Unit | Star Pisces | Queen Victoria |
|---|---|---|---|---|
| Hotelling Time | | hr | 12 | 24 |
| Emission Factors of Auxiliary Engine | NOx [1] | g/kWh | 12.07 | 12.98 |
| | RSP [2] | g/kWh | 0.32 | |
| Emission Rates of Auxiliary Engine [3] | NOx | g/s | 12.39 | 26.43 |
| | RSP | g/s | 0.33 | 0.65 |
| Emission Factors of Auxiliary Boiler [4] | NOx | g/kWh | 2.00 | |
| | RSP | g/kWh | 0.19 | |
| Emission Rates of Auxiliary Boiler [5] | NOx | g/s | 0.48 | 0.56 |
| | RSP | g/s | 0.05 | 0.05 |
| Total Emission Rates per Exhaust [6] | NOx | g/s | 3.22 | 6.75 |
| | RSP | g/s | 0.09 | 0.18 |

Notes:

[1] Emission limit for Tier 1 engines stated in *MARPOL 73/78 Annex VI Regulation for the Prevention of Air Pollution from Ships*, from

http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-(NOx)-%E2%80%93-Regulation-13.aspx

[2] Table 3-28 of *MVEIS* [3]. Emission factors for MGO (sulphur content of 0.5%) fuel was adopted.

[3] Emission Rate = Emission Factor x Engine Power x Load Factor ÷ 3600

[4] Table 3-29 of *MVEIS* [3]. Emission factors for MGO (sulphur content of 0.5%) fuel was adopted.

[5] Emission Rate = Emission Factor x Engine Power ÷ 3600

[6] Total Emission Rate = Emission Rate of Auxiliary Engine + Emission Rate of Auxiliary Boiler

# 5 PLANNED PIERS AT WKCD

5.1.1.1 Two planned piers would be developed at the southern and northern sides of the WKCD for the potential marine traffic demand during WKCD's event periods and a new marine service within Victoria Harbour. According to the proposed schedule provided by Transport Department, there would be a maximum of 4 regular in-harbour marine services daily from 11:00 to 21:00 using the southern pier. As there is no information available for the northern pier at the time of study, the northern pier was not taken into account in the assessment. The latest location of the southern pier as advised by WKCDA was adopted in the assessment.

In-harbour Marine Vessels Berthing at the Southern Pier of WKCD

5.2 Due to the lack of available information of the marine vessels to be used for in-harbour services, the passenger vessels were assumed to be ferries. According to Transport Department's website and information provided by Transport Department, Fortune Ferry Company would be the operator of the ferry services and the expected passenger carrying capacity is about 150 persons. Vessel type of "Others" was therefore assumed with reference to the approved *Tung Chung New Town Extension EIA Report* (*TCNTE EIA Report*) [8], where the ferry services are also provided by Fortune Ferry Company. During hotelling mode, the in-harbour marine vessels rely on the auxiliary engines to supply electrical needs. Emission during hoteling at the pier was modelled as "POINT" source with AERMOD. Vertical plume was assumed for the hotelling emission at 1mAG, with exit temperature of 373K, exit velocity of 0m/s and stack diameter of 0.3m with reference to the approved *TCNTE EIA Report* [8]. These assumptions are also applicable for a ferry of similar size (with an approximate passenger carrying capacity about 160 persons) based on observation. The auxiliary engine information for the in-harbour marine vessels and location of the southern pier are summarized in **Table 5.1**.

**Table 5.1 Auxiliary Engine Information and Locations of Pier for In-harbour Marine Vessels**

| Parameters | Unit | In-harbour Marine Vessels | |
|---|---|---|---|
| Coordinates for Southern Pier | - | X-Coordinate | Y-Coordinate |
| | | 834397.6 | 817838.7 |
| Auxiliary Engine Power [1] | kW | 115 | |
| Load Factor for Hotelling [2] | - | 0.43 | |

Notes:

[1] Table 4-6 of MVEIS [3]. Vessel type "Others" with the max. engine power was assumed.

