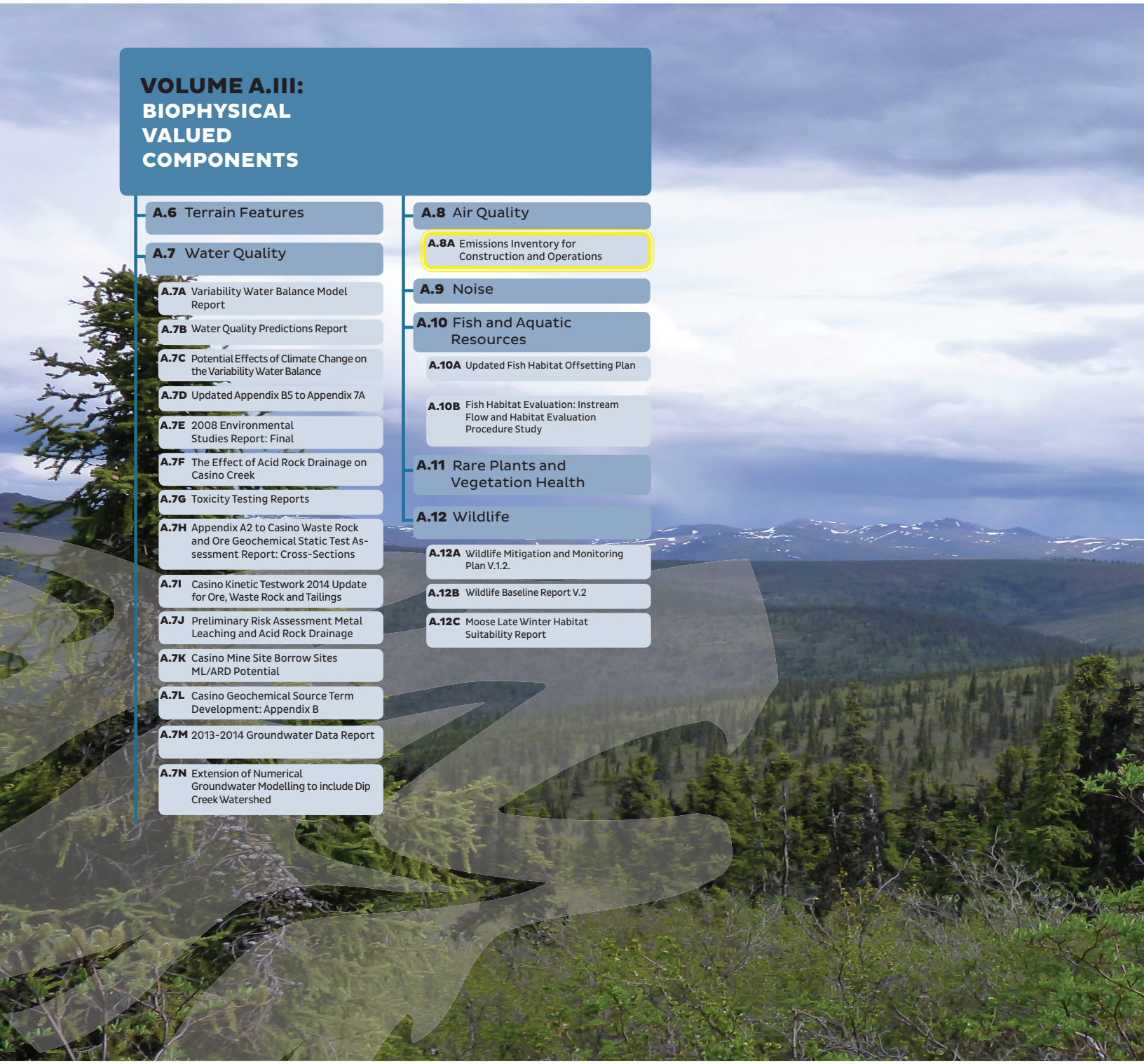
APPENDIX A.8A: Emissions Inventory for Construction and Operations



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A.8A EMISSIONS INVENTORY FOR CONSTRUCTION AND OPERATIONS

A.8A.1 CONSTRUCTION PHASE AIR EMISSIONS INVENTORY

The Casino project air emissions inventory was compiled from the feasibility study (M3 2013) and preliminary engineering design information provided in the Proposal for the Casino Project submitted by Casino Mining Corporation on January 3, 2014 to YESAB. The essential information was obtained from the following sections of the feasibility study:

- Mine production schedule;
- Mine major equipment fleet requirements;
- Project Schedule section 24.1.12; and
- Project Infrastructure Layouts.

Emissions of criteria air contaminants (CACs) associated with the construction were estimated for various types of combustion sources, including off road construction equipment (drills, dozers and graders, etc.), earth moving equipment (haul trucks, loaders and cranes, etc.), power generators, and motor vehicles. Air emissions of particulate matter were estimated for activities such as blasting, truck loading and unloading, drilling, processing, and hauling within the mine pit and along the Project haul roads, airport access road, explosive storage road and main access road. These emissions are named as fugitive emissions because they do not disperse into air from a specific point/area.

The emissions estimations were calculated by using emission factors which were developed by several regulatory agencies such as Environment Canada's Pits and Quarries Guidance (NPRI 2009), United States Environmental Protection Agency AP-42 (US EPA 1995), and Australian Mining Emission Estimation Technique Manuals (NPI 2008, NPI 2012). These emission factors are useful when there is no actual data collected such as stack measurements or manufacturer specifications and are therefore ideal for proposed industrial developments to estimate anticipated air emissions that could occur during the life time of the projects.

The temporary nature of construction differentiates it from operation phase emission sources because construction consists of a series of different operations, each with its own duration and potential for air emissions. Construction activities are expected to have a definable beginning and end and emissions are considerably variable over the different phases of the construction process. This is in contrast to the operations phase, where emissions are either relatively steady or follow a daily/hourly cycle.

Construction of the proposed mine is anticipated to be completed within 3 years and activity is expected to reach its maximum level during Project year -1 because the material movement and equipment use will be higher compared to other construction years. Earth moving and equipment use are considerably lower during construction years -2 and -3. Since a conceptual construction plan is not available, the air emissions were estimated by using an annual material movement summary and off road equipment requirements assuming that all activities would occur regularly within the proposed schedule and be relative to the amount of material movement. Direct mill feed is relatively low during year -1 therefore the majority of particulate matter emissions originated from unpaved roads. Top soil stockpiles were considered not vegetated during this period and are therefore considered sources of fugitive emissions during strong winds.

