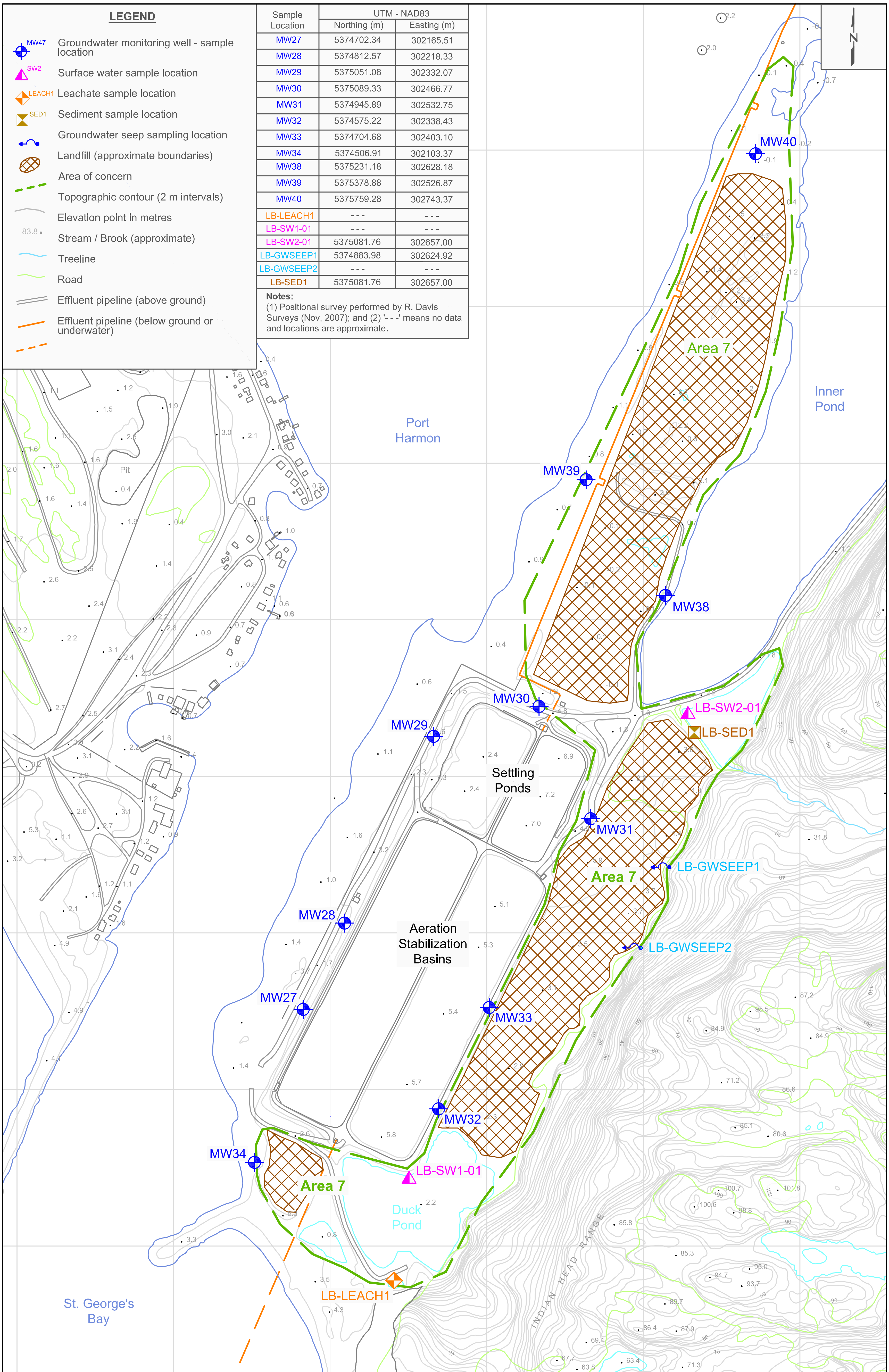
Appendix PPD7-A

Construction Debris Storage Site Figures

Figure 1 Location of old landfill to be used for storing construction debris to provide access for ESA site work.	Project No. 3168-2	Document Reference FFC-NL-3168-2	FFC
	Location Stephenville, NL	Date October 2023	



Sample Location	UTM - NAD83	
	Northing (m)	Easting (m)
MW27	5374702.34	302165.51
MW28	5374812.57	302218.33
MW29	5375051.08	302332.07
MW30	5375089.33	302466.77
MW31	5374945.89	302532.75
MW32	5374575.22	302338.43
MW33	5374704.68	302403.10
MW34	5374506.91	302103.37
MW38	5375231.18	302628.18
MW39	5375378.88	302526.87
MW40	5375759.28	302743.37
LB-LEACH1	- - -	- - -
LB-SW1-01	- - -	- - -
LB-SW2-01	5375081.76	302657.00
LB-GWSEEP1	5374883.98	302624.92
LB-GWSEEP2	- - -	- - -
LB-SED1	5375081.76	302657.00

Notes:
(1) Positional survey performed by R. Davis Surveys (Nov, 2007); and (2) '- - -' means no data and locations are approximate.

Figure 2 Area of Concern 7 - Soil, water and sediment sampling locations.

Project No.	Scale
479-2B	200m Grid
Location: Stephenville, NL	Date: June 2008

FFC

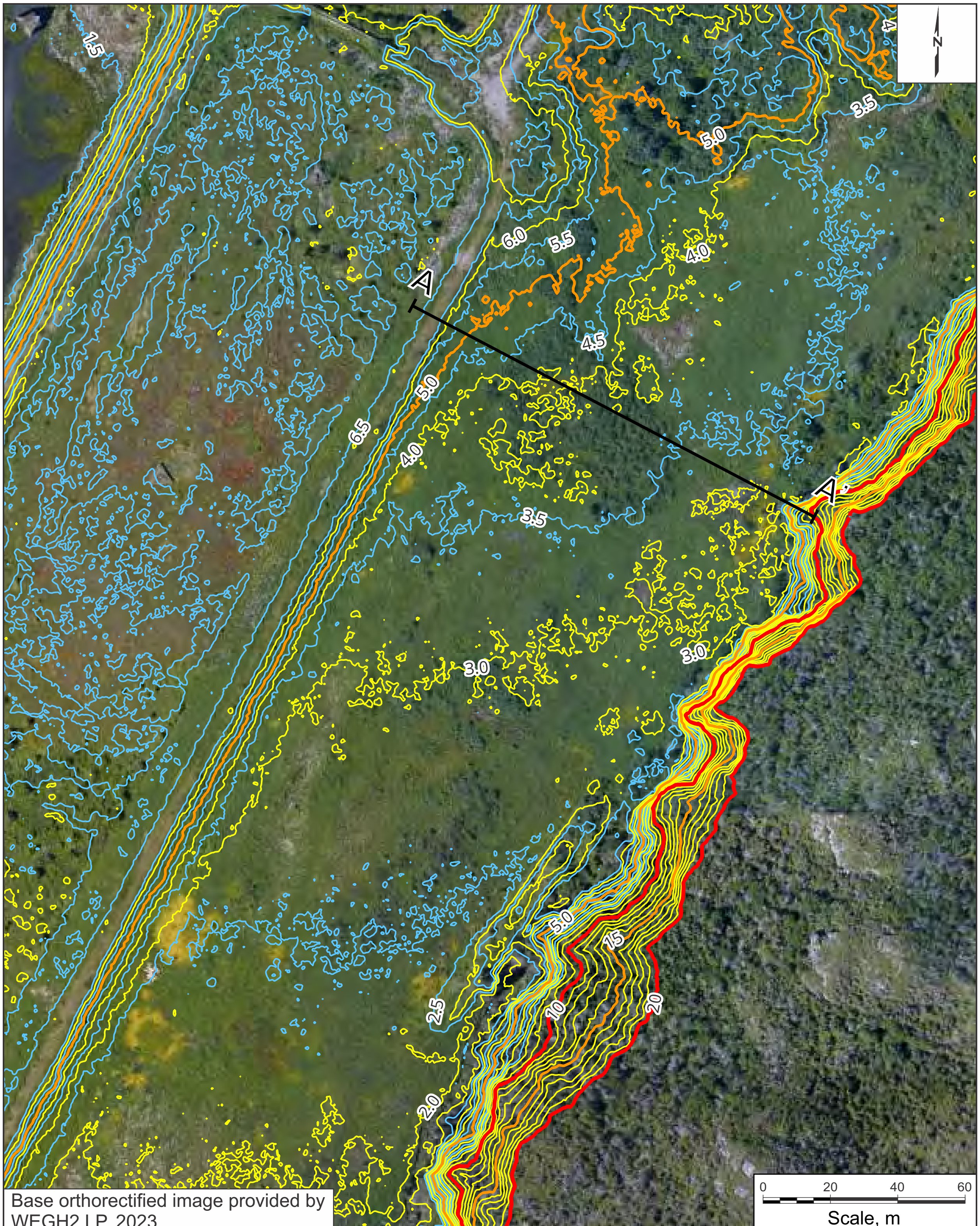


Figure 3 Elevation contour map at the proposed long-term storage site.	Project No. 3168-2	Document Reference FFC-NL-3168-2	FFC
	Location Stephenville, NL	Date November 2023	

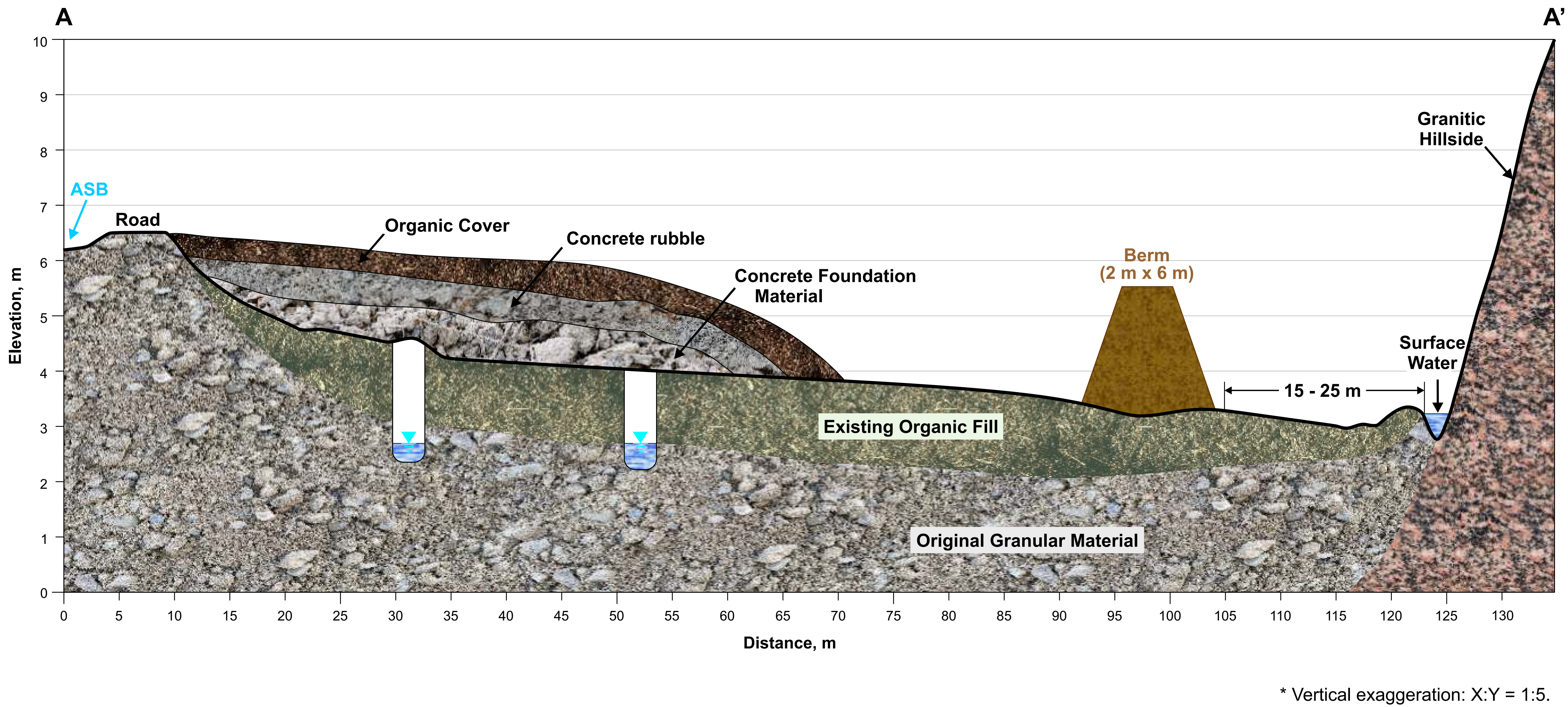


Figure 4 Schematic showing general slope and layered placement of concrete blocks from plant foundation, overlain by a layer of concrete rubble, which in turn is overlain by old organic materials from site.

