Application 31157 - Appendix O - Marine Cargo Carrier Emissions

Marine Emissions

Project: **Phillips66 Rodeo Renewed Project**
Year: June 2018 - May 2021
Location: Rodeo Site, San Francisco Refinery, Rodeo, CA

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Nomenclature:
OGV: ocean going vessels (tankers, ATB barges)
HC: harbor craft (i.e. assist tugs, tow tugs)

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Marine Table 1. Deadweight Tonnage and Average Build Time by Vessel Type

Tanker Class	Deadweight tonnage Minimum	Deadweight tonnage Maximum	Average Build Time
Tanker - Smallest	-	4,999	1
Tanker - Small	5,000	9,999	0
Tanker - Handysize	10,000	19,999	1
Tanker - Handymax	20,000	59,999	1
Tanker - Panamax	60,000	79,999	1
Tanker - Aframax	80,000	119,999	1
Tanker - Suezmax	120,000	199,999	2

Source:
[1] DWT Source: Methodologies for Estimating Port-Related and Good Movement Mobile Source Emissions, Table 3.4 Oil Tankers
[2] Average Build Time Source: Methodologies for Estimating Port-Related and Good Movement Mobile Source Emissions, Table C.5 Oil Tankers
Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10102U0.pdf

Marine Table 2. Summary of Baseline Vessel Traffic and Tier Mix

Year	Vessel Type	Total Vessel Activity		by Engine Tier Calls - Berthing				Slide Valves		by Engine Tier Calls - Anchorage				Slide Valves - Anchored Vessels	
		Calls to Berth	Calls to Anchorage	Tier 0	Tier 1	Tier 2	Tier 3	With	Without	Tier 0	Tier 1	Tier 2	Tier 3	With	Without
June 2018 - May 2021	Tanker - Smallest	3	0	1	2	0	0	0	3	0	0	0	0	0	0
June 2018 - May 2021	Tanker - Handysize	1	1	1	0	0	0	1	0	1	0	0	0	1	0
June 2018 - May 2021	Tanker - Handymax	39	23	3	20	13	3	26	13	2	12	7	2	15	8
June 2018 - May 2021	Tanker - Panamax	8	3	0	8	0	0	2	6	0	3	0	0	1	2
June 2018 - May 2021	Tanker - Aframax	6	0	0	4	2	0	4	2	0	0	0	0	0	0
June 2018 - May 2021	Tanker - Suezmax	13	7	2	6	5	1	7	6	1	3	3	0	4	3
June 2018 - May 2021	Barge	72	2	0	7	3	63	0	0	0	0	0	2	0	0
June 2018 - May 2021	ATB Barge	28	0	0	8	0	19	0	0	0	0	0	0	0	0
June 2018 - May 2021	**Total**	**171**	**36**	**7**	**55**	**23**	**86**	**41**	**30**	**4**	**19**	**10**	**4**	**21**	**13**

Note:
[1] Activity Calls to Berth are Provided by p66
[2] Tier Split is based on Baseline Tier Vessel Mix for Applicable Vessel Types

Marine Table 3. Average Call Durations at Berth and During Anchorage

		Annual Average	
Year	Vessel Type	Hotelling Time at Berth (hr/call)	Time at Anchorage (hr/call)
June 2018 - May 2021	Tanker - Smallest	37	0.0
June 2018 - May 2021	Tanker - Handysize	28	2.7
June 2018 - May 2021	Tanker - Handymax	51	2.9
June 2018 - May 2021	Tanker - Panamax	37	3.4
June 2018 - May 2021	Tanker - Aframax	37	0.0
June 2018 - May 2021	Tanker - Suezmax	30	3.3
June 2018 - May 2021	Barge	26	3.4
June 2018 - May 2021	ATB Barge	39	0.0

Note:
[1] Average duration per vessel type derived from annual vessel call data information, provided by P66 marine terminal operator

Marine Table 4. OGV Main Engine Rated Power and Vessel Speed

		Annual Average	OGV Maximum Rated Vessel Speed
Year	Vessel Type	Main Eng Avg (kW)	Speed (knots)
June 2018 - May 2021	Tanker - Smallest	1,679	14
June 2018 - May 2021	Tanker - Handysize	5,475	15
June 2018 - May 2021	Tanker - Handymax	8,861	16
June 2018 - May 2021	Tanker - Panamax	11,679	16
June 2018 - May 2021	Tanker - Aframax	13,415	16
June 2018 - May 2021	Tanker - Suezmax	18,941	16
June 2018 - May 2021	Barge	0	0
June 2018 - May 2021	ATB Barge	3,401	15

Note:
[1] Main engine average kW based on ship data provided by P66 averaged over vessel type
[2] Barges are not self-propelled; no propulsion engines.

Source:
[1] Vessel Speed Source: Methodologies for Estimating Port-Related and Good Movement Mobile Source Emissions, Table C.1 Oil/Chemical Tankers, Panamax is based on Bulk Carrier Panamax.
Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10102U0.pdf

Marine Table 5. OGV Average Aux Engine & Aux Boiler Loads

Vessel Type	Engine Type	Average Loads (kW)			
		Transit	Maneuvering	Berthing	Anchorage
Tanker - Smallest	Auxiliary Engine	132	182	143	143
Tanker - Smallest	Auxiliary Boiler	0	0	358	55
Tanker - Handysize	Auxiliary Engine	453	622	490	490
Tanker - Handysize	Auxiliary Boiler	0	0	1,226	189
Tanker - Handymax	Auxiliary Engine	621	854	672	672
Tanker - Handymax	Auxiliary Boiler	0	0	1,681	259
Tanker - Panamax	Auxiliary Engine	562	772	609	609
Tanker - Panamax	Auxiliary Boiler	0	0	1,521	234
Tanker - Aframax	Auxiliary Engine	585	805	634	634
Tanker - Aframax	Auxiliary Boiler	0	0	1,586	244
Tanker - Suezmax	Auxiliary Engine	1,548	2,129	1,677	1,677
Tanker - Suezmax	Auxiliary Boiler	0	0	4,193	645
Barge	Auxiliary Engine	40	40	70	70
Barge	Pump Generator	0	0	547	0
ATB Barge	Auxiliary Engine	439	439	761	761
ATB Barge	Pump Generator	0	0	711	0

Note:
[1] Tanker loads based on ship engine data and load factors from ARB
[1] Pump sizes from real world barge spec sheets (Centerline fleet spec sheets) mutiplied by barge pump load factor (CARB)
[2] Barge Aux engine sizes from real world barge spec sheets (Centerline fleet spec sheets) mutiplied by barge generator load factor (CARB)
[3] Aux engine sizes from real world barge spec sheets (Centerline fleet spec sheets) mutiplied by ocean tug auxiliay engine load factor during transit (CARB)

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Marine Table 6. Auxiliary Engine and Boiler Load Factors for Tankers

Mode	Auxiliary Engine	Auxiliary Boiler
Transit	0.24	0
Maneuvering	0.33	0
Anchorage	0.26	0.1
Berthing	0.26	0.65

Source:

[1] ARB Marine Emissions Model v2.3L
Available at: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road
[2] Appendix D Emissions Estimation Methodology for Ocean-Going Vessels Table II-10, ARB 2011
Available at: https://www.arb.ca.gov/regact/2011/ogv11/ogv11appd.pdf

Marine Table 7. Load Factors for Barges Auxiliary Engines and Pumps

Source Type	Aux Engine load factor
Pump	0.71
Generator	0.75
Ocean Tug	0.43

Source:

[1] Pump and Generator Source: MSEI CARB Off-road Model - Barge and Dredge
Available at: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road
[2] Ocean Tug Source: San Pedro Bay Ports Emissions Inventory Methodology Report April 2019, Table 3.1.
Available at: https://kentico.portoflosangeles.org/getmedia/3559520c-b85d-45ad-ad68-9947c34b980d/WV_FINAL_SPBP_Emissions_Inventory-_Methodology_4-25-19_scg

Marine Table 8. OGV Transit Speed (knots) by Vessel Type

Year	Vessel Type	Anchorage	Berthing	Manuevering	Light 8 EastBound Route to Maneuvering	Mile Rock 1 nm west of Golden Gate Bridge to Light 8 EastBound Route	Pilot Station Sea Buoy to Mile Rock 1 nm west of Golden Gate Bridge	Pilot Station Sea Buoy to Outer Ring of Bouys
June 2018 - May 2021	Tanker - Smallest	0	0	5	8	10	12	12
June 2018 - May 2021	Tanker - Handysize	0	0	5	8	10	12	12
June 2018 - May 2021	Tanker - Handymax	0	0	5	8	10	12	12
June 2018 - May 2021	Tanker - Panamax	0	0	5	8	10	12	12
June 2018 - May 2021	Tanker - Aframax	0	0	5	8	10	12	12
June 2018 - May 2021	Tanker - Suezmax	0	0	5	8	10	12	12
June 2018 - May 2021	Barge	0	0	5	8	10	12	12
June 2018 - May 2021	ATB Barge	0	0	5	8	10	12	12

Source:

[1] ERM. 2016. Estimated Emissions Increases and Human Health Risk Impacts Associated with the Marine Terminal III Project. June