[2] Table 4-10 of *MVEIS* [3]

5.3 Each vessel was assumed to hotel at the pier for 5 minutes with reference to the approved *TCNTE EIA Report* [8]. The emission factors were referenced to *MVEIS* published by HKUST [3]. All RSP emissions were assumed for FSP as a conservative approach. The average emission rates for each vessel are presented in **Table 5.2**.

**Table 5.2 Hotelling Emission Information for In-harbour Marine Vessels**

| Parameters | | Unit | In-harbour Marine Vessels |
|---|---|---|---|
| Hotelling Time [1] | | hr | 0.08 |
| Emission Factors of Auxiliary Engine [2] | NOx | g/kWh | 10 |
| | RSP | g/kWh | 0.4 |
| Emission Rates for Hotelling for each Vessel [3] | NOx | g/s | 1.145E-02 |
| | RSP | g/s | 4.579E-04 |

Notes:

[1] 5 minutes for hoteling was assumed with reference to the approved *TCNTE EIA Report* [8].

[8] Civil Engineering and Development Department. 2015. *Tung Chung New Town Extension EIA Report*. Prepared by Ove Arup & Partners Hong Kong Ltd.

[2] Table 4-16 of *MVEIS* [3]
[3] Emission Rate = Emission Factor x Engine Power x Load Factor x Hotelling Time ÷ 3600

In-harbour Marine Vessel Movement in Victoria Harbour

5.4 During cruising mode, the in-harbour marine vessels cruise with main engine and auxiliary engine at a max. speed of 10 knots according to the Schedule 4 of CAP 313A. Emissions from the in-harbour marine vessels cruising within Victoria Harbour were modelled as "AREA" sources with AERMOD with a route width of 30m and an exhaust height of 1mAG with reference to the approved *TCNTE EIA Report* [8]. The engine information for the in-harbour marine vessels and locations of the cruising route presented in **Table 5.3**.

**Table 5.3 Engine Information for In-harbour Marine Vessels and Locations of Cruising Route**

| Parameters | Unit | In-harbour Marine Vessels | |
|---|---|---|---|
| Coordinates for Cruising Route | - | X-Coordinate | Y-Coordinate |
| | | 834383.1 | 817831.8 |
| | | 834472.8 | 817733.9 |
| Main Engine Power [1] | kW | 707 | |
| Main Engine Load Factor [2] | - | 0.45 | |
| Auxiliary Engine Power [3] | kW | 115 | |
| Auxiliary Engine Load Factor [4] | - | 0.43 | |

Notes:
[1] Table 4-5 of *MVEIS* [3]. Vessel type "Others" with the max. engine power was assumed.
[2] Table 4-7 of *MVEIS* [3]. Slow cruise was assumed based on the speed limit of 10 knots for Victoria Harbour according to Schedule 4 of CAP 313A as a conservative approach.
[3] Table 4-6 of *MVEIS* [3]. Vessel type "Others" with the max. engine power was assumed.
[4] Table 4-10 of *MVEIS* [3]. Slow cruise was assumed based on the speed limit of 10 knots for Victoria Harbour according to Schedule 4 of CAP 313A as a conservative approach.

5.5 The emission factors were referenced to *MVEIS* published by HKUST [3]. All RSP emissions were assumed for FSP as a conservative approach. The emission factors and emission rates for each in-harbour marine vessels are presented in **Table 5.4** below.

