Feasibility Update Study Ventilation Technical Report for the Lac des lles Mine, Ontario, Canada

Report Prepared for North American Palladium Ltd.





Report Prepared by



SRK Consulting (Canada) Inc. 5CN006.005 July 20, 2018



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Cover: Lac des Iles Mine

Executive Summary

SRK Consulting (Canada) Inc. (SRK) was commissioned by North American Palladium Ltd. (NAP) to complete a Feasibility Technical Update Study of the Lac des Iles Mine (LDI).

The LDI property is located approximately 140 kilometres north of the city of Thunder Bay, via Highway 527 in northwestern Ontario. Refer to Figure i.

In May 2017, NAP filed a technical report entitled, "NI 43-101 Technical Report Feasibility Study Incorporating the Life of Mine Plan for Lac des Iles Mine". This report included a revised estimate of mineral reserves and mineral resources for LDI that are considered to be material to the NAP's business and the associated life of mine plan (LOMP) schedules production over 9.5 years to 2026.



Figure i: Lac des lles Mine Site Location

As a result of optimization efforts performed on the Near Surface Zones, this feasibility technical update study report includes the revisions to the associated LOMP schedules and production to 2028 as referenced in Figure ii. This work involved upgrading the previous designs to detailed feasibility level on the Near Surface Zones, inclusive of the following:

- Roby NE Extension Zone
- Roby NW Zone
- Roby FW Zone
- Roby SW Floor Zone
- Roby S Zone
- Sheriff South Zone
- B2 Zone



Figure ii: Production Profile – All Production Areas

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1 Introduction

This document provides the design basis for the ventilation facilities that will service all orebodies and operations included in the Lac des Iles Mine (LDI). This includes the Near Surface Zones, Upper and Lower Offsets.

The overall final ventilation system design is a "push / pull" system. Under normal operating conditions the shaft and main fresh air intakes are utilized to provide LDI (all mining areas) with approximately 958 cubic metres per second (m³/s) (2,029,600 cubic feet per minute [cfm]). The return air system will consist of the main exhaust fans, 220 Level underground return air (RA) boosters and new ramp portal.

All primary fans are to be controlled by variable frequency drives (VFD) to mesh the production rate with the air volume requirements, thereby optimizing energy (power and propane) usage. Parallel fan setups are recommended for all primary installations.

2 Ventilation

The current ventilation installation consists of a push-pull system using a network of main fans on surface and booster fans underground. The main fresh air system consists of one 600 horsepower (HP) fan and propane-fired heater installed in the Roby pit. This fan supplies approximately 217 m³/s of air to 560 Level then down to 825 Level. The shaft fresh air system consists of two 350 HP fans and propane-fired heater that deliver 203 m³/s of air to 825 Level.

Return air exhausts from underground via the ramp, and the exhaust fans located in the open pit. The ramp exhausts approximately 96 m^3 /s and the pit exhaust fans draw approximately 291 m^3 /s from the mine.

As mining underground progresses at depth, the ventilation system will require upgrading. Additionally, to allow for the Near Surface Zones, additional ventilation systems will be required. These upgrades are discussed below.

2.1 Expansion Underground

NAP recently converted to a sublevel stoping (SLS) mining method in the lower portion of LDI that includes an increase in the production rate. LDI's 2018 life of mine plan (LOMP) includes mining of the SLS to 1305 Level, together with planned mining in the Upper Offset and B2 zones. This plan necessitates upgrades to the current ventilation system in order to meet the revised LOMP.

2.2 Near Surface Zones

The ventilation design for the Near Surface Zones is designed to function as a standalone system, independent of the current ventilation system at LDI.

The ventilation is configured as a push-pull system with the majority of fan duty located within the supply portion of the mine. All intake air will be heated as required, utilizing propane gas direct-fired heaters on the surface intake during the winter months.

The design of the ventilation system is based on air quantity requirements determined from the preliminary estimated diesel equipment fleet of load, haul, dump (LHD) trucks and haulage trucks.

Under normal operating conditions, the new 5.5-metre (18-foot) diameter fresh air raise (FAR) will provide 437 m³/s (927 Kcfm) of fresh air from fans operating in parallel on surface. The fresh air delivered through the FAR is distributed in a controlled manner to the various underground working areas.

Return air (RA) for the mining zones will be via the new ramp/portal, 220 Level underground RA booster fans, and by the development of RA raises/drifts at the extents of the mining zones extending and daylighting into the pit wall.

Flow through ventilation for the mining zones will be achieved via regulators and/or auxiliary boosters to control the amount of airflow required. The amount of fresh air allocated to a level depends on the number of production/development areas on the level.

3 Ventilation Airflows, Fans, and Raises

3.1 Ventilation System Design Parameters

The best practice in ventilation design considers the following elements:

- Ramp systems maintained in fresh air
- Maintain optimum velocity within raises, travelways and workplaces. Maximum velocities enforced in the designs are presented in Table 1

Table 1: Airway Velocity Criteria

Area/Airway	Maximum Velocity (m/s)
Ramp or other primary travelway	6
Ventilation drift (no regular personnel access)	10
Raise (not used for escapeway)	20
Upcasting shaft range to avoid (for water suspension)	(7 to 12)

- One pass ventilation is employed for primary ventilation systems
- Limited use of recycled air

3.2 Airflow Requirements

The estimated underground air volume requirements are based on the Ontario Occupational Health and Safety Act, Regulations 854 Section 183.1 (3).

The regulation states:

"The flow of air must be at least 0.06 cubic metres per second for each kilowatt of the diesel-powered equipment operating in the workplace".

The airflow requirement is commonly expressed in cfm and the conversion is 100 cfm per HP.

The maximum ventilation demand would occur if all mobile equipment in the mine was operating simultaneously. Although this is possible, in practice it is very unlikely to occur. To estimate a more likely peak ventilation demand, utilization factors were applied to the mobile equipment.