Marine Table 9. OGV Transit Distance (nm) by Vessel Type

Year	Vessel Type	Anchorage	Berthing	Manuevering	Light 8 EastBound Route to Maneuvering	Mile Rock 1 nm west of Golden Gate Bridge to Light 8 EastBound Route	Pilot Station Sea Buoy to Mile Rock 1 nm west of Golden Gate Bridge	Pilot Station Sea Buoy to Outer Ring of Bouys
June 2018 - May 2021	Tanker - Smallest	0	0	0.2	11.79	19	10	6.5
June 2018 - May 2021	Tanker - Handysize	0	0	0.2	11.79	19	10	6.5
June 2018 - May 2021	Tanker - Handymax	0	0	0.2	11.79	19	10	6.5
June 2018 - May 2021	Tanker - Panamax	0	0	0.2	11.79	19	10	6.5
June 2018 - May 2021	Tanker - Aframax	0	0	0.2	11.79	19	10	6.5
June 2018 - May 2021	Tanker - Suezmax	0	0	0.2	11.79	19	10	6.5
June 2018 - May 2021	Barge	0	0	0.2	11.79	19	10	6.5
June 2018 - May 2021	ATB Barge	0	0	0.2	11.79	19	10	6.5

Source:

[1] ERM. 2016. Estimated Emissions Increases and Human Health Risk Impacts Associated with the Marine Terminal III Project. June
[2] Moffat and Nichol, ENVIRON. 2010. Port of Richmond 2005 Seaport Air Emissions Inventory. June

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Marine Table 10. Barge auxiliary engines and pump composite emission factors

Year	Engine Type	Horsepower	Horsepower Bin	Tier level mix				Composite Emission Factors (g/hp-hr)				
				Tier 0	Tier 1	Tier 2	Tier 3	VOC	CO	NOx	PM10	PM2.5
June 2018 - May 2021	Auxiliary - Barge	63	50<HP<=120	0%	9%	4%	87%	0.10	3.17	2.82	0.04	0.04
June 2018 - May 2021	Auxiliary - ATB	685	500<HP<=750	0%	29%	1%	70%	0.15	0.99	2.97	0.06	0.06
June 2018 - May 2021	Pump - Barge	515	500<HP<=750	0%	9%	4%	87%	0.07	0.97	1.75	0.02	0.02
June 2018 - May 2021	Pump - ATB Barge	670	500<HP<=750	0%	29%	1%	70%	0.15	0.99	2.97	0.06	0.06

Note:
[1] Average model year assumed based on Tier level information, conservatively as first phase in year
Source:
[1] MSEI CARB Off-Road Model - Barge and Dredge Available at: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road

Marine Table 11. Main Engine Fleet-wide Emission Factors

Year	Vessel Type	Emission Factors (g/kW-hr) - Weighted										
		PM_{10}	$PM_{2.5}$	DPM	NOx	SOx	CO	HC	VOC	CO2	CH4	N2O
June 2018 - May 2021	Tanker - Smallest	0.255	0.240	0.255	16.289	0.389	1.400	0.600	0.632	589.000	0.012	0.029
June 2018 - May 2021	Tanker - Handysize	0.255	0.240	0.255	16.753	0.389	1.400	0.600	0.632	589.000	0.012	0.029
June 2018 - May 2021	Tanker - Handymax	0.255	0.240	0.255	14.667	0.389	1.400	0.600	0.632	589.000	0.012	0.029
June 2018 - May 2021	Tanker - Panamax	0.255	0.240	0.255	15.980	0.389	1.400	0.600	0.632	589.000	0.012	0.029
June 2018 - May 2021	Tanker - Aframax	0.255	0.240	0.255	15.391	0.389	1.400	0.600	0.632	589.000	0.012	0.029
June 2018 - May 2021	Tanker - Suezmax	0.255	0.240	0.255	14.945	0.389	1.400	0.600	0.632	589.000	0.012	0.029
June 2018 - May 2021	Barge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
June 2018 - May 2021	ATB Barge	0.173	0.159	0.173	4.259	0.426	1.605	0.280	0.294	649.000	0.010	0.029

Note:
[1] Emission factors shown represent Tier mix for category
[2] Slow speed diesel: engine speed < 150 rpm; assumed as default for propulsion engines for tankers and medium speed diesel for ATB Barges
Source:
[1] By Tier emission factors from San Pedro Bay Ports Emission Inventory Methodology Report Version 1-2019, Tables 2.3 and 2.4. April 2019.
Available at: https://kentico.portoflosangeles.org/getmedia/3559520c-b85d-45ad-ad68-9947c34b980d/WV_FINAL_SPBP_Emissions_Inventory-_Methodology_4-25-19_scg

Marine Table 12. Auxiliary Engine Fleet-wide Emission Factors

Year	Vessel Type	Emission Factors (g/kW-hr) - Weighted										
		PM_{10}	$PM_{2.5}$	DPM	NOx	SOx	CO	HC	VOC	CO2	CH4	N2O
June 2018 - May 2021	Tanker - Smallest	0.255	0.240	0.255	12.700	0.455	1.400	0.600	0.632	686.000	0.012	0.029
June 2018 - May 2021	Tanker - Handysize	0.255	0.240	0.255	13.420	0.455	1.400	0.600	0.632	686.000	0.012	0.029
June 2018 - May 2021	Tanker - Handymax	0.255	0.240	0.255	11.129	0.455	1.400	0.600	0.632	686.000	0.012	0.029
June 2018 - May 2021	Tanker - Panamax	0.255	0.240	0.255	12.220	0.455	1.400	0.600	0.632	686.000	0.012	0.029
June 2018 - May 2021	Tanker - Aframax	0.255	0.240	0.255	11.597	0.455	1.400	0.600	0.632	686.000	0.012	0.029
June 2018 - May 2021	Tanker - Suezmax	0.255	0.240	0.255	11.389	0.455	1.400	0.600	0.632	686.000	0.012	0.029
June 2018 - May 2021	Barge	0.058	0.054	0.058	3.786	0.007	4.250	0.133	0.141	652.000	0.007	0.031
June 2018 - May 2021	ATB Barge	0.081	0.074	0.081	3.977	0.007	1.332	0.196	0.207	652.000	0.007	0.031

Note:
[1] Emission factors shown represent Tier mix for category
[2] VOC/HC Conversion Factor for Diesel Off-Road Engines: Conversion Factors for Hydrocarbon Emission Components (EPA-420-R-05-015, December 2005)
[3] Barge tug emission factors are used to estimate Sox and GHG emission factors for barges
[4] Tanker auxiliary engines are medium speed.
Source:
[1] San Pedro Bay Ports Emission Inventory Methodology Report Version 1-2019, Tables 2.9 and 2.10. April 2019.
Available at: https://kentico.portoflosangeles.org/getmedia/3559520c-b85d-45ad-ad68-9947c34b980d/WV_FINAL_SPBP_Emissions_Inventory-_Methodology_4-25-19_scg

Marine Table 13. Harbor Craft Tug Characteristics by Vessel Type

Year	Vessel type	HC Classification	Engine Type	Engine Count per HC (total installed power already considered)	HC Average MY	HC Average HP	HC Average kW	Load Factor	Tugs per call
June 2018 - May 2021	Tanker - Smallest	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
June 2018 - May 2021	Tanker - Smallest	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
June 2018 - May 2021	Tanker - Handysize	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
June 2018 - May 2021	Tanker - Handysize	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
June 2018 - May 2021	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
June 2018 - May 2021	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
June 2018 - May 2021	Tanker - Panamax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
June 2018 - May 2021	Tanker - Panamax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
June 2018 - May 2021	Tanker - Aframax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
June 2018 - May 2021	Tanker - Aframax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
June 2018 - May 2021	Tanker - Suezmax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	3
June 2018 - May 2021	Tanker - Suezmax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	3
June 2018 - May 2021	ATB Barge	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	1
June 2018 - May 2021	ATB Barge	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	1
June 2018 - May 2021	Barge	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	1
June 2018 - May 2021	Barge	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	1
June 2018 - May 2021	Barge	Tugboat	Propulsion - Tug	1	2007	4,474	3,338	0.31	1
June 2018 - May 2021	Barge	Tugboat	Auxiliary - Tug	1	2007	444	331	0.43	1

Note:
[1] ERM. 2016. Estimated Emissions Increases and Human Health Risk Impacts Associated with the Marine Terminal III Project. June
[2] Conservatively assumed oldest Tier 2 engines (MY2007), consistent with Marine Terminal III Project (ERM, 2016)
[3] Load factors from San Pedro Ports Emissions Inventory Methodology Report. https://kentico.portoflosangeles.org/getmedia/3559520c-b85d-45ad-ad68-9947c34b980d/WV_FINAL_SPBP_Emissions_Inventory-_Methodology_4-25-19_scg

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Marine Table 14. Harbor Craft time required to assist vessel (hr/one-way trip)

Tug Type	Maneuvering	Light 8 EastBound Route to Maneuvering + between Jobs transit	Mile Rock 1 nm west of Golden Gate Bridge to Light 8 EastBound Route	Pilot Station Sea Buoy to Mile Rock 1 nm west of Golden Gate Bridge + Travel to Vessel	Pilot Station Sea Buoy to Outer Ring of Bouys	Manuevering percent, time allocation
Barge Assist	0.29	5.08	1.90	1.42	0.00	3.3%
Barge Tug	0.29	1.47	1.90	0.83	0.54	5.8%

Note:
[1] The between jobs transit accounts for a tug leaving after vessel tied to wharf and one coming back before vessel leaving wharf. For large vessels there is an extra third tug required during maneuvering. Barges only require 1 assist tug.
[2] The estimated travel time between jobs was assumed to be estimated from a tug home base just off of Angel Island.
Source:
[1] ERM. 2016. Estimated Emissions Increases and Human Health Risk Impacts Associated with the Marine Terminal III Project. June

