Air Emission Inventory Overview – Glycol Expansion Project

Pacific Coast Terminals Co. Ltd.

Prepared for:
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INTRODUCTION

Pacific Coast Terminals Co. Ltd. (PCT) is a multi-purpose marine bulk terminal located in Vancouver Fraser Port Authority (VFPA) on the Burrard Inlet in Port Moody, British Columbia. PCT handles shipments of sulphur, ethylene glycol, canola oil, and potash on a regular basis. PCT has announced its intentions to undertake an expansion of its ethylene glycol operations (Glycol Expansion Project), allowing for increased throughput to accommodate rising market demands.

The Emission Inventory presented in this report supports the application to accommodate the proposed Glycol Expansion Project. The scope of this inventory includes a comparison of emissions of ethylene glycol related operations with and without the Glycol Expansion Project.

The expected changes in operations due to the Glycol Expansion Project include: increases in marine traffic/product loaded onto ships for export, the addition of a rail track (to accommodate an increased number of railcars per train), and increased material handling and transfers in/out of storage tanks. Hence, the emission sources included in this inventory are as follows:

- Ethylene glycol marine vessel calling at the PCT terminal, and associated tugboat assist activities
- Ethylene glycol rail locomotives arriving and departing from the PCT site
- Ethylene glycol handling/storage at the PCT site

Projected ethylene glycol related annual activity levels for these sources are presented in **Table 1** below:

Table 1: Ethylene Glycol-Related Annual Activity Levels – Current and With Expansion Project

Activity		Current	With Glycol Expansion Project
Marine Vessel Calls		46	65
Rail Activity	Trains	257	257
	Railcars per Train	39	50
Material Handling/Storage*		889,500 tonnes/yr	1,250,000 tonnes/yr

*Note: Throughput values shown in the table are based on recent throughput data from 2020 and projected throughput values with the Glycol Expansion Project. For reference, recent throughput values for 2017, 2018 2019, 2020, and 2021 are 812,743, 710, 681, 766,000, 889,500 and 721,800 tonnes/yr respectively. 2020 was chosen as it is considered representative of likely maximum future activity rates with no glycol expansion project.

The emission estimates include the following air contaminants:

Criteria Air Contaminants (CACs):

Nitrogen oxides (NO_x), sulphur oxides (SO_x), carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM, as total PM, PM_{10} and $PM_{2.5}$) and ammonia (NH_3)

Greenhouse Gases (GHGs):

Carbon dioxide equivalent (CO_2e), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)

Diesel Particulate Matter (DPM)

Black Carbon (BC)

Releases of other compounds are not considered to be significant and have not been included in this inventory.

INVENTORY SCOPE/DETAILS

The primary objective of this Emission Inventory is to provide an overview of the projected impact that proposed Glycol Expansion Project will have on on-site air emissions and off-site supply chain air emissions.

The PCT site is defined by the property line and includes all rail unloading and ship loading activities. On-site rail locomotive travel starts from the site entrance gate and on-site marine vessel activity includes emissions from ships while at berth. The off-site supply chain geographic boundary has been developed for rail and marine vessel travel. The rail supply chain boundary extends from the site entrance gate to the rail switch yard located approximately 6.4 km east of the site, which is where rail cars are combined prior to travel to the PCT site. Typically, different combinations of rail cars will arrive at the switch yard from different origins, at which point rail cars will be combined for different destinations, including PCT or other destinations farther away. Based on the complexity of activities at the switch yard, it was determined that this was an appropriate extent of the offsite supply chain geographic boundary. The site marine vessel supply chain boundary extends from PCT berths past the Lions Gate Bridge and Burrard Inlet, ending at the limit of VFPA jurisdiction in the Strait of Georgia. **Figure 1**, illustrating the supply chain boundaries considered for this emission inventory is shown below for reference.

Figure 1: Supply Chain Boundary

As summarized in **Table 1**, the Glycol Expansion Project is expected to allow PCT to handle 1,250,000 tonnes of ethylene glycol per year. Due to expected increases in throughput and as a conservative estimate, PCT is projected to accommodate up to 65 ship calls per year in the expansion scenario. It is worth noting however that as ship calls are influenced by vessel capacity, the actual number of ships may be significantly lower in the future (as vessel capacity continue to increase). Vessel capacity is not controlled by PCT but by shipping companies.

