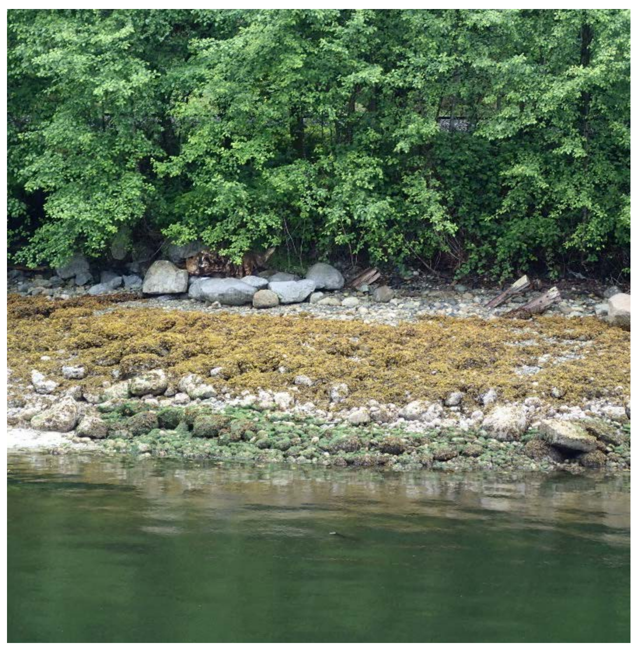
WESTRIDGE MARINE TERMINAL ENVIRONMENTAL AIR ASSESSMENT

WESTRIDGE MARINE TERMINAL UPGRADE AND EXPANSION PROJECT APPLICATION TO VANCOUVER FRASER PORT AUTHORITY



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APPENDIX A:

SUMMARY OF CHANGES IN FACILITY DESIGN AND ASSESSMENT CRITERIA USED IN THE AIR QUALITY ASSESSMENTS FOR THE EDMONTON TERMINAL, BURNABY TERMINAL AND WESTRIDGE MARINE TERMINAL

ACRONYMS

Definition/ Acronym	Description
bpd	Barrels per Day
BTEX	Benzene, Toluene, Ethyl benzene and Xylenes
H2S	Hydrogen Sulphide
IFRT	Internal Floating Roof Tank
IG	Inert Gas
JF	Jet Fuel
kbbl	Kilo (1000) Barrel (unit of volume)
K	Degree Kelvin
m	Meter
m/s	Meters per Second
NEB	National Energy Board
NO_2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
ppmv	Parts per million by volume
SO_2	Sulphur Dioxide
TAN	Total Acid Number
TRS	Total Reduced Sulphur
TVAU	Tank Vapour Adsorption Unit
US EPA	United States Environmental Protection Agency
VCU	Vapour Combustion Unit
VFRT	Vertical Fixed Roof Tank
VOC	Volatile Organic Compounds

INTRODUCTION

Each section in this Appendix summarizes the engineering design and assumptions changes for the modelled facility emission sources included at the Edmonton Terminal, Burnaby Terminal and Westridge Marine Terminal. The three reports that were compared include:

1. Technical Report 5C-4 of Volume 5C, Air Quality and Greenhouse Gas Technical Report (NEB Filing IDs A3S1U0 to A3S1U7) (referred to in this document as the "2013 Technical Report"); and
2. Supplemental Air Quality Technical Report for Technical Update No. 2 (NEB Filing ID A4A4E3) (referred to in this document as the "Supplemental Technical Report No.2").
3. Supplemental Air Quality Technical Report for Technical Update No. 3 (referred to in this document as the "Supplemental Technical Report No.3").

The changes in the assumptions and methodology for the modelled marine emission sources are summarized in Appendix C of this report.

CALPUFF/CALMET MODEL VERSION

Table A-1 summarizes the changes in the versions of the CALMET/CALPUFF dispersion modelling system that was used.

Table A-1: Dispersion Model Versions

Model	Supplemental Technical Report No. 3	Supplemental Technical Report No. 2	2013 Technical Report
CALMET	6.5.0	6.334	
CALPUFF	7.2.1	6.42	

Edmonton Terminal

This section summarizes the changes in modeled parameters for the Edmonton Terminal. Table A-2 summarizes the modelled emission sources at Edmonton Terminal for the Base and Application Cases. The product storage tanks were the only emission sources modeled as there are no other continuous emissions. The number of tanks, which were modelled for the 2013 Technical Report, and the 2016 Supplemental Facilities Technical Report No. 3 in the Base Case and Application Case change between the two reports. Table A-3 summarizes the changes in facilities modelling for the Edmonton Terminal. Also, some tank configurations/and products have changed as shown in Table A- 4 and Table A- 5.

