NI 43-101 Technical Report

BLOOM LAKE MINE

FEASIBILITY STUDY PHASE 2

Fermont, Quebec, CANADA

This report was prepared for Quebec Iron Ore Inc. on behalf of Champion Iron Limited.

MINERAI DE FER QUÉBEC
QUEBEC IRON ORE

Prepared by qualified persons:

André Allaire, P. Eng. ....*BBA Inc.*
Isabelle Leblanc, P. Eng. ....*BBA Inc.*
Pierre-Luc Richard, P. Geo.............*BBA Inc.*
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Philippe Rio Roberge, P. Eng. ....*WSP Canada Inc.*

Effective Date: June 20, 2019

Signature Date: August 2, 2019

BBA SOUTEX WSP

DATE AND SIGNATURE PAGE

This report is effective as of the 20th day of June 2019.

"Signed and sealed original on file"	*August 2, 2019*
André Allaire, P. Eng. BBA Inc.	Date
"Signed and sealed original on file"	*August 2, 2019*
Isabelle Leblanc, P. Eng. BBA Inc.	Date
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Pierre-Luc Richard, P. Geo. BBA Inc.	Date
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Mathieu Girard, P. Eng. Soutex	Date
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CERTIFICATE OF QUALIFIED PERSON

André Allaire, P. Eng., PhD

This certificate applies to the NI 43-101 Technical Report for the "Bloom Lake Mine – Feasibility Study Phase 2" located in Fermont, Quebec prepared for Quebec Iron Ore Inc. (QIO) issued on August 2, 2019 (the "Technical Report") and effective June 20, 2019.

I, André Allaire, P. Eng., PhD., as a co-author of the Technical Report, do hereby certify that:

1. I am currently employed as President in the consulting firm BBA Inc.: 2020 Robert-Bourassa Blvd, Suite 300, Montréal, Québec H3A 2A5 Canada.
2. I graduated from McGill University of Montreal with a B.Eng. in Metallurgy in 1982, an M. Eng. In 1986 and a Ph.D. in 1991. I have practiced my profession continuously since my graduation. My relevant experience for the purpose of the Technical Report is:
   - (1982-1984); Process Metallurgist, Horne division, Noranda Inc.
   - (1984-1988); Graduate Studies, Metallurgical Department, McGill University
   - (1988-2000); Process Metallurgist and Study Manager, Hatch & Associés Inc.
   - (2000-2004); Manager Process and Metallurgy, Met-Chem Canada Inc.
   - (2004-2011); Director, Mining and Metals, BBA Inc.
   - (2011-2013); VP Market, Mining and Metals, BBA Inc.
   - (2013-to date); President, BBA Inc.
3. I am in good standing as a member of the Order of Engineers of Québec (# 38480) and a member of the Canadian Institute of Mining Metallurgy and Petroleum.
4. I have read the definition of "qualified person" set out in the NI 43-101 – Standards of Disclosure for Mineral Projects ("NI 43-101") and certify that, by reason of my education, affiliation with a professional association, and past relevant work experience, I fulfill the requirements to be a qualified person for the purposes of NI 43-101.
5. I am independent of the issuer applying all the tests in Section 1.5 of NI 43-101.
6. I am responsible for the coordination, consolidation and review of this Technical Report. I have also authored and am responsible for Chapters 2, 3, 4, 5, 6, 18 (except sections 18.4 to 18.6), 19, 22, 23, 24, and relevant sections of Chapters 1, 21, 25, 26, and 27.
7. I personally visited the Bloom Lake property that is the subject to the Technical Report during the week of May 28, 2018.
8. I have had prior involvement with the property that is the subject of the Technical Report having participated in the feasibility studies of Bloom Lake from 2006 to 2010.
9. I have read NI 43-101 and the sections of the Technical Report for which I am responsible have been prepared in compliance with NI 43-101.
10. As at the effective date of the Technical Report, to the best of my knowledge, information and belief, the sections of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the portions of the Technical Report for which I am responsible not misleading.

Dated and signed this 2nd day of August, 2019.

"Signed and sealed original on file"

André Allaire, P. Eng., PhD

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CERTIFICATE OF QUALIFIED PERSON

Isabelle Leblanc, P. Eng.

This certificate applies to the NI 43-101 Technical Report for the "Bloom Lake Mine – Feasibility Study Phase 2" located in Fermont, Quebec prepared for Quebec Iron Ore Inc. (QIO) issued on August 2, 2019 (the "Technical Report") and effective June 20, 2019.

I, Isabelle Leblanc, P. Eng., as a co-author of the Technical Report, do hereby certify that:

1. I am currently employed as Department Manager of Mining and Geology in the consulting firm BBA Inc.: 2020 Robert-Bourassa Blvd., Suite 300, Montreal, Quebec H3A 2A5, Canada.
2. I graduated from the mining engineering program of École Polytechnique de Montreal in 2007 and I have practiced my profession continuously since that time.
3. I am in good standing as a member of the Order of Engineers of Québec (#144395), a member of the Australasian Institute of Mining and Metallurgy and a member of the Canadian Institute of Mining Metallurgy and Petroleum.
4. I have read the definition of "qualified person" set out in NI 43-101 – Standards of Disclosure for Mineral Projects (NI 43-101) and certify that, by reason of my education, affiliation with a professional association, and past relevant work experience, I fulfill the requirements to be a qualified person for the purposes of NI 43-101.
5. I am independent of the issuer applying all the tests in Section 1.5 of NI 43-101.
6. I am responsible for the preparation of Chapters 15 and 16 as well as the relevant portions of Chapters 1, 21, 25, 26 and 27 of the Technical Report.
7. I personally visited the Bloom Lake property that is the subject to the Technical Report during the week of September 24, 2018.
8. I have had prior involvement with the property that is the subject of the Technical Report having participated in the feasibility studies of Bloom Lake from 2006 to 2010.
9. I have read NI 43-101 and the sections of the Technical Report for which I am responsible have been prepared in compliance with NI 43-101.
10. As at the effective date of the Technical Report, to the best of my knowledge, information and belief, the sections of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the portions of the Technical Report for which I am responsible not misleading.

Dated and signed this 2nd day of August, 2019.

"Signed and sealed original on file"

Isabelle Leblanc, P. Eng.

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CERTIFICATE OF QUALIFIED PERSON

Pierre-Luc Richard, P. Geo

This certificate applies to the NI 43-101 Technical Report for the "Bloom Lake Mine – Feasibility Study Phase 2" located in Fermont, Quebec prepared for Quebec Iron Ore Inc. (QIO) issued on August 2, 2019 (the "Technical Report") and effective June 20, 2019.

I, Pierre-Luc Richard, P. Geo., as a co-author of the Technical Report, do hereby certify that:

1. I am a Principal Geologist with BBA Inc. located at 2020 Robert-Bourassa Blvd, Suite 300, Montréal, Québec, Canada, H3A 2A5.
2. I am a graduate of Université du Québec à Montréal in Resource Geology in 2004. I also obtained a M.Sc. from Université du Québec à Chicoutimi in Earth Sciences in 2012.
3. I am a member in good standing of the Ordre des Géologues du Québec (OGQ Member No. 1119), the Association of Professional Geoscientists of Ontario (APGO Member No. 1714), and the Northwest Territories Association of Professional Engineers and Geoscientists (NAPEG Member No. L2465).
4. I have worked in the mining industry for more than 15 years. My exploration expertise has been acquired with Richmont Mines Inc., the Ministry of Natural Resources of Québec (Geology Branch), and numerous companies through my career as a consultant. My mining expertise was acquired at the Beaufor mine and several other producers through my career. I managed numerous technical reports, mineral resource estimates and audits as a consultant from February 2007 to March 2018 and as a consultant for BBA since.
5. I have read the definition of "qualified person" set out in the NI 43-101 – Standards of Disclosure for Mineral Projects (NI 43-101) and certify that, by reason of my education, affiliation with a professional association, and past relevant work experience, I fulfill the requirements to be a qualified person for the purposes of NI 43-101.
6. I am independent of the issuer applying all the tests in Section 1.5 of NI 43-101.
7. I am responsible for the preparation of Chapters 7 to 12 and 14. I am also responsible for the relevant portions of Chapters 1, 25, 26, and 27 of the Technical Report.
8. I personally visited the Bloom Lake property that is the subject to the Technical Report during the week of March 18, 2019.
9. I have had no prior involvement with the property that is the subject of the Technical Report.
10. I have the read NI 43-101 and the sections of the Technical Report for which I am responsible have been prepared in compliance with the NI 43-101.
11. As at the effective date of the Technical Report, to the best of my knowledge, information and belief, the sections of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the portions of the Technical Report for which I am responsible not misleading.

Dated and signed this 2nd day of August, 2019.

"Signed and sealed original on file"

Pierre-Luc Richard, P. Geo.

CANADA'S BEST MANAGED COMPANIES Platinum member

CERTIFICATE OF QUALIFIED PERSON

Mathieu Girard, P. Eng.

This certificate applies to the NI 43-101 Technical Report for the "Bloom Lake Mine – Feasibility Study Phase 2" located in Fermont, Quebec prepared for Quebec Iron Ore Inc. (QIO) issued on August 2nd, 2019 (the "Technical Report") and effective June 20th, 2019.

I, Mathieu Girard, P. Eng., as a co-author of the Technical Report, do hereby certify that:

1. I am a professional engineer employed as a senior metallurgist with Soutex, located at 357 rue Jackson, Québec City, Province of Québec, Canada;
2. I received a Bachelor's degree in Material and Metallurgy Engineering from Université Laval in 2000, and a Master's degree in Metallurgical Engineering from Université Laval in 2004;
3. I am a member in good standing of the Ordre des Ingénieurs du Québec (no. 129366);
4. I have over fifteen (15) years of experience in mineral processing operation support, optimization and design. I first worked for Algosys (now Ion) then joined Soutex in 2005 as a metallurgist;
5. I have read the definition of "Qualified Person" set out in the NI 43-101 – Standards of Disclosure for Mineral Projects (NI 43-101) and certify that, by reason of my education, affiliation with a professional association, and past relevant work experience, I fulfill the requirements to be a Qualified Person for the purposes of NI 43-101.
6. I am independent of the issuer applying all the tests in Section 1.5 of NI 43-101.
7. I am responsible for the preparation of chapters 13 and 17, with the exception of sections 17.10.1 and 17.10.4. I am also responsible for the relevant portions of chapters 1, 21, 25, 26 and 27 of the Technical Report.
8. I personally visited the property that is the subject to the Technical Report on March 21st, 2019.
9. I have had prior involvement with the property that is the subject of the Technical Report: Phase 1 start-up and optimisation (2009 to 2011), Phase 2 Engineering (2011-2012), Phase 1 Restart (2018).
10. I have read NI 43-101 and the sections of the Technical Report for which I am responsible have been prepared in compliance with NI 43-101.
11. As at the effective date of the Technical Report, to the best of my knowledge, information and belief, the sections of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the portions of the Technical Report for which I am responsible not misleading.

Dated and signed this 2nd day of August, 2019.

"Signed and sealed original on file"

Mathieu Girard, P. Eng.

CERTIFICATE OF QUALIFIED PERSON

Philippe Rio Roberge, P. Eng.

This certificate applies to the NI 43-101 Technical Report for the "Bloom Lake Mine – Feasibility Study Phase 2" located in Fermont, Quebec prepared for Quebec Iron Ore Inc. (QIO) issued on August 2, 2019 (the "Technical Report") and effective June 20, 2019.

I, Philippe Rio Roberge, P. Eng., as a co-author of the Technical Report, do hereby certify that:

1. I am a Civil Engineer, Team Lead in geotechnical mining with WSP Canada located at 1600, René-Lévesque West, Montreal, Quebec, Canada.
2. I am a graduate of the University of Sherbrooke, Bachelor of Civil Engineering 2006, Sherbrooke, Quebec, Canada.
3. I am a member in good standing of "Ordre des Ingénieurs du Québec", license 142781.
4. My relevant experience includes 12 years of experience in tailings storage facility design and management.
5. I have read the definition of "qualified person" set out in the NI 43-101 – Standards of Disclosure for Mineral Projects (NI 43-101) and certify that, by reason of my education, affiliation with a professional association, and past relevant work experience, I fulfill the requirements to be a qualified person for the purposes of NI 43-101.
6. I am independent of the issuer applying all the tests in Section 1.5 of NI 43-101.
7. I am responsible for the preparation of chapters 1.11, 1.12, 18.4, 18.5, 18.6, 20, 21.2.5, 21.2.13, 21.3.6, 25.4, 26.4, 26.5.
8. I personally visited the property that is the subject to the Technical Report on January 8th, 2018.
9. I have had prior involvement with the property that is the subject of the Technical Report as a Qualified Person in the Phase 1 study and as a tailings consultant for the current operation.
10. I have read NI 43-101 and the sections of the Technical Report for which I am responsible have been prepared in compliance with NI 43-101.
11. As at the effective date of the Technical Report, to the best of my knowledge, information and belief, the sections of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the portions of the Technical Report for which I am responsible not misleading.

Dated and signed this 2nd day of August 2019

"Signed and sealed original on file"

Philippe Rio Roberge, P. Eng.

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TABLE OF ABBREVIATIONS	
Abbreviation	**Description**
σ_{ci}	Uniaxial compressive strength
3D	Three dimensional
A	Ampere
a	Annum (year)
AACE	American Association of Cost Engineers
AARQ	Atlas of Amphibians and Reptiles of Quebec
Al_2O_3	Aluminum oxide
AMP	Amphibolite
Au	Gold
B	Billion
BAPE	*Bureau d'audience publique sur l'environnement du Québec*
BBA	BBA Inc.
BHP	BHP Billiton
BID	Bedded iron deposits
BIF	Banded iron formation
BLR	Bloom Lake Railway
BPH	Booster pumphouse
Ca	Calcium
CAD or $	Canadian dollar (examples of use: CAD2.5M / $2.5M)
CaO	Calcium oxide
CAPEX	Capital expenditure
CCAA	Companies' Creditors Arrangement Act
CCIC	Cleveland-Cliffs Iron Company
CEAA	Canadian Environmental Assessment Act
CFR	Cost and Freight
CIM	Canadian Institute of Mining, Metallurgy and Petroleum
Cliffs	Cliffs Natural Resources
CLM	Consolidated Thompson-Lundmark Gold Mines Limited
Consolidated Thompson	Consolidated Thompson Gold Mines Limited
CMMS	Computerized Maintenance Management System
conc.	Concentrate
CSN	Companhia Siderúrgica Nacional
CV	Coefficient of variation
DDH	Diamond drillhole
DFO	Department of Fisheries and Oceans
Directive 019	MELCC - *Directive 019 sur l'industrie minière* (Provincial guidelines for the mining industry)

TABLE OF ABBREVIATIONS	
Abbreviation	**Description**
DL	Detection limit
DRI	Direct reduced iron
DSO	Direct shipping ore
EA	Environmental assessment
ECCC	Environment and Climate Change Canada
EEM	Environmental effects monitoring
EIA	Environmental impact assessment
EIS	Environmental impact statement
EPCM	Engineering, Procurement, Construction Management
EQA	Environmental Quality Act
et al.	et alla (and others)
F_{80}	80% passing - Feed size
Fe	Iron
FEL	Front-end loader
Fe_2O_3	Hermatite
Fe_2O_4	Magnetite
FIOD	Fermont Iron Ore District
FMG	Fortescue Metals Group Ltd.
FOB	Free on Board
FS	Feasibility study
G&A	General and Administration
Ga	Billion years
GEO	Great Oxidation Event
GFC	Global financial crisis
GN	Gneiss
GPS	Global positioning system
HDPE	High-density polyethylene (pipe)
HEN	H. E. Neal & Associates Ltd.
HLS	Heavy liquid separation
HPA	Hydraulic Placement Area
HQ	Hydro-Québec
HSE	Health, Security and Environment
HVAC	Heating, ventilation and air conditioning
I/O	Input/output
IBA	Impact and benefit agreement
ID^2	Inverse distance squared
IF	Iron formation

TABLE OF ABBREVIATIONS	
Abbreviation	**Description**
IFM	Magnetite Iron Formation
IOC	Iron Ore Company of Canada
IRA	Inter-ramp angle
IRR	Internal rate of return
ISO	International Organization for Standardization
IT	Information technology
Jalore	Jalore Mining Company Limited
J&L	Jones and Laughlin Steel Corporation
KNA	kriging neighbourhood analysis
K_{80}	80% passing – Particle size
K_2O	Potassium oxide
Lakefield	Lakefield Research
LIMS	Low Intensity Magnetic Separators
LOM	Life of mine
M	Million
MAG	Magnetic
MELCC	*Ministère de l'Environnement et de la Lutte contre les changements climatiques* (Ministry of Environment, and Action against Climate Change) - formerly known as *Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs* (MDDEFP)
MDMER	Metal and Diamond Mining Effluent Regulations
MERN	*Ministère de l'Énergie et Ressources naturelles* (Ministry of Energy and Natural Resources)
MFFP	*Ministère des Forêts, de la Faune et des Parcs*
MFL	Manpower Forecasting and Levelling
Mg	Magnesium
MgO	Magnesium oxide
MLA	Mineral Liberation Analyzer
Mn	Manganese
MPa	Mega pascals
MRN	*Ministère des Ressources naturelles*
MRE	Mineral Resource Estimate
MS	Mica Schist
MSEP	MineSight Economic Planner
MTO	Material take-off
MVA	Mega volt ampere
MWDS	Mine Waste Disposal Site
M&I	Measured and Indicated

TABLE OF ABBREVIATIONS	
Abbreviation	**Description**
Na_2O	Sodium Oxide
NN	Nearest neighbour
No.	Number
NOH	Net Operating Hour
NPV	Net present value
NQ	NQ- Caliber drillhole
NSR	Net smelter return
OK	Ordinary Kriging
OPEX	Operational expenditure
OR	Operational Readiness
OHS	Occupational Health, Safety
P	Phosphor
Pa	Pascal
P_{80}	80% passing - Product size
PCN	Project change notice
PEA	Preliminary economic assessment
pH	Potential of hydrogen
PhD	Doctor of philosophy
PFD	Process flow diagram
PMF	Probable Maximal Flood
PMP	Project Management Plan
PSD	Particle size distribution
QA/QC	Quality Assurance / Quality Control
QIO	Quebec Iron Ore
QNS&L	Quebec North Shore and Labrador
QP	Qualified person
QR	Quartz rock
QRIF	Quartz Rock Iron Formation
QRMS	Quartz Rock Mica Schist
QUECO	Quebec Cobalt and Exploration Limited
QZ	Quartzite
RQD	Rock quality designation
S	Sulphur
SOE	State-owned enterprises
SARA	Species at Risk Act
SAT	Satmagan
SEDAR	System for electronic document analysis and retrieval

TABLE OF ABBREVIATIONS	
Abbreviation	**Description**
SFPPN	*La Société ferroviaire et portuaire de Pointe-Noire*
SIF	Silicate iron formation
SiO_2	Silicon dioxide / silica
SM	Suspended matter
SMC	Sursho Mining Corporation
SRM	Standard reference materials
TiO_2	Titanium dioxide
TMF	Tailings management facility
TSF	Tailings storage facility
UCC	Up-current classifier
UCS	Uniaxial compressive strength
USD or US$	United States dollar (examples of use: USD2.5M / US$2.5M)
UTM	Universal Transverse Mercator
vs.	Versus
WGM	Watts, Griffis and McOuat Ltd.
WHIMS	Wet High Intensity Magnetic Separators
WSIF	Waste Silicate Iron Formation
WTP	Water treatment plant
XRF	X-ray fluorescence

TABLE OF ABBREVIATIONS – UNITS OF MEASURE	
Unit	**Description**
Metric	
deg. or °	angular degree
m^3	cubic metre
m^3/h	cubic metres per hour
m^3/s	cubic metres per second
d	day (24 hours)
°C	Degrees Celsius
Ø	diameter
$/t	Dollars per metric tonne
dmt	dry metric ton
dmtu	dry metric ton unit
G	Giga
g	gram
h	hour (60 minutes)
Gt	Gigatonne
kg	kilogram
kg/m^2	kilograms per metre square
kg/m^3	kilograms per metre cube
kg/t	kilograms per tonne
km	kilometre
km/h	kilometre per hour
kt	kilotonne
kW	kilowatt
kWh/t	kilowatt hour per tonne
L	Litre
L/min	Litres per minute
MW	Megawatt
m	metre
m/h	metres per hour
m/s	metres per second
µm	micron
mm	millimetre
M	Million
Mt	Million tonne
Mtpy	Million tonnes per year
min	minute (60 seconds)

TABLE OF ABBREVIATIONS – UNITS OF MEASURE	
Unit	**Description**
Metric	
ppm	parts per million
%	Percent
% solids	Percent solids by weight
s	second
m^2	square metre
K	Thousand (000)
t	tonne (1,000 kg) (metric ton)
tpd	tonnes per day
tph	tonnes per hour
tpy	tonnes per year
V	Volt
W	Watt
wk	week
y	year (365 days)

TABLE OF ABBREVIATIONS – UNITS OF MEASURE	
Unit	**Description**
Imperial	
°F	Degrees Fahrenheit
ft or ‘	feet (12 inches)
ha	Hectare
hp	horsepower
in. or ”	inch
k	Kips
lb / lbs	Pound / pounds
MBtu	Million British thermal units
mesh	US Mesh
oz	Troy ounce
st	short ton (2,000 lbs)

1. EXECUTIVE SUMMARY

All monetary units in the Bloom Lake Mine – Feasibility Study Phase 2 Report (the "Report") are in Canadian dollars (CAD or $), unless otherwise specified.

1.1 Introduction

In December 2006, an environmental impact assessment (EIA) of the Bloom Lake Mine project (the "Project") was submitted to the agencies. Decree 137-2008 authorizing the Project was adopted on February 20, 2008 by the provincial government. Consolidated Thompson Iron Mines Limited began the construction of the mining infrastructure in 2008 and commenced mining operations in 2010 with the Phase 1 concentrator plant (referred to as "Phase 1 (Consolidated Thompson) plant" in this document).

The mine was sold to Cliffs Natural Resources Inc. (Cliffs) in 2011, which continued the Phase 2 (Cliffs) construction project until the Project was halted in November 2012, and conducted mining operations until they were suspended in December 2014. The site was employing approximately 600 people.

In January 2015, Cliffs sought creditor protection under Companies' Creditors Arrangement Act (CCAA), resulting in the mine being put on a care and maintenance program and placed into creditor protection.

In April of 2016, Champion Iron Limited (Champion or ''the Company'') acquired the Bloom Lake assets through its subsidiary Quebec Iron Ore (QIO) and the Quinto Claims for a cash consideration of $10.5M ($9.75M for Bloom Lake and $0.75M for Quinto) and the assumption of liabilities. Quebec Iron Ore Inc. is 63.2% owned by Champion Iron Limited, with the remaining 36.8% equity interest owned by *Ressources Québec* (RQ), acting as a mandatory of the Government of Quebec. On May 29, 2019, the Company announced a transaction to acquire RQ's 36.8% equity interest in QIO and the transaction would increase Champion's stake in QIO to 100%. For more information on the capital restructuring, please refer to the Company's press release dated May 29, 2019, available under the Company's filings on SEDAR at www.sedar.com.

Following acquisition of the Bloom Lake assets by QIO, a feasibility study to identify areas for improvement or correction was completed in February 2017 and resulted with the restart of the operation in February 2018 on time and on budget.

During its first full year of operation (2019 Fiscal Year), the Bloom Lake site produced 6,994,500 wet metric tonnes of 66.4% iron ore concentrate which is an improvement of approximately 1,000,000 wet metric tonnes over 2014 production. The production total cash cost during 2019 was $49.40/dmt and the all-in sustaining cost was $55.80/dmt.

As part of an expansion plan to increase the mine production, the design and construction of a second concentrator plant (referred to as "Phase 2 plant" in this document) was initiated to increase nominal capacity. QIO is authorized by the Decree 849-2011 to increase its production to 16 million tonnes (Mt) of concentrate per annum.

Given the amount of work that Cliffs has already committed in preparing the Phase 2 plant, mine and tailings expansion, the Bloom Lake project represents a low capital investment for a considerable increase in high grade iron ore concentrate production.

The scope of this feasibility study is to develop a plan to complete the construction of the Phase 2 concentrator including improvements to maximise production efficiency and modifications to other areas to support the operation of both concentrators. Feasibility study level engineering was performed on each of these areas to outline work to be performed. The resulting capital cost estimate reflects a Class 3 study as defined by the Association for the Advancement of Cost Engineering (AACE) as described in Recommended Practice N° 18R-97 about Cost Estimating Classification System. The expected accuracy for this study should be in the range of -10% on the low side to +15% on the high side.

The following Technical Report (the "Report") presents the results of the feasibility study (FS) for the Phase 2 expansion of Bloom Lake's operations. This Report, titled "Bloom Lake Mine – Feasibility Study Phase 2", was prepared by Qualified Persons (QPs) following the guidelines of the "Canadian Securities Administrators" National Instrument 43-101 (effective June 30, 2011), and in conformity with the guidelines of the Canadian Mining, Metallurgy and Petroleum (CIM) Standard on Mineral Resources and Reserves. The major Study contributors and their respective areas of responsibility are presented in Table 1-1.

Table 1-1: Major contributors to the feasibility study

Consulting Firm or Entity	Area of responsibility
BBA	▪ Geology; ▪ Development of the mine pit, overburden removal and required mining infrastructure facilities, geological settings and mineralization, mining plan, mining methods, explosives; ▪ Reviewing of crushing, crushed ore reclaiming and milling area; ▪ Tailings pumping and pipeline from the inlet of the plant tailings pumps to the inlet of the tailings booster pumps BPH1; ▪ Tailings pumping and pipeline from the inlet of the tailings booster pumps BPH1 to the tailings storage; ▪ Transportation of the concentrate to the port facilities; ▪ Review of Port facility study; ▪ Project Execution Plan.
Soutex	▪ Mineral processing, metallurgical testing & recovery methods; ▪ Increase in concentrate production by modifications to the gravity separation circuit along with the addition of a magnetic circuit; ▪ Metallurgical testing including design, fabrication and installation, and excluding electrical and instrumentation. ▪ Estimation of mill feed tonnage.
WSP	▪ Surface water management plan, water management structures and pumping stations; ▪ Tailings storage management; development of a new tailings filling plan; containment infrastructure; ▪ Environmental and permitting; ▪ Cost update of the site restoration plan.

All monetary units in the Study are in Canadian dollars (CAD or $), unless otherwise specified. Costs are based on second quarter (Q2 Calendar Year) 2019 dollars.

1.2 Key Project Outcomes

The following list details the key project outcomes as determined from the Study:

- Mineral reserves for the Bloom Lake project are estimated at 807 million tonnes at an average grade of 29.0% iron (Fe);
- Mine plan forecasts a life of mine (LOM) of 20 years;
- Phase 1 and Phase 2 combined average iron metallurgical recovery of 82.4% relative to average plant feed grade of 29.0% Fe;
- Cumulative non-discounted after-tax cash flow of $5.2 billion (included all forecasted CAPEX);
- After-tax net present value at 8% discount rate of $2,384 million considering Phase 1 and 2 combined;
- After-tax net present value at 8% discount rate of $956 million considering Phase 2 only;
- Pre-tax internal rate of return (IRR) of 42.4% or after-tax IRR of 33.4%, considering Phase 2 only, with a 2.4 years payback on initial capital;
- Total revenue over LOM of $24.0 billion considering Phase 1 and 2 combined;
- Initial capital costs (pre-production) of $589.8 million;
- Average yearly production of 15 million dry tonnes of iron ore concentrate at 66.2% Fe;
- Total LOM average operating costs (total cash cost) of $46.6/t, FOB Sept-Îles;
- LOM average iron ore price at 66.2% Fe CFR China (62% Fe index plus premium for extra Fe content) of USD84.1/t;
- Construction is estimated to last for a period of 21 months.

1.3 Access, Local Resources and Infrastructure

The mine site lies approximately 13 km west of the town of Fermont (central geographical coordinates 52° 50' N and 67° 16' W). A 5-km access road has been constructed to connect the Bloom Lake mine with Highway 389. It is accessible by road from Baie-Comeau on the north shore of the Saint Lawrence River, as well as by road from the Wabush airport in Newfoundland & Labrador. The Wabush airport is located approximately 30 km from the Bloom Lake mine. The mine site is located approximately 950 km northeast of Montreal.

The rail access to port consists of three separate segments. The first segment is the rail spur on site, consisting of a 31.9 km long segment that is operational and connects to the Quebec North Shore and Labrador (QNS&L) railway at the Wabush Mines facilities in Wabush, Labrador. This first segment belongs to QIO. The second segment uses the QNS&L railway from Wabush to Arnaud Junction in Sept-Îles. The third section is from Arnaud junction to Pointe-Noire (Sept-Îles), property of "*Les Chemins de Fer Arnaud*", Sept-Îles, Quebec, where the concentrate is unloaded, stockpiled, and loaded onto vessels. The third segment is owned by the SFPPN (Société Ferroviaire et Portuaire de Pointe-Noire), a limited partnership composed by the Government of Quebec through the Société du Plan Nord and other industrial partners. The assets were acquired by the SFPPN from Cliffs' CCAA. QIO is a current member of the SFPPN board of directors.

The town of Fermont has a population of 2,474 as per Statistics Canada, and is the residential town for employees working for ArcelorMittal's Mont Wright mine operations. The town has all the required infrastructure to support the employees and families who live there. QIO currently owns a total of 383 rooms in the town of Fermont distributed among the following installations:

- One house, fully furnished, located on *rue Bougainville* (with 7 rooms);
- Four houses located on rue des Mélèzes (with 5 rooms each and built in 2012);
- Twenty-two (22) houses, fully furnished, located on *rue des Bâtisseurs* (12 with 8 rooms each, 6 with 7 rooms each and 4 with 5 rooms each and built in 2009);
- Two blocks (hotels) of 99 rooms of lodging located on *rue du Fer* (built in 2013);
- One multi-purpose complex that includes a cafeteria, a gym and recreational facilities.

Current accommodations are fully equipped with furniture, linen, and wiring for communications and entertainment and can house 383 people and provide a total of 1,800 meals per day. Additional infrastructure will be added as part of the Phase 2 project in order to house additional staffing.

The electrical power for the project is supplied by Hydro-Québec from a T-tap off the 315 kV transmission line L3039 (Montagnais-Normand) which terminates in an existing 315-34.5 kV substation (Substation W), owned by QIO. The substation is located along Provincial Route 389 and includes 2 x 315-34.5 kV, 48/64/80 MVA, oil-filled power transformers. It feeds the existing concentrator plant and mine site via 34.5 kV distribution lines. The distribution lines will be modified, as described in further detail in Chapter 18, to meet the electrical needs of the power supply of the Phase 2 expansion and mine requirements. The modifications also provide an increased reliability of the site power supply.

1.4 Geology

The Bloom Lake Iron Deposit lies within the Fermont Iron Ore District (FIOD), a world-renowned iron-mining camp at the southern end of the Labrador Trough within the geological Grenville Province. The Labrador Trough extends along the margins of the eastern boundary of the Superior-Ungava craton for more than 1,200 km and is up to 75 km wide at its central part. The Bloom Lake deposit, including the Bloom Lake West property, is located within the Parautochtonous Deformation Belt of the Grenville Province of the Canadian Shield, just south of the Grenville Front. The Grenville Front, the northern limit of the Grenville Province, truncates the Labrador Trough, separating the Churchill Province greenschist metamorphic grade part of the Labrador Trough rocks from their highly metamorphosed and folded counterparts in the Grenville Province.

The Bloom Lake deposit comprises gently plunging synclines on a main east-west axis separated by a gently north to northwest plunging anticline. One of these synclines is centred on Triangle Lake, while the centre for the other is located just north of Bloom Lake. The Bloom Lake property is centred primarily on the eastern syncline but covers a portion of the northern limb of the western one. These synclines are the result of a minimum of two episodes of folding and are of regional scale.

The iron formation and quartzite are conformable within a metasedimentary series of biotite-muscovite-quartz-feldspar-hornblende-garnet-epidote schists and gneisses in a broad synclinal structure. This succession, following the first stage of folding and faulting, was intruded by gabbroic sills that were later metamorphosed and transformed into amphibolite gneiss with foliation parallel with that in adjacent metasediments.

Two separate iron formation units are present; these join northwest of Bloom Lake, but are separated by several dozen metres of gneiss and schist in the southern part of the structure. Quartzite, present below the upper member throughout the eastern part of the area, pinches out near the western end. Folded segments and inclusions of iron formation in the central part of the syncline, which are surrounded by amphibolite, are in most cases thought to be part of an overlying sheet that was thrust over the main syncline during the first period of deformation. The lower unit is less than 30 m thick in some places and is considerably thinner than the upper unit. The iron content ranges from 32% to 34% in this facies. In places, the silicate facies to the east contain more than 50% cummingtonite, which in part is magnesium rich.

1.5 Mineral Resource Estimate

BBA was retained by QIO to audit the updated Mineral Resource Estimate (MRE) for the Bloom Lake Mine project prepared by Jean-Michel Dubé, P. Geo. from QIO. Drillhole information up to 2018 was considered for this estimate with only partial information from the 2018 drilling program used for 3D modelling and classification. The 2019 Bloom Lake Mineral Resource Estimate presented herein was prepared under the supervision and approved by Pierre-Luc Richard, P. Geo., from BBA. Mr. Richard is an independent "Qualified Person" as defined by NI 43-101.

The QP reviewed the resource parameters presented by QIO, including the following items: geological model and domain strategy, statistical study of assays and composites, variography analysis, interpolation and search ellipse settings, estimation process and classification of the resource. During the course of the audit, the QP proposed revising some of the parameters that contributed to establishing the updated parameters.

Geovia Surpac 2019HF1 v.7.0.1949.0 was used for the geological modelling and to generate the drillhole intercepts for each solid, compositing, 3D block modelling and interpolation. Statistical studies were conducted using Excel and Snowden Supervisor v.8.9.

The methodology for the audit involved the following steps:

- Database verification;
- Review of the 3D modelling of the geological and structural models;
- Review of the drillhole composite generating process for each mineralized units;
- Basic statistics;
- High grade value study;
- Geostatistical analysis including variography;
- Review of the block model construction;
- Review of the grade interpolation (including all profiles, scripts and macros);
- Block model validation;
- Review of the Resource classification;
- Cut-off grade calculation and pit shell optimization;
- Review of the mineral resource statement.

Because of the folded nature of the deposit, the geological model was divided into multiple structural domains to accommodate grade interpolation. Although domains existed in the previous model, it was necessary to revisit the approach during the course of the current MRE update. A total of 22 domains were created using Geovia Surpac for the current MRE. In the QP's opinion, the geological model and the Structural Domains are appropriate for the size, grade distribution and geometry of the mineralized zones and are suitable for the resource estimation of the Bloom Lake project. The model appears to be compatible with the anticipated mining and grade control methods as well as to the size and type of equipment to be used.

For mineralized units, density values were calculated based on the formula established and used during the operational period:

$$SG = \text{Fe\%} \times 0.0284 + 2.5764$$

Density values were calculated from the density of host rock, adjusted by the amount of iron as determined by metal assays. Waste material was assigned the density of porous dolomite (2.71 g/cm^3). The calculation was made on blocks in the block model.

A 3D directional variography was carried out on the composites using the Snowden Supervisor v8.9 software. Variograms were modelled in the three orthogonal directions to define a 3D ellipsoid for each structural domain. The three directions of ellipsoid axes were set by using the variogram fans and visually confirmed with geological knowledge of the deposit. The QP participated in the variography study and considers them appropriate to be used in the ordinary kriging (OK) estimation.

The block model for the Project was set in Geovia Surpac 2019HF1 v.7.0.1949.0. The interpolation was run with the use of two passes on a set of points extracted from the 6.0 m composited data. The block model grades were estimated using OK methods constrained inside the mineralized wireframes. Every step of the block modelling process was revised to ensure fair representation of the available data in the Bloom Lake resource model.

The estimated block grades were classified into Measured, Indicated and Inferred Mineral Resource categories using drill spacing, geological continuity, number of holes used, and slope of regression. When needed, a series of clipping boundaries were created manually in 3D views to either upgrade or downgrade classification in order to avoid artifacts due to automatically generated classification. All remaining estimated but unclassified blocks were flagged as "Exploration Potential".

The Measured, Indicated and Inferred Mineral Resources for the Bloom Lake project presented herein is estimated at a cut-off grade of 15% Fe, inside an optimized Whittle open pit shell based on a long term iron price of USD61.50/dmt for 62% Fe content, a premium of USD12.70/dmt for the 66.2% Fe concentrate and an exchange rate of 1.24 CAD/USD. The Measured and Indicated Mineral Resource for the Project is estimated at 893.5 Mt with an average grade of 29.3% Fe, and Inferred Mineral Resource at 53.5 Mt with an average grade of 26.2% Fe (Table 1-2).

Table 1-2: Mineral resources estimate for the Bloom Lake project

Classification	Tonnage (dry) kt	Fe %	CaO %	Sat %	MgO %	Al_2O_3 %
Measured	379,100	30.2	1.4	4.4	1.4	0.3
Indicated	514,400	28.7	2.5	7.7	2.3	0.4
Total M&I	893,500	29.3	2.1	6.3	1.9	0.4
Inferred	53,500	26.2	2.8	8.0	2.4	0.4

Notes on Mineral Resources:

1. The independent qualified person for the 2019 MRE, as defined by NI 43-101 Guidelines, is Pierre-Luc Richard, P. Geo, of BBA Inc. The effective date of the estimate is April 19, 2019. CIM definitions and guidelines for Mineral Resource Estimates have been followed.
2. These mineral resources are not mineral reserves as they do not have demonstrated economic viability. The MRE presented herein is categorized as Measured, Indicated and Inferred resources. The quantity and grade of reported Inferred resources in this MRE are uncertain in nature and there has been insufficient exploration to define these Inferred resources as Indicated or Measured; however, it is reasonably expected that the majority of Inferred mineral resources could be upgraded to Indicated mineral resources with continued exploration.
3. Resources are presented as undiluted and in situ for an open pit scenario and are considered to have reasonable prospects for economic extraction. The constraining pit shell was developed using pit slopes varying from 42 to 46 degrees. The pit shell was prepared using Minesight.
4. The MRE was prepared using GEOVIA Surpac 2019HF1 v.7.0.1949.0 and is based on 569 surface drillholes (141,289 m) and a total of 11,397 assays.
5. Density values were calculated based on the formula established and used by the issuer.
6. Grade model resource estimation was calculated from drillhole data using an ordinary kriging interpolation method in a block model using blocks measuring 10 m x 10 m x 14 m (vertical) in size.
7. The estimate is reported using a cut-off grade of 15% Fe. The MRE was estimated using a cut-off grade of 15% Fe, inside an optimized open pit shell based on a long term iron price of USD61.50/dmt for 62% Fe content, a premium of USD12.70/dmt for the 66.2% Fe concentrate and an exchange rate of 1.24 CAD/USD. The cut-off grade will need to be re-evaluated in light of future prevailing market conditions and costs.
8. Calculations are in metric units (metre, tonne). Metal contents are presented in percent (%). Metric tonnages are rounded and any discrepancies in total amounts are due to rounding errors.
9. The author is not aware of any known environmental, permitting, legal, title-related, taxation, socio-political or marketing issues, or any other relevant issues not reported in this Technical Report that could materially affect the Mineral Resource Estimate.

1.6 Mineral Reserves

The mineral reserve for the Bloom Lake project is estimated at 807.0 Mt at an average grade of 29.0% Fe as summarized in Table 1-3. The MRE was prepared by BBA. The resource block model was generated by Champion Iron and reviewed by BBA.

The mine design and mineral reserve estimate (MRE) have been completed to a level appropriate for feasibility studies. The MRE stated herein is consistent with the CIM definitions and is suitable for public reporting. As such, the mineral reserves are based on Measured and Indicated (M&I) Mineral Resources, and do not include any Inferred Mineral Resources. The Inferred Resources contained within the mine design are classified as waste.