Project No. 3168-2	Document Reference FFC-NL-3168-2
Location Stephenville	Date November 2023

FFC

Appendix PPD9-A

Preliminary Wastewater Effluent Composition

Revision B
January 10, 2024

By: MDP. Chk: AB, Appr: JF

World Energy Green Hydrogen
Preliminary Waste Water Effluent Composition

	Units	Raw Water Supply		High TDS Water 1st pass RO Reject Water (SOURCED FROM Stantec final report)	High TSS Water Combined Utilties/Effluent Sump (SOURCED FROM Stantec final report)	Total WWT Feed stream (by mass proportioning)	Estimated removal efficiency across WWT (assumed per discussions with Stantec, typical removals for selected technologies/target parameters)	Preliminary (and estimated) Effluent composition	Effluent Limit (NLR 65/03 Schedule A)	Comments
		Min.	Max.							
Flowrate	m^3/hr			35	240	275	-	275		
pH	-	7.32	6.15	7.3	6.5 - 9.0	-	-	6.5-8	5.5 - 9.9	Chemistry to be finalized during FEED, likely in a neutral pH range
Reactive Silica as SiO2	mg CaCO3/L	2.95	0.9	21.3	1.35	3.9	Not targeted for removal	3.9		- See Note 2. - Largely from the source surface water feeding the high purity RO plant
Chloride	mg/L	24	7	237.2	12	40.7	Not targeted for removal	40.7		- See Note 2. - Largely from the source surface water feeding the high purity RO plant
Fluoride	mg/L	<0.12	<0.12	0.8	0.06	0.2	Not targeted for removal	0.2		- See Note 2. - Largely from the source surface water feeding the high purity RO plant
Sulphate	mg/L	5	<2	33.3	2.5	6.4	Not targeted for removal	6.4		- See Note 2. - Largely from the source surface water feeding the high purity RO plant
Turbidity	NTU	5	<0.5	0.0	15.8	13.8	95	0.7		Standard removal efficiency for clarification process
Electrical Conductivity	umho/cm	147	86	1393	465	583	Not targeted for removal	583		The is another method of indicating total dissolved solids.
Nitrate + Nitrite as N	mg/L	0.24	<0.05	0.8	0.065	0.16	Not targeted for removal	0.2	10	- See Note 2. - Exists in equilibrium and is highly reactve and dependent on other streams combining with it. Source surface water is higher than effluent.
Nitrate as N	mg/L	0.24	<0.05	0.8	0.065	0.16	Not targeted for removal	0.2	10	- See Note 2. - Exists in equilibrium and is highly reactve and dependent on other streams combining with it. Source surface water is higher than effluent.
Ammonia as N	mg/L	0.24	< 0.02	1.6	0.12	0.31	Not targeted for removal here (reduced upstream at NH3 plant)	0.3	2	- See Note 2. - Exists in equilibrium and is highly reactve and dependent on other streams combining with it; We can treat with polishing if needed. There is an upstream ammonia management system for a single source point from the ammonia plant that reduces ammonia significantly before this step.
Total Organic Carbon	mg/L	9.7	3.9	17.6	3.65	5.4	>40	<3.3		- See Note 2. - Removed because we are adding coagulation and flocculation ahead of WWT; needs piloting/modelling to confirm
Ortho-Phosphate as P	mg/L	0.05	< 0.01	0.3	0.025	0.1	Not targeted for removal	0.1		- See Note 2 - This would be residual from boiler/utilities blow down water
Total Sodium	mg/L	17	0.5	112.5	53.8	61.3	Not targeted for removal	61.3		Current source is likely surface water feeding the high purity RO plant but it could be increased with chemistry for the WWT system i.e. if caustic is needed for pH or coagulation enhancement
Total Potassium	mg/L	15	0.1	3.3	1.6	1.8	Not targeted for removal	1.8		Largely from the source surface water feeding the high purity RO plant
Total Calcium	mg/L	18.1	4.5	119.9	57.3	65.3	Not targeted for removal	65.3		Largely from the source surface water feeding the high purity RO plant
Total Magnesium	mg/L	3.2	1.8	21.3	10.1	11.5	Not targeted for removal	11.5		Largely from the source surface water feeding the high purity RO plant
TSS-Total Suspended Solids	mg/L	10	0	0	55.2	48.2	95	2.4	30	Standard removal efficiency for clarification process

PRELIMINARY EFFLUENT WATER COMPOSITION

Notes:
1) Metals concentrations do not include corrosion byproduct contributions at this time but the WWT system is designed to handle this during operation.
2) No reported value; used Non-Detection Limit divided by 2

World Energy Green Hydrogen
Preliminary Waste Water Effluent Composition

	Units	Raw Water Supply		High TDS Water 1st pass RO Reject Water (SOURCED FROM Stantec final report)	High TSS Water Combined Utilties/Effluent Sump (SOURCED FROM Stantec final report)	Total WWT Feed stream (by mass proportioning)	Estimated removal efficiency across WWT (assumed per discussions with Stantec, typical removals for selected technologies/target parameters)	Preliminary (and estimated) Effluent composition	Effluent Limit (NLR 65/03 Schedule A)	Comments
		Min.	Max.							
TDS-Total Dissolved Solids	mg/L	104	44	921	329.2	404.5	Not targeted for removal	404.5	1000	Concentration swings will be reduced through equalization tank ahead of clarifier
Total Aluminum	ug/L	183	34	1020.8	579.3	635.5	Not targeted for removal	635.5		Aluminum can be contributed by source surface water and by additives such as coagulant at low dosages - no differentiation between total and dissolved in this analysis
Total Antimony	ug/L	3	<2	16.7	9.5	10.4	Not targeted for removal	10.4		No differentiation between total and dissolved
Total Arsenic	ug/L	<2	<2	11.2	6.3	6.9	Not targeted for removal	6.9	500	No differentiation between total and dissolved
Total Barium	ug/L	27	6	150.6	85.5	93.8	Not targeted for removal	93.8	5000	No differentiation between total and dissolved
Total Beryillium	ug/L	<2	<2	11.2	6.3	6.9	Not targeted for removal	6.9		No differentiation between total and dissolved
Total Bismuth	ug/L	<2	<2	11.2	6.3	6.9	Not targeted for removal	6.9		No differentiation between total and dissolved
Total Boron	ug/L	10	5	13.7	19	18.3	Not targeted for removal	18.3	5000	No differentiation between total and dissolved
Total Cadmium	ug/L	< 0.09	<0.017	0.1	0.1	0.1	Not targeted for removal	0.1	50	No differentiation between total and dissolved
Total Chromium	ug/L	<2	<1	5.6	3.2	3.5	Not targeted for removal	3.5	1000	No differentiation between total and dissolved
Total Cobalt	ug/L	<1	<1	5.6	3.2	3.5	Not targeted for removal	3.5		No differentiation between total and dissolved
Total Copper	ug/L	2	<1	11.2	6.3	6.9	Not targeted for removal	6.9	300	No differentiation between total and dissolved
Total Iron	ug/L	391	54	520	2063.1	1866.7	>40	<1120	10000	No differentiation between total and dissolved
Total Lead	ug/L	3.1	<0.5	17.3	9.8	10.8	Not targeted for removal	10.8	200	No differentiation between total and dissolved
Total Manganese	ug/L	176	4	981.7	557.1	611.1	Not targeted for removal	611.1		No differentiation between total and dissolved
Total Molybdenum	ug/L	<2	<2	11.2	6.3	6.9	Not targeted for removal	6.9		No differentiation between total and dissolved
Total Nickel	ug/L	<2	<2	11.2	6.3	6.9	Not targeted for removal	6.9	500	No differentiation between total and dissolved
Total Phosphorous	ug/L	0.5	0.02	0.2	0.1	0.1	Not targeted for removal	0.1	0.5	No differentiation between total and dissolved
Total Selenium	ug/L	<1	<1	5.6	3.2	3.5	Not targeted for removal	3.5	10	No differentiation between total and dissolved
Total Silver	ug/L	<0.1	<0.1	0.6	0.3	0.3	Not targeted for removal	0.3	50	No differentiation between total and dissolved
Total Strontium	ug/L	40	18	265	126.6	144.2	Not targeted for removal	144.2		No differentiation between total and dissolved
Total Thallium	ug/L	<0.1	<0.1	0.6	0.3	0.3	Not targeted for removal	0.3		No differentiation between total and dissolved
Total Tin	ug/L	<2	<2	11.2	6.3	6.9	Not targeted for removal	6.9		No differentiation between total and dissolved
Total Titanium	ug/L	3	<2	11.2	6.3	6.9	Not targeted for removal	6.9		No differentiation between total and dissolved
Total Uranium	ug/L	<0.2	<0.2	1.1	0.6	0.7	Not targeted for removal	0.7		No differentiation between total and dissolved
Total Vanadium	ug/L	<2	<2	11.2	6.3	6.9	Not targeted for removal	6.9		No differentiation between total and dissolved
Total Zinc	ug/L	7	<5	28	7.7	10.3	Not targeted for removal	10.3	500	No differentiation between total and dissolved
Total Mercury	ug/L	<0.026	<0.026	0.1	0.1	0.1	Not targeted for removal	0.1	5	No differentiation between total and dissolved

Notes:
1) Metals concentrations do not include corrosion byproduct contributions at this time but the WWT system is designed to handle this during operation.
2) No reported value; used Non-Detection Limit divided by 2

Appendix PPD11-A

Detailed Emission Inventory

Blasting Emissions - Construction

Source Description

Blasting using ANFO explosives. Blasting in quarries will occur to generate the required rock/aggregate used during construction, but also blasting will occur for cuts required for construction of the windfarm and road design. Emissions source from the explosive detonation and from the dust generated by blasting. Blasting during construction will occur once per week.

Methodology

Air contaminant releases from blasting during construction are estimated based on information provided by Dexter (construction contractor) and published emission factors (from the US EPA AP-42 Chapter 13.3 Explosives Detonation and ECCC NPRI guidance document Pits and Quarries Reporting Guide)

The depth of the quarries was assumed negligible during construction and therefore no put retention factors were assumed. This is conservative.

Ammonium Nitrate Emulsion assumed, therefore, AP-42 emission factors for ammonium nitrate with fuel oil (ANFO) are used.

Emission Factors

Contaminant	EF	Units	Source
NOx	8	kg/Mg	US EPA AP-42 Ch 13.3
CO	34	kg/Mg	US EPA AP-42 Ch 13.3
SO2	1	kg/Mg	US EPA AP-42 Ch 13.3
PM	578.34	kg/Blast	Calculated based on blast area and equation from ECCC NPRI Pits and Quarries Guide
PM10	0.52	scale factor (fraction of total PM)	US EPA AP-42 Ch 13.3
PM2.5	0.3	scale factor (fraction of total PM)	US EPA AP-42 Ch 13.3

Assumed and provided blasting Information from Dexter/WE

Item	Quantity	Unit	Source/Assumption
Total Explosives (site-wide, full construction)	10,000	tonnes	Blasting section of Project Description indicated 4,000,000 to 10,000,000 kg of explosives (full site).
Total Annual Explosives (site-wide)	4,000	tonnes	Calculated based on 30 months of construction, assumed evenly split during construction period
Construction Duration	30	months	Table 2.3 of the PD
Rock required	8,000,000	m3	Blasting section of Project Description indicated 4,000,000 to 8,000,000 m3 of rock excavation required (full site)
Blast depth	3.5	m	Blasting section of Project Description indicated road rock cut depth of 3.5 m and quarry rock cut depth of 8 m. Using 3.5 m as it is conservative when estimating the blast area.
Blast area (site-wide, full construction)	2,285,714	m2	Calculated Area = volume / depth
Blast area per blast	19,048	m2	Based on~ 1 blast per week (communication with Dexter) over the 30 month construction period

Release Estimates

Air Contaminant	CAS#	Total Annual Emissions	Total Construction Phase Emissions
		(t/a)	(t/construction)
NOX	10102-44-0	32.0	80
CO	630-08-0	136.0	340
SO2	7446-09-5	4.0	10
TSP	N/A-1	30.1	69.4
PM10	N/A-2	15.6	36.1
PM2.5	N/A-3	9.0	20.8

Sample Calculations

Explosive Detonation

Annual CO Emissions = Emission Factor [kg/Mg] x Explosive Used [kg/blast] x Number of Blasts [#/year] x conversion

Annual CO Emissions = $34 \frac{\text{kg CO}}{\text{Mg ANFO}} \times 4{,}000 \frac{\text{MG ANFO}}{\text{year}} \times \frac{1 \text{ tonne CO}}{1000 \text{ kg CO}}$

Annual CO Emissions = $136.0 \frac{\text{tonne}}{\text{year}}$

Blasting of Ore

TPM Emission Factor [kg/blast] = $0.00022 \times A^{1.5}$

Where A = horizontal area (m^2) when blasting depth <21 m.

TPM Emission Factor = $0.00022 \times \left(19{,}048 \frac{m^2}{\text{blast}}\right)^{1.5}$

TPM Emission Factor = $578.34 \frac{\text{kg}}{\text{blast}}$

TPM Emissions = $\text{EF} \times \frac{\text{Blasts}}{\text{hour}} \times \text{Conversion}$

TPM Emissions = $578.34 \frac{\text{kg}}{\text{blast}} \times 52 \frac{\text{blast}}{\text{year}} \times \frac{1 \text{ tonne}}{1000 \text{ kg}}$

TPM Emissions = $30.1 \frac{\text{tonne}}{\text{year}}$

Storage Piles - Fugitive Dust - Wind Erosion Emissions Estimates - Construction

Source Description

Construction materials are stockpiled outside around the construction activities. Emissions result from wind erosion of stockpile surfaces.