Table A-2: Summary of all Modelled Emission Sources for the Base and Application Cases, Edmonton Terminal

Supplemental Technical Report No. 3	2013 Technical Report
Base Case	
Storage Tank Numbers 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38 and 39	Storage Tank Numbers 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 31, 32, 33, 34, 35, 36, 37, 38 and 39 Tanks 29 and 30 were not modelled.
Application Case	
Storage Tank Numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38 and 39	Storage Tank Numbers 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38 and 39 Tanks 4, 29 and 30 were not modelled.

Table A-3: Summary of all Modelling Changes for the Base and Application Cases

Emission Activity	Supplemental Technical Report No.3	2013 Technical Report
Product Selection, Base Case	Heavy Crude (Low TAN/High Tan Dilbit) Light Sour/Light Sweet Crude Refined Product	Heavy Crude (Low TAN Dilbit) Light Sour Crude Refined Product
Product Selection, Application Case	Heavy Crude (High TAN Dilbit, Low TAN Dilbit Light Sour/Light Sweet Crude Refined Product	Heavy Crude (Low TAN Dilbit) Light Sour Crude Refined Product
New Tank Vapour Adsorption Units (TVAUs) (Proposed emission controls on Tank Numbers 1, 2, 3, 4 [1]	99.5% collection 0% VOC destruction 0% total removal efficiency for VOC 99.9% H_2S destruction 99.4% total removal efficiency for H_2S 99.7% Mercaptans destruction 99.2% total removal efficiency for Mercaptans	No TVAUs
Product Throughput, Base Case	Heavy Crude (Low TAN Dilbit): 70,000 bpd Light/Synthetic Crude: 170,000 bpd Refined Product: 47,000 bpd Total: 287,000 bpd	Heavy Crude (Low TAN Dilbit): 66,000 bpd Light/Synthetic Crude: 186,000 bpd Refined Product: 48,000 bpd Total: 300,000 bpd
Application Case Throughput	High TAN Dilbit, Low TAN Dilbit: 539,000 bpd Light Sour/Light Sweet Crude: 312,400 bpd Refined Product: 26,000 bpd Total: 877,400 bpd	Heavy Crude (Low TAN Dilbit): 540,000 bpd Light/Synthetic Crude: 278,205 bpd Refined Product: 71,795 bpd Total: 890,000 bpd

Notes: [1] Recovery efficiency for the reduced sulphur components removal was based on discussions with TVAU technology vendor.

The different products assumed in each individual tank modelled for the Base Case are summarized in Table A- 4. The different products assumed in each individual tank modelled for the Application Case are summarized in Table A- 5.

Table A- 4: Summary of Tanks and Assumed Products Modelled at Edmonton Terminal, Base Case

Tank ID Number	2016 Supplemental s Technical Report No.3		2013 Technical Report	
	Tank Design[1]	Product	Tank Design	Product
5	EFRT	Refined Product	EFRT	Refined Product
6	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Light Sour Crude
7	DEFRT	Light Sweet Crude	DEFRT	Light Sour Crude
8	EFRT	Refined Product	EFRT	Refined Product
9	EFRT	Refined Product	EFRT	Refined Product
10	EFRT	Light Sour Crude	EFRT	Light Sour Crude
11	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
12	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
13	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
14	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
15	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
16	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
17	DEFRT	Refined Product	DEFRT	Refined Product
18	EFRT	Refined Product	EFRT	Refined Product
19	DEFRT	Refined Product	DEFRT	Refined Product
20	DEFRT	Light Sour Crude	DEFRT	Light Sour Crude
21	DEFRT	Light Sweet Crude	DEFRT	Light Sour Crude
22	DEFRT	Heavy Crude (Low TAN/High TAN Dilbit)	DEFRT	Heavy Crude (Low TAN Dilbit)
23	DEFRT	Light Sweet Crude	DEFRT	Heavy Crude (Low TAN Dilbit)
24	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
25	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
26	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Light Sour Crude
27	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
28	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Light Sour Crude
29	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	Not Modelled	
30	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	Not Modelled	
31	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Light Sour Crude
32	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
33	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
34	EFRT	Light Sweet Crude	EFRT	Heavy Crude (Low TAN Dilbit)
35	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
36	EFRT	Heavy Crude (Low TAN/High TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
37	EFRT	Light Sweet Crude	EFRT	Heavy Crude (Low TAN Dilbit)
38	EFRT	Light Sweet Crude	EFRT	Heavy Crude (Low TAN Dilbit)
39	EFRT	Light Sweet Crude	EFRT	Heavy Crude (Low TAN Dilbit)

Notes: [1] EFRT is external floating roof tank and DEFRT is domed external floating roof tank.