Table 1-3: Mineral Reserve Estimate

Classification	Diluted ore tonnage (dry Mt)	Fe %	CaO %	Sat %	MgO %	Al_2O_3 %
Proven	346.0	29.9	1.5	4.7	1.4	0.3
Probable	461.0	28.2	2.6	7.9	2.5	0.6
Total Proven & Probable	**807.0**	**29.0**	**2.2**	**6.5**	**2.0**	**0.5**

1. The mineral reserves were estimated using the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Standards for Mineral Resources and Reserves, Definitions and Guidelines prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council on May 10th, 2014.
2. The independent and qualified person for the mineral reserves estimate, as defined by NI 43-101, is Isabelle Leblanc, P. Eng., from BBA. The effective date of the estimate is May 17, 2019.
3. Inside the final open pit design, all the Measured Resources and associated dilution (waste material at 0% Fe) have been converted into Proven Mineral Reserves. Inside the final open pit design, all the Indicated Resources and associated dilution (waste material at 0%Fe) have been converted into Probable Mineral Reserves.
4. The reference point of the mineral reserve is the primary crusher feed.
5. Mineral Reserves are based on the December 31, 2020 mining surface.
6. Mineral Reserves are estimated at a cut-off grade of 15% Fe.
7. Mineral Reserves are estimated using a long-term iron price reference price (Platt's 62%) of USD60.89/dmt and an exchange rate of 1.24 CAD/USD. An Fe concentrate price adjustment of USD12.70/dmt was added.
8. Bulk density of ore is variable but averages 3.40 t/m^3.
9. The average strip ratio is 0.88:1.
10. The mining dilution was calculated using a 1 m contact skin.
11. The average mining dilution is 1.1% at a grade of 0% Fe. Dilution was applied block by block and shows a wide range of local variability.
12. The average ore loss is 0.8% at a grade of 31% Fe. Ore loss was applied block by block and shows a wide range of local variability.
13. The author is not aware of any known environmental, permitting, legal, title-related, taxation, socio-political or marketing issues, or any other relevant issues not reported in the Technical Report, that could materially affect the Mineral Reserve Estimate.
14. Numbers may not add due to rounding.

The open pit optimization was conducted to determine the optimal economic shape of the open pit to guide the pit design process. This task was undertaken using the MineSight Economic Planner (MSEP) software that is based on the Lerchs-Grossmann algorithm. The method works on a block model of the ore body, and progressively constructs lists of related blocks that should, or should not, be mined. The method uses the values of the blocks to define a pit outline that has the highest possible total economic value, subject to the required pit slopes defined as structure arcs in the software. This section describes all the parameters used to calculate block values in MSEP.

Dilution was calculated block by block by evaluating which material types are in contact. Ore loss occurs in amphibolite and overburden rock types, while dilution occurs in gneiss and quartz rock types.

For this Feasibility Study, Measured and Indicated resource blocks were considered for optimization purposes. The pit optimization parameters are stated in Table 1-4.

Table 1-4: Optimization parameters

Parameter	Base value	Unit
MINING COSTS		
Mining Cost	2.50	CAD/t mined
Incremental Bench Cost	0.039	CAD/t /14 m
PROCESSING & G&A COSTS		
G&A Cost	2.76	CAD/t milled
Concentrator Cost	3.70	CAD/t milled
Total Operating Cost	6.46	CAD/t milled
NET VALUE & PAYMENT		
CFR 62% Iron	61.50	USD/t (base selling price at revenue factor 1)
Concentrate Premium	12.70	USD/t/%
CFR 66.2% Iron	74.20	USD/t
Exchange Rate	1.24	CAD/USD
CFR 66.2% Iron	92.01	CAD/t
Shipping and Logistics	18.88	CAD/t
Selling Costs	26.04	CAD/t
Iron Price FOB Bloom Lake	47.09	CAD/t
Iron Recovery	varies	%
Weight Recovery	varies	%
Discount Rate	8.0	%
Concentrate Production Rate	15.00	Mtpy

A pit slope design study was carried out by Golder Associates Inc. (Golder) following a request from the previous owner of the project. The conclusions of this study have been used as an input to the pit optimization.

1.7 Mining

The operation consists of a conventional surface mining method using an owner mining approach with electric hydraulic shovels, wheel loaders and mine trucks. The study consists of resizing the open pit based on parameters outlined in Chapter 16 and producing a 20-year LOM plan to feed two plants at a nominal rate of 41.9 Mtpy. .

Drill and blast specifications are established to effectively single pass drill and blast a 14 m bench. For this bench height, a 311 mm blast holes size is proposed with a 6.25 m burden by 7.25 m spacing with 1.5 m of sub-drill in ore. The blast pattern in waste material varies slightly with the various rock types. These drill parameters, combined with a high energy bulk emulsion with a density of 1.2 kg/m^3, result in a powder factor of 0.40 kg/t. Blast holes are initiated with electronic detonators and primed with 450 g boosters. The bulk emulsion product is a gas-sensitized pumped emulsion blend specifically designed for use in wet blasting applications.

Loading in the pit will be done by up to four electric drive hydraulic face shovels equipped with a 28 m^3 bucket. The shovels are matched with a fleet of 218 t payload capacity mine trucks. The project already owns three Caterpillar 6060 electric drive hydraulic front shovels. The hydraulic shovels will be complemented by up to four production front-end wheel loader (FEL) with a 12 m^3 bucket. Two Komatsu WA1200-6 units are available on site as well as one LeTourneau L1850 unit.

Haulage will be performed with 218-tonne class mine trucks. The existing truck fleets consist of seven Caterpillar 793D and three Caterpillar 793F mechanical drive trucks. The initial fleet required will be 13 trucks growing to 32 trucks in Year 6.

Mining of the Bloom Lake project is planned in six phases with a starter phase and two pushbacks in both the West and Chief's Peak pits. Waste rock will be disposed of in four distinct waste dumps. The original northern location used by the previous owner and three new locations to the south. In-pit dumping has not been planned for the project to avoid the possibility of future re-handling. The open pit generates 707 Mt of overburden and waste rock for a strip ratio of 0.88:1.

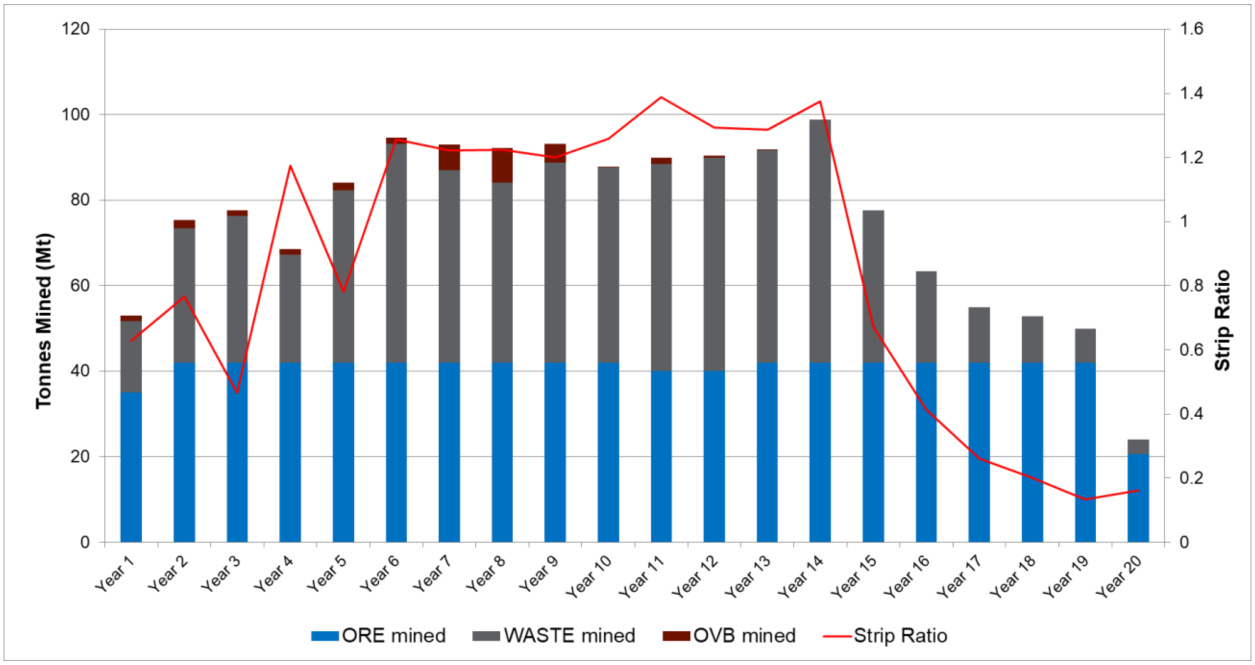


Figure 1-1: Mine production

1.8 Mineral Processing and Metallurgical Testing

The Bloom Lake deposit has been extensively tested since the mid-1970's by previous owners and has showed good potential for gravity recovery of the iron bearing minerals.

The proposed Phase 2 (QIO) flowsheet was developed to improve overall iron recovery compared to the already well-performing Phase 1 (QIO) flowsheet commissioned in February 2018. The Phase 2 concentrator has a robust design allowing for greater operational flexibility and thus aids in avoiding potential tonnage constraints.

The Phase 2 (QIO) flowsheet development was mostly based on the results from a process audit of the operating Phase 1 (QIO) concentrator and results from the test program performed at COREM under the supervision of Soutex. The test program was divided in two main stages:

1. Optimization tests were conducted for each stage to either confirm an equipment performance or test a new equipment performance. In the case where a significant quantity of material was required for a downstream equipment, a production run was also used to generate an adequate sample mass.
2. Variability tests run were performed on the developed flowsheet using five different ore blends composed from eight different ore types collected across Bloom Lake three main pits. Goal of the variability tests run was to confirm flowsheet robustness when processing different ore types and feed grades.

The proposed flowsheet is presented in Figure 1-2.

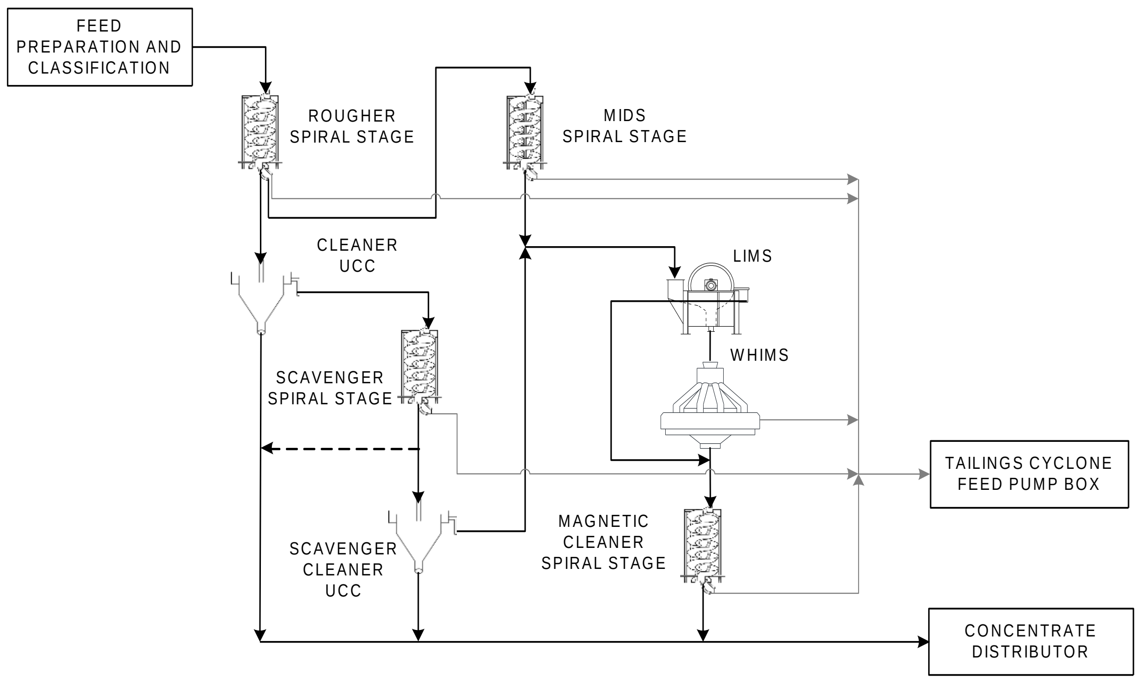


Figure 1-2: Phase 2 (QIO) flow diagram

The flowsheet developed includes the following modifications over the Phase 1 (QIO) flowsheet:

- Redirection of the mids spiral stage concentrate to the magnetic separation circuit to prevent coarse silica being sent to the cleaner up-current classifiers (UCC);
- Addition of a scavenger cleaner UCC stage to increase recovery at the scavenger spiral stage and increase robustness to feed variations.

With the information obtained from the testwork program, the variability testwork results in particular, and the operational experience of the Phase 1 (QIO) concentrator, the following recovery equation was determined:

$$\%Fe_{Rec.} = -0.03593Fe^2 + 3.1900Fe - 0.59683MgO - 0.00495MgO^2 + 0.01424FeMgO + 20.678$$

This equation takes into account the magnesium, measured as MgO, feed grade and assumes it represents actinolite, which contains iron that is not recoverable. The model is applied over the life of mine annual average iron feed grade range of 27% to 31% and MgO feed grades up to 3.5%. Figure 1-3 shows the recovery model developed for Phase 2 (QIO).

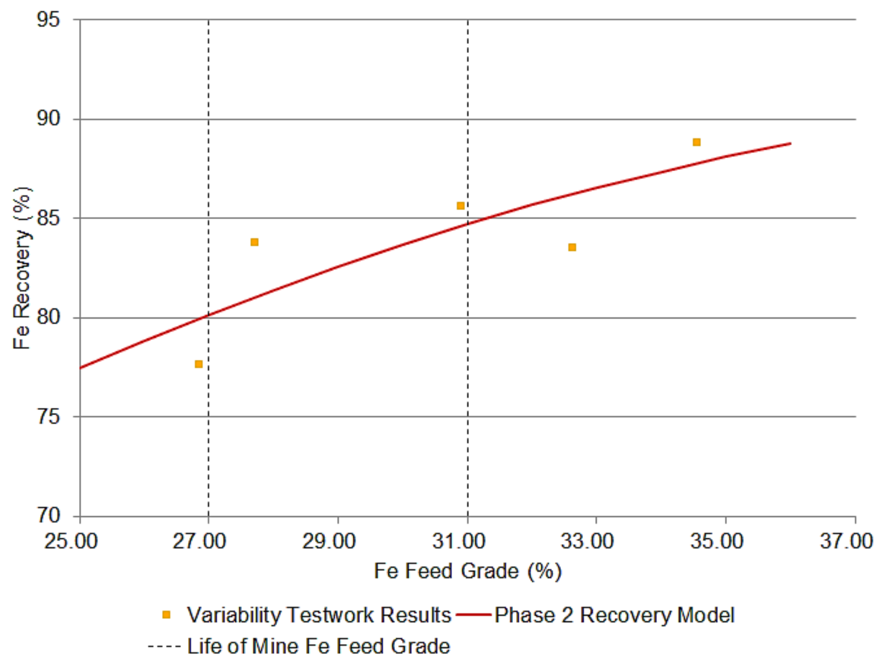


Figure 1-3: Iron recovery vs. iron feed grade

1.9 Recovery Methods

The Bloom Lake Phase 2 (QIO) is designed to process ore at a nominal rate of 2,650 tph. With the new Life of Mine design, the projected production is 7.75 Mtpy of concentrate at a 29.0% Fe feed grade and concentrate grade of 66.2% Fe. The Phase 1 and Phase 2 combined expected weight recovery is 36.0% and iron recovery is 82.4%. The simplified process flow diagram (PFD) for the new Phase 2 is presented in Figure 1-4.

1.9.1 Circuit Description

Ore from the mine is delivered to Crusher 1 and Crusher 2. Crushed ore from Crusher 2 falls on a surge conveyor, which transports it to the crushed ore buffer stockpile and is then transferred on the overland crushed ore conveyor. Crushed ore from Crusher 1 is fed to a surge bin where it is reclaimed via a conveyor system and transported to the common crushed ore stockpile area.

Crushed ore from the stockpile is fed to an AG mill by the means of the mill feed conveyor. The Phase 2 (QIO) project will upgrade the original two 7,500 hp (5,593 kW) motors to 8,400 hp (6264 kW) each. The additional available power will make it possible to increase tonnage when the power draw is high and no other constraint is active. The power increase means that ore-specific power can reach 4.7 kWh/t at the design feed rate of 2,650 tph, which is higher than the Phase 1 (QIO) design value of 4.5 kWh/t at 2,482 tph.

Ground ore is discharged from the mill to feed the scalping screens. The undersize of each scalping screen is pumped to the classification screens' feed distributors arranged to evenly split the feed to the North and South lines. Scalping and classification screen oversize is conveyed back to the AG Mill while static screens and classification screens undersize is collected in a pump box (one for each production line) to be pumped to the gravity concentration circuit. Dilution water originating from the filtrate tank is added to the classification screen undersize pump boxes to ensure a stable rougher feed density.

The Phase 2 separation circuit developed, as in Phase 1 (QIO), is a multi-stage circuit comprised of rougher, middlings, scavenger and mag cleaner spirals, cleaner and scavenger-cleaner Up-current classifiers, low intensity magnetic separators (LIMS) and wet high intensity magnetic separator (WHIMS). It is designed to remove gangue material, mostly silica, from hematite and magnetite to achieve the desired 82.5% Phase 2 iron recovery, with a key difference being the inclusion of up-current classifiers in the scavenger stage.

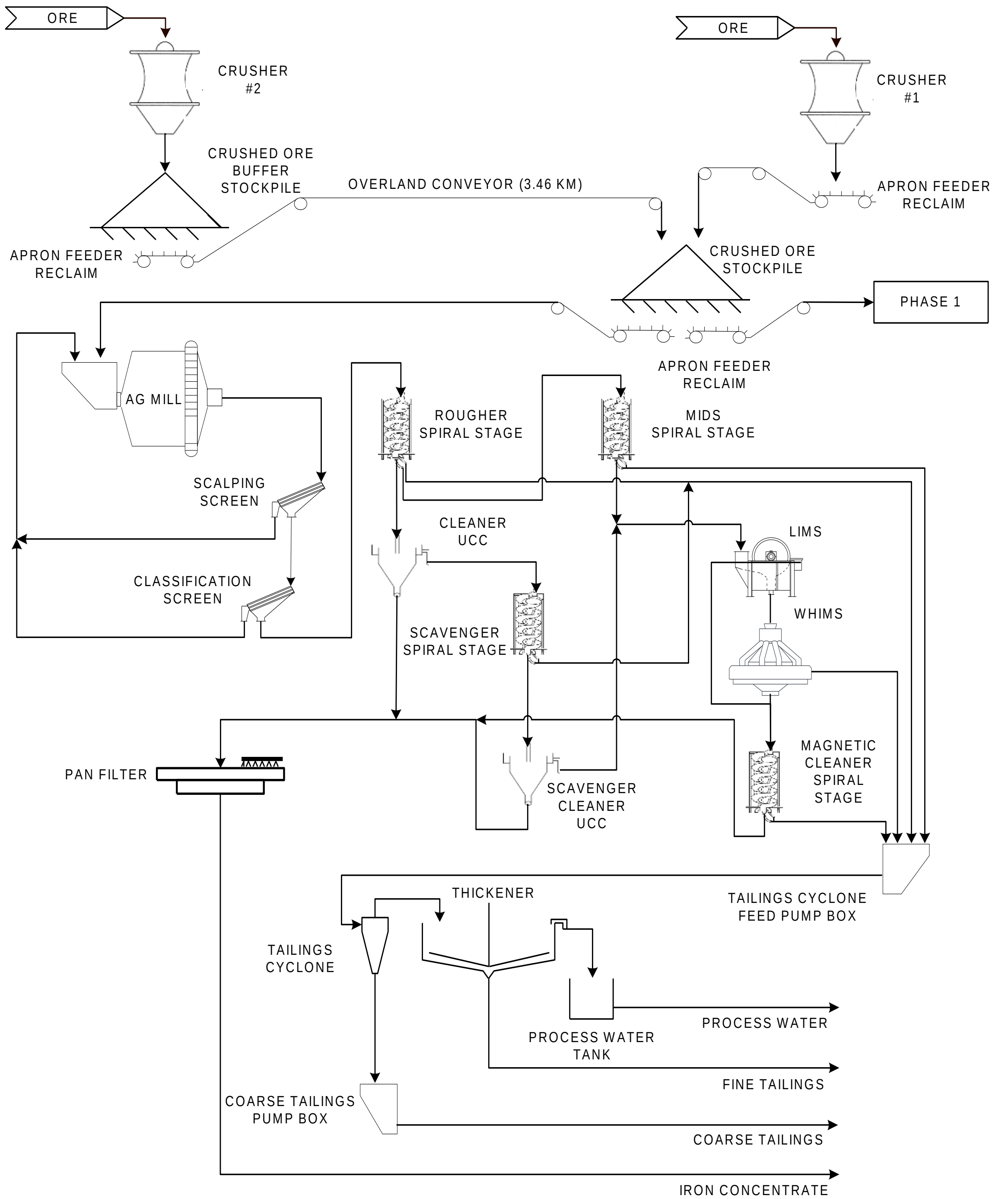


Figure 1-4: Simplified process flow diagram Phase 2 (QIO)

1.9.2 Gravity Circuit Operation

In the gravity circuit, the combination of spirals at the rougher stage and UCC at the cleaner stage enables the removal of silica of all sizes. The roughers will maximize iron recovery while preventing coarse silica from reaching the cleaner stage. The cleaner stage will remove fine and mid-sized silica to achieve a final concentrate silica grade lower than the 4.5% target. The mids spirals will recover misplaced iron from the rougher stage middlings while removing mid-size to coarse silica. Sending the mids concentrate to the magnetic separation circuit stage prevents the reintroduction of coarse silica in the cleaner UCC stage.

The tails coming from the rougher is a high flow, but low percent solids stream from which water can be recovered through dewatering cyclones and reused in the process. The rougher spirals tails dewatering cyclone overflow is pumped in the required quantity to the mill feed chute and the scalping screen pump boxes for density control.

A combination of spirals and UCC is also used at the scavenger and scavenger cleaner stages. The scavenger is operated to maximize iron recovery while removing mid-sized silica. The scavenger cleaner stage is operated to remove fine silica. To maximize iron recovery when the scavenger spiral grade meets specifications, the scavenger-cleaner UCC stage can be bypassed.

1.9.3 Magnetic Circuit Operation

A combination of LIMS, WHIMS and spirals is used to scavenge iron from the scavenger cleaner UCC overflow and mids spirals concentrate. The LIMS recovers magnetite and the remaining hematite enters the WHIMS stage to ensure the efficient operation and availability of the WHIMS. The WHIMS magnetic intensity is adjusted to maximize hematite recovery from paramagnetic minerals. The LIMS and WHIMS magnetic concentrates are fed to the mag cleaner spiral stage where the settings are adjusted to achieve the final concentrate target grade of 4.5% SiO_2.

1.9.4 Concentrate Operation

The concentrate is collected into the concentrate collector launders. From there, it goes into a 4-way pan filter feed distributor that splits the feed into 4 horizontal pan filters. The addition of a common 4-way feed distributor results in equal distribution of the concentrate to the operating filters. The concentrate pan filter area is 1.7 times that of the Phase 1 (QIO) filters, meaning that only three filters are required in operation and stopping a pan filter for maintenance will not imply tonnage reduction.

Phase 2 concentrate is transferred to the Phase 2 transfer tower. From there, it can go to Phase 1 silo, Phase 2 silo or the Phase 2 emergency stockpile. When train loading begins, the concentrate is transferred to the Phase 1 hopper and tilt chute for loading into railcars. Calcium chloride is added in the winter months to prevent the concentrate from sticking onto the railcar walls.

1.9.5 Tailings Operation

The tailings cyclone cluster feed pump boxes receive tails from the various separation stages and feed the tailings thickening cyclone clusters that produce a dense and coarse underflow reporting to the coarse tailings collection box and a fine and dilute overflow that reports to the tailings thickener.

The tailings thickener underflow is pumped to the fine tailings tank where it is mixed with Phase 1 fine tailings. The material is pumped through the booster station to the fine tailings storage facility (TSF). The tailings thickener has a surface of 2.1 times larger than that of the Phase 1 (QIO) thickener. The increased thickener surface area allows the rise rate to be greatly reduced, which increases stability and control of the overflow water quality. The thickener overflow is gravity fed into the process water tank to be reused throughout the concentrator.

The tailings cyclone cluster underflow (coarse tailings) is gravity fed to a pump box. From there, the tailings stream is pumped via a series of coarse tailings pumps to booster stations as it is transported to the coarse TSF.

1.10 Infrastructure

1.10.1 Mine Infrastructure

The entire mine infrastructure used for the current mining operations will be upgraded to the new mine plan requirements. Most of the required infrastructure is already constructed with a few new additions/modifications that will be required. The facilities breakdown is detailed in Table 1-5 .

Table 1-5: Mine infrastructure

Infrastructure	Condition (existing or new/modified)
Mine maintenance garage (Phase 1)	Existing
Mine maintenance garage (Phase 2) 2023	New
Garage SMS Secondary truck maintenance	New
Truck wash bay	Existing
Fuel storage and distribution system	Existing
Mine electrical infrastructure	New
A cafeteria at the West Pit (to minimize lost time for truck drivers' breaks)	Existing
Spare parts containers located around the site to store drilling equipment, surveyor equipment and environmental equipment	Existing
Mobile shovel bucket repair shop	Existing
Dispatch system, complete with trailers, offices and a cafeteria	Existing
Aggregates crusher plant (contractor)	Existing

1.10.2 Infrastructure Located at the Processing Plants

The vast majority of the required infrastructure for Phase 2 is available and currently used for Quebec Iron Ore operations. Figure 1-5 shows the location of the major infrastructure located at the Bloom Lake site. The process plant building required for Phase 2 has already been constructed and certain equipment has already been installed. The structure is complete and the building walls have been closed. Non-process buildings include:

- A service building attached to the Phase 1 process plant which houses:
  - Maintenance shops;
  - Unloading and warehousing completely stocked with parts and supplies;
  - Electrical/instrument repair shop;
  - Boiler plant to provide steam to both plants for heating and filter cake drying. The boiler plant also hosts the boiler water treatment system;
  - Offices for administration, purchasing, human resources, technical services (engineering and geology), training and plant operating personnel;
  - Laboratory equipped for metallurgical testwork, wet and dry assaying;
  - Lunchroom, men and women change rooms, sanitary and locker facilities;
  - Communications room;
  - Compressor room to provide service air and instrument air to both concentrators;
  - Fresh water storage tank and water treatment facilities for both plants;
  - Electrical room.
- Eight various utility domes used as warehouses or shops for contractors.

1.10.3 Train Loading Station

The Phase 2 expansion will involve the addition of a second silo having a capacity of 30,000 t and linked to the existing load-out station. A series of conveyors will allow both plants to discharge their concentrate in both silos allowing greater operational flexibility. No significant modification is planned for the existing train loading facilities apart from the connection of Silo 2 to the load out, integration of the second silo conveyor inlet and some minor systems improvements to the existing train loading facilities.

1.10.4 Rail Infrastructure

The rail network consists of three separate segments to transport iron ore concentrate from the mine site to the port.

1. **First segment** of rail referred to as the Bloom Lake Railway (BLR) consists of a 32-km long segment that connects the mine site to the Quebec North Shore and Labrador (QNS&L) railway at the Wabush Mines facilities in Wabush, Labrador;
2. **Second segment** uses the QNS&L railway from Wabush to Arnaud junction in Sept-Îles, which has a mainline track of approximately 395 km;
3. **Third segment** is from Arnaud junction to Pointe-Noire (Sept-Îles), which is the property of SFP Pointe-Noire (SFPPN).

The current fleet is composed of 735 insulated ore cars dedicated to move Bloom Lake concentrate. As part of the expansion, QIO will require an extra 450 railcars for a total of four long trains (240 railcars) and one short train (168 railcars). A 5% spare fleet allowance is considered to provide reliable operations. Rail additions will be required along the Bloom Lake railway, at Arnaud Junction and at the Pointe-Noire terminal. One of the major changes to be performed is related to the dumper track at the Pointe-Noire Terminal in order to unload the 240-car train by cuts of 82 cars instead of 55 cars as is performed for current operations. This modification reduces the unloading cycle time and maximizes the car dumper capacity.

1.10.5 Port Infrastructure

The concentrate is unloaded from railcars at Pointe Noire, which is owned by SFPPN and controlled by the Government of Quebec, and can be either loaded directly onto a vessel or stockpiled to be reclaimed and loaded at a later date. As part of the expansion project, the infrastructure must be upgraded to accommodate an average yearly throughput of 15 Mt of concentrate. To allow efficient and reliable operations, modifications will be performed to increase the stockpiling capacity, reduce the railcars unloading cycle and increase the stacking and reclaiming performance.

The infrastructure modifications required for Phase 2 operations are as follows:

- Dismantling of the existing rail segment located after the rail dumper;
- Excavation, blasting and back-fill to support the new rail segment that will be installed after the rail dumper;
- Move the existing access road for Port de Sept-Îles and Aluminerie Alouette;
- Construction of a new site service road;
- Relocation of the aqueduct network;
- Relocation of the 25 kV electrical line;

- Relocation of the Telus telecommunications infrastructure;
- Construction of new culverts;
- Addition of a new stacker-reclaimer;
- Extension of conveyors CV-2 & CV-3 by 300 m;
- Addition of 600 hp motors on conveyors CV-2 & CV-3.

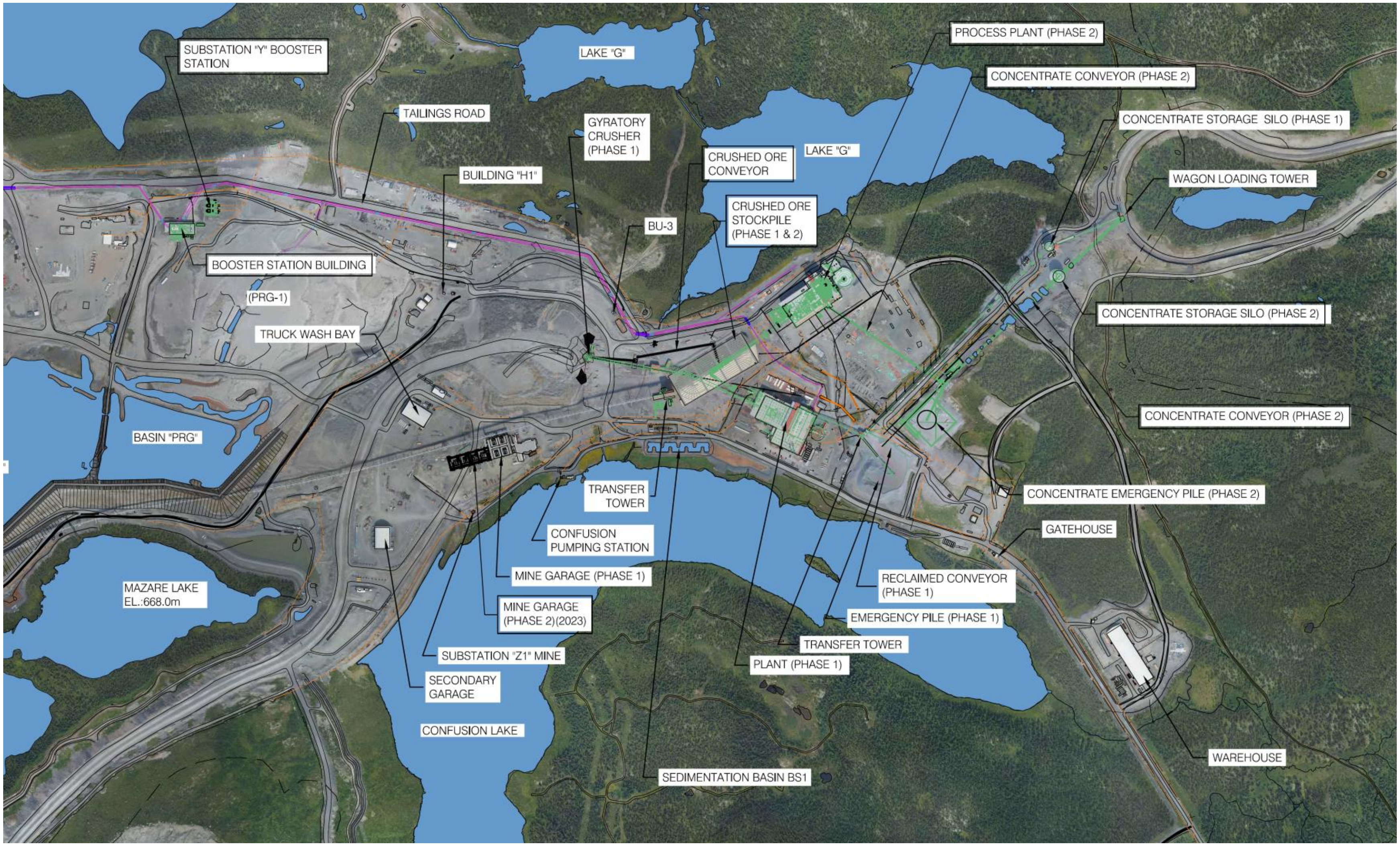


Figure 1-5: Major infrastructure located on the Bloom Lake site

1.11 Tailings and Surface Water Management

The tailings management strategy is developed around tailings slurry pumping and hydraulic placement of an annual average of 26.8 Mt of tailings that are separated in two feeds: coarse (85%) and fine (15%). This separation optimizes the footprint, utilizes the existing infrastructure and reduces the overall environmental risks by maximizing each material given their distinct properties and behaviours. Slurry pumping and hydraulic deposition is a safe and economic way to transport and store large quantities of tailings.

The tailings management strategy for the expansion project is compatible with the current management strategy. Fine tailings are stored year-round in Basin *A*, which is contained by centreline or downstream construction dikes. Coarse tailings are stored in the current *HPA-Sud* and *HPA-Ouest* storage areas as well as the new *HPA-Nord* storage area. The coarse tailings are contained by upstream 10H:1V sloped filtering dikes built solely on stable coarse draining tailings. Most construction work in the fine tailings basin is expected to be executed by contractors, while the coarse tailings management facility (TMF) will be mostly built by the QIO personnel and equipment

The surface water management system is composed of a network of ditches, collection basins, pumping stations and retention ponds. Since Bloom Lake restart, some upgrades on the current conveying surface water management system have been done to increase robustness and reliability. These improvements are applied in the design of the water management systems around the new permitted areas *HPA-Nord* TSF and *Halde-Sud* waste dump. These new permitted areas will also include water retention basins sized to hold water volumes according to applicable legislations. Therefore, they do not impact the current water management system during the spring thaw period. Water from these basins can then be pumped to the existing system in a controlled manner during the remainder of the year. These water basins are dammed by centreline construction dikes that will be built to the highest safety design and construction standards. Finally, the current water treatment plant located next to the TSF will be winterized and upgraded to accommodate increases in the required treatment capacity due to the new permitted areas. This upgrade will be necessary when the future *HPA-Nord* TSF and *Halde-Sud* waste dump are constructed.

1.12 Environment

The mine has been authorized for operation under the federal environmental authorities and provincial governments.

No other federal authorizations are required to operate the second concentrator. Therefore, Bloom Lake can increase the annual ore production to 16 Mtpy. Fish habitats (lakes, ponds, and streams) are present within *HPA-Nord* TSF and the *Halde Sud* waste stockpile locations. Under Section 36(3) of the Fisheries Act, it is forbidden to deposit deleterious substances such as tailings and waste rock in water frequented by fish. However, the MDMER includes provisions (regulatory amendment) allowing the use of a natural water body frequented by fish for mine waste disposal. The assessment of alternative reports is currently reviewed by ECCC. Upon acceptance, the process of amendment of Schedule 2 of the MDMER will be initiated. According to the Project development schedule, disposal of tailings in *HPA-Nord* and waste rock in *Halde Sud* stockpile will not be required before 2026, thus allowing sufficient time than required for QIO to complete the federal permitting process.

At the provincial level, Bloom Lake has also received operational permits for the mine, the dust collection systems, the railroad and the wastewater treatment systems. With the infrastructure facilities authorized, the expansion Project can go forward without delays. The storage capacity for waste rocks and tailings is secured by permits up to 2024 at a production rate of 16 Mtpy. Consultations and presentations to the First Nations and the local community have been conducted since December 2018 to consider their concerns throughout the development of the expansion project. Various committees are ongoing to ensure a follow-up on the IBA (First Nations) or the mine activities (community stakeholders). QIO maintains positive relationships with the community and has become a reference for First Nations involvements in terms of training, employment and environment.

The same mining effluent will be maintained with the expansion, and the requirements (Directive 019 and MDMER) in terms of monitoring will remain unchanged. Other monitoring programs are ongoing on the site with regards to groundwater and air quality.

A revised closure plan was submitted to MERN in 2018 which covered five years of mining operations. According to Section 232.6 of the Quebec Mining Act (L.R.Q., c. M 13.1), QIO shall submit a revised closure plan to the Minister for approval every 5 years or whenever amendments to the plan are justified by changes in the mining activities. QIO must also provide a financial guarantee covering the closure plan cost to the provincial government in accordance with Section 111 of the Regulation Respecting Mineral Substances other than Petroleum, Natural Gas and Brine (Chapter M-13.1, r. 2).

1.13 Market Studies

QIO engaged Wood Mackenzie to provide an iron ore market study for use in the Bloom Lake Mine Feasibility Study Phase 2 NI 43-101 technical report.

The market study covers the following topics, details can be found in Chapter 19:

1. Market study executive summary
2. Iron ore market overview
3. Iron ore products
4. Major iron ore markets size and structures
5. Major sources of internationally traded iron ore
6. Iron ore demand evolution: 2000-2018
7. Iron ore supply evolution: 2000-2018
8. Forecast demand of iron ore: 2019-2040
9. Forecast supply of iron ore: 2019-2040
10. Iron ore pricing
11. Iron ore pricing evolution
12. Dry bulk freight outlook
13. QIO's Bloom Lake concentrate price forecast

Iron ore is commonly sold on a Cost and Freight (CFR) or Free on Board (FOB) basis. Under a CFR sale, the product changes hands as it is unloaded at the arrival port and the pricing includes shipping costs. In recent years, there has been a strong trend to CFR sales, as this gives sellers control over shipping. A FOB sale is for iron ore delivered on board a vessel at the loading port, and the price is usually determined by netting back the cost of ocean freight (to China) from the CFR China price.

The future Bloom Lake concentrate prices were estimated based on the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) guidance on commodity pricing adopted on November 28, 2015. Table 1-6 presents the base case price forecasts for the first three years of operation as well as for the LOM. The base case economic assumption utilizes a conservative blended average gross realized price of USD84.1/t (66.2% Fe CFR China) for the LOM. Given recent events in Brazil fail to be recognized in the 3-year moving average as suggested by CIM, the base case price assumption also incorporates analyst consensus to capture the short-term pricing dynamic in the industry. The P65 analyst consensus of 9 well recognized global research firms was utilized for the basis of the price for Years 1 to 3. For the remaining LOM, the P65 iron price is based on the average of the P65 analyst long-term consensus and the P62 3-year trailing average with a 15% premium, being a discount to the estimated long-term premium of P65 to P62 of 20% by Wood Mackenzie. Such estimates for P65 then receives a pro-rata adjustment for premium at 66.2% and marketing fees to arrive at a net realized price for the concentrate of 66.2% produced at Bloom Lake.

Table 1-6: Bloom Lake concentrate base case price estimates
Prices in USD/dry metric ton (dmt) and in real 2019 terms

Year	62%Fe Index CFR China (3-year moving avg)	62%Fe Index CFR China + 15% (3-year moving avg)	65%Fe Index CFR China analyst consensus	Realized price 66.2% CFR China net of marketing fees	Freight	Net realized price 66.2% FOB
2021			91.36	91.56	22.27	69.29
2022			88.07	88.26	21.61	66.65
2023			84.24	84.42	20.85	63.57
2024 and +	71.54	82.27	84.24	83.43	20.65	62.78
Average LOM		**83.90**		**84.10**	**21.54**	**62.56**

Source: PLATTS

1.14 Capital Cost Estimate

The capital cost estimate was based on the detailed engineering material take-offs, bids received from vendors and contractors from the previous study phase, and some data from historical projects. As the project was under construction and 65-70% complete, parts of the estimate are based on advanced detailed engineering. The initial capital cost estimate does not include taxes, replacement capital or additional working capital requirements after commissioning and start-up. The cost estimate, presented herein, is calculated and presented in Canadian (CAD or $) dollars and is dated Q2 2019. The conversion rates used to transfer foreign currencies to CAD are shown in Table 1-7.