Marine Table 15. Harbor Craft Tug Emission Factors

Year	Engine Type	Emission Factors (g/kW-hr)									
		PM_{10}	$PM_{2.5}$	DPM	NOX	SOX	CO	VOC	CO2	CH4	N2O
June 2018 - May 2021	Propulsion	0.290	0.266	0.000	7.796	0.007	5.65	0.81	652.00	0.01	0.03
June 2018 - May 2021	Auxiliary	0.287	0.264	0.000	6.924	0.007	5.39	0.75	652.00	0.01	0.03
June 2018 - May 2021	Propulsion - Tug	0.290	0.266	0.000	7.796	0.007	5.65	0.81	652.00	0.01	0.03
June 2018 - May 2021	Auxiliary - Tug	0.213	0.196	0.000	7.146	0.007	5.61	0.80	652.00	0.01	0.03

Note:
[1] Additional tugobat is used to haul barges
Source:
[2] ARB Harbor Craft Emissions Inventory Database
Available at: http://www.arb.ca.gov/msei/california_harbor_craft_emissions_inventory_database_10072011.mdb

Marine Table 16. Fuel Consumption Emission Factors by Engine and Fuel Type

Engine	Engine Speed	Fuel Consumption (g/kw-hr)	Fuel Type
Main	Slow	185	Marine Distilate
Aux	Any	217	Marine Distilate
Boiler	Any	305	Residual Fuel Oil
Assist Tugboat - Auxiliary	Any	137	ULSD
Assist Tugboat - Propulsion	Any	137	ULSD
Tugboat - Auxiliary - Tug	Any	137	ULSD
Tugboat - Propulsion - Tug	Any	137	ULSD

Source:
[1] OGV Source: Appendix D Emissions Estimation Methodology for Ocean-Going Vessels Table II-10, ARB 2011
Available at: https://www.arb.ca.gov/regact/2011/ogv11/ogv11appd.pdf
[2] HC Source: Appendix B Emissions EstimationMethodology for Commercial Harbor Craft Operating in California, ARB
Available at: https://www.arb.ca.gov/msei/chc-appendix-b-emission-estimates-ver02-27-2012.pdf

Marine Table 17. Fuel Consumption by Engine Type

Engine Type	Year	Sum of Kw-Hrs	Fuel Consumption (g)	Fuel Density (g/gal)	Fuel Consumption (gal)
Assist Tugboat - Auxiliary	June 2018 - May 2021	172,515	23,670,633	3,180	7,444
Assist Tugboat - Propulsion	June 2018 - May 2021	4,220,855	579,139,197	3,180	182,119
Aux	June 2018 - May 2021	4,074,636	884,196,056	3,407	259,533
Boiler	June 2018 - May 2021	5,934,262	1,809,949,799	3,483	519,715
Main	June 2018 - May 2021	2,312,764	427,861,264	3,407	125,588
Pump Generator	June 2018 - May 2021	1,808,296	-	-	-
Tugboat - Auxiliary - Tug	June 2018 - May 2021	92,658	12,713,538	3,180	3,998
Tugboat - Propulsion - Tug	June 2018 - May 2021	673,116	92,357,604	3,180	29,043
June 2018 - May 2021 Total		**19,289,101**	**-**	**-**	**1,127,440**

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Marine Table 18. Baseline Emissions per Call by Vessel Type - Transit and Hotelling Only

			Emissions per Call (lbs/call)										
Year	**Vessel Type**	**No. of Calls**	**PM_{10}**	**$PM_{2.5}$**	**DPM**	**NOx**	**SOx**	**CO**	**HC**	**VOC**	**CO2**	**CH4**	**N2O**
June 2018 - May 2021	Tanker - Smallest	3	9.61	9.05	5.63	408.33	28.26	32.12	18.26	19.23	42654.32	0.37	2.91
June 2018 - May 2021	Tanker - Handysize	1	24.06	22.65	13.94	1182.58	73.29	99.80	35.63	37.52	110623.21	0.85	7.59
June 2018 - May 2021	Tanker - Handymax	39	55.20	51.96	29.36	2054.91	172.22	201.88	87.41	92.04	259916.85	1.89	18.19
June 2018 - May 2021	Tanker - Panamax	8	41.51	39.07	24.59	1911.74	123.17	149.46	79.80	84.03	185932.40	1.67	12.77
June 2018 - May 2021	Tanker - Aframax	6	43.47	40.91	25.97	2071.91	130.82	174.27	72.66	76.51	197496.30	1.68	13.52
June 2018 - May 2021	Tanker - Suezmax	13	88.51	83.30	50.86	3655.34	267.19	334.02	150.61	158.59	403288.70	3.27	27.76
June 2018 - May 2021	ATB Barge	28	14.09	12.96	14.09	618.06	8.66	210.19	31.74	33.43	100453.65	1.16	4.74
June 2018 - May 2021	Barge	72	1.28	1.18	1.28	92.06	0.27	61.32	3.60	3.79	23637.95	0.26	1.12

Note:
[1] Emissions per call based on transit and hotelling only, excludes anchorage and tugs

Marine Table 19. Baseline Emissions per Call by Vessel Type - including Tugs

			Emissions per Call (lbs/call)										
Year	**Vessel Type**	**No. of Calls**	**PM_{10}**	**$PM_{2.5}$**	**DPM**	**NOx**	**SOx**	**CO**	**HC**	**VOC**	**CO2**	**CH4**	**N2O**
June 2018 - May 2021	Tanker - Smallest	3	32.81	30.39	28.82	1030.23	28.85	484.20	86.16	83.71	94893.05	1.11	5.40
June 2018 - May 2021	Tanker - Handysize	1	47.26	43.99	37.14	1804.48	73.88	551.87	103.54	102.01	162861.94	1.59	10.08
June 2018 - May 2021	Tanker - Handymax	39	78.40	73.30	52.56	2676.80	172.82	653.95	155.31	156.53	312155.57	2.63	20.67
June 2018 - May 2021	Tanker - Panamax	8	64.71	60.41	47.78	2533.63	123.77	601.53	147.71	148.52	238171.12	2.41	15.25
June 2018 - May 2021	Tanker - Aframax	6	66.66	62.25	49.16	2693.81	131.42	626.34	140.56	140.99	249735.03	2.42	16.01
June 2018 - May 2021	Tanker - Suezmax	13	112.09	105.00	74.45	4287.61	267.80	793.64	219.64	224.15	456399.17	4.02	30.28
June 2018 - May 2021	ATB Barge	28	25.69	23.63	25.69	929.01	8.96	436.23	65.70	65.67	126573.01	1.53	5.98
June 2018 - May 2021	Barge	72	19.43	17.87	19.43	583.13	0.74	419.16	57.36	54.85	64974.86	0.85	3.09

Note:
[1] Emissions per call based on transit and hotelling only with tug assists, excludes anchorage

Marine Table 20. Baseline Total Annual Emissions by Vessel Category

	Annual Emissions (tons/year)										
CATEGORY	**PM_{10}**	**$PM_{2.5}$**	**DPM**	**NOx**	**SOx**	**CO**	**HC**	**VOC**	**CO2**	**CH4**	**N2O**
Barge and tugs - Transit	0.87	0.80	0.87	23.68	0.13	16.74	2.51	2.39	2,159	0.03	0.10
Barge and tugs - Hotelling	0.19	0.17	0.19	10.27	0.02	4.46	0.47	0.50	1,991	0.02	0.09
Tankers with assist tugs - Transit	1.29	1.20	1.29	60.45	1.03	18.61	3.55	3.49	3,670	0.06	0.18
Tankers with assist tugs - Hotelling	1.55	1.46	0.66	42.30	5.16	4.94	2.21	2.33	7,778	0.04	0.56
TOTAL	**3.90**	**3.63**	**3.01**	**136.70**	**6.34**	**44.75**	**8.74**	**8.71**	**15,598**	**0.16**	**0.94**

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Marine Emissions

Project: **Phillips66 Rodeo Renewed Project**
Year: Future
Location: Rodeo Site, San Francisco Refinery, Rodeo, CA

Key tables	Notes
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Nomenclature:
OGV: ocean going vessels (tankers, ATB barges)
HC: harbor craft (i.e. assist tugs, tow tugs)

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Marine Table 21. Future Emissions per Call by Vessel Type - Transit and Hotelling Only