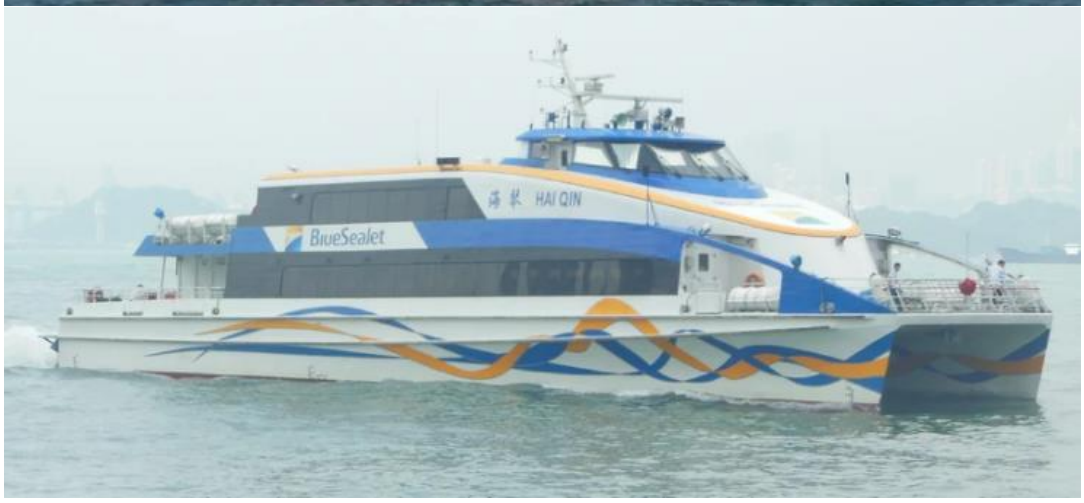
**Table 5.4 Emission Information for each In-harbour Marine Vessel Movement**

| Parameters | | Unit | In-harbour Marine Vessels |
|---|---|---|---|
| Distance Travelled | | m | 265.66 |
| Victoria Harbour Speed Limit [1] | | knots | 10 |
| | | km/hr | 18.5 |
| Cruising Time [2] | | hr | 0.01 |
| Area of Route | | $m^2$ | 7969.80 |
| Emission Factors of Main Engine [3] | NOx | g/kWh | 10 |
| | RSP | g/kWh | 0.3 |
| Emission Factors of Auxiliary Engine [3] | NOx | g/kWh | 10.0 |
| | RSP | g/kWh | 0.4 |
| Emission Rates of Main Engine [4] | NOx | $g/m^2/s$ | 1.591E-06 |
| | RSP | $g/m^2/s$ | 4.772E-08 |
| Emission Rates of Auxiliary Engine [4] | NOx | $g/m^2/s$ | 2.472E-07 |
| | RSP | $g/m^2/s$ | 9.889E-09 |
| Total Emission Rates for each In-harbour Marine Vessel Movement [5] | NOx | $g/m^2/s$ | 1.838E-06 |
| | RSP | $g/m^2/s$ | 5.761E-08 |