Table A- 5: Summary of Tanks and Assumed Products Modelled at Edmonton Terminal (Proposed Tanks are Highlighted), Application Case

Tank ID Number	2016 Supplemental Technical Report No.3		2013 Technical Report	
	Tank Design	Product	Tank Design	Product
1	IFRT with TVAU	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
2	IFRT with TVAU	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
3	IFRT with TVAU	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
4	IFRT with TVAU	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	Not Modelled	
5	EFRT	Refined Product	EFRT	Refined Product
6	EFRT	Refined Product	EFRT	Light Sour Crude
7	DEFRT	Refined Product	DEFRT	Light Sour Crude
8	EFRT	Refined Product	EFRT	Refined Product
9	EFRT	Refined Product	EFRT	Refined Product
10	EFRT	Light Sweet Crude	EFRT	Heavy Crude (Low TAN Dilbit)
11	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
12	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
13	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
14	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
15	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
16	EFRT	Light Sweet Crude	EFRT	Light Sour Crude
17	DEFRT	Light Sweet Crude	DEFRT	Refined Product
18	EFRT	Light Sweet Crude	EFRT	Refined Product
19	DEFRT	Light Sweet Crude	DEFRT	Light Sour Crude
20	DEFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	DEFRT	Heavy Crude (Low TAN Dilbit)
21	DEFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	DEFRT	Light Sour Crude
22	DEFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	DEFRT	Heavy Crude (Low TAN Dilbit)
23	DEFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	DEFRT	Heavy Crude (Low TAN Dilbit)
24	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
25	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
26	EFRT	Light Sour Crude	EFRT	Light Sour Crude
27	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
28	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
29	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	Not Modelled	
30	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)		
31	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Light Sour Crude
32	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Light Sour Crude
33	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
34	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Light Sour Crude
35	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
36	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Light Sour Crude
37	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
38	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
39	EFRT	Heavy Crude (High TAN Dilbit, Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)

<u>**Notes:**</u> IFRT is internal floating roof tank, EFRT is external floating roof tank and DEFRT is domed external floating roof tank. TVAU is tank vapour adsorption unit.

Burnaby Terminal

This section summarizes the changes in the modeled parameters for the Burnaby Terminal. Table A- 6 summarizes the modelled emission sources at Burnaby Terminal. The product storage tanks were the only emission sources modeled as there are no other continuous emissions. Table A- 7 summarizes the changes in facilities modelling for the Burnaby Terminal among the three key technical reports. The same number of tanks was modelled for the 2013 Technical Report, and Supplemental Technical Reports No.2 and No.3. The number of tanks in the Base Case and Application Case did not change between the three reports; however, some tank configurations changed as shown in Table A-8 and Table A-9.

Table A- 6: Summary of all Modelled Emission Sources for the Burnaby Terminal, Base and Application Cases

Supplemental Technical Report No. 3	Supplemental Technical Report No. 2	2013 Technical Report
Base Case		
Storage Tank Numbers 71, 72, 73, 74, 81, 82, 83, 84, 85, 86, 87, 88 and 90		
Application Case		
Storage Tank Numbers 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 93, 95, 96, 97 and 98		

Table A- 7: Summary of Modelling Changes for the Burnaby Terminal, Base and Application Cases

Emission Activity	Supplemental Technical Report No.3	Supplemental Technical Report No.2	2013 Technical Report
Product Selection, Base Case	Heavy Crude (Low TAN Dilbit) Light Sour/Light Synthetic Crude Refined Product		Heavy Crude (Low TAN Dilbit) Light Sour/Light Synthetic Crude Refined Product
Product Selection, Application Case	High TAN Dilbit, Low TAN Dilbit Light Sweet Crude Refined Product	High TAN Dilbit, Low TAN Dilbit High TAN Synbit and Dilsynbit Light Synthetic/Light Sweet Crude Refined Product	Heavy Crude (Low TAN Dilbit) Light Sour/ Light Synthetic Crude Refined Product
Existing scrubbers (Existing tank emission controls on Tank Numbers 86, 87, 88 and 90)	No scrubbers	80% collection efficiency 80% VOC scrubbing efficiency 64% total removal efficiency for VOCs 0% TRS scrubbing efficiency 0% total removal efficiency for TRS	
New Tank Vapour Adsorption Units (TVAUs) (Proposed emission controls on Tank Numbers 74, 75, 76, 77, 78, 79, 80, 89, 91, 93, 95, 96, 97 and 98 [1]	99.5% collection 0% VOC removal 0% total removal efficiency for VOC 99.9% H_2S removal 99.4% total removal efficiency for H_2S 99.7% Mercaptans removal 99.2% total removal efficiency for Mercaptans	80% collection 0% VOC removal 0% total removal efficiency for VOC 95% TRS removal 76% total removal efficiency for TRS	80% collection 80% VOC removal; 64% total removal efficiency for VOC 0% TRS removal 0% total removal efficiency for TRS
Product Throughput, Base Case	Heavy Crude (Low TAN Dilbit): 54,000 bpd Light/Synthetic Crude: 58,000 bpd Refined Product: 34,000 bpd Total: 146,000 bpd		Heavy Crude (Low TAN Dilbit): 18,000 bpd Light/Synthetic Crude: 18,000 bpd Refined Product: 48,000 bpd Total: 84,000 bpd
Emission Activity	**Supplemental Technical Report No.3**	**Supplemental Technical Report No.2**	**2013 Technical Report**
Application Case Throughput	High TAN Dilbit, Low TAN Dilbit: 493,500 bpd Light Synthetic/Light Sweet Crude: 191,000 bpd Refined Product: 26,000 bpd Total: 710,500 bpd	High TAN Dilbit, Low TAN Dilbit: 461,500 bpd High TAN Synbit and Dilsynbit: 31,500 bpd Light Synthetic/Light Sweet: 186,000 bpd Refined Product: 31,500 bpd Total: 710,500 bpd	Heavy Crude (Low TAN Dilbit): 4,153 bpd Light/Synthetic Crude: 4,153 bpd Refined Product: 71,795 bpd Total: 80,100 bpd
Product Throughput – additional note on working losses	Product throughput at Westridge Marine Terminal was included in the Burnaby Terminal product throughput. This was used to estimate annual working loss emissions from Burnaby Terminal storage tanks.		Product throughput at Westridge Marine Terminal was not included in the Burnaby Terminal product throughput. This affects annual working loss emissions from Burnaby Terminal storage tanks. This does not affect the 1-hour or 24-hour averaging periods because the maximum daily working losses were determined based on tank pump rates, not product throughput.