Methodology

Air contaminant releases due to wind erosion of storage piles are estimated based on information provided by Dexter (construction company) and published emission factors from the ECCC NPRI Pits and Quarries Reporting Guide. CALMET predicted meteorological data for the Project site (wind speeds and precipitation) are used along with data from the ECCC operated Stephenville Station (days with snow cover) to estimate releases.

Emission Factors & Emission Factors Calculations

Contaminant	Emission Factor (kg/m2yr)
TSP	2.36E-02
PM10	1.18E-02
PM2.5	4.72E-03

Calculation Method - ECCC NPRI Pits and Quarries Reporting Guide (Section 8.9 Emissions Due to Wind Erosion of Stockpile Surfaces)

$EF = 1.12 * 10^{-4} * J * 1.7 * (s/1.5) * 365 * ((365-P)/235) * (I/15)$

Where,

EF: Emission factor in (kg/m^2)

J: Particulate aerodynamic factor

s: Average silt loading of storage pile in percent (%)

P: Average number of days during the year with at least 0.254 mm of precipitation

I: Percentage of time in the year with unobstructed wind speed >19.3 km/h in percent (%)

EF Calc. Input	Value	Source
Silt Content	0.5%	Silt content from Mojave Desert Air Quality Management District, 2000 for "limestone"
Days with precip and/or snow cover	255	Min Annual CALMET predicted precipitation data for grid cell containing the project site and snow cover data from ECCC climate normals for Stephenville station (2020 -2022)
Percentage of time with winds >19.3 km/h	32.56	CALMET predicted winds for grid cell containing the project site (surface level - 10 m)

Particle aerodynamic factors for TPM, PM10 and PM2.5

J(TPM) =	1
J(PM10) =	0.5
J(PM2.5) =	0.2

Emission Inputs

Item	Quantity	Unit	Source/Assumption
Volume of stockpiled material per site	200,000	m3	Email from Chris Barron (Dexter) on May 17, 2023 re. ballpark amount of excess stockpiled material per
Stockpile height	10	m	Heights will be kept low, 10m was assumed.
Piles per site	20	#	Assumed 20 smaller stockpiles make up the total volume, equally distributed in size*
Volume per pile	10,000	m3	Calculated: total volume stockpiled / number of piles
Surface area per pile	3,332	m2	Calculated based on assumed rectangular piles, 100 m width, 30 m depth, 10 m height, slope of 33.7 degrees with w side, slope of 11.3 degrees from d side
Total surface area of all piles (assumed 20 piles at two sites)	133,280	m2	Calculated based on surface area per pile and number of piles (both sites)

*While it was assumed that there were 20 smaller stockpiles that made up the total volume equally, this does not have a large influence on total surface area. For example, had one large pile been use instead, the surface area total would be ~120000. Using more piles is conservative.

Emission Rates

Air Contaminant	CAS#	Emission Rates (T/a)	
		Each Pile	Total (assumed 20 piles, two sites)
TSP	N/A-1	0.08	3.15
PM10	N/A-2	0.04	1.57
PM2.5	N/A-3	0.02	0.63

Sample Calculations

TPM Emissions = Emission Factor × Surface Area of Stockpiles × Conversion

Emission Factor TPM = 1.12 * 10-4 * J * 1.7 * (s/1.5) * 365 * ((365-P)/235) * (I/15)

**Parameters defined above*

$$\text{Emission Factor TPM} = 1.12 \times 0.0001 \times 1 \times 1.7 \times \frac{0.5}{1.5} \times 365 \times \frac{(365 - 255)}{235} \times \frac{33}{15}$$

$$\text{Emission Factor TPM} = 0.024 \frac{kg}{m^2\ year}$$

$$\text{TPM Emissions} = 0.024 \frac{kg}{m^2\ year} \times 133280\ m^2 \times \frac{1}{1000} \frac{tonne}{kg}$$

$$\text{TPM Emissions} = 3.15 \frac{tonne}{year}$$

Transfer Points - Fugitive Dust Emissions Estimates - Construction

Source Description Fugitive dust releases generated from material transfer (at drop points) from loading and unloading of stockpiles.

Methodology Emissions from material transfers are estimated based on information provided by World Energy and published emission factors from the US EPA AP-42 Chapter 13.2.4 Aggregate Handling and Storage Piles. CALMET meteorological data for the Project site (wind speeds) are used to estimate the releases.

Emission Factors & Emission Factors Calculations

Contaminant	Emission Factor (kg/Mg)
TSP	7.10E-03
PM10	3.36E-03
PM2.5	5.08E-04

From US EPA AP-42 Ch 13.2.4

The quantity of particulate emissions generated by either type of drop operation, per kilogram (kg) (ton) of material transferred, may be estimated, with a rating of A, using the following empirical expression:[11]

$$E = k(0.0016)\,\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\ \text{(kg/megagram [Mg])}$$

$$E = k(0.0032)\,\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\ \text{(pound [lb]/ton)} \qquad (1)$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

Particle Size Multiplier, k

TSP	0.74
PM10	0.35
PM2.5	0.053

EF Calc. Input	Value	Source
Average Wind Speed (m/s)	4.58	CALMET predicted average wind speed at project site (2020-2022), at surface level (Level01 - 10 m)
Crushed Limestone Moisture Content	1.1%	Moisture content from US EPA Table 13.2.4-1, upper range for crushed limestone.

Emission Inputs

Item	Quantity	Unit	Source/Assumption
Average Bulk Density of Aggregate	1,475	kg/m3	Sourced from: https://civiltoday.com/civil-engineering-materials/aggregate/198-density-of-aggregate#:~:text=The%20approximate%20bulk%20density%20of%20aggregate%20is,%2D1750%20kg%2Fm3.
High Level Estimate of crushed/screened aggregate for both sites	1,500,000	m3	Section 2.5.1 of the PD
Months of Construction	30	months	Table 2.3 of the PD
Usage per Year for crushed/screened aggregate for both sites	600,000	m3/year	Calculated based on number of months of construction
Add rate (to stockpile for crushed/screened aggregate)	885	kt/year	Calculated from density of aggregate and the quantity of aggregate used per year, assuming all aggregate used was added to a stockpile
Remove Rate (to stockpile for crushed/screen aggregate)	885	kt/year	Calculated from density of aggregate and the quantity of aggregate used per year, assuming all aggregate used was removed from a stockpile
Total material transferred	1,770,000	tonnes/year	Calculated from material added + removed

Emissions Estimates

Air Contaminant	CAS#	Total Annual Releases (T/a)
TSP	N/A-1	12.56
PM10	N/A-2	5.94
PM2.5	N/A-3	0.90

Sample Calculations

TPM Emissions = Emission Factor × Stockpiled Amount × Conversion

Emission Factor TPM = Particle size multiplier * (0.0016) * (Mean wind speed/2)^1.3 / (Material Moisture Content/2)^1.4

$$\text{Emission Factor TPM} = \frac{0.74 \times 0.0016 \times \left(\frac{4.58}{2.20}\right)^{1.3}}{\left(\frac{0.01}{2.00}\right)^{1.4}}$$

$$\text{Emission Factor TPM} = 0.00710\ \frac{\text{kg TPM}}{\text{Megagram}}$$

$$\text{TPM Emissions} = 0.00710\ \frac{\text{kg TPM}}{\text{Megagram}} \times 1\ \frac{\text{1 megagram}}{\text{1 tonne}} \times \frac{1{,}770{,}000}{1}\ \frac{\text{tonne}}{\text{year}} \times \frac{1}{1000}\ \frac{\text{tonne}}{\text{kg}}$$

$$\text{TPM Emissions} = 12.56\ \frac{\text{tonne}}{\text{year}}$$

Crushing and Screening Emissions - Construction

Source Description

Releases of particulates are expected from crushing and screening activities. The construction uses mobile crushers, with 2 at each side. It is assumed that this contains a primary crusher and screen. It was noted that there would be dust collection during crushing.

Methodology

Releases are estimated based on operating information provided by the design team (Dexter) and published emission factors from the US EPA (AP-42 Chapter 11.19.2 - Crushed Stone Processing and Pulverized Mineral Processing - US EPA 2004) as well as from the Australian National Pollutant Inventory document "Emission estimation technique manual for Gold Ore Processing", Version 2.0. PM2.5 emissions are estimated based on emission factors for low moisture ore (<= 4%) in Table 2.3 of the Nevada DEP Guidance on Emission Factors for the Mining Industry. Moisture content was assumed to be 2.1% based on the mositure content presented in AP-42 Table 13.2.4-1 for Various Limestone Products under stone quarrying and processing. The "controlled" emission factors were used as they apply to materials that have moisture content >1.5% (whether naturally or through wet suppression) and to capture the control from dust collection.

Emission Inputs

Item	Quanity	Unit	Source/Assumption
Total Crushed Aggregate	1,500,000	m3	Table 2.3 of the PD, over the full duration of construction (30 months)
Average Bulk Density of Aggegragate (kg/m3)	1,475	kg/m3	Sourced from: https://civiltoday.com/civil-engineering-materials/aggregate/198-density-of-aggregate#:~:text=The%20approximate%20bulk%20density%20of%20aggregate%20is,%2D1750%20kg%2Fm3.
Total Crushed Aggregate	2,212,500	tonnes	Calculated from volume using density
Months of Construction	30	months	Table 2.3 of the PD
Total Annual Aggregate	885,000	tonnes/year	Calculated based on number of months of construction

Emission Factors

Source	Air Contaminant	EF (kg/Mg)	Source
Primary Crusher	TSP	0.01	AUS NPI 2006
	PM10	0.004	AUS NPI 2006
	PM2.5	0.00061	Nevada DEP 2017
Grizzly Screen	TSP	0.0125	US EPA AP-42 Ch 11.19.2
	PM10	0.0043	US EPA AP-42 Ch 11.19.2
	PM2.5	0.00065	Nevada DEP 2017

Emissions factors for low moisture content ore (<4%)

Release Estimates

Air Contaminant	CAS#	Total - Both Sites Annual Emission Rate (tonne/year) Primary Crushing	Sceening	Total
TSP	N/A-1	8.85	11.06	19.91
PM10	N/A-2	3.54	3.81	7.35
PM2.5	N/A-3	0.54	0.58	1.11

Sample Calculation

Full Site

Annual Primary Crushing TPM

Annual Primary Crushing TPM Emissions (tonne/yea) = $\frac{885000 \text{ tonnes}}{\text{year}} \times \frac{0.01 \text{ kg}}{1 \text{ tonne}} \times \frac{1 \text{ tonne}}{1000 \text{ kg}}$

Annual Primary Crushing TPM Emissions (tonne/year) = $\frac{8.85 \text{ tonnes}}{\text{year}}$

Fugitive Emissions of Particulate Matter from Laydown Areas - Construction

Source Description

Emissions result from wind erosion of the laydown area where the wind turbine components are stored.

Methodology

The equation for estimating the Fugitive PM emissions was the same as that used for fugitive emissions from storage piles and is sourced from Mojave Desert Air Quality Management District (MDAQMD), Mineral Handling and Processing Industries, Table 2, 2000, as presented in the ECCC NPRI "Pits and quarries reporting guide." The laydown areas are based on the required areas to be cleared for construction of each turbine site.

Emission Factors & Emission Factors Calculations

Contaminant	Emission Factor [kg/m^2]
TSP	2.36E-02
PM10	1.18E-02
PM2.5	4.72E-03

Calculation Method - ECCC NPRI Pits and Quarries Reporting Guide (Section 8.9 Emissions Due to Wind Erosion of Stockpile Surfaces)

EF = 1.12 * 10^{-4} * J * 1.7 * (s/1.5) * 365 * ((365-P)/235) * (I/15)

Where,

EF: Emission factor in (kg/m^2)

J: Particulate aerodynamic factor

s: Average silt loading of storage pile in percent (%)

P: Average number of days during the year with at least 0.254 mm of precipitation

I: Percentage of time in the year with unobstructed wind speed >19.3 km/h in percent (%)

The particle aerodynamic factor for TPM, PM_{10} and $PM_{2.5}$ are:

$J_{(TPM)}$ =	1
$J_{(PM10)}$ =	0.5
$J_{(PM2.5)}$ =	0.2

EF Calc. Input	Value	Source
Silt Content	0.5%	Silt content from Mojave Desert Air Quality Management District, 2000 for "limestone"
Days with precip and/or snow cover	255	Min Annual CALMET predicted precipitation data for grid cell containing the project site and snow cover data from ECCC climate normals for Stephenville station (2020 -2022)
Percentage of time with winds >19.3 km/h	32.56	CALMET predicted winds for grid cell containing the project site (surface level - 10

Calculation Inputs

1 It is assumed that the silt content from the laydown area is negligible as the areas highlighted are all paved at the airport with the exception of the laydown area at construction site.