Marine vessel emissions associated with the ethylene glycol related operations are produced from tankers carrying the product and the tugboats that assist in vessel maneuvering. Commercial ships such as tankers are considered to have three sources of combustion emissions: the main engine (ME), the auxiliary engines (AE), and the boilers. When at berth or anchoring, the ship's auxiliary engines and boilers operate to power ship equipment, including the operation of cranes used for loading. When maneuvering or in transit, the ship's main engines also operate for propulsion. To be consistent with previous emission inventories completed for PCT [1], 34,000 DWT tankers were used as the representative/average ship size used for ethylene glycol transport.

The activity times considered for ship-related operations are consistent with estimated activity times presented in previous inventories [1] and were determined based on a combination of previous annual occupancy data, projections provided by PCT, and data provided by Port Metro Vancouver (PMV). A breakdown of the activity times considered for ship-related activity used for this inventory is shown in **Table 2** for reference. Additional details are included in Appendix A for reference.

Table 2: Ship Activity Times

Ship	Activity Times Per Ship Call (h)			
	In transit	Berth	Anchor	Maneuvering
Tanker 34,000 DWT[(a)]	1	81	32	4
Tug	-	-	-	7.5[(b)]

a) 34,000 DWT tankers were selected as the average/representative ship size used for Ethylene Glycol transport
b) Total hours of maneuvering activity for all tugs per ship call

Rail operations related to ethylene glycol transport are completed using 'switching' locomotives operated by CP Rail. Before railcars are unloaded, they are positioned in the unloading area by the railway. Once there, cars are secured in position and unloaded. After the liquid contents of the railcars are pumped to storage tanks, empty railcars are replaced with loaded ones by the railway and the process is repeated. Empty railcars are removed from the site and returned to the CP Rail switching yard in preparation for their return trip to various plants of origin in Alberta.

The activity times considered for rail-related operations were determined based on previous annual occupancy data [1] and projections provided by PCT. Although it is expected that there will not be any changes to the number of trains in the expansion scenario, the number of railcars per train is expected to increase due to anticipated changes to rail infrastructure on-site, leading to increases in switchyard activity.

A summary of the rail related activity times used for this inventory is shown in **Table 3**.

Table 3: Rail Activity Times

Delivery Engine Type	Activity Times Per Delivery (minutes)				
	On-site Idling	On-Site Travel	Off-Site Travel	Switchyard Activity	
				Current	With Glycol Expansion Project
Switcher	320	16	128	240	360

Due to the anticipated increase in number of railcars per train in the expansion scenario, switchyard activity is expected to increase from 240 minutes per delivery (in the current scenario) to 360 minutes per delivery (for the expansion scenario, based on an increased number in expected switcher movements). Other rail-related activity (e.g., idling, work on/off site) is expected to be similar to current levels as the projected number of trains for the expansion scenario is the same.

VOC emissions due to ethylene glycol storage/material handling emissions are the sum of breathing losses (Standard Classification Code – 40705603), working losses (Standard Classification Code –

40705604) [3] and ship loading operations. Emission from breathing losses are based on storage capacity while working losses are based on current/project ethylene glycol throughput levels. Emission from ship loading operations are based on maximum operating hours and limits in PCT's Air Emissions Permit with Metro Vancouver.

To note, projected post glycol expansion emissions are conservative and contain additional safety margins as fuel consumption rates/best available technologies/fuel regulations were assumed to be constant in the two scenarios. As time progresses and technologies improve, more efficient engines, controls, and stringent fuel regulations are anticipated which would result in further emission reductions.

Estimated emissions for on-site and offsite operations related to ethylene glycol for marine, rail, and material handling/storage are shown below in **Table 4** and **Table 5** respectively. Estimated combined emissions for on-site and off-site supply chain operations related to ethylene glycol for marine, rail, and material handling/storage are shown below in **Table 6**.

EMISSION REDUCTION MEASURES/INITIATIVES

Emission changes due to the expansion project can be primarily attributed to increases in marine vessel activity. Increases in marine vessel activity are based on conservative supply/demand estimates and vessel size estimates which are dependant on 3rd party shipping parties.

While vessel traffic may increase, trains and other possible sources are expected to remain consistent. PCT handles ethylene glycol using industry leading control technologies such us nitrogen blanket and breathing/working losses are minimal and not expected to be affected by this increase in throughput.