Table 1-7: Currency conversion rates

Country	Currency	Equivalent
United States	1.00 USD	1.32 CAD

The summary table for the capital cost estimate (CAPEX) is found in Table 1-8.

Table 1-8: Estimated pre-production capital costs

Category	Pre-production M$
General	$28.2
Mine – Phase 2	$37.6
Crusher and stockpile	$24.3
Concentrator	$165.0
Tailings and water management	$50.2
Services	$30.5
Rail and Port	$73.4
Owner's Costs (all-inclusive indirect costs)	$105.1
Contingency	$75.5
Total	**$589.8M**
Deposits	$44.0
Total including deposits	**$633.8M**

1.15 Operating Cost Estimate (OPEX)

Mining operating costs were generally developed from first principles, internal benchmarking information for similar projects and vendor quotes. For the concentrator, G&A and tailings operating costs, a portion of the unit rates and consumptions were based on actual operation costs and consumptions as per QIO's experience with Phase 1 actual operational costs. Other costs and consumptions required were derived by QIO, and WSP for the tailings management, have been compiled from a variety of sources and are mainly based on historical data, operating budgets and vendor quotes. Costs for concentrate transportation were established by QIO based on agreements with the rail transport providers.

A summary of the average operating cost of Phase 1 and Phase 2 combined over the life of mine is shown in Table 1-9.

Table 1-9: Total estimated average LOM operating cost (Phase 1 + Phase 2) ($/t dry concentrate)

Category	Avg. (LOM)
	$/t conc.
Mining	$13.4
Crushing and Conveying	$1.7
Process Plant	$7.9
Concentrate Shipping	$16.8
Water and Tailings Management	$2.1
General and Administrative	$4.7
Total OPEX (cash cost)	**$46.6**
Sustainability	**$1.3**
Sustaining Capital (1)	**$4.4**
All-in sustaining cost	**$52.3**

(1) The total sustaining capital costs is estimated at **$4.4/t** over the LOM (capital expenses incurred from Year 1 of production to the end of the mine life), which includes items such as mine equipment fleet additions and replacements, facilities additions, rail car leasing, improvements and costs related to phasing of the TMF.

1.16 Economic Analysis

The economic/financial assessment of the Bloom Lake Phase 2 Project of Quebec Iron Ore Inc. is based on Q2-2019 price projections in USD currency and cost estimates in Canadian currency. A spot exchange rate of USD0.76 per CAD was assumed to convert particular components of the cost estimates into CAD and forward exchange rate estimates were used to convert USD market price projections into CAD. No provision was made for the effects of inflation. The evaluation was carried out on a 100%-equity basis. The evaluation presented is based on expenditures for Phase 2 only to avoid distorting the results with Phase 1 concentrate production. Current Canadian tax regulations were applied to assess the corporate taxes, while the regulations in Quebec (originally proposed as Bill 55, December 2013) were applied to assess the mining taxes. The financial indicators under base case conditions are presented in Table 1-10.

Table 1-10: Financial model indicators, Phase 2 only

Financial Results	Unit	Value
Pre-tax NPV @ 4%	M CAD	2,222.7
Pre-tax NPV @ 6%	M CAD	1,838.5
Pre-tax NPV @ 8%	M CAD	1,531.8
Pre-tax IRR	%	42.4
After-tax NPV @ 4%	M CAD	1,415.6
After-tax NPV @ 6%	M CAD	1,160.4
After-tax NPV @ 8%	M CAD	955.7
After-tax IRR	%	33.4
After-tax Payback Period on initial capital	years	2.4

A sensitivity analysis reveals that the Project's viability will not be significantly vulnerable to variations in capital costs and freight, within the margins of error associated with Feasibility-Study-level estimates. However, the Project's viability remains more vulnerable to the USD/CAD exchange rate and OPEX and to a more pronounced degree, future market prices of iron ore concentrate. Refer to Chapter 19 for further details on the market price analysis.

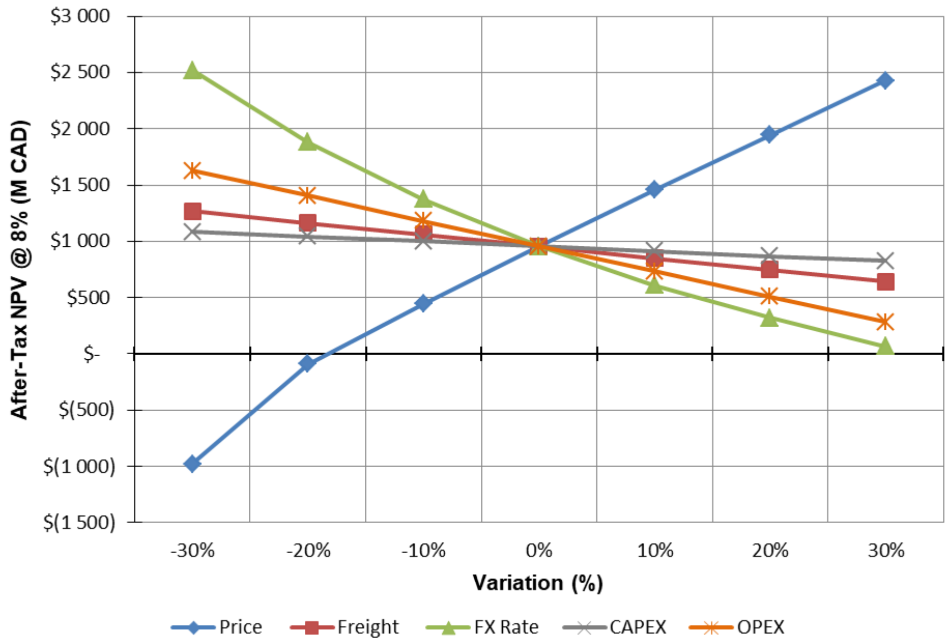


Figure 1-6: Sensitivity of the net present value (after-tax) to financial variables

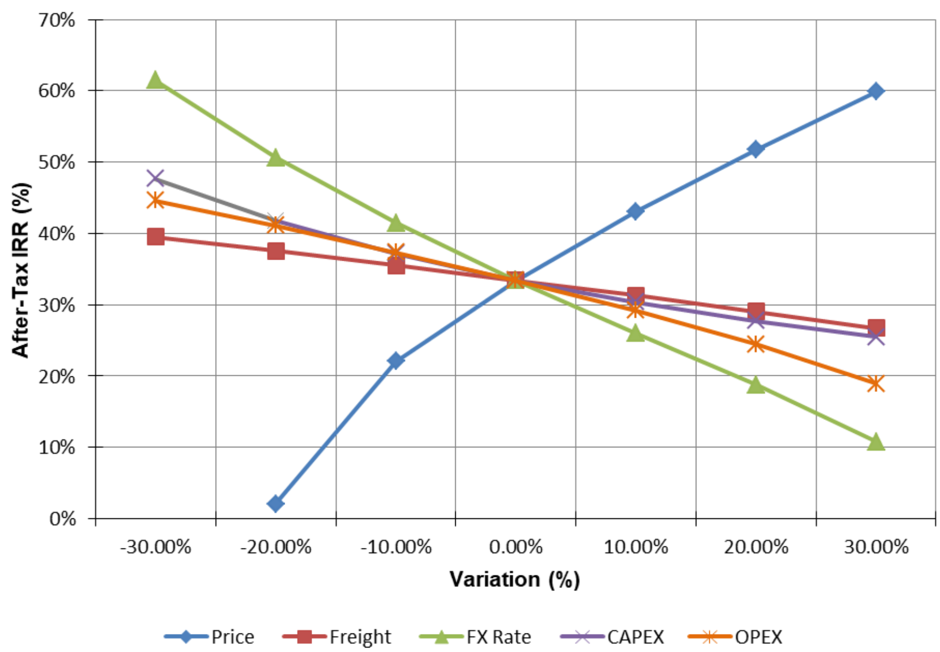


Figure 1-7: Sensitivity of internal rate of return (after-tax) to financial variables

1.17 Project Execution and Schedule

QIO has a very good understanding of the challenges involved in the Phase 2 project, which are quite different from Phase 1. The success of the Phase 2 project requires an effective execution strategy from the Project kick-off to the full production ramp-up. In this regard, QIO has started the preparation of a Project Management Plan (PMP) with the related execution plans (Health, Security and Environment (HSE), Project Execution, Engineering, Procurement, Construction, Project Services and Operational Readiness).

The preliminary project schedule is developed to a feasibility study level and will be further defined during the baseline definition exercise started in early July 2019. The preliminary schedule covers the period from the kick-off up to the commercial operation of the Phase 2 project. Pursuant to the strong economics outlined in this Study, QIO's board has approved an initial budget of $68M to advance the Project during the remainder of 2019. This budget will serve for early works during the summer of 2019, definition and procurement work for long-lead items and advancement of detailed engineering to respect the Project's major milestones. The major milestones of the Project are listed in Table 1-11:

Table 1-11: Phase 2 project schedule milestones

Milestone Month	Description
June 2019	Phase 2 Feasibility Study completion
July 2019	Phase 2 Project kick-off, start of early works and detailed engineering
M0	Board approval for remaining project budget
M9	Start of pre-commissioning activities
M12	Start of commissioning activities
M14	Start of operation and ramp-up
M19	Phase 2 commercial operation

1.18 Risk Management

Several risk identification workshops were held during the FS to identify and manage the potential risk exposures of the Bloom Lake Phase 2 project. The attendances were stakeholders from Quebec Iron Ore and the different partners collaborating to the FS. The findings of those workshops were compiled in a risk register followed by an assessment of the frequency and consequence of an item in order to get a risk priority number using a risk priority matrix. The risk register and the risk priority matrix are similar to the ones used for the restart of Bloom Lake Mine in 2017. After an exercise of mitigation done during the last workshop, the resulting division of material and main risks are reported in Figure 1-8.

The Project risk register will be revisited, reviewed and updated regularly during the Phase 2 project execution. Each risk owner will be responsible to provide any update to the mitigation action items and to re-assess the risk as the Project develops.

Additional risk workshops will be scheduled during the Project in different forms (e.g., HAZOP, HAZID, etc.) to address specific aspects in HSE, Engineering, Procurement, Construction, Commissioning and Operation.

Assessment Levels

The pie chart in Figure 1-8 indicates the risk division in the different category of the Project risk register after mitigation:

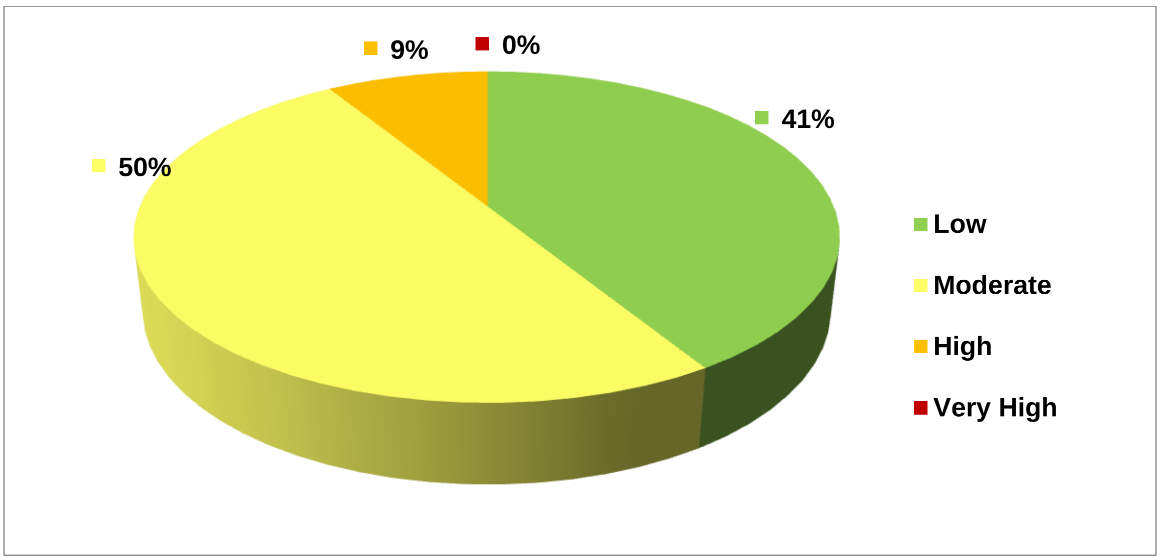


Figure 1-8: Risk register assessment levels

1.19 Conclusions

The Bloom Lake Phase 2 project is financially and technically feasible with an estimated initial capital cost of $589.8 M and initial deposits of $44M. The economic analysis of the Project shows an IRR of 33.4% and a simple payback period of 2.4 years after taxes.

The expected level of accuracy of the capital and operating cost estimates for this study should be in the range of -10% on the low side to +15% on the high side. The capital cost estimate includes a 15% contingency on the pre-production capital costs and includes contingencies on the indirect costs.

1.20 Recommendations

Given the positive financial results from the economic analysis of the Study, it is recommended that the Project advance to the next phase. The following general recommendations are put forward for the continuation of this Project into the next phases which are: detailed engineering, procurement, and construction. It is QIO's intent to start commissioning activities in month 12 of the schedule and be in commercial production by Month 19 of the schedule. For this to become a reality, it is imperative that a focus be placed on critical path purchase orders (long-lead items) and start early works and detailed engineering in a timely fashion.

2. INTRODUCTION

2.1 Background

In December 2006, an environmental impact assessment (EIA) of the Bloom Lake Mine project (the "Project") was submitted to the agencies. Decree 137-2008 authorizing the Project was adopted on February 20, 2008 by the provincial government. Consolidated Thompson Iron Mines Limited began the construction of the mining infrastructure in 2008 and commenced mining operations in 2010 with the Phase 1 concentrator plant (referred to as "Phase 1 (Consolidated Thompson) plant" in this document).

The mine was sold to Cliffs Natural Resources Inc. (Cliffs) in 2011, which continued the Phase 2 (Cliffs) construction project until the Project was halted in November 2012, and conducted mining operations until they were suspended in December 2014. The site was employing approximately 600 people.

In January 2015, Cliffs sought creditor protection under Companies' Creditors Arrangement Act (CCAA), resulting in the mine being put on a care and maintenance program and placed into creditor protection.

In April of 2016, Champion Iron Limited (Champion or ''the Company'') acquired the Bloom Lake assets through its subsidiary Quebec Iron Ore (QIO) and the Quinto Claims for a cash consideration of $10.5M ($9.75M for Bloom Lake and $0.75M for Quinto) and the assumption of liabilities. Quebec Iron Ore Inc. is 63.2% owned by Champion Iron Limited, with the remaining 36.8% equity interest owned by *Ressources Québec* (RQ), acting as a mandatory of the Government of Quebec. On May 29, 2019, the Company announced a transaction to acquire RQ's 36.8% equity interest in QIO and the transaction would increase Champion's stake in QIO to 100%. For more information on the capital restructuring, please refer to the Company's press release dated May 29, 2019, available under the Company's filings on SEDAR at www.sedar.com.

Following acquisition of the Bloom Lake assets by QIO, a feasibility study to identify areas for improvement or correction was completed in February 2017 and resulted with the restart of the operation in February 2018 on time and on budget.

During its first full year of operation (2019 Fiscal Year), the Bloom Lake site produced 6,994,500 wet metric tonnes of 66.4% iron ore concentrate, which is an improvement of approximately 1,000,000 wet metric tonnes over 2014 production. The production total cash cost during 2019 was $49.4/dmt and the all-in sustaining cost was $55.8/dmt.

As part of an expansion plan to increase the mine production, the design and construction of a second concentrator plant (referred to as "Phase 2 plant" in this document) was initiated to increase nominal capacity to about 15 Mt of concentrate per annum.

Given the amount of work that Cliffs has already committed in preparing the Phase 2 plant, mine and tailings expansion, the Bloom Lake project represents a low capital investment for a considerable increase in high grade iron ore concentrate production.

2.2 Scope

The scope of this feasibility study is to develop a plan to complete the construction of the Phase 2 concentrator including improvements to maximize production efficiency and modifications to other areas to support the operation of both concentrators. Feasibility study level engineering was performed on each of these areas to outline work to be performed. The resulting capital cost estimate reflects a Class 3 study as defined by the Association for the Advancement of Cost Engineering (AACE) as described in Recommended Practice N° 18R-97 about Cost Estimating Classification System. The expected accuracy for this study should be in the range of -10% on the low side to +15% on the high side.

The following Technical Report (the "Report") presents the results of the feasibility study (FS) for the Phase 2 expansion of Bloom Lake's operations. This Report, titled "Bloom Lake Mine – Feasibility Study Phase 2", was prepared by Qualified Persons (QPs) following the guidelines of the "Canadian Securities Administrators" National Instrument 43-101 (effective June 30, 2011), and in conformity with the guidelines of the Canadian Mining, Metallurgy and Petroleum (CIM) Standard on Mineral Resources and Reserves.

This Report is considered effective as of June 20, 2019.

Past technical reports on the Project can be accessed from SEDAR's electronic database http://www.sedar.com/.

2.3 Basis of the Report

Information presented in this Report is based on the following:

- Information provided by Quebec Iron Ore;
- Phase 1 process audit results;
- Metallurgical testwork performed by COREM in their metallurgical testing facilities using samples from the operating Phase 1 (QIO) concentrator and from the Bloom Lake mine;
- Information from the CIMA+ Phase 2 (Cliffs) design drawings and specifications;
- Current and previous operations data;
- AG Mill grinding performance studies by SGS;
- Mineral Technologies – Metallurgical testwork for the Bloom Lake restart of Phase 1 (QIO);
- Soutex – Metallurgical testwork for the Bloom Lake Phase 2 (Cliffs) concentrator.

2.4 Description of the Project

The Bloom Lake Mine Phase 2 project includes the following elements:

- A new mining plan for Bloom Lake, which will include additional support mobile equipment;
- Modifications to crusher 1 to allow feeding both concentrators;
- Process flowsheet upgrade within the existing Phase 2 concentrator. The flowsheet upgrade focus is to improve the recovery of iron by the concentrator, with specific attention given to improving recoveries of the coarser (+425 microns) and fine (-106 microns) iron minerals while having no adverse effect on the recovery of other size fractions;
- Modifications to the Phase 2 concentrator required for the upgrade to the iron recovery circuit flowsheet include:
  - Replacement of the spirals used for the restart of the Phase 1 (QIO) concentrator;
  - Installation of new spirals in a revised circuit configuration;
  - Installation of two stages of up-current classifiers to complement the spirals. The use of the two types of gravity separation technology performs well in maximizing iron recovery in a robust manner across a broad range of particle sizes;
  - Installation of an iron-scavenging magnetic circuit. The magnetic circuit uses both LIMS and WHIMS to target recovery of fine iron that otherwise reports to the gravity circuit tailings. This circuit provides an incremental increase to plant iron recoveries;
  - Additional process equipment modifications to ensure ancillary equipment specifications match the required duty of the upgraded flowsheet.
- Revised tailings management plan and storage facilities;
- Revised water management plan.

2.5 Division of Responsibility

At a high level, the division of responsibilities is as follows:

Table 2-1: High level division of responsibility

Description	Responsible
Geology	BBA
Development of the mine pit, overburden removal and required mining infrastructure, geological settings and mineralization, mining plan, mining methods, explosives	BBA
Reviewing of crushing, crushed ore reclaiming and milling area	BBA
Mineral processing, metallurgical testing & recovery methods; increase in concentrate production by modifications to the gravity separation circuit along with the addition of a magnetic circuit; metallurgical testing including design, fabrication and installation, and excluding electrical and instrumentation	Soutex
Tailings pumping and pipeline from the inlet of the plant tailings pumps to the inlet of the tailings booster pumps BPH1	BBA
Tailings pumping and pipeline from the inlet of the tailings booster pumps BPH1 to the tailings storage	BBA
Surface water management plan, water management structures and pumping stations	WSP
Tailings storage management; development of a new tailings filling plan; containment infrastructure facilities	WSP
Environmental and permitting	WSP
Cost update of the site restauration plan	WSP
Transportation of the concentrate to the port facilities	QIO/BBA
Port facilities	QIO/BBA

2.6 Qualified Persons

The qualified persons (QPs) responsible for the creation of this report are:

- André Allaire, P. Eng. – BBA Inc.
- Isabelle Leblanc, P. Eng. – BBA Inc.
- Pierre-Luc Richard, P. Geo. – BBA Inc.
- Mathieu Girard, P. Eng. – Soutex
- Philippe Rio Roberge, P. Eng. – WSP Canada Inc.

2.7 Site Visits

All qualified persons who worked on this study have visited the site either in the past or as part of this current mandate.

- Isabelle Leblanc visited during the week of September 24, 2018;
- Pierre-Luc Richard visited during the week of March 18, 2019;
- André Allaire visited during the week of May 28, 2018;
- Mathieu Girard visited during the week of March 18, 2019;
- Philippe Rio Roberge visited during the week of January 8, 2018.

3. RELIANCE ON OTHER EXPERTS

The authors have written this technical report using existing information gathered from previous studies and engineering design work undertaken for the Phase 1 and 2 operations, historical operational data from the Phase 1 concentrator, historical data from the operation of the Bloom Lake mine, technical field surveys and a metallurgical testwork campaign. The existing technical data and information was sourced from the document archives located at the Bloom Lake mine. The authors of this Report have not carried out a thorough review of each consultant's work. The sections provided for this Report were supplied by reputable consultants, and there is no reason to doubt the validity of the information.

BBA has not verified the legal titles of the Property nor any underlying agreement(s) that may exist concerning the licenses or other agreement(s) between third parties, but has relied on Quebec Iron Ore (QIO) for conducting the proper legal due diligence. The status of the mining claims under which QIO holds title to the mineral rights for the Bloom Lake project has been compiled and verified by QIO. The description of the property is provided for general information purposes only.

In defining the proposed mine design in Chapter 16, BBA has relied upon pit design slope profile recommendations provided by Golder Associates Inc. (Golder) as well as underground inflows for the Chief's Peak pit. Golder updated their historical geotechnical assessment (Golder, 2014) based on site experience gained from Phase 1 operations (Golder, 2019).

Technical evaluation and costing of the Phase 2 modifications related to the rail and port systems were sub-contracted to SYSTRA Canada (SYSTRA) and AXOR Experts-Conseils (AXOR) respectively. Technical reports were provided to QIO and reviewed by BBA for their integration into the Study.

Wood Mackenzie was retained by QIO to provide an updated product market study. Wood Mackenzie is a specialist economics consultant in the metals and mineral resources sector. They provide high-level or in-depth, independent advisory and consulting services, market analysis, and project reviews across a range of mineral and metals industries for resources and infrastructure companies, investment organizations, financial institutions, public sector enterprises, consultancies, and legal firms. The study provided by Wood Mackenzie is used as support of the iron ore selling price used in the Project economic analysis for this study as reflected in the financial analysis of Chapter 22.

For this Feasibility Study Report, BBA has performed the economic analysis on a pre-tax basis and has relied on QIO and its tax consultant to provide annual tax payment estimates for performing the post-tax economic analysis, as outlined in Chapter 22 of this Report. Any statements and opinions expressed in this document are given in good faith and in the belief that such statements and opinions are not false or misleading at the effective date of this Report.

4. PROPERTY, DESCRIPTION AND LOCATION

The Bloom Lake property is located in the Labrador Trough area straddling the border between Quebec and Labrador. There are several iron ore mines in the area including Mont-Wright owned by ArcelorMittal and Carol Lake owned by Iron Ore Company of Canada (IOC). Scully Mine, located in Labrador and once owned by Cliffs Natural Resources (Cliffs), ended its activities in 2014 and is now owned by Tacora Resources (Tacora). Tacora has recently reactivated operations at Scully Mine; the first train of concentrate from the concentrator arrived in Pointe Noire at the end of June 2019.

The Bloom Lake property is owned by Quebec Iron Ore (QIO). QIO has owned the property and the facilities at the Bloom Lake mining site since April 12, 2016.

4.1 Property Description and Location

The mining site is located in the north-eastern part of the province of Quebec, adjacent to the Labrador/Newfoundland border, in Normanville Township, Kaniapiskau County. The property is centred at latitude 52° 50’ North and longitude 67° 16’ West, 13 km west of the town of Fermont and 30 km southwest of the municipalities of Wabush and Labrador City (Figure 4-1).

All of the surface rights are property of the Crown, that is, the Federal Government of Canada.

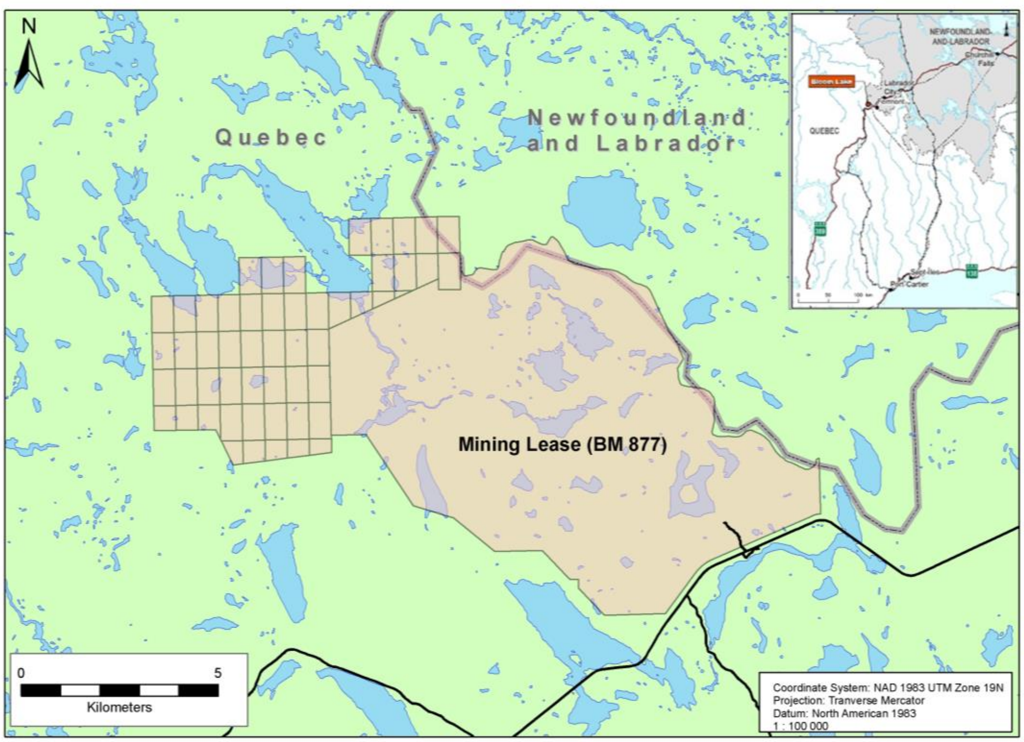


Figure 4-1: Property overview map

4.2 Mineral Titles

4.2.1 Nature and Extent of Issuer's Interest

As of May 2019, QIO holds 100% of 53 claims located north and northwest of the Mining Lease (BM877); these claims cover a total of 2,392.3 ha. The claims outside the mining lease are in good standing and are listed, with the Mining Lease, in Table 4-1.

Table 4-1: QIO Mining lease and claims

BM 877	CDC 99937	CDC 1133847	CDC 2082936	CDC 2082960
CDC 99894	CDC 99938	CDC 2082926	CDC 2082937	CDC 2082961
CDC 99895	CDC 99939	CDC 2082927	CDC 2082938	CDC 2082975
CDC 99902	CDC 99965	CDC 2082928	CDC 2082939	CDC 2082976
CDC 99903	CDC 99969	CDC 2082929	CDC 2082940	CDC 2082977
CDC 99910	CDC 99970	CDC 2082930	CDC 2082941	CDC 2082978
CDC 99911	CDC 99971	CDC 2082931	CDC 2082946	CDC 2082979
CDC 99918	CDC 99972	CDC 2082932	CDC 2082947	CDC 2082980
CDC 99919	CDC 1133844	CDC 2082933	CDC 2082957	CDC 2082981
CDC 99935	CDC 1133845	CDC 2082934	CDC 2082958	CDC 2188096
CDC 99936	CDC 1133846	CDC 2082935	CDC 2082959	

4.3 Royalties, Agreement and Encumbrances

There are no royalties, agreements or encumbrances on the mining site.

4.4 Permitting

The mine has already been authorized for operation under the federal environmental authority including the Department of Fisheries and Oceans (DFO) Canada, Transport Canada, Natural Resources Canada and Environment Canada.

Overall, a total of 38 certificates of authorization have been issued by the provincial government to the Bloom Lake iron mine in the past and the most relevant are listed in Table 20-1 in Chapter 20. Note that infrastructure such as the pit, waste rock piles, tailings management facilities and water management structure, as well as the treatment plant, have all been authorized. A few of these authorizations will require modifications to consider the new mine plan including the new waste rock dumps.

4.5 Other Significant Factors and Risks

There are no other known significant factors or risks that have not been disclosed in this report.

5. ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

5.1 Access

The mine site lies approximately 13 km west of the town of Fermont (central geographical coordinates 52° 50' N and 67° 16' W). A 5-km access road has been constructed to connect the Bloom Lake mine with Highway 389. It is accessible by road from Baie-Comeau on the north shore of the Saint Lawrence River, as well as by road from the Wabush airport in Newfoundland & Labrador. The Wabush airport is located approximately 30 km from the Bloom Lake mine. The mine site is located approximately 950 km northeast of Montreal.

The rail access to port consists of three separate segments. The first segment is the rail spur on site, consisting of a 31.9-km long segment that is operational and connects to the Quebec North Shore and Labrador (QNS&L) railway at the Wabush Mines facilities in Wabush, Labrador. This first segment belongs to QIO. The second segment employs the QNS&L railway from Wabush to Arnaud Junction in Sept-Îles. The third section is from Arnaud junction to Pointe-Noire (Sept-Îles), property of "*Les Chemins de Fer Arnaud*", Sept-Îles, Quebec, where the concentrate is unloaded, stockpiled, and loaded onto vessels. The third segment is owned by the SFPPN (*Société Ferroviaire et Portuaire de Pointe-Noire*), a limited partnership composed by the Government of Quebec through the *Société du Plan Nord* and other industrial partners. The assets were acquired by the SFPPN from Cliffs' CCAA. QIO is a current member of the SFPPN board of directors.

5.2 Climate (Source: Environment Canada)

The climate at Fermont is defined as sub-arctic with temperatures ranging from -40°C to +25°C. The prevailing winds are mostly from the west at an average speed of 14 km/h. Average daily maximum temperatures above freezing normally starts in April and falls below freezing by end of October.

5.3 Local Resources, Infrastructure

The town of Fermont has a population of 2,474 as per Statistics Canada, and is the residential town for employees working for ArcelorMittal's Mont-Wright mine operations. The town has all the required infrastructure to support employees and families who live there. QIO currently owns a total of 383 rooms in the town of Fermont distributed among the following installations:

- One house, fully furnished, located on rue Bougainville (with seven rooms);
- Four houses located on *rue des Mélèzes* (with five rooms each and built in 2012);

- Twenty-two (22) houses, fully furnished, located on *rue des Bâtisseurs* (12 with eight rooms each, six with seven rooms each and four with five rooms each and built in 2009);
- Two blocks (hotels) of 99 rooms of lodging located on *rue du Fer* (built in 2013);
- One multi-purpose complex that includes a cafeteria, a gym and recreational facilities.

Current accommodations are fully equipped with furniture, linen, and wiring for communications and entertainment and can house 383 people and provide a total of 1,800 meals per day. Additional infrastructure will be added as part of the Phase 2 project in order to house additional staffing.

The electrical power for the Project is supplied by Hydro-Québec from a T-tap off the 315 kV transmission line L3039 (Montagnais-Normand), which terminates in an existing 315-34.5 kV substation (Substation W), owned by QIO. The substation is located along Provincial Route 389 and includes 2 x 315-34.5 kV, 48/64/80 MVA, oil-filled power transformers. It feeds the existing concentrator plant and mine site via 34.5 kV distribution lines. The distribution lines will be modified, as described in further detail in Chapter 18, to meet the electrical needs of the power supply of the Phase 2 expansion and mine requirements. The modifications also provide an increased reliability of the site power supply.

5.4 Physiography

The topography of the claims' area is relatively hilly. The average elevation varies between 671 m and 762 m and the highest peaks culminate at about 808 m.

6. HISTORY

6.1 Prior Ownership and Exploration

In 1951, following the discovery of a cobalt showing at Bloom Lake, James and Michael Walsh staked claims for Mr. Bill Crawford of Sursho Mining Corporation (SMC). In February 1952, Quebec Cobalt and Exploration Limited (QUECO) was incorporated to acquire the claims held by SMC.

In 1952, a crew of six prospectors, under the supervision of Mr. K. M. Brown, began a program to prospect an area that included the Bloom Lake property. In June 1952, Mr. R. Cunningham, a mining geologist with Québec Metallurgical Industries, began to map the various cobalt occurrences at Bloom Lake. Although the results for cobalt were disappointing, several zones of magnetite-hematite iron formation (IF) were identified between Bloom Lake and Lac Pignac and were sampled. Further exploration was conducted in 1953.

In 1954, Cunningham supervised a program to investigate the iron occurrences through line cutting, geological mapping, and magnetometer surveys. In 1955, Jones and Laughlin Steel Corporation (J&L) optioned the property from QUECO. Cleveland-Cliffs Iron Company (CCIC) joined with J&L and conducted a diamond drill program from 1956 through 1957. Two drills were brought to the property and two series of holes, the "QC" and the "X" series, were drilled to test IF on the Bloom Lake property. Holes X-1 to X-11 (XRT - ¾" diameter core) amounted to 446 m and Holes QC-1 to QC-30 (AXT size 1.28" diameter core) totalled 4,769 m. The holes were largely drilled on sections of 800 ft to 1,000 ft apart (244 m to 305 m). Four of these drillholes were drilled on the west part of the property.

More drilling was conducted in 1966 by Boulder Lake Mines Incorporated, a subsidiary of CCIC, and Jalore Mining Company Limited (Jalore), a subsidiary of J&L. Holes X-12 to 20, totalling 175 m, and other holes were drilled as part of this campaign, but these were not on the present property. Some ground magnetometer surveying was also conducted in 1966. J&L's option on the property was terminated in 1968.

In 1971, exploration on the property was renewed by a QUECO-sponsored program that was managed by H. E. Neal & Associates Ltd. (HEN). The exploration program consisted of line cutting, geological mapping, gravity and magnetometer surveys, and diamond drilling in 1971 and 1972.

These holes were drilled to investigate the potential for IF beneath the amphibolite on the eastern side of the property. Nine drillholes were done in 1971 for a total of 1,834.23 m (341 samples) and 12 were drilled in 1972 (3,497.79 m and 341 samples). Eight of the drillholes were done on Bloom Lake West in 1971 and five were drilled in 1972. The mapping and magnetometer surveys were designed to fill in areas not previously surveyed. The gravity survey was conducted to help evaluate the potential for IF beneath the amphibolite.

In 1973, Republic Steel Corporation optioned the property and HEN prepared a "Preliminary Evaluation" of the property that consisted of currently held property and claims further to the west. This work was conducted until 1976. The evaluation included "mineral reserve" estimates, a metallurgical test program, and preliminary mine design. The mine design included pit outline, dump area, access roads, and railway spur. Dames and Moore prepared the mine design and "reserve" estimates. Lakefield Research (Lakefield) conducted the metallurgical testwork.

In 1998, a major exploration program was conducted by Watts, Griffis and McOuat (WGM) for QCM, which then held the Bloom Lake property under option from Consolidated Thompson-Lundmark Gold Mines Limited (CLM). QCM held the option on the property until 2001, but no work was conducted between 1998 and 2005. The 1998 program included line cutting, surveying, road building, camp construction, diamond drilling, geological mapping, mini-bulk sampling, bench-scale preliminary metallurgical testwork, preparation of a "mineral resource" estimate, camp demobilization, and site clean-up.

In 2005, CLM retained WGM to conduct a technical review, including the preparation of a mineral resource estimate for the Bloom Lake iron deposit to assist CLM in making business decisions and future planning. The technical review was prepared in compliance with the standards of NI 43-101 in terms of structure and content. The mineral resource estimate was prepared in accordance with NI 43-101 guidelines and CIM standards. In 2006, Consolidated Thompson-Lundmark Gold Mines Limited changed the name of the Company to Consolidated Thompson Iron Mines Limited (Consolidated Thompson). This name change reflected the Company's focus on iron ore mining and exploration.

From 2006 to 2007, Consolidated Thompson drilled 17 drillholes (2,884.36 m) on the site of the future pit in order to get a sample for metallurgical testwork. The Lakefield laboratory performed these tests. In 2006, bulk sampling took place in the area of the future pit.

Overall, 243 drillholes were made between 1957 and 2009 for a total of 45,386 m and 273 drillholes in 2010, 2012 and 2013 for a total of 89,197 m. Four geotechnical holes were drilled in 2014. The complete description of the drill programs are described in Chapter 10.

The construction of the Bloom Lake mining started in 2008 and the plant was commissioned by Consolidated Thompson Iron Mines Limited in December 2009.

Almost immediately after start-up, Consolidated Thompson started a feasibility study to double the Bloom Lake site production by the addition of a second concentrator. The study was completed in June 2010 and the construction of the Phase 2 concentrator started in Q4 of 2010 under CLM and continued after the acquisition of the Bloom Lake site by Cliffs Natural Resources (Cliffs) in May 2011.

The Phase 2 concentrator construction was halted in November 2012 due to falling iron ore prices. Operations at the Bloom Lake site were halted in December 2014 due to the declining iron ore concentrate prices and high operating costs.

On April 12, 2016, Champion Iron Mines Limited acquired the Bloom Lake assets in a CCAA proceeding and restarted the operations on February 16, 2018.

6.2 Operations Under Current Ownership

Operations at the Bloom Lake site were resumed in February 2018 after completing major modifications to the beneficiation circuit as well as to other parts of the site with the aim to increase concentrate production while ensuring a low production cost. The site achieved a concentrate production of 6,994,500 wet metric tons for its first full year of operation (fiscal year ending March 31, 2019).

6.3 Historic Production

Table 6-1 shows the historical mining extraction and concentrate production from 2010 to 2019 in dry metric tons per year unless otherwise stated.

Table 6-1: Production at the Bloom Lake Mine from 2010 to 2019

	2010	2011	2012	2013	2014[1]	2015 to 2017	2018 [2] [3]	2019 [2] [3]
Iron ore mined	10.3	16.9	17.0	17.6	19.3	0	2.7	19.7
Iron ore processed	8.2	15.6	15.8	18.4	18.9	0	1.8	18.5
Iron ore concentrate production	3.2	5.5	5.5	5.9	5.9	0	0.6	7.0

[1] Production halted in mid-December 2014.

[2] Fiscal years ending on March 31, 2018 and 2019 respectively.

[3] Values provided are in wet metric tons.

7. GEOLOGICAL SETTING AND MINERALIZATION

7.1 Regional Geology

The Bloom Lake Iron Deposit lies within the Fermont Iron Ore District (FIOD), a world-renowned iron-mining camp at the southern end of the Labrador Trough within the geological Grenville Province. The Labrador Trough extends along the margins of the eastern boundary of the Superior-Ungava craton for more than 1,200 km and is up to 75 km wide at its central part. The Bloom Lake deposit, including the Bloom Lake West property, is located within the Parautochtonous Deformation Belt of the Grenville Province of the Canadian Shield, just south of the Grenville Front. The Grenville Front, the northern limit of the Grenville Province, truncates the Labrador Trough, separating the Churchill Province greenschist metamorphic grade part of the Labrador Trough rocks from their highly metamorphosed and folded counterparts in the Grenville Province.