Item	Quanity	Unit	Source/Assumption
Annual Number of Wind Turbines Constructed	131.2	#	Calculated based on months of construction (30 months) and total number of turbines over the construction period (328). Assumed evenly distributed per month.
Laydown surface area per wind turbine	10,000	m2	1 turbine laydown area is 1 ha (1 ha = 10000m2), as described in section 2.5.3 of the PD
Surface area of laydown areas (per year)	1,312,000	m2	Calculated from annual number of turbines constructed and temporary laydown area per wind turbine site

Total Emissions Summary

Substance	NPRI CAS-No	Emission Rate [tonnes/year]
Total Particulate Matter	N/A-1	30.97
Particulate matter less than or equal to 10 micrometers (µm) (PM10)	N/A-2	15.49
Particulate matter less than or equal to 2.5 µm (PM2.5)	N/A-3	6.19

Sample Calculations

TPM Emissions = Emission Factor × Surface Area of Stockpiles × Conversion

Emission Factor TPM = 1.12 * 10-4 * J * 1.7 * (s/1.5) * 365 * ((365-P)/235) * (I/15)
**Parameters defined above*

$$\text{Emission Factor TPM} = 1.12 \times 0.0001 \times 1 \times 1.7 \times \frac{0.5}{1.5} \times 365 \times \frac{(365 - 254.667)}{235} \times \frac{33}{15}$$

$$\text{Emission Factor TPM} = 0.02361 \ \frac{\text{kg}}{\text{m}^2\ \text{year}}$$

$$\text{TPM Emissions} = 0.024 \ \frac{\text{kg}}{\text{m}^2\ \text{year}} \times 1312000 \ \text{m}^2 \times \frac{1}{1000} \ \frac{\text{tonne}}{\text{kg}}$$

$$\text{TPM Emissions} = 31.0 \ \frac{\text{tonne}}{\text{year}}$$

Particulate Emissions from Unpaved Roads - Construction

Source Description

Access roads to wind turbines are unpaved. It was indicated that dust suppression would be used, as required. It was assumed that dust suppressant was applied once per month during summer months. The period of construction occurs over 30 months.

Methodology

Emissions calculated using method from US EPA, AP-42, Chapter 13.2.2, Equation 13.2.2(1a), the road distances, the number of vehicles on the roads, and the vehicle weights.

Calculation Inputs

Item	Value	Source
Number of days with >0.2 mm rain plus number of days with snow >0.2 mm (snow cover)[1]	255	Min Annual CALMET predicted precipitation data for grid cell containing the project site and snow cover data from ECCC climate normals for Stephenville station (2020 - 2022)
Silt Content (%)[2]	8.5%	Silt content obtained from US EPA AP-42 Chapter 13 Table 13.2.2-1, for "Construction

Compound	k [kg/VKT]	a	b
Total Particulate Matter[1]	1.381	0.7	0.45
Particulate matter less than or equal to 10 micrometers (µm) (PM10)	0.423	0.9	0.45
Particulate matter less than or equal to 2.5 µm (PM2.5)	0.042	0.9	0.45

[1]Parameters for PM-30 assumed to be equal to TPM as stated in US EPA, AP-42, Chapter 13, Table 13.2.2-2

Unit conversion
1 mile = 1.609 km
1 lb = 0.453592 kg

Sample Calculation

EF = k x (s/12)^a x (W/2.72)^b]

Where

EF = Emission Factor (kg/VKT)
VKT/yr = km/yr (total unpaved road travelled)
s = % (surface material silt content)
W = metric tonnes (mean vehicle weight)

EF TPM (Mainland Access Road) = [1.381 kg/VMT x (8.5% / 12)^ 0.7 x (61.70 tons / 3)^ 0.45]

EF TPM = 0.1684 kg/VKT

Annual TPM Emissions = EF x VKT x (1- Control Efficiency) x (Natural Adjustment) x Conversion

Natural Adjustment = (Operational Days - Days with snow cover or rain >0.2 mm of rain) / Operational Days x 100

Natural Adjustment = (365 - 254.6666667) x 100 / 365

Natural Adjustment = 30%

Annual TPM Emissions (Mainland Access Road) = 0.1684 kg/VKT x 537.6 km/year x (1-0.84) x 0.30 x 1/1000 tonne/kg

Annual TPM Emissions (Mainland Access Road) = 0.0044 tonnes/year

Annual Emissions Summary

Compound	NPRI CAS	Annual Emissions [tonne/year]
Total Particulate Matter[1]	N/A-1	0.067
Particulate matter less than or equal to 10 micrometers (µm) (PM10)	N/A-2	0.002
Particulate matter less than or equal to 2.5 µm (PM2.5)	N/A-3	0.000

[1]PM-30 assumed to be equal to TPM as stated in US EPA, AP-42, Chapter 13, Table 13.2.2-2

Emissions Calculations

World Energy

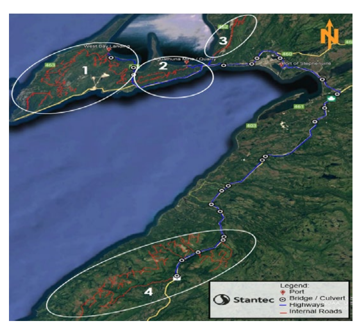
Road Segment - Origin	Road Segment - Destination	Segment Length [m]	# WTG Accessed via Road Segment[3]	# Vehicles per year[4]	Mean vehicle weight [tonnes/ vehicle][5]	VKT/yr	TPM Emission Factor [kg/VKT]	PM10 Emission Factor [kg/VKT]	PM2.5 Emission Factor [kg/VKT]	Natural Adjustment [%]	Control Adjustment [%][2]	TPM Emission[1] [tonne/year]	PM10 Emission [tonne/year]	PM2.5 Emission [tonne/year]
Mainland Access Road	Port au Port - transportation of WTGs	2,000	37	269	62	537.6	0.1684	0.0054	0.0005	30%	16%	4.38E-03	1.40E-04	1.40E-05
Mainland All network, connector and pad roads	Port au Port - transportation of WTGs	3,000	37	338	62	1015.2	0.1684	0.0054	0.0005	30%	16%	8.27E-03	2.65E-04	2.65E-05
Cape Road All access, network, connector and pad roads accessed from main highway	Port au Port - transportation of WTGs	3,000	38	338	62	1015.2	0.1684	0.0054	0.0005	30%	16%	8.27E-03	2.65E-04	2.65E-05
West Bay Access Road and Network road	Port au Port - transportation of WTGs	2,000	9	338	62	676.8	0.1684	0.0054	0.0005	30%	16%	5.51E-03	1.77E-04	1.77E-05
Red Brook, Limestone, Lower Cove and Ship Cove Access roads and network roads	Port au Port - transportation of WTGs	3,000	28	338	62	1015.2	0.1684	0.0054	0.0005	30%	16%	8.27E-03	2.65E-04	2.65E-05
Boswarlos All access, network and pad roads	Port au Port - transportation of WTGs	2,000	15	293	62	585.6	0.1684	0.0054	0.0005	30%	16%	4.77E-03	1.53E-04	1.53E-05
Site C - northern most sites All network, connector and pad roads	Codroy - transportation of WTGs	4,000	164	802	62	3,206	0.1684	0.0054	0.0005	30%	16%	2.61E-02	8.38E-04	8.38E-05
Construction equipment and materials[6]	All	2,000	-	120	15.00	240	0.0891	0.0029	0.0003	30%	16%	1.03E-03	3.32E-05	3.32E-06
TOTAL												**0.067**	**0.002**	**2.14E-04**

[1]PM-30 assumed to be equal to TPM as stated in US EPA, AP-42, Chapter 13, Table 13.2.2-2
[2]Controlled factor of 84% for dust suppressant WRAP (2004) Fugitive Dust Control Measures Applicable for the Western Regional Air Partnerships.
[3]Assumptions:
The number of Wind Turbine Generators (WTGs) accessed per road segment was provided by the design team.
There are 4 options for Codroy access roads, but routes have not yet been finalized. Therefore it is assumed each WTG will travel 2 km. The total length of the access road for this site is 4 km.
Assuming the following road options are not used (the lengths of the roads have not been provided and there are other roads that could be used in their place): White Hills Road, Bald Mountain Access Road
Assuming the entire length of the road segments are being travelled for all WTGs (conservative estimate since some will be closer than others)
[4]Multiplied number of vehicles by two, to account for round trip
[5]Assumed the gross vehicle weight is 61.7 tonnes, which is the heaviest of components as per: https://www.richardstransport.com/services/wind-turbines
[6]Assumed all construction equipment and materials travel 2 km on unpaved roads

DATA:

Delivery of oversize wind turbine components per day:

Areas	Number of turbines	Number of Components	Daily Delivery Round Trips	Days of Turbine Delivery	# Round Trips	# Round Trips per year	Total Port au Port
Area 1	121	1,694	6	282	1,692	677	**2,394**
Area 2	24	336	6	56	336	134.40	
Area 3	26	364	6	61	366	146.40	
Area 4	143	2,002	6	334	2,004	801.60	
Total	314	4,396	24	733	4,398	1,759	



		# WTGs	Area	# Round Trips Total	#Round Trips per year
Mainland Access Road	Port au Port - transportation of WTGs	37	2	336	134
MainlandAll network, connector and pad roads	Port au Port - transportation of WTGs	37	1	423	169.20
Cape RoadAll access, network, connector and pad roads acc	Port au Port - transportation of WTGs	38	1	423	169.20
West BayAccess Road and Network road	Port au Port - transportation of WTGs	9	1	423	169.20
Red Brook, Limestone, Lower Cove and Ship Cove Access roa	Port au Port - transportation of WTGs	28	1	423	169.20
BoswarlosAll access, network and pad roads	Port au Port - transportation of WTGs	15	3	366	146.40
Site C - all sites (northern & southern)	Codroy - transportation of WTGs	164	4	1,002	400.80
				3,396	**1,202.40**

Construction Equipment & materials:

From\To	Area 1	Area 2	Area 3	Area 4
Port of Stephenville	30	30	30	30
West Bay				
Aguathuna Mine / Quarry				

120 total construction deliveries

Mobile Equipment Releases - Construction

Source Description Emissions from the combustion of diesel fuel used in heavy equipment during the construction phase.

Methodology Air contaminant releases from combustion of fuel in large mobile equipment are estimated based on models and operational information provided by Dexter and published emission factors (from the US EPA AP-42 Chapter 3.4 Large Stationary Diesel And All Stationary Dual-fuel Engines - for engines >600 hp and Chapter 3.3 Gasoline and Diesel Industrial Engines).

Emissions Summary

Species	CAS-No	Annual Emissions [tonne/year]
NOX	10102-44-0	35.60
SO2	7446-09-5	41.34
CO	630-08-0	310.46
TSP	N/A-1	1.19
PM10	N/A-2	1.19
PM2.5	N/A-3	1.19

Emission Inputs
Construction Fleet

Type	Model/Description	No. Units	Rated Engine Power (output)	Rated Engine Power (output)	Operating Hours/yr	Assumed Operating Hours/day	Model Specs Source
			hp	MMBTU/hr			
Excavators	C390	1	524	1.33	3000	12	390F L (2017) | Peterson Cat
	C349	8	424	1.08	3000	12	349 Hydraulic Excavator | Cat | Caterpillar
	C336	2	300	0.76	3000	12	336 Hydraulic Excavator | Cat | Caterpillar
	C324	3	188	0.48	3000	12	Caterpillar 324D L Excavator Specs, Dimensions, Comparisons : CEG (constructionequipmentgui
	C305	2	49.2	0.13	3000	12	Caterpillar 305 Excavator Specs – www.MiniExcavatorThumbs.com
Haul Trucks	HM400	14	473	1.20	3000	12	HM400-5 articulated truck | Komatsu
	Live Bottom	5	550	1.40	3000	12	Assumed to be: https://slingers.com/product/2015-fatboy-slinger-truck/
	Tandem	5	455	1.16	3000	12	Assumed to be: https://www.customtruck.com/rental/vocational-trucks/dump-trucks/tandem-axle-19-cu-yd-rear-dump-truck/751-0300
Dozers	D8	2	354	0.90	3000	12	D8 Dozers | Bulldozers | Crawler Dozers | Cat | Caterpillar
	D6	3	215	0.55	3000	12	D6 Dozers | Bulldozers | Crawler Dozers | Cat | Caterpillar
	D4	1	130	0.33	3000	12	D4 Dozers | Bulldozers | Crawler Dozers | Cat | Caterpillar
Roller	CS56	5	157	0.40	3000	12	CS56B Vibratory Soil Compactor | Cat | Caterpillar
Loader	988	2	541	1.38	3000	12	988K Large Wheel Loader | Cat | Caterpillar
	980	2	393	1.00	3000	12	980 Wheel Loader | Cat | Caterpillar
	IT38	2	180	0.46	3000	12	Caterpillar IT38G Wheel Loader Specs, Dimensions, Comparisons : CEG (constructionequipment
Cranes	LG 1750	4	686	1.75	1500	6	Liebherr LG 1750 Crane Overview and Specifications | Bigge.com
	JLG Lift	8	84	0.21	1500	6	Assumed to be: 600S Telescopic Boom Lift | JLG
Concrete	Concrete Plant	2		0.00			
	Cement Transport	4		0.00			
	Concrete Truck	14	425	1.08	1500	6	Assume MP 7: https://www.macktrucks.com/-/media/files/brochures/why-mack-for-concrete-mixer.pdf
	Concrete Pump Truck	2	485	1.24	1500	6	Assume larger pump: https://dyconcretepumps.com/concrete-pumps/chassis-options/mack/
	Crushing Spread	2		0.00			
D&B	Copco L8	2	430	1.10	1500	6	ROC F9TH eng (driftermachine.com)
	Copco D9	3	33.5	0.09	1500	6	07708100015264695331605201853.pdf (kengroup.kz)
	Explosives Truck	2	485	1.24	1500	6	From the PD, pumper trucks take explosives from tankers to blasting sites and can carry up to 12
Grader	G140	2	160	0.41	3000	12	New Holland G140 Motor Grader Specs & Dimensions :: RitchieSpecs
Support	Flat Deck	4	360	0.92	1500	6	Assume higher hp version of truck class: https://freightliner.com/trucks/ m2-106-
	Water Truck	2	700	1.78	1500	6	Assume CAT 777: https://www.cat.com/en_US/products/new/equipment/off-highway-
	Fuel Truck	3	370	0.94	1500	6	Upper range of hp around 370: https://trucktanks.com/fuel-trucks-oilmens/
	Telehandler	2	111	0.28	1500	6	Assumed to be: https://www.cat.com/en_US/products/new/equipment/telehandlers/telehandlers/113441.ht
	support Cranes	10	400	1.02	1500	6	Assumed higher range of examples here: https://gingerichcrane.com/equipment/crawler-cranes
	Boom Truck	4	173	0.44	1500	6	Assumed: https://cranenetwork.com/uploads/specs/5997f28800295ce036007a64a.pdf
	Pickups	30	250	0.64	3000	12	Assume F150 higher range
	Lightning/Pumps/Gens	100+		0.00			