			Emissions per Call (lbs/call)										
Year	Vessel Type	No. of Calls	PM10	PM2.5	DPM	NOx	SOx	CO	HC	VOC	CO2	CH4	N2O
Future	Tanker - Handymax 8	28	50.56	47.59	27.37	2024.99	156.75	187.05	80.78	85.06	236574.83	1.76	16.50
Future	Tanker - Handymax 7	32	53.08	49.96	28.45	2095.83	165.15	195.10	84.38	88.85	249243.99	1.83	17.41
Future	Tanker - Handymax 6	24	31.03	29.20	19.00	1475.99	91.67	124.68	52.87	55.68	138388.86	1.20	9.39
Future	Tanker - Handymax 5	18	37.33	35.13	21.70	1653.09	112.67	144.80	61.88	65.16	170061.75	1.38	11.68
Future	Tanker - Handymax 4	4	55.37	52.12	29.44	2160.23	172.78	202.41	87.65	92.30	260761.41	1.90	18.25
Future	Tanker - Handymax 3	46	19.69	18.53	14.14	1157.22	53.88	88.46	36.67	38.62	81377.65	0.88	5.26
Future	Tanker - Handymax 2	42	21.45	20.19	14.90	1206.81	59.76	94.10	39.19	41.27	90246.06	0.93	5.90
Future	Tanker - Handymax 1	7	26.50	24.94	17.06	1348.81	76.59	110.23	46.41	48.87	115641.96	1.07	7.74
Future	ATB Barge small 4	34	3.28	3.02	3.28	167.69	8.00	80.76	8.23	8.67	41820.50	0.51	1.96
Future	ATB Barge small 3	34	3.83	3.52	3.83	207.64	8.12	101.56	10.15	10.69	52304.79	0.63	2.45
Future	ATB Barge small 2	40	3.91	3.60	3.91	213.79	8.13	104.76	10.45	11.00	53917.75	0.65	2.53
Future	ATB Barge small 1	6	4.26	3.92	4.26	238.94	8.21	117.84	11.66	12.27	60516.26	0.72	2.84
Future	ATB Barge large 2	29	6.21	5.71	6.21	357.75	10.93	177.62	17.42	18.35	91004.07	1.07	4.28
Future	ATB Barge large 1	18	7.07	6.50	7.07	420.02	11.11	210.03	20.42	21.50	107342.76	1.25	5.06

Note:
Emissions per call based on transit and hotelling only, excludes anchorage and tugs

Marine Table 22. Future Emissions per Call by Vessel Type - including Tugs

			Emissions per Call (lbs/call)										
Year	Vessel Type	No. of Calls	PM10	PM2.5	DPM	NOx	SOx	CO	HC	VOC	CO2	CH4	N2O
Future	Tanker - Handymax 8	28	73.76	68.93	50.57	2646.89	157.34	639.12	148.68	149.54	288813.56	2.50	18.98
Future	Tanker - Handymax 7	32	76.28	71.30	51.65	2717.72	165.74	647.17	152.28	153.34	301482.71	2.57	19.90
Future	Tanker - Handymax 6	24	54.23	50.54	42.20	2097.89	92.26	576.75	120.78	120.16	190627.58	1.94	11.87
Future	Tanker - Handymax 5	18	60.53	56.47	44.90	2274.98	113.26	596.87	129.78	129.64	222300.48	2.12	14.17
Future	Tanker - Handymax 4	4	78.57	73.46	52.63	2782.12	173.38	654.49	155.55	156.78	313000.13	2.64	20.73
Future	Tanker - Handymax 3	46	42.88	39.87	37.34	1779.11	54.48	540.53	104.58	103.10	133616.37	1.62	7.75
Future	Tanker - Handymax 2	42	44.65	41.53	38.10	1828.70	60.35	546.17	107.10	105.76	142484.78	1.67	8.39
Future	Tanker - Handymax 1	7	49.70	46.29	40.26	1970.70	77.19	562.30	114.31	113.36	167880.69	1.81	10.23
Future	ATB Barge small 4	34	14.88	13.69	14.88	478.63	8.29	306.80	42.18	40.91	67939.86	0.88	3.20
Future	ATB Barge small 3	34	15.43	14.19	15.43	518.59	8.41	327.59	44.10	42.93	78424.15	1.00	3.70
Future	ATB Barge small 2	40	15.51	14.27	15.51	524.74	8.43	330.79	44.40	43.24	80037.12	1.02	3.77
Future	ATB Barge small 1	6	15.86	14.59	15.86	549.89	8.51	343.88	45.61	44.52	86635.62	1.09	4.09
Future	ATB Barge large 2	29	17.81	16.38	17.81	668.70	11.22	403.66	51.37	50.59	117123.43	1.44	5.52
Future	ATB Barge large 1	18	18.67	17.17	18.67	730.97	11.41	436.06	54.37	53.74	133462.13	1.62	6.30

Note:
Emissions per call based on transit and hotelling only with tug assists, excludes anchorage

Marine Table 23. Future Total Annual Emissions by Vessel Category

	Annual Emissions (tons/year)										
CATEGORY	PM10	PM2.5	DPM	NOx	SOx	CO	HC	VOC	CO2	CH4	N2O
Barge and tugs - Transit	1.11	1.02	1.11	31.46	0.70	20.97	3.06	2.94	3895.20	0.06	0.18
Barge and tugs - Hotelling	0.19	0.18	0.19	13.91	0.04	7.24	0.67	0.70	3649.51	0.04	0.17
Tankers with assist tugs - Transit	3.40	3.15	3.39	154.01	2.37	51.52	9.25	9.04	9422.20	0.15	0.47
Tankers with assist tugs - Hotelling	2.37	2.23	1.02	66.58	7.89	7.56	3.38	3.56	11907.86	0.07	0.86
TOTAL	**7.07**	**6.57**	**5.70**	**265.97**	**11.01**	**87.29**	**16.36**	**16.24**	**28874.76**	**0.31**	**1.68**

Marine Table 24. Deadweight Tonnage and Average Build Time by Vessel Type

Tanker Class	Deadweight tonnage Minimum	Deadweight tonnage Maximum	Average Build Time
Tanker - Smallest	-	4,999	1
Tanker - Small	5,000	9,999	0
Tanker - Handysize	10,000	19,999	1
Tanker - Handymax	20,000	59,999	1
Tanker - Panamax	60,000	79,999	1
Tanker - Aframax	80,000	119,999	1
Tanker - Suezmax	120,000	199,999	2

Note:
DWT Source: Methodologies for Estimating Port-Related and Good Movement Mobile Source Emissions, Table 3.4 Oil Tankers
Average Build Time Source: Methodologies for Estimating Port-Related and Good Movement Mobile Source Emissions, Table C.5 Oil Tankers
Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10102U0.pdf

Marine Table 25. Summary of Future Vessel Traffic and Tier Mix

Year	Vessel Type	Total Vessel Activity		by Engine Tier Calls - Berthing				Slide Valves		by Engine Tier Calls - Anchorage				e Valves - Anchored Ve	
		Calls to Berth	Calls to Anchorage	Tier 0	Tier 1	Tier 2	Tier 3	With	Without	Tier 0	Tier 1	Tier 2	Tier 3	With	Without
Future	Tanker - Handymax 8	7	3	1	4	2	0	5	2	0	2	1	0	2	1
Future	Tanker - Handymax 7	42	21	4	24	14	0	28	14	2	12	7	0	14	7
Future	Tanker - Handymax 6	46	22	4	27	15	0	31	15	2	13	7	0	15	7
Future	Tanker - Handymax 5	4	2	0	2	1	0	3	1	0	1	1	0	1	1
Future	Tanker - Handymax 4	18	9	2	10	6	0	12	6	1	5	3	0	6	3
Future	Tanker - Handymax 3	24	12	2	14	8	0	16	8	1	7	4	0	8	4
Future	Tanker - Handymax 2	32	16	3	18	11	0	21	11	1	9	5	0	10	5
Future	Tanker - Handymax 1	28	14	2	16	9	0	19	9	1	8	5	0	9	5
Future	ATB Barge small 4	6	0	0	1	0	5	0	0	0	0	0	0	0	0
Future	ATB Barge small 3	40	0	0	4	0	36	0	0	0	0	0	0	0	0
Future	ATB Barge small 2	34	0	0	3	0	31	0	0	0	0	0	0	0	0
Future	ATB Barge small 1	34	0	0	3	0	31	0	0	0	0	0	0	0	0
Future	ATB Barge large 2	18	0	0	2	0	16	0	0	0	0	0	0	0	0
Future	ATB Barge large 1	29	0	0	3	0	26	0	0	0	0	0	0	0	0
Future	**Total**	**362**	**98**	**18**	**131**	**67**	**146**	**134**	**67**	**9**	**57**	**33**	**0**	**65**	**33**

Note:
Activity Calls to Berth are Provided by p66
Tier Split is based on Baseline Tier Vessel Mix for Applicable Vessel Types

Marine Table 26. Average Call Durations at Berth and During Anchorage

			Annual Average - Uncontrolled	
Year	Vessel Type	Parcel size (Bbls)	Hotelling Time at Berth (hr/call)	Time at Anchorage (hr/call)
Future	Tanker - Handymax 8	70,000	18.7	2.9
Future	Tanker - Handymax 7	70,000	13.0	2.9
Future	Tanker - Handymax 6	70,000	11.0	2.9
Future	Tanker - Handymax 5	250,000	51.5	2.9
Future	Tanker - Handymax 4	250,000	31.0	2.9
Future	Tanker - Handymax 3	250,000	23.9	2.9
Future	Tanker - Handymax 2	300,000	48.9	2.9
Future	Tanker - Handymax 1	300,000	46.0	2.9
Future	ATB Barge small 4	80,000	20.5	0.0
Future	ATB Barge small 3	80,000	17.4	0.0
Future	ATB Barge small 2	80,000	16.7	0.0
Future	ATB Barge small 1	80,000	11.7	0.0
Future	ATB Barge large 2	150,000	26.0	0.0
Future	ATB Barge large 1	150,000	21.0	0.0

Source:
Average durations and parcel scenarios at-berth per vessel type forecasted by P66 for the Project

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Marine Table 27. OGV Main Engine Rated Power and Vessel Speed