The western half of the Labrador Trough, consisting of a thick sedimentary sequence, can be divided into three sections based on changes in lithology and metamorphism (north, central and south). The Trough is comprised of a sequence of Proterozoic sedimentary rocks including iron formations (IF), volcanic rocks and mafic intrusions known as the Kaniapiskau Supergroup. The Kaniapiskau Supergroup consists of the Knob Lake Group in the western part of the Trough and the Doublet Group, which is primarily volcanic, in the eastern part. The Kaniapiskau Supergroup within the Grenville Province is highly metamorphosed and complexly folded. It was named Gagnon Group before correlations were made between sequences located on each side of the Grenville Front. It occurs as numerous isolated segments. From the base to the top, it includes a sequence of gneisses and schists, a group of chemically precipitated sediments, and more schists, including some distinctive aluminous varieties. Gabbro sills intrude parts of the sequence, and granites are found in the gneiss.

The Central or Knob Lake Range section extends for 550 km south from the Koksoak River to the Grenville Front located 30 km north of Wabush Lake. The principal iron formation unit, the Sokoman Formation, part of the Knob Lake Group, forms a continuous stratigraphic unit that thickens and thins from sub-basin to sub-basin throughout the fold belt.

Iron deposits in the Grenville part of the Labrador Trough comprise Bloom Lake, Lac Jeannine, Fire Lake, Mont Wright and Mount Reed, and the Luce, Humphrey and Scully deposits in the Wabush area. The high-grade metamorphism of the Grenville Province is responsible for recrystallization of both iron oxides and silica in primary iron formation, producing coarse-grained sugary quartz, magnetite, specular hematite schists (meta-taconites) that are of improved quality for concentrating and processing.

Figure 7–1 shows the simplified geological map of the Labrador Trough.

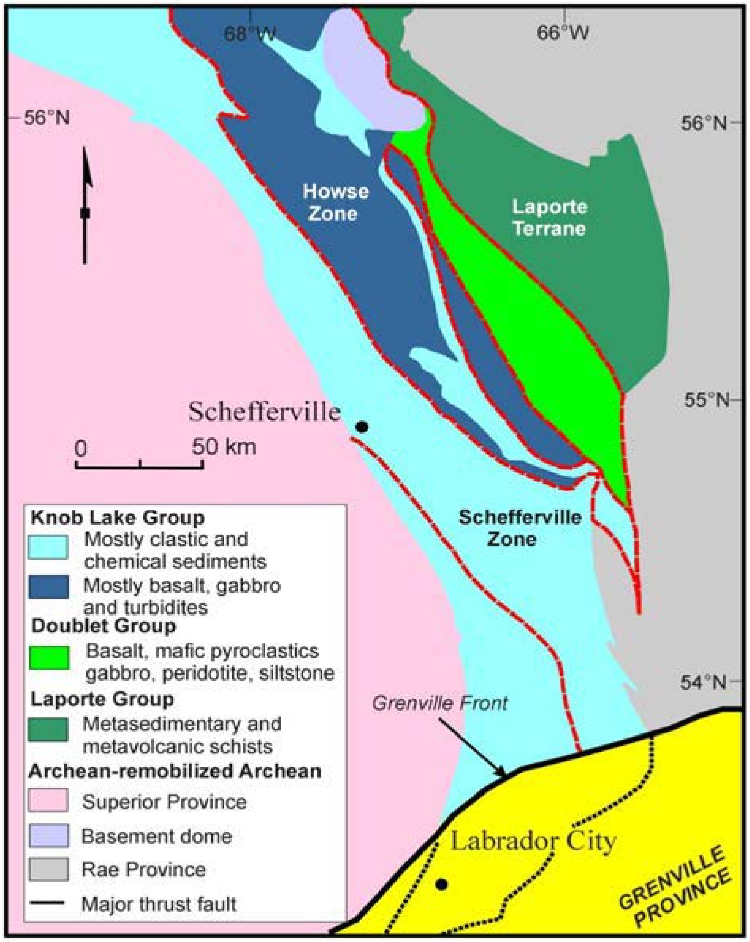


Figure 7–1: Simplified geological map of the Labrador Trough (Gross, 2009)

In the region, at least two stages of deformation are recognized. The first stage produced linear belts that trend northwest, like the well-defined structural trends in the central part of the Labrador geosyncline; the second stage formed linear belts that trend east to northeast, parallel with the major structural trends developed in the Grenville Province. Folds now present both stages of deformation in form and orientation. For example, in the Wabush Lake area, folds trend N20°E and in the central part of the area, around Lamelee Lake and Midway Lake, they trend N35°W. Isoclinal and recumbent folds overturned to the west or southwest are common, and it is inferred that this deformation produced thrust faults striking northwest and dipping east. Structures developed during the earlier stage of deformation are believed to have been similar to those now seen in the central part of the Labrador geosyncline, and it is highly probable that the structures produced by this early stage of deformation, in the south and those in the central and northern regions, were the result of the same orogeny.

The second stage of structural deformation took place during the Grenville orogeny between 0.8 and 1.2 Ga years ago. Its effects are not so intense north of Wabush Lake near the margin of the Grenville belt as they are throughout the region to the south. Near the margin of the Grenville belt, cross-folds trending east or northeast appear to be superimposed on the earlier northwest-trending structures. Around Mont Wright and farther south, the trend of the overall structure is east to northeast and the prevailing dip of foliation is 55°N. Tightly folded and faulted structures developed during the earlier stage of deformation were further deformed by folding and faulting during the Grenville orogeny. Oblique sections through the resulting complex fold structures are exposed at the present erosion surface. Many of the minor folds appear to plunge steeply to the northwest, but the axes of these folded folds are not straight for any appreciable distance.

Regional structures developed during the Grenville orogeny play out against the stable craton area of the ancient Superior Province. Folds and faults along the northwest margin of the Grenville Province trend west, and the general pattern of folds overturned to the south or southeast formed in conjunction with north-dipping reverse faults indicates overriding of the northerly blocks towards the southeast. The relative amount of movement between adjacent fault blocks is suggested by the position of iron formation in local structures. At Bloom Lake, iron formation is present in a relatively simple syncline that extends to a much greater depth than that in the Boulder Lake basin situated at the north. Still farther south at Mont Wright, the erosion surface cuts the upper part of steeply plunging folds. Southeast froms the margin of the Grenville belt, the dips of westerly striking faults are progressively less steep, and the greatest amount of movement appears to have taken place between the Bloom Lake fault block and the Mont Wright block.

The iron formation and associated metasedimentary rocks, which were derived from an assemblage of continental shelf-type sediments, do not appear to extend south beyond a line trending northeast from the Hart-Jaune River linear to Plaine Lake and northeast to Ossokmanuan Lake. Granite-gneisses, charnockites and anorthosites are part of the rock assemblage south of this line. These typical deep-seated Grenville rocks may have been thrust northwest along a system of faults that coincide with this line. The large suite of gabbro intrusions in the area between Wabush Lake and Ossokmanuan Lake were probably intruded along faults in this linear zone.

7.2 Local Geology

7.2.1 General

The geology and geological interpretations for the Bloom Lake property are based on data from a number of sources. These sources include the diamond drilling and mapping done on the property as part of the 1998 program, presented by Watts, Griffs and McOuat in 2005, as well as the drilling conducted in 1956, 1957, 1967, 1971, 1972 and 2007-2014 programs. The geological interpretation relies heavily on the mapping programs conducted in 1952 and the ground magnetic surveys carried out in 1967 and 1971/72 as compiled in 1973 and the survey done in April 2008. The calculated magnetic vertical gradient in the Bloom Lake area is presented in Figure 7–2.

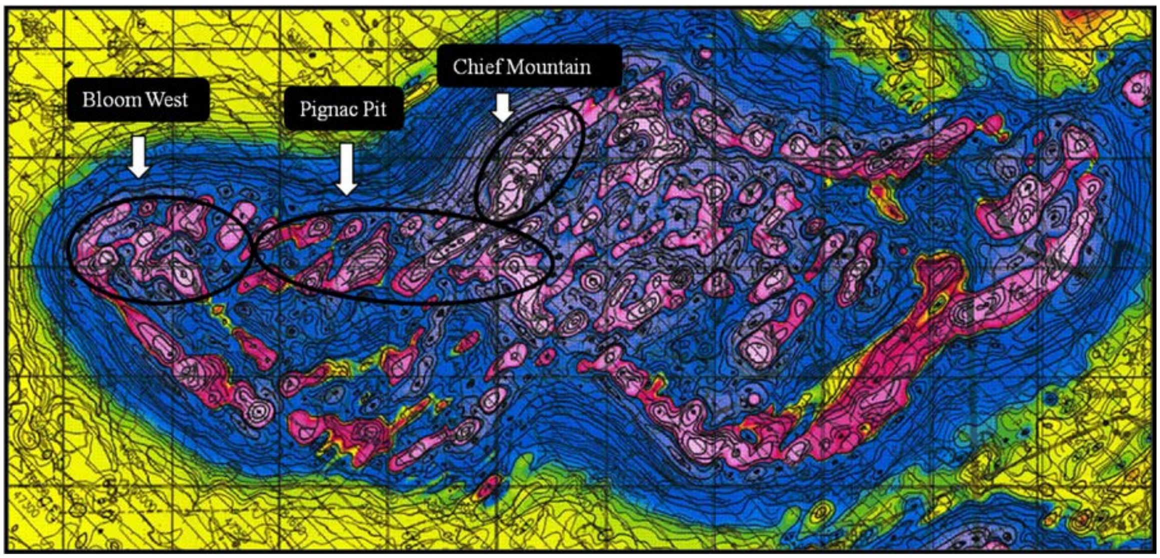


Figure 7–2: The calculated magnetic vertical gradient in the Bloom Lake area

The following local geology description and structural interpretation are mostly from Rioux (2009).

Several rock type codes are hybrid codes of the main rock types and are not described separately. Iron formations are described in Section 7.3 of this chapter.

Gneiss (GN)

With the current knowledge, gneiss constitutes the basic unit for metasedimentary rocks. This rock presents a typical banding varying from 1 cm to 2 m. Most of its composition is mafic and the felsic bands are dominated by feldspars with quartz in minor quantity. Biotite is abundant through the gneiss and many transitions to mica schists occur. The gneiss contains less mica but more feldspar and quartz than QRMS (see below). The basal QRMS sequence consists mostly of muscovite and biotite schist with characteristic porphyroblasts of garnet and feldspar.

Quartz Rock (QR) and its Related Variant Quartz Rock Iron Formation (QRIF)

QR is used to define a rock type consisting mostly of quartz, 95%+, vitreous, grey or pinkish colour, with minimal to no specularite and/or magnetite content. This material may have been derived from chert, quartzite or quartz pebble conglomerate and the various textural varieties are not distinctly coded or distinguished.

QRIF intervals were defined on the basis of a quartz dominant rock containing less than 15% of total iron, but containing some iron in the form of specularite and/or magnetite or silicate. QRIF is therefore a rock often transitional between IF and QR, or SIF and QR. The QRIF may contain minor actinolite-SIF.

Quartz Rock Mica Schist (QRMS)

It is used mainly for the schist sequence at the base of the IF sequence beneath the QR unit. QRMS has occasionally, however, been used for coding thin mica-rich units within the IF sequence.

Silicate Iron Formation (SIF)

Two main types have been recognized on the property. One of them is dominated by actinolite, while in the other, grunerite is most prevalent. The two types can be transitional into one another and likely there is also some tremolite-rich SIF present. The IF in these areas is also often enriched in magnetite as compared with specularite. These units are less abundant in the west part of the property than in the eastern half of the Bloom Lake pit area and Chief’s Peak.

Amphibolite (AMP)

It is dominantly a competent, dark green to black, medium to coarse grained rock consisting mainly of hornblende, biotite and feldspar. This rock is relatively homogeneous and marked by a very pronounced foliation. Grain size varies widely. The occurrence of millimetric reddish garnet is observed over distances of 10 m. The amphibolite-IF contacts are sharp. A narrow argillized zone of amphibolite often occurs immediately above the IF contact.

Gabbro

Bodies of medium-grained gabbro and amphibolite stand as hills among the quartz-bearing rocks of the Gagnon Group. They were apparently injected into the competent rocks during deformation and themselves remobilized during the later stages of metamorphism. The gabbro was originally ophitic in texture with speckled textures into foliated amphibolite. Gabbro is more common in the northern part of the injected zone and amphibolite is more present in the southern part. In places, gabbro cores remain in the centre of thick amphibolite sills. The typical gabbro of this type contains 40% to 50% plagioclase with other mafic minerals (olivine, hypersthene) and a few percent of opaque oxides.

7.2.2 Structural Geology

The Bloom Lake deposit comprises gently plunging synclines on a main east-west axis separated by a gently north to northwest plunging anticline. One of these synclines is centred on Triangle Lake, while the centre for the other is located just north of Bloom Lake. The Bloom Lake property is centred primarily on the eastern syncline but covers a portion of the northern limb of the western one.

These synclines are the result of a minimum of two episodes of folding and are of regional scale.

In addition to these regional scale folds, which have created the large-scale shape of Bloom Lake deposit, there are several other folds of diverse orientation on the property. It is not clear if all folding directions represent distinct folding episodes or progressive change in fold orientation with time.

Clearly visible on the ground magnetic survey map, a major discontinuity oriented north-northeast can be seen in the central portion of the west part. In drillhole, many zones of gravel, gouges, muddy and brecciated are clearly associated with it, suggesting a fault zone. More so, difficulties in correlating orebodies on each side of the possible fault strongly militate in that direction.

Also, thorough interpretation of geomorphic lineaments from aerial photographs demonstrates a north-northeast tendency, it is important to note that Triangle Lake and associated stream configuration suggest a north-northwest discontinuity associated with the north-northeast one.

7.3 Mineralization

The Bloom Lake deposits are about 24 km southwest of Labrador City and about 8 km north of the Mont Wright range. The western 6 km of this range contains very large reserves of specular hematite-magnetite iron formation in a synclinal structure that is regarded as a southwest extension of the Wabush Lake ranges.

The iron formation and quartzite are conformable within a metasedimentary series of biotite-muscovite-quartz-feldspar-hornblende-garnet-epidote schists and gneisses in a broad synclinal structure. This succession, following the first stage of folding and faulting, was intruded by gabbroic sills that were later metamorphosed and transformed into amphibolite gneiss with foliation parallel with that in adjacent metasediments. Two separate iron formation units are present; these join northwest of Bloom Lake, but are separated by several dozen metres of gneiss and schist in the southern part of the structure. Quartzite, present below the upper member throughout the eastern part of the area, pinches out near the western end. Folded segments and inclusions of iron formation in the central part of the syncline, which are surrounded by amphibolite, are in most cases thought to be part of an overlying sheet that was thrust over the main syncline during the first period of deformation. The large amphibolite mass in the central part of the area was apparently emplaced along the zone of weakness created by this early thrust fault.

Iron formation in the western 5 km to 6 km of the structure is predominantly thehematite-quartz facies that form the major zones of potential ore. The hematite is of the specularite type and has a silvery-grey colour and is non-magnetic. It is most often occurring as anastomosing to discontinuous stringers and of bands less than 10 cm thick in a quartz or actinolite-quartz matrix. Bands tend to be folded and deformed but also can be regular and tabular. Quartz is milky and granular.

Magnetite is scarce and typically occurs in narrow millimetric veinlets associated with quartz-carbonate veining material. The crystals are sub- to euhedral and demonstrate the typical dull to sub- metallic luster. When associated to hematite-enriched mineralization, the magnetite occurs as blebs of porous grains, often granoblastic, that may extend up to several centimetres. Enriched magnetite horizons are mostly found, but not always, in the upper portion of the iron formations in close contact with the amphibolite mass.

With the actual state of geological knowledge in the western sector of the Bloom Lake deposit, magnetite-rich IF is less important in volume than in the eastern half of the Bloom Lake pit area. The thickness of drillhole intercepts is lower than 10 vertical metres. Many drillholes did not return significant magnetite intersections. Very few actinolite or grunerite minerals associated with magnetite mineralization were described in the western holes.

A fairly abrupt change in facies takes place along strike east of a line passing northwest across Bloom Lake, east of where the grunerite-Ca-pyroxene-actinolite-magnetite-carbonate facies predominates.

The lower unit is less than 30 m thick in some places and is considerably thinner than the upper unit. The iron content ranges from 32% to 34% in this facies. In places, the silicate facies to the east contain more than 50% cummingtonite, which in part is magnesium rich, and the manganese content ranges from 0.1% to more than 2.0%. Mueller (1960) studied the complex assemblage of minerals in this rock and discussed chemical reactions during metamorphism in considerable detail. He has shown that a close approach to chemical equilibrium in the amphibolite metamorphic facies is indicated by the orderly distribution of Mg, Fe and Mn among coexisting actinolite, Ca-pyroxene and cummingtonite, and the restriction in the number and type of minerals in association with each other. Furthermore, a comparison between the composition of the silicates and the presence or absence of hematite shows that the Mg to Mg plus Fe ratio is increased, but is much less variable when hematite is present.

Re-modelling of the deposit in 2014 added two new domains in the ore classification (MAG – Magnetite Iron Formation and WSIF – Grunerite-rich Iron Formation) in addition to the existing HEM (Hematite Iron Formation) and SIF (Silicate Iron Formation).

The iron formation forms a long doubly plunging syncline that is canoe-shaped but buckled across the centre to produce two distinct oval-shaped basins. Although this structure appears to be relatively simple in form, it seems to have been developed during two stages of deformation. Folding along northwest-trending axes and overthrusting of the upper iron formation during the first stage of deformation appear to have been followed by gabbro intrusion, folding along east-west axes, faulting, and metamorphism during the Grenville orogeny.

8. DEPOSIT TYPES

Bloom Lake property mineralization style is a deposit typical of the Superior-Lake type.

The peaks in iron sedimentation took place between ~2.65 and 2.32 Ga and again from ~1.90 to 1.85 Ga. Their deposition is linked to the geochemical and environmental evolution of the planet such as the Great Oxidation Event (GOE) at ca. 2.4 Ga, the growth of continents, as well as the mantle plume activity and rapid crustal growth (see Figure 8–1).

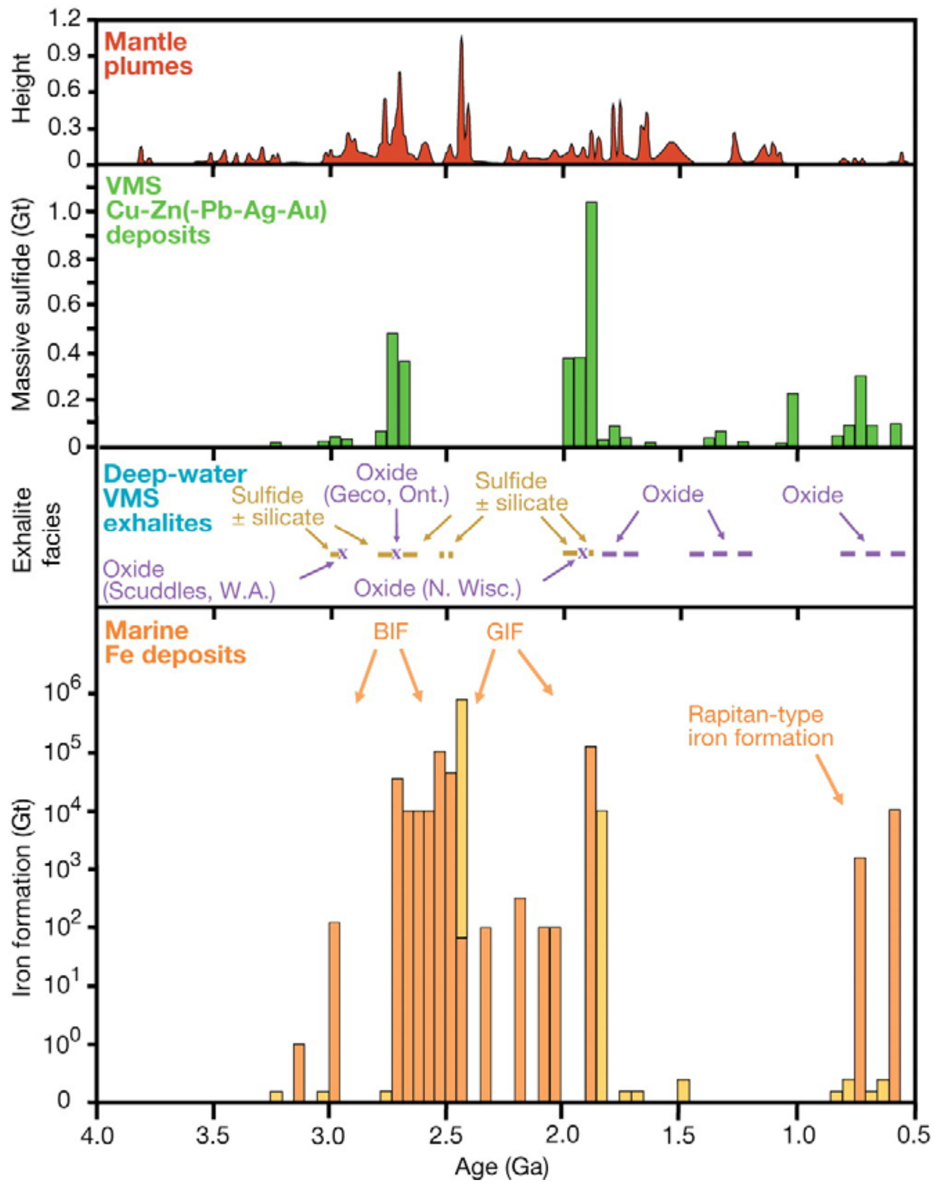


Figure 8–1: Time distribution of the iron formation deposition (Bekker et al., 2011)

The Labrador Trough contains four main types of iron deposits:

1. Soft iron ores formed by supergene leaching and enrichment of the weakly metamorphosed cherty iron formation (IF); they are composed mainly of friable fine grained secondary iron oxides (hematite, goethite, limonite).
2. Taconites, the fine-grained, weakly metamorphosed iron formations with above average magnetite content; they are commonly called magnetite iron formation.
3. More intensely metamorphosed, coarser-grained iron formations, termed metataconites that contain specular hematite and subordinate amounts of magnetite as the dominant iron minerals.
4. Minor occurrences of hard high-grade hematite ore occur southeast of Schefferville.

Secondary enrichment included the addition of secondary iron and manganese that appear to have moved in solution and filled pore spaces with limonite-goethite. Secondary manganese minerals, i.e., pyrolusite and manganite, form veinlets and vuggy pockets. The types of iron ores developed in the deposits are directly related to the original mineral facies. The predominant blue granular ore was formed from the oxide facies of the middle iron formation. The yellowish-brown ore, composed of limonite-goethite, formed from the carbonate-silicate facies, and the red painty hematite ore originated from mixed facies in the argillaceous slaty members.

All iron ore deposits in the Labrador Trough formed as chemical sediments on a continental margin that were lithified and variably affected by alteration and metamorphism that had important effects on grade, mineralogy and grain size. Faulting and folding led to repetition of sequences in many areas, increases the surface extent and mineable thicknesses of the iron ore deposits. Underlying rocks are mostly quartzite or mica schist. Transition from these rocks and the mineralized iron formation may happen up to over 10 m vertically. All rock sequences have been heavily metamorphosed by intense folding phases that are part of the Grenville Orogen.

IF sequences range commonly from 25% to 40% iron oxide, mainly hematite of the specularite type with minor amount of magnetite (remainder mostly quartz) and can have thicknesses (ignoring minor intercalated bands of schist and quartz rock) of up to 200 m. These are the sequences that are of economic importance.

For iron formation to be mined economically, the iron content must generally be greater than 30%, but also iron oxides must be amenable to concentration (beneficiation) and the concentrates produced must be low in manganese and deleterious elements such as silica, aluminum, phosphorus, sulphur and alkalis. For bulk mining, the silicate and carbonate lithofacies, as well as other rock types interbedded within the iron formation, must be sufficiently segregated from the magnetite. Iron formations repeated by folding are often required to produce sufficiently thick sections for mining in the Mont Wright / Wabush area.

9. EXPLORATION

This chapter of the report will briefly describe all relevant exploration work other than drilling conducted by Quebec Iron Ore on the Bloom Lake project from March 17, 2017 (corresponding to the effective date of the previous NI 43-101 Technical Report on the Bloom Lake Mine Restart Feasibility Study) to January 1, 2019. The complete description of the drill programs is described in Chapter 10.

9.1 2018 Magnetic Survey

During the summer of 2018, a drone-born magnetic survey was done on some of the Quebec Iron Ore claims north and west of the Bloom Lake Mining Lease (Figure 9-1). The survey was done with a 50-m line spacing to the north and 100 m line spacing to the west. The decision to switch from 50 m to 100 m was made in order to cover as much ground as possible as the fall weather was settling in. The survey was not completed as planned, but is scheduled to be resumed during summer of 2019.

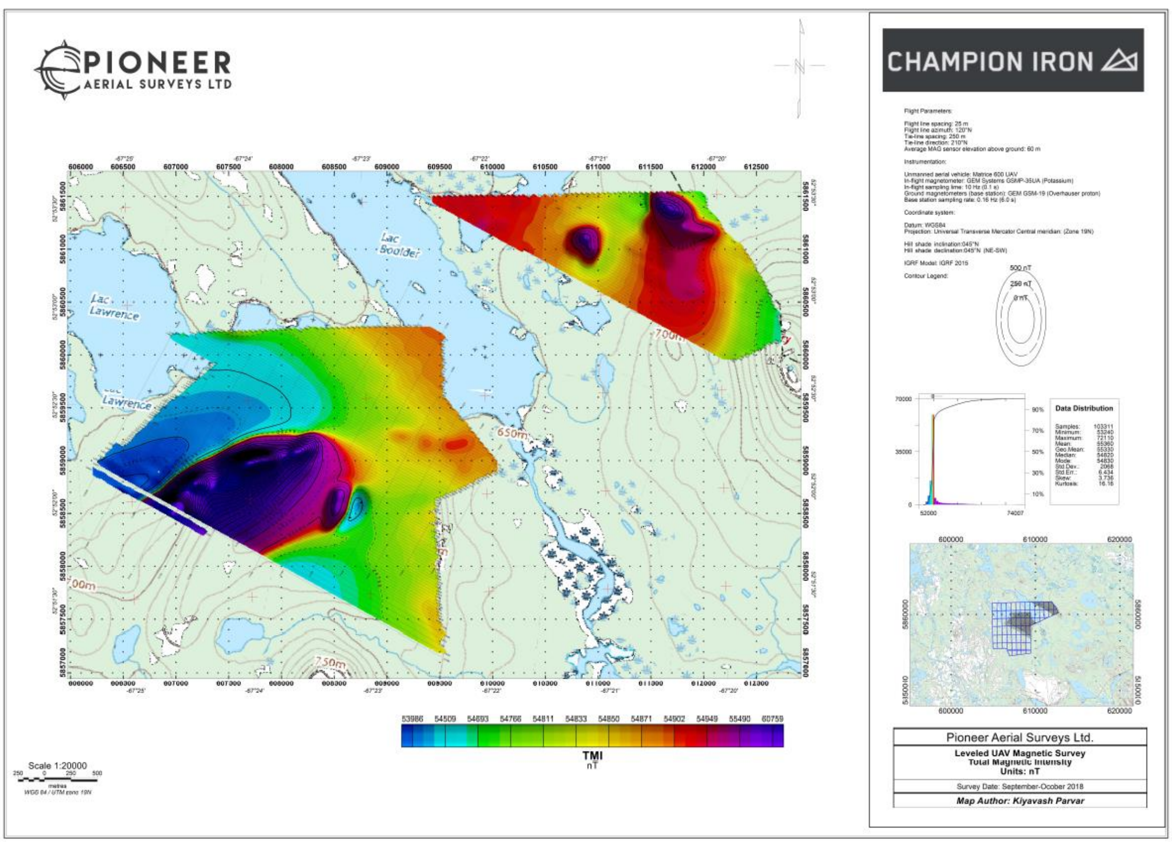


Figure 9-1: Plan view of the magnetic survey conducted in 2018

9.2 2018 Database Standardization

The restart of the Bloom Lake mining operation provided the opportunity to review and homogenize the lithological descriptive codes. This was required due to major discrepancies between exploration, production and drill and blast databases as well as between various drilling programs throughout the years.

The rock names and chemical limits for the different types of mineralization were preserved as often as possible, but the numerical codes were modified, and a more systematic approach was implemented. As shown in Table 9-1, all the mineralization related codes now start with “2” (200 series) with the oxide-rich mineralization having “0” as a second digit (20x), and the silicate mineralization having “1” as the second digit (21x). The limonite mineralization has “2” as the second digit (22x). The third digit adds an extra layer of information in regard to the mineralogy.

The same logic was used for unmineralized material where the first digit “3” indicates unmineralized material, the second digit represents the type of material and the third digit represents mineralogical or textural details. Table 9-1 summarizes the new lithological codification throughout the years and various databases.

This review made it significantly more convenient for the use of macro-commands in the block-modelling software.

Table 9-1: Lithological codification throughout the years and various databases

Description	Rock Type (current)	Rock_Code (current)	Rock Type (Cliffs era)	Rock_Code (Cliffs era)	Rock Code Phase 1 FS
Iron Formation (undiff.)	IF	200	IF/IF-PKJ/PKJ	200, 214	20
Oxides Iron Formation	OIF	201	OIF	210	20
Hematite Iron Formation	IFH	202			20
Magnetite Iron Formation	IFM	203	IFM	212	21
Low grade Iron Formation (<15% Fe)	QRIF	204	QR/QRIF	213	31
Geothite Iron Formation	IFG	205			
Hematite-silicates Iron Formation (4% < Cao+Mgo < 6%)	IFHS	208			
Magnetite-silicates Iron Formation (4% < Cao+Mgo < 6%)	IFMS	209			
Silicates Iron Formation	SIF	210	SCIF/SIF	220	23
Actinolite Iron Formation	SIFA	211	SIFA	222	24
Grunerite Iron Formation	SIFG	212	GIF/GSIF/SIFG	221	25
High Silicates Iron Formation (>12% Cao+Mgo)	WSIF	213	WSIF	223	34
Fine-grained Limonitic Mineralization	LIMO	221	LIMO	42	22
Quartzite (<5% Fe)	QR	330	QR	30	30
Quartz-Mica Schist	QRMS	331	QRMS/QR-GN	31	32
Mica Schist	MS	332	MS	32	33
Amphibolite	AMP	340	AMP	40	40
Gabbro	GAB	341	GAB	41	40
Argilite	ARG	342	FAI	42	22
Gneiss	GN	350	GN/GNF/GNM	50	50-51-52
Marbe	MAR	360	DOL	60	360
Core Lost	CNR	390	CNR	999	60
Overburden	OB	391	MT	10	10
Mine Waste or Filling	REM	392			
Casing	CAS	393			
Air	AIR	399			99

10. DRILLING

This chapter summarizes the drilling completed on the Property by Quebec Iron Ore during the 2018 drilling program from February to June 2018. The complete drilling database consists of 569 surface drillholes from historical and recent drilling programs that occurred between 1957 and 2018 for a total of 141,288 m. Historical drilling information dated before the 2018 campaign may be referred to in the 2017 Technical Report on the Bloom Lake Mine Re-Start Feasibility Study (Ausenco, 2017).

10.1 2018 Drilling Program

In 2018, 36 holes totalling 4,938.3 m were drilled. The holes are listed in Table 10-1.

Table 10-1: 2018 drilling program

Hole-ID	UTM Easting	UTM Northing	Elevation	Final depth	Dip	Azimuth
BL-18-01	615,025.00	5,854,295.00	799.25	197	-60	180
BL-18-02	614,875.10	5,854,200.00	808.82	190	-60	180
BL-18-03	614,874.90	5,854,093.00	806.18	133	-50	180
BL-18-04	614,575.10	5,854,194.00	811.14	212	-60	180
BL-18-05	614,375.10	5,854,249.00	796.18	187	-50	180
BL-18-06	614,374.90	5,854,363.00	802.13	262	-55	180
BL-18-07	614,085.90	5,854,436.00	775.21	241	-55	180
BL-18-08	613,849.80	5,854,497.00	763.91	122	-55	180
BL-18-09	614,945.00	5,854,139.00	799.99	136	-60	180
BL-18-10	615,625.00	5,855,304.00	703.43	70	-55	360
BL-18-11	615,625.00	5,855,302.00	703.43	230	-60	180
BP-18-01	614,425.00	5,855,240.00	704.00	112	-50	0
BP-18-02	614,500.00	5,855,250.00	704.00	241	-50	0
BP-18-03	614,590.00	5,855,290.00	690.00	91	-60	0
BP-18-04	614,950.00	5,855,300.00	704.00	140	-90	0
BP-18-05	615,325.00	5,855,150.00	704.00	205	-45	0
BP-18-06	615,400.00	5,855,250.00	704.00	165	-50	0
BP-18-06A	615,400.00	5,855,250.00	704.00	142	-60	180
BP-18-07	615,475.00	5,855,350.00	704.00	133	-50	0
BP-18-08	614,603.00	5,855,365.00	704.00	130	-60	0
BP-18-09	614,425.00	5,855,414.00	704.00	73	-60	0
BP-18-10	615,625.00	5,855,440.00	718.00	151	-60	0

Hole-ID	UTM Easting	UTM Northing	Elevation	Final depth	Dip	Azimuth
BP-18-11	615,099.90	5,855,358.00	691.39	117	-60	0
BP-18-12	615,174.90	5,855,391.00	691.15	57	-59	0
BP-18-13	615,249.80	5,855,392.00	691.46	72	-68	0
BP-18-14	615,325.00	5,855,400.00	690.00	87	-63	0
BP-18-15	615,399.30	5,855,362.00	691.68	48	-74	0
BP-18-15A	615,399.30	5,855,362.00	691.68	116	-74	0
BP-18-16	615,250.00	5,855,330.00	691.57	99	-90	0
BP-18-17	615,174.90	5,855,330.00	691.20	117	-90	0
BP-18-18	614,499.80	5,855,398.00	706.11	132	-75	0
BP-18-19	614,575.00	5,855,415.00	704.00	117	-85	0
BP-18-20	614,665.00	5,855,389.00	691.62	108	-65	0
BP-18-21	614,799.90	5,855,390.00	678.67	90	-62	0
BP-18-22	614,950.10	5,855,365.00	679.90	108	-57	0
BP-18-23	614,758.10	5,855,375.00	692.52	108	-50	0

10.1.1 Drilling Results

Results for the 2018 drill program were pending during the preparation of the block model for the current resource estimate.

Partial results (180 out of 471) were received during the redaction of this Report confirming that the mineralized zones were actually mineralized with significant grades above the cut-off grade, hence confirming the model.

The QP has not been provided with all the results, therefore conclusions herein are based on limited information.

10.2 Drilling Methodology

10.2.1 Drillhole Location / Set-up

The holes were collared on-site with a portable Garmin GPS. This position could vary from a few metres to accommodate drilling, depending on the ground conditions, but still maintain the relative position and spacing relative to the other holes.

10.2.2 Drillhole Orientation at Start-up

Drilling azimuth reference was provided through calculation of points of coordinates. The traditional use of a compass was not recommended due to the high level of magnetism developed by some horizons of the underlying iron formations.

10.2.3 Downhole Deviation Tests

Deviation and inclination tests were carried out in the holes. A Flexit instrument was used to measure both orientation and inclination of all the drillholes. This instrument provided useful magnetic susceptibility values.

Readings were taken every 15 m to 30 m with an overall average of 24.6 m. All the data obtained with the Flexit instrument were analyzed and all the inappropriate data were eliminated if deviation was too large and/or if the magnetic susceptibility was too high.

10.2.4 Coring

Drill cores are provided by the Drilling Contractor in NQ size (47.6 mm). The core is collected in a standard drilling tube and the drillers place the core into wooden core boxes. The driller marks the depth in metres (m) after each run, usually every 4 m.

The drillhole is terminated by the Bloom Lake site geologist once the targeted depth is reached and the core at the drill site is reviewed with respect to target lithologies, alteration and mineralization.

Once the drillhole is terminated and the final downhole survey reading collected, the drill crew pulls the rods for mobilization to the next drill site.

Casings can be left in the hole, but are usually removed.

10.2.5 Collar Surveying

All the drillhole collars were surveyed in-house by the mine site surveying team. Surveyors used a Trimble R8 instrument to survey the drillhole collars. Survey measurements were precise to three decimals, but for unexplained reasons, some of the recent hole coordinates were rounded to the nearest integer before importing the data into Surpac.

The inclination and direction of the drill collars were measured using a clinometer and then the direction was verified against Flexit readings for most holes.

10.2.6 Core Handling

At the drill rig, all the used core boxes were carefully closed with tape and were transported by either snowmobile or ATV to a pick-up truck that brought them to the core shack at the end of each shift. No core boxes were left outside the core shack.

The core shack was established inside an industrial dome on site used for various purposes. The author was able to visit the core shack during his site visit. In the core shack area, a number of inclined tables were installed for core logging with several core racks for boxes storage. An area was also organized for sampling.

All the boxes were labelled, photographed in lots of five and most of them were photographed in detail, three to four pictures being taken for each box. The core boxes were systematically measured to validate the marks of the drillers. Measuring was also done to calculate the rock quality designation (RQD) and the core recovery.

10.2.7 Core Logging

The core was logged using standard methods. Rock types were identified and intervals were measured according to the marks done by the drillers. Geological logging took into account the general colour of the rock, the relative percentage of constituents, the grain size distribution, the alteration, the contact with other rocks, the texture and the variation of these elements, when significant. A particular attention was given to the orientation of foliations relative to the core axis. Geotechnical features in the core, such as RQD were noted.

The mineralized units to be sampled were marked with a grease pencil at 3 m to 6 m intervals, depending on the mineral content, with some exceptions as low as 1.25 m and as long as 15 m.

10.2.8 Core Storage

The core was stored at the mine site, underneath the snow at the time of the author's site visit.

11. SAMPLE PREPARATION, ANALYSES AND SECURITY

11.1 Sampling Methods

11.1.1 Assay Samples

11.1.1.1 Sampling (Core Sample Selection)

In general, only mineralized intervals are sampled. The iron content of samples must be equal to or greater than 15%. This estimate is done visually by the person core logging.

The two factors that are taken into consideration are the grade cut-off for samples and the length of the samples. Samples are taken before, through and after the potentially mineralized zone.

To create representative and homogenous samples, sampling honours lithological contacts. The protocol states that the minimum sample interval in the hole will not be less than 1.0 m. The maximum sample interval will not exceed 6.0 m. No sample will cross a major rock boundary, alteration boundary or mineralization boundary.

Sampling intervals are determined by the geologist during logging and marked on the core boxes or on the core itself using coloured lumber pencils with a line drawn at right angles to the core axis.

The sample sequence includes blank samples and duplicate samples that are inserted into the sample stream using sample numbers that are in sequence with the core samples. No Standard Reference Materials (SRMs) were used for the 2018 program.

The sample length for the majority of intervals collected varies from 3.0 m to 6.0 m. A total of 21 samples out of 314 are outside this interval.

11.1.1.2 Core Sampling (Core Saw Splitting)

A geotechnician trained in core cutting procedures executes the core cutting at the Core Shack. The logging geologist has already clearly marked out all pertinent cores for cutting and sampling. The geologist staples a paper sample tag containing a sample number corresponding with the required sample interval at the start of the sample interval. The logging geologist also staples a metal tag containing the sample number onto the box. This is a permanent sample reference that will remain on the wooden core tray. The geotechnician removes the paper sample tag and places it inside of the plastic bag.

The core is divided in half using an hydraulic splitter. One half is retained and kept in the core box for later reference and the other half is put into a plastic sample bag. A sample assay tag is placed in the plastic sample bag and the bag is tied off.

For quality assurance purposes, “DUPLICATE” core samples are generated by sending the second ½ core sample to the lab. The sample bags are prepared in the same manner as the original sample and immediately follow the original core sample with the corresponding sample number.

A “BLANK” is included in the sequence as part of the QA/QC process. Blank material is technically devoid of any metals.

11.1.2 Density Samples

Specific gravity was determined using an air comparison pycnometer. It should be noted that this method does not take into account existing porosity in a rock and some of the oxide iron formation does contain vugs due to calcite removal.