The utilization factors reflect the likely combination of equipment that will be running during the busiest periods of any working shift (i.e. during the work periods with high diesel activity). Refer to Table 2. Fractional Equipment factors refer to transient equipment location within areas.

Ventilation utilization should not be confused with operator utilization (or "seat time"). For example, a haul truck may only operate for 6 hours during a 10-hour shift (60% utilized), but the 6 hours are primarily during the nominal 8 hours of high diesel activity. It is the period of high diesel activity for which the ventilation system must be designed to support. During the periods of low activity, ventilation on demand (VOD) settings can be used to reduce the ventilation flows accordingly.

Utilization factors vary with the type of equipment and reasonable judgement was used. Equipment such as drill jumbos, which operate on diesel power only while moving from one workplace to the next, are utilized much less than LHDs or haul trucks.

Table 2: Utlization Cycle

Shift Start	Work Period	Lunch	Work Period	Shift End
Low activity	High diesel activity	Low activity	High diesel activity	Low activity

Ventilation simulation modelling and associated facility designs were prepared based on these airflows. Details of the airflow requirement calculations are provided in Appendix A.

The peak fresh airflow capacity for the mining of LDI's 2018 LOMP includes mining of the SLS to 1305 Level, together with planned mining in the Upper Offset and B2 zones has been presented in Table 3.

Milestone	Stage	FA Capacity m ³ /s (Kcfm)
U/G Expansion	LOMP 2018	558 (1,181)

Mining of the Near Surface Zones over the LOMP by milestone will be as follows:

- Milestone 1
 - Roby FW Zone with one production front and one development front.
 - Roby SW Floor Zone with one development front.
- Milestone 2
 - Roby FW Zone with one production front and one development front.
 - Roby SW Floor Zone with one production front and one development front.
 - Roby NE Extension Zone with one development front.
- Milestone 3
 - Roby FW Zone with one production front.
 - Roby SW Floor Zone with one production front and one development front.
 - Roby NE Extension Zone with one production front.
 - Roby NW Zone with one production front.
 - Sheriff Zone with one development front.
- Milestone 4
 - Roby FW Zone with one production front.
 - South Zone with one production front and one development front.
 - Sheriff Zone with one production front.

The peak fresh airflow capacity for mining the underground expansion and Near Surface Zones is presented in Table 4.

Milestone	Stage	FA Capacity m ³ /s (Kcfm)
Milestone 1	Year 2020	234 (497)
Milestone 2	Year 2024	407 (861)
Milestone 3	Year 2026	437 (927)
Milestone 4	Year 2028	367 (778)

Table 4: Near Surface Zones Peak Fresh Air Ventilation System Capacities

4 Ventilation Modelling

The ventilation simulation modelling and associated facility designs were prepared based on the following:

- Ventsim ventilation numerical model software
- Mine development and production plans, including access and production level 3D designs.
- Mine production schedules.
- Underground mobile equipment list and engine power estimates.
- Airflow requirements as calculated under the initial design criteria.
- Creation of numerical model for steady state ventilation milestone to determine infrastructure requirements and schedule.

The ventilation models were prepared to simulate the airflows during each of the determined stages and the selected peak production year. During this year, mining is active in most areas and the ventilation demand is at its highest. The ventilation numerical models for the 2018 LOMP and underground expansion are presented for illustration purposes in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7. The long sections are provided in Appendix B.



Figure 1: Underground Expansion 2018 LOMP

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Figure 2: Near Surface Zones Milestone 1 2020



Figure 3: Near Surface Zones Milestone 2 2024



Figure 4: Near Surface Zones Milestone 3 2026 (A)



Figure 5: Near Surface Zones Milestone 3 2026 (B)





Figure 6: Near Surface Zones Milestone 4 2028 (A)



Figure 7: Near Surface Zones Milestone 4 2028 (B)

4.1 Main Fans

The design of the Near Surface Zones ventilation system is based on air quantity requirements determined from the estimated diesel fleet and considering the criteria provided by LDI engineering personnel.

The main ventilation system consists of the following installations:

- New Near Surface Zone main fresh air supply fans and propane direct-fired heaters.
- New RA underground booster fans at 220 Level.

Installation of variable frequency drives on all main fans will allow flexibility in the air volume capacity to meet the production requirements. General arrangement drawings of the proposed ventilation installations are provided in Appendix C.

Figure 8 illustrates the typical fresh air fan installation on surface. Figure 9 illustrate a typical underground RA booster fan installation. The main fan operating duty points are listed in Table 5.

Table 5: Main Fan Duty Points

System	Number of Fans	Operating Duty Point	Connected Fan kW	Mine Air Heater
Near surface fresh air	2	218.5 m ³ /s at 1,020 Pascal SP	2 × 522 kW (700 HP)	2 × 12 MW
220 Level RA boosters	2	302 m³/s at 1,470 Pascal SP	2 × 373 kW (500) HP	

4.2 Main Fresh Air Intake Raise Mine Air Heating

Fresh air mine air heating systems will be required to heat the mine air during the winter months. The heating system capacity is designed for a 47° C (80° F) temperature fluctuation range to allow for heating of the mine air at low temperatures. The direct propane gas fired heating systems includes heaters, common control room, valve trains, and electrics.

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Figure 8: Typical Main Fresh Air System

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Figure 9: Typical Underground Return Air Booster Fans

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	TYPICAL UN BOOSTER F	DERGROUND
	ARRANGE	MENT PLAN
	AND S	
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4.3 Mine Air Heating Natural Gas Consumption

The mine air heaters are designed for a maximum temperature differential of 47° C (- 40° F to + 40° F) but will modulate to provide an output temperature setpoint in the intake raise collar of +2.0°C (35.6°F) during winter months. The estimated total mine propane gas consumption and associated costs (C\$0.40 per litre) by milestone and per heating season are summarized in Table 6. Detailed heating calculations by location and milestone are provided in Appendix D.