__Notes__: [1] Recovery efficiency for the reduced sulphur components removal was based on discussions with the TVAU technology vendor

The differences in each individual tank design type and assumed product stored for the Base Case are summarized in Table A-8. The differences in each individual tank modelled for the Application Case are summarized in Table A-9.

Table A-8: Summary of Tank Design and Assumed Products Modelled at Burnaby Terminal, Base Case

Tank ID Number	Supplemental Technical Report No.3		Supplemental Technical Report No.2		2013 Technical Report	
	Tank Design	Product	Tank Design	Product	Tank Design	Product
71	EFRT	Light Sweet Crude	EFRT	Refined Product	EFRT	Refined Product
72	EFRT	Refined Products	EFRT	Light Sour/Light Synthetic	EFRT	Light Sour/Light Synthetic
73	DEFRT[2]	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT	Refined Product	DEFRT	Refined Product
74 [2]	EFRT	Light Sweet Crude	EFRT	Light Sour/Light Synthetic	EFRT	Light Sour/Light Synthetic
81	DEFRT	Light Sweet Crude	DEFRT	Light Sour/Light Synthetic	DEFRT	Light Sour/Light Synthetic
82	EFRT	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
83	EFRT	Light Sweet Crude	EFRT	Heavy Crude (Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
84	EFRT	Light Sweet Crude	EFRT	Heavy Crude (Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
85	EFRT	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)	EFRT	Heavy Crude (Low TAN Dilbit)
86	DEFRT (w/o scrubber)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	DEFRT (w/ scrubber)	Light Sour/Light Synthetic	DEFRT (w/ scrubber)	Light Sour/Light Synthetic
87	DEFRT[2] (w/o scrubber)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)	DEFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)
88	DEFRT[2] (w/o scrubber)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)	DEFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)
90	DEFRT[2] (w/o scrubber)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)	DEFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)

Notes: IFRT is internal floating roof tank, EFRT is external floating roof tank and DEFRT is domed external floating roof tank.

[1] Tank 74 will be demolished, and a larger tank will be built with the same ID at Burnaby Terminal as part of the Project expansion

[2] Tanks with light aluminum roofs are internal floating roof tanks; however, they were modelled as domed external floating roof tanks with support columns as US EPA TANKS model does not recognize domed IFRT's.

Table A-9: Summary of Tank Design and Assumed Products Modelled at Burnaby Terminal, Application Case