Although the degree of porosity has not been quantified, it is estimated on the basis of visual examination of the drill core to be generally less than 2%. It should be noted that specific gravity was not measured for all drillholes.

11.1.3 Lab Methods of Preparation, Processing and Analysis

Core samples were shipped to the COREM Laboratory in Quebec City, Quebec, for analysis in 2018.

11.1.3.1 Lab Accreditation and Certification

COREM was accredited in 2017 by the Standards Council of Canada under ISO 17025:2005.

Quality control for the routine sample analysis included COREM’s own quality control procedures, involving internal and external checks.

11.1.3.2 Sample Analysis Procedure

At COREM, the samples were crushed to reduce each sample to 3.35 mm (6 mesh).

A whole rock analysis was done on each sample to measure the following parameters (in %): Fe_{Total}, SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, Cr_2O_3, V_2O_5, ZnO, and loss on ignition (LOI).

The LOI at 400°C and 1,000°C is determined during the procedure.

Additional analyses included determination of magnetic iron with a Satmagan magnetic analyzer.

11.1.4 Sample Shipping and Security

At the Bloom Lake site, sample bags are stored in a core shack until they are removed to be delivered to TST Overland Express in Wabush, using pick-up trucks. Once delivered to TST Overland Express in Wabush, the bags are put on pallets and sealed with plastic wrap-ups.

11.2 Quality Assurance and Quality Control (QA/QC)

Canadian National Instrument 43-101 (NI 43-101) Standards of Disclosure for Mineral Projects requires mining companies to report results in Canada to comply with the CIM Best Practice Guidelines. The guidelines describe which items are required to be in the reports, but do not provide guidance for Quality Assurance and Quality Control (QA/QC) programs.

QA/QC programs have two components: Quality Assurance (QA) deals with the prevention of problems using established procedures, while Quality Control (QC) aims to detect problems, assess them, and take corrective actions. QA/QC programs are implemented, overseen and reported on by a Qualified Person as defined by NI 43-101.

QA programs should be rigorous, applied to all types and stages of data acquisition and include written protocols for: sample location, logging and core handling; sampling procedures; laboratories and analysis; and data management and reporting.

QC programs are designed to assess the quality of analytical results for accuracy, precision and bias. This is accomplished through the regular submission of standards, blanks and duplicates with regular batches of samples submitted to the lab, and the submission of batches of samples to a second laboratory for check assays.

The materials conventionally used in mineral exploration QC programs include standards, blanks, duplicates, and check assays. Definitions of these materials are presented hereunder:

- **Standards** are samples of known composition that are inserted into sample batches to independently test the accuracy of an analytical procedure. They are acquired from a known and trusted commercial source.
- **Blanks** consist of material that is predetermined to be free of elements of economic interest to monitor for potential sample contamination during analytical procedures at the laboratory.
- **Duplicate** samples are submitted to assess both assay precision (repeatability) and to assess the homogeneity of mineralization. Duplicates can be submitted from all stages of sample preparation with the expectation that better precision is demonstrated by duplicates further along in the preparation process.
- **Check Assays** consist of a selection of original pulps that are submitted to a second analytical laboratory for the same analysis as at the primary laboratory. The purpose is to assess the assay accuracy of the primary laboratory relative to the secondary laboratory.

Quality control samples were inserted into the sample batches sent to the laboratory during the 2018 drilling program. Inserts included duplicate samples and blank samples. No standards were inserted.

11.2.1 Lab QA/QC

Quality control for the routine sample analysis included COREM's own quality control procedures, involving internal and external checks.

11.2.2 Quebec Iron Ore QA/QC

In addition to the Lakefield's internal QA/QC protocol, Quebec Iron Ore inserted duplicate and blank samples in the drill core samples.

No external check was carried out for the 2018 drill program.

11.2.2.1 Duplicates

Duplicate samples are submitted to assess both assay precision (repeatability) and to assess the homogeneity of mineralization.

QIO utilizes core duplicates with one half of core being used for the primary analysis and the other half for the subsequent duplicate analysis, leaving no core in the core box for record keeping.

Results for the 2018 drill program were pending during the preparation of the block model for the current resource estimate.

Partial results (180 out of 471) were received during the redaction of this Report confirming that the mineralized zones were actually mineralized with significant grades above the cut-off grade, hence confirming the model.

The QP has not been provided with all the results, therefore conclusions can only be partial based on the limited information received.

11.2.2.2 Blanks

Blanks are used to monitor for potential sample contamination that may take place during sample preparation and/or assaying procedures at the primary laboratory. There are three types of blanks commonly used in QC programs, these being "Coarse Blanks", "Fine Blanks" and "Pulp Blanks". Only coarse blanks were used for the 2018 drilling program.

Samples coming from barren lithologies, mainly amphibolites, were used for blanks during the 2018 drilling program.

Results for the 2018 drill program were pending during the preparation of the block model for the current resource estimate.

Partial results (180 out of 471) were received during the redaction of this Report confirming that the mineralized zones were actually mineralized with significant grades above the cut-off grade, hence confirming the model.

The QP has not been provided with all the results, therefore conclusions can only be partial based on the limited information received.

11.3 Assessment of Results

Results were received by email in Excel files by representatives of Quebec Iron Ore.

11.3.1 Conclusion

Results for the 2018 drill program were pending during the preparation of the block model for the current resource estimate. Partial results (180 out of 471) were received during the redaction of this Report confirming that the mineralized zones were actually mineralized with significant grades above the cut-off grade, hence confirming the model. The QP has not been provided with all the results and, therefore, conclusions can only be partial based on the limited information received for the 2018 drilling program.

The QP reviewed the sample preparation, analytical and security procedures, as well as insertion rates and the performance of blanks and duplicates for the drilling program up to 2018, during discussions with on-site geologists, and concluded that no significant assay biases are present. According to the QP's opinion, the procedure and the quality of the data are adequate to industry standards and support the mineral resource estimate.

12. DATA VERIFICATION

The Mineral Resource Estimate (MRE) in this report is based on drill data from different drilling programs held since 1956. The most recent program was held in 2018 by the issuer.

For the purpose of this MRE, BBA performed a basic validation on the entire database. All data were provided by Quebec Iron Ore in UTM NAD 83 Zone 19. The database close-out date for the resource estimate is May 19, 2019; data from 569 drillholes (141,289 m) were incorporated in the resource estimate.

12.1 Site Visit

Pierre-Luc Richard of BBA visited the Bloom Lake project from March 19 to March 21, 2019. The site visit included a visual inspection of available core, a field tour (Figure 12-1) and discussions of the current geological interpretations and block modelling approach with geologists and engineers of Quebec Iron Ore.

Figure 12-1: Pits visited during the site visit

The site visit also included a review of sampling and assays procedures, QA/QC program, downhole survey methodologies, and descriptions of lithologies (Figure 12-2).

Figure 12-2: Core review in the core logging facility

12.2 Drilling and Sampling Procedure

Quebec Iron Ore procedures are described in Chapters 10 and 11 of the current report. Discussions held with on-site geologists allowed to confirm said procedures were adequately applied.

The bulk of the core was under the snow during the site visit. BBA could only review some limited amount of core sections. All core boxes reviewed were labelled and either laid out on logging tables or properly stored inside the core shack. Sample tags were present in the boxes and it was possible to validate sample numbers and confirm the presence of mineralization in witness half-core samples from the mineralized zones (Figure 12-2).

No drilling was underway during the QP's site visit. On-site geologists explained the entire path of the drill core, from the drill rig to the logging and sampling facility and finally to the laboratory.

12.3 Historical Drillhole Database

The historical information used in this report was taken mainly from reports produced before the implementation of NI 43-101. In most cases, little or no information is available about sample preparation, analytical or security procedures. However, BBA assumes that exploration activities conducted by previous companies were in accordance with prevailing industry standards at the time.

The conversion of the old drillholes coordinates was done by Watts, Griffis and McOuat Limited (WGM) in 2005. The method of conversion was not specified in their report dated May 26, 2005.

The latest database validation was performed by G-Mining in 2017 and is reported in a technical report dated July 2017. G-Mining has taken core samples to compare with assay grades available in the drilling database of the Bloom Lake project. The sampling was carried out independently by the qualified person responsible for the resource estimate during a site visit in September 2016. A total of 12 samples were selected and analyzed for iron content. G-Mining was of the opinion that the check assay results are reasonably close to those of the original assays and that consequently, the assay results included in the database of the Bloom Lake Project are reliable and can be used for resource estimation.

12.4 Recent Drillhole Database

Quebec Iron Ore provided a database to BBA. The database contained coordinates of drillhole collars, deviation tests, lithological contacts, and assay results. Verifications were done to make sure logging was made in accordance with protocols.

12.4.1 Assays

Results for the 2018 drill program were pending during the preparation of the block model for the current resource estimate.

Partial results (180 out of 471) were received during the redaction of this Report confirming that the mineralized zones were actually mineralized with significant grades above the cut-off grade, hence confirming the model.

Since the QP has not been provided with all the results, conclusions herein can only be based on limited information. That being said, it is the opinion of the QP that sufficient validation was made to ensure that the data used for the MRE is valid. Note that assay results from the 2018 drill program were not used for interpolation.

12.4.2 Drillhole Location

For drilling conducted in 2018, all drill collars have been surveyed using differential GPS equipment.

BBA validated that the difference between the coordinates used for the block model and the survey is not material to the purpose of this MRE. Differences within 1 m were locally noted.

12.4.3 Downhole Survey

During the 2018 drilling program, a Flexit instrument was used to measure both orientation and inclination of the drillholes. This instrument provided useful magnetic susceptibility values. Readings were taken every 15 m or 30 m. All data obtained with the Flexit instrument were analyzed and all inappropriate data were eliminated if deviation was too large and/or if the magnetic susceptibility was too high. For some 45 holes drilled in 2012 and 2013, deviation and inclination readings were taken with a Gyro instrument every 5 m.

12.4.4 QA/QC

Historical data was reviewed and did not yield issues.

Results for the 2018 drill program were pending during the preparation of the block model for the current resource estimate. Partial results (180 out of 471) were received during the redaction of this Report. Therefore, the QP has not been provided with the QA/QC reports for the 2018 drill program.

12.5 Conclusion

The QP is of the opinion that the drilling protocols in place are adequate. The database for the Bloom Lake Project is of good overall quality. Minor variations may have been noted during the validation process but have no material impact on the MRE. It is the QP's opinion that the Bloom Lake database is appropriate to be used for a Mineral Resource Estimate.

13. MINERAL PROCESSING AND METALLURGICAL TESTING

The following nomenclature is used in the current section to differentiate the various operation of the Bloom Lake Mine:

- Phase 1 (Consolidated Thompson or CLM): Phase 1 operation as designed and started under the Consolidated Thompson ownership and operated until 2014;
- Phase 1 (QIO): Phase 1 operation as designed and started under the Quebec Iron Ore ownership and operated since 2018;
- Phase 2 (Cliffs): Phase 2 project as designed and partially constructed under the Cliffs Natural Resources;
- Phase 2 (QIO): Phase 2 project detailed in the current report.

13.1 Introduction

In 2018, the Phase 1 (QIO) restart showed that the flowsheet, which was based on the original Phase 2 (Cliffs) flowsheet along with improvements proposed by Mineral Technologies, allows for high iron recoveries and an excellent final concentrate grade control. The combination of spiral and up-current classifier (UCC) stages allows silica of all particle sizes to be removed, while keeping iron losses to a minimum. The inclusion of the magnetic circuit has allowed iron, that otherwise would have been sent to tails, to be recovered. For this reason, the Phase 1 (QIO) flowsheet was used as the basis for the Phase 2 (QIO) flowsheet design. The Phase 1 (QIO) separation circuit is presented in Figure 13-1.

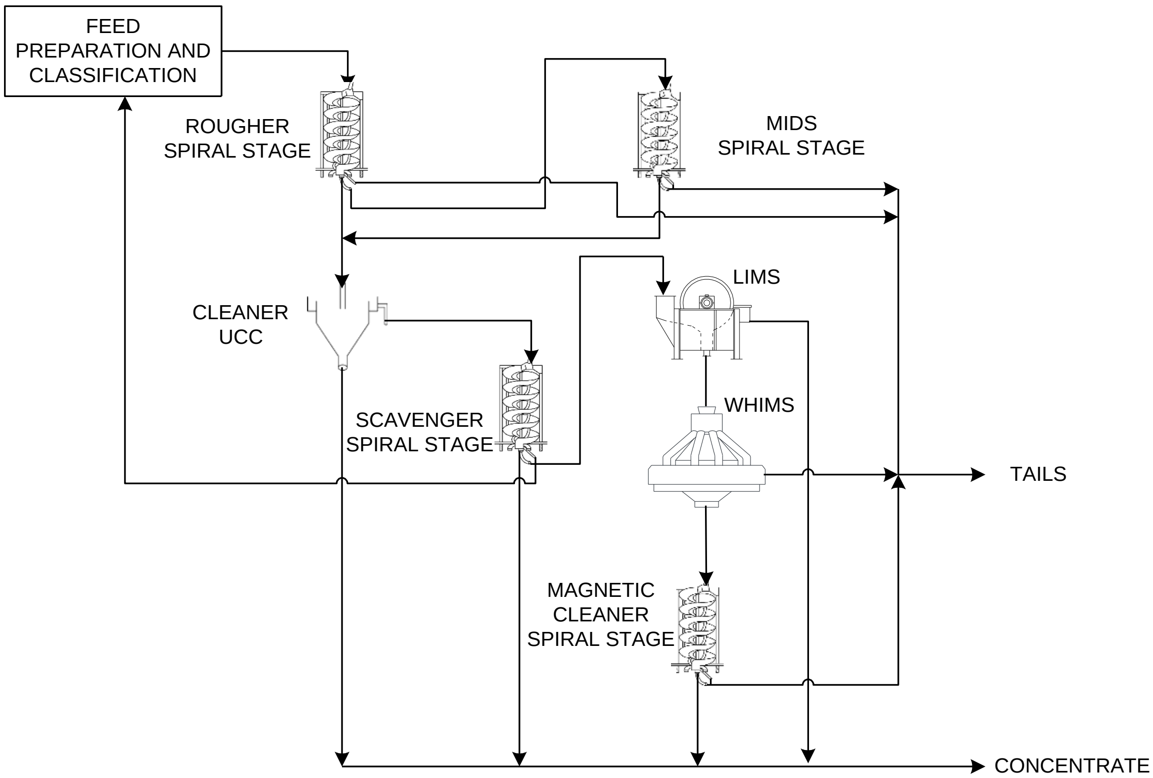


Figure 13-1: Separation circuit Phase 1 (QIO)

The operational experience acquired since the Phase 1 (QIO) restart has highlighted improvement opportunities in some of the process stages. The main opportunities are to:

- Improve the scavenger stage to allow for better concentrate grade control;
- Assess the possibility of scavenging fine iron from the rougher stage tails;
- Increase the fine tailings thickening capacity, as well as the concentrate filtration and handling capacity, to maximize production.

With these opportunities in mind, and the extensive historical testwork and operation data available, a testwork program was established for the separation circuit to represent the envisioned Phase 2 (QIO) flowsheet. The separation flowsheet proposed for the Phase 2 (QIO) concentrator is presented in Figure 13-2.

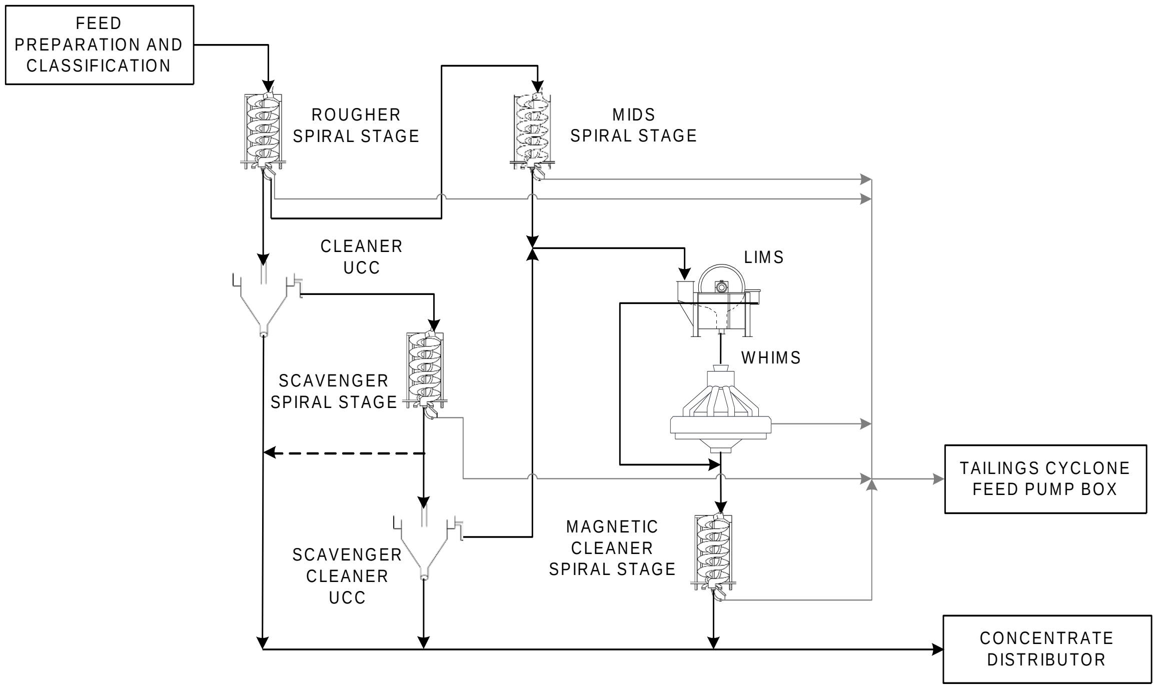


Figure 13-2: Separation circuit Phase 2 (QIO)

A validation of the Phase 1 (QIO) flowsheet performances was done by conducting extensive sampling campaigns to establish a base case prior to optimization work. Furthermore, screening, thickening and filtration lab scale testwork was conducted to ensure sufficient capacity of these stages.

This chapter presents a summary of the historical testwork and the Phase 2 (QIO) testwork, including:

- The flowsheet audit of Phase 1 (QIO);
- Phase 2 (QIO) testwork at COREM;
- Screening testwork at Derricks;
- Settling testwork at FLSmidth;
- Filtration testwork at Bokela.

Finally, the recovery model developed for Phase 2 (QIO) is presented.

13.2 Historical Testwork

The QIO ore has been extensively tested over the past several decades. This section covers the historical testwork prior to this project, presented in the light of Bloom Lake successive development phases:

- Testwork prior to Phase 1 (Consolidated Thompson) (before 2010);
- Original Phase 2 (Cliffs) Testwork (2010 – 2014);
- Phase 1 (QIO) Restart Testwork (2016 - 2017).

13.2.1 Testwork Prior to Phase 1 (before 2010)

Several engineering studies were carried out before the Phase 1 start-up in early 2010. BBA conducted a Conceptual Study for the development of a 5 Mtpy iron ore concentrate mine and concentrator in 2005-2006. In the feasibility that followed in 2007 the project was expanded to 7 Mtpy. Another feasibility study was realized in 2008 for the production of 8 Mtpy of iron ore concentrate (Consolidated Thompson Iron Mines Ltd and BBA inc., 2008). This section includes the testwork that was realized to support each study.

Metallurgical Testwork at Lakefield Research (1975-1976)

In 1975-1976, Republic Steel Corporation requested a metallurgical testwork program from Lakefield Research on drill core samples from the Bloom Lake property. Seventeen drill core composites of magnetite-specularite samples were withdrawn; nine samples from the Chief's Peak Pit and eight samples from the Western Extension of the Chief's Peak Pit, known as West Pit. All samples were crushed to minus 35 mesh (425 µm) and tested on a Wilfley Table to produce a gravity concentrate.

Metallurgical Testwork at Lakefield Research (1998)

In 1998, Watts, Griffis and McOuat (WGM), on behalf of Quebec Cartier Mining, which then held the property under option, requested Lakefield Research Limited to carry out metallurgical testwork on drill core samples of the Bloom Lake property. A total of 75 holes were drilled and heavy liquid tests were done on 1,267 samples.

Metallurgical Testwork at SGS (2005)

In 2005, WGM, on behalf of Consolidated Thompson-Lundmark Gold Mines Ltd. (Consolidated Thompson), requested metallurgical testwork at SGS Laboratory (Lakefield). Eleven mini-bulk samples, each weighing about 500 kg, were taken from outcroppings on Bloom Lake property and were sent to the SGS Laboratory for gravity separation testwork

Confirmatory Metallurgical Testwork at SGS (2006)

In 2006, Breton Banville & Associés (BBA), on behalf of Consolidated Thompson Iron Mines, (A. Allaire, et al., 2006), requested a metallurgical testwork program at the SGS Laboratory. Thirty-two (32) drill core samples for metallurgical testing and 32 drill core samples for grindability testing were obtained from 12 bore holes located in the west, central, northeast and southeast areas of the Bloom Lake pit. The samples were collected at different depths.

13.2.1.1 Gravity Separation

Table 13-1 summarizes the different weight recovery relations that were obtained over the different studies performed for the Phase 1 (Consolidated Thompson) gravity circuit.

The relatively high concentrate grade and iron recovery for gravity separation suggested that the ore was well liberated at 35 mesh (425 µm) throughout the ore body and that it could be possible to perform gravity separation at a coarser grind. The Phase 1 start-up in early 2010 was realized with classification screens with 35 mesh (425 µm) apertures, but the screens' openings were increased to 20 mesh (850 µm) sometime after start-up with no negative impact on concentrate grade or recovery observed.

In the 1976 report by WGM it was assumed that, in the worst case, any iron tied up with MgO in the form of actinolite would not be recovered. It was estimated that for each 1% MgO in the ore, there was 0.194% Fe attached to it. The 2006 confirmatory testwork confirmed that the actinolite was rejected with the silica during the gravity concentration process. No correction for MgO was implemented for the 2006 weight recovery curves.

Table 13-1: Gravity separation weight recoveries

Testwork	Average concentrate Fe grade (%)	Weight recovery relationship	Weight recovery (%)	Fe recovery (%)
1975-1976	67.1	WR = 1.16 * % Fe (head) + 2.48	37.3	83.3
2005	67.2	WR = 1.3788 * % Fe (head) - 3.1746	38.2	85.6
2006	67.8	WR = 1.3015 * % Fe (head)	39.0	88.3

13.2.1.2 Magnetic Separation

At 10% Fe_3O_4 feed grade, the magnetic confirmatory testwork results showed that an additional weight recovery of 2.5% could be accounted for if a magnetite plant was implemented. The magnetite plant, planned for Year 3 of Phase 1 (CLM), was not implemented due to lower than expected magnetite content in the magnetite plant feed and lower than expected Phase 1 (CLM) production rates.

13.2.1.3 Grindability

The grindability confirmatory tests confirmed that a 36' x 19'-9'' AG mill with an installed power of 10,071 kW (13,500 hp) was appropriate for processing the tonnage required for the 7 Mtpy iron ore concentrate production. The average mill feed rate was 2,156 tph and the power consumption in primary grinding was 3.82 kWh/t of concentrator feed. In the 8 Mtpy study, the AG Mill selected was a 36' x 20' long mill driven by dual 5,590 kW (7,500 hp) motors. The average mill feed rate was 2,372 tph and the power consumption in primary grinding was 4.2 kWh/t of concentrator feed.

13.2.1.4 Phase 1 Flowsheet

Figure 13-3 presents Phase 1 (CLM) high level flowsheet that was developed and commissioned in 2010. The gravimetric flowsheet is a classic 3-stage spiral flowsheet with recirculation of the cleaner and recleaner tails. The magnetic scavenging circuit was never built.

After the start-up the classification screens aperture was set at 850 µm and was operating without any liberation issues until operations stopped in 2014.

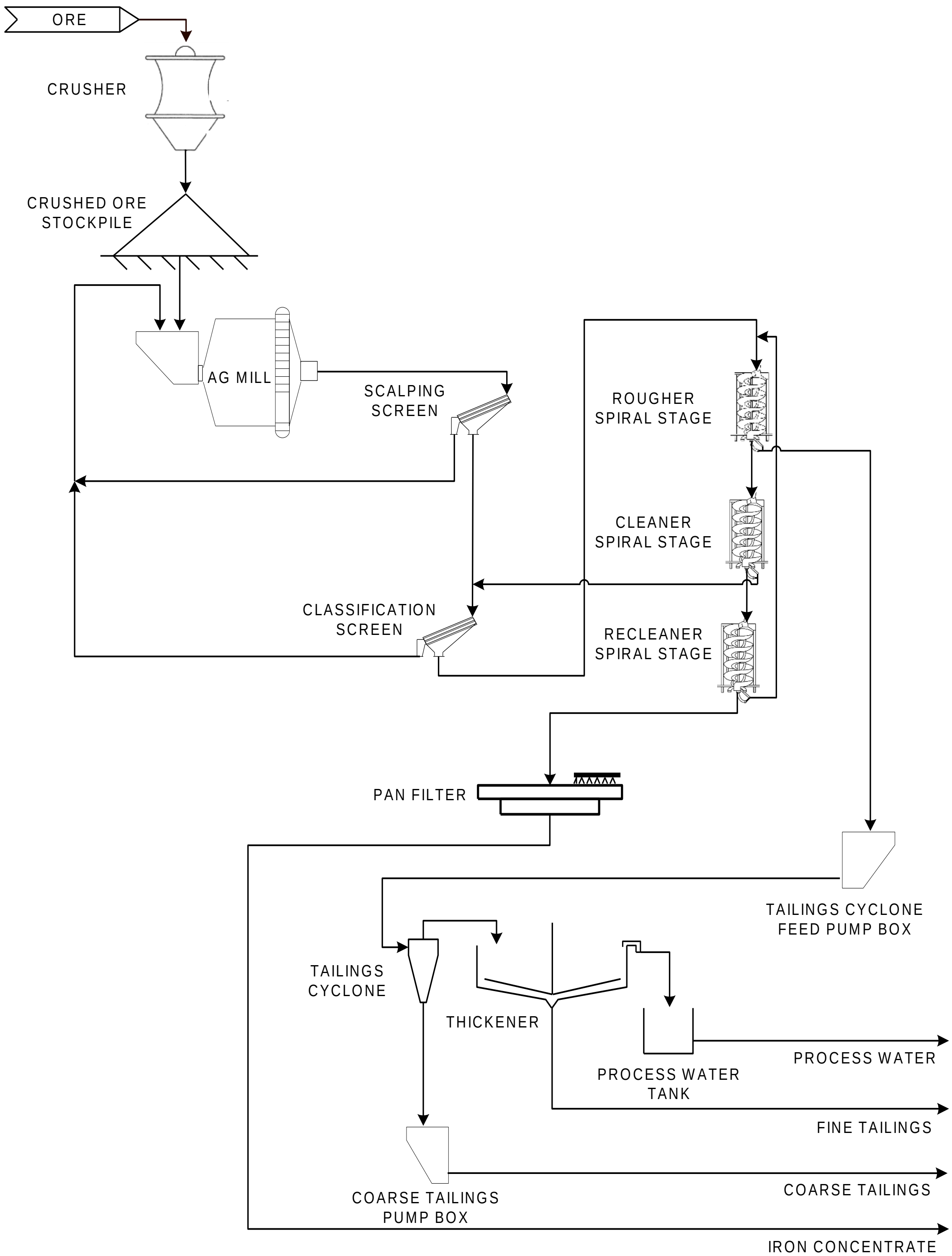


Figure 13-3 : Phase 1 (Consolidated Thompson) high level flowsheet

13.2.2 Phase 2 (Cliffs) Testwork (2010-2011)

The Phase 1 concentrator commenced operations in 2010 at a production target of 8 Mtpy of concentrate. As part of an expansion plan to increase the mine production, the design of a second concentrator plant (Phase 2) was then initiated to increase the nominal capacity to about 16 Mtpy of concentrate (Soutex, 2012). To support Phase 2 engineering, testwork was realized to characterize the future zones to be mined and to support flowsheet improvements from Phase 1. The subsections below summarize the testwork that was conducted.

13.2.2.1 West Pit (2010) Characterization

In 2010, 40 samples were utilized in testwork to characterize the ore from the West pit. The objective was to compare West pit samples' characteristics to the ones of the Chief's Peak pit, which was processed in the Phase 1 (Consolidated Thompson) concentrator. These tests included mineralogy analysis, heavy media separation tests, Wilfley Table tests, and grindability testwork (Soutex, 2011a).

From a mineralogical point of view, grinding the ore at 100% passing 850 µm, as done in the Phase 1 concentrator, enabled adequate hematite liberation for recovery by a subsequent gravity separation process. However, three composites characterizing the three main zones of Bloom West pit were generated, ground to 95% passing 425 µm for comparison with the previous Chief's Peak pit Characterization tests and underwent heavy media testing using a media of density 3.3.

The heavy media tests confirmed that a high iron grade concentrate can be produced at a particle size distribution of 95% passing 425 µm with the samples from West pit, as this was the case with those from the Chief's Peak pit tested before 2010.

Samples were tested on a Wilfley Table. The West pit test results were better or comparable to the results from the Chief's Peak pit samples.

Thirty-eight (38) samples from West pit were subject to SPI grindability tests. The results are compared to the Chief's Peak pit Confirmatory Testwork realized in 2006 in Table 13-2.

Table 13-2: West pit grindability hardness data

Zone	Year	Ci (kWh/t)	SPI (minutes)	Standard Deviation (%)
West Pit	2010	14.7	7.1	3.9
Chief's Peak Pit	2006	9.2	21.8	18.1

The results showed that the Chief's Peak pit samples were harder (with higher SPI values) than the West Pit samples.

13.2.2.2 Phase 2 (Cliffs) Piloting (2011)

Pilot tests were conducted in the Phase 1 concentrator in order to evaluate the performance and operational ease of new process equipment at different locations according to a proposed more efficient flowsheet. Figure 13-4 schematically represents the four pilot tests conducted on the process (Soutex, 2011b).

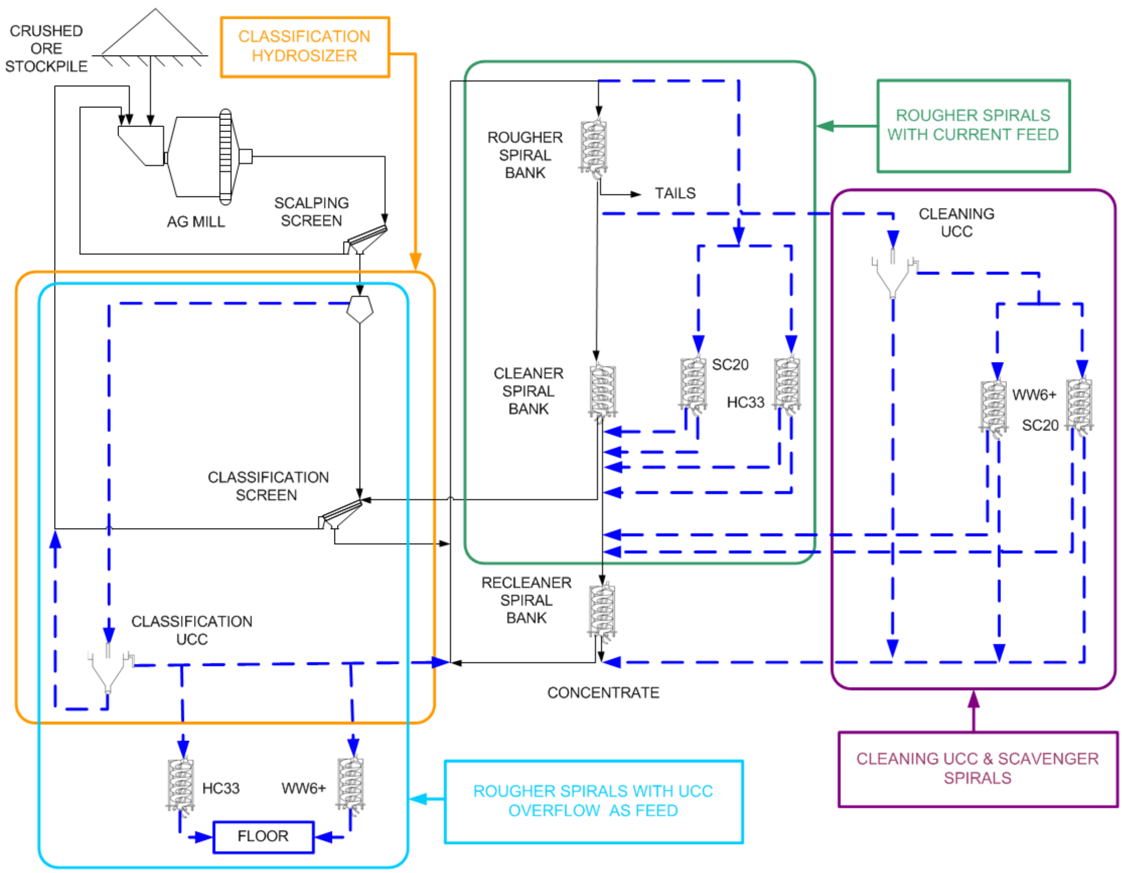


Figure 13-4: Phase 2 pilot tests - 2011

Figure 13-5 presents the Phase 2 (Cliffs) proposed flowsheet following piloting. Phase 2 (Cliffs) was never completed. The Phase 2 (Cliffs) construction project was halted in November 2012 and Phase 1 (Consolidated Thompson) operations were suspended in December 2014 by Cliffs.

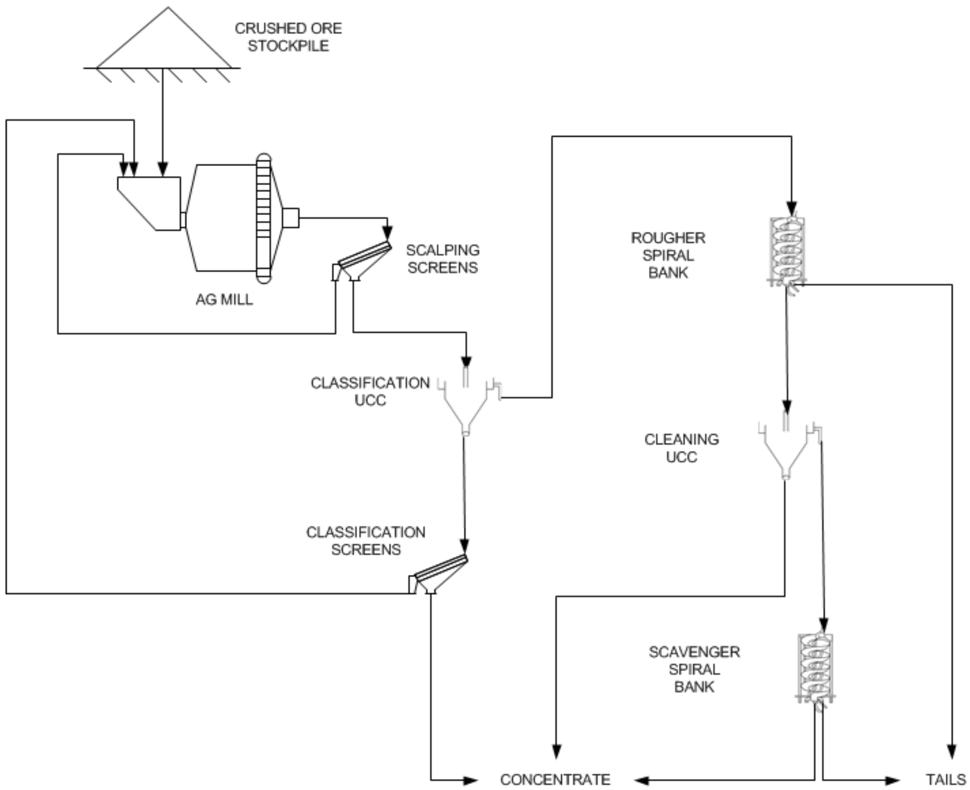


Figure 13-5: Phase 2 (Cliffs) simplified flowsheet

13.2.2.3 Magnetite Plant Testwork

In the previous Phase 1 8-Mtpy study, a magnetite plant was planned in order to recover 600,000 tpy of magnetite concentrate (for one phase). This assumption was based on:

- The Chief's Peak pit mine plan that stated the crude ore contains approximately 30% iron and 10% magnetite (it had since been revised to 8%);
- A very limited amount of mineral concentration testwork.

In order to develop a process flowsheet for the magnetite plant processing the gravity tailings from Phase 1 and 2 concentrators, bench scale testwork program was conducted at SGS (Lakefield, Ontario) in 2011 (Soutex, 2013a) and a pilot plant testwork program was conducted at COREM (Soutex, 2013b).

The magnetite plant testwork (Soutex, 2013c) has shown that:

- The iron under the magnetite form, in the gravity separation circuit, concentrates in a similar way to the hematite;
- The weight recovery obtained, in the magnetite separation circuit, increases linearly with the magnetite grade in the magnetite separation circuit feed.

Considering the gravity plant weight recovery, the weight yield obtained of 1.4% from crude ore at the nominal magnetite grade of 8% is significantly lower compared to the 2.5% value predicted in the original 8-Mtpy study. The mag plant was judged to be non-economically viable and was therefore never built.

13.2.2.4 Phase 2 (Cliffs) Settling Testwork

In September 2011, FLSmidth undertook sedimentation and rheology testing on fine tailings samples from the Bloom Lake concentrator (FLSmidth, 2011). All the tests were conducted with a thickener feed at 3.3% solids. The results from the testing program indicated that one 45 m diameter High Rate Thickener with a sidewall of 4.3 m is sufficient to handle 351 tph of tailings.

13.2.2.5 Phase 2 (Cliffs) Filtration Testwork

In 2011, Bokela undertook a study to evaluate the performance of the XL-Type filters (68 m^2) for the Bloom Lake Phase 2 Expansion (Bokela, 2011). Bokela confirmed that the maximum design throughput of 342 tph can be achieved with this filter and indicated that the XL-Type filter could filter up to 500 tph.

13.2.3 Phase 1 (QIO) Testwork

After Quebec Iron Ore (QIO) acquired the Bloom Lake assets from Cliffs in early 2016, Mineral Technologies was mandated to design an upgraded flowsheet for the Phase 1 concentrator (Ausenco, 2017). The Phase 1 upgrade would be facilitated by making use of the process equipment already bought in the Phase 2 concentrator, which was under construction when the mine's operation had stopped.

The Phase 1 (QIO) upgraded flowsheet development was initially based on historical Phase 1 (Consolidated Thompson) data, Phase 2 (Cliffs) piloting and the proposed Phase 2 (Cliffs) flowsheet design as well as Mineral Technologies experience.

The proposed flowsheet was similar to the Phase 2 (Cliffs) flowsheet with the following modifications:

- An expected increased iron recovery, thanks to the processing of a portion of the gravity tailings streams in a scavenging magnetic circuit for the production of a lower grade Magnetic circuit concentrate;
- A method to process the rougher spirals middlings without recirculation back to the rougher spirals feed;

- A classification circuit comparable to the initial Phase 1 (Consolidated Thompson) flowsheet, which involves screening only instead of using classification up-current classifier as initially planned in the Phase 2 (Cliffs) flowsheet.

The proposed and tested flowsheet is presented in Figure 13-6 below.