These sources are captured under stationary combustion

Source: Table 2.5 in the Project Description, hours were provided via email from Chris Barron at Dexter (average utilization of 3000 hrs per unit per year for earthmoving equipment, half that for everything else equipment). This averages to just over 8 hours per day, it was assumed in summer months operations could be longer so 12 hours was conservatively used

Emission Factors - Diesel Fuel

US EPA/Canada CEPA Tier 1, 2, 3 and 4 NOx, CO and PM Emission Standards for Off-Road Heavy-Duty Diesel Engines

	Engine Power (hp)	Tier	Model Year	Emission Factors (g/hp-hr)		
				NO_x [a]	CO	TSP
				10102-44-0	630-08-0	N/A-1
	≥100 to <175	Tier 1	1997–2000	6.9	-	-
		Tier 2	2003–2006	4.5	3.7	0.22
		Tier 3	2007–2011	2.8	3.7	0.22
		Tier 4 transitional	2012–2013	0.3	-	0.01
100		Tier 4 final	2014+	0.3	3.7	0.01
	≥175 to <300	Tier 1	1996–2002	6.9	8.5	0.4
		Tier 2	2003–2005	4.5	2.6	0.15
		Tier 3	2006–2010	2.8	2.6	0.15
		Tier 4 transitional	2011–2013	-	-	0.01
175		Tier 4 final	2014+	0.3	2.6	0.01
	≥300 to <600	Tier 1	1996–2000	6.9	8.5	0.4
		Tier 2	2001–2005	4.5	2.6	0.15
		Tier 3	2006-2010	2.8	2.6	0.15
		Tier 4 transitional	2011–2013	0.3	2.6	0.01
300		Tier 4 final	2014+	0.3	2.6	0.01
	≥600 to <750	Tier 1	1996–2001	6.9	8.5	0.4
		Tier 2	2002–2005	4.5	2.6	0.15
		Tier 3	2006-2010	2.8	2.6	0.15
		Tier 4 transitional	2011–2013	0.3	2.6	0.01
600		Tier 4 final	2014+	0.3	2.6	0.01
	≥750	Tier 1	2000–2005	6.9	8.5	0.4
		Tier 2	2006–2010	4.5	2.6	0.15
		Tier 4 transitional	2011–2014	2.6	2.6	0.07
750		Tier 4 final	2015+	2.6	2.6	0.03

Air Contaminant	CAS#	Uncontrolled EF (lb/MMBTU) *	
		Diesel Engines (AP-42 Ch 3.3)	Large Diesel Engines (AP-42 Ch 3.4)
NOX	10102-44-0	4.41	3.2
SO2	7446-09-5	0.29	0.505
CO	630-08-0	0.95	0.85
TSP	N/A-1	0.31	0.1
PM10	N/A-2	0.31	0.1
PM2.5	N/A-3	0.31	0.1

NOTES:
"-"= not available
SOURCES:
Canadian Off-Road Compression-Ignition Engine Emission Regulations (ECCC, 2005)
Nonroad Compression-Ignition Engines - Exhaust Emission Standards (US EPA, 2016a)
* Particulate from diesel combustion assumed to be <1 um

Diesel HHV	0.137	MMBTU/gal	from US EPA AP-42 Appendix A Misc. Data and Conversion Factors
Diesel S Content	0.5	%	
Assumed Diesel Engin	0.4		

Emissions Estimates

Parameter	Hourly Emission Rates (g/s)						Annual Emission Rates (tonnes/year)					
	TSP	PM10	PM2.5	NOX	SO2	CO	TSP	PM10	PM2.5	NOX	SO2	CO
	N/A-1	N/A-2	N/A-3	10102-44-0	7446-09-5	630-08-0	N/A-1	N/A-2	N/A-3	10102-44-0	7446-09-5	630-08-0
C390	1.46E-03	1.46E-03	1.46E-03	4.37E-02	4.88E-02	3.78E-01	0.02	0.02	0.02	0.47	0.53	4.09
C349	9.42E-03	9.42E-03	9.42E-03	2.83E-01	3.16E-01	2.45E+00	0.10	0.10	0.10	3.05	3.41	26.46
C336	1.67E-03	1.67E-03	1.67E-03	5.00E-02	5.59E-02	4.33E-01	0.02	0.02	0.02	0.54	0.60	4.68
C324	1.57E-03	1.57E-03	1.57E-03	4.70E-02	5.25E-02	4.07E-01	0.02	0.02	0.02	0.51	0.57	4.40
C305 - Note 1												
HM400	1.84E-02	1.84E-02	1.84E-02	5.52E-01	6.17E-01	4.78E+00	0.20	0.20	0.20	5.96	6.66	51.65
Live Bottom	7.64E-03	7.64E-03	7.64E-03	2.29E-01	2.56E-01	1.99E+00	0.08	0.08	0.08	2.48	2.77	21.45
Tandem	6.32E-03	6.32E-03	6.32E-03	1.90E-01	2.12E-01	1.64E+00	0.07	0.07	0.07	2.05	2.29	17.75
D8	1.97E-03	1.97E-03	1.97E-03	5.90E-02	6.59E-02	5.11E-01	0.02	0.02	0.02	0.64	0.71	5.52
D6	1.79E-03	1.79E-03	1.79E-03	5.38E-02	6.01E-02	4.66E-01	0.02	0.02	0.02	0.58	0.65	5.03
D4	3.61E-04	3.61E-04	3.61E-04	1.08E-02	1.21E-02	1.34E-01	0.00	0.00	0.00	0.12	0.13	1.44
CS56	2.18E-03	2.18E-03	2.18E-03	6.54E-02	7.31E-02	5.67E-01	0.02	0.02	0.02	0.71	0.79	6.12

988	3.01E-03	3.01E-03	3.01E-03	9.02E-02	1.01E-01	7.81E-01	0.03	0.03	0.03	0.97	1.09	8.44
980	2.18E-03	2.18E-03	2.18E-03	6.55E-02	7.32E-02	5.68E-01	0.02	0.02	0.02	0.71	0.79	6.13
IT38	1.00E-03	1.00E-03	1.00E-03	3.00E-02	3.35E-02	2.60E-01	0.01	0.01	0.01	0.32	0.36	2.81
LG 1750	7.62E-03	7.62E-03	7.62E-03	2.29E-01	4.45E-01	1.98E+00	0.04	0.04	0.04	1.23	2.40	10.70
JLG Lift	1.87E-03	1.87E-03	1.87E-03	5.60E-02	6.26E-02	6.91E-01	0.01	0.01	0.01	0.30	0.34	3.73
Concrete Plant												
Cement Transport												
Concrete Truck	1.65E-02	1.65E-02	1.65E-02	4.96E-01	5.54E-01	4.30E+00	0.09	0.09	0.09	2.68	2.99	23.21
Concrete Pump Truck	2.69E-03	2.69E-03	2.69E-03	8.08E-02	9.03E-02	7.01E-01	0.01	0.01	0.01	0.44	0.49	3.78
Crushing Spread												
Copco L8	2.39E-03	2.39E-03	2.39E-03	7.17E-02	8.01E-02	6.21E-01	0.01	0.01	0.01	0.39	0.43	3.35
Copco D9 - Note 1												
Explosives Truck	2.69E-03	2.69E-03	2.69E-03	8.08E-02	9.03E-02	7.01E-01	0.01	0.01	0.01	0.44	0.49	3.78
G140	8.89E-04	8.89E-04	8.89E-04	2.67E-02	2.98E-02	2.31E-01	0.01	0.01	0.01	0.29	0.32	2.50
Flat Deck	4.00E-03	4.00E-03	4.00E-03	1.20E-01	1.34E-01	1.04E+00	0.02	0.02	0.02	0.65	0.72	5.62
Water Truck	3.89E-03	3.89E-03	3.89E-03	1.17E-01	2.27E-01	1.01E+00	0.02	0.02	0.02	0.63	1.23	5.46
Fuel Truck	3.08E-03	3.08E-03	3.08E-03	9.25E-02	1.03E-01	8.02E-01	0.02	0.02	0.02	0.50	0.56	4.33
Telehandler	6.17E-04	6.17E-04	6.17E-04	1.85E-02	2.07E-02	2.28E-01	0.00	0.00	0.00	0.10	0.11	1.23
support Cranes	1.11E-02	1.11E-02	1.11E-02	3.33E-01	3.73E-01	2.89E+00	0.06	0.06	0.06	1.80	2.01	15.60
Boom Truck	1.92E-03	1.92E-03	1.92E-03	5.77E-02	6.45E-02	5.00E-01	0.01	0.01	0.01	0.31	0.35	2.70
Pickups	2.08E-02	2.08E-02	2.08E-02	6.25E-01	6.99E-01	5.42E+00	0.23	0.23	0.23	6.75	7.54	58.50
Lightning/Pumps/Gens												
						Total	**1.19E+00**	**1.19E+00**	**1.19E+00**	**3.56E+01**	**4.13E+01**	**3.10E+02**

1Not included due to too small of an engine size (emission factor not application) - assumed negligible

These sources are captured under stationary combustion

Stationary Diesel Consumption - Construction

Source Description Stationary Diesel Combustion includes generators, heaters, mobile crushers/batch plant and generators for tower lights.

Methodology Emissions were estimated using emission factors sourced from US EPA, AP 42 Chapter 3.3 - Stationary Internal Combustion Sources, Gasoline and Diesel Industrial Engines.

Calculation Inputs

Item	Quantity	Unit	Source/Assumption
Diesel usage - PaP	1	ML	Email from Chris Barron (Dexter) on May 17, 2023 noting "the only meaningful generator use is for mobile crushers/batch plant, ~1ML per site." This is over the full construction period.
	36882.43	MMBtu*	
Diesel usage - Codroy	1	ML	
	36882.43	MMBtu*	
PaP Construction Duration	27	months	Section 2.4 of the Project Description (PD)
Codroy Construction Duration	27	months	
Monthly Diesel Usage - PaP	1366.02	MMBtu/month	Calculated based on construction duration
Monthly Diesel Usage - Codroy	1366.02	MMBtu/month	
Annual Diesel Usage - PaP	16392.19	MMBtu/year	Calculated based on number of months per year and monhtly usage
Annual Diesel Usage - Codroy	16392.19	MMBtu/year	

*Diesel consumption converted from ML/year to MMBTu/year using Heating value of 139,600 Btu/gal (Perry's Chem. Eng. Handbook), and conversion of 1 gallon = 3.785 L