Tank ID Number	Supplemental Technical Report No. 3		Supplemental Technical Report No. 2		2013 Technical Report	
	Tank Design	Product	Tank Design	Product	Tank Design	Product
71	EFRT	Light Sweet Crude	EFRT	Light Crude / Synthetic	EFRT	Light Sour /Synthetic Crude
72	EFRT	Refined Products	EFRT	Refined Product	EFRT	Refined Product
73	DEFRT	Light Sweet Crude	IFRT	Light Crude / Synthetic	DEFRT	Light Sour /Synthetic Crude
74 [1]	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Dilbit, Low TAN Dilbit	IFRT (w/ TVAU)	Light Sour /Synthetic Crude
75	IFRT (w/ TVAU)	Light Sweet Crude	IFRT (w/ TVAU)	High TAN Dilbit, Low TAN Dilbit	IFRT (w/ TVAU)	Light Sour /Synthetic Crude
76	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Dilbit, Low TAN Dilbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
77	IFRT (w/ TVAU)	Light Sweet Crude	IFRT (w/ TVAU)	Light Crude / Synthetic	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
78	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Dilbit, Low TAN Dilbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
79	IFRT (w/ TVAU)	Light Sweet Crude	IFRT (w/ TVAU)	Light Crude / Synthetic	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
80	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Dilbit, Low TAN Dilbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
81	DEFRT	Light Sweet Crude	DEFRT	Light Crude / Synthetic	DEFRT	Light Sour /Synthetic Crude
82	EFRT	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	EFRT	High TAN Dilbit, Low TAN Dilbit	DEFRT	Heavy Crude (Low TAN Dilbit)
83	EFRT	Light Sweet Crude	EFRT	Light Crude / Synthetic	EFRT	Light Sour /Synthetic Crude
84	EFRT	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	EFRT	High TAN Dilbit, Low TAN Dilbit	EFRT	Light Sour /Synthetic Crude
85	EFRT	Light Sweet Crude	EFRT	Light Crude / Synthetic	EFRT	Light Sour /Synthetic Crude
86	DEFRT (w/o scrubber)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	DEFRT (w/ scrubber)	High TAN Dilbit, Low TAN Dilbit	DEFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)
87	DEFRT (w/o scrubber)	Light Sweet Crude	IFRT (w/ scrubber)	Light Crude / Synthetic	DEFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)
88	DEFRT (w/o scrubber)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ scrubber)	High TAN Dilbit, Low TAN Dilbit	DEFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)
89	IFRT (w/ TVAU)	Light Sweet Crude	IFRT (w/ TVAU)	Light Crude / Synthetic	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
90	DEFRT (w/o scrubber)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ scrubber)	High TAN Dilbit, Low TAN Dilbit	DEFRT (w/ scrubber)	Heavy Crude (Low TAN Dilbit)
91	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Synbit and Dilsynbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
93	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Synbit and Dilsynbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
95	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Synbit and Dilsynbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
96	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Dilbit, Low TAN Dilbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
97	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Dilbit, Low TAN Dilbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)
98	IFRT (w/ TVAU)	Heavy Crude (High TAN Dilbit/Low TAN Dilbit)	IFRT (w/ TVAU)	High TAN Dilbit, Low TAN Dilbit	IFRT (w/ TVAU)	Heavy Crude (Low TAN Dilbit)

Notes: [1] Tank 74 will be demolished, and a larger tank will be built with the same ID at Burnaby Terminal as part of the Project expansion.
IFRT is internal floating roof tank, EFRT is external floating roof tank and DEFRT is domed external floating roof tank. TVAU is tank vapour adsorption unit.

Table A-10: TVAU stack emission modelling, Burnaby Terminal

TVAU Stack Parameters and Modelling Approach	2016 Supplemental Technical Report No.3	2014 Supplemental Technical Report No.2	2013 Technical Report
All Storage Tanks With TVAUs	For storage tanks with TVAUs, only 0.5% of total emissions (i.e. the amount uncollected by TVAUs) were modelled through the roof of the tanks. The remaining collected and undestructed emissions were modelled through vertical TVAU stacks. The TVAU stack height was modelled at the TVAU carbon vessel height (i.e. about 6 m above the steel platform (Figure 5 of the main report). The stack diameter and exit velocity were set to 0.3048 m (12") and 14.3 m/s, respectively.	For storage tanks with TVAUs, all undestructed emissions were assumed to be coming through the roof of the storage tank. The tank emissions were generally modelled in accordance with the Air Dispersion Modelling Guideline for Ontario (OMECC 2009). Each floating tank was modelled with eight point sources around the circumference of the tank, with the tank emissions equally distributed between the eight sources. The stack height was specified at the tank height. The stack diameter and exit velocity were set to 0.001 m and 0.001 m/s, respectively (OMECC 2009).	

Westridge Marine Terminal

This section summarizes the modeled changes for the Westridge Marine Terminal.

Westridge Marine Terminal Emissions

Table A-11 compares the changes in the modelled emission sources at Westridge Marine Terminal.