Milestone	Stage	Litres of Propane	Cost of Propane (C\$)
Milestone 1	Year 2020	5,931,909	2,372,763
Milestone 2	Year 2024	7,285,464	2,914,185
Milestone 3	Year 2026	7,526,508	3,010,603
Milestone 4	Year 2028	6,976,185	2,790,474

Table 6: Total Mine Propane Gas Cost Summary (During Winter Months)

5 Contingency

Due to the close proximity of the Near Surface Zones to the existing main fresh air and pit return air surface fans, LDI requested that SRK review the impacts of relocating both the main fresh air and pit return air surface fans, if required due to the expansion, as a contingency. It was determined, should the need for this replacement of facilities be required, it most likely would be during Milestone 2, 2024.

The contingency ventilation system consists of the following installations:

- Replacement of the main fresh air fan will consist of developing a new 218-metre long, 4.9-metre (16-foot) diameter fresh air raise from surface complete with fans, heaters and propane supply.
- Replacement of the pit RA surface fans will consist of the installation of new RA underground booster fans located at 600 Level.

Installation of variable frequency drives on all main fans will allow flexibility in the air volume capacity to meet the production requirements.

A site plan identifying the fan locations is provided in Figure 10 and Figure 11. A schematic of the mine with the contingency option is presented for illustration purposes in Figure 12. The main fan operating duty points are listed in Table 5.

The contingency main fan operating duty points are listed in Table 7.

Table 7: Contingency Main Fan Duty Points

System	Number of Fans	Operating Duty Point	Connected Fan kW
New Main FA Fans	2	118 m³/s at 835 Pascal SP	2 × 224 kW (300 HP)
600 Level RA Boosters	2	173.5 m ³ /s at 1524 Pascal SP	2 × 522 kW (700) HP



Figure 10: Contingency Site Plan



Figure 11: Contingency Site Plan



Figure 12: Contingency Schematic

Page 20

6 Conclusion

Based on the evaluation of the information provided, the proposed ventilation system meets legislative and best practice ventilation design principles.

SRK recommends that as LDI continues to finalize life of mine planning, it will be important to update the numerical model and associated staged scenarios to define ventilation requirements and more precisely define main fan operating requirements.

SRK also suggest LDI undertake a mine wide ventilation survey in order to adequately correlate the numerical models prior developing and purchasing major ventilation mine infrastructure items.

The scope of the ventilation survey will be to measure pressure and quantity in all areas of the underground mining complex. Also, all other ventilation controls, main fans, and booster fans will be measured throughout the mine. Data collected during the survey will be used to calculate friction factors and resistances for future mine development as well as make recommendations for system optimization and any energy saving changes to the ventilation system.

Regards

SRK Consulting (Canada) Inc.

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Jacques "Jake" Jodouin, CET LEL Principal Consultant (Mine Ventilation)

APPENDIX A

Airflow Determination

	Preliminary	- UG	Diesel Eq	uipment	Fleet - Milesto	one 1			
Unit	Qu	antity	Hp each	kW each	Utilization	Total Hp	Total kW	Total CFM (100cfm/hp)	Total M3/Sec
			Sout	h Ramp D	evelopment			(1000111/11p)	
Development									
Jumbo		0.5	99	74	25%	12	9	1,238	1
8yd LHD		0.5	343	256	100%	172	128	17,150	8
Maclean Bolter		0.5	160	119	25%	20	15	2,000	1
63t Truck		0	758	565	100%	0	0	0	0
Toyota Jeep		0.5	128	95	50%	32	24	3,200	2
								23,588	11
Production		0	242	257	100%	0	0	0	0
8 ya LHD		0	343	256	100%	0	0	0	0
Tavata Jaan		0	/58	202	100%	0	0	0	0
Naciona Beltor		0	128	95	5U%	0	0	0	0
Maclean Boller		0	100	119	2370	0	0	0	0
Ramp								<u> </u>	0
63t Truck	(0.33	758	565	100%	250	187	25.014	12
Grader	().33	138	103	50%	23	17	2,277	1
Fuel and lube Tru	ick ().33	173	129	50%	29	21	2,855	1
Boom Truck	().33	173	129	50%	29	21	2,855	1
								30,146	14
Summary									
Development		1			100%			23,588	11
Production		0			100%			0	0
Ramp		1			100%			30,146	14
								50 700	05
Subtotal								53,733	25
	SUBTOTAL		onoity			0.075	0.075	53,733	25
	SUBIUTAL	0/6 0	ensity	1	1	0.075	0.075	33,733	
Iotal								53 733	25
				FW Z	one			00//00	
Development									
Jumbo		1	99	74	25%	25	18	2,475	1
8yd LHD		1	343	256	100%	343	256	34,300	16
Maclean Bolter		1	160	119	25%	40	30	4,000	2
63t Truck		0	758	565	100%	0	0	0	0
Toyota Jeep		1	128	95	50%	64	48	6,400	3
Due due them								47,175	22
Production		2	242	257	100%	1.020	7/7	102.000	40
8yd LHD		3	343	200	100%	1,029	/6/	102,900	49
Toyota leep		1	128	95	50%	64	48	6.400	3
Maclean Bolter		0	120	119	25%	0	40	0,400	0
		-				_	-	109,300	52
Ramp									
63t Truck	2	2.33	758	565	100%	1,766	1317	176,614	83
Grader	().33	138	103	50%	23	17	2,277	1
Fuel and lube Tru	ick ().33	173	129	50%	29	21	2,855	1
Boom Truck	().33	173	129	50%	29	21	2,855	1
								184,600	87
Summary					4000/			17.175	0.0
Development		1			100%			47,175	22
Production		1			100%			109,300	52
Namp		<u> </u>			100%			104,000	07
Subtotal								341.075	161
								341,075	161
	SUBTOTAL	U/G D	ensity			0.075	0.075	341,075	
Total								341,075	161
			-	South We	est Floor	1	1		
Development		0.5	00	74	059/	10	0	1.000	1
Odline Odline		0.5	343	74 256	∠3% 100%	12	9 129	1,238	R R
Maclean Bolter		0.5	160	119	25%	20	15	2,000	1
63t Truck		0	758	565	100%	0	0	0	0
Toyota Jeep		0.5	128	95	50%	32	24	3,200	2
								23,588	11
Production									
8yd LHD		0	343	256	100%	0	0	0	0
63t Truck		0	758	565	100%	0	0	0	0
Toyota Jeep		0	128	95	50%	0	0	0	0
Maclean Bolter		0	160	119	25%	0	0	0	0
								0	0
Ramp			750	F/F	100%	250	107	25.014	10
Grader	(1.33	/58	202 102	100%	250	187	25,014	12
Evel and lube Tru	ick (1.33	130	103	50%	23	21	2,277	1
Boom Truck).33	173	127	50%	29	21	2,000	1
boomindok			170	127	0070	- /	2.1	33.000	16
Summary									
Development		1			100%			23,588	11
Production		1			100%			0	0
Ramp		1			100%			33,000	16
Subtotal								56,588	27
								56,588	27
SUBTO	JIAL U/G De	nsity I	A REQUI	KED		0.075	0.075	56,588	27
	IDTOTO		101.55						
S	DRIOTAL	ALL :	LONES					451,396	213
Co	ntingenc	:y/Le	eakage			10%		45,140	21
To	otal Min	e Su	Inface					496 535	234
									2.54