Although mitigation measures and technologies related to marine vessels are not directly under PCT control, PCT intends to continue their commitment to minimizing their emission impacts in controllable areas of operation, while accommodating increasing market demands for the movement of goods in the region.

Over the years and as a result of their commitment to the environment, PCT has attained certification and member status in the Green Marine and Climate Smart environmental programs.

EMISSION INVENTORY RESULTS

Table 4: Ethylene Glycol Project – On-Site Emissions Overview

Scenario	Throughput	Category	NOx	SOx	CO	VOCs	PM_{10}	$PM_{2.5}$	DPM	Black Carbon	NH_3	CO_2	CH_4	N_2O	$CO_2e^{(a)}$
	Tonnes Glycol/yr		Tonnes/yr												
Current	889,500	Marine Vessels	17.62	1.24	2.99	0.56	0.52	0.47	0.47	0.21	0.01	1980.67	0.18	0.05	2000.02
		Rail	2.82	0.00	0.64	0.31	0.07	0.06	0.06	0.06	0.00	246.61	0.01	0.10	277.35
		Storage	-	-	-	0.52	-	-	-	-	-	-	-	-	-
		TOTAL	**20.44**	**1.24**	**3.63**	**1.39**	**0.59**	**0.54**	**0.54**	**0.26**	**0.01**	**2227.28**	**0.19**	**0.15**	**2277.37**
With Glycol Expansion Project	1,250,000	Marine Vessels	24.89	1.76	4.23	0.79	0.73	0.67	0.67	0.29	0.01	2798.77	0.25	0.07	2826.11
		Rail	3.71	0.00	0.84	0.40	0.09	0.08	0.08	0.07	0.00	310.33	0.02	0.13	349.01
		Storage	-	-	-	0.60	-	-	-	-	-	-	-	-	-
		TOTAL	**28.60**	**1.76**	**5.07**	**1.79**	**0.82**	**0.75**	**0.75**	**0.37**	**0.01**	**3109.10**	**0.27**	**0.20**	**3175.12**
Difference (+/-)			**+8.16**	**+0.51**	**+1.44**	**+0.40**	**+0.24**	**+0.22**	**+0.22**	**+0.10**	**0.00**	**+881.82**	**+0.08**	**+0.05**	**+897.75**

a) 100-Year Horizon Year Global Warming Potential

Table 5: Ethylene Glycol Project – Supply Chain Emissions Overview

Scenario	Throughput	Category	NOx	SOx	CO	VOCs	PM_{10}	$PM_{2.5}$	DPM	Black Carbon	NH_3	CO_2	CH_4	N_2O	$CO_2e^{(a)}$
	Tonnes Glycol/yr		Tonnes/yr												
Current	889,500	Marine Vessels	15.38	0.35	1.73	0.49	0.35	0.32	0.32	0.02	0.01	884.32	0.09	0.02	893.83
		Rail	4.81	0.00	1.09	0.53	0.11	0.11	0.11	0.09	0.00	209.72	0.01	0.09	235.86
		TOTAL	**20.20**	**0.35**	**2.82**	**1.01**	**0.47**	**0.43**	**0.43**	**0.11**	**0.01**	**1094.04**	**0.11**	**0.11**	**1129.69**
With Glycol Expansion Project	1,250,000	Marine Vessels	21.74	0.50	2.44	0.69	0.50	0.45	0.45	0.03	0.01	1249.58	0.13	0.03	1263.02
		Rail	4.81	0.00	1.09	0.53	0.11	0.11	0.11	0.09	0.00	209.72	0.01	0.09	235.86
		TOTAL	**26.55**	**0.50**	**3.53**	**1.22**	**0.61**	**0.57**	**0.57**	**0.12**	**0.01**	**1459.30**	**0.15**	**0.12**	**1498.88**
Difference (+/-)			**+6.35**	**+0.14**	**+0.71**	**+0.20**	**+0.15**	**+0.13**	**+0.13**	**+0.01**	**0.00**	**+365.26**	**+0.04**	**+0.01**	**+369.19**