Table A-11: Summary of all Modelled Emission Sources, Westridge Marine Terminal, Base and Application Cases

Supplemental Technical Report No.3	Supplemental Technical Report No.2	2013 Technical Report
Base Case		
VCU emissions (from fugitive vapours collected at one berth) **Uncollected fugitive emissions (0.5%) during loading from one berth** **Auxiliary engine and boiler emissions from tanker at one berth location** **Tanks # 93, 201, 202 with jet fuel (JF)**	VCU emissions (from fugitive vapours collected at one berth) No fugitive emissions during loading at berth Auxiliary engine and boiler emissions from tanker at one berth location Tanks # 93, 201, 202 with JF	VCU emissions (from fugitive vapours collected at one berth) Uncollected fugitive emissions (10%) during loading from one berth Auxiliary engine and boiler emissions from tanker at one berth location Tanks # 93, 201, 202 with JF
Application Case		
VCU emissions (from fugitive vapours collected at one berth) **VRUs emissions (from fugitive vapours collected at two berths, one for each VRU)** **Uncollected fugitive emissions (0.5%) during loading from three berths** **Auxiliary engine and boiler emissions from tankers at three berth locations** **Tanks # 93, 201, 202 with JF**	VCU emissions (from fugitive vapours collected at one berth) VRUs emissions (from fugitive vapours collected at two berths, one for each VRU) No fugitive emissions during loading at three berths Auxiliary engine and boiler emissions from tankers at three berth locations Tanks # 93, 201, 202 with JF VRU tanks #1 and #2 with light sour / synthetic crude	VCU emissions (from fugitive vapours collected at one berth) VRUs emissions (from fugitive vapours collected at two berths, one for each VRU) Uncollected fugitive emissions (10%) during loading from three berths Auxiliary engine and boiler emissions from tankers at three berth locations Tanks # 93, 201, 202 with JF VRU tanks #1 and #2 with light sour /synthetic crude

Note: [1] The updated engineering design in 2016 only included the jet fuel storage tanks at Westridge Marine Terminal. The light sour storage tanks were decommissioned and not included in the updated modelling to inform engineering design in 2016.

Westridge Marine Terminal Vapour Abatement Technologies

Fugitive emissions from vessel loading were modelled as either uncollected fugitive emissions at berth (2013 Technical Report and 2016 Supplemental Technical Report No.3), collected vapours destroyed by the VCU, or collected vapours removed by the VRUs (Application Case only). Table A-13 compares the changes in Westridge Marine Terminal fugitive emission estimates. Table A-14 and Table A- 15 summarize the changes in the VCU emission estimates and stack parameters between the Base Case and Application Case, respectively. Table A- 16 summarizes the changes in the VRU emission estimates and stack parameters for the Application Case.

Westridge Marine Terminal Tanks

Table A-12 summarizes the modeled changes for the Westridge Marine Terminal storage tanks for the Base and Application Cases.

Table A-12: Summary of Changes for Modelling of Storage Tanks, Westridge Marine Terminal, Base and Application Cases

Emission Activity	2016 Supplemental Technical Report No.3	2014 Supplemental Technical Report No.2	2013 Technical Report
Base Case Product Selection for Storage Tanks	JF		
Application Case Product Selection for Storage Tanks	JF	JF Light Sour/Light Synthetic [1]	JF Light Sour/Synthetic Crude
Base Case Product Selection for Loading	Heavy Crude (Low TAN/High Tan Dilbit) Light Sweet Crude JF	Heavy Crude (Low TAN Dilbit) Light Sour/Light Synthetic JF	Heavy Crude (Low TAN Dilbit) Light Sour/Light Synthetic
Application Case Product Selection for Loading	Heavy Crude (Low TAN/High Tan Dilbit) Light Sweet Crude	High TAN Dilbit, Low TAN Dilbit High TAN Synbit and Dilsynbit Light Synthetic/Light Sweet	Heavy Crude (Low TAN Dilbit) Light Sour/Light Synthetic JF
Base Case Throughput	Heavy Crude (Low TAN Dilbit): 49,418 bpd Light Sweet Crude: 13,582 bpd Refined Product: 0 bpd Total: 63,000 bpd		Heavy Crude (Low TAN Dilbit): 45,180 bpd Light/Synthetic Crude: 17,820 bpd Refined Product: 0 bpd Total: 63,000 bpd
Application Case Throughput	High TAN Dilbit, Low TAN Dilbit: 493,500 bpd Light Sweet Crude: 135,000 bpd Refined Product: 0 bpd Total: 628,500 bpd	High TAN Dilbit, Low TAN Dilbit: 461,500 bpd High TAN Synbit and Dilsynbit: 31,500 bpd Light Synthetic, Light Sweet: 135,500 bpd Refined Product: 0 bpd Total: 628,500 bpd	Heavy Crude (Low TAN Dilbit): 532,456 bpd Light/Synthetic Crude: 99,435 bpd Refined Product: 0 bpd Total: 631,900 bpd

Note: [1] The updated engineering design in 2016 only included the jet fuel storage tanks at Westridge Marine Terminal. The light sour storage tanks were decommissioned and were not included in the modelling to inform engineering design in 2016.