Prei	iminary - UG	Diesel Eo	uipment	Fleet - Milesto	one 2	T - 4 - 1 1 - 14/	Tetel OFM	T-4-1 MO (C
Unit	Quantity	Hp each	kw each	(diesel engine)	lotal Hp	lotal kW	(100cfm/hp)	lotal M3/Sec
			FW Z	one			V 101 10 10	
Development								
Jumbo	0	99	74	25%	0	0	0	0
8yd LHD Macloop Poltor	0	343	256	100%	0	0	0	0
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	0	128	95	50%	0	0	0	0
							0	0
Production								
8 yd LHD	2	343	256	100%	686	512	68,600	32
63t Iruck	0	758	565	100%	0	0	0	0
Nacloan Boltor	1	128	95 110	50%	64	48	6,400	3
Maclean Boller	0	100	119	2370	0	0	75.000	35
Ramp							10,000	00
63t Truck	3	758	565	100%	2,274	1696	227,400	107
Grader	0.33	138	103	50%	23	17	2,277	1
Fuel and lube Truck	0.33	173	129	50%	29	21	2,855	1
Boom Truck	0.33	173	129	50%	29	21	2,855	1
Summony							232,532	110
Development	0			100%			0	0
Production	1			100%			75.000	35
Ramp	1			100%			232,532	110
Subtotal							307,532	145
							307,532	145
SUI	BTOTAL U/G D	ensity	1		0.075	0.075	307,532	
Iotal							307 522	145
Total			South We	est Floor			307,332	145
Development								
Jumbo	0.5	99	74	25%	12	9	1,238	1
8yd LHD	0.5	343	256	100%	172	128	17,150	8
Maclean Bolter	0.5	160	119	25%	20	15	2,000	1
63t Truck	0	758	565	100%	0	0	0	0
loyota Jeep	0.5	128	95	50%	32	24	3,200	11
Production							23,300	11
8vd LHD	3	343	256	100%	1.029	767	102,900	49
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	1	128	95	50%	64	48	6,400	3
Maclean Bolter	0	160	119	25%	0	0	0	0
							109,300	52
Ramp	2.5	750	575	100%	2722	1070	2(5.200	105
Grador	3.5	129	103	50%	2,003	1978	205,300	125
Evel and lube Truck	0.33	173	129	50%	29	21	2,277	1
Boom Truck	0.33	173	129	50%	29	21	2,855	1
							273,286	129
Summary								
Development	1			100%			23,588	11
Production	1			100%			109,300	52
Ramp				100%			273,286	129
Subtotal							406.174	192
			1	1			406,174	192
SU	BTOTAL U/G D	ensity			0.075	0.075	406,174	
Total							406,174	192
Povelenment		1	NEI	EXT	1	1		
lumbo	0.5	00	74	25%	12	9	1 238	1
8vd LHD	0.5	343	256	100%	172	128	17,150	8
Maclean Bolter	0.5	160	119	25%	20	15	2,000	1
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	0.5	128	95	50%	32	24	3,200	2
							23,588	11
Production		0.40	05.4	1000/				<u>^</u>
8yd LHD	0	343	256	100%	0	0	0	0
Toyota Jeen	0	128	95	50%	0	0	0	0
Maclean Bolter	0	160	119	25%	0	0	0	0
							0	0
Ramp								
63t Truck	0.5	758	565	100%	379	283	37,900	18
Grader	0.33	138	103	50%	23	17	2,277	1
Fuel and lube Truck	0.33	173	129	50%	29	21	2,855	1
ROOM ILICK	0.33	173	129	50%	29	21	2,855	1
Summary							43,880	22
Development	1			100%			23.588	11
Production	1		1	100%	1		0	0
Ramp	1			100%			45,886	22
Subtotal							69,474	33
			050		0.075	0.075	69,474	33
SUBTOTA	L 0/G Density I	AREQUI	RED		0.075	0.075	69,474	33
CLIDT								
SOBI	UTAL ALL	LOINES					783,179	370
Conti	ngency/Le	eakage	2		10%		78,318	37
Tota	I Mine Su	rface					861,496	407