a) 100-Year Horizon Year Global Warming Potential

Table 6: Ethylene Glycol Project – On-Site + Supply Chain Emissions Overview

Scenario	Throughput	Category	NOx	SOx	CO	VOCs	PM_{10}	$PM_{2.5}$	DPM	Black Carbon	NH_3	CO_2	CH_4	N_2O	CO_2e[(a)]
	Tonnes Glycol/yr		Tonnes/yr												
Current	889,500	Marine Vessels	33.00	1.59	4.72	1.05	0.87	0.79	0.79	0.23	0.01	2864.99	0.27	0.07	2893.85
		Rail	7.64	0.00	1.74	0.83	0.18	0.18	0.18	0.15	0.00	456.33	0.03	0.19	513.21
		Storage	-	-	-	0.52	-	-	-	-	-	-	-	-	-
		TOTAL	**40.64**	**1.60**	**6.45**	**2.40**	**1.05**	**0.97**	**0.97**	**0.38**	**0.01**	**3321.32**	**0.30**	**0.26**	**3407.06**
With Glycol Expansion Project	1,250,000	Marine Vessels	46.63	2.25	6.67	1.48	1.23	1.12	1.12	0.32	0.02	4048.35	0.39	0.10	4089.13
		Rail	8.52	0.01	1.94	0.93	0.20	0.20	0.20	0.16	0.00	520.04	0.03	0.22	584.86
		Storage	-	-	-	0.60	-	-	-	-	-	-	-	-	-
		TOTAL	**55.15**	**2.26**	**8.60**	**3.01**	**1.44**	**1.32**	**1.32**	**0.48**	**0.02**	**4568.39**	**0.42**	**0.32**	**4674.00**
Difference (+/-)			**+14.51**	**+0.66**	**+2.15**	**+0.61**	**+0.38**	**+0.35**	**+0.35**	**+0.11**	**+0.01**	**+1247.08**	**+0.12**	**+0.06**	**+1266.94**

a) 100-Year Horizon Year Global Warming Potential

CONCLUSION

Based on this assessment of the potential air emissions associated with the Glycol Expansion Project, and although emissions are expected to increase from current operations, projected emissions are conservative and proportional to activity/throughput changes. Overall emissions on an intensity basis (e.g., emissions/unit throughput) for ethylene glycol operations with expansion are projected to be similar-to/less than PCT's emission intensity in the current case (as shown in **Table 7**). Since emissions resulting from glycol handling are minor relative to overall facility emissions, increases in air emissions are not expected to be an item of concern in this project.

Table 7: Ethylene Glycol Project Emissions Intensity Comparison – On-Site + Supply Chain

Scenario	NOx	SOx	CO	VOCs	PM_{10}	$PM_{2.5}$	DPM	Black Carbon	NH_3	CO_2	CH_4	N_2O	CO_2e[a]
	Emissions Intensity (Tonnes Emissions/1000 Tonnes Ethylene Glycol Throughput)												
Current	0.05	1.80E-03	7.25E-03	2.70E-03	1.18E-03	1.09E-03	1.09E-03	4.22E-04	1.67E-05	3.73	3.37E-04	2.95E-04	3.83
With Glycol Expansion Project	0.04	1.81E-03	6.88E-03	2.41E-03	1.15E-03	1.05E-03	1.05E-03	3.88E-04	1.66E-05	3.65	3.33E-04	2.56E-04	3.74
% Difference	**-3%**	**0%**	**-5%**	**-11%**	**-3%**	**-3%**	**-3%**	**-8%**	**-1%**	**-2%**	**-1%**	**-13%**	**-2%**

a) 100-Year Horizon Year Global Warming Potential

APPENDIX A: EMISSIONS METHODOLOGY

MARINE VESSELS

Tankers

As noted above, marine vessel emissions associated with the ethylene glycol project are produced from tankers carrying the product and the tugboats that assist in vessel maneuvering. Commercial ships such as tankers are considered to have three sources of combustion emissions: the main engine (ME), the auxiliary engines (AE), and the boilers. When at berth or anchoring, ships auxiliary engines and boilers operate to power ship equipment, including the operation of cranes used for loading. When maneuvering or in transit, the ships main engines also operate for propulsion.

The general calculation of emissions for ships is shown in Equation 1 below

Equation 1:

Emissions (tonnes/y) = [EF (g/kW-hr) * Traffic Count (ships/y) * Ship Engine Size (kW/ship) * Load Factor* Activity time (hr) * 1 tonne/ 1,000,000 g]

Ship engine size for ethylene glycol tankers, and load factors are consistent with previous PCT emission inventories [1] and are based on assessment data and/or derived from the Marine Emissions Inventory Tool 4.0 (MEIT) developed by Transport Canada and Environment Canada. Activity-based emission factors for tankers and tugboat engines are also consistent with factors used in previous PCT emission inventories and are derived from MEIT.