		Annual Average	OGV Maximum Rated Vessel Speed
Year Basis	**Vessel Type**	**Main Eng Avg (kW)**	**Speed (knots)**
Future	Tanker - Handymax	8,861	14
Future	Tanker - Handymax	8,861	15
Future	Tanker - Handymax	8,861	16
Future	Tanker - Handymax	8,861	16
Future	Tanker - Handymax	8,861	16
Future	Tanker - Handymax	8,861	16
Future	ATB Barge small	3,401	0
Future	ATB Barge large	4,474	15

Note:
Main engine average kW based on ship data provided by P66 averaged over vessel type

Vessel Speed Source: Methodologies for Estimating Port-Related and Good Movement Mobile Source Emissions, Table C.1 Oil/Chemical Tankers, Panamax is based on Bulk Carrier Panamax

Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10102U0.pdf

Marine Table 28. OGV Average Aux Engine & Aux Boiler Loads

Vessel Type	Engine Type	Average Loads (kW)			
		Transit	**Maneuvering**	**Berthing**	**Anchorage**
Tanker - Handymax	Auxiliary Engine	621	854	672	672
Tanker - Handymax	Auxiliary Boiler	0	0	1,681	259
Tanker - Handymax	Auxiliary Engine	621	854	672	672
Tanker - Handymax	Auxiliary Boiler	0	0	1,681	259
Tanker - Handymax	Auxiliary Engine	621	854	672	672
Tanker - Handymax	Auxiliary Boiler	0	0	1,681	259
Tanker - Handymax	Auxiliary Engine	621	854	672	672
Tanker - Handymax	Auxiliary Boiler	0	0	1,681	259
Tanker - Handymax	Auxiliary Engine	621	854	672	672
Tanker - Handymax	Auxiliary Boiler	0	0	1,681	259
Tanker - Handymax	Auxiliary Engine	621	854	672	672
Tanker - Handymax	Auxiliary Boiler	0	0	1,681	259
ATB Barge small	Auxiliary Engine	439	439	761	761
ATB Barge small	Pump Generator	0	0	711	0
ATB Barge large	Auxiliary Engine	577	577	1,000	1,000
ATB Barge large	Pump Generator	0	0	1,273	0

Note:
Tanker loads based on ship engine data and load factors from ARB

Pump sizes from real world barge spec sheets (Centerline fleet spec sheets) mutiplied by barge pump load factor (CARB)

Barge Aux engine sizes from real world barge spec sheets (Centerline fleet spec sheets) mutiplied by barge generator load factor (CARB)

Aux engine sizes from real world barge spec sheets (Centerline fleet spec sheets) mutiplied by ocean tug auxiliay engine load factor during transit (CARB)

Marine Table 29. Auxiliary Engine and Boiler Load Factors for Tankers

Mode	Auxiliary Engine	Auxiliary Boiler
Transit	0.24	0
Maneuvering	0.33	0
Anchorage	0.26	0.1
Berthing	0.26	0.65

Note:
ARB Marine Emissions Model v2.3L
Available at: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road
Appendix D Emissions Estimation Methodology for Ocean-Going Vessels Table II-10, ARB 2011
Available at: https://www.arb.ca.gov/regact/2011/ogv11/ogv11appd.pdf

Marine Table 30. Load Factors for Barges Auxiliary Engines and Pumps

Source Type	Aux Engine load factor
Pump	0.71
Generator	0.75
Ocean Tug	0.43

Note:
Pump and Generator Source: MSEI CARB Off-road Model - Barge and Dredge
Available at: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road
Ocean Tug Source: San Pedro Bay Ports Emissions Inventory Methodology Report April 2019, Table 3.1.
Available at: https://kentico.portoflosangeles.org/getmedia/3559520c-b85d-45ad-ad68-9947c34b980d/WV_FINAL_SPBP_Emissions_Inventory-_Methodology_4-25-19_scg

Marine Table 31. OGV Transit Speed (knots) by Vessel Type

Year	Vessel Type	Anchorage	Berthing	Manuevering	Light 8 EastBound Route to Maneuvering	Mile Rock 1 nm west of Golden Gate Bridge to Light 8 EastBound Route	Pilot Station Sea Buoy to Mile Rock 1 nm west of Golden Gate Bridge	Pilot Station Sea Buoy to Outer Ring of Bouys
Future	Tanker - Smallest	0	0	5	8	10	12	12
Future	Tanker - Handysize	0	0	5	8	10	12	12
Future	Tanker - Handymax	0	0	5	8	10	12	12
Future	Tanker - Panamax	0	0	5	8	10	12	12
Future	Tanker - Aframax	0	0	5	8	10	12	12
Future	Tanker - Suezmax	0	0	5	8	10	12	12
Future	Barge	0	0	5	8	10	12	12
Future	ATB Barge	0	0	5	8	10	12	12

Note:
ATB Barge large and small assumed same transit Speed

Marine Table 32. OGV Transit Distance (nm) by Vessel Type

Year	Vessel Type	Anchorage	Berthing	Manuevering	Light 8 EastBound Route to Maneuvering	Mile Rock 1 nm west of Golden Gate Bridge to Light 8 EastBound Route	Pilot Station Sea Buoy to Mile Rock 1 nm west of Golden Gate Bridge	Pilot Station Sea Buoy to Outer Ring of Bouys
Future	Tanker - Smallest	0	0	0.2	11.79	19	10	6.5
Future	Tanker - Handysize	0	0	0.2	11.79	19	10	6.5
Future	Tanker - Handymax	0	0	0.2	11.79	19	10	6.5
Future	Tanker - Panamax	0	0	0.2	11.79	19	10	6.5
Future	Tanker - Aframax	0	0	0.2	11.79	19	10	6.5
Future	Tanker - Suezmax	0	0	0.2	11.79	19	10	6.5
Future	Barge	0	0	0.2	11.79	19	10	6.5
Future	ATB Barge	0	0	0.2	11.79	19	10	6.5

Note:
ATB Barge large and small assumed same transit distance

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Marine Table 33. Barge auxiliary engines and pump composite emission factors

Year	Engine Type	Horsepower	Horsepower Bin	Tier level mix				Composite Emission Factors (g/hp-hr)				
				Tier 0	Tier 1	Tier 2	Tier 3	VOC	CO	NOx	PM10	PM2.5
Future	Auxiliary - Barge	515	50<HP<=120	1%	10%	1%	87%	0.10	3.07	2.68	0.04	0.03
Future	Auxiliary - ATB small	670	500<HP<=750	0%	10%	0%	90%	0.09	0.96	1.85	0.03	0.02
Future	Pump - ATB Barge small	670	500<HP<=750	1%	10%	1%	87%	0.07	0.94	1.62	0.02	0.02
Future	Pump - ATB Barge large	599	500<HP<=750	0%	10%	0%	90%	0.09	0.96	1.85	0.03	0.02

Note:
MSEI CARB Off-Road Model - Barge and Dredge
Available at: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road
Average engine age (model year) assumed based on Tier level information from barge spec sheets, conservatively as first phase in year of a specific C2 engine tier level

Marine Table 34. Main Engine Fleet-wide Emission Factors

Year	Vessel Type	Emission Factors (g/kW-hr) - Weighted										
		PM10	PM2.5	DPM	NOx	SOx	CO	HC	VOC	CO2	CH4	N2O
Future	Tanker - Handymax 8	0.255	0.240	0.255	15.538	0.389	1.400	0.600	0.632	589.000	0.012	0.029
Future	Tanker - Handymax 7	0.255	0.240	0.255	15.538	0.389	1.400	0.600	0.632	589.000	0.012	0.029
Future	Tanker - Handymax 6	0.255	0.240	0.255	15.538	0.389	1.400	0.600	0.632	589.000	0.012	0.029
Future	Tanker - Handymax 5	0.255	0.240	0.255	15.538	0.389	1.400	0.600	0.632	589.000	0.012	0.029
Future	Tanker - Handymax 4	0.255	0.240	0.255	15.538	0.389	1.400	0.600	0.632	589.000	0.012	0.029
Future	Tanker - Handymax 3	0.255	0.240	0.255	15.538	0.389	1.400	0.600	0.632	589.000	0.012	0.029
Future	Tanker - Handymax 2	0.255	0.240	0.255	15.538	0.389	1.400	0.600	0.632	589.000	0.012	0.029
Future	Tanker - Handymax 1	0.255	0.240	0.255	15.538	0.389	1.400	0.600	0.632	589.000	0.012	0.029
Future	ATB Barge small 4	0.094	0.086	0.094	2.936	0.426	1.166	0.151	0.159	649.000	0.010	0.029
Future	ATB Barge small 3	0.094	0.086	0.094	2.936	0.426	1.166	0.151	0.159	649.000	0.010	0.029
Future	ATB Barge small 2	0.094	0.086	0.094	2.936	0.426	1.166	0.151	0.159	649.000	0.010	0.029
Future	ATB Barge small 1	0.094	0.086	0.094	2.936	0.426	1.166	0.151	0.159	649.000	0.010	0.029
Future	ATB Barge large 2	0.093991942	0.086472587	0.093991942	2.936	0.426	1.16584127	0.150640464	0.158624408	649	0.01	0.029
Future	ATB Barge large 1	0.093991942	0.086472587	0.093991942	2.936	0.426	1.16584127	0.150640464	0.158624408	649	0.01	0.029