Westridge Marine Terminal Vapour Abatement Technologies

Fugitive emissions from vessel loading were modelled as either uncollected fugitive emissions at berth (2013 Technical Report and Supplemental Technical Report No.3), collected vapours destroyed by the VCU, or collected vapours removed by the VRUs (Application Case only). Table A-13 compares the changes in Westridge Marine Terminal fugitive emission estimates. Table A-14 and Table A- 15 summarize the changes in the VCU emission estimates and stack parameters between the Base Case and Application Case, respectively. Table A- 16 summarizes the changes in the VRU emission estimates and stack parameters for the Application Case.

Table A-13: Summary of Changes in Estimating Fugitive Emissions, Westridge Marine Terminal

Emission Activity	Supplemental Technical Report No.3	Supplemental Technical Report No.2	2013 Technical Report
Fugitive Emissions from Vessel Loading	Total VOCs, H_2S, mercaptans and BTEX emissions were estimated based on Levelton tanker loading results (Levelton Consultants Ltd., 2015) (more details are in Section 2.5 of this report). Some vapours were not collected by the VCU and VRUs (0.5% of vapours from loading) and were modelled as fugitive emissions during loading more details are in Section 2.5 of this report).	Total VOCs, H_2S, mercaptans and BTEX emissions were estimated based on HYSIS tanker loading simulation upstream of the VCU and VRUs. Fugitive emissions were not modelled (assumed 100% collection efficiency during entire time of loading).	Total VOCs emissions upstream of the VCU and VRUs were estimated based on US EPA AP-42, Chapter 5.2: Transportation And Marketing Of Petroleum Liquids (US EPA 1991) emission factor for loading. H_2S, mercaptans and BTEX emissions were calculated based on speciation factors from calculated VOCs based on product compositions. Some vapours were not collected from the VCU (10% of vapours from loading) and were modelled as fugitive emissions during loading.

Table A-14: **Summary of Changes to VCU Emission Estimates and Stack Parameters, Base Case**

Emission Activity	Supplemental Technical Report No.3	Supplemental Technical Report No.2	2013 Technical Report
Collection Efficiency	99.5%[1]	100%	90%
VOC Destruction Efficiency	99%	98%	98%
Reduced Sulphur Destruction Efficiency	98%	70%	70%
BTEX, H_2S and Mercaptans Emissions	BTEX emission rates were based on mass emission rate of 2.4 mg VOC vented per liter of liquid loaded (as per VCU manufacturer's info for the new VCU). H_2S and mercaptans emission rates were based on real time measurements from Levelton for Low-TAN/High TAN Dilbit, applying the total reduction efficiency of 98%	BTEX emission rates were based on HYSIS simulation results for Low-TAN Dilbit, applying total reduction efficiency of 98%. H_2S and mercaptans emission rates were based on HYSIS simulation results for Low-TAN Dilbit, applying the total reduction efficiency of 70%	BTEX emission rates were based on VOC speciation for the products and reduction efficiency of 98%. H_2S and mercaptans emissions rates were based on VOC speciation for the Project and destruction efficiency of 70%
Combustion Emission Estimate	PM emission rate was based on US EPA AP-42, Chapter 1.5: Liquefied Petroleum Gas Combustion (US EPA 2008a) CO and NOx emission were provided by the VCU vendor for the new VCU and were used for the existing VCU too. SO_2 emission rate was based on H_2S and methyl mercaptan stoichiometric combustion assuming 100% conversion All CAC emissions (SO_2, NO_X, PM and CO) included tanker inert gas (IG) and combustion emissions	CO and PM emission rates were based on US EPA AP-42, Chapter 1.5: Liquefied Petroleum Gas Combustion (US EPA 2008a) NOx emission rate was based on vendor performance guarantee with an emission factor of 64.4 g/GJ heat input SO_2 emission rate was based on H_2S and methyl mercaptan stoichiometric combustion assuming 100% conversion All CAC emissions (SO_2, NO_X, PM and CO) included tanker inert gas (IG) and combustion emissions	CO, PM and NO_x emission rates were based on US EPA AP-42, Chapter 13.5: Industrial Flares (US EPA 2008b) SO_2 emission rate was based on H_2S and methyl mercaptan stoichiometric combustion assuming 100% conversion CAC emissions did not include tanker IG emissions
Modelled Stack Parameters	21.3 m height 3.5 m inner diameter 1,255 K exit temperature 8.2 m/s exit velocity	21.3 m height 3.51 m inner diameter 1,255 K exit temperature 8.2 m/s exit velocity	21.3 m height 3.51 m inner diameter 1,255 K exit temperature 16 to 31 m/s exit velocity

Notes: [1] Uncollected vapours were assumed to be 0.5% fugitive emissions from tankers and 0.0001% fugitive emissions from connecting piping.