Tanker details including engine power/load factors during various activities and emission factors are presented in Table A- 1 and Table A- 2 for reference.

Table A- 1: Tanker Details

Size Category	Representative Capacity	Engine Type	Engine Power (kW)	Engine Load			
				In Transit	Maneuvering	Berthed	Anchoring
Tanker	34,000 DWT	ME	7,400	0.4	0.1	-	-
		AE	900	0.3	0.3	0.3	0.3

Table A- 2: Tanker AE/ME Emission Factors

Ship Type	Engine Type	units	NOx	SOx[b]	CO	VOC	PM_{10}	$PM_{2.5}$	DPM	Black Carbon	NH_3	CO_2	CH_4	N_2O
Tanker	AE	g/kW-h	12.5[a]	0.42	1.1	0.4	0.3	0.27	0.27	0.007	0.001	670	0.06	0.017
	ME		16.6[a]	0.42	1.4	0.6	0.3	0.27	0.27	0.007	0.021	621	0.06	0.017

a) based on a weighted average of IMO EFs and approximate ship age distribution. Approximate ship age distribution is as follows: 0-5 years: 25%, 6-10 years: 20%, 11-15 years: 15%, 16-20 years: 15%, >20 years 25%
b) fuel sulphur level of 0.1% assumed for ships and engines based on mandates by the International Maritime Organization for all vessels operating within emission control areas.
c) $PM_{2.5}$ factors are assumed to be 92% of PM_{10} factors[4]. DPM is assumed to be equal to $PM_{2.5}$ per the EPA NONROAD Model

The emission factors were combined with effective engine power settings, annual ship calls, and the activity levels highlighted in Table 2, to determine emissions in tonnes of pollutant per year according to Equation 1.

The activity times considered for ship-related operations (Table 2) are consistent with estimated activity times presented in previous inventories and are based on provided data as well as estimates based on distances travelled, tug assist distances, and ship speeds. Where applicable, information provided by the PMV from the Narrows Movement Restricted Area (MRA) Procedures and the Harbour Operations Manual [5] were used.

Ships travelling in transit mode through Georgia Strait are restricted to a speed of 12 knots. Ships enter the harbour in transit mode from the Georgia Strait to the Lions Gate Bridge, and then slow down to manoeuvring mode. Within the inner harbour east of the Lions Gate Bridge, ships are required to travel at a safe speed, sufficient for the vessel to take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions. The speed of the vessel must also have due regard for small craft, towing, log loading, bunkering, diving operations. Since the Harbour Operations Manual does not specify a numerical speed limit in this portion of the harbour, the speed of all PCT vessels in this portion of manoeuvring mode operations has been assumed to be 9 knots.

As ships approach the Second Narrows Bridge and travel through the Movement Restricted Area (MRA), they slow down further to 6 knots, and this is often where tugs will begin to escort the ships to the PCT berths. Some ships, particularly tankers, may receive escorts through the inner harbour to the Lions Gate Bridge, but this is not always the case. To be conservative, and to account for some ships that may have tug escorts prior to reaching the MRA, it has been assumed that tugs assist the ships all the way to PCT. Upon leaving the MRA east of Berry Point, they speed up and continue to manoeuvre to berth. When berths are not available, ships wait in anchor mode in English Bay, west of the Lions Gate Bridge. Ships remain at berth while loading and unloading.

A figure summarizing marine activity parameters and distances is shown in Figure A- 1 below.