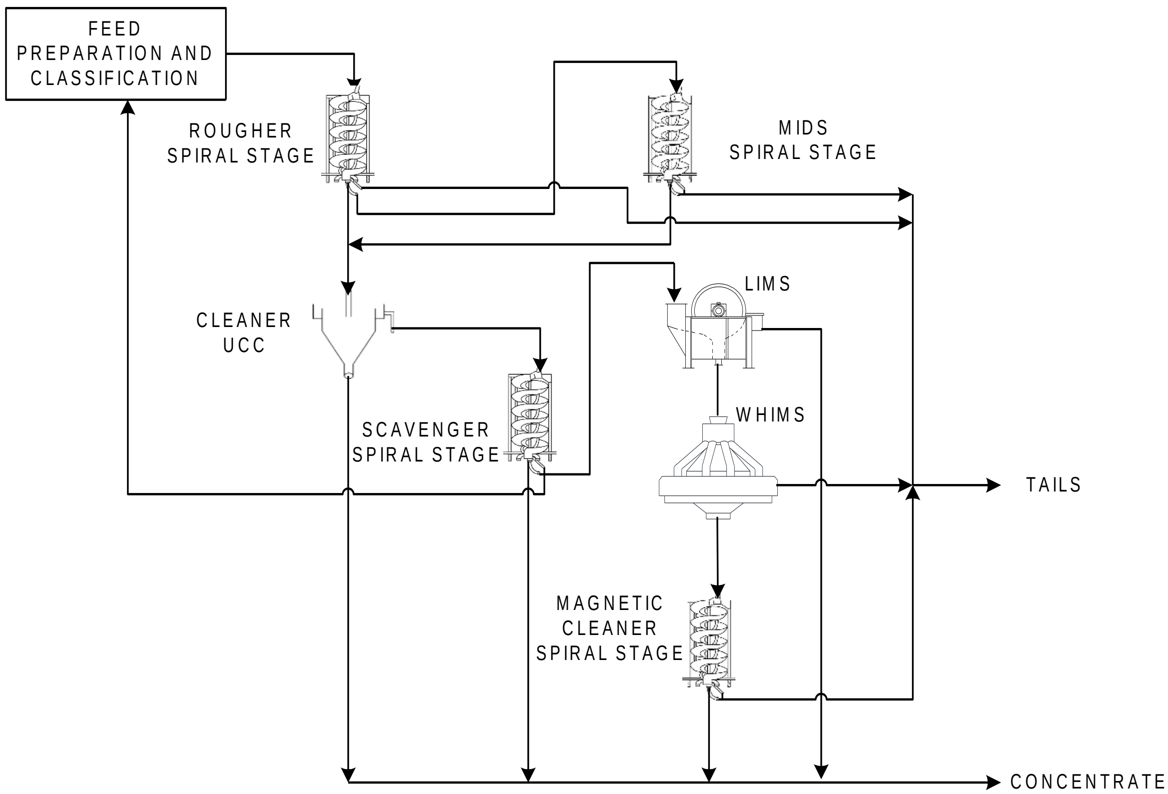


Figure 13-6: Phase 1 (QIO) tested flowsheet

Table 13-3 presents the metallurgical balance resulting from the testwork. The results showed a weight yield to the gravity concentrate of 37.8% with an additional 1% coming from the LIMS/WHIMS scavenger circuit and translates to an overall iron recovery of 81.1%.

The testwork data was used to update a metallurgical model developed by MT. The model predicted a theoretical maximum iron recovery from the flowsheet of 85.3% and an expected plant recovery of 83.3% from a continuous plant operation treating ore of similar characteristics to the sample tested at the expected life of mine (LOM) feed grade of 30% Fe. This recovery of 83.3% for a 30% Fe feed grade, was used for Phase 1 (QIO) design.

Table 13-3: Testwork global metallurgical balance

Product	% weight	Assays									Distribution		
		Fe (%)	SiO_2 (%)	Al_2O_3 (%)	P (%)	S (%)	CaO (%)	TiO_2 (%)	Mn (%)	MgO (%)	Fe (%)	SiO_2 (%)	Al_2O_3 (%)
Gravity Concentrate (total)	37.8	66.9	3.53	0.27	0.01	0.01	0.09	0.16	0.08	0.09	79.5	2.6	13.4
Magnetic Circuit Concentrate	1.0	48.2	29.3	0.40	0.02	0.01	0.31	0.26	0.09	0.30	1.6	0.6	0.6
Magnetic Circuit Rejects	13.5	7.5	85.8	1.29	0.04	0.01	0.81	0.11	0.03	0.77	3.2	22.1	23.4
Gravity Circuit Rejects	47.6	10.5	82.3	0.98	0.02	0.01	0.43	0.09	0.03	0.53	15.7	74.8	62.6
Calculated Feed	100.0	31.8	52.4	0.75	0.02	0.01	0.35	0.12	0.05	0.39	100.0	100.0	100.0

13.3 Phase 1 (QIO) Flowsheet Audit at QIO

Sampling campaigns were conducted in the Bloom Lake Phase 1 (QIO) concentrator in November, 2018. The campaigns' goals were:

- To set a base case for Phase 2 (QIO) design by characterizing the Phase 1 (QIO) concentrator performances under various feed conditions;
- To gather bulk samples for the testwork to be performed at COREM.

13.3.1 Phase 1 Characterization

A total of 41 samples were gathered for each of the four sampling campaigns performed between November 12 and 15, 2018 (Soutex, 2019). The North and South circuits were sampled individually to allow comparison. Size by size assays were performed on every sample and data reconciliation was performed. Figure 13-7 shows the campaign sampling points' locations.

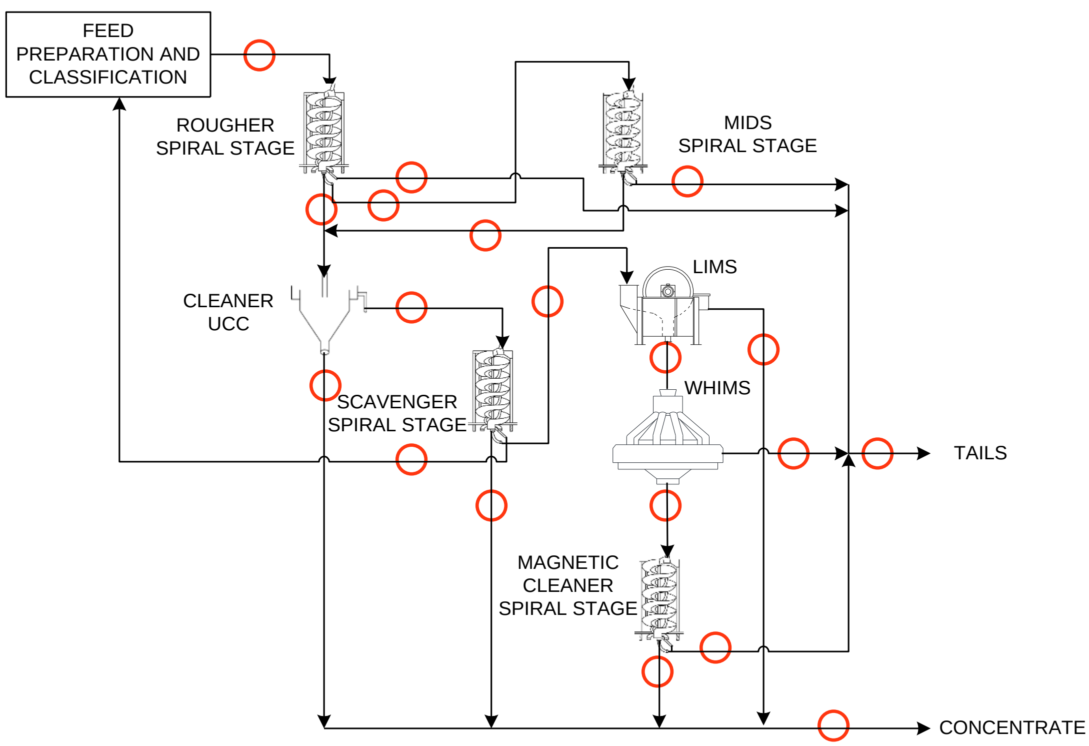


Figure 13-7: Sampling points in Phase 1 (QIO) concentrator

The sampling points covered the entirety of both the North and South gravity and magnetic separation circuits with the exception of the north WHIMS tails due to a faulty sampling valve.

Mining operations were adjusted throughout the campaigns so as to produce ore blends that were representative of typical concentrator feed blends:

- Blend containing limonite;
- Life of mine blend;
- Blend containing silicates.

The results from the campaigns were compared to the Phase 1 (QIO) design values. Table 13-4 presents the comparison between the campaigns and the design. The detailed results are presented in the sampling campaigns report.

Table 13-4: Sampling campaigns results vs. design values

Stream	Campaigns average					Design values				
	Weight Rec.		Grade	Fe Rec.		Weight Rec.		Grade	Fe Rec.	
	Global	Stage	Fe	Global	Stage	Global	Stage	Fe	Global	Stage
	%	%	%	%	%	%	%	%	%	%
Fresh Feed	94.7	-	33.2	98.0	-	96.0	-	29.9	99.5	-
Rougher Spirals										
Rougher Spirals Feed	100.0	100.0	32.1	100.0	100.0	100.0	100.0	28.8	100.0	100.0
Rougher Spirals Concentrate	49.8	49.8	55.2	85.7	85.7	45.0	45.0	49.2	76.9	76.9
Rougher Spirals Tails	30.1	30.1	9.5	8.9	8.9	22.0	22.0	7.2	5.5	5.5
Rougher Spirals Middlings	20.1	20.1	8.7	5.4	5.4	33.0	33.0	15.4	17.6	17.6
Mids Spirals										
Mids Spirals Concentrate	2.4	12.1	28.4	2.2	39.7	10.2	31.0	29.7	10.6	59.9
Mids Spirals Tails	17.6	87.9	6.0	3.3	60.3	22.8	69.0	8.9	7.1	40.1
Cleaner Up Current Classifiers										
Cleaner UCC Feed	52.3	100.0	53.9	87.9	100.0	55.2	100.0	45.6	87.4	100.0
Cleaner UCC Overflow	24.0	45.9	37.4	28.0	31.8	25.3	45.8	19.5	17.1	19.6
Cleaner UCC Underflow	28.3	54.1	67.9	59.9	68.2	29.9	54.2	67.7	70.3	80.4
Scavenger Spirals										
Scavenger Spirals Concentrate	10.9	45.4	59.8	20.3	72.6	5.8	23.0	61.8	12.5	72.9
Scavenger Spirals Middlings	7.8	32.4	23.4	5.7	20.3	15.4	61.0	7.7	4.1	24.2
Scavenger Spirals Tails	5.3	22.2	12.1	2.0	7.2	4.0	16.0	3.6	0.5	2.9
LIMS										
LIMS Feed	7.8	100.0	23.4	5.7	100.0	15.4	100.0	7.7	4.1	100.0
LIMS Concentrate	0.1	0.8	58.3	0.1	2.1	0.2	1.0	54.0	0.3	7.0
WHIMS Feed	7.7	99.2	23.1	5.6	97.9	15.3	99.0	7.3	3.8	93.0
WHIMS										
WHIMS Tails	6.3	82.0	16.0	3.2	56.8	12.4	81.0	2.6	1.1	29.3
Mags Cleaner Spirals Feed	1.4	18.0	55.4	2.4	43.2	2.9	19.0	27.0	2.7	70.7
Mags Cleaner Spirals										
Mags Cleaner Spirals Concentrate	1.1	76.1	62.9	2.1	86.5	1.1	38.0	49.4	1.9	69.5
Mags Cleaner Spirals Tails	0.3	23.9	31.3	0.3	13.5	1.8	62.0	13.3	0.8	30.5
Global										
Tailings Cyclones Feed	54.4	54.4	9.2	15.6	15.6	58.3	58.3	7.1	14.4	14.4
Pan Filters Concentrate	40.3	40.3	65.5	82.4	82.4	37.0	37.0	66.2	85.0	85.0

13.3.1.1 Rougher Spirals Stage

The iron recovery at the rougher stage was, on average, 85.7% in the concentrate and 5.4% in the middlings. The rougher concentrate recovery was significantly higher and the rougher middlings recovery was significantly lower in the campaigns than their design values. This resulted in a slightly lower overall iron recovery at that stage and a significantly lower feed rate to the mids spirals. The rougher spirals were eliminating coarse silica very well and produced on average a concentrate at 55.2% Fe and middlings at 8.7% Fe.

13.3.1.2 Mids Spirals Stage

The iron recovery at the mids spirals stage was, on average, 39.7% representing 2.2% of the global recovery. This was significantly lower in the campaigns than the design values but was offset by a higher than design recovery at the rougher concentrate. The combined rougher and mids stages recovery, 87.9%, was slightly higher than the design value of 87.5%. The mids spirals were eliminating coarse silica very well except during one of the campaigns. This resulted in sending coarse silica to the cleaner up-current classifiers stage. On average, the mids concentrate grade was 28.4% Fe which is consistent with the design value.

13.3.1.3 Cleaner Up-Current Classifiers Stage

The iron recovery at the cleaner UCC underflow was, on average, 68.2%. This was significantly lower in the campaigns than the design value which resulted in sending more feed to the scavenger spirals stage. The cleaner UCC were eliminating fine silica very well but could also remove mid-sized silica at the expense of iron recovery. The coarse silica getting to the cleaner UCC feed was reporting to the underflow, meaning that not properly removing coarse silica at the rougher and mids stages, as happened during one of the campaigns, impacted the final concentrate grade.

13.3.1.4 Scavenger Spirals Stage

As a result of the lower recovery at the cleaner up-current classifier underflow, the scavenger spirals were receiving almost twice the amount of iron than designed but a tonnage similar to the design. This led to producing more scavenger spirals concentrate while less cleaner UCC concentrate was produced. On average, the scavenger spiral concentrate iron grade was 59.8%, which is low compared to the design value of 61.8%. The iron recovery was similar to the design value. That lower grade combined with the higher proportion of scavenger concentrate in the final concentrate meant that, on average, the final concentrate grade and iron recovery were lower than designed. The scavenger spirals mids, feeding the LIMS stage, had an iron grade three times higher than the design at a lower tonnage.

13.3.1.5 LIMS Stage

The LIMS concentrate tonnage was very low during the campaigns as a result of the low magnetite content in the ore. The average iron grade obtained was slightly higher than in the design at 58.3%. Although below the final concentrate target grade, the LIMS concentrate tonnage was too low to significantly affect the final concentrate.

13.3.1.6 WHIMS Stage

The iron recovery at the WHIMS stage was well below the design value at 43.2%, on average, compared to 70.7%. This might have been caused by the higher amount of iron feeding the WHIMS as a result of the high scavenger mids iron grade.

13.3.1.7 Magnetic Cleaner Spirals Stage

The magnetic cleaner spiral stage performed better during the campaign compared to the design values because of the higher iron feed grade and lower feed tonnage. The iron recovery was 85.6%, on average, compared to the 69.5% design value and the iron grade obtained was 62.9% compared to 49.4% in the design. This higher concentrate iron grade helped minimize the impact of the proportionally higher tonnage of scavenger concentrate in the final concentrate.

13.3.2 Flowsheet Audit Conclusions

The Phase 1 (QIO) flowsheet audit has allowed valuable information to be gathered, which was used to define the testwork program. The main conclusions are:

- The rougher stage performs well and its concentrate iron recovery is higher than designed;
- The mids stage receives less feed and its concentrate iron recovery is lower than expected but is offset by the higher recovery to rougher concentrate;
- The recovery at the cleaner stage's underflow is lower than expected and result in more material being sent to the scavenger stage;
  - This requires being more aggressive at the scavenger stage to meet final concentrate grade.
- The scavenger stage has been identified as the stage where the most potential gain was possible both in terms of grade and recovery;
- The magnetic circuit did not perform as expected in the WHIMS stage where the iron recovery was lower than expected.

13.4 Phase 2 (QIO) Testwork

Testwork at COREM was started in November 2018 (COREM, 2019). The main objectives of the metallurgical testwork were to:

- Improve the scavenger stage to allow for better concentrate grade control and higher recovery;
- Assess the possibility of scavenging fine iron from the rougher tails;
- Validate the performances of the stages already performing well in Phase 1 (QIO).

13.4.1 Testwork Program

The testwork program was based on the experience acquired through the Phase 1 (QIO) operation and results from the sampling campaigns. The sections of the Phase 1 (QIO) process that are performing well were tested without modifications and the ones that needed optimization were more extensively tested. Given past testwork on spiral model comparison and the benefits of having both phases operating with the same spiral model, only WW6+ spirals were tested.

13.4.1.1 Testwork Flowsheet

The following is a list of the main points concerning the testwork flowsheet:

- The rougher stage was tested with no flowsheet modifications on a WW6+ spiral;
- The mids stage was tested with no flowsheet modifications on a WW6+ spiral;
- The cleaner stage was tested on an up-current classifier. Unlike in the Phase 1 (QIO) concentrator, the mids scavenger spiral concentrate was not fed to the cleaner stage because of its low iron grade. The mids scavenger spiral concentrate is rather combined with the scavenger cleaner stage tails for further upgrading.
- The scavenger stage required more extensive testing to optimize its grade and recovery. As a result, a scavenger-cleaner stage was added to the test program so that the scavenger stage could be set at maximizing recovery while the scavenger-cleaner stage would provide a high grade concentrate. The following technologies were tested as a scavenger-cleaner stage:
  - WW6+ Spirals;
  - Reflux ®Classifier;
  - Up-Current Classifier (UCC).

- The magnetic circuit was tested with scavenger-cleaner UCC overflow and mids concentrate as feed. A LIMS/WHIMS (horizontal carousel) configuration was tested as in Phase 1 (QIO) testwork. Testwork was also done on the mags cleaning stage with a WW6+ spiral processing the LIMS & WHIMS magnetic concentrate. The objective was to maximize recovery with the LIMS/WHIMS stage, while the cleaner stage would provide a high grade concentrate.
- A scavenger LIMS & WHIMS stage was tested on the screened rougher tails to assess the possibility of recovering fine iron particles from the rougher tails.

The testwork program flowsheet overview is shown in Figure 13-8.

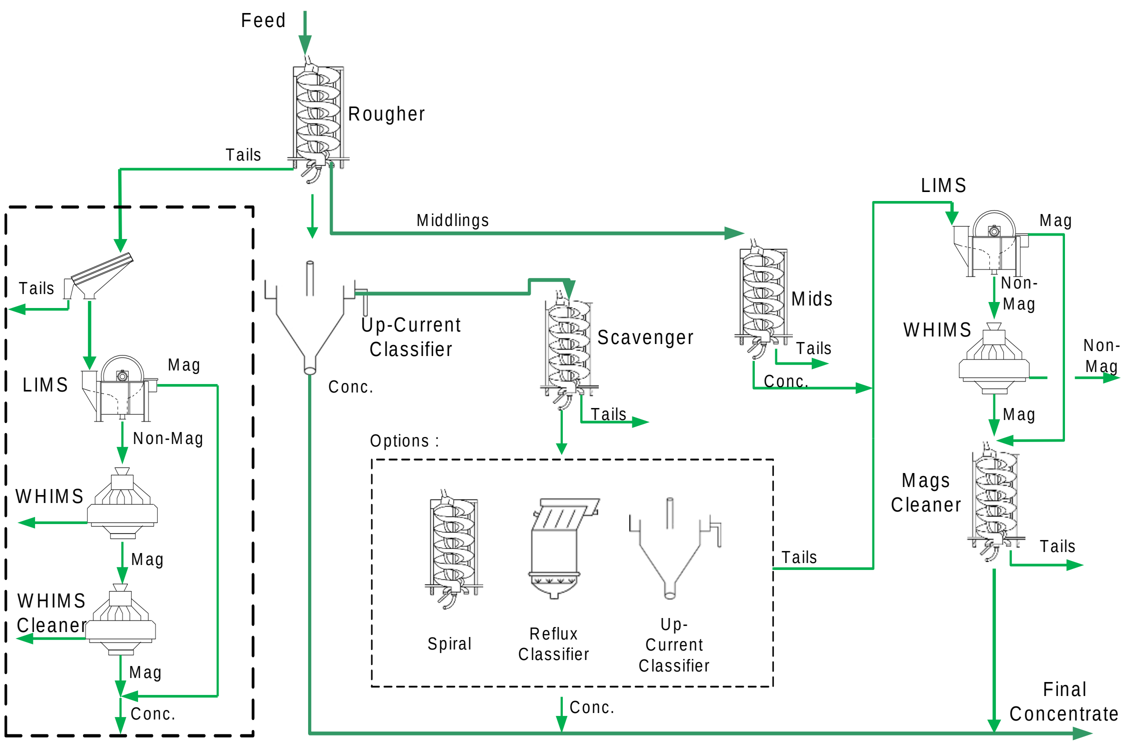


Figure 13-8: Testwork flowsheet

The analysis in the metallurgical testwork included:

- X-ray fluorescence (XRF) chemical assays on all streams;
- Satmagan magnetite grade on all streams;
- Particle Size Distributions on selected streams;
- XRF chemical assays per size on selected streams;
- Percent solids on selected streams;
- Determination of Fe by titration on selected streams.

13.4.1.2 Approach

The testwork objectives were:

- Evaluate the individual equipment performance with respect to iron recovery and concentrate grade;
- Evaluate rough optimal throughput for each piece of processing equipment;
- Perform preliminary optimization of process parameters.

A staged approach was used during the testwork, with each upgrading stage being tested and roughly optimized before testing the downstream upgrading stage.

As a first step, optimization tests were conducted for each stage. In the case where a significant quantity of material was required for a downstream process, a production run was also used to generate an adequate sample mass.

Variability testwork was conducted on different ore blends to assess the metallurgical performance of each blend. Five ore blends were prepared from eight mine samples collected from selected zones.

13.4.2 Sample Description

Samples were taken from the Phase 1 (QIO) concentrator and in the pits to provide material for the testwork:

- A bulk rougher feed sample;
- A cleaner UCC overflow sample;
- A rougher tails bulk sample;
- And variability bulk samples.

13.4.2.1 Bulk Rougher Feed (3 t) Sample

A bulk rougher feed sample was taken to be used as feed material for the rougher stage testwork. The concentrate and middlings obtained from the tested rougher stage were then used as feed material for the cleaner and mids stages respectively. To ensure an adequate quantity of samples for testing, the bulk rougher feed (3 t) sample was taken from two sources:

- Operational Backup samples:
  - Mass totalled 600 kg;
  - Composited from the period of February 16 to September 15, 2018.

- Daily samples:
  - Mass totalled 2,400 kg;
  - Composited from the Day Shift operation samples during the period of September 15 to 17, 2018.

The material was blended at COREM.

13.4.2.2 Cleaner UCC Overflow Sample

Two Cleaner UCC Overflow samples were taken:

- Small 21 kg composite sample;
- Large 7-tonne sample.

A 21 kg composite sample of Cleaner UCC Overflow was sampled from October 25 to 28, 2018. This sample was sent to COREM and allowed a rapid chemical evaluation on a size by size basis and mineralogical analysis in order to plan the testwork. The size by size assays are shown in Table 13-5 and the size by size assay distributions are shown in Table 13-6.

Table 13-5: Cleaner overflow size by size assays

Size fraction (µm)	Weight (%)	Mag. (%)	SiO_2 (%)	Fe_T (%)	MgO (%)	CaO (%)
+300	3.5	1.2	86.1	6.4	1.9	1.6
-300+212	7.8	2.2	77.3	12.4	2.3	1.8
-212+150	19.3	6.0	52.8	30.7	1.7	1.4
-150+75	44.7	11.2	29.7	47.6	1.3	1.1
-75+45	14.6	14.6	23.8	51.6	1.2	1.2
-45+38	2.8	14.4	25.4	49.6	1.7	1.3
-38	7.2	10.5	42.0	35.8	2.6	2.0
Calculated feed	100	9.7	39.8	39.9	1.6	1.3
Analyzed feed	100	9.8	39.8	39.2	1.6	1.3

Table 13-6: Cleaner overflow size by size assay distributions

Size fraction (µm)	Weight (%)	Mag. (%)	SiO_2 (%)	Fe_T (%)	MgO (%)	CaO (%)
+300	3.5	0.4	7.7	0.6	4.2	4.4
-300+212	7.8	1.8	15.2	2.4	11.4	10.9
-212+150	19.3	11.9	25.6	14.8	20.6	20.1
-150+75	44.7	51.8	33.4	53.3	37.7	37.9
-75+45	14.6	22	8.7	18.9	11.1	13.2
-45+38	2.8	4.2	1.8	3.5	3.0	2.8
-38	7.2	7.8	7.6	6.4	12.0	10.7
Total	**100**	**100**	**100**	**100**	**100**	**100**

It was expected that the amount of cleaner overflow generated would not be sufficient for the testwork program on subsequent stages. Therefore a cleaner UCC overflow bulk sample was taken in the plant and used as feed material for the scavenger stage, hence generating material for the scavenger cleaner and mags circuit stages. The sample is slightly different from the cleaner UCC overflow generated by the Phase 2 (QIO) flowsheet because the mids concentrate is not to be fed to the cleaner stage. However, because of the small quantity of mids concentrate feeding the cleaner stage compared to the rougher concentrate, the sample still represents, very well, the Phase 2 (QIO) cleaner overflow. A composite Cleaner Overflow bulk sample of approximately seven tons was taken from November 13 to 16, 2018. This sample was used as a scavenger stage feed during the testwork program.

The cleaner up-current classifier overflow sample was collected into 24 drums filled from four different up-current classifiers, two on the north side and two on the south side. The collecting was performed by unplugging a scavenger spiral feed hose, coming from the cleaner up-current classifier overflow, and tying it to a temporary hose leading to the drums.

13.4.2.3 Rougher Tails Sample

A 19 kg composite sample of rougher tails was sampled from October 25 to 28, 2018. This small sample was sent to COREM and allowed a rapid chemical evaluation on a size by size basis and mineralogical analysis in order to plan the testwork. The size by size assays are shown in Table 13-7 and the size by size assay distributions are shown in Table 13-8. The qualitative mineralogical analysis of the rougher tails sample is shown in Table 13-9.

Table 13-7: Rougher tails size by size assays

Size fraction (µm)	Weight (%)	Mag. (%)	SiO_2 (%)	Fe_T (%)	MgO (%)	CaO (%)
+850	3.3	0.7	99.3	3.0	0.6	0.9
-850+600	6.4	0.7	92.4	3.6	0.7	1.1
-600+425	11.1	0.6	92.2	3.6	0.9	1.1
-425+300	13.2	0.6	92.9	3.2	1.0	1.0
-300+212	11.6	0.6	93.2	2.6	1.3	1.1
-212+150	9.5	0.6	88.8	2.2	1.7	1.4
-150+75	12.9	0.8	75.9	3.5	2.8	2.0
-75+45	7.9	2.8	65.6	11.0	3.9	2.6
-45+38	3.0	5.2	65.6	18.6	3.7	2.6
-38	21.2	5.4	58.8	22.6	3.5	2.6
Calculated feed	100.0	2.0	82.9	8.3	2.1	1.7
Analyzed feed	100.0	1.8	82.5	8.1	2.2	1.7

Table 13-8: Rougher tails size by size assay distribution

Size fraction (µm)	Weight (%)	Mag. (%)	SiO_2 (%)	Fe_T (%)	MgO (%)	CaO (%)
+850	3.3	1.2	3.7	1.2	0.9	1.8
-850+600	6.4	2.3	7.1	2.7	2.1	4.1
-600+425	11.1	3.4	12.3	4.7	4.9	7.0
-425+300	13.2	4	14.8	5.1	6.4	7.9
-300+212	11.6	3.5	13	3.7	7.1	7.8
-212+150	9.5	2.9	10.6	2.5	7.5	7.6
-150+75	12.9	5.2	13.8	5.3	17.0	15.2
-75+45	7.9	11.2	7.2	10.4	14.3	12.2
-45+38	3.0	7.9	2.4	6.7	5.2	4.6
-38	21.2	58.4	15.1	57.7	34.6	31.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 13-9: Rougher tails mineralogical analysis

Size fraction (µm)	Iron oxides Liberation	Comments
+850	< 10 %	Associations with quartz mostly as inclusions - Large amphiboles particles
-600+425	< 10 %	
-425+300	30-50 %	Few free particles and mostly inclusions in quartz
-300+212	60-80 %	Free particles and inclusions in quartz
-212+150	80-90 %	Large and free Fe oxides particles with very few associations with quartz and inclusions
-150+75	80-90 %	
-75	80-90 %	Large amount of goethite/limonite covering the particles

The qualitative mineralogical analysis of the rougher tails sample is based on binocular observations made for each size fraction. In this context, the iron oxides particles are considered liberated when at least 90% of their surface is hematite or magnetite.

The results from the sample's analysis showed that most of the iron (about 75%) is in the -75 µm fraction and that iron particles finer than 212 µm are liberated at 80-90%, which represents 83% of the iron oxides. Based on this information, a composite rougher tails bulk sample of approximately 3 tons was taken from November 13 to 16, 2018 to provide material for fine iron scavenging testwork.

The rougher spiral tails were collected into 12 drums filled from two samplings points, one on the north side and one on the south side. The filling was performed by unplugging the manual sampler discharge port hose and tying a temporary hose leading to the drums. The manual sampler consists of a cutter mounted on guiding rods inside a box fed from the top by the tails from one rougher spiral bank. The cutters were positioned in the middle of the stream for time needed to fill the drums. This way of sampling is not ideal so a comparison between this bulk sample and the rougher tails' samples taken during the sampling campaigns was done. The bulk sample has a similar iron distribution and slightly lower iron grade compared to the campaigns' average, so the bulk sample is considered representative. Between each filling of the drums, the material was left to settle and the excess water removed. This process was done several times until the drums were full.

13.4.2.4 Bulk Variability Samples

13.4.2.4.1 Description

Eight samples of approximately two to three tonnes each, and representing different lithologies, were taken from the three pits in the mine: West, Pignac and Chief's Peak.

Figure 13-9 shows the locations where the variability samples were collected in the different pits.

Figure 13-9: Bulk variability samples location

The eight samples descriptions and chemical composition are presented in Table 13-10 and Table 13-11 respectively.

Table 13-10: Variability bulk samples identification

Sample No.	Description	Pit
1	Hematite 1	West Pit
2	Hematite 2	West Pit
3	Hematite 1	Pignac Pit
4	Hematite 2	Pignac Pit
5	Hematite	Chief's Peak Pit
6	Silicates	Pignac Pit
7	Silicates 1	Chief's Peak Pit
8	Silicates 2	Chief's Peak Pit

Table 13-11: Variability bulk samples head grades

Sample	Analysis				
	Fe (%)	SiO_2 (%)	MgO (%)	CaO (%)	Mag. (%)
Hematite 1 West Pit	34.4	51.1	-	-	0.9
Hematite 2 West Pit	32.9	51.2	0.2	0.2	1.8
Hematite 1 Pignac Pit	29.9	55.4	0.3	0.3	1.8
Hematite 2 Pignac Pit	25.5	62.9	0.1	0.1	2.8
Hematite Chief's Peak Pit	37.8	41.4	2.0	1.4	7.5
Silicates Pignac Pit	19.9	56.5	6.5	4.9	9.4
Silicates 1 Chief's Peak Pit	30.6	46.8	4.3	3.5	8.1
Silicates 2 Chief's Peak Pit	26.9	52.9	3.4	2.5	29.5

13.4.2.4.2 Sample Comminution

The bulk variability samples were sent to SGS Lakefield for initial preparation. Samples were first stage crushed to 100% passing 12.7 mm using two jaw crushers, a cone crusher and a screen. A portion of roughly 200 kg of the Chief's Peak pit Hematite sample was used for batch HPGR tests and a locked-cycle HPGR test with a 850 µm screen. These tests' results were used to set the parameters for processing the batch samples. The bulk samples were crushed in a HPGR and screened to 100% passing 850 µm. The particle size distributions obtained are presented in Figure 13-10.

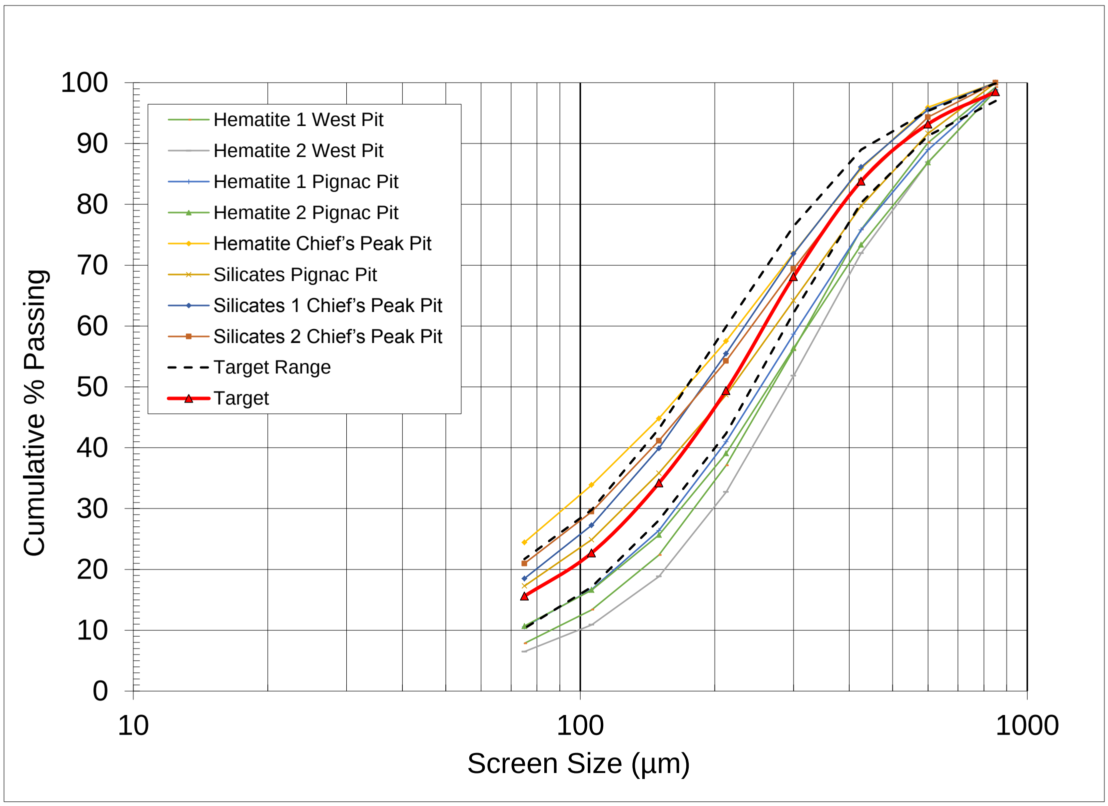


Figure 13-10: Variability samples particle size distributions

The samples P_{80} are between 362 µm and 523 µm, which is a coarser range than what is generally seen in the Phase 1 (QIO) concentrator (around 325 µm to 425 µm). Hematite samples from West pit and Pignac pit are the samples with the highest P_{80}. It is, however, considered normal to have a broader particle size distribution on the eight variability samples than what is observed in operation since operation PSD are measured on blended material.

Each of the eight variability samples was subjected to a complete mineralogical characterization (MLA), including a modal analysis (or a determination of mineral proportions) and a liberation analysis. An iron oxide particle is considered free if more than 95% of its content corresponds to valuable iron oxide minerals. The variability bulk samples modal analysis is shown in Table 13-12 and the variability bulk samples liberation analysis is shown in Table 13-13.

Table 13-12: Variability bulk sample modal analysis

Sample	Weight (%)				
	Hematite	Magnetite	Quartz	Iron hydroxides	Amphiboles
Hematite 1 West Pit	51.2	1.0	46.9	0.3	0.1
Hematite 2 West Pit	49.8	1.1	45.2	0.6	0.3
Hematite 1 Pignac Pit	41.9	2.2	50.2	1.4	0.2
Hematite 2 Pignac Pit	34.4	3.3	57.0	4.5	0.4
Hematite Chief's Peak Pit	49.4	7.8	34.1	0.7	4.5
Silicates Pignac Pit	19.1	10.7	36.4	0.3	24.2
Silicates 1 Chief's Peak Pit	39.5	9.3	31.5	0.1	15.8
Silicates 2 Chief's Peak Pit	6.0	33.1	42.3	0.2	7.4

Table 13-13: Variability bulk sample liberation analysis

Sample	+600 µm	-600+425 µm	-425 +300 µm	-300 +212 µm	-212 +106 µm	-106 µm	Total
Hematite 1 West Pit	89.5	88.7	88.1	93.2	96.7	98.1	92.8
Hematite 2 West Pit	93.8	94.5	93.3	95.4	97.4	97.9	95.3
Hematite 1 Pignac Pit	78.6	79.1	84.1	89.7	94.5	96.6	89.0
Hematite 2 Pignac Pit	48.3	55.3	67.8	75.6	86.3	91.3	73.9
Hematite Chief's Peak Pit	93.9	94.8	95.0	95.6	97.6	96.6	96.1
Silicates Pignac Pit	68.9	78.9	87.2	91.1	95.4	97.1	90.9
Silicates 1 Chief's Peak Pit	80.1	84.5	87.6	91.3	94.2	98.0	93.1
Silicates 2 Chief's Peak Pit	71.5	77.1	84.8	93.1	95.6	96.7	91.4

13.4.2.4.3 Heavy Liquid Tests

The eight variability samples were submitted to heavy liquid separation (HLS) and results were compared to Bloom Lake heavy liquid results database for the corresponding lithologies: iron formation (IF), mostly consisting of hematite, and silicate iron formation (SIF). The separation was performed at a density of 3.3 and the -75 µm fraction was removed, as for the historical HLS tests. The HLS database consists of testwork results from drill core samples taken throughout the deposit. A diamond drillhole map for the Bloom Lake project is presented in Figure 14-23.

The comparison of the sink iron grade and HLS iron recovery for the eight variability samples with the Bloom Lake HLS results database are presented in Figure 13-11 and Figure 13-12 respectively. The dots appearing above the distributions' bars represent the variability samples. Their colour matches the pit and lithology they represent. Their location on the X-axis indicates the sample Fe grade or Fe recovery, while their location on the Y-axis is arbitrary and was selected for clarity purposes.