Notes:
By Tier emission factors from San Pedro Bay Ports Emission Inventory Methodology Report Version 1-2019, Tables 2.3 and 2.4. April 2019.
Available at: https://kentico.portoflosangeles.org/getmedia/3559520c-b85d-45ad-ad68-9947c34b980d/WV_FINAL_SPBP_Emissions_Inventory-_Methodology_4-25-19_scg
Emission factors shown represent Tier mix for category
Slow speed diesel: engine speed < 150 rpm; assumed as default for propulsion engines for tankers and medium speed diesel for ATB Barges

Marine Table 35. Auxiliary Engine Fleet-wide Emission Factors

Year	Vessel Type	Emission Factors (g/kW-hr) - Weighted										
		PM10	PM2.5	DPM	NOx	SOx	CO	HC	VOC	CO2	CH4	N2O
Future	Tanker - Handymax 8	0.255	0.240	0.255	11.799	0.455	1.400	0.600	0.632	686.000	0.012	0.029
Future	Tanker - Handymax 7	0.255	0.240	0.255	11.799	0.455	1.400	0.600	0.632	686.000	0.012	0.029
Future	Tanker - Handymax 6	0.255	0.240	0.255	11.799	0.455	1.400	0.600	0.632	686.000	0.012	0.029
Future	Tanker - Handymax 5	0.255	0.240	0.255	11.799	0.455	1.400	0.600	0.632	686.000	0.012	0.029
Future	Tanker - Handymax 4	0.255	0.240	0.255	11.799	0.455	1.400	0.600	0.632	686.000	0.012	0.029
Future	Tanker - Handymax 3	0.255	0.240	0.255	11.799	0.455	1.400	0.600	0.632	686.000	0.012	0.029
Future	Tanker - Handymax 2	0.255	0.240	0.255	11.799	0.455	1.400	0.600	0.632	686.000	0.012	0.029
Future	Tanker - Handymax 1	0.255	0.240	0.255	11.799	0.455	1.400	0.600	0.632	686.000	0.012	0.029
Future	ATB Barge small 4	0.034	0.032	0.034	2.485	0.007	1.293	0.119	0.126	652.000	0.007	0.031
Future	ATB Barge small 3	0.034	0.032	0.034	2.485	0.007	1.293	0.119	0.126	652.000	0.007	0.031
Future	ATB Barge small 2	0.034	0.032	0.034	2.485	0.007	1.293	0.119	0.126	652.000	0.007	0.031
Future	ATB Barge small 1	0.034	0.032	0.034	2.485	0.007	1.293	0.119	0.126	652.000	0.007	0.031
Future	ATB Barge large 2	0.034	0.032	0.034	2.485	0.007	1.293	0.119	0.126	652.000	0.007	0.031
Future	ATB Barge large 1	0.034	0.032	0.034	2.485	0.007	1.293	0.119	0.126	652.000	0.007	0.031

Note:
San Pedro Bay Ports Emission Inventory Methodology Report Version 1-2019, Tables 2.9 and 2.10. April 2019.
Available at: https://kentico.portoflosangeles.org/getmedia/3559520c-b85d-45ad-ad68-9947c34b980d/WV_FINAL_SPBP_Emissions_Inventory-_Methodology_4-25-19_scg
Emission factors shown represent Tier mix for category
Tanker auxiliary engines are medium speed.

Marine Table 36. Harbor Craft Tug Characteristics by Vessel Type

Year	Vessel type	HC Classification	Engine Type	Engine Count per HC (total installed power already considered)	HC Average MY	HC Average HP	HC Average kW	Load Factor	Tugs per call
Future	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
Future	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
Future	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
Future	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
Future	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
Future	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
Future	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
Future	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
Future	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
Future	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
Future	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
Future	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
Future	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
Future	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
Future	Tanker - Handymax	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	2
Future	Tanker - Handymax	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	2
Future	ATB Barge small	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	1
Future	ATB Barge small	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	1
Future	ATB Barge large	Assist Tugboat	Propulsion	1	2007	4,344	3,241	0.31	1
Future	ATB Barge large	Assist Tugboat	Auxiliary	1	2007	128	95	0.43	1

Note:
ERM. 2016. Estimated Emissions Increases and Human Health Risk Impacts Associated with the Marine Terminal III Project. June
Conservatively assumed oldest Tier 2 engines (MY2007), consistent with Marine Terminal III Project (ERM, 2016)
Load factors from San Pedro Ports Emissions Inventory Methodology Report. https://kentico.portoflosangeles.org/getmedia/3559520c-b85d-45ad-ad68-9947c34b980d/WV_FINAL_SPBP_Emissions_Inventory-_Methodology_4-25-19_scg

Marine Table 37. HC time required to assist vessel (hr/one-way trip)

Tug Type	Maneuvering	Light 8 EastBound Route to Maneuvering + between Jobs transit	Mile Rock 1 nm west of Golden Gate Bridge to Light 8 EastBound Route	Pilot Station Sea Buoy to Mile Rock 1 nm west of Golden Gate Bridge + Travel to Vessel	Pilot Station Sea Buoy to Outer Ring of Bouys	Manuevering percent, time allocation
Barge Assist	0.29	5.08	1.90	1.42	0.00	0.03
Barge Tug	0.29	1.47	1.90	0.83	0.54	0.03

Note:
ERM. 2016. Estimated Emissions Increases and Human Health Risk Impacts Associated with the Marine Terminal III Project. June
1. The between jobs transit accounts for a tug leaving after vessel tied to wharf and one coming back before vessel leaving wharf. For large vessels there is an extra third
2. The estimated travel time between jobs was assumed to be estimated from a tug home base just off of Angel Island.

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Marine Table 38. Harbor Craft Tug Emission Factors

Year	Engine Type	Emission Factors (g/kW-hr)									
		PM10	PM2.5	DPM	NOX	SOX	CO	VOC	CO2	CH4	N2O
Future	Propulsion	0.290	0.266	0.000	7.796	0.007	5.65	0.81	652.00	0.01	0.03
Future	Auxiliary	0.287	0.264	0.000	6.924	0.007	5.39	0.75	652.00	0.01	0.03

Note:
ARB Harbor Craft Emissions Inventory Database
Available at: http://www.arb.ca.gov/msei/california_harbor_craft_emissions_inventory_database_10072011.mdb

Marine Table 39. Fuel Consumption Emission Factors by Engine and Fuel Type

Engine	Engine Speed	Fuel Consumption (g/kw-hr)	Fuel Type
Main	Slow	185	Marine Distilate
Aux	Any	217	Marine Distilate
Boiler	Any	305	Residual Fuel Oil
Assist Tugboat - Auxiliary	Any	137	ULSD
Assist Tugboat - Propulsion	Any	137	ULSD
Tugboat - Auxiliary - Tug	Any	137	ULSD
Tugboat - Propulsion - Tug	Any	137	ULSD

Note:
OGV Source: Appendix D Emissions Estimation Methodology for Ocean-Going Vessels Table II-10, ARB 2011
Available at: https://www.arb.ca.gov/regact/2011/ogv11/ogv11appd.pdf
HC Source: Appendix B Emissions EstimationMethodology for Commercial Harbor Craft Operating in California, ARB
Available at: https://www.arb.ca.gov/msei/chc-appendix-b-emission-estimates-ver02-27-2012.pdf

Marine Table 40. Fuel Consumption by Engine Type

Engine Type	Year	Sum of Kw-Hrs	Fuel Consumption (g)	Fuel Density (g/gal)	Fuel Consumption (gal)
Assist Tugboat - Auxiliary	Future	401,715	55,118,942	3,180	17,333
Assist Tugboat - Propulsion	Future	9,828,594	1,348,571,446	3,180	424,079
Aux	Future	8,171,363	1,773,185,753	3,407	520,473
Boiler	Future	9,102,121	2,776,146,837	3,483	797,152
Main	Future	6,463,100	1,195,673,432	3,407	350,959
Pump Generator	Future	2,641,476	-	-	-
Future Total		**36,608,369**	**-**	**-**	**2,109,997**

Marine Table 41. Future Vessel Activity and Parcel Size

CATEGORIES	Annual calls	Call duration (hr)	Parcel size (Bbls)
Tanker - Handymax 1	7.0	18.7	70,000
Tanker - Handymax 2	42.0	13.0	70,000
Tanker - Handymax 3	46.0	11.0	70,000
Tanker - Handymax 4	4.0	51.5	250,000
Tanker - Handymax 5	18.0	31.0	250,000
Tanker - Handymax 6	24.0	23.9	250,000
Tanker - Handymax 7	32.0	48.9	300,000
Tanker - Handymax 8	28.0	46.0	300,000
ATB Barge small 1	6.0	20.5	80,000
ATB Barge small 2	40.0	17.4	80,000
ATB Barge small 3	34.0	16.7	80,000
ATB Barge small 4	34.0	11.7	80,000
ATB Barge large 1	18.0	26.0	150,000
ATB Barge large 2	29.0	21.0	150,000

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Rail Emissions

Project: **Phillips66 Rodeo Renewed Project**
Year: June 2018 - May 2021
Location: Butane Loading Rack, San Francisco Refinery, Rodeo, CA