Unit	Quantity	Hp each	kW each	Utilization	Total Hp	Total kW	Total CFM	Total M3/Sec
	5			(diesel engine)			(100cfm/hp)	
			FW Z	one				
Development								
Jumbo	0	99	/4	25%	0	0	0	0
8yd LHD Macloan Poltor	0	343	250	100%	0	0	0	0
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	0	128	95	50%	0	0	0	0
10,010 0000		120	70	0070	0	0	0	0
Production								
8 yd LHD	1	343	256	100%	343	256	34,300	16
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	1	128	95	50%	64	48	6,400	3
Maclean Bolter	0	160	119	25%	0	0	0	0
-							40,700	19
Ramp	1	750	F/F	100%	75.0	F/F	75.000	27
Grader	0.2	138	202	50%	/30	505 10	1 380	30
Evel and lube Truck	0.2	173	103	50%	14	10	1,300	1
Boom Truck	0.2	173	129	50%	17	13	1,730	1
	0.2	170	127	0070	.,		78,910	37
Summary								
Development	0			100%			0	0
Production	1			100%			40,700	19
Ramp	1			100%			78,910	37
·								
Subtotal							119,610	56
							119,610	56
SUBTO	TAL U/G D	ensity	1		0.075	0.075	119,610	
Tatal							110 (10	F/
Iotai			South We	est Floor			119,610	50
Development								
Jumbo	0.5	99	74	25%	12	9	1,238	1
8yd LHD	0.5	343	256	100%	172	128	17,150	8
Maclean Bolter	0.5	160	119	25%	20	15	2,000	1
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	0.5	128	95	50%	32	24	3,200	2
							23,588	11
Production								
8yd LHD	3	343	256	100%	1,029	767	102,900	49
63t Iruck	0	/58	565	100%	0	0	0	0
loyota Jeep	1	128	95 110	50%	64	48	6,400	3
Iviaciean boiter	0	160	119	23%	0	0	109.300	52
Ramp							109,300	52
63t Truck	3.5	758	565	100%	2 653	1978	265 300	125
Grader	0.2	138	103	50%	14	10	1,380	1
Fuel and lube Truck	0.2	173	129	50%	17	13	1,730	1
Boom Truck	0.2	173	129	50%	17	13	1,730	1
							270,140	127
Summary								
Development	1			100%			23,588	11
Production	1			100%			109,300	52
Ramp	1			100%			270,140	127
California							400.000	100
Subtotal							403,028	190
SUBTO		anaitu			0.075	0.075	403,028	190
30810		ensity			0.075	0.075	403;026	
Total							403,028	190
			NE E	XT				
Development								
Jumbo	0	99	74	25%	0	0	0	0
8yd LHD	0	343	256	100%	0	0	0	0
Maclean Bolter	0	160	119	25%	0	0	0	0
63t Iruck	0	/58	565	100%	0	0	0	0
loyota Jeep	0	128	95	50%	0	0	U	0
Production							0	0
RVd LHD	2	242	254	100%	694	510	68 600	30
63t Truck	∠ ∩	343 758	565	100%	000	012	00,000	32 0
Toyota leen	1	128	95	50%	64	48	6 400	3
Maclean Bolter	0	160	119	25%	0	0	0	0

Preliminary - UG Diesel Equipment Fleet - Milestone 3

[75.000	35
Ramp								
63t Truck	1	758	565	100%	758	565	75.800	36
Grader	0.2	138	103	50%	14	10	1,380	1
Fuel and lube Truck	0.2	173	129	50%	17	13	1,730	1
Boom Truck	0.2	173	129	50%	17	13	1,730	1
							80,640	38
Summary								
Development	0			100%			0	0
Production	1			100%			75,000	35
Ramp	1			100%			80,640	38
Subtotal							155,640	73
							155,640	73
SUBTOTAL U/	G Density	FA REQUI	RED		0.075	0.075	155,640	73
Dovelopment		1	INV	v		1		
lumbo	0	00	74	25%	0	0	0	0
8vd LHD	0	343	256	100%	0	0	0	0
Maclean Bolter	0	160	119	25%	0	0	0	0
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	0	128	95	50%	0	0	0	0
							0	0
Production								
8yd LHD	1	343	256	100%	343	256	34,300	16
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	1	128	95	50%	64	48	6,400	3
Maclean Bolter	0	160	119	25%	0	0	0	0
-							40,700	19
Ramp	-		F (F	40531				0.1
63t Iruck	1	/58	565	100%	/58	565	/5,800	36
Grader	0.2	138	103	50%	14	10	1,380	1
Fuel and lube Iruck	0.2	1/3	129	50%	17	13	1,730	1
BOOM ITUCK	0.2	173	129	50%	17	13	1,730	20
Summany	_						60,040	30
Development	0			100%			0	0
Production	1			100%			40.700	19
Ramp	1			100%			80.640	38
Subtotal							121,340	57
							121,340	57
SUBTOTAL U/	G Density	FA REQUI	RED		0.075	0.075	121,340	57
Development .	-		She	rriff				
Development	0.5	00	74	250/	10	0	0	0
	0.5	242	74	25%	170	9	0	0
Macloop Poltor	0.5	343	200	25%	20	120	0	0
63t Truck	0.5	758	565	100%	20	0	0	0
Toyota Jeep	0.5	128	95	50%	32	24	0	0
10,000 0000	0.0	120	70	00,0	02	2.	0	0
Production								
8yd LHD	0	343	256	100%	0	0	0	0
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	0	128	95	50%	0	0	0	0
Maclean Bolter	0	160	119	25%	0	0	0	0
							0	0
kamp	0.5	750	F/F	1000/	270	202	27.000	10
63T IFUCK	0.5	/58	565	100%	3/9	283	37,900	18
Eucl and lubo Truck	0.2	130	103	50%	14	10	1,360	1
Boom Truck	0.2	173	129	50%	17	13	1,730	1
boomindex	0.2	175	127	5576	.,	10	42.740	20
Summary							1217.10	20
Development	1			100%			0	0
Production	0	1		100%	l	1	0	0
Ramp	1			100%			42,740	20
Subtotal							42,740	20
							42,740	20
SUBTOTAL U/	G Density	FA REQUI	RED		0.075	0.075	42,740	20
SUBTO			842,358	398				
Conting	ency/Le	eakage			10%		84,236	40
Total	line Su	Inface					926 592	127
		nace					720,373	437