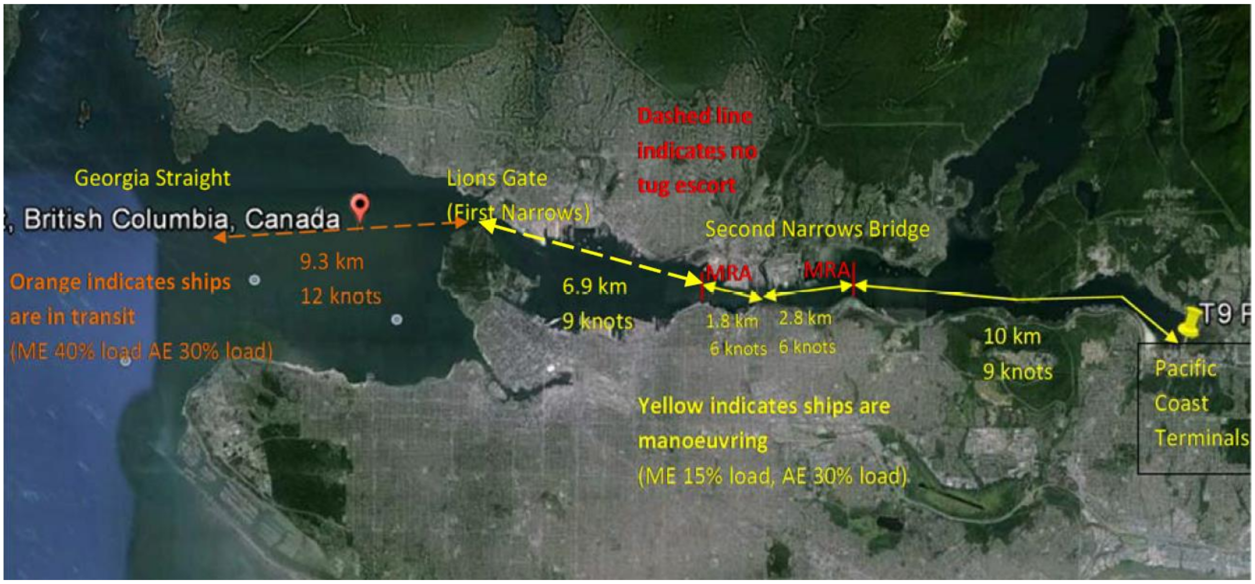

Figure A- 1: Distance, Speed and Tug Assist Details for Marine Vessels

Boilers in ships are not associated with ship propulsion. Boilers provide heat and hot water and they also warm residual fuel oil prior to use. Boiler sizes in general are not correlated with the size of the ship. Boiler emission calculation methodology follows the same general approach as previously described for the ships, except it is based on fuel consumption instead of engine size as shown in Equation 2 below.

Equation 2:

Emissions (kg/period) = [EF (kg/tonnes fuel) * Traffic Count (ships/period) * Fuel Consumption Rate (tonnes fuel/h) * Activity time (hr)]

Boilers operate while ships are manoeuvring and while at berth, and therefore share the same assumptions as identified for ships with respect to ship movements and activity times. A boiler fuel consumption rate of 0.11 tonnes/hr was used based on Tanker boiler fuel consumption rates from MEIT.

Similar to ship emission factors, boiler emission factors are consistent with factors used in previous PCT emission inventories [1]. Boiler emission factors are expressed in kg/tonne of fuel used and were primarily obtained from MEIT. Since information on Black Carbon emission rates from ship boilers were not readily available, the conservative assumption that Black Carbon is equivalent to $PM_{2.5}$ was applied. Boiler emission factors are shown in Table A- 3 for reference.

Table A- 3: Boiler Emissions Factors

Engine Type	units	NOx	SOx[b]	CO	VOCs	PM_{10}	$PM_{2.5}$	DPM	Black Carbon	NH_3	CO_2	CH_4	N_2O
Boiler	kg/tonne fuel	12.3	2.0	4.6	0.38	0.53	0.49	0.49	0.49	0.01	3188	0.29	0.08

a) fuel sulphur level of 0.1% assumed for ships and engines based on mandates by the International Maritime Organization for all vessels operating within emission control areas.
b) $PM_{2.5}$ factors are assumed to be 92% of PM_{10} factors [4]. DPM is assumed to be equal to $PM_{2.5}$ per the EPA NONROAD Model

Tugs

Tugboats assist the ships in manoeuvring to and from the port. Tugs do not berth near the PCT facility and therefore manoeuvring is the only activity assessed for tugs. The tugboat emission calculation methodology follows the same general approach as previously described for the ships.