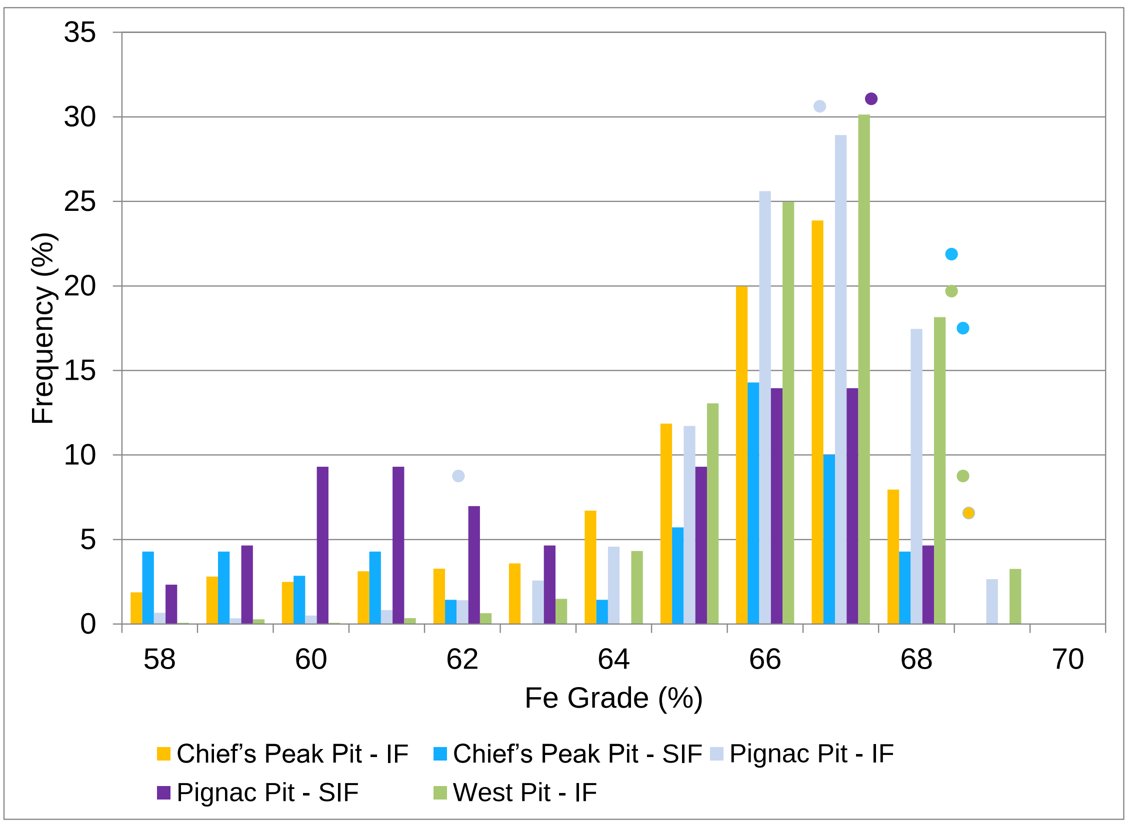


Figure 13-11: HLS sink iron grade comparison

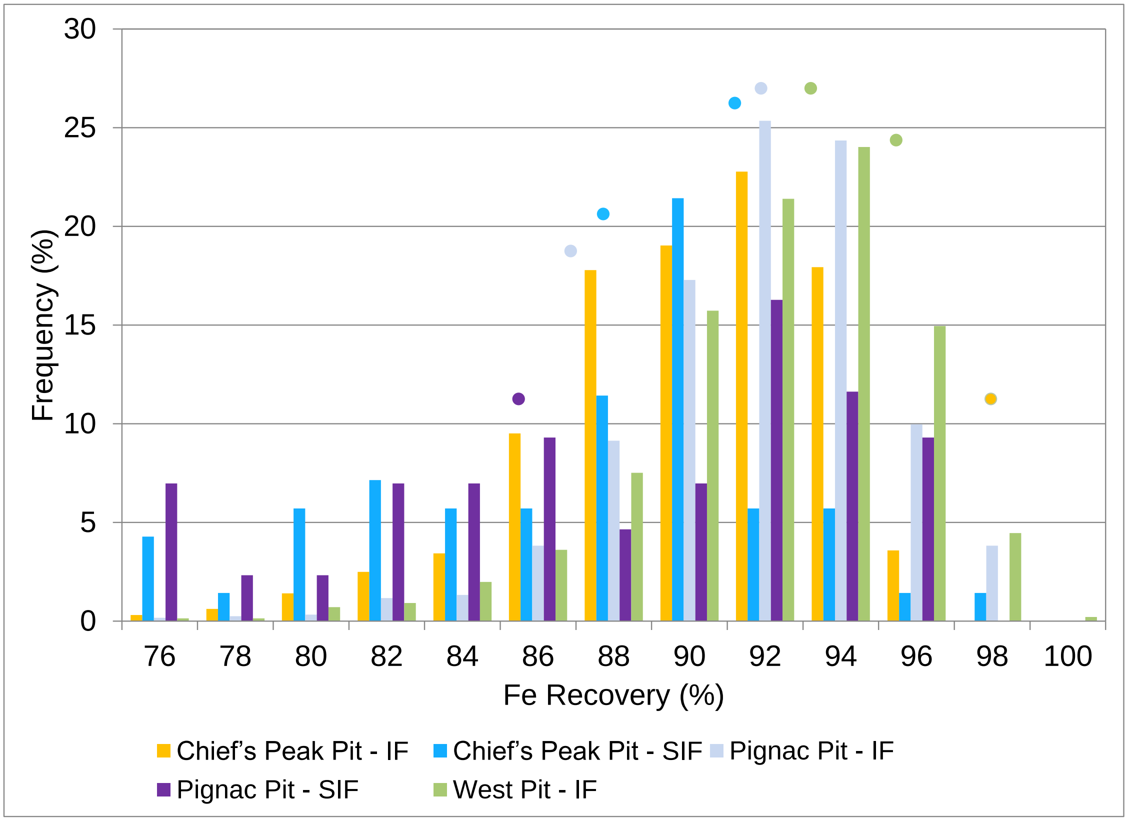


Figure 13-12: HLS iron recovery comparison

The variability samples HLS sink iron grades and recoveries are well distributed within the high frequency range of the historical HLS iron grades and recoveries. The iron grades of the variability samples are on the high side of the distribution. This can be explained by the coarser grind used for the historical HLS. Special care was taken with the variability sample to generate a size distribution close to the operation, which is significantly finer and can be assumed more liberated.

The eight variability samples can be considered representative of the Bloom Lake deposit.

13.4.2.4.4 Variability Blend Composition

The eight variability samples were combined into five ore blends based on operational experience and life of mine plan to assess the developed flowsheet performance robustness to ore type variations.

For the variability testing the five ore blends were combined, as indicated in Table 13-14 .

Table 13-14: Variability sample composition

Blend	Proportion %	Sample	Assays			
			Fe %	SiO_2 %	MgO %	CaO %
1	50	Hematite 1 West Pit	34.6	46.6	1.6	1.4
	50	Silicates 1 Chief's Peak Pit				
2	60	Hematite 2 Pignac Pit	26.9	56.7	1.5	1.2
	40	Silicates 2 Chief's Peak Pit				
3	50	Hematite 1 West Pit	30.9	54.4	0.2	0.2
	50	Hematite 1 Pignac Pit				
4	40	Silicates 1 Chief's Peak Pit	32.6	47.4	2.1	1.7
	30	Hematite Chief's Peak Pit				
	30	Hematite 1 Pignac Pit				
5	50	Silicates Pignac Pit	27.7	51.1	3.5	2.7
	20	Hematite Chief's Peak Pit				
	30	Hematite 2 West Pit				

13.4.3 Assay QC/QA

Data reconciliation was performed on all the testwork results using Bilmat software. Step by step testwork reconciliation was performed by prioritizing chemical analysis, particle size distributions, chemical analysis per size and percent solids respectively. Variability testwork reconciliation was performed on chemical analysis only.

Throughout the testwork program, chemical analysis of the samples was conducted using the X-Ray fluorescence method (XRF) at COREM. To ensure the quality of the assays, the variability testwork samples iron was also analyzed by potassium dichromate titration. COREM lab is ISO/CEI 17025 certified and that certification covers both XRF and titration analysis methods. Both methods gave identical results within the methods precision level. The results are presented in Figure 13-13.

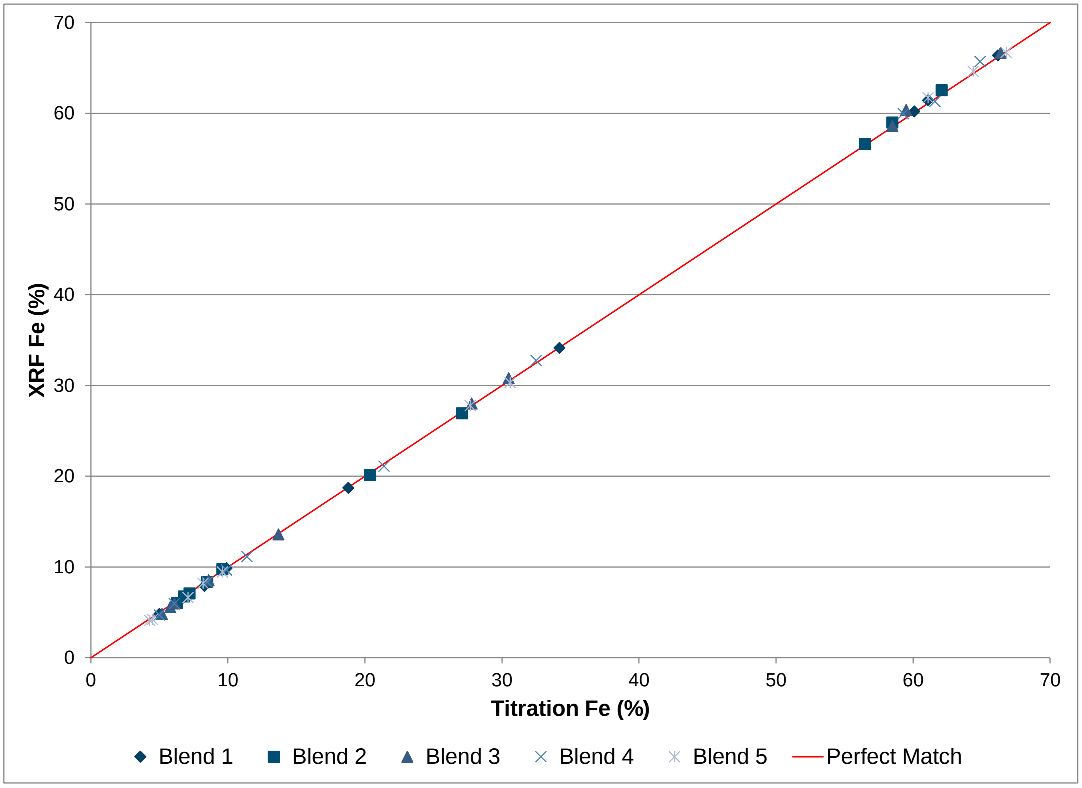


Figure 13-13: Iron assay method comparison

13.4.4 Step by Step Testwork

13.4.4.1 Data Processing

Given the nature of the spiral testwork setup, it was necessary to normalize weight and iron recoveries at the measured fresh feed assay in order to be able to compare the closed loop tests and open circuit production. The weight recovery to the iron concentrate and the iron recovery are calculated based on the same feed grade for all the spiral tests at each stage. The equations used for normalization are as follows, with the feed grade being the analyzed head sample and not the recalculated one:

$$Weight\ Recovery = \frac{Fe\ Grade_{Feed} - Fe\ Grade_{Tails}}{Fe\ Grade_{Concentrate} - Fe\ Grade_{Tails}}$$

$$Iron\ Recovery = Weight\ Recovery \times \frac{Fe\ Grade_{Concentrate}}{Fe\ Grade_{Feed}}$$

The test results from all the tests were reconciled using the Bilmat software.

13.4.4.2 Rougher Testwork

20 optimization tests were done. The solids tonnage per spiral start was varied from 1.8 tph to 3.0 tph. The wash water and % solids parameters were held at 1.1 tph (same as Phase 1 (QIO) concentrator) and 40% respectively. Two (2) concentrate port opening patterns were tested and the better one was chosen for the following tests.

The production tests involved running the test with all the available material while using the optimized conditions as found in the optimization tests.

The production test was performed at 2.1 tph at 40% solids. The Rougher concentrate generated was used in the UCC Cleaner tests and the Rougher middlings generated were used in the mids spirals testwork.

The Rougher optimization and production test results are presented in Table 13-15. The iron recovery versus solids feed rate is presented in Figure 13-14. The iron recovery versus the concentrate iron grade is presented in Figure 13-15.

Table 13-15: Rougher testwork results summary

	Feed		Concentrate			Middlings			Tails		
	Flowrate	Assays	Assays	Recovery		Assays	Recovery		Assays	Recovery	
Test	Solids (tph)	Fe (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
RGH 1	3.00	31.8	55.8	88.9	50.8	6.4	3.4	16.9	7.6	7.7	32.3
RGH 2	3.00	31.8	59.1	88.8	47.9	7.4	6.0	25.9	6.2	5.1	26.2
RGH 11	3.01	31.8	54.4	90.9	53.2	6.5	5.1	24.9	5.8	4.0	21.9
RGH 16	2.94	31.8	56.8	90.4	50.7	5.4	4.2	24.7	7.0	5.4	24.6
RGH 3	2.70	31.8	55.5	91.6	52.6	5.8	3.3	18.3	5.5	5.1	29.1
RGH 4	2.70	31.8	55.4	91.7	52.7	5.3	4.5	26.6	5.9	3.8	20.7
RGH 12	2.70	31.8	55.4	91.9	52.8	5.6	4.8	27.0	5.2	3.3	20.2
RGH 17	2.70	31.8	57.0	90.8	50.8	5.5	4.5	26.1	6.4	4.7	23.2
RGH 5	2.40	31.8	54.7	92.2	53.7	5.1	4.8	29.6	5.7	3.0	16.6
RGH 6	2.40	31.8	56.6	91.3	51.3	5.5	5.4	31.3	6.0	3.3	17.3
RGH 13	2.40	31.8	55.5	91.4	52.5	5.7	4.7	26.2	5.7	3.8	21.3
RGH 18	2.42	31.8	57.3	90.9	50.5	5.4	5.3	30.9	6.6	3.9	18.6
RGH 7	2.10	31.8	57.0	91.5	51.1	5.4	5.5	32.4	5.8	3.0	16.5
RGH 8	2.10	31.8	57.4	91.0	50.5	6.1	6.2	32.3	5.2	2.8	17.2
RGH 14	2.10	31.8	55.6	91.6	52.5	5.7	5.0	27.9	5.6	3.5	19.6
RGH 19	2.10	31.8	56.0	91.7	52.1	5.1	4.9	30.8	6.3	3.4	17.1
RGH 9	1.80	31.8	56.2	91.4	51.8	5.9	6.0	31.9	5.1	2.6	16.3
RGH 10	1.80	31.8	55.3	91.4	52.6	6.2	6.4	32.9	4.8	2.2	14.4
RGH 15	1.83	31.8	55.2	92.0	53.1	5.5	5.2	30.5	5.3	2.7	16.5
RGH 20	1.80	31.8	55.8	92.1	52.5	4.8	5.2	34.7	6.8	2.7	12.7
RGH Prod.	2.10	31.8	55.3	87.2	50.2	6.6	6.0	28.8	10.4	6.9	21.0

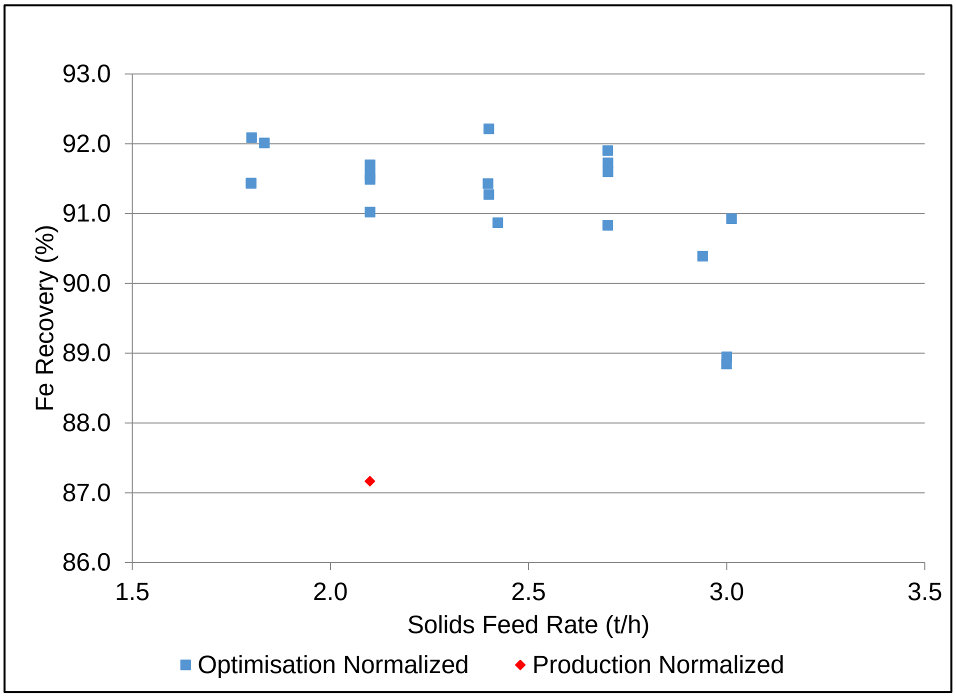


Figure 13-14: Rougher testwork – Iron recovery vs. solids feed rate

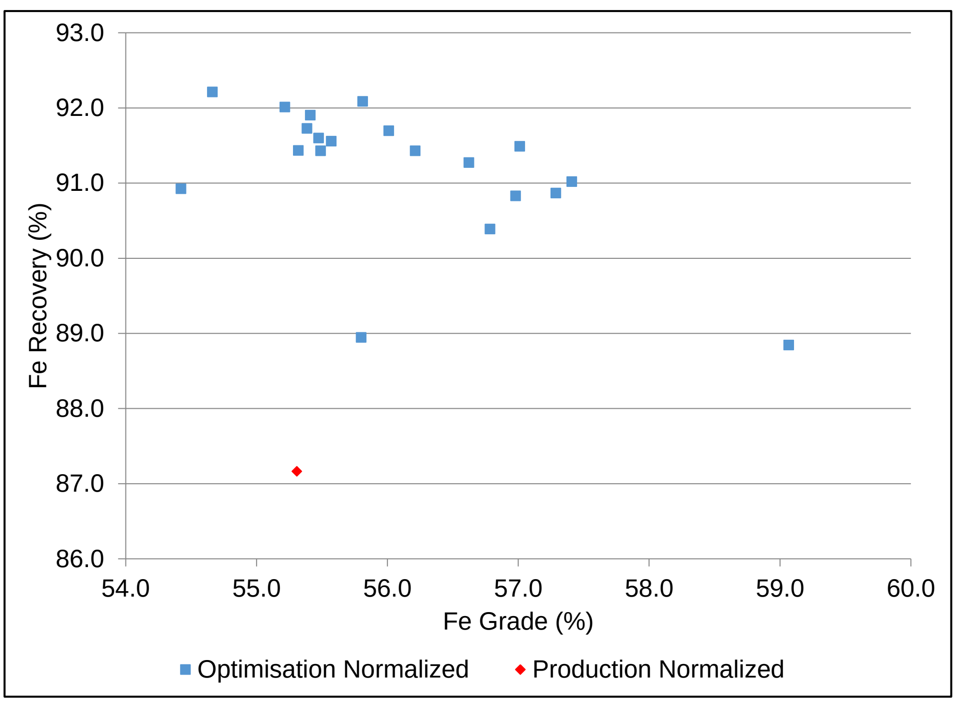


Figure 13-15: Rougher testwork – Recovery vs. iron grade curve

The main conclusions of these tests are:

- There is a significant decrease in the spirals iron recovery at 3.0 tph. Below this tonnage, the iron recovery is stable;
- The final concentrate iron grades are not significantly different from one another (majority from 55 to 57.5%);
- The middlings iron grade is very low;
- The rougher performance is very high, at mostly above 90% iron recovery.

The production test was significantly less efficient than the optimization tests, but coherent with plant performance. This difference in performance is caused by the closed loop set up used at COREM for the optimization tests versus no recirculation for the production tests, even though the results were normalized.

13.4.4.3 Mids Testwork

Four mids tests were performed with spirals. The feed for the mids testwork originated from the rougher production tests. The solids tonnage per spiral start was varied from 1.5 tph to 3.0 tph. The wash water and % solids parameters were held at 1.1 tph and 40% respectively.

The production tests involved running the test with all the available material while using the optimized conditions as found in the optimization tests.

The results led to one production test at 2.3 tph at 40% solids. The mids spiral concentrate generated was used in the LIMS/WHIMS tests.

The mids optimization and production test results are presented in Table 13-16. The solids feed rate versus the iron recovery is presented in Figure 13-16. The solids feed rate versus the iron grade is presented in Figure 13-17. The recovery curve versus concentrate grade is presented in Figure 13-18.

Table 13-16: Mids testwork results summary

	Feed		Concentrate			Tails		
	Flowrate	Assays	Assays	Recovery		Assays	Recovery	
Test	Solids (tph)	Fe (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
MIDS 1	2.94	6.60	41.27	21.12	3.37	5.38	78.88	96.63
MIDS 2	2.35	6.60	33.59	25.17	4.94	5.19	74.83	95.06
MIDS 3	1.76	6.60	24.86	27.58	7.32	5.15	72.42	92.68
MIDS 4	1.52	6.60	23.78	27.90	7.74	5.15	72.10	92.26
MIDS Prod.	2.34	6.60	23.56	37.08	10.38	4.63	62.92	89.62

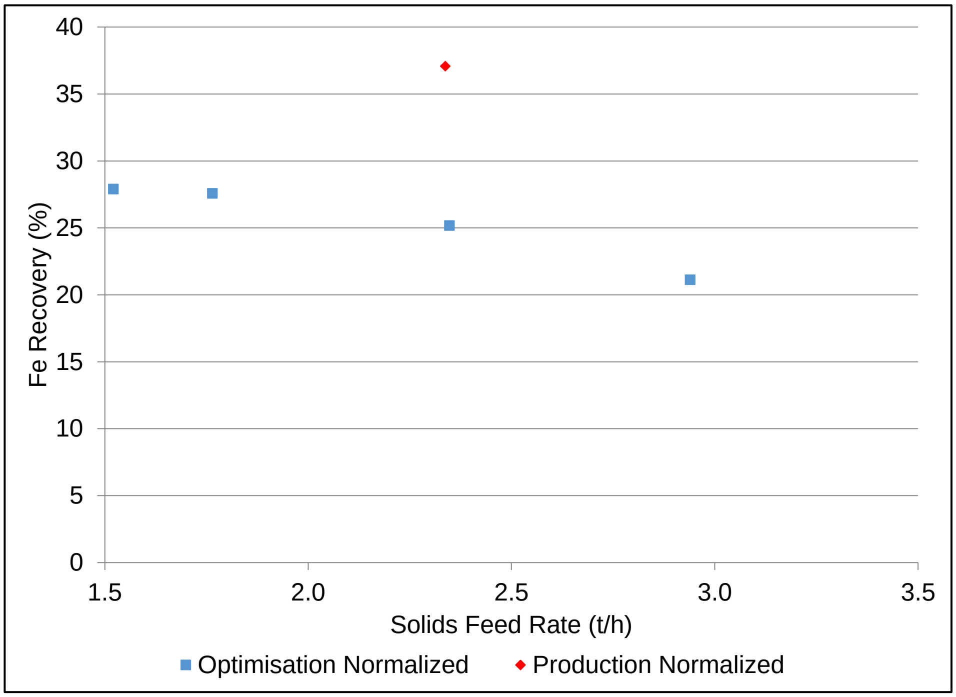


Figure 13-16: Mids testwork – Iron recovery vs. solids feed rate

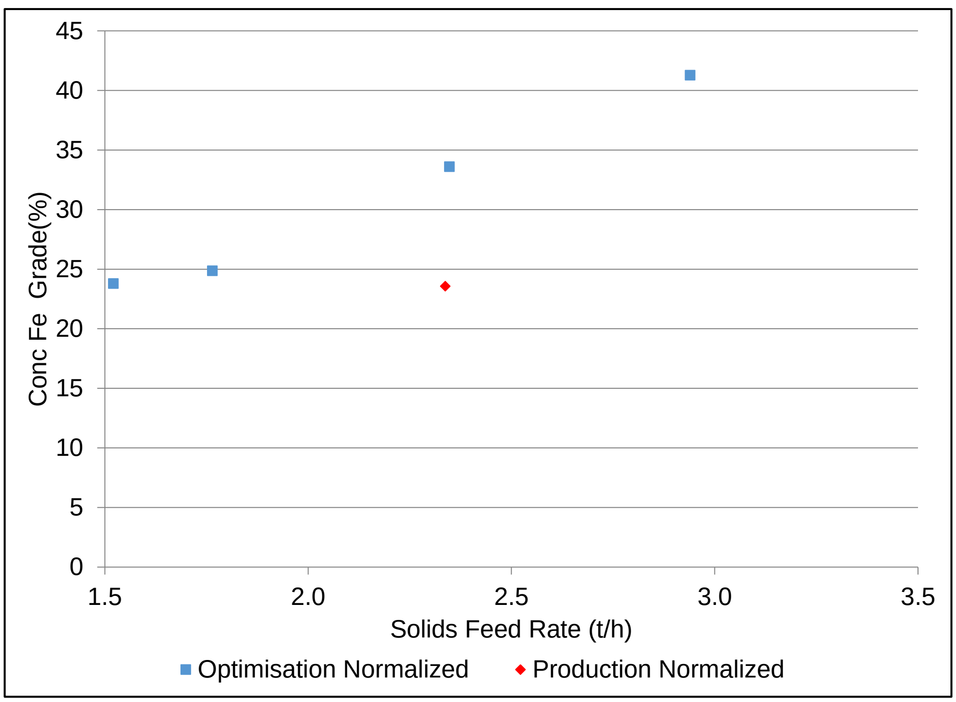


Figure 13-17: Mids testwork – Concentrate iron grade vs. solids feed rate

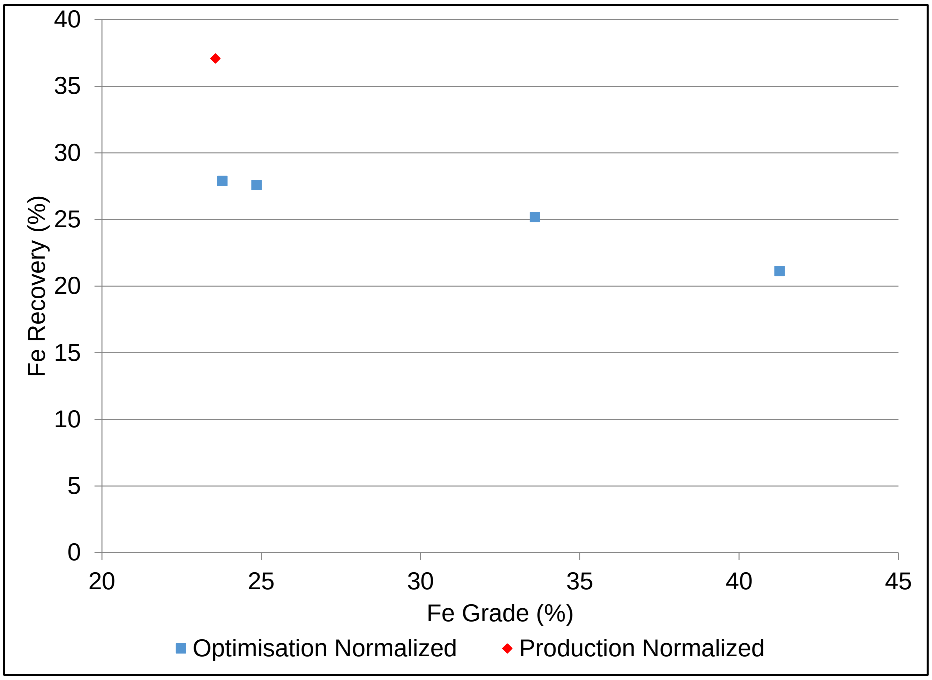


Figure 13-18: Mids testwork – Recovery vs. iron grade curve

The main conclusions derived from these tests are:

- The head grade was very low for the testwork which led to low recoveries and grade;
- The iron recovery decreases as the tonnage increases;
- The concentrate iron grade increases as feed tonnage increase.

The results of the production test show:

- This test performed significantly better than the optimization testwork which could be explained by the smaller concentrate quantity generated, relative to the mids and tails, compared to what is generated at the rougher stage. The bias between the closed loop tests and open circuit production is therefore less important;
- This test performance is close to the performance observed in the Phase 1 (QIO) concentrator.

13.4.4.4 Cleaner UCC Testwork

Two Cleaner UCC tests were performed on the rougher spiral concentrate. These tests were performed using only the splitters concentrate (C1) from the rougher therefore at a higher feed grade than what it would be in operation. The wash water addition rates tested were 0.50 and 0.65 m^3/t feed. The feed rate was held at 1.2 tph. No production tests were required for this stage.

In contrast to the Phase 1 operation, the mids concentrate was not mixed with the rougher concentrate to feed the cleaner stage. This modification was made based on the mids testwork and sampling campaign results showing that the mids concentrate represents a very low iron tonnage, has a very low iron grade and can potentially present coarse silica if not operated adequately To avoid potentially contaminating the cleaner stage with coarse silica, the mids concentrate was tested in a magnetic circuit.

The Cleaner UCC optimization test results are presented in Table 13-17. The concentrate iron recovery versus the rise rate is presented in Figure 13-19.

Table 13-17: Cleaner UCC testwork results summary

	Feed			Underflow			Overflow		
	Solids	Rise	Assays	Assays	Recovery		Assays	Recovery	
Test	Loading (tph/m^2)	Rate (cm/sec)	Fe (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
Cleaner 1	29.1	1.4	60.1	68.2	73.3	64.6	45.3	26.7	35.4
Cleaner 2	29.1	1.2	60.1	68.1	81.8	72.2	39.5	18.2	27.8

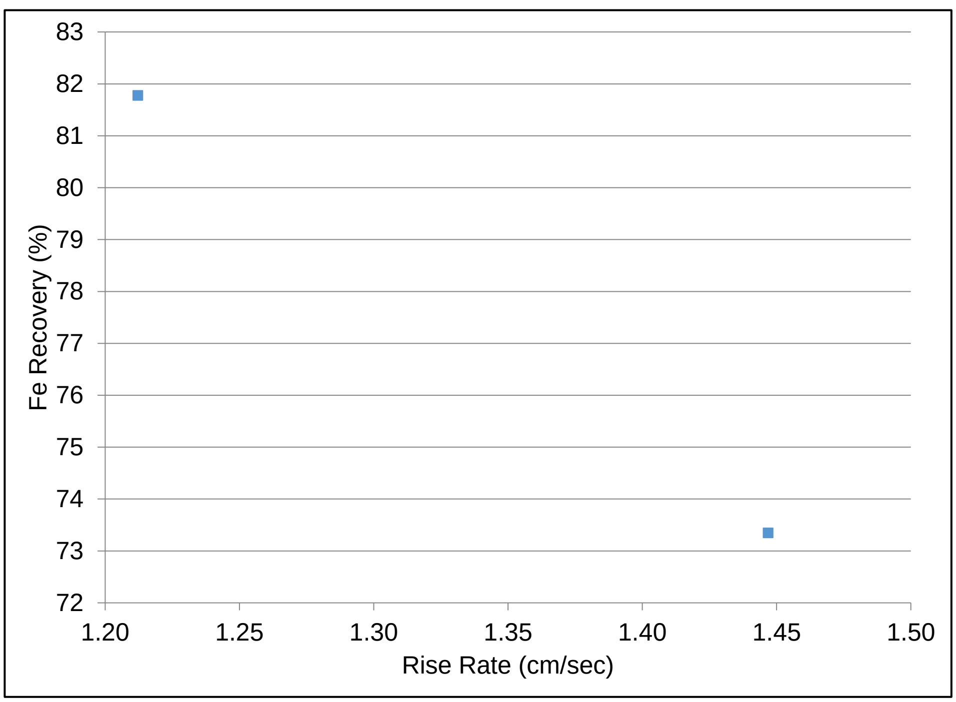


Figure 13-19: Cleaner UCC iron recovery vs. rise rate

The main conclusions derived from these tests are:

- The cleaner UCC stage produces a concentrate at the desired grade with a stage Fe recovery of around 80%;
- The testing was conducted at a low loading due to the limitation in feed availability and the available equipment size;
- The feed density was more or less controlled, because water was added to provide adequate pumping conditions;
- The iron recovery follows the rise rate for same solids loading.

13.4.4.5 Scavenger Spirals Testwork

Twenty (20) scavenger tests were performed with spirals. The solids tonnage per spiral start was varied from 0.8 tph to 1.8 tph. The wash water addition rate varied from 1.1 to 2.0 tph. The % solids varied from 20 to 40% solids.

The production test involved running the test with all the available material while using the optimized conditions as found in the optimization tests.

One production test was performed at 1.1 tph and 28% solids. The scavenger spiral concentrate generated was used in the scavenger cleaner tests.

The scavenger spiral optimization and production test results are presented in Table 13-18. The concentrate iron grade versus the iron recovery is shown in Figure 13-20 and the concentrate iron grade versus the solids feed tonnage is shown in Figure 13-21

Table 13-18: Scavenger spiral testwork results summary

	Feed	Concentrate			Middlings			Tails		
	Flowrate	Assays	Recovery		Assays	Recovery		Assays	Recovery	
Test	Solids (tph)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
SCV 1	1.49	52.8	93.7	65.4	6.1	2.2	13.4	7.1	4.1	21.3
SCV 2	1.49	54.0	93.1	63.5	6.3	2.2	12.9	7.3	4.7	23.6
SCV 3	1.46	56.8	92.6	60.0	6.5	2.5	14.4	7.0	4.8	25.6
SCV 4	1.45	58.3	91.6	57.8	7.1	2.8	14.5	7.5	5.6	27.7
SCV 5	1.45	55.4	92.7	61.6	6.1	2.4	14.7	7.6	4.9	23.7
SCV 6	1.79	59.5	89.0	55.0	6.8	3.3	18.0	10.5	7.7	26.9
SCV 7	1.53	58.9	91.3	57.1	6.5	3.4	19.3	8.2	5.3	23.5
SCV 8	1.35	58.7	92.4	58.0	6.1	3.4	20.5	7.2	4.2	21.6
SCV 9	1.14	60.0	92.7	56.9	5.9	3.9	24.5	6.6	3.4	18.7
SCV 10	0.84	61.0	92.3	55.8	7.4	4.7	23.5	5.2	2.9	20.8
SCV 11	1.17	60.3	89.7	54.7	7.6	4.0	19.4	9.0	6.3	25.8
SCV 12	1.21	59.7	90.3	55.6	6.8	3.6	19.4	9.1	6.2	25.0
SCV 13	1.16	58.4	91.4	57.6	7.2	2.8	14.1	7.5	5.8	28.3
SCV 14	1.19	58.7	91.6	57.4	7.6	3.3	16.1	7.1	5.1	26.5
SCV 15	1.22	56.3	92.2	60.3	7.6	2.5	11.9	7.1	5.3	27.8
SCV 16	1.43	51.2	93.5	67.2	5.7	1.9	12.4	8.3	4.6	20.5
SCV 17	1.41	56.4	91.9	60.0	7.2	2.7	14.0	7.6	5.4	26.1
SCV 18	1.38	57.8	91.9	58.5	8.3	2.7	11.9	6.8	5.4	29.6
SCV 19	1.52	58.2	90.8	57.4	10.4	2.9	10.1	7.2	6.3	32.4
SCV Prod.	1.10	57.3	93.0	59.8	6.0	2.3	14.4	6.6	4.7	25.9

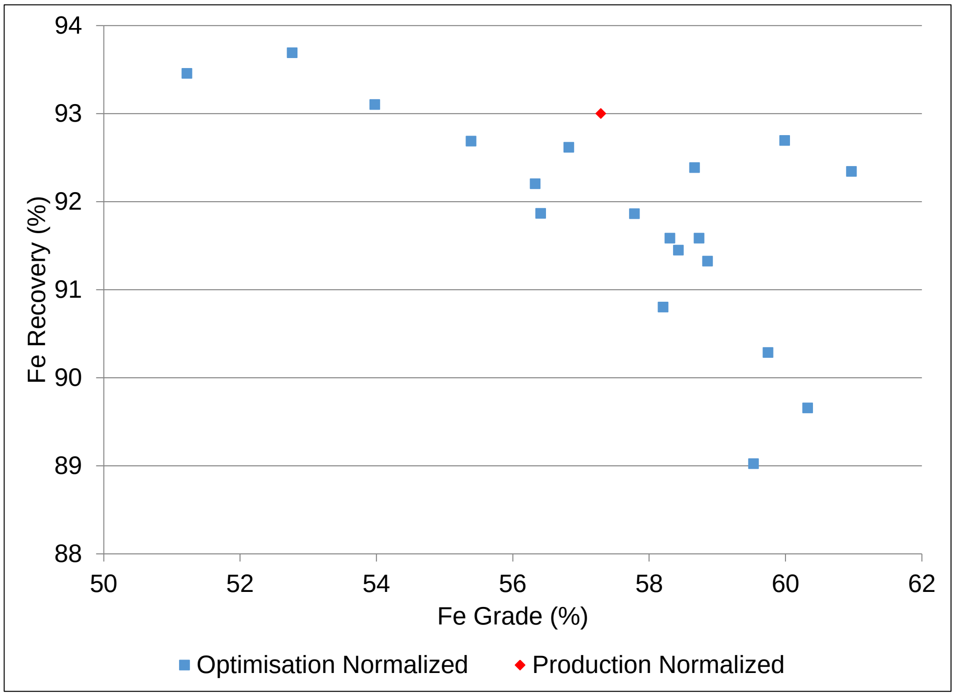


Figure 13-20: Scavenger spirals iron recovery vs. iron grade

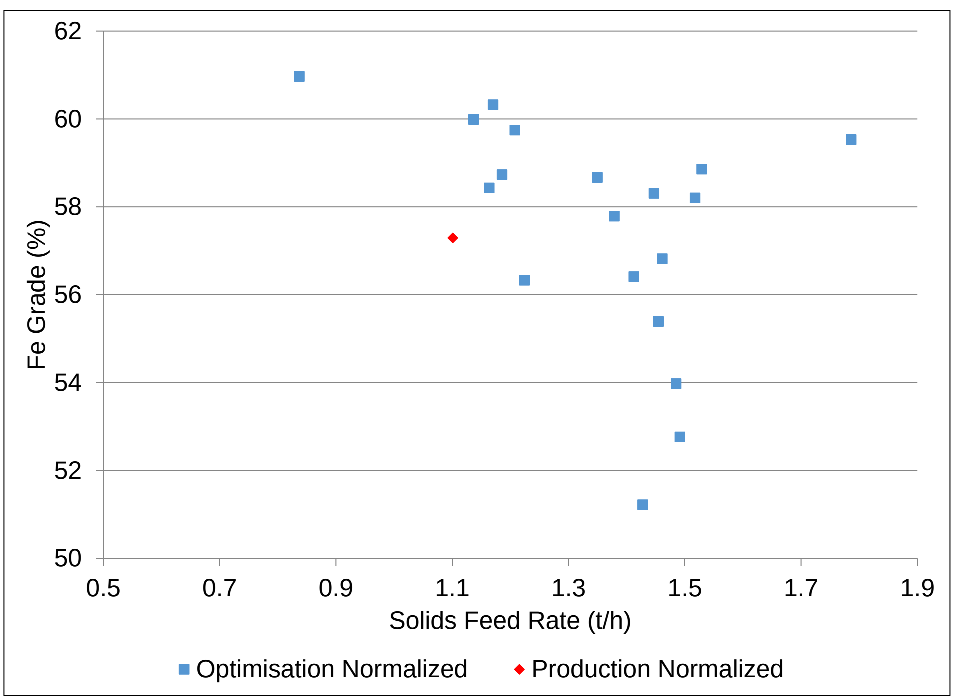


Figure 13-21: Scavenger spirals iron grade vs. feed tonnage

The production test was slightly above the recovery versus grade curve of the optimization tests. As opposed to the rougher spiral testwork, the production test result is very similar to the optimization test results. The coarse iron present at the rougher stage tends to collect more rapidly in the spirals' splitters and sinks faster to the bottom of the pump box compared to the fine iron present at the scavenger stage. In optimization tests, the fine iron at the scavenger stage had a longer retention time in the spiral and pump box compared to the rougher stage thus reducing the bias observed in closed loop spiral tests.

The main conclusions derived from these tests are:

- There were large differences in Fe recoveries between the tests in laboratory and the sampling campaigns, irrespective of the loadings;
- The tests were not able to produce a concentrate above 60% Fe with the C1+C2 concentrates, and not above 63% Fe with the C1 concentrate only. It, therefore, does not meet the final concentrate grade target;
- The testwork on the feed rate has shown an improvement of the performance with a lower feed rate;
- The testwork has shown an improvement of performance at higher feed densities;
- The production of a high iron grade scavenger concentrate results in high losses in recovery and confirms the need for a scavenger-cleaner stage.

13.4.4.6 Scavenger Cleaner Testwork

As observed in the sampling campaigns, the scavenger stage could not achieve a final concentrate iron grade in one stage. Therefore, a scavenger cleaner stage was tested. Three different technologies were tested to see which one produced the best results. The technologies tested were:

- Spirals;
- Reflux Classifier™;
- Up-Current Classifier (UCC).

The following three sections elaborate on the testing conducted for each technology.

13.4.4.6.1 Scavenger Cleaner - Spirals Testwork

Twelve (12) Scavenger Cleaner tests were performed with spirals. The solids tonnage per spiral start was varied from 0.86 tph to 1.80 tph. The % solids varied from 30 to 45% solids. The wash water flowrate varied from 1.1 tph to 1.56 tph.

The scavenger cleaner spiral optimization test results are presented in Table 13-19.