Key Tables	Notes
Rail Table 1. Average Butane Rail Rack Daily Process Parameters for 2018-2021	
Rail Table 2. Average Butane Rail Rack Annual Process Parameters for 2018-2021	
Rail Table 3. Constants and Factors	
Rail Table 4. Average 2018-2021 Tier Distribution for Locomotive Engines	
Rail Table 5. Class I Line-Haul Emission Factors (g/bhp-hr)	
Rail Table 6. Class I Line-Haul Emission Factors (g/gal)	
Rail Table 7. Average Locomotive Composite Emission Factors for 2018-2021	
Rail Table 8. Average Consumption of Diesel Fuel for Union Pacific in 2018-2020	
Rail Table 9. Average Railroad Operating Statistics for Union Pacific in 2018-2020	
Rail Table 10. Summary of Average 2018-2021 Baseline Butane Rail Rack Daily Emissions (lbs/day)	
Rail Table 11. Summary of Average 2018-2021 Baseline Butane Rail Rack Annual Emissions (tons/yr)	

Rail Table 1. Average Butane Rail Rack Daily Process Parameters for 2018-2021

Daily Parameter	Value	Units	Reference & Notes
Number of Tank Cars	4.38	cars/day	Data based on project design basis (P66, 2021)
Butane Average Load per Car (bbl)	733	bbl/car	Data based on project design basis (P66, 2021)
Butane Average Load per Car (gal)	30,803	gal/car	Calculated
Butane Weight per Car	75	short tons/car	Calculated
Butane to be Transported	328	short tons/day	Calculated
Tare Weight of Empty Tank Car	48.8	short tons/car	Ref: Eight-axle tank wagon for oil products, https://www.searates.com/reference/tank/
Daily Weight of Empty Tank Cars	232	tare short tons/day	Calculated Tare Weight
Daily Weight of Filled Tank Cars	560	gross short tons/day	Freight Weight + Tare Weight

Note:
[1] Annual process parameters are used to calculate annual inbound and outbound throughput.

Rail Table 2. Average Butane Rail Rack Annual Process Parameters for 2018-2021

Annual Parameter	Value	Units	Reference & Notes
Number of Tank Cars	1,600	cars/year	Data based on project design basis (P66, 2021)
Butane Average Load per Car (bbl)	733	bbl/car	Data based on project design basis (P66, 2021)
Butane Average Load per Car (gal)	30,803	gal/car	Calculated
Butane Weight per Car	75	short tons/car	Calculated
Butane to be Transported	119,736	short tons/year	Calculated
Tare Weight of Empty Tank Car	48.8	short tons/car	Ref: Eight-axle tank wagon for oil products, https://www.searates.com/reference/tank/
Annual Weight of Empty Tank Cars	84,803	tare short tons/year	Calculated Tare Weight
Annual Weight of Filled Tank Cars	204,540	gross short tons/year	Freight Weight + Tare Weight

Note:
[1] Annual process parameters are used to calculate annual inbound and outbound throughput.

Rail Table 3. Constants and Factors

Constants and Factors	Value	Units	Reference & Notes
Density of Butane	4.86	lbs/gal	Ref: Liquified Gas Conversion Chart (LACFD 2018). Available at: https://fire.lacounty.gov/wp-content/uploads/2019/08/Gas_Conversion_Chart.pdf
Net Aggregated Fuel Consumption Index	956	ton-miles/gal	Calculated, includes idling
Percent of Train Weight for Locomotives	8.6%		Calculated
Pound to Gram	453.592	g/lb	
Density of Diesel Fuel	3200	g/gal	Ref: Emission Factors for Locomotives, EPA-420-F-09-025, April 2009. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100500B.PDF?Dockey=P100500B.PDF
Class I Locomotive Fuel Consumption to Horsepower-Hour Conversion Factor	20.8	(hp-hr/gal)	Ref: Emission Factors for Locomotives (EPA 2009)
Class I Line-haul Brake Specific Fuel Consumption (BSFC)	154	(g/hp·hr)	Ref: Table 8.4., Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions, EPA 2020. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10102U0.pdf
Fuel Sulfur Conversion Factor	97.8%		Ref: Emission Factors for Locomotives (EPA 2009)
Sulfur Content of Diesel Fuel	15	ppmw	Ref: California Diesel Fuel Standard (CARB 2014)
Molar Mass of SO_2	64	g/mol SO_2	
Molar Mass of S	32	g/mol S	

Rail Table 4. Average 2018-2021 Tier Distribution for Locomotive Engines

Locomotive Diesel Engines	Percentage
Pre-Tier	0%
Tier 0	5%
Tier 0+	5%
Tier 1	1%
Tier 1+	30%
Tier 2	7%
Tier 2+	26%
Tier 3	21%
Tier 4	6%

Source:

[1] CARB 2021 Line-Haul Locomotive Emission Inventory. February Available at:ww2.arb.ca.gov/sites/default/files/2021-02/2021_line_haul_locomotive_emission_inventory_final.pdf

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Rail Table 5. Class I Line-Haul Emission Factors (g/bhp-hr)

Tier Level	PM_{10}	HC	NOx	CO	$PM_{2.5}$	VOC	SO_2
Pre-Tier	0.32	0.48	13	1.28	0.29	0.51	0.09
Tier 0	0.32	0.48	8.6	1.28	0.29	0.51	0.09
Tier 0+	0.2	0.3	7.2	1.28	0.18	0.32	0.09
Tier 1	0.32	0.47	6.7	1.28	0.29	0.49	0.09
Tier 1+	0.2	0.29	6.7	1.28	0.18	0.31	0.09
Tier 2	0.18	0.26	4.95	1.28	0.17	0.27	0.09
Tier 2+	0.08	0.13	4.95	1.28	0.07	0.14	0.09
Tier 3	0.08	0.13	4.95	1.28	0.07	0.14	0.09
Tier 4	0.015	0.04	1	1.28	0.01	0.04	0.09

Note:
[1]+ Indicates revised standards in 40 CFR Part 1033.
[2] $PM_{2.5}$ emission factor is 92% of PM_{10} .
[3] VOC emissions is assumed to be 1.053 times HC emissions (EPA 2009)
[4] Equation 4.5 in 2017 Line haul Locomotive Model & Update.
Source:
[1] Table 4-7, 2017 Line haul Locomotive Model & Update, California Air Resources Board, Off Road Diesel Analysis Section, October 2017. Available at:

Rail Table 6. Class I Line-Haul Emission Factors (g/gal)

Tier Level	PM_{10}	HC	NOx	CO	$PM_{2.5}$	VOC	SO_2
Pre-Tier	6.7	10.0	270.4	26.6	6.1	10.5	2.0
Tier 0	6.7	10.0	178.9	26.6	6.1	10.5	2.0
Tier 0+	4.2	6.2	149.8	26.6	3.8	6.6	2.0
Tier 1	6.7	9.8	139.4	26.6	6.1	10.3	2.0
Tier 1+	4.2	6.0	139.4	26.6	3.8	6.4	2.0
Tier 2	3.7	5.4	103.0	26.6	3.4	5.7	2.0
Tier 2+	1.7	2.7	103.0	26.6	1.5	2.8	2.0
Tier 3	1.7	2.7	103.0	26.6	1.5	2.8	2.0
Tier 4	0.3	0.8	20.8	26.6	0.3	0.9	2.0

Note:
[1] Unit conversion (g/bhp-hr to g/gal) from Rail Table 7.

Rail Table 7. Average Locomotive Composite Emission Factors for 2018-2021

Criteria Pollutants/GHG	Emission Factor (g/gal)	Emission Factor (lb/1000 gal)
PM_{10}	2.9	6.4
$PM_{2.5}$	2.7	5.9
NOx	115.8	255.2
CO	26.6	58.7
VOC	4.6	10.2
SO_2	2.0	4.3

Source:

[1] CAP EF source: Table 4-7, 2017 Line haul Locomotive Model & Update, California Air Resources Board, Off Road Diesel Analysis Section, October 2017. Available at: https://ww3.arb.ca.gov/msei/ordiesel/locolinehaul2017ei.docx

[2] Tier Distribution Source:CARB 2021 Line-Haul Locomotive Emission Inventory. Available at ww2.arb.ca.gov/sites/default/files/2021-02/2021_line_haul_locomotive_emission_inventory_final.pdf

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Rail Table 8. Average Consumption of Diesel Fuel for Union Pacific in 2018-2020

Kind of locomotive service	Diesel oil (gals)
Freight	880,454,408
Yard Switching	83,806,861
Freight and Yard	**964,261,269**

Source:

[1] Table 750. Consumption of Diesel Fuel, Class I Railroad Annual Report R-1, Union Pacific Railroad, 2018. Available at: https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_up_r1_2018.pdf

[2] Table 750. Consumption of Diesel Fuel, Class I Railroad Annual Report R-1, Union Pacific Railroad, 2019. Available at: https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_up_r1_2019.pdf

[3] Table 750. Consumption of Diesel Fuel, Class I Railroad Annual Report R-1, Union Pacific Railroad, 2020. Available at: https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_up_r1_2020.pdf

Rail Table 9. Average Railroad Operating Statistics for Union Pacific in 2018-2020

Freight Trains, Cars, Cnts., and Caboose	UP Gross ton-miles (thousands)
Road Locomotives	73,298,734
Freight Trains, Cars, Cnts., and Caboose	254,278,555
Unit Trains	
Way Trains	14,903,755
Through Trains	569,776,098
Non-Revenue	10,030,167
Total	**922,287,309**

Source:

[1] Table 755. Consumption of Diesel Fuel, Class I Railroad Annual Report R-1, Union Pacific Railroad, 2018. Available at: https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_up_r1_2018.pdf

[2] Table 755. Consumption of Diesel Fuel, Class I Railroad Annual Report R-1, Union Pacific Railroad, 2019. Available at: https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_up_r1_2019.pdf