Table A.8A.1–1 summarizes the Project's mined material flow summary which was derived from the feasibility study.

Table A.8A.1-1 Construction Phase (year -1) Annual Material Movement

Mine Facility	Year - 1 (tonnes/year)	Truck Trips	One way Distance (km)	Annual Travel Distance (km)
To Waste Storage Area	5,262,000	14,496	9.648	279,712
Overburden	1,206,000	3,322		
Leach Cap	3,960,000	10,909		
Supergene Oxide And Unclassified	96,000	264		
To Supergene Oxide - Stockpile	9,950,000	27,410	4.105	225,040
To Gold Ore Stockpile	21,654,000	59,653	2.441	291,225
To Direct Mill Feed	4,510,000	12,424	3.550	88,220
Total Materials Moved	41,376,000	113,983		

Note: Leach Cap will be used for Embankment construction therefore included in road to Waste Storage Area

Open pit activities during construction are similar to those during the operations phase, and are based on blasting, drilling, loading and hauling activities. The blasting is assumed to take place once a day and ANFO will be used for explosive detonation. Table A.8A.1–2 summarizes the air emissions estimated for open pit activities and corresponding emission factors.

Table A.8A.1-2 Open Pit Particulate Matter Emissions during Construction

Mine Activity	Emission Factor	Units	Total Emissions (tonnes per blast)	Total Emissions (tonnes/year)
Blasting (AP-42 Table 11.9-2)				
Total Particulate Matter (TPM)	$= 0.00022 * Area^{1.5}$	kg/blast	0.22	80.3
PM_{10}	0.52 x TPM		0.1144	41.756
$PM_{2.5}$	0.03 x TPM		0.0066	2.409
# of blasts per day	1 per days, 7 per week			
Estimated area impacted per blast (m^2)	10,000	m^2		
Drilling (SCC 3-05-020-10)				
Total Particulate Matter (TPM)	8.46619×10^{-05}	(kg/Mg)		3.503
PM10	4.00428×10^{-05}	(kg/Mg)		1.657
PM2.5	6.06362×10^{-06}	(kg/Mg)		0.251
Haul Truck Loading(SCC 3-05-020-31)				
Total Particulate Matter (TPM)	0.000105714	(kg/Mg)		4.374
PM10	0.00005	(kg/Mg)		2.069
PM2.5	7.57143×10^{-06}	(kg/Mg)		0.313

Processing activities will start during year -1 with the commissioning of the sulphide ore flotation mill. Table A.8A.1–3 and Table A.8A.1–4 summarize the particulate matter emission estimates at these facilities.

Table A.8A.1-3 Particulate Emissions from the Primary Crusher Unit

Parameter	Reference	Emission Factor (kg/Mg)			Total Emissions Crusher 1 (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Crusher*	SCC 3-03-024-01	0.2	0.02	0.02	90.20	9.02	9.02
Truck Unloading at Crusher Unit*	SCC 3-05-020-31	$2x10^{-05}$	$8 x10^{-06}$	$1 x10^{-06}$	0.008	0.004	0.001

*Mitigation Efficiency = 90%

Environment Canada Pits and Quarries Guidance, Crusher Emission Control Techniques, Enclosed Building Mitigation Efficiency

PM2.5 emission factor is not available therefore assumed to be same as PM10 as conservative approach, Project ore/waste considered as low-moisture because it is less than 4%

TPM and PM2.5 emission factors are not available for unloading therefore they were calculated by AP-42 general aerodynamic size distribution factors using PM10 EF.

Table A.8A.1-4 Oxide Ore Processing Facility Emissions

Mine Activity	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Conveyor Drop-Off at Plant	SCC 3-05-020-06	0.0015	0.00055	0.00055	6.77	2.48	2.48
SAG Mill	SCC 3-03-024-10	1.2	0.16	0.16	closed circuit to secondary crushing		
Pebble Crushing	SCC 3-03-024-02	0.600	0.000	0.000	closed circuit to cyclone		
Cyclone	SCC 3-03-024-11	0.300	0.000	0.000	closed circuit to ball mill		
Ball Mill	SCC 3-03-024-10	1.2	0.16	0.16	27.06	3.61	3.61

Mitigation with Fabric Filter (AP-42 Table B.2.3) discharging from building

Site historical meteorological data indicate that the Project does not experience wind gusts very often. The wind speeds exceeded 5.4 metres/second hourly average for only 4.4% of the time from 2008 to 2012. Considering the gust speed and approximate silt contents, particulate matter emissions were estimated for each ore, waste, and topsoil stockpiles. Usually topsoil stockpiles are covered by grass however during the construction phase, it was assumed to be too early for vegetation growth and they are included in wind erosion estimations. Wind erosion emission estimates are summarized in Table A.8A.1–5.

Table A.8A.1-5 Wind Erosion Emissions

Mine Facility	Value (tonnes/year)		
	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Storage Area	1.64	0.82	0.33
Low Grade Supergene Oxide Pile	0.47	0.23	0.09
Supergene Oxide Ore Stockpile	1.87	0.94	0.37
Marginal Grade Ore pile	1.87	0.94	0.37

Mine Facility	Value (tonnes/year)		
Low Grade Supergene Sulphite	0.47	0.23	0.09
Waste Storage Area	0.29	0.14	0.03
Topsoil Piles	10.06	5.04	2.01
Topsoil Overburden Piles	13.00	6.50	2.60

Fugitive dust also occurs at stockpiles due to unloading and earth moving activities, and these emissions are summarized in Table A.8A.1–6 and Table A.8A.1–7.