Equation 3:

Emissions (tonnes/y) = [EF (g/kW-hr) * Traffic Count (tugs/y) * Tug Engine Size (kW/tug) * Load Factor* Activity time (hr) * 1 tonne/ 1,000,000 g]

Assumptions for tug related activities are consistent with previous PCT emission inventories and include the following:

- Fuel type is marine diesel oil
- Main engine load of 32% during maneuvering
- Engine power of 4500 kW; and
- 7.5 hours of tug manoeuvring per ship call

The 7.5 hours of tug manoeuvring per ship call is based on an estimated 3 tugs per ship during approach, 2 tugs per ship during departure, and an approximate escort time of 1.5 hours per approach/departure (between the west end of the MRA and PCT). A load factor of 32% is assumed for manoeuvring based on an evaluation of tugboats prepared for the California Air Resources Board (CARB) by the University of California [6].

Since MEIT tug emission factors consider ocean going tugs, emission factors from other sources were used to represent emissions for the harbour tugs in this study. To be conservative, Tier 1 emission factors were used where applicable. Since NH_3 and black carbon emissions factors for tugs are not readily available, typical factors for ships were applied as a best estimate. Tug emission factors used in this study are consistent with factors used in previous PCT emission inventories and are shown in Table A- 4 for reference.

Table A- 4: Tugboat Emission Factors

Ship Type	units	NOx	SOx	CO	VOCs	PM_{10}	$PM_{2.5}$	DPM	Black Carbon	NH_3	CO_2	CH_4	N_2O
Tug	g/kW-h	9.8	0.0063	1.5	0.27	0.25	0.23	0.23	0.007	0.005	690	0.09	0.020

NOx, CO, VOC, CH_4 and N_2O emission factors based on Category 1 Harbor Vehicles [4]
NH_3 emission factor per MEIT 4.0 for ships
SO_2 emission factor per MEIT 4.0, assuming a sulphur level of 0.0015% as mandated by the Sulphur in Diesel Fuel Regulations
PM emission factor per MEIT 4.0, PM_{10} = PM and $PM_{2.5}$ = 92% PM_{10}[4], DPM=$PM_{2.5}$
Black Carbon emission factor = 0.007 g/kW-h per Murphy, et. al [7]

RAIL

Rail operations related to ethylene glycol transport are completed using ‘switching’ locomotives operated by CP Rail. The assessment of emissions for rail locomotives related to ethylene glycol operations include both switch delivery locomotives as well as on-site switch yard locomotive activities. Approaches to calculating emission rates varied depending on the contaminant being assessed. In general, emission rates were defined for each contaminant based on emission factors and locomotive parameters.

The general rail locomotive emissions calculation is as follows:

Equation 4:

Emissions (tonnes/year) = [Emission Rate (kg/hr-locomotive) * Traffic Count (trips/period) * Locomotives (locomotives/trip) * Operating Time (hr)]

The parameters used to estimate the rail locomotive emission rates include power rating, load factors, fuel consumption rates, duty cycles, and estimated engine tiers. The switchers in the locomotive fleet are assumed to have a power rating of 3,800 hp and have Tier 1 engines.

The Railway Association of Canada (RAC) duty cycle for switcher locomotives as published in the Locomotive Emissions Monitoring Program 2010 [2] was used for all yard switcher locomotives that break apart and reassemble unit trains at PCT. However, for the switcher and line-haul locomotives that deliver commodities to the PCT site, the RAC duty cycle was considered unrepresentative of the type of activity that these locomotives would experience in the short distances of track between PCT and the off-site project boundary at the CP rail switchyard. Instead, it was assumed that the unit train delivery locomotives operate 50% in notch 2 and 50% in notch 3 from the CP switchyard to the PCT site. It was assumed that while the unit train is disassembled by the smaller yard switchers at the PCT site, the delivery locomotives are in idle mode. The load factors for the throttle settings were derived from the Port of Long Beach 2007 Air Emissions Inventory [8]. The rail parameters considered for the inventory are summarized in Table A-5 and are consistent with parameters used in previous PCT emission inventories [1].