Table A-15: Summary of Changes to VCU Emission Estimates and Stack Parameters, Application Case

Emission Activity	Supplemental Technical Report No.3	Supplemental Technical Report No.2	2013 Technical Report
Collection Efficiency	99.5%[1]	100%	90%
VOC Destruction Efficiency	99%	98%	98%
Reduced Sulphur Destruction Efficiency	H_2S Removal Efficiency (through adsorption vessel upstream of the VCU) 99.5%-99.97%[2] H_2S Combustion Efficiency 99%[3] Mercaptan Combustion Efficiency 99.9%[4]	99.998%	70% (same as Base Case)
BTEX, H_2S and Mercaptans Emissions	H_2S, mercaptans and BTEX emission rates were based on vendor specs.	Benzene emission rate was based on vendor specs. TEX emissions were based on HYSIS simulation results, applying total reduction efficiency of 98%. H_2S and mercaptans emission rates were based on HYSIS simulation results, applying the total reduction efficiency of 99.998%.	BTEX emission rates were based on VOC speciation profiles for the products and reduction efficiency of 98%. H_2S and mercaptans emission rates were based on VOC speciation for the Project and destruction efficiency of 70%.
Combustion Emission Estimate	PM emission rate was based on US EPA AP-42, Chapter 1.5: Liquefied Petroleum Gas Combustion (US EPA 2008a). SO_2, CO and NOx emission rates were based on vendor specs. All CAC emissions (SO_2, NO_X, PM and CO) included tanker inert gas (IG) and combustion emissions	CO and PM emission rates were based on US EPA AP-42, Chapter 1.5: Liquefied Petroleum Gas Combustion (US EPA 2008a). NOx emission rate was based on vendor performance guarantee with an emission factor of 64.4 g/GJ heat input. SO_2 emission rate was based on H_2S and methyl mercaptan stoichiometric combustion. All CAC emissions (SO_2, NO_X, PM and CO) included tanker IG and combustion emissions.	CO, PM and NO_x emission rates were based on US EPA AP-42, Chapter 13.5: Industrial Flares (US EPA 2008b). SO_2 based on H_2S and methyl mercaptan stoichiometric combustion assuming 100% conversion. CAC emissions did not include tanker IG emissions.
Modelling Stack Parameters	20 m height 3.35 m inner diameter 1,144 K exit temperature 13.41 m/s exit velocity	21.3 m height 3.51 m inner diameter 1,255 K exit temperature 5.6 to 11.9 m/s exit velocity	21.3 m height 3.51 m inner diameter 1,255 K exit temperature 16 to 31 m/s exit velocity

Notes: [1] Uncollected vapours (0.5% fugitive emissions from tankers and 0.0001% fugitive emissions from connecting piping)
[2] For inlet H_2S concentrations ranging from 200 ppmv to 4500 ppmv.
[3] H_2S combustion efficiency for the H_2S portion not being collected in the adsorption vessel.
[4] Mercaptans are not being collected in the VCU-destined vapour stream.

Table A-16: Summary of Changes to VRU Emission Estimates and Stack Parameters, Application Case

Emission Activity	Supplemental Technical Report No.3	Supplemental Technical Report No.2	2013 Technical Report
Collection Efficiency	99.5%[1]	100%	90%
VOC Recovery Efficiency	99%	98%	75%
Reduced Sulphur Recovery Efficiency	H_2S Removal Efficiency (through adsorption vessel upstream of the VRU) 99.5%-99.97%[2] Mercaptans Removal Efficiency (through adsorption vessel downstream of the VRU) 99.9[3]	99.9%	80%
BTEX, H_2S and mercaptans emissions	H_2S, mercaptans and BTEX emission rates were based on vendor specs.	Benzene emission rate was based on vendor specs. TEX emissions were based on HYSIS simulation results, applying total recovery efficiency of 98%. H_2S and mercaptans emission rates were based on HYSIS simulation results, applying the total recovery efficiency of 99.9%.	BTEX emission rates were based on VOC speciation profiles for the product and a recovery efficiency of 75%. H_2S and mercaptans emission rates were based on VOC speciation for the Project and total recovery efficiency of 80%.
CAC Emissions	CAC emissions (SO_2, NO_X, PM and CO) from tanker IG were included	CAC emissions (SO_2, NO_X, PM and CO) from tanker IG were included	Tanker IG emissions were not included
Modelled Stack Parameters	20 m height 0.356 m inner diameter 288.6 K exit temperature 14.4 m/s exit velocity	19.8 m height 0.36 m inner diameter 288.6 K exit temperature 12.8 m/s exit velocity	10 m height 0.0001 m inner diameter 288.6 K exit temperature 0.001 m/s exit velocity

Notes: [1] Uncollected vapours were assumed to be 0.5% fugitive emissions from tankers and 0.0001% fugitive emissions from connecting piping.

[2] For inlet H_2S concentrations ranging from 200 ppmv and 4500 ppmv, respectively.

[3] For inlet methyl mercaptan concentration range of 50 ppmv to 500 ppmv.

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