Table A.8A.1-6 Earth Moving Air Emissions

Mine Facility	Value (tonnes/year)		
	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile Area	97.02	72.77	10.19
Supergene Oxide Ore Stockpile Area	164.36	123.27	17.26
Waste Storage Area	181.66	136.24	19.07

Emission factor is from USEPA AP-42 Table 11.9-2 Overburden Bulldozing
Silt content = 6.9 assumed for gold ore, moisture=3% feasibility study
Silt content = 6.9 assumed for supergene oxide ore, moisture=2% feasibility study
Silt content = 7.5 assumed for waste, moisture=2% feasibility study
Silt contents were used from AP-42 and moisture contents were taken from feasibility study

Table A.8A.1-7 Truck Loading/Unloading Emissions

Mine Facility	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	2.29	1.08	0.16
Supergene Oxide Ore Stockpile	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	1.05	0.50	0.08
Waste Storage Dump	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	0.56	0.26	0.04

Note: Total Material dump at storage areas were derived from production schedule in feasibility study

Large unit construction activities are expected to have a beginning and an end and vary over the construction phase as activities change on a daily basis. Therefore, construction emissions are estimated area wide (e.g., power plant construction, concentrator area construction, crusher area construction, etc.) regardless of detailed construction activities. Since there is no conceptual plan for construction phase, general construction emission factors were used by assuming that each unit requiring erection would take around 90 days of heavy construction activity. This does not include mechanical and electrical installations which are negligible in terms of air emission estimates. Table A.8A.1–8 summarizes the estimated emissions for the largest unit construction activities.

Table A.8A.1-8 Other Construction Activities

Mine Facility	Value (tonnes/day)	Total Emissions (tonnes/year)*
Power Plant Construction =		
Total Particulate Matter (TPM)	0.404	36.31
PM_{10}	0.191	17.18
$PM_{2.5}$	0.029	2.60
Concentrator Construction =		
Total Particulate Matter (TPM)	0.269	24.21
PM_{10}	0.127	11.45
$PM_{2.5}$	0.019	1.73
Crusher Area =		
Total Particulate Matter (TPM)	0.022	2.02
PM_{10}	0.011	0.95
$PM_{2.5}$	0.002	0.14

Fugitive dust from haul roads is the largest and most contributor to particulate matter emissions during construction. AP-42 Section Unpaved Roads (US EPA 1995) was used as the main reference to calculate emissions during construction by using the following formula:

$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}$$

where:

- E is size specific emission factor (lb/VMT)
- s is surface material silt content (%)
- W is mean vehicle weight (tonnes)
- k (lb/VMT) is equal to 0.15 for $PM_{2.5}$, 1.5 for PM_{10} and 4.9 for TPM
- a is equal to 0.9 for $PM_{2.5}$ and PM_{10} and 0.7 for TPM
- b is equal to 0.45 for $PM_{2.5}$, PM_{10}, and TPM.

The truck trips were estimated by using the annual production schedule and the capacity of haul trucks. The summary of the unpaved road emissions are summarized in Table A.8A.1–9.

Table A.8A.1-9 Unpaved Road Emissions

Road Type	Average Weight (tonnes)	Daily Total Travelled Distance (km)	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Haul Road 1 To Waste Storage Area	443	766	184.4	48.8	4.9
Haul Road 2 To Supergene Oxide Stockpile	443	617	148.3	39.3	3.9
Haul Road 3	443	798	192.0	50.8	5.1

Road Type	Average Weight (tonnes)	Daily Total Travelled Distance (km)	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
To Gold Ore Stockpile					
Haul Road 4 Direct Mill Feed	443	242	58.2	15.4	1.5
Haul Road 5 Explosive Building Access Road	30	5	0.4	0.1	0.03
Access Road	30	1,617	376.9	94.0	41.2
Airport Road	30	440	185.1	54.6	11.2

Table A.8A.1–10 summarizes the total particulate emissions from all mine facilities during the peak construction year.

Table A.8A.1-10 Total Particulate Matter Emissions During Peak Construction Year

Mine Facility	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Roads			
Haul Road 1	184.4	48.8	4.9
Haul Road 2	148.3	39.3	3.9
Haul Road 3	192.0	50.8	5.1
Haul Road 4	58.2	15.4	1.5
Haul Road 5	0.4	0.1	0.03
Access Road	376.9	94.0	41.2
Airport Road	185.1	54.6	11.2
Crusher Unit			
Crusher	90.2	9.0	9.0
Truck Unloading	0.008	0.004	0.001
Sulphite Ore Plant			
Conveyor Drop Off	0.026	0.008	0.002
Sag Mill	-	-	-
Pebble Crushing	-	-	-
Cyclone	-	-	-
Ball Mill (Before Mitigation)	268.2	71.5	71.5
General Construction Activities *			
Power Plant	36.3	17.2	2.6
Concentrator	24.2	11.5	1.7
Second Crusher	2.0	1.0	0.1
Earth Moving/Surfacing			
Gold Ore Stockpiles	97.0	72.8	10.2
Supergene Oxide Ore Stockpiles	164.4	123.3	17.3

Mine Facility	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Waste Storage Dump	181.7	136.2	19.1
Loading/Unloading			
Gold Ore Stockpiles	2.3	1.1	0.2
Supergene Oxide Ore Stockpiles	1.1	0.5	0.1
Waste Storage Dump	0.56	0.26	0.04
Wind Erosion			
Gold Ore Storage Area	1.6	0.8	0.3
Low Grade Supergene Oxide Pile	0.5	0.2	0.1
Supergene Oxide Ore Stockpile	1.9	0.9	0.4
Marginal Grade Ore Pile	1.9	0.9	0.4
Low Grade Supergene Sulphite	0.5	0.2	0.1
Waste Storage Area	0.3	0.1	0.0
Topsoil Piles	10.1	5.0	2.0
Topsoil Overburden Piles	12.5	6.5	2.6

*Assumed that construction at Power Plant, Concentrator Building and Second Crusher could take 90 days

Air emission estimates from fuel combustion were based on the power rating, utilization factor for each piece of equipment and emission factors from the NONROAD2008 model (US EPA 2008) or USEPA AP-42 Emission Factors (US EPA 2005).

US EPA has developed the NONROAD2008 model to provide emissions factors for predicting accurate and reproducible non-road emissions inventories. NONROAD2008 provides emissions estimates based on fuel-use in a diverse collection of vehicles and equipment. NONROAD2008 provides emission factors for each equipment type and power rating such as haul trucks, graders, dozers, pumps, etc. It was assumed that the sulphur content of the diesel fuel was 0.0015% (15 mg/kg). This is consistent with the *Sulphur in Diesel Fuel Regulations* – Regular Sulphur Diesel Fuel - Type A fuel that is mainly limited to off-road applications (Environment Canada 2010).