Annual Emissions Summary/Emission Calculations

Substance	CAS Number	Diesel Emission Factor (lb/MMBtu)	PaP Annual Emissions [tonne/year]	Codroy Annual Emissions [tonne/year]	Total Annual Emissions [tonne/year]
Acetaldehyde	75-07-0	7.67E-04	5.70E-03	5.70E-03	1.14E-02
Acrolein	107-08-8	9.25E-05	6.88E-04	6.88E-04	1.38E-03
Anthracene	120-12-7	1.87E-06	1.39E-05	1.39E-05	2.78E-05
Benzene	71-43-2	9.33E-04	6.94E-03	6.94E-03	1.39E-02
1,3-butadiene	106-99-0	3.91E-05	2.91E-04	2.91E-04	5.82E-04
Formaldehyde	50-00-0	1.18E-03	8.78E-03	8.78E-03	1.76E-02
Naphthalene	91-20-3	8.48E-05	6.31E-04	6.31E-04	1.26E-03
Propylene	115-07-1	2.58E-03	1.92E-02	1.92E-02	3.84E-02
Toluene	108-88-3	4.09E-04	3.04E-03	3.04E-03	6.08E-03
Isomers of xylene	1330-20-7	2.85E-04	2.12E-03	2.12E-03	4.24E-03
Acenaphthene	83-32-9	1.42E-06	1.06E-05	1.06E-05	2.11E-05
Acenaphthylene	208-96-8	5.06E-06	3.76E-05	3.76E-05	7.53E-05
Benzo (a) anthracene	56-55-3	1.68E-06	1.25E-05	1.25E-05	2.50E-05
Benzo (a) pyrene	50-32-8	1.88E-07	1.40E-06	1.40E-06	2.80E-06
Benzo (b) fluoranthene	205-99-2	9.09E-05	6.76E-04	6.76E-04	1.35E-03
Benzo (k) fluoranthene	207-08-9	1.55E-07	1.15E-06	1.15E-06	2.31E-06
Dibenzo (a,h) anthracene	53-70-3	5.83E-07	4.34E-06	4.34E-06	8.67E-06
Benzo (g,h,i) perylene	191-24-2	4.89E-07	3.64E-06	3.64E-06	7.27E-06
Fluoranthene	206-44-0	7.61E-06	5.66E-05	5.66E-05	1.13E-04
Fluorene	86-73-7	2.92E-05	2.17E-04	2.17E-04	4.34E-04
Indeno(1,2,3-c,d) pyrene	193-39-5	3.75E-07	2.79E-06	2.79E-06	5.58E-06
Phenanthrene	85-01-8	2.94E-05	2.19E-04	2.19E-04	4.37E-04
Pyrene	129-00-0	4.78E-06	3.56E-05	3.56E-05	7.11E-05
Total PAHS		1.68E-04	1.25E-03	1.25E-03	2.50E-03
Carbon monoxide (CO)	630-08-0	9.50E-01	7.07E+00	7.07E+00	1.41E+01
Oxides of nitrogen (NOx), expressed as nitrogen dioxide (NO2)	10102-44-0	4.41E+00	3.28E+01	3.28E+01	6.56E+01
Total Particulate Matter	N/A-1	3.10E-01	2.31E+00	2.31E+00	4.61E+00
Particulate matter less than or equal to 10 micrometers (µm) (PM10)	N/A-2	3.10E-01	2.31E+00	2.31E+00	4.61E+00
Particulate matter less than or equal to 2.5 µm (PM2.5)	N/A-3	3.10E-01	2.31E+00	2.31E+00	4.61E+00
Sulphur dioxide (SO2)	7446-09-5	2.90E-01	2.16E+00	2.16E+00	4.31E+00
Volatile organic compounds	NA - M16	3.60E-01	2.68E+00	2.68E+00	5.35E+00
Benzene	71-43-2	9.33E-04	6.94E-03	6.94E-03	1.39E-02
1,3-butadiene	106-99-0	3.91E-05	2.91E-04	2.91E-04	5.82E-04
Formaldehyde	50-00-0	1.18E-03	8.78E-03	8.78E-03	1.76E-02
Propylene	115-07-1	2.58E-03	1.92E-02	1.92E-02	3.84E-02
Toluene	108-88-3	4.09E-04	3.04E-03	3.04E-03	6.08E-03
Isomers of xylene	1330-20-7	2.85E-04	2.12E-03	2.12E-03	4.24E-03

Sample Calculations

Sample calculation for Port au Port

Annual Acetaldehyde Emissions (tonnes/year) = Diesel Energy Consumed [MMBTu/year]x EF [lb/MMBtu] x Conversion

$$\text{Annual Acetaldehyde Emissions (tonnes/year)} = \frac{16392 \text{ MMBtu}}{\text{year}} \times \frac{7.67\text{E-}04 \text{ lb}}{\text{MMBtu}} \times \frac{1 \text{ kg}}{2.204 \text{ lb}} \times \frac{1 \text{ tonne}}{1000 \text{ kg}}$$

$$\text{Annual Acetaldehyde Emissions (tonnes/year)} = \frac{5.70\text{E-}03 \text{ tonne}}{\text{year}}$$

Emission estimates from flare - emergency NH3 flaring and continuous pilot - Operations

Source Description The facility will have a flare that will be used to flare ammonia or hydrogen during non-routine events. The flare pilot will be lit using butane. It is expected that the flare will only be used once per year and that the full flaring event will be 1-hour. The flare has 3 heads, each with

Methodology The combustion of butane in the flare will likely result in thermal NOx emissions. The combustion of ammonia in the flare will likely result in both thermal NOx and fuel NOx emissions. Thermal NOx emissions are estimated using emission factors from the AP-42 Chapter 13.5 Industrial Flares (US EPA 1995) and from the Texas Commission on Environmental Quality (TCEQ) 2021 Emissions Inventory Guidelines (RG-360/21). Particulate emissions from the butane in the flare were estimated based on emission factors presented in the article "Black carbon particulate matter emission factors for buoyancy-driven associated gas flares" (McEwen & Johnson 2012).

Residual emissions of non-inerts (ammonia and butane) are calculated assuming a destruction efficiency of 98% (obtained from US EPA AP-42 Chapter 13.5, 1995).

Emissions Summary

			Emission Rate (g/s)			Tonnes/year
Source	**Scenario**	**Species**	**Hourly**	**Daily**	**Annual**	**Annual**
Flare 1 - 3 (each)	Pilot	Butane (C4H10)	1.17E-02	1.17E-02	1.17E-02	0.3691
		Nitrogen Oxides (Nox)	8.40E-04	8.40E-04	8.40E-04	0.0265
		Carbon Monoxide (CO)	6.79E-03	6.79E-03	6.79E-03	0.2141
		Particulate Matter (PM)	1.77E-07	1.77E-07	1.77E-07	5.57E-06
	NH3 Release	Ammonia (NH3)	64.9	2.7	0.007	0.23
		Nitrogen Oxides (Nox)	18.4	0.77	0.002	0.066108766

Emission Inputs

	Item	Quantity	Unit	Source/Assumption
	Flare Destruction efficiency	98%	%	US EPA AP-42 Chapter 13.5, 1995
Butane (C4H10) (continuous pilot)	**Density**	2.48	kg/m3	at 15°C, 1 bara. Obtained from https://www.engineeringtoolbox.com/butane-density-specific-weight-temperature-pressure-d_2080.html
	Flow	30	SCFH	Flaring inputs were provided from ARUP from Rebecca Curtis via email on May 5, 2023
	Flow	0.8	m3/hr	Converted from SCFH
	Mass Flow C4H10	2.1	kg/hr	Converted from volumetric flow using density
	% C4H10	100%	%	Assumption
Ammonia (NH3) (intermittent release)	**Release[a]**	11.5	tons/hour	imperial tons. Flaring inputs were provided from ARUP from Rebecca Curtis via email on May 5, 2023
	Temp[a]	450	°C	Flaring inputs were provided from ARUP from Rebecca Curtis via email on May 5, 2023
	Pressure[a]	300	bar(g)	Flaring inputs were provided from ARUP from Rebecca Curtis via email on May 5, 2023
	% NH3	100%	%	Assumption
	Mass Flow NH3	11,685	kg/hr	Converted from release in tons/hour

[a] Flaring inputs were provided from ARUP from Rebecca Curtis via email on May 5, 2023

Conversion Units

1	MJ =	947.8170	BTU	
1	lb =	0.45	kg	
1	SCFH =	35.31468492	m3/hr	*68F, 14.696 psi a

Heating Values

Species	LHV (MJ/kg)	HHV (MJ/kg)	Source
Ammonia	18.9	22.5	https://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html
Butane	45.3	49.1	

Emission Factors

Thermal NOX

Species	Emission Factor	Units	Source
Nitrogen Oxides	0.068	lb/10^6 Btu	US EPA 1995
Carbon monoxide	0.37	lb/10^6 Btu	US EPA 1995
Carbon monoxide	0.5496	LB/MMBTU	TCEQ 2021
Particulate Matter	0.74798	kg/10^3 m3 fuel	McEwen & Johnson 2012

Fuel NOx (ammonia)

Species	Mass basis	Units	Source
Nitrogen oxides	0.50%	Mass basis, kgNOx/kg NH3	TCEQ 2021

Sample Calcs

Thermal NOX

Thermal Nox emissions from NH3= Mass Flow NH3 (kg/hr) x HHV (MG/kg) x Emission Factor (lb Nox/BTU) x Conversions

Thermal Nox emissions from NH3=
$$\frac{11684.6 \text{ kg NH3}}{\text{hr}} \times \frac{22.5 \text{ MJ}}{\text{kg}} \times \frac{947.8170 \text{ BTU}}{1 \text{ MJ}} \times \frac{0.068 \text{ lb Nox}}{1000000 \text{ BTU}} \times \frac{0.45 \text{ kg}}{1 \text{ lb}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

Thermal Nox emissions from NH3=
$$\frac{2.135 \text{ g}}{\text{s}}$$

Thermal Nox emissions from butane =
$$\frac{2.1 \text{ kg butane}}{\text{hr}} \times \frac{49.1 \text{ MJ}}{\text{kg}} \times \frac{947.8170 \text{ BTU}}{1 \text{ MJ}} \times \frac{0.068 \text{ lb Nox}}{1000000 \text{ BTU}} \times \frac{0.45 \text{ kg}}{1 \text{ lb}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

Thermal Nox emissions from butane =
$$\frac{0.00 \text{ g}}{\text{s}}$$

CO emissions from butane =
$$\frac{2.1 \text{ kg butane}}{\text{hr}} \times \frac{49.1 \text{ MJ}}{\text{kg}} \times \frac{947.8170 \text{ BTU}}{1 \text{ MJ}} \times \frac{0.5496 \text{ lb CO}}{1000000 \text{ BTU}} \times \frac{0.45 \text{ kg}}{1 \text{ lb}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

CO emissions from butane =
$$\frac{0.01 \text{ g}}{\text{s}}$$

PM emissions from butane =
$$\frac{0.8 \text{ m3}}{\text{hour}} \times \frac{0.74798 \text{ kg}}{1000 \text{ m3}} \times \frac{1 \text{ hour}}{3600 \text{ sec}}$$

PM emissions from butane =
$$\frac{1.76504\text{E-07 g}}{\text{s}}$$

Fuel NOx

Fuel Nox from NH3 = Mass Flow NH3 (kg/hr) x Emission Factor (kg Nox/KG NH3) x Conversion

Fuel Nox from NH3 =
$$\frac{11684.6 \text{ kg NH3}}{\text{hr}} \times \frac{0.50\% \text{ Kg Nox}}{\text{Kg NH3}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

Fuel Nox from NH3 =
$$\frac{16.2 \text{ g}}{\text{s}}$$

Residual Emissions

NH3 Residual Emissions= Mass Flow NH3 (kg/hr) x (1 - % destruction) x Conversion

NH3 Residual Emissions=
$$\frac{11684.6 \text{ kg}}{\text{hr}} \times (1 - 0.98) \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

NH3 Residual Emissions=
$$\frac{64.914 \text{ g}}{\text{s}}$$

Emission estimates from the Cooling Tower - Operations

Source Description The ammonia/hydrogen plant has an open recirculating cooling tower to support the electrolyzer. Assume that it runs 24/7/365.

Methodology Particulate releases are estimated from the cooling tower following the method described in Environment and Climate Change Canada's (ECCC) NPRI "Wet cooling towers: guide to reporting" (ECCC 2023) which follows the approach in AP-42 Chapter 13.4. It was conservatively assumed that TPM = PM10 = PM2.5. The emissions are total for the full cooling tower unit and will be modelled split evenly by cell.

Emissions Estimates

	Emission Rate (g/s)			tonne/ year
Air Contaminant	**hourly**	**daily**	**annual**	**annual**
TPM	0.42	0.42	0.42	13.09
PM10	0.42	0.42	0.42	13.09
PM2.5	0.42	0.42	0.42	13.09

Calculation Inputs

Item	Value	Units	Source
TDS Concentration	649	mg/L (ppmw)	provided by ARUP
Make up rate:	1,300	GPM	provided by ARUP
Total water supply:	50,700	GPM	provided by ARUP
Total water supply:	11,515,187	L/h	converted from GPM
Annual Operational Hours	8,760	hours/year	Assumed 24/7/365

AP-42 Table 13.4-1 (Metric And English Units). PARTICULATE EMISSIONS FACTORS FOR WET COOLING TOWERSa

Tower Typed	Total Liquid Drift Circulating Water Flow
Induced Draft (SCC 3-85-001-01, 3-85-001-20, 3-85-002-01)	0.020

Note under table: Total liquid drift is water droplets entrained in the cooling tower exit air stream. Factors are for % of circulating water flow (10-2 L drift/L [10-2 gal drift/gal] water flow) and g drift/daL (lb drift/103 gal) circulating water flow. 0.12 g/daL = 0.1 lb/103 gal; 1 daL = 10 L.

W = M - E - D
Where
W = Drift Loss
M = Make-Up Water
E = Evaporated Water
D = Blow Down Water
With limited information on the blowdown water and evaporated water flows, a conservative drift value was applied

TPM Emissions = TSD (mg/L) x Drift Loss (%) x Circulating Water Rate (L/h) x Conversion

Hourly TPM Emissions (g/s) = 649 mg/L x 0.02% x 11515186.8 L/h x 1 hr / 3600 s x 1 g / 1000 mg

$$\text{Hourly TPM Emissions (g/s)} = 649\,\frac{mg}{L} \times 0.02\% \times 11515186.8\,\frac{L}{h} \times \frac{1\,hr}{3600\,s} \times \frac{1\,g}{1000\,mg}$$

Hourly TPM Emissions (g/s) = 0.42 g/s

Emissions Estimates from Emergency Diesel Combustion Turbine - Operations

Source Description There will be one 50 MW biodiesel backup power unit (combustion turbine)
It will only run during emergencies. The plant can run for 13 hrs in survival mode, it was assumed that 4 of these events occur each year (assmuption provided by ARUP), the generator will run for 52 hr/year.