	Preliminary - UC	Diesel Ec	uipment	Fleet - Milesto	one 4			7
Unit	Quantit	y Hp each	kW each	(diesel engine)	lotal Hp	lotal kW	(100cfm/hp)	Iotal M3/Sec
			FW Z	one			(1000111/110)	
Development			T					
Jumbo	0	99	74	25%	0	0	0	0
8yd LHD	0	343	256	100%	0	0	0	0
Maclean Bolter	0	160	119	25%	0	0	0	0
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	0	128	95	50%	0	0	0	0
							0	0
Production		242	057	100%	(0)	510	(0.(00	20
8 yd LHD	2	343	256	100%	686	512	68,600	32
63t Iruck	0	/58	565	100%	0	0	0	0
loyota Jeep	1	128	95	50%	64	48	6,400	3
Maclean Bolter	0	160	119	25%	0	0	75.000	0
Ramp							/5,000	30
62t Truck	2	759	545	100%	1 5 1 6	1120	151.600	70
Grader	0.33	138	103	50%	23	17	2 277	12
Evel and lube Tru	ICK 0.33	173	129	50%	29	21	2,277	1
Boom Truck	0.33	173	129	50%	29	21	2.855	1
							156.732	74
Summary								
Development	0			100%			0	0
Production	1			100%			75,000	35
Ramp	1			100%			156,732	74
Subtotal							231,732	109
							231,732	109
	SUBTOTAL U/G	Density			0.075	0.075	231,732	
Total							231,732	109
Development.			Sou	uth	1	1		
Development	1	00	74	259/	25	10	2.475	1
Oditibu	1	343	74	25%	212	10 254	2,475	16
Macloan Boltor	1	160	230	25%	343	200	34,300	10
62t Truck	0	759	545	100%	40	0	4,000	0
Toyota leep	1	128	95	50%	64	48	6 400	3
lojota soop		120	,,,	0070	01	10	47,175	22
Production								
8vd LHD	2	343	256	100%	686	512	68.600	32
63t Truck	0	758	565	100%	0	0	0	0
Toyota Jeep	0.5	128	95	50%	32	24	3,200	2
Maclean Bolter	0	160	119	25%	0	0	0	0
							71,800	34
Ramp								
63t Truck	3	758	565	100%	2,274	1696	227,400	107
Grader	0.33	138	103	50%	23	17	2,277	1
Fuel and lube Tru	uck 0.33	173	129	50%	29	21	2,855	1
Boom Truck	0.33	173	129	50%	29	21	2,855	1
							235,386	111
Summary				1000/			17.475	0.0
Development	1			100%			47,175	22
Production	1	-		100%			71,800	34
Ramp				100%			233,380	111
Subtotal							354 361	167
Subiotal							354,301	167
	SUBTOTAL U/G	Density			0.075	0.075	354 361	107
			1	1	0.070	0.070	001,001	
Total							354,361	167
			She	rriff				
Development								
Jumbo	0	99	74	25%	0	0	0	0
8yd LHD	0	343	256	100%	0	0	0	0
Maclean Bolter	0	160	119	25%	0	0	0	0
63t Truck	0	758	565	100%	0	0	0	0
Ioyota Jeep	0	128	95	50%	0	0	0	0
Dreduction		-	-				0	U
Production	1	242	257	100%	242	257	24.200	17
62t Truck	1	343 750	∠50 545	100%	343	250	34,300	10
Toyota Joon		100	05	50%	22	2/	3 200	2
Macloan Rolter	0.5	120	110	25%	0	0	0,200	0
wadean boller		100	117	2 J /0	0	U	37,500	18
Ramp				1	1		27,000	
63t Truck	1	758	565	100%	758	565	75,800	36
Grader	0.33	138	103	50%	23	17	2,277	1
Fuel and lube Tri	uck 0.33	173	129	50%	29	21	2,855	1
Boom Truck	0.33	173	129	50%	29	21	2,855	1
			1		1		83,786	40
Summary								
Development	0			100%			0	0
Production	1			100%			37,500	18
Ramp	1			100%			83,786	40
Subtotal							121,286	57
							121,286	57
SUBTO	OTAL U/G Density	FA REQUI	RED		0.075	0.075	121,286	57
S	UBTOTAL ALL	ZONES					707,379	334
Co	ontingency/l	eakade	•		10%		70,738	33
T	otal Mino S	urface					770 11/	2/7
		unace					1/8.116	367

APPENDIX B

Staged Long sections













APPENDIX C

General Arrangement Drawings



E	Т	

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	RE	VIEW	
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DRAV CHEC	^{VN:} E.FRATIN ^{KED:} K.BOUFFARD		1
JLR #	27962-000		I



	6" DYWIDAG - 4' EMBEDMENT C/W EYE BOLT & LOCK-NUT	
	304mm 600V RACK XXXXX 40,000 1030mm 1030mm 1030mm 1000 100	
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<u>NOTES</u>

1. INSTALL A $\frac{1}{2}$ " X 4" X 36" COPPER GROUND BUS AS SHOWN.

2. ELECTRICAL INSTALLATION SHALL CONFORM TO LATEST CANADIAN ELECTRICAL CODE AND CSA-M421 "USE OF ELECTRICITY IN MINES".

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PROFESSIONAL STAMP	PROJECT NORTH
PROJECT: NORTH AMERIC VENTILATION FEA LAC DES ILES M	AN PALLADIUM ASIBILITY STUDY 11NE, ONTARIO
DRAWING: TYPICAL UNE BOOSTER FAN LAY(DERGROUND SWITCHROOM DUT
DESIGN: S. MARTIN DRAWN: E. FRATIN CHECKED: M. WEAVER	DRAWING #:

JLR #: 27962-000



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APPENDIX D

Heating Calculations

Baseline Data - Thunder Bay

Month	Days / Month	Mean Temperature Outside (°F)	Temperature Setpoint (°F)	Heating Required?
October	31	41	35.6	No
November	30	26.6	35.6	Yes
December	31	11	35.6	Yes
January	31	5.4	35.6	Yes
February	29	10	35.6	Yes
March	31	22	35.6	Yes
April	30	37.22	35.6	No