The estimates from NONROAD2008 are conservative. The outputs have built-in adjustments for in-use operation versus new engine test results (*e.g.,* deterioration and transient operation). The air emissions were estimated for equipment provided in the feasibility study and time allocations were estimated by considering the available information in the feasibility study.

Other emission factors used in the air dispersion modelling assessment are provided in the US EPA's AP-42 document such as Chapter 3.4 Large Stationary Diesel and All Stationary Duel-Fuel Engines and Chapter 13.3 Explosives Detonation (US EPA 1995). Table A.8A.1–11 summarizes the Project's mined material flow chart.

Detailed blasting data were not available, therefore the ANFO use was estimated by using 0.25 times the powder factor and material extracted from the open pit in a year. It was assumed that blasting emissions would disperse in one hour which is the shortest modelling time interval for this study. The blasting was also assumed to occur once a day. Table A.8A.1–12 summarizes the blasting emission estimates.

Table A.8A.1-11 Mine Fleet and Percentage of Working Locations

Mine Fleet Equipment	Type	Operating Time (hr/day)	# of vehicles	Percentage of Working Locations (%)										
				Open pit	Waste Storage	Supergene Oxide Stockpile	Gold Stockpile	Power Plant Construction	Concentrator Construction	Crusher Construction	HL1	HL2	HL3	HL4
P&H 320XPC Drill	Drill	18	1	100										
P&H 4100XPC Cable Shovel	Shovel	16	1	100										
Cat 797F Truck	Truck	21	8	15	5	5	5				22	18	23	7
Cat D11T Track Dozer	Dozer	16	2		25			25	25	25				
Cat D10T Track Dozer	Dozer	16	2			25		25	25	25				
Cat 854K Wheel Dozer	Dozer	16	2				25	25	25	25				
Cat 24M Motor Grader	Grader	12	2	30				10	10	10	10	10	10	10
Water Truck - 30,000 gal	Water Truck	12	2	20							20	20	20	20
Cat 345D Excavator	Excavator	12	1	25				25	25	25				
Atlas Copco ECM 720 Drill	Drill	16	1	70				20	20	20				
Cat 992K Wheel Loader	Loader	16	1	25				25	25	25				
Cat 777F Truck	Truck	21	3					20	20	20	10	10	10	10

Note: Definition of HL1 to HL 4 can be seen in Table A.8A.1–10

Table A.8A.1-12 Blasting Emissions

Species	Emission Factor [a] (kg/Mg ANFO)	Daily ANFO [b] (tonnes)	Daily Air Emissions (kg)	Emission Rate [c] (g/s/m^2)
CO	34	28.34	963.55	$1.12x10^{-03}$
NO_x	8	28.34	226.72	$2.62x10^{-04}$
SO_2	1	28.34	28.34	$3.28x10^{-05}$

[a] Source: US EPA AP-42 Section 13.3
[b] Assuming a powder factor of 0.250 Kg ANFO/tonnes with 41,376,000 tonnes extraction during year -1
[c] Assuming that blasting emissions will be released from 10,000 m^2 surface within one hour

The auxiliary power plant will be active during construction and is composed of three 6.7 MW large stationary diesel generators. An incinerator will be used for domestic refuse waste. An incinerator commonly used in the mining industry was assumed for this study. The emission rates are not available, therefore stack emissions were assumed to be equal to the Ontario Guideline A-7 emission limits (Ontario MOE 2010) as a conservative approach. The emissions rates for the auxiliary power plant and incinerator are summarized in Tables A.8A.1-13 and A.8A.1-14, respectively.

Table A.8A.1-13 Auxiliary Power Plant

Parameter	Value	Units	Reference
Stack Height	20	m	
Stack Diameter	1	m	
Stack Velocity at operating temperature	16.4	m/s	
Stack Gas Temp	518.3	°C (965°F)	
Efficiency	90%		
Installed Power	6.7	MW	
NO_X	18.356	g/s	AP-42 Table 3.4-1
CO	0.017	g/s	AP-42 Table 3.4-1
SO_2	0.098	g/s	Table 3.4-1 emission factor and ultra-low sulphur
TPM	0.714	g/s	AP-42 Table 3.4-2
PM_{10}	0.587	g/s	AP-42 Table 3.4-2
$PM_{2.5}$	0.569	g/s	AP-42 Table 3.4-2

Table A.8A.1-14 Incinerator Emissions

Parameter	Value	Units	Notes
Stack Height	11	m	
Stack Diameter	0.66	m	
Stack Velocity at operating temperature	3.3	m/s	
Stack Gas Temp	20	°C	Wet Scrubber reduces the stack temp
NO_X	0.223	g/s	
CO	0.045	g/s	
SO_2	0.063	g/s	
TPM	0.016	g/s	
PM_{10}	0.016	g/s	Assumed to be same as TPM
$PM_{2.5}$	0.016	g/s	Assumed to be same as TPM

A.8A.2 OPERATIONS PHASE AIR EMISSIONS INVENTORY

The air emissions inventory for the operations phase was generated from USEPA AP-42 document – Compilation of Air Pollutant Emission Factors, Volume 1 – Stationary Point and Area Sources, Environment Canada National Pollutants Inventory (NPRI) Pits and Quarries Guidance, and NONROAD2008a model. Supplemental emission factors were used from Australian Emission Estimation Technique Manual for Mining V 3.1 where there is insufficient data to estimate emissions.

The production schedule and mining equipment fleet activities formed the basis of year-by-year variations in the emissions model. As a conservative approach, the anticipated worst year was modelled for the operation phase.

Year 1, year 11 and year 12 were considered as the potential worst case air emissions as open pit depth is not very deep during year 1 and particulate matter might not be retained in the pit, waste amount and equipment use peak during year 11 and total material movement peaks during year 12. Due to the distance between the the waste storage area and the open pit, year 11 was chosen as the worst case year due to haulage distances and maximum equipment use during that year. Therefore, air emissions are predicted to be at their worst for all criteria air contaminants in year 11. Table A.8A.2–1 summarizes the Project's mined material flow summary derived from feasibility study.