[3] Table 755. Consumption of Diesel Fuel, Class I Railroad Annual Report R-1, Union Pacific Railroad, 2020. Available at: https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_up_r1_2020.pdf

Rail Table 10. Summary of Average 2018-2021 Baseline Butane Rail Rack Daily Emissions (lbs/day)

Pollutant/GHG	BAAQMD
NOx	7.09E+00
CO	1.63E+00
VOC	2.83E-01
PM_{10}	1.78E-01
$PM_{2.5}$	1.64E-01
SO_2	1.19E-01

Rail Table 11. Summary of Average 2018-2021 Baseline Butane Rail Rack Annual Emissions (tons/yr)

Pollutant/GHG	BAAQMD
NOx	1.29E+00
CO	2.97E-01
VOC	5.17E-02
PM_{10}	3.24E-02
$PM_{2.5}$	2.98E-02
SO_2	2.18E-02

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Rail Emissions

Project: **Phillips66 Rodeo Renewed Project**
Year: June 2018 - May 2021
Location: Carbon Plant, San Francisco Refinery, Rodeo, CA

Key Tables	Notes
Rail Table 12. Average Carbon Plant Rail Rack Daily Process Parameters for 2018-2021	
Rail Table 13. Average Carbon Plant Rail Rack Annual Process Parameters for 2018-2021	
Rail Table 14. Average 2018-2021 Tier Distribution for Locomotive Engines for Carbon Plant	
Rail Table 15. Summary of Average 2018-2021 Baseline Carbon Plant Rail Rack Daily Emissions (lbs/day)	
Rail Table 16. Summary of Average 2018-2021 Baseline Carbon Plant Rail Rack Annual Emissions (tons/yr)	

Rail Table 12. Average Carbon Plant Rail Rack Daily Process Parameters for 2018-2021

Daily Parameter	Value	Units	Reference & Notes
Number of Railcars	2.83	cars/day	3 visits per week/ 7 cars per week on avg (P66, 2021)
Petroleum Coke Weight per Car	90	short tons/car	(P66, 2021)
Petroleum Coke to be Transported	255	short tons/day	Calculated
Tare Weight of Empty Open Wagons	31	short tons/car	Ref: Six-axle all-metal open wagon, https://www.searates.com/reference/open/
Daily Weight of Empty Open Wagons	95	tare short tons/day	Calculated Tare Weight
Daily Weight of Filled Railcars	350	gross short tons/day	Freight Weight + Tare Weight

Note:
[1] Daily process parameters are used to calculate daily inbound and outbound throughput.

Rail Table 13. Average Carbon Plant Rail Rack Annual Process Parameters for 2018-2021

Annual Parameter	Value	Units	Reference & Notes
Number of Railcars	442	cars/year	Carbon Plant data from P66, 2018-2021 3 year average
Petroleum Coke Weight per Car	90	short tons/car	(P66, 2021)
Petroleum Coke to be Transported	39,780	short tons/year	Calculated
Tare Weight of Empty Open Wagons	31	short tons/car	Ref: Six-axle all-metal open wagon, https://www.searates.com/reference/open/
Annual Weight of Empty Open Wagons	14,885	tare short tons/year	Calculated Tare Weight
Annual Weight of Filled Railcars	54,665	gross short tons/year	Freight Weight + Tare Weight

Note:
[1] Daily process parameters are used to calculate daily inbound and outbound throughput.

Rail Table 14. Average 2018-2021 Tier Distribution for Locomotive Engines for Carbon Plant

Locomotive Diesel Engines	Percentage
Pre-Tier	0%
Tier 0	5%
Tier 0+	5%
Tier 1	1%
Tier 1+	29%
Tier 2	7%
Tier 2+	26%
Tier 3	21%
Tier 4	6%

Source:

[1] CARB 2021 Line-Haul Locomotive Emission Inventory. February Available at:ww2.arb.ca.gov/sites/default/files/2021-02/2021_line_haul_locomotive_emission_inventory_final.pdf

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Rail Table 15. Summary of Average 2018-2021 Baseline Carbon Plant Rail Rack Daily Emissions (lbs/day)

Pollutant/GHG	BAAQMD
NOx	3.98E+00
CO	9.17E-01
VOC	1.58E-01
PM_{10}	9.93E-02
$PM_{2.5}$	9.14E-02
SO_2	6.72E-02

Rail Table 16. Summary of Average 2018-2021 Baseline Carbon Plant Rail Rack Annual Emissions (tons/yr)

Pollutant/GHG	BAAQMD
NOx	3.10E-01
CO	7.15E-02
VOC	1.24E-02
PM_{10}	7.74E-03
$PM_{2.5}$	7.13E-03
SO_2	5.24E-03

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Rail Emissions

Project: **Phillips66 Rodeo Renewed Project**
Year: 2024 (Project)
Location: Rodeo Site, Rodeo, CA

Key Tables	Notes
Rail Table 17. Rodeo Site Rail Rack Daily Process Parameters for 2024	
Rail Table 18. Rodeo Site Rail Rack Annual Process Parameters for 2024	
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Rail Table 20. Composite Emission Factors for Year 2024 for Locomotives	
Rail Table 21. Summary of 2024 Future Rodeo Site Rail Rack Daily Emissions (lbs/day)	
Rail Table 22. Summary of 2024 Future Rodeo Site Rail Rack Annual Emissions (tons/yr)	

Rail Table 17. Rodeo Site Rail Rack Daily Process Parameters for 2024

Daily Parameter	Value	Units	Reference & Notes
Number of Tank Cars	16	cars/day	Based on project design basis (P66, 2021)
Tallow Average Load per Car (bbl)	620	bbl/car	Based on project design basis (P66, 2021)
Tallow Average Load per Car (ft^3)	3,481	ft^3/car	Calculated
Tallow Weight per Car	98	short tons/car	Calculated
Tallow to be Transported	1,568	short tons/day	Calculated
Tare Weight of Empty Tank Car	42.2	short tons/car	Ref: CBTX DOT 111, https://www.gbrx.com/media/1466/tank29000.pdf
Daily Weight of Empty Tank Cars	732	tare short tons/day	Calculated Tare Weight
Daily Weight of Filled Tank Cars	2,300	gross short tons/day	Freight Weight + Tare Weight

Note:
[1] Daily process parameters are used to calculate daily inbound and outbound throughput.

Rail Table 18. Rodeo Site Rail Rack Annual Process Parameters for 2024

Annual Parameter	Value	Units	Reference & Notes
Number of Tank Cars	5,840	cars/year	Based on project design basis (P66, 2021)
Tallow Average Load per Car (bbl)	620	bbl/car	Based on project design basis (P66, 2021)
Tallow Average Load per Car (ft^3)	3,481	ft^3/car	Calculated
Tallow Weight per Car	98	short tons/car	Calculated
Tallow to be Transported	572,271	short tons/year	Calculated
Tare Weight of Empty Tank Car	42.2	short tons/car	Ref: CBTX DOT 111, https://www.gbrx.com/media/1466/tank29000.pdf
Annual Weight of Empty Tank Cars	267,346	tare short tons/year	Calculated Tare Weight
Annual Weight of Filled Tank Cars	839,617	gross short tons/year	Freight Weight + Tare Weight

Note:
[1] Annual process parameters are used to calculate annual inbound and outbound throughput.

Rail Table 19. 2024 Tier Distribution for Locomotive Engines

Locomotive Diesel Engines	Percentage
Pre-Tier	0%
Tier 0	3%
Tier 0+	5%
Tier 1	0%
Tier 1+	29%
Tier 2	3%
Tier 2+	33%
Tier 3	20%
Tier 4	7%

Source:

[1] CARB 2021 Line-Haul Locomotive Emission Inventory. February Available at:ww2.arb.ca.gov/sites/default/files/2021-02/2021_line_haul_locomotive_emission_inventory_final.pdf

Rail Table 20. Composite Emission Factors for Year 2024 for Locomotives

Criteria Pollutants/GHG	Emission Factor (g/gal)	Emission Factor (lb/1000 gal)
PM_{10}	2.6	5.8
$PM_{2.5}$	2.4	5.3
NOx	112.4	247.8
CO	26.6	58.7
VOC	4.2	9.3
SO_2	2.0	4.3

Source:

[1] CAP EF source: Table 4-7, 2017 Line haul Locomotive Model & Update, California Air Resources Board, Off Road Diesel Analysis Section, October 2017. Available at: https://ww3.arb.ca.gov/msei/ordiesel/locolinehaul2017ei.docx

[2] Tier Distribution Source: CARB 2021 Line-Haul Locomotive Emission Inventory. Available at ww2.arb.ca.gov/sites/default/files/2021-02/2021_line_haul_locomotive_emission_inventory_final.pdf

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Rail Table 21. Summary of 2024 Future Rodeo Site Rail Rack Daily Emissions (lbs/day)

Pollutant/GHG	BAAQMD
NOx	2.61E+01
CO	6.19E+00
VOC	9.81E-01
PM_{10}	6.11E-01
$PM_{2.5}$	5.62E-01
SO_2	4.54E-01

Rail Table 22. Summary of 2024 Future Rodeo Site Rail Rack Annual Emissions (tons/yr)

Pollutant/GHG	BAAQMD
NOx	4.77E+00
CO	1.13E+00
VOC	1.79E-01
PM_{10}	1.11E-01
$PM_{2.5}$	1.03E-01
SO_2	8.28E-02