Table A- 5: Switch Locomotive Effective Power and Fuel Consumption

Parameter	Throttle Notch Position										Total
	Idle	1	2	3	4	5	6	7	8	Dynamic Brake	
Percent of Time in Notch Position.[1]	0.8	4.7	14.2	27.8	42	57.3	72.5	89.7	105.3	3.8	-
Effective Power [hp]	30.4	179	540	1056	1596	2177	2755	3409	4001	144	-
Effective Fuel Consumption [L/hr][2, 3]	25.5	49.7	93.4	194.2	295.4	385.7	544.9	665.9	761.1	33.4	-
Idle											
Percent of Time in Notch Position.[1]	100	-	-	-	-	-	-	-	-	-	100
Effective Power [hp]	30.4	-	-	-	-	-	-	-	-	-	30.4
Effective Fuel Consumption [L/hr] [2, 3]	25.5	-	-	-	-	-	-	-	-	-	25.5
Delivery Work On-Site/Off-Site											
Percent of Time in Notch Position.[1]	-	-	50	50	-	-	-	-	-	-	100
Effective Power [hp]	-	-	269.8	528.2	-	-	-	-	-	-	798
Effective Fuel Consumption [L/hr] [2, 3]	-	-	46.7	97.1	-	-	-	-	-	-	143.8
Yard Switching Work On-Site											
Duty Cycle (%)[4]	84.9	5.4	4.2	2.2	1.4	0.6	0.3	0.2	0.6	0.2	100
Effective Power [hp]	25.8	9.6	22.7	23.2	22.3	13.1	8.3	6.8	24	0.3	156
Effective Fuel Consumption [L/hr] [2, 3]	21.7	2.7	3.9	4.3	4.1	2.3	1.6	1.3	4.6	0.1	46.6

1 The Port of Long Beach 2007 Air Emissions Inventory [8].
2 Measurement and Evaluation of Fuels and Technologies for Passenger Rail Service in North Carolina [9]
3 L/hr = litres per hour.
4 Locomotive Emissions Monitoring Program 2010.

Emission rates for four of the CACs assessed, namely CO, NOx, VOCs, and PM, were derived from the U.S. EPA locomotive emission standards for line-haul and switcher locomotives as published in the RAC Locomotive Emissions Monitoring Program 2010 [2]. The emission rates for were similarly derived from RAC [2].

Table A- 6: CAC Emission Factors

Tier	Emission Factor (g/bhp-hr)			
	CO	Nox	VOCs	PM
1	2.5	11	1.2	0.26

Table A- 7: GHG Emission Factors

Emission Factor (kg/L)		
CO_2	CH_4	N_2O
2.66	0.00015	0.0011

The emission rate for ammonia was assumed to be 0.005 g/L, identical to the rate used for the Deltaport Third Berth Project [10]. CAC and GHG emission rates are detailed below. As per the U.S. EPA recommendations for estimating emissions from compression ignition engines [11], the relative $PM_{2.5}$ emissions are estimated to be 97% of PM emissions while PM_{10} emissions are assumed to be equal to

PM emissions. A sulphur content of 15 ppm was assumed based on the sulphur in Diesel Fuel Regulations. DPM emissions were assumed to equal $PM_{2.5}$ emissions.

Based on emission factors and locomotive parameters, emission rates in kg/hr were developed and emissions estimated using Equation 4. Emission rates are calculated differently depending on emission factor units. Examples of the general formulas used to calculate for emission rates in kg/hr are shown below for reference.

Emission Rate (kg/hr) = EF (g/bhp-hr) * Effective Horsepower (hp) * 0.001kg/1g * 1.014 bhp/hp

Emission Rate (kg/hr) = Emission Factor (kg/L) x hours x effective fuel consumption (L/hr)

STORAGE

As noted above, emissions due to storage/material handling emissions are broken down to breathing losses (Standard Classification Code – 40705603), working losses (Standard Classification Code – 40705604) [3] and ship loading operations.

Breathing and working losses are based on emission factors used/provided by Metro Vancouver to determine VOC emissions for permit fee calculations. Metro Vancouver provided emissions factors for breathing and working losses are 0.052 lb VOC / 1000-gallon storage capacity and 0.002 lb VOC / 1000-gallon throughput, respectively.

PCT's has 6 tanks on-site for ethylene glycol storage totalling approximately 13,950,000 gallons in storage capacity. Based on actual and projected ethylene glycol throughput levels (tonnes/yr) and assuming an average ethylene glycol density of 1.1155 kg/L, volumetric ethylene glycol throughputs for the current scenario and the scenario with expansion are ~211,100,000 gallons and ~297,000,000 gallons respectively.

Emission from ship loading operations are based on maximum operating hours and limits in PCT's permit, which have been conservatively based on a maximum ethylene glycol throughput of 2,000,000 tonnes/year. This includes an emission limit of 625 mg/m^3, a flowrate limit of 14.5 m^3/min, and maximum operational loading time of 1350 hours/year.

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