Table A.8A.2-1 Material Movement Schedule Year 11

MINE FACILITY	Material Movement (tonnes/year)	Truck Trips	One way Distance (km)	Annual Travel Distance (km)
To Waste Storage Area	52,698,000	145,174	8.922	2,590,506
To Low Grade Ore - Hypogene Stockpile	1,642,000	4,523	6.082	55,025
To Low Grade Ore - Supergene Sulfide Stockpile	3,196,000	8,804	2.461	43,334
To Low Grade Ore - Supergene Oxide Stockpile	105,000	289	8.124	700
From Supergene Oxide - Stockpile	3,600,000	39,860	2.461	196,183
From Gold Ore Stockpile	7,862,000	87,050	0.894	155,680
To Direct Mill Feed	41,095,000	113,209	3.550	803,854
Total Materials Moved	**110,198,000**	**303,576**		

Note: Includes open pit activity and reclaim from stockpiles

Project emissions from mine fleet combustion sources were quantified based on information regarding the type, quantity and power rating provided in the feasibility study. The maximum operating time of equipment was estimated and air emissions from the diesel equipment were estimated by NONROAD2008a model based on the horsepower (hp) rating and utilization factor for each piece of equipment.

US EPA has developed the NONROAD2008 model (NONROAD) to provide emissions factors for predicting accurate and reproducible off road emissions inventories. The model provides emissions estimates based on fuel-use in a diverse collection of vehicles and equipment, classified categories.

The estimates from NONROAD are conservative. The model outputs have built in adjustments for in-use operation versus new engine test results (e.g., deterioration and transient operation). Given the inherent conservative estimations in NONORAD, the emission factors used for the Project air emissions inventory provide appropriate representation of a worst-case scenario.

Fugitive dust from haul roads is the largest source of particulate matter for the Project due to haul road distances from the open pit to ore stockpiles, crushers and waste storage area. Air emission factors for the crushers, waste rock dump area, ore stockpile, truck dump, process units (screen, mill, secondary crushing, etc.) are primarily derived from AP-42 emission factors. Some emission factors exist for only TPM or PM10 therefore other particulate matter emission factors could not be directly estimated. In these circumstances AP-42's generic aerodynamic particle size distribution was used to estimate other particulate matter emission factors. Overall, ore/waste moisture content was considered as dry because AP-42 considers materials below 4% as dry therefore low moisture emission factors were used for the assessment.

Precipitation normals were assumed to be the natural mitigation for particulate matter. The climate normals (1981-2010) were reviewed from Environment Canada's Burwash and Whitehorse meteorological stations and percentage of wet days were estimated as 68.2% and 67.9%, respectively (Table A.8A.2–2). As a conservative approach, the station with less precipitation (Whitehorse) was used as a natural mitigation factor (Table A.8A.2–2). The wet day estimation method was used from NPRI's pits and quarries guidance.

Table A.8A.2-2 Regional Data for Natural Mitigation Wet Day Estimation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	% of Wet Days
Burwash														
Days >= 0.2 mm precipitation	7.8	6.4	5.4	4.1	8	10.8	13.7	10.7	8.7	9.2	9.9	7.6		
Days >= 1 cm snow on the ground	29.7	27.8	29.7	15.3	1.7	0.03	0	0.1	2	13.7	26.6	30.1		
Total number of mitigated days	**31**	**28**	**31**	**19.4**	**9.7**	**10.83**	**13.7**	**10.8**	**10.7**	**22.9**	**30**	**31**	**249.03**	**68.2%**
Whitehorse														
>= 0.2 mm precipitation	11.2	8.3	6.4	4.4	8	10.9	13.5	12.5	11.9	11.5	11.5	11.2		
>= 1 cm snow on the ground	31	28.2	29.2	14.4	0.26	0	0	0.08	0.96	8.5	28.3	30.3		
Total number of mitigated days	**31**	**28**	**31**	**18.8**	**8.26**	**10.9**	**13.5**	**12.58**	**12.86**	**20**	**30**	**31**	**247.9**	**67.9%**

Regular open pit activities are based on blasting, drilling, loading and hauling. Blasting was assumed to take place once a day using ANFO for explosive detonation. Table A.8A.2–3 show the air emission estimated for open pit activities and the corresponding emission factors used.

Table A.8A.2-3 Open Pit Particulate Matter Emissions

Open Pit Activity	Emission Factor	Unit	Total Emissions (tonnes per blast)	Total Emissions (tonnes/year)
Blasting (AP-42 Table 11.9-2)				
Total Particulate Matter (TPM)	$= 0.00022 * Area^{1.5}$	kg/blast	0.22	80.3
PM_{10}	0.52 x TPM	kg/blast	0.1144	41.7
$PM_{2.5}$	0.03 x TPM	kg/blast	0.0066	2.4
# of blasts	1 per day	blasts/day		
Area impacted per blast (m2)	10000	m^2		

Open Pit Activity	Emission Factor	Unit	Total Emissions (tonnes per blast)	Total Emissions (tonnes/year)
Drilling (SCC 3-05-020-10 and aerodynamic size distribution)				
Total Particulate Matter (TPM)	$8.46619x10^{-05}$	(kg/Mg)		8.4
PM_{10}	$4.00428x10^{-05}$	(kg/Mg)		3.9
$PM_{2.5}$	$6.06362x10^{-06}$	(kg/Mg)		0.6
Haul Truck Loading(SCC 3-05-020-31)				
Total Particulate Matter (TPM)	0.000105714	(kg/Mg)		10.4
PM_{10}	0.00005	(kg/Mg)		4.9
$PM_{2.5}$	$7.57143x10^{-06}$	(kg/Mg)		0.7

There are two primary crushers at site in an enclosed building as indicated in the feasibility study, the crushers units also include unloading emission sources. The estimated emissions from the crusher units are summarized in Table A.8A.2–4.