Methodology Air Contaminant releases from combustion of diesel fuel in the combustion turbine used during construction are estimated in this worksheet. The release estimates are based on power demand provided by ARUP and emission factors sourced from US EPA AP-42 Chapter 3.1 - Stationary Gas Turbines. It was assumed the sulfur content of the fuel will be 15 ppmw (0.0015%)

Emission Factors

		Emission Rate (g/s)			tonnes/year
Contaminant	**Emission Factor (lb/MMBtu)**	**hourly**	**daily**	**annual**	**annual**
Nitrogen Oxides	0.88	70.06	37.95	0.42	13.11
Carbon Monoxide	0.0033	0.26	1.42E-01	1.56E-03	0.0492
Sulphur Dioxide	0.001515	0.12	6.53E-02	7.16E-04	0.0226
Total Particulate Matter	0.012	0.96	5.17E-01	5.67E-03	0.1788
Lead	0.000014	1.11E-03	6.04E-04	6.62E-06	0.00021
VOCs	0.00041	3.26E-02	1.77E-02	1.94E-04	0.00611
1,3-Butadiene	0.000016	1.27E-03	6.90E-04	7.56E-06	0.00024
Benzene	0.000055	4.38E-03	2.37E-03	2.60E-05	0.00082
Formaldehyde	0.00028	2.23E-02	1.21E-02	1.32E-04	0.0042
Naphthalene	0.000035	2.79E-03	1.51E-03	1.65E-05	0.00052
PAHs	0.00004	3.18E-03	1.72E-03	1.89E-05	0.00060
Arsenic	0.000011	8.76E-04	4.74E-04	5.20E-06	0.00016
Beryllium	0.00000031	2.47E-05	1.34E-05	1.47E-07	0.00000
Cadmium	0.0000048	3.82E-04	2.07E-04	2.27E-06	0.00007
Chromium	0.000011	8.76E-04	4.74E-04	5.20E-06	0.00016
Lead	0.000014	1.11E-03	6.04E-04	6.62E-06	0.00021
Manganese	0.00079	6.29E-02	3.41E-02	3.73E-04	0.0118
Mercury	0.0000012	9.55E-05	5.17E-05	5.67E-07	0.00002
Nickel	0.0000046	3.66E-04	1.98E-04	2.17E-06	0.00007
Selenium	0.000025	1.99E-03	1.08E-03	1.18E-05	0.00037

Emission Inputs

Item	Quantity	Unit	Source/Assumption
Average Power demand	50,000	kW	output - provided by WEGH2
	171	MMBTu	converted from kW
Thermal efficiency	30%	%	assumed based on typical efficiencies of CTs
Alternator efficiency	90%	%	assumed based on typical efficiencies of CTs
Heat from Fuel (Power)	185,185	Kw	calculated based on output power, thermal and alternator efficiency
	631.9	MMBTu	converted from kW
# CT in operation	1	#	provided
Operating time	13	hours/day	provided by WEGH2
Operating events	4	times/year	provided by WEGH2
Annual operation	52	hours/year	calculated

Sample Calculation

Hourly ER Nitrogen Oxides (g/s) = Power Demand (MMBtu) x Emission Factor (lb/MMBtu) x Conversion

Hourly ER Nitrogen Oxides (g/s) = $\frac{631.9 \text{ MMBTu}}{\text{h}} \times \frac{0.88 \text{ lb}}{\text{MMBTu}} \times \frac{453.592 \text{ g}}{1 \text{ lb}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$

Hourly ER Nitrogen Oxides (g/s) = $\frac{70.1 \text{ g}}{\text{s}}$

Emission inputs and emission factors for marine vessels - Operations

Ammonia carriers will be used to ship the product from the Port of Stephenville, with the three most common vessel sizes being 30,000 m3, 52,000 m3, and 80,000 m3. World Energy provided the number of trips per month depending on the vessel size - if the mid-sized vessel was used, there would be 4 tanks per month at maximum production. The loading system will be a jettyless floating offloading system, floated to the vessel using tugs. Maneuvering will take 2 hours, while loading was estimated from the loading pipe rate combined with the product volume (ship capacity).

The vessel used was conservatively assumed to be the 50,000 m3 Capacity Vessel (LNG Tank Clipper Mars) as this vessel combusts MGO/HFO opposed to LNG which the larger vessel uses. Due to Canadian water regulations, MGO with maximum sulphur content of 0.10% must be used in Canadian jurisdictions.

Vessel Information

Item	Value	Units	Source/Assumptions
Vessel type:	LPG Tanker Clipper Mars	-	Chosen from three possible vessel specs provided by Reg Mullet (World Energy). Conservatively chosen as this vessel combusts MGO/HFO opposed to LNG which the larger vessel uses.
Tank capacity[a]	60284	m^3	Clipper Mars specification sheet - see note a
Anhydrous Ammonia full load [a]	40174	m^3	Clipper Mars specification sheet - see note a
Main Engine Fuel [a]	MGO (while in Canadian waters)	-	Clipper Mars specification sheet - see note a
Main Engine RPM (rpm) [a]	98	rpm	Clipper Mars specification sheet - see note a
Aux Engine Fuel[a]	MGO (while in Canadian waters)	-	Clipper Mars specification sheet - see note a
MGO Density	855	kg/m^3	Obtained from: https://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html
Maximum Vessel Size[b]	43544	DWT	Clipper Mars specifications - see note b
Marine Gas Oil HHV	12.75	kWh/kg	Obtained from: https://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html

[a] Clipper Mars Ship Information for Gas Carriers, available at: https://solvangship.no/wp-content/uploads/2020/06/CForm-Clipper-Mars.pdf

[b] Sourced from: https://www.marinetraffic.com/en/ais/details/ships/shipid:312420/mmsi:258667000/imo:9377078/vessel:CLIPPER_MARS

Operations Information

	Marine Terminal Operations		Total
	LNGTankers	Assist Tugboats	
Number of Vessels in Port area at One Time	1	2	3
Number of Vessels per Year [a]	48	96	144
Maneuvering time per vessel (hours)[a]	2	2	
Loading time per vessel (hotelling) (hrs) [b]	43	-	
Total Time Maneuvering (hrs/yr)	96	192	
Total Time Hotelling (hrs/yr)	2067	-	
Main Engine Rating Power (kW) [c, d]	10,150	1,540	-
Auxiliary Engine Rating Power (kW) [c, d]	3,600	100	-
Boiler Engine Rating Power (kW)	1,446	-	

[a] Provided by Reg Mullet (World Energy) - that there will be 4 vessels per month, maneuvering to loading area takes 2 hours.

[b] Estimated from the vessel product volume and the loading pipe flowrate (1,400 m3/h) as used in the Quantitative Risk Assessment (QRA)

[c] Clipper Mars Ship Information for Gas Carriers, available at: https://solvangship.no/wp-content/uploads/2020/06/CForm-Clipper-Mars.pdf

[d] Based on "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories" April 2009, US EPA. Available at: https://www.epa.gov/sites/default/files/2016-06/documents/2009-port-inventory-guidance.pdf by ICF Consulting April 2009

Fuel consumption

	Average Fuel Consumption		
	ton/day	tonne/hour	m3/hour
Vessel - Main Engine [a]	38	1.4364	1.6800
Vessel - AUX, Loading [a]	7	0.2646	0.3095
Vessel - AUX, Discharging [a]	5	0.1890	0.2210
Vessel - AUX, Idle [a]	4	0.1512	0.1768
Vessel - Boiler [a]	3	0.1134	0.1326
Tug - Main Engine [b]	-	0.3652	0.4271
Tug - Aux [b]	-	0.0238	0.0278

[a] Clipper Mars Ship Information for Gas Carriers, available at: https://solvangship.no/wp-content/uploads/2020/06/CForm-Clipper-Mars.pdf

[b] According to the US EPA "Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data", EPA420-R-00-002, February 2000:

- Fuel Consumption (g/kW/hr) = 14.1205/Load Factor + 205.7169

Emission Factors

Criteria Air contaminants

Emission Factors [a]	Main Propulsion Engines		Auxiliary Engines		Auxiliary Boilers	Assist Tugboats
	Maneuvering	Hotelling	Maneuvering	Hotelling		
Tanker Load Factor [a, b]	0.06	-	0.33	0.26	0.6	0.45
Fuel Type	Marine Gas Oil (MGO)		MGO		MGO	MGO
Average Sulphur Content (%) [a]	0.1		0.1		0.1	0.1
NO_x (g/kWh) [c, d, e]	17.00	17.00	12.10	12.10	2.41	13.20
CO (g/kWh) [d, e, f, g]	1.40	1.40	1.10	1.10	0.60	1.10
HC (g/kWh) [d, e, f, g]	0.60	0.60	0.40	0.40	-	0.50
PM_{10} (g/kWh) [d, e, f, g]	0.19	0.19	0.18	0.18	0.12	0.72
$PM_{2.5}$ (g/kWh) [d, e, f, g]	0.17	0.17	0.17	0.17	0.03	0.58
SO_2 (g/kWh) [d, e, f, g]	0.36	0.36	0.42	0.42	1.71	0.01
Tanker Emission Factor Adjustment Factors at 6% Load (Table 2-15):						
NO_x	1.60	-	-	-	-	-
CO	3.25	-	-	-	-	-
HC	4.35	-	-	-	-	-
PM_{10}	2.04	-	-	-	-	-
$PM_{2.5}$	2.04	-	-	-	-	-
SO_2	1.61	-	-	-	-	-

[a] Based on the Canadian requirement that marine fuel must not exceed 0.10% mass sulphur within the Canadian Jurisdiction of the NA-ECA.

[b] At lower speeds, the Propeller Law should be used to estimate ship propulsion loads:

$LF = (AS/MS)^3$,

where: LF = load factor (%),

AS = actual speed (knots), and

MS = maximum speed (knots).

Assumptions for Maneuvering Bulk Carriers: Inbound AS = 5 knots, and Outbound AS = 8 knots.

Since the average cruise speed for tankers is 14.8 knots (Table 2-6) and the load factor at cruise speed is 76% (Table 2-7),

$MS = AS / LF^{1/3} = 14.8 / 0.76^{1/3} = 16.22$ knots.

[c] Clipper Mars Ship Information for Gas Carriers, available at: https://solvangship.no/wp-content/uploads/2020/06/CForm-Clipper-Mars.pdf

[d] Category 2 Harbor Craft Emission Factors (g/kWh), Table 3-8. SO2 adjusted by Table 3-9 correction factor for ultra low sulphur.

[e] Based on AP-42 Chapter 1.3: Fuel Oil Combustion for Boilers < 100 MMBTu/h Distillate Oil Fired (2010), available at: https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s03.pdf **Expressed in units of kg/m3 of fuel combusted.**

[f] Main Engine Emission Factors (g/kWh), Table 2-9, slow speed diesel (SSD) engines using MGO (0.10% Sulphur)

[g] Auxiliary Engine Emission Factors (g/kWh), Table 2-16, using Marine Gas Oil (MGO)

Speciated Organic Compounds and PAHs

Contaminant	Emission Factors [a] (lb/MMBTu)	Emission Factor Rating	Emission Factors (kg/kWh)
Benzene	0.000776	E	1.20E-06
Toluene	2.81E-04	E	4.36E-07
Xylenes	1.93E-04	E	2.99E-07
Propylene	2.79E-03	E	4.33E-06
Formaldehyde	7.89E-05	E	1.22E-07
Acetaldehyde	2.52E-05	E	3.91E-08
Acrolein	7.88E-06	E	1.22E-08
naphtalene	1.30E-04	E	2.02E-07
Acenaphthylene	9.23E-06	E	1.43E-08
Acenaphthene	4.68E-06	E	7.26E-09
Fluorene	1.28E-05	E	1.99E-08
Phenanthrene	4.08E-05	E	6.33E-08
Anthracene	1.23E-06	E	1.91E-09
Fluoranthene	4.03E-06	E	6.25E-09
Pyrene	3.71E-06	E	5.75E-09
Benz(a)anthracene	6.22E-07	E	9.65E-10
Chrysene	1.53E-06	E	2.37E-09
Benzo(b)fluoranthene	1.11E-06	E	1.72E-09
Benzo(k)fluoranthene	2.18E-07	E	3.38E-10
Benzo(a)pyrene	2.57E-07	E	3.99E-10
Indeno(1,2,3-cd)pyrene	4.14E-07	E	6.42E-10
Dibenz(a,h)anthracene	0.000000346	E	5.37E-10
Benzo(g,h,l)perylene	0.000000556	E	8.62E-10
Total PAH	0.000212	E	3.29E-07

[a] Source: U.S. EPA AP-42 Section 3.4 Large Stationary Diesel

Conversion

1 kg =	2.2	lb
1 kWh =	3412.142	BTU

Emission estimates for marine vessels in the port - Operations

Source Description

Ammonia carriers will be used to ship the product from the Port of Stephenville, with the three most common vessel sizes being 30,000 m3, 52,000 m3, and 80,000 m3. World Energy provided the number of trips per month depending on the vessel size - if the mid-sized vessel was used, there would be 4 tanks per month at maximum production. The loading system will be a jettyless floating offloading system, floated to the vessel using tugs. Maneuvering will take 2 hours, while loading was estimated from the loading pipe rate combined with the product volume (ship capacity).