Propane Cost (\$/L) 0.4

Thunder Bay, Ontario Canada Climate Data Thunder Bay Average Monthly Climate Data & Extremes

Forecasts	& Conditi	ons	Canada Ra	dar (Canada Sa	tellite	Weather	Alerts			Climate	Director	у	•
Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Daily Average (°C)	-14.8	-12	-5.5	2.9	9.5	14	17.6	16.6	11	5	-3	-11.6	2.5	c
Standard Deviation	3.1	3.4	2.5	1.7	1.6	1.1	1.2	1.5	1.3	1.7	2	3.4	0.9	c
Daily Maximum (°C)	-8.6	-5.6	0.3	9	16.4	20.6	24.2	23.1	17.1	10.4	1.7	-6.1	8.5	c
Daily Minimum (°C)	-21.1	-18.4	-11.2	-3.3	2.5	7.3	11	10.1	4.9	-0.5	-7.7	-17	-3.6	c
Extreme Maximum (°C)	8.3	12.2	22.8	28.3	35.2	35.6	37.2	40.3	31.7	28.3	21.7	12.2		
Date (yyyy/dd)	1942/23	1976/25	1946/28	1942/24+	1986/30	1956/12	1975/30	1983/07	1976/11	1943/08	1975/04	1962/03		
Extreme Minimum (°C)	-41.1	-40	-36.7	-22.2	-8.9	-2.8	0	-1.1	-8.3	-13.3	-30.6	-37.8		
Date (yyyy/dd)	1951/30	1951/01+	1943/02	1954/04	1954/04+	1949/07+	1969/06	1976/29	1942/25+	1942/28+	1976/30	1976/13		
Precipitation:														
Rainfall (mm)	2.5	2.8	17.5	29.5	65	85.7	89	87.5	87.5	57	31.5	3.6	559	C
Snowfall (cm)	41.2	26.9	26.8	12.4	1.7	0	0	0	0.5	6.1	27.8	44.1	187.6	c
Precipitation (mm)	31.3	24.9	41.6	41.5	66.5	85.7	89	87.5	88	62.6	55.6	37.5	711.6	c
Average Snow Depth (cm)	31	31	24	5	0	0	0	0	0	0	3	15	9	c
Median Snow Depth (cm)	30	30	23	3	0	0	0	0	0	0	1	14	8	c
Snow Depth at Month-end (cm)	34	32	13	0	0	0	0	0	0	0	9	24	9	c
Extreme Daily Rainfall (mm)	25.4	17.8	26.7	69.3	76.2	49.3	53.8	87.1	131.2	47.8	63	42.7		
Date (yyyy/dd)	1975/10	1971/26	1957/14	1954/30	1971/24	1947/04	1973/27	1973/19	1977/08	1968/09	1973/21	1948/05		
Extreme Daily Snowfall (cm)	51.6	33.5	37.8	24.1	21.6	0	0	0	9.2	16.3	34.5	42		

Propane Users Data

Stage 1								
Temperature Airflo								
Area	Setpoint (°F)	(Acfm)						
Shaft FA	35.6	372000						
Main FA	35.6	498000						
Near Surface FA	35.6	496500						
760 FA Raise	35.6	233100						

Stage 2								
	Temperature Airflow							
Area	Setpoint (°F)	(Acfm)						
Shaft FA	35.6	372000						
Main FA	35.6	498000						
Near Surface FA	35.6	861500						
760 FA Raise	35.6	233100						

Stage 3								
	Temperature Airflow							
Area	Setpoint (°F)	(Acfm)						
Shaft FA	35.6	372000						
Main FA	35.6	498000						
Near Surface FA	35.6	926500						
760 FA Raise	35.6	233100						

Stage 4								
	Airflow							
Area	Setpoint (°F)	(Acfm)						
Shaft FA	35.6	372000						
Main FA	35.6	498000						
Near Surface FA	35.6	778100						
760 FA Raise	35.6	233100						

Currently using December Temperature Setpoint for all months

Propane Consumption Sheet

Basic Calculation is as Follows

Volume of Propane = [(Airflow in Acfm) * (Temp Setpoint-Temp Outside) * (1.08 Btu/(Acfm*F*hr)) * 24 hr/day * (Days in Month)] / [(21897 Btu / L of Propane)]

				Stage 1				
			Propane	Propane	Propane	Propane	Propane	
			Consumption	Consumption	Consumption	Consumption	Consumption	Total Winter
	Temperature	Airflow	November	December	January	February	March	Consumption
Area	Setpoint (°F)	(Acfm)	(Litre)	(Litre)	(Litre)	(Litre)	(Litre)	(Litre)
Shaft FA	35.6	372,000	118,893	335,807	412,251	326,912	185,650	1,379,514
Main FA	35.6	498,000	159,164	449,548	551,885	437,641	248,531	1,846,768
Near Surface FA	35.6	496,500	158,684	448,194	550,222	436,322	247,782	1,841,206
760 FA Raise	35.6	233,100	74,500	210,421	258,322	204,847	116,330	864,421
Subtotal	-	1,599,600	511,241	1,443,971	1,772,680	1,405,723	798,293	5,931,909

	Stage 2											
		i	Propane	Propane	Propane	Propane	Propane					
		,	Consumption	Consumption	Consumption	Consumption	Consumption	Total Winter				
	Temperature	Airflow	November	December	January	February	March	Consumption				
Area	Setpoint (°F)	(Acfm)	(Litre)	(Litre)	(Litre)	(Litre)	(Litre)	(Litre)				
Shaft FA	35.6	372,000	118,893	335,807	412,251	326,912	185,650	1,379,514				
Main FA	35.6	498,000	159,164	449,548	551,885	437,641	248,531	1,846,768				
Near Surface FA	35.6	861,500	275,340	777,683	954,716	757,083	429,938	3,194,761				
760 FA Raise	35.6	233,100	74,500	210,421	258,322	204,847	116,330	864,421				
Subtotal	-	1,964,600	627,897	1,773,460	2,177,174	1,726,484	980,449	7,285,464				