Table A.8A.2-4 Emissions from the Primary Crusher Units

Parameter	Emission Factor (kg/Mg)		Total Emissions Crusher 1 (tonnes/year)	Total Emissions Crusher 2 (tonnes/year)
Crusher	SCC 3-03-024-01	SCC 3-03-024-05		
	Low-moisture ore	High-moisture ore		
Total Particulate Matter (TPM)	0.2	0.01	893.9	155.1
PM_{10}	0.02	0.004	89.4	15.5
$PM_{2.5}$	0.02	$7.16x10^{-04}$	89.4	15.5
Crusher Mitigation Efficiency =	90%			
Environment Canada Pits and Quarries Guidance, Crusher Emission Control Techniques, Enclosed Building Mitigation Efficiency PM2.5 emission factor is not available therefore assumed to be same as PM10 as conservative approach, Project ore/waste considered as low-moisture because it is less than 4% therefore SC-3-03-024-05 was not used for estimations.				
Truck Unloading at Crusher Unit	SCC 3-05-020-31			
Total Particulate Matter (TPM)	$2.x10^{-05}$		0.076	0.062
PM_{10}	$8.x10^{-06}$		0.036	0.029
$PM_{2.5}$	$1.x10^{-06}$		0.005	0.004
Mitigation Efficiency =	90%			
Environment Canada Pits and Quarries Guidance, Crusher Emission Control Techniques, Enclosed Building Mitigation Efficiency. TPM and $PM_{2.5}$ emission factors are not available therefore they were calculated by generic aerodynamic size distribution factors using PM_{10} EF.				

Processing at the Project consists of two processing facilities, one for sulphide ore and one for oxide ore. The sulphide ore processing facility will produce mineral concentrates of copper and molybdenum using conventional flotation technology. The copper concentrate will be dewatered and transported as a filtered cake by highway trucks. The molybdenum concentrate will be dewatered and packaged in super sacks for transport. The feasibility study indicates that the unit will operate in a closed circuit, therefore secondary crushing, mill and cyclone emissions are within the process building and not released to atmosphere.

The oxide ore processing facility will produce gold and silver Doré bars via heap leach and carbon adsorption technology. Copper contained in the oxide ore will be recovered as a copper sulphide precipitate using SART technology. This facility includes conveyor drop off, secondary crushing and screening emission.

Table A.8A.2–5 and Table A.8A.2–6 summarize the emission estimations from the processing facilities.

Table A.8A.2-5 Sulphide Ore Processing Facility Emissions

Mine Facility	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Conveyor Drop-Off Point at Plant	SCC 3-05-020-06 uncontrolled	0.0015	0.00055	0.00055	67.0	24.6	24.6
	SCC 3-05-020-06 controlled	$7.00x10^{-05}$	$2.30x10^{-05}$	$6.50x10^{-06}$			
SAG Mill	SCC 3-03-024-10	1.2	0.16	0.16	closed circuit to secondary crushing		
Pebble Crushing	SCC 3-03-024-02	0.600	0.284	0.043	closed circuit to cyclone		
Cyclone	SCC 3-03-024-11	0.300	0.142	0.021	closed circuit to ball mill		
Ball Mill	SCC 3-03-024-10	1.2	0.16	0.16	268.2	71.5	71.5

Mitigation with Fabric Filter (AP-42 Table B.2.3) discharging from building

Table A.8A.2-6 Oxide Ore Processing Facility Emissions

Mine Facility	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Conveyor Drop-Off Point at Plant	SCC 3-05-020-06 uncontrolled	$1.50x10^{-03}$	$5.50x10^{-04}$	$5.50x10^{-04}$	11.8	4.3	4.3
Secondary Crushing*	SCC 3-03-024-02	$6.00x10^{-01}$	$2.84x10^{-01}$	$4.30x10^{-02}$	235.9	111.6	16.9
Screening	SCC 3-05-020-21	0.15	0.036	0.036	59	14.2	14.2

*Mitigation 90% as per EC P&Q section 8.6 Covered Screen with building filter

Site historical meteorological data indicate that the Project site does not experience wind gusts very often. The wind speeds exceed 5.4 metres/second hourly average for only 4.4% of the time from 2008 to 2012. However, the erosion related particulate emission were estimated and used in the model for exposed stockpiles and tailings beach. Table A.8A.2–7 summarizes the erosion emission estimations.

Table A.8A.2-7 Wind Erosion Emissions

Mine Facility	Emission Factor (tonnes/year)		
	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile (4ha)	1.87	0.94	0.37
Low Grade Supergene Stockpile (4ha)	1.87	0.94	0.37
Supergene Oxide Ore Stockpile (4ha)	1.87	0.94	0.37
Low Grade Hypogene Ore Stockpile (4 ha)	1.87	0.94	0.37
Low Grade Supergene Oxide Stockpile (1 ha)	0.47	0.23	0.09
Waste Storage (4 ha)	0.09	0.04	0.01
Tailings Beach (18 ha)	13.4	6.7	2.7

Earth moving activities such as bulldozing generate dust to move unloaded material at stockpile areas. Since ore/waste moisture content is low, the earth moving activities is included in the emissions inventory (Table A.8A.2–8). The air emissions predicted for loading/unloading activities are summarized in Table A.8A.2–9.

Table A.8A.2-8 Earth Moving Air Emissions

Mine Facility	Emission Factor (tonnes/year)		
	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile	97.0	72.8	10.2
Low Grade Supergene Stockpile	164.4	123.3	17.3
Supergene Oxide Ore Stockpile	164.4	123.3	17.3
Low Grade Hypogene Ore Stockpile	164.4	123.3	17.3
Low Grade Supergene Oxide Stockpile	82.2	61.6	8.6
Waste Storage	90.8	68.1	9.5

Table A.8A.2-9 Truck Loading/Unloading Emissions

Mine Facility	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Low Grade Supergene Pile	SCC 3-05-020-31	$1.69x10^{-05}$	$8.00x10^{-06}$	$1.21x10^{-06}$	0.028	0.013	0.002
Gold Ore Stockpile	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	0.831	0.393	0.060
Supergene Oxide Ore Stockpile	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	0.006	0.003	0.0001
Low Grade Hypogene Ore Pile	SCC 3-05-020-31	$1.69x10^{-05}$	$8.00x10^{-06}$	$1.21x10^{-06}$	0.028	0.013	0.002
Low Grade Supergene Oxide	SCC 3-05-020-31	$1.69x10^{-05}$	$8.00x10^{-06}$	$1.21x10^{-06}$	0.0018	0.0008	0.0001
Waste Storage Dump	SCC 3-05-020-31	$1.69x10^{-05}$	$8.00x10^{-06}$	$1.21x10^{-06}$	0.891	0.013	0.004

Note: Total Material dump at storage areas were derived from production schedule in feasibility study