Methodology

The air contaminant emissions are calculated here using vessel information and emission factors from the "Marine Vessels - EFs and Inputs" sheet. The estimates assume that the tug boats are operated during loading as part of the jettyless floating offloading system.

Emissions of speciated organic compounds and metals were estimated from the emission factor (AP-42 Chapter 1.3) and the fuel usage rates. Emissions of the criteria air contaminants (NO2, CO, HC, PM10, PM2.5, and SO2) were estimated using the emission factors (see sources on "Marine Vessels - EFs and Inputs" sheet), the engine power rating (KW), and the load factor.

Emission Estimates
Criteria Air Contaminants

	Maximum Emission Rates		
	Marine Terminal Operations		Total
	LNGTankers	Assist Tugboats	
Number of Vessels in Port area at One Time	1	2	3
Maximum Vessel Size (DWT)*	43544	-	-
Main Engine Rating Power (kW) [a, b]	10,150	1,540	-
Auxiliary Engine Rating Power (kW) [b]	3,600	100	-
Auxiliary Boiler Rating Power (KW)	1,446	-	-
Operating Mode while in Port	Hotelling	-	-
Tug Engine Emissions (maneuvering)			
NO_x (g/s)	-	2.54	2.54
CO (g/s)	-	0.21	0.21
HC (g/s)	-	0.10	0.10
PM_{10} (g/s)	-	0.14	0.14
$PM_{2.5}$ (g/s)	-	0.11	0.11
SO_2 (g/s)	-	0.00	0.00
Main Engine Emissions (Hotelling)			
NO_x (g/s)	-	-	-
CO (g/s)	-	-	-
HC (g/s)	-	-	-
PM_{10} (g/s)	-	-	-
$PM_{2.5}$ (g/s)	-	-	-
SO_2 (g/s)	-	-	-
Auxiliary Engine Emissions (Hotelling)			
NO_x (g/s)	3.146	-	3.15
CO (g/s)	0.286	-	0.29
HC (g/s)	0.104	-	0.10
PM_{10} (g/s)	0.047	-	0.05
$PM_{2.5}$ (g/s)	0.044	-	0.04
SO_2 (g/s)	0.109	-	0.11
Auxiliary Boiler Emissions [b]			
NO_x (g/s)	0.089	-	0.09
CO (g/s)	0.022	-	0.02
HC (g/s)	-	-	0.00
PM_{10} (g/s)	0.004	-	0.00
$PM_{2.5}$ (g/s)	0.001	-	0.00
SO_2 (g/s)	0.063	-	0.06
TOTAL HOURLY MAXIMUM EMISSIONS			
NO_x (g/s)	**3.235**	**5.08**	8.32
CO (g/s)	**0.308**	**0.42**	0.73
HC (g/s)	**0.104**	**0.19**	0.30
PM_{10} (g/s)	**0.051**	**0.28**	0.33
$PM_{2.5}$ (g/s)	**0.045**	**0.22**	0.27
SO_2 (g/s)	**0.172**	**0.00**	0.17
TOTAL ANNUAL MAXIMUM EMISSIONS			
NO_x (g/s)	**0.733**	**1.151**	1.88
CO (g/s)	**0.070**	**0.096**	0.17
HC (g/s)	**0.024**	**0.044**	0.07
PM_{10} (g/s)	**0.012**	**0.063**	0.07
$PM_{2.5}$ (g/s)	**0.010**	**0.050**	0.06
SO_2 (g/s)	**0.039**	**0.001**	0.04

TOTAL ANNUAL MAXIMUM EMISSIONS - tonne/year		
NO_x (t/y)	23.11	18.15
CO (t/y)	2.20	1.51
HC (t/y)	0.74	0.69
PM_{10} (t/yr)	0.37	0.99
$PM_{2.5}$ (t/y)	0.32	0.79
SO_2 (t/y)	1.23	0.01

Speciated Organic Compounds & PAHs - Per Tug Boat

Contaminant	Hourly - g/s			Daily - g/s			Annual - g/s			Annual - tonne/year			
	Tug Engine Emissions (Maneuverings)	Aux Engine Emissions (loading/ hotelling)	Aux Boiler Emissions	Tug Engine Emissions (maneuvering)	Aux Engine Emissions (loading/ hotelling)	Aux Boiler Emissions	Tug Engine Emissions (maneuvering)	Aux Engine Emissions (loading/ hotelling)	Aux Boiler Emissions	Tug Engine Emissions (maneuvering)	Aux Engine Emissions (loading/ hotelling)	Aux Boiler Emissions	Marine Vessel (aux + boiler)
Benzene	2.32E-04	3.13E-04	2.90E-04	2.32E-04	3.13E-04	2.90E-04	3.05E-05	7.09E-05	6.57E-05	9.61E-04	2.24E-03	2.07E-03	4.31E-03
Toluene	8.39E-05	1.13E-04	1.05E-04	8.39E-05	1.13E-04	1.05E-04	1.10E-05	2.57E-05	2.38E-05	3.48E-04	8.09E-04	7.50E-04	1.56E-03
Xylenes	5.76E-05	7.78E-05	7.21E-05	5.76E-05	7.78E-05	7.21E-05	7.58E-06	1.76E-05	1.63E-05	2.39E-04	5.56E-04	5.15E-04	1.07E-03
Propylene	8.33E-04	1.13E-03	1.04E-03	8.33E-04	1.13E-03	1.04E-03	1.10E-04	2.55E-04	2.36E-04	3.45E-03	8.04E-03	7.45E-03	1.55E-02
Formaldehyde	2.36E-05	3.18E-05	2.95E-05	2.36E-05	3.18E-05	2.95E-05	3.10E-06	7.21E-06	6.68E-06	9.77E-05	2.27E-04	2.11E-04	4.38E-04
Acetaldehyde	7.52E-06	1.02E-05	9.42E-06	7.52E-06	1.02E-05	9.42E-06	9.89E-07	2.30E-06	2.13E-06	3.12E-05	7.26E-05	6.73E-05	1.40E-04
Acrolein	2.35E-06	3.18E-06	2.95E-06	2.35E-06	3.18E-06	2.95E-06	3.09E-07	7.20E-07	6.67E-07	9.76E-06	2.27E-05	2.10E-05	4.37E-05
Naphthalene	3.88E-05	5.24E-05	4.86E-05	3.88E-05	5.24E-05	4.86E-05	5.10E-06	1.19E-05	1.10E-05	1.61E-04	3.74E-04	3.47E-04	7.22E-04
Acenaphthylene	2.76E-06	3.72E-06	3.45E-06	2.76E-06	3.72E-06	3.45E-06	3.62E-07	8.43E-07	7.81E-07	1.14E-05	2.66E-05	2.46E-05	5.12E-05
Acenaphthene	1.40E-06	1.89E-06	1.75E-06	1.40E-06	1.89E-06	1.75E-06	1.84E-07	4.27E-07	3.96E-07	5.80E-06	1.35E-05	1.25E-05	2.60E-05
Fluorene	3.82E-06	5.16E-06	4.78E-06	3.82E-06	5.16E-06	4.78E-06	5.03E-07	1.17E-06	1.08E-06	1.58E-05	3.69E-05	3.42E-05	7.10E-05
Phenanthrene	1.22E-05	1.65E-05	1.52E-05	1.22E-05	1.65E-05	1.52E-05	1.60E-06	3.73E-06	3.45E-06	5.05E-05	1.18E-04	1.09E-04	2.26E-04
Anthracene	3.67E-07	4.96E-07	4.60E-07	3.67E-07	4.96E-07	4.60E-07	4.83E-08	1.12E-07	1.04E-07	1.52E-06	3.54E-06	3.28E-06	6.83E-06
Fluoranthene	1.20E-06	1.63E-06	1.51E-06	1.20E-06	1.63E-06	1.51E-06	1.58E-07	3.68E-07	3.41E-07	4.99E-06	1.16E-05	1.08E-05	2.24E-05
Pyrene	1.11E-06	1.50E-06	1.39E-06	1.11E-06	1.50E-06	1.39E-06	1.46E-07	3.39E-07	3.14E-07	4.59E-06	1.07E-05	9.90E-06	2.06E-05
Benz(a)anthracene	1.86E-07	2.51E-07	2.32E-07	1.86E-07	2.51E-07	2.32E-07	2.44E-08	5.68E-08	5.27E-08	7.70E-07	1.79E-06	1.66E-06	3.45E-06
Chrysene	4.57E-07	6.17E-07	5.72E-07	4.57E-07	6.17E-07	5.72E-07	6.01E-08	1.40E-07	1.30E-07	1.89E-06	4.41E-06	4.08E-06	8.49E-06
Benzo(b)fluoranthene	3.31E-07	4.48E-07	4.15E-07	3.31E-07	4.48E-07	4.15E-07	4.36E-08	1.01E-07	9.40E-08	1.37E-06	3.20E-06	2.96E-06	6.16E-06
Benzo(k)fluoranthene	6.51E-08	8.79E-08	8.15E-08	6.51E-08	8.79E-08	8.15E-08	8.56E-09	1.99E-08	1.85E-08	2.70E-07	6.28E-07	5.82E-07	1.21E-06
Benzo(a)pyrene	7.67E-08	1.04E-07	9.61E-08	7.67E-08	1.04E-07	9.61E-08	1.01E-08	2.35E-08	2.18E-08	3.18E-07	7.40E-07	6.86E-07	1.43E-06
Indeno(1,2,3-cd)pyrene	1.24E-07	1.67E-07	1.55E-07	1.24E-07	1.67E-07	1.55E-07	1.63E-08	3.78E-08	3.50E-08	5.13E-07	1.19E-06	1.11E-06	2.30E-06
Dibenz(a,h)anthracene	1.03E-07	1.40E-07	1.29E-07	1.03E-07	1.40E-07	1.29E-07	1.36E-08	3.16E-08	2.93E-08	4.28E-07	9.97E-07	9.24E-07	1.92E-06
Benzo(g,h,l)perylene	1.66E-07	2.24E-07	2.08E-07	1.66E-07	2.24E-07	2.08E-07	2.18E-08	5.08E-08	4.71E-08	6.88E-07	1.60E-06	1.48E-06	3.09E-06
Total PAH	6.33E-05	8.55E-05	7.92E-05	6.33E-05	8.55E-05	7.92E-05	8.32E-06	1.94E-05	1.79E-05	2.63E-04	6.11E-04	5.66E-04	1.18E-03

[a] Obtained from the Clipper Mars Ship Information for Gas Carriers, available at: https://solvangship.no/wp-content/uploads/2020/06/CForm-Clipper-Mars.pdf
-Main Engine Rating Power 10,150 kW; Auxiliary Engine Rating Power 3,600 kW
-Auxiliary Boiler Fuel Consumption Rate = 0.114 tonnes per hour (3 ton per day)
[b] According to ""Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories" April 2009, US EPA. Available at: https://www.epa.gov/sites/default/files/2016-06/documents/2009-port-inventory-guidance.pdf
by ICF Consulting, April 2009
- Assist Tugboat Propulsion Engine Power = 1,540 kW and Assist Tugboat Auxiliary Engine Power = 100 kW (Table 3-10)

Sample Calculations

NOx Hourly Emis, Hotelling (g/s) = Engine Rating Power (kW) x Load Factor x Emission Factor (g/kWh) x Conversion

NOx Hourly Emis, Hotelling (g/s) = 3,600 kw x 0.26 x 12.10 g/kWh x 1 hour/3600 s

NOx Hourly Emis, Hotelling (g/s) = 3.146 g/s

Benzene Hourly Emis, Hotelling (g/s)= Engine Rating Power (kW) x Load Factor x Emission Factor (g/kWh) x Conversion

Benzene Hourly Emis, Hotelling (g/s)= 3,600 kw x 0.26 x 1.20E-06 kg/kWh x 1 hour/3600 s x 1000 g/1 kg

Benzene Hourly Emis, Hotelling (g/s)= 3.13E-04 g/s

Rev. Table 6-1 Air Contaminant Releases – Construction

Air Contaminant	CAS #	Emission Rate (tonnes/year)								
		Blasting	Stockpile Fugitives	Transfer Points at Stockpiles	Crushing and Screening	Laydown Areas Fugitives	Unpaved Roads Fugitives	Mobile Combustio n Sources – Heavy Equipment	Stationary Combustion	Total
NOx	10102-44-0	32.0	-	-	-	-	-	36	65.6	133
CO	630-08-0	136	-	-	-	-	-	310	14.1	461
SO_2	7446-09-5	4.0	-	-	-	-	-	41	4.3	50
TPM	N/A-1	30.1	3.2	12.6	19.9	31.0	0.067	1.2	4.6	165
PM_{10}	N/A-2	15.6	1.6	5.9	7.3	15.5	0.002	1.2	4.6	38
$PM_{2.5}$	N/A-3	9.0	0.6	0.9	1.1	6.2	2.14E-04	1.2	4.6	15.8