	Stage 3											
			Propane	Propane	Propane	Propane	Propane					
			Consumption	Consumption	Consumption	Consumption	Consumption	Total Winter				
	Temperature	Airflow	November	December	January	February	March	Consumption				
Area	Setpoint (°F)	(Acfm)	(Litre)	(Litre)	(Litre)	(Litre)	(Litre)	(Litre)				
Shaft FA	35.6	372,000	118,893	335,807	412,251	326,912	185,650	1,379,514				
Main FA	35.6	498,000	159,164	449,548	551,885	437,641	248,531	1,846,768				
Near Surface FA	35.6	926,500	296,114	836,359	1,026,749	814,205	462,377	3,435,805				
760 FA Raise	35.6	233,100	74,500	210,421	258,322	204,847	116,330	864,421				
Subtotal	-	2,029,600	648,671	1,832,136	2,249,207	1,783,605	1,012,888	7,526,508				

	Stage 4											
			Propane	Propane	Propane	Propane	Propane					
			Consumption	Consumption	Consumption	Consumption	Consumption	Total Winter				
	Temperature	Airflow	November	December	January	February	March	Consumption				
Area	Setpoint (°F)	(Acfm)	(Litre)	(Litre)	(Litre)	(Litre)	(Litre)	(Litre)				
Shaft FA	35.6	372,000	118,893	335,807	412,251	326,912	185,650	1,379,514				
Main FA	35.6	498,000	159,164	449,548	551,885	437,641	248,531	1,846,768				
Near Surface FA	35.6	778,100	248,685	702,397	862,292	683,792	388,317	2,885,483				
760 FA Raise	35.6	233,100	74,500	210,421	258,322	204,847	116,330	864,421				
Subtotal	-	1,881,200	601,242	1,698,174	2,084,750	1,653,192	938,828	6,976,185				

				Stage 2					
			Propane	Propane	Propane	Propane	Propane		
	Temperature	Airflow	Cost	Cost	Cost	Cost	Cost	Total	Cost per
Area	Setpoint (°F)	(Acfm)	November	December	January	February	March	Winter Cost	1000 Acfm
Shaft FA	35.6	372,000	\$ 47,557	\$ 134,323	\$164,900	\$130,765	\$ 74,260	\$ 551,805	\$ 1,483
Main FA	35.6	498,000	\$ 63,665	\$ 179,819	\$220,754	\$ 175,056	\$ 99,412	\$ 738,707	\$ 1,483
Near Surface FA	35.6	861,500	\$110,136	\$ 311,073	\$381,886	\$ 302,833	\$171,975	\$ 1,277,904	\$ 1,483
760 FA Raise	35.6	233,100	\$ 29,800	\$ 84,168	\$103,329	\$ 81,939	\$ 46,532	\$ 345,768	\$ 1,483
Subtotal	-	1,964,600	\$251,159	\$ 709,384	\$870,870	\$ 690,593	\$392,180	\$ 2,914,185	\$ 1,483

				Stage 3					
			Propane	Propane	Propane	Propane	Propane		
	Temperature	Airflow	Cost	Cost	Cost	Cost	Cost	Total	Cost per
Area	Setpoint (°F)	(Acfm)	November	December	January	February	March	Winter Cost	1000 Acfm
Shaft FA	35.6	372,000	\$ 47,557	\$ 134,323	\$164,900	\$ 130,765	\$ 74,260	\$ 551,805	\$ 1,483
Main FA	35.6	498,000	\$ 63,665	\$ 179,819	\$220,754	\$ 175,056	\$ 99,412	\$ 738,707	\$ 1,483
Near Surface FA	35.6	926,500	\$118,446	\$ 334,543	\$410,700	\$ 325,682	\$184,951	\$ 1,374,322	\$ 1,483
760 FA Raise	35.6	233,100	\$ 29,800	\$ 84,168	\$103,329	\$ 81,939	\$ 46,532	\$ 345,768	\$ 1,483
Subtotal	-	2,029,600	\$259,468	\$ 732,854	\$899,683	\$713,442	\$405,155	\$ 3,010,603	\$ 1,483

Stage 4									
			Propane	Propane	Propane	Propane	Propane		
	Temperature	Airflow	Cost	Cost	Cost	Cost	Cost	Total	Cost per
Area	Setpoint (°F)	(Acfm)	November	December	January	February	March	Winter Cost	1000 Acfm
Shaft FA	35.6	372,000	\$ 47,557	\$ 134,323	\$164,900	\$ 130,765	\$ 74,260	\$ 551,805	\$ 1,483
Main FA	35.6	498,000	\$ 63,665	\$ 179,819	\$220,754	\$ 175,056	\$ 99,412	\$ 738,707	\$ 1,483
Near Surface FA	35.6	778,100	\$ 99,474	\$ 280,959	\$344,917	\$273,517	\$155,327	\$ 1,154,193	\$ 1,483
760 FA Raise	35.6	233,100	\$ 29,800	\$ 84,168	\$103,329	\$ 81,939	\$ 46,532	\$ 345,768	\$ 1,483
Subtotal	-	1,881,200	\$240,497	\$ 679,270	\$833,900	\$661,277	\$375,531	\$ 2,790,474	\$ 1,483

Propane Consumption Summary Sheet

Total Mine Summary Heating requirements per heating season Total Litres of Propane Period Total Cost of Propane 5,931,909 \$ 2,372,763 Stage 1 Stage 2 7,285,464 \$ 2,914,185 Stage 3 7,526,508 \$ 3,010,603 Stage 4 6,976,185 \$ 2,790,474

Data for calculations taken from Volume and Cost sheets