Fugitive emissions from haul roads were estimated based on U.S. EPA emission factors for unpaved roads. Haul roads are predicted to generate the majority of particulate emissions. It was assumed that a dust control program (i.e. applying water to control dust emissions) would be applied and would control fugitive dust emissions from haul roads by approximately 75%, and natural mitigation (precipitation and snow cover) would also aid to suppress fugitive dust. The Whitehorse and Burwash weather stations (Table A.8A.2-2) were considered for natural mitigation data and Whitehorse was used in calculations (67.9%) as a conservative approach. Regular activity consists of ore/waste hauling, explosive transport, airport transportation and access road materials supply and concentrate transport. Table A.8A.2–10 summarizes the fugitive emissions predicted for haul roads and overall particulate matter emissions are summarized in Table A.8A.2–11. Similar to the construction phase emissions calculations for haul roads, fugitive dust was calculated using AP-42 Section Unpaved Roads (US EPA 1995):

$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}$$

where:

- E is size specific emission factor (lb/VMT)
- s is surface material silt content (%)
- W is mean vehicle weight (tonnes)
- k (lb/VMT) is equal to 0.15 for PM2.5, 1.5 for PM10 and 4.9 for TPM
- a is equal to 0.9 for PM2.5 and PM10 and 0.7 for TPM
- b is equal to 0.45 for PM2.5, PM10, and TPM.

Table A.8A.2-10 Unpaved Road Emissions

Road Name	Average Weight (tonnes)	Daily Total Travelled Distance for all vehicles (km)	Daily Total TPM (tonnes/year)	Daily Total PM_{10} (tonnes/year)	Daily Total $PM_{2.5}$ (tonnes/year)
Haul Road 1 To Waste Storage Area	443	7097.3	1539	395	40
Haul Road 2 To Low Grade Ore – Hypogene Stockpile	443	150.8	33	8	1
Haul Road 3 To Low Grade Ore – Supergene Sulphide Stockpile	443	118.7	26	7	1
Haul Road 4 To Low Grade Ore – Supergene Oxide Stockpile	443	12.9	3	1	0.1
Haul Road 5 From Supergene Oxide – Stockpile	127	537.5	117	30	3
Haul Road 6 From Gold Ore Stockpile	127	426.5	92	24	2
Haul Road 7 Direct Mill Feed	443	2202.3	478	123	12
Haul Road 8 Explosive Storage Access Road	30	13.9	3	1	0.1
Access Road	30	6469.5	1508	1442	144
Airport Road	30	366.6	85	82	8

Table A.8A.2-11 Daily Total Emission During Operations

Mine Facility	Daily Total TPM (tonnes/year)	Daily Total PM10 (tonnes/year)	Daily Total PM2.5 (tonnes/year)
ROADS			
Haul Road 1	1539	395	40
Haul Road 2	33	8	1
Haul Road 3	26	7	1
Haul Road 4	3	1	0.1
Haul Road 5	117	30	3
Haul Road 6	92	24	2
Haul Road 7	478	123	12
Haul Road 8	3	1	0.1
Access Road	1508	1442	144
Airport Road	85	82	8
CRUSHER UNIT TO SULPHIDE ORE FACILITY			
Crusher	893.9	89.4	89.4
Truck Unloading	0.076	0.036	0.036
CRUSHER UNIT TO OXIDE ORE FACILITY			
Crusher	155.1	15.5	15.5
Truck Unloading	0.062	0.029	0.004
SULPHITE ORE PLANT			
Conveyor Drop Off	67.0	24.6	24.6
SAG Mill	-	-	-
Pebble Crushing	-	-	-
Cyclone	-	-	-
Ball Mill	268.2	71.5	71.5
OXIDE ORE PLANT			
Conveyor Drop-Off	11.8	4.3	4.3
Screening	59.0	14.2	14.2
Secondary Crushing	235.9	111.6	16.9
EARTH MOVING/SURFACING			
Low Grade Supergene Stockpiles	164.4	123.3	17.3
Gold Ore Stockpiles	97.0	72.8	10.2
Supergene Oxide Ore Stockpiles	164.4	123.3	17.3
Low Grade Hypogene Ore Stockpiles	164.4	123.3	17.3
Low Grade Supergene Oxide Stockpiles	82.2	61.6	8.6
Waste Storage Dump	90.8	68.1	9.5
LOADING/UNLOADING			
Low Grade Supergene Stockpiles	0.028	0.013	0.002

Mine Facility	Daily Total TPM (tonnes/year)	Daily Total PM10 (tonnes/year)	Daily Total PM2.5 (tonnes/year)
Gold Ore Stockpiles	0.831	0.393	0.060
Supergene Oxide Ore Stockpiles	0.006	0.003	0.0004
Low Grade Hypogene Ore Stockpiles	0.028	0.013	0.002
Low Grade Supergene Oxide Stockpiles	0.0018	0.0008	0.0001
Waste Storage Dump	0.891	0.013	0.004
WIND EROSION			
Gold Ore Storage Area	1.87	0.94	0.37
Low Grade Supergene Pile	1.87	0.94	0.37
Supergene Oxide Ore Stockpile	1.87	0.94	0.37
Low Grade Hypogene Ore pile	1.87	0.94	0.37
Low Grade Supergene Oxide	0.47	0.23	0.09
Waste Storage	0.09	0.04	0.01
Tailings Beach	13.42	6.72	2.68
ANNUAL TOTAL (tonnes)	**6362**	**3027**	**532**

Project emissions from mine fleet combustion sources were quantified based on information regarding the type, quantity and power rates of the equipment. Other large sources include the natural gas fired power plant and auxiliary power plant.

The mine fleet emissions were estimated using NONROAD2008a model, and the equipment type, function, and number of vehicles was obtained from the feasibility study (M3 2013). The allocations were estimated by professional judgement by considering material amounts moved during year 11. The mine fleet, models, number of vehicles and allocation used for modelling are summarized in Table A.8A.2–12 and resulting air emissions for the mine fleet are in Table A.8A.2–13.