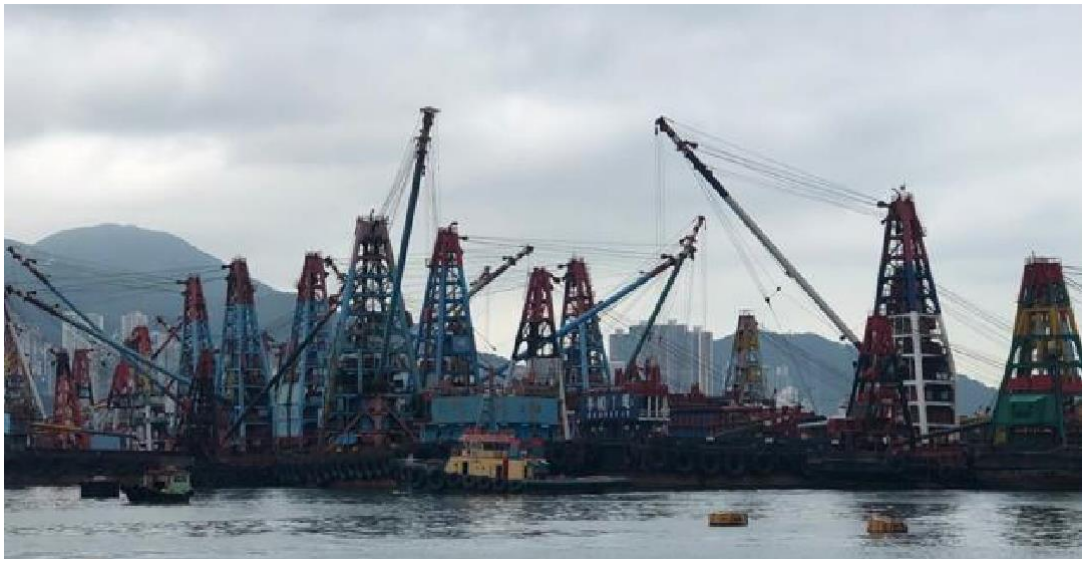
Notes:
[1] Schedule 4 of Shipping and Port Control Regulations (CAP 313A), as illustrated in https://www.mardep.gov.hk/en/publication/pdf/hps_speed_limit.pdf.
[2] Cruising Time = Distance Travelled ÷ Max. Allowable Cruising Speed in Victoria Harbour
[3] Table 4-16 of *MVEIS* [3]
[4] Emission Rate = Emission Factor x Engine Power x Load Factor x Cruising Time ÷ Area of Route ÷ 3600
[5] Total Emission Rate = Emission Rate of Main Engine + Emission Rate of Auxiliary Engine

**Annex A – Photos of Typical Vessels for Each Vessel Type Identified within the Study Area**

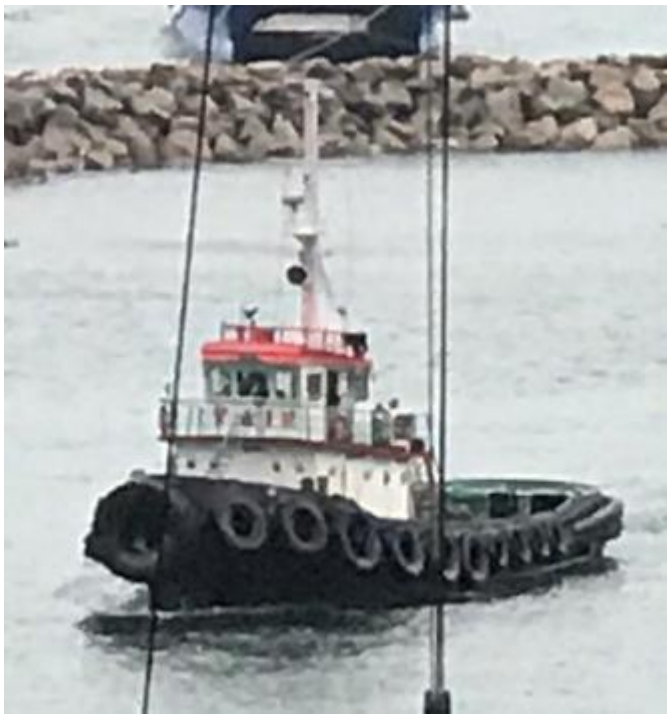
Macau and China Ferries


Derrick Lighter Barge



Tug



Cruise

## Annex B – Site Surveys for Tug Movement Entering and to NYMTTS

27 Nov 2019

| Time | Number of Vessels Entering / Leaving NTMTTS |
|---|---|
| 13:00 – 14:00 | 6 |
| 14:00 – 15:00 | 9 |
| 15:00 – 16:00 | 8 |
| 16:00 – 17:00 | 8 |

8 Jun 2020

| Time | Number of Vessels Entering / Leaving NTMTTS |
|---|---|
| 08:00 – 09:00 | 8 |
| 09:00 – 10:00 | 7 |
| 10:00 – 11:00 | 4 |
| 11:00 – 12:00 | 5 |