Table A.8A.2-12 Mine Fleet and Percentage of Working Locations

Mine Fleet Equipment	Type	Operating Time (hr/day)	# of vehicles	Percentage of Working Locations (%)													
				Open pit	Low Grade SUP	SUP Oxide	Low Grade HYP	Low Grade SUP Oxide	Waste Storage	Gold Ore	HL1	HL2	HL3	HL4	HL5	HL6	HL7
P&H 320XPC Drill	Drill	15	3	100													
P&H 4100XPC Cable Shovel	Shovel	11	3	100													
Cat 994F Wheel Loader	Loader	5.5	2			100											
Cat 797F Truck	Truck	21	24	10	5		5	5	5		15	20	5	15	5	5	5
Cat D11T Track Dozer	Dozer	11	3		20	20	20	10	10	20							
Cat D10T Track Dozer	Dozer	11	3		20	20	20	10	10	20							
Cat 854K Wheel Dozer	Dozer	11	3		20	20	20	10	10	20							
Cat 24M Motor Grader	Grader	11	3	40	10	10	10	10	10	10							
Water Truck - 30,000 gal	Water Truck	5.5	3	30							10	10	10	10	10	10	10
Cat 345D Excavator	Excavator	5.5	1	100													
Atlas Copco ECM 720 Drill	Drill	15	1	100													
Cat 992K Wheel Loader	Loader	11	1							100							
Cat 777F Truck	Truck	17	10			10				10					40	40	

Table A.8A.2-13 Mine Fleet Air Emissions

Operating Time (hr/day)	Fleet Summary	Function	Power (hp)	Quantity	Emissions (g/hp-hour)				
					NOx	CO	PM10	PM2.5	SO2
15	P&H 320XPC Drill	Drill	1000	3	3.5465	1.078	0.1478	0.143366	0.0042
11	P&H 4100XPC Cable Shovel	Shovel	3973	3	2.7121	0.8347	0.0927	0.089919	0.0038
5.5	Cat 994F Wheel Loader	Loader	1463	2	3.9716	1.244	0.1747	0.169459	0.0043
21	Cat 797F Truck	Truck	4000	24	2.7121	0.8347	0.0927	0.089919	0.0038
11	Cat D11T Track Dozer	Dozer	850	3	3.5465	1.078	0.1478	0.143366	0.0042
11	Cat D10T Track Dozer	Dozer	580	3	1.9344	0.7839	0.12	0.1164	0.0042
11	Cat 854K Wheel Dozer	Dozer	907	3	3.5465	1.078	0.1478	0.143366	0.0042
11	Cat 24M Motor Grader	Grader	533	3	1.8859	0.7642	0.1177	0.114169	0.0042
5.5	Water Truck - 30,000 gal	Water Truck	1026	3	2.7121	0.8347	0.0927	0.089919	0.0038
5.5	Cat 345D Excavator	Excavator	380	1	1.6317	0.661	0.1041	0.100977	0.0041
15	Atlas Copco ECM 720 Drill	Drill	385	1	3.8949	1.1523	0.1812	0.175764	0.0044
11	Cat 992K Wheel Loader	Loader	814	1	3.9716	1.244	0.1747	0.169459	0.0043
17	Cat 777F Truck	Truck	1016	10	2.7121	0.8347	0.0927	0.089919	0.0038
2	Cat 345D Excavator	Excavator	380	1	1.6317	0.661	0.1041	0.100977	0.0041

Note: The list provided in feasibility study, power ratings and quantity provided in feasibility study (M3 2013).
Non-road model includes deterioration factors in the model.
Operating times estimated with professional judgement by considering material movement during year 11.

Detailed blasting data were not available, therefore the ANFO use was estimated by using 0.25 times the powder factor and material extracted from the open pit in a year. It was assumed that blasting emissions would disperse in one hour which is the shortest modelling time interval for this study. The blasting was also assumed to occur once a day. Table A.8A.2–14 summarizes the blasting emission estimations.

Table A.8A.2-14 Blasting Emissions

Species	Emission Factor [A] (kg/Mg ANFO)	Daily ANFO [B] (tonnes)	Daily Air Emissions (kg)	Emission Rate [c] ($g/s/m^2$)
CO	34	67.63	2299.33	1.18x10-03
NO_x	8	67.63	541.02	2.78x10-04
SO_2	1	67.63	67.63	3.48x10-05

[A] source: US EPA AP-42 Section 13.3
[B] Assuming a powder factor of 0.225 Kg ANFO/tonnes with 98736000 tonnes extraction during year 11
[c] Assuming that blasting emissions will be released from 10000 m^2 surface within one hour

During operations, power is provided by a natural gas fired power plant (two at 47 MW capacity each) with heat recovery steam generators, and supported by the auxiliary power plant, which is composed of three 6.7 MW generators. Combined gas plants show variable emissions characteristics depending on gas composition, heat recovery system, and changing power demand which changes air emission rates considerably. Since details such as design, fuel consumption, stack clusters, emission control techniques and heat recovery combination of this combined plant were not available, the emission rates were estimated by using power output ratings provided by Australia's emission estimation technique manual for combustion engines Combustion Engines version 3.0, Table 51. The emission factors are developed for uncontrolled natural gas turbines. It was assumed that gas turbines could provide 90% efficiency with an additional 5% preventive maintenance time. The resulting emissions predictions are summarized in Table A.8A.2–15 for the natural gas fired power plant. For the auxiliary power plant, emissions during operations are the same as during construction (Table A.8A.1-13)

Table A.8A.2-15 Natural Gas Power Plant Emission Rates

Parameter	Value	Unit	Reference
Stack Height	20	m	
Stack Diameter	3	m	
Stack Velocity at operating temperature	25.0	m/s	
Stack Gas Temp	312.15	°C	
Efficiency	90%		
Installed Power	2x47	MW	Nominal rates (kg/kWh)
NO_X	12.930	g/s	$4.95x10^{-04}$
CO	3.320	g/s	$1.27x10^{-04}$
SO_2	0.020	g/s	$7.86x10^{-07}$
TPM	$7.68x10^{-02}$	g/s	$2.94x10^{-06}$
PM_{10}	$7.68 x10^{-02}$	g/s	$2.94x10^{-06}$
$PM_{2.5}$	$7.68 x10^{-02}$	g/s	$2.94x10^{-06}$

Similarly to the construction phase, an incinerator will be used to manage domestic refuse waste. The incinerator emissions during operations were assumed to be the same as during construction, as summarized in Table A.8A.1-14.

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