Table 13-19: Scavenger cleaner spirals testwork results summary

	Feed		Concentrate			Tails		
	Flowrate	Assays	Assays	Recovery		Assays	Recovery	
Test	Solids (tph)	Fe (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
Spiral Scav 1	1.76	57.07	63.75	93.97	84.13	21.68	6.03	15.87
Spiral Scav 2	1.48	57.07	64.24	95.20	84.57	17.77	4.80	15.43
Spiral Scav 3	1.10	57.07	64.16	96.01	85.40	15.61	3.99	14.60
Spiral Scav 4	0.86	57.07	63.76	98.05	87.77	9.08	1.95	12.23
Spiral Scav 5	1.34	57.07	64.00	97.13	86.62	12.24	2.87	13.38
Spiral Scav 6	1.40	57.07	64.21	96.55	85.82	13.88	3.45	14.18
Spiral Scav 7	1.42	57.07	63.69	96.36	86.35	15.23	3.64	13.65
Spiral Scav 8	1.32	57.07	64.40	96.45	85.47	13.95	3.55	14.53
Spiral Scav 9	1.38	57.07	63.27	97.14	87.62	13.20	2.86	12.38
Spiral Scav 10	1.33	57.07	63.64	96.93	86.92	13.38	3.07	13.08
Spiral Scav 11	1.80	57.07	63.64	94.75	84.96	19.93	5.25	15.04
Spiral Scav 12	1.45	57.07	62.62	95.91	87.41	18.55	4.09	12.59

The concentrate iron recovery versus solids feed rate is presented in Figure 13-22 and the concentrate iron recovery versus iron grade is presented in Figure 13-23.

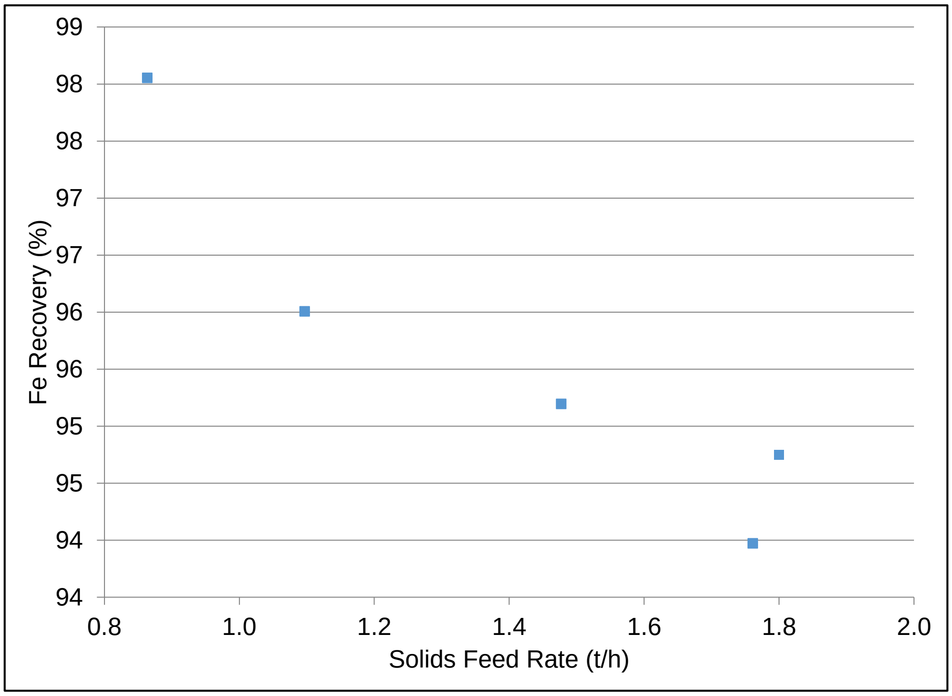


Figure 13-22: Scavenger cleaner spirals, iron recovery vs. solids feed rate

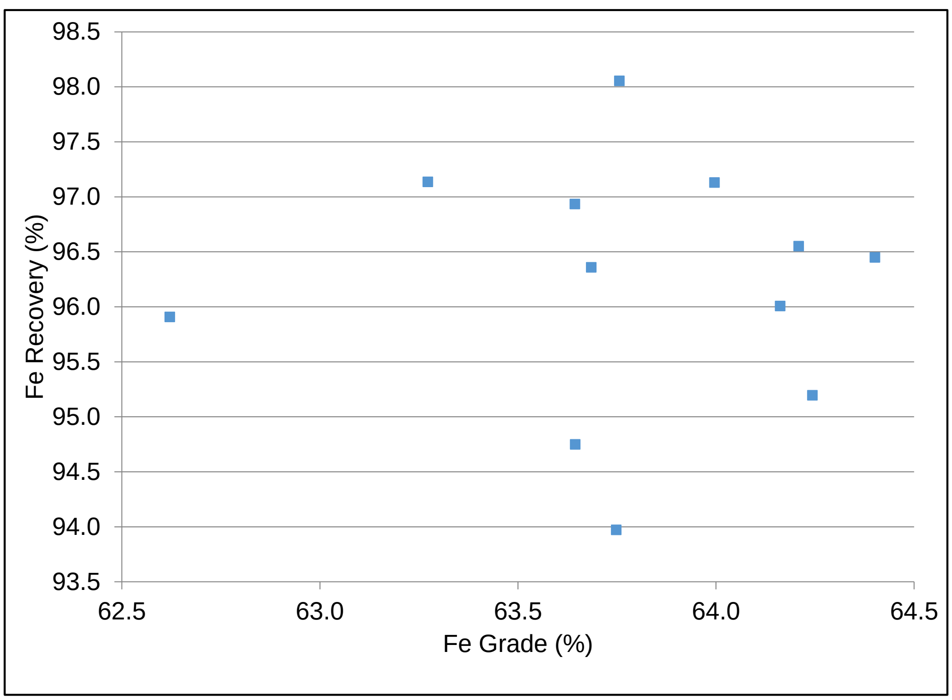


Figure 13-23: Scavenger cleaner spirals, iron recovery vs. iron grade

The main conclusions derived from these tests are:

- The iron recoveries obtained with the scavenger spirals stage are very high;
- It was not possible to produce a concentrate at the final grade, although producing a grade as high as possible was attempted. As a result, no production test was performed using this equipment;
- Rougher, mids and scavenger spirals have performed significantly better in closed-loop testwork than what is observed in the plant (5 to 10% less iron recovery). As a result, lower recoveries could be expected in operation compared to the presented results;

13.4.4.6.2 Scavenger Cleaner - Reflux Testwork

Five reflux scavenger cleaner tests were performed on the scavenger spiral concentrate. The wash water addition rates tested ranged from 1.0 to 4.0 L/min. The feed rate was held at 0.09 tph.

The results of the reflux scavenger cleaner testwork are presented in Table 13-20. The reflux scavenger concentrate iron recovery versus wash water is shown in Figure 13-24.

Table 13-20: Reflux scavenger testwork results summary

	Feed		Underflow			Overflow		
	Flowrate	Assays	Assays	Recovery		Assays	Recovery	
Test	Solids (tph)	Fe (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
Reflux Scav 1	0.09	57.07	69.04	76.31	63.09	36.62	23.69	36.91
Reflux Scav 2	0.09	57.07	69.34	83.80	68.97	29.80	16.20	31.03
Reflux Scav 3	0.09	57.07	69.07	90.52	74.79	21.47	9.48	25.21
Reflux Scav 4	0.09	57.07	68.39	83.96	70.07	30.58	16.04	29.93
Reflux Scav 5	0.09	57.07	68.95	33.79	27.96	52.46	66.21	72.04

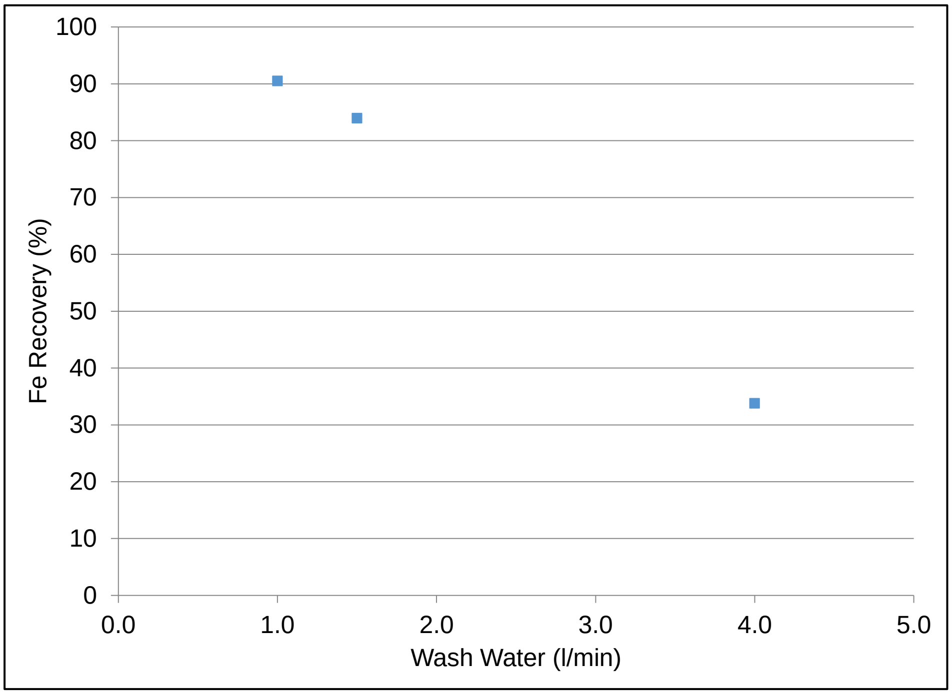


Figure 13-24: Reflux scavenger iron recovery vs. wash water flowrate

The main conclusions derived from these tests are:

- The reflux classifier testing led to an extremely high concentrate grade with high recoveries;
- Additional time and more sample material would have been required to perform extensive testwork;
- Operational experience with the reflux classifier is limited in iron ore processing. However, the achieved concentrate grade and high recoveries confirm the equipment potential to recover fine iron when compared to UCC;
- Extensive piloting would be required to introduce this technology in the flowsheet.

Although the tests showed very good results, no production tests were performed using this equipment due to the high level of uncertainty surrounding this equipment at this stage.

13.4.4.6.3 Scavenger Cleaner - UCC Testwork

Four UCC scavenger cleaner tests were performed on the scavenger spiral concentrate. The wash water addition rates tested ranged from 3 to 10 L/min. The feed rate ranged from 0.70 tph to 0.80 tph.

The laboratory scale UCC requires a high amount of material for testwork:

- To achieve a minimum loading, more than 0.7 tph must be fed to the equipment;
- The underflow compaction zone held a significant amount of material, thus:
  - Each test conditions must be held for a minimum of time for the compaction zone to be in steady state;
  - Operation in close loop is not a way to reduce the amount of required material since a very large pump box and sample weight would be needed to palliate the different residence time of the underflow and overflow.

Consequently, a limited amount of optimization tests were performed.

One production test was performed with the UCC. The overflow generated was tested in the LIMS and WHIMS. The wash water addition was set at 4 L/min and the feed rate was set at 0.8 tph.

A summary of the UCC scavenger cleaner is shown in Table 13-21. The concentrate iron recovery versus iron grade is shown in Figure 13-25. The size-by-size weight, iron and silica recovery to the scavenger-cleaner UCC underflow is shown in Figure 13-26.

Table 13-21: UCC scavenger testwork results summary

	Feed		Underflow			Overflow		
	Flowrate	Assays	Assays	Recovery		Assays	Recovery	
Test	Solids (tph)	Fe (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
UCC Scav 1	0.80	57.07	68.78	84.14	69.82	29.99	15.86	30.18
UCC Scav 2	0.80	57.07	68.81	43.01	35.68	50.56	56.99	64.32
UCC Scav 3	0.70	57.07	68.60	80.89	67.30	33.35	19.11	32.70
UCC Scav 4	0.70	57.07	68.70	71.25	59.19	40.21	28.75	40.81
UCC Scav Prod.	0.80	57.07	68.61	74.08	61.63	38.55	25.92	38.37

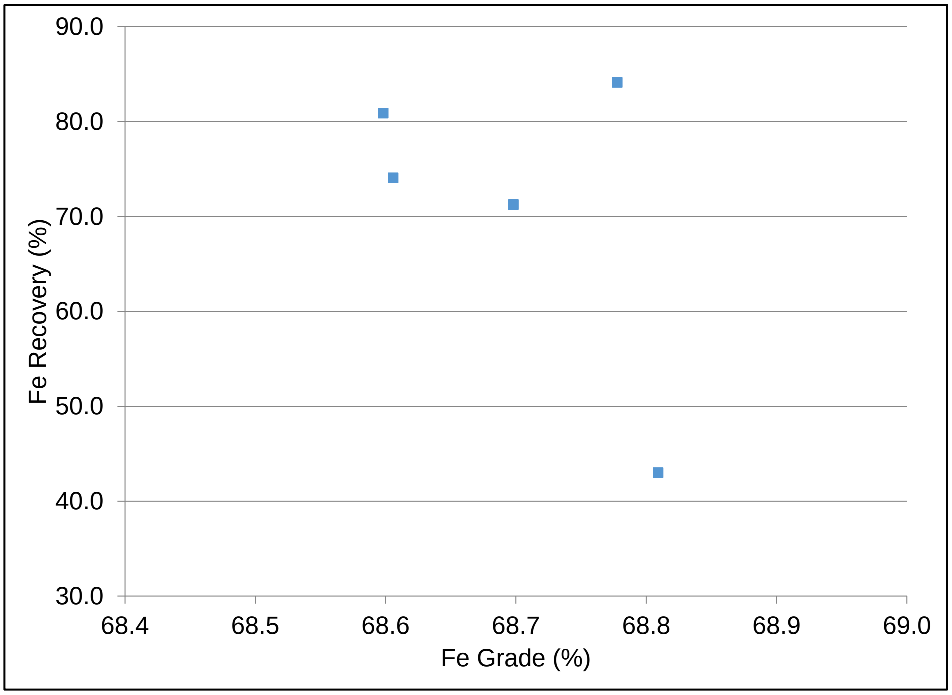


Figure 13-25: UCC scavenger-cleaner iron recovery vs. iron grade

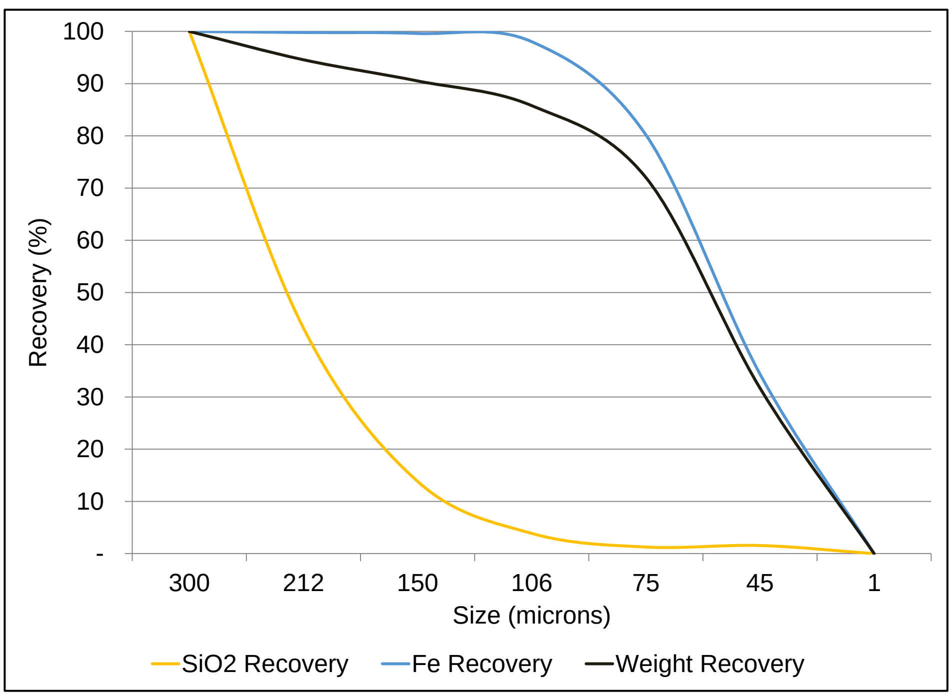


Figure 13-26: Size-by-size recovery to scavenger-cleaner UCC underflow

The main conclusions derived from these tests are:

- The Up-Current Classifier allowed the production of a very high grade concentrate;
- The recoveries obtained are considered satisfying:
  - All tests led to concentrate above 68.5% Fe grade for Fe recoveries as high as 85%;
  - The results present a potential for higher recoveries at lower Fe concentrate grade, which were not tested due to limited sample.
- The Up-Current Classifier allowed the removal of fine silica more efficiently than spirals;
- The use of an Up-Current Classifier for the cleaning of a spiral concentrate does not present a risk as its performance has been demonstrated in operation.

13.4.4.7 LIMS and WHIMS Testwork

A series of LIMS and WHIMS test was performed in lab scale equipment on mids concentrate and on scavenger cleaner UCC overflow separately, as well as on a feed composed of 40% mids concentrate and 60% scavenger cleaner UCC overflow. The aim of those tests was to compare the performance of each feed. The ratio used was deemed representative of what will feed the magnetic circuit in the Phase 2 (QIO) concentrator.

The LIMS and WHIMS optimization testwork was performed on the scavenger cleaner UCC overflow only. The non-magnetic tails of the LIMS was used as WHIMS feed. Four optimization tests were performed in which the WHIMS magnetic field intensity was varied at the following levels: 7,000, 9,000, 11,000 and 13,000 Gauss.

The production tests involved running the test with all the available material while using the optimized conditions as found in the optimization tests.

The results led to two production tests. The production tests were conducted on a feed composed of 40% mids spiral concentrate and 60% UCC overflow. The production tests were done at 11,000 Gauss for the WHIMS stage. Production test #1 was performed with the WHIMS' six concentrate hoses reporting to the magnetic concentrate. In production test #2, a portion (one hose out of six) from the WHIMS magnetic stream was diverted to a non-magnetic stream to see if the grade could be improved.

A summary of the LIMS and WHIMS lab scale testwork is shown in Table 13-22. A summary of the LIMS and WHIMS optimization and production testwork is shown in Table 13-23. The optimization testwork LIMS and WHIMS concentrates were combined prior to analysis due to the low magnetite content in the feed thus resulting in very low LIMS concentrate quantity. The production concentrate results show the value of combined LIMS and WHIMS assays. The concentrate iron recovery versus iron grade is shown in Figure 13-27.

Table 13-22 LIMS and WHIMS lab scale testwork results summary

Stream	Mids Concentrate		Scav Cleaner UCC O/F		60/40 Mix	
	Fe Grade (%)	Fe Recovery (%)	Fe Grade (%)	Fe Recovery (%)	Fe Grade (%)	Fe Recovery (%)
Feed	38.9	100.0	22.2	100.0	32.4	100.0
Concentrate	53.2	97.8	30.5	95.3	44.3	95.8
Tails	3.0	2.2	3.4	4.7	4.6	4.2

Table 13-23: LIMS and WHIMS testwork results summary

Test	WHIMS Magnetic Field Intensity (Gauss)	Feed		Concentrate			Tails		
		Flowrate	Assays	Assays	Recovery		Assays	Recovery	
		Solids (tph)	Fe (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
40/60 Prod 1	11,000	0.20	32.41	49.85	96.81	62.94	2.79	3.19	37.06
40/60 Prod 2	11,000	0.20	32.41	56.27	94.17	54.24	4.13	5.83	45.76
Scav Cleaner OF 1	7,000	0.20	38.54	58.87	93.53	61.23	6.43	6.47	38.77
Scav Cleaner OF 2	9,000	0.20	38.54	58.53	93.50	61.56	6.52	6.50	38.44
Scav Cleaner OF 3	11,000	0.20	38.54	58.32	94.22	62.26	5.90	5.78	37.74
Scav Cleaner OF 4	13,000	0.20	38.54	55.81	97.09	67.04	3.41	2.91	32.96

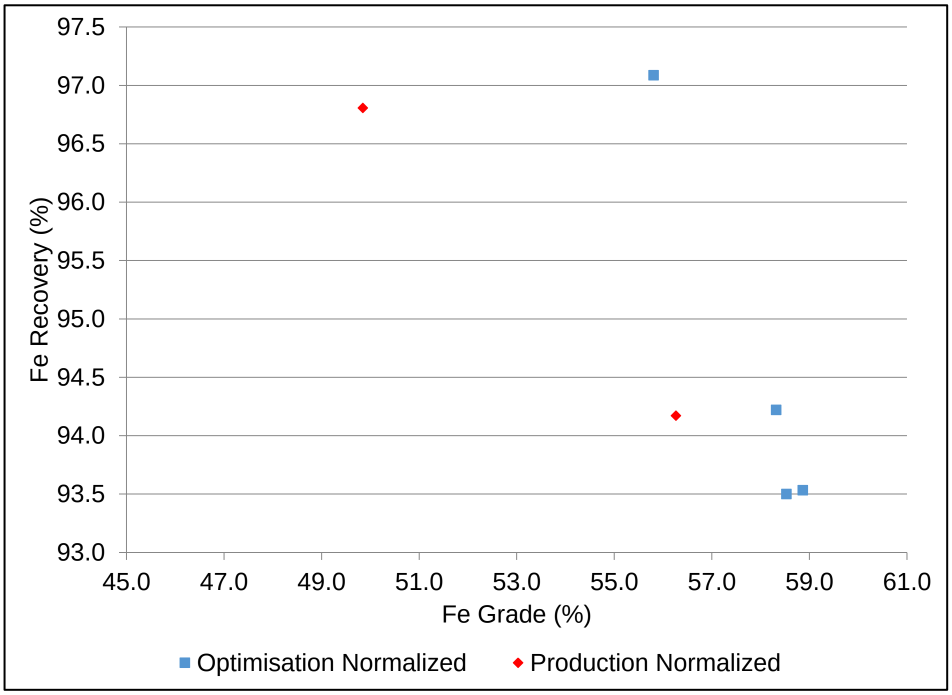


Figure 13-27: LIMS-WHIMS iron recovery vs. iron grade

The main conclusions drawn from the tests are:

- There was no significant difference between 7,000 and 9,000 Gauss on the WHIMS;
- Increasing the WHIMS magnetic field strength to 11,000 Gauss gave a slightly better iron recovery without significantly affecting the iron grade;
- Having a WHIMS magnetic field intensity at 13,000 significantly increases the iron recovery but also significantly decreases the iron grade;
- The optimization and production testwork produced similar results;
- Mixing 40% mids concentrate and 60% UCC scavenger cleaner overflow did not significantly affect the iron recovery but it did decrease the concentrate iron grade;
- The production tests performed better than Phase 1 (QIO) results in terms of iron recovery and iron grade.

13.4.4.8 Mag Cleaner Spirals Testwork

Two mag cleaner tests were performed on the WHIMS concentrate in a WW6+ spiral. The wash water addition rates tested ranged from 1.1 tph to 1.3 tph. The feed rate ranged from 1.2 tph to 1.3 tph. No production test was required at this stage.

The mag cleaner spiral testwork results are shown in Table 13-24. The mag cleaner spiral concentrate iron recovery versus iron grade is shown in Figure 13-28.

Table 13-24: Mag cleaner spiral testwork results

	Feed		Concentrate			Tails		
	Flowrate	Assays	Assays	Recovery		Assays	Recovery	
Test	Solids (tph)	Fe (%)	Fe (%)	Fe (%)	Mass (%)	Fe (%)	Fe (%)	Mass (%)
Mag Cleaner 1	1.19	50.3	60.0	89.7	75.3	20.9	10.3	24.7
Mag Cleaner 2	1.32	50.3	64.8	73.7	57.3	30.9	26.3	42.7

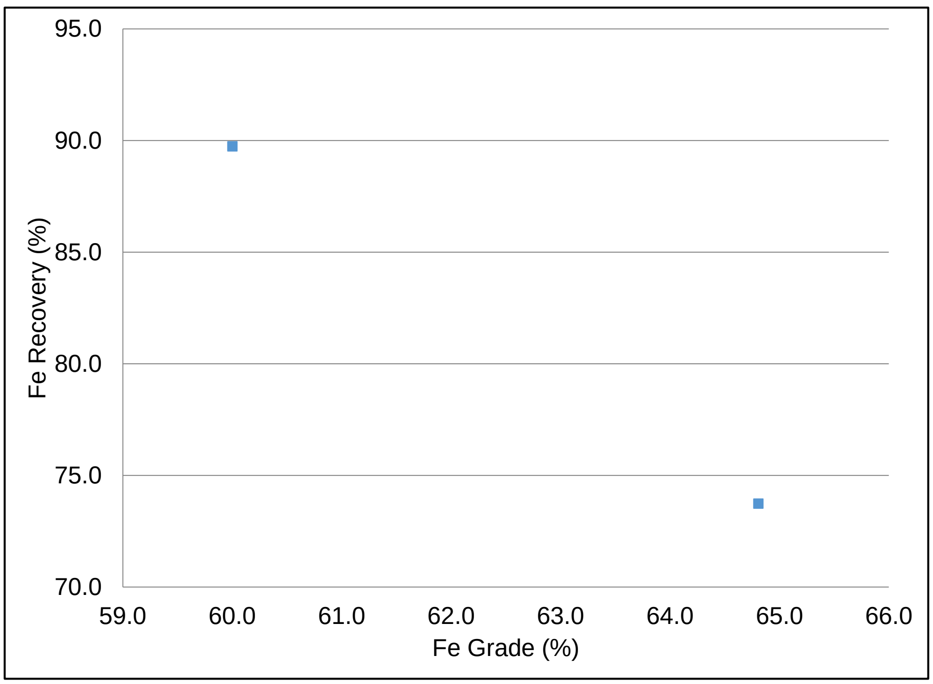


Figure 13-28: Mag cleaner spirals iron recovery vs. iron grade

The testwork results show that:

- The feed provided to the Mag Cleaner spiral is different from the Phase 1 (QIO) feed. However, the performance obtained are similar;
- A concentrate grade at 64.8% Fe was achieved with the spirals at a low iron recovery of 73.4%;
- The iron recovery decrease significantly with the production of a higher Fe grade concentrate.

13.4.4.9 Rougher Tails Testwork

LIMS and WHIMS exploratory testwork was performed to investigate the possibility of recovering iron from the rougher tails. For the testwork, the rougher tails were screened at 150 µm as the material finer than 150 µm contained most of the iron. The -150 µm portion represented approximately 52% of the sample mass, 83% of the sample iron, at a 19% Fe grade. The testwork flowsheet is presented in Figure 13-29.

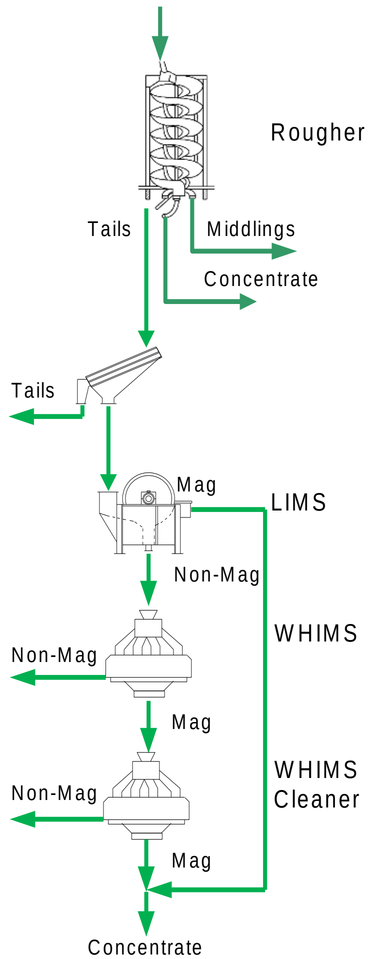


Figure 13-29: Rougher tails testwork

The rougher tails passing 150 µm was subjected to a LIMS and a WHIMS stage. Four optimization tests were performed in which the magnetic field intensity of the WHIMS was varied at 7,000, 9,000, 11,000 and 13,000 Gauss. The LIMS intensity was kept constant at 2,000 Gauss.

The production test was optimized and performed at 11,000 Gauss.

Additional WHIMS cleaner stage tests were also performed on the concentrate generated during the production test.

A summary of the LIMS testwork is shown in Table 13-25 while WHIMS testwork are presented in Table 13-26. The amount of magnetic concentrate recovered at the LIMS stage during the optimization tests was considered not significant. Table 13-27 presents a reconciled mass balance of the rougher tails scavenging testwork that included a cleaner WHIMS stage.

Table 13-25: Rougher tails LIMS testwork summary

Test	Magnetic strength (Gauss)	Concentrate			
		Mass Rec. (%)	SiO_2 (%)	Fe_T (%)	Fe_T Rec. (%)
Optimization	2,000	N/A	36.3	42.5	N/A
Production	2,000	0.8	27.6	48.7	24.6

Table 13-26: Rougher tails WHIMS testwork summary

Test	Magnetic Strength (Gauss)	Concentrate				Tails			
		Mass Rec. (%)	SiO_2 (%)	Fe_T (%)	Fe_T Rec. (%)	Mass Rec. (%)	SiO_2 (%)	Fe_T (%)	Fe_T Rec. (%)
1	7,000	21.6	32.3	43.3	48.8	78.4	73.8	12.5	51.2
2	9,000	39.5	37.1	39.3	77.6	60.5	81.6	7.4	22.4
3	11,000	42.2	39.5	36.8	81.0	57.8	83.2	6.3	19.0
4	13,000	45.3	40.7	36.2	82.1	54.7	83.0	6.5	17.9
Production	11,000	54.4	48.8	30.7	88.7	45.6	82.9	7.3	11.3
Production Cleaner	11,000	35.4	9.7	60.0	69.2	64.6	69.9	15.2	30.8

Applying the results presented in Table 13-27 to the Phase 2 (QIO) mass balance, the rougher tails scavenger option would represent approximately an additional 40 tph of concentrate for Phase 2 (QIO), and 3.0% of iron recovery. Given that the rougher tails scavenger concentrate does not meet the target of 66.2% Fe, the other three concentrates (cleaner UCC, scavenger cleaner UCC and mags cleaner spirals) would have to be slightly upgraded for the final concentrate to be at 66.2%. The Phase 2 (QIO) mass balance produced uses a very conservative Fe grade at the scavenger cleaner UCC concentrate and an increase of this concentrate grade is easily achievable.

Table 13-27: Rougher tails scavenger testwork mass balance

Stream	Recovery Weight (%)	Recovery Fe (%)	Grade SiO_2 (%)	Grade Fe (%)
Rougher tails	100	100	79.3	11.9
Rougher tails +150 µm	48	16	93.7	4.1
Rougher tails -150 µm	52	84	66.3	19.0
LIMS Concentrate	0	2	27.6	48.7
WHIMS Concentrate	25	66	48.9	30.8
WHIMS Tails	27	17	83.2	7.4
WHIMS Cleaner Concentrate	9	45	9.7	60.0
WHIMS Cleaner Tails	16	21	69.9	15.2
Final Concentrate	9	46	10.5	59.5

The testwork results show that:

- It was possible to produce a Fe concentrate grade of 59.5% while recovering 46% of the iron lost to the rougher tails with two stages of WHIMS;
- Further testwork is required to improve the flowsheet and finalise the economics of the circuit.

13.4.5 Variability Testwork

Following the step by step testwork and based on Phase 1 (QIO) experience, a flowsheet was developed with the aim of producing a low silica concentrate at a high iron recovery while allowing a good robustness to feed characteristics variations.

Variability tests were conducted on five different ore blends to assess the metallurgical performance of each blend. These tests were performed in open circuit except for the mag cleaner stage which was performed in closed circuit due to the low quantity of material making its way through the circuit to feed that stage. The rougher spirals were fed between 2.2 tph and 2.3 tph. The wash water was set at 1.1 tph on all the spiral stages. The UCC wash water was set at 10 L/min and 4 L/min for the cleaner and scavenger cleaner stages respectively. The spiral adjustment used were those determined during the step by step testwork and were not adjusted for the different ore blends.

A summary of the testwork results of the variability samples is provided in Table 13-28 while the detailed results for each blend are detailed in Table 13-29 to Table 13-33.

Table 13-28: Variability blend testwork summary of results

Blend	Stream	Analysis				Recovery (Global)			
		Fe (%)	SiO_2 (%)	MgO (%)	CaO (%)	Fe (%)	SiO_2 (%)	MgO (%)	CaO (%)
1	Feed	34.6	46.6	1.6	1.4	100.0	100.0	100.0	100.0
	Final concentrate	66.9	3.9	0.3	0.2	88.3	3.8	8.2	8.0
	Final tails	7.2	82.8	2.8	2.3	11.7	96.2	91.8	92.0
2	Feed	26.9	56.7	1.5	1.2	100.0	100.0	100.0	100.0
	Final concentrate	63.5	8.0	0.3	0.3	78.4	4.7	7.5	9.1
	Final tails	8.8	80.9	2.0	1.5	21.6	95.3	92.5	90.9
3	Feed	30.9	54.4	0.2	0.2	100.0	100.0	100.0	100.0
	Final concentrate	66.9	4.0	0.0	0.1	84.6	2.9	10.5	15.5
	Final tails	7.4	87.3	0.3	0.3	15.4	97.1	89.5	84.5
4	Feed	32.6	47.4	2.1	1.7	100.0	100.0	100.0	100.0
	Final concentrate	65.3	4.6	0.5	0.5	83.6	4.0	10.1	11.0
	Final tails	9.1	78.2	3.3	2.6	16.4	96.0	89.9	89.0
5	Feed	27.7	51.1	3.5	2.7	100.0	100.0	100.0	100.0
	Final concentrate	66.0	4.1	0.8	0.6	83.5	2.8	7.6	7.1
	Final tails	6.9	76.8	5.0	3.8	16.5	97.2	92.4	92.9

All the blends gave very good results with respect to the concentrate silica target of 4.5% and iron recoveries except blend #2, which consisted in hematite from the Pignac pit and silicates and magnetite from Chief's Peak pit. Despite having all the same operation parameters (wash water flowrates, feed rates, etc.) all the blends gave recoveries consistent with the recovery model established which means that the Phase 2 flowsheet is robust under a variety of feed blends.

Of the five blends, blend #2 is the one with the lowest feed iron grade (26.85%) which is also lower than the rougher feed bulk sample iron grade (31.84%) used for the optimization and production testwork. This is in line with the recovery model's predictions.

13.4.5.1 Rougher and Mids Stages

The rougher and mids stages iron grades and recoveries for the five blends are shown in Table 13-29.

Table 13-29: Rougher and mids stages iron and silica grades and recoveries

Stream	Blend 1 (%)	Blend 2 (%)	Blend 3 (%)	Blend 4 (%)	Blend 5 (%)
Fe Grade					
Rougher spirals feed	34.6	26.9	30.9	32.6	27.7
Rougher spirals concentrate	50.5	48.8	53.3	49.6	54.3
Rougher spirals tails	8.5	9.7	9.1	11.2	8.2
Rougher spirals mids	6.5	7.1	6.2	5.9	4.8
Mids spirals concentrate	20.4	16.6	17.9	12.9	12.9
Mids spirals tails	4.9	6.0	5.1	4.9	4.1
SiO_2 Grade					
Rougher spirals feed	46.6	56.7	54.4	47.4	51.1
Rougher spirals concentrate	25.4	27.4	22.9	25.2	18.3
Rougher spirals tails	80.4	78.4	84.2	73.7	73.6
Rougher spirals mids	84.6	85.2	90.0	84.8	81.4
Mids spirals concentrate	63.3	70.4	72.7	72.6	67.8
Mids spirals tails	87.0	86.8	91.7	86.5	82.5
Fe Recovery (Stage)					
Rougher spirals feed	100.0	100.0	100.0	100.0	100.0
Rougher spirals concentrate	92.0	82.2	87.5	88.5	86.7
Rougher spirals tails	4.5	12.4	8.3	8.4	8.9
Rougher spirals mids	3.6	5.4	4.2	3.1	4.5
Mids spirals concentrate	32.1	23.2	25.7	26.8	19.8
Mids spirals tails	67.9	76.8	74.3	73.2	80.2

The rougher stage gave pretty consistent results under the various blends. As would be expected, the lower feed grades resulted in lower concentrate iron grades and recoveries with blend #5 showing better than expected results. The mids stage gave lower concentrate Fe recoveries and grades than what was observed during the sampling campaigns which is the result of the high rougher concentrate recoveries.

The particle size distribution of the Hematite 2 Pignac pit sample, used in blend #2, is coarser than what is usually seen in the Phase 1 (QIO) concentrator. Therefore liberation was probably at cause, as the liberation for iron oxide in this sample was poor (see Table 13-13).

13.4.5.2 Cleaner Stage

The cleaner stage iron grades and recoveries for the five blends are shown in Table 13-30. The cleaner UCC underflow silica distribution is shown in Figure 13-30

Table 13-30: Cleaner stage iron and silica grades and recoveries

Stream	Blend #1 (%)	Blend #2 (%)	Blend #3 (%)	Blend #4 (%)	Blend #5 (%)
Fe Grade					
Cleaner UCC feed	50.5	48.8	53.3	49.6	54.3
Cleaner UCC underflow	67.6	64.0	67.4	65.5	66.1
Cleaner UCC overflow	25.6	23.6	27.0	31.5	24.5
SiO_2 Grade					
Cleaner UCC feed	25.4	27.4	22.9	25.2	18.3
Cleaner UCC underflow	3.0	7.4	3.6	4.1	4.0
Cleaner UCC overflow	58.1	60.4	59.3	49.1	54.3
Fe Recovery (Stage)					
Cleaner UCC feed	100.0	100.0	100.0	100.0	100.0
Cleaner UCC underflow	79.4	81.8	82.4	70.2	87.3
Cleaner UCC overflow	20.6	18.2	17.6	29.8	12.7

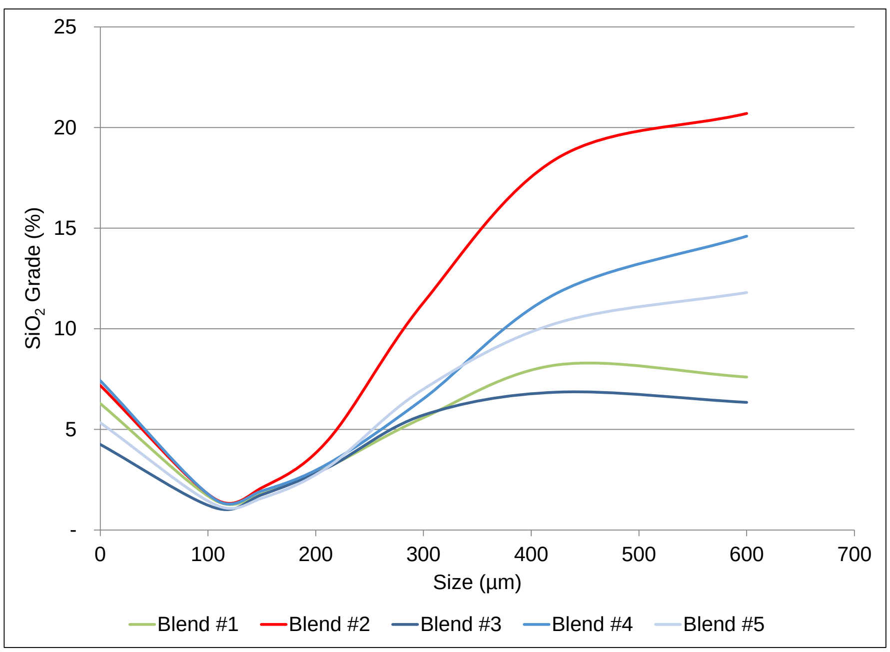


Figure 13-30: Silica grade by size in cleaner UCC underflow

Blends #1 and #3 to #5 all had similar rejection of fine silica but various levels of mid-sized and coarse silica at the cleaner stage. All of them gave good underflow grades and recoveries and the parameter adjustments in operation would easily allow maximising those grades and recoveries. Blend #2, on the other hand, has by far the highest proportion of coarse silica of all the tests meaning that coarse silica rejection was insufficient at the rougher stage. Given that the cleaner concentrate accounts in this case for 85% of the final concentrate, a better coarse silica rejection at the rougher stage would have significantly improved the final grade.

13.4.5.3 Scavenger and Scavenger Cleaner Stages

The scavenger and scavenger cleaner grades and recoveries for the five blends are shown in Table 13-31.

Table 13-31: Scavenger and scavenger cleaner stages iron and silica grades and recoveries

Stream	Blend #1 (%)	Blend #2 (%)	Blend #3 (%)	Blend #4 (%)	Blend #5 (%)
Fe Grade					
Scavenger spirals feed	25.6	23.6	27.0	31.5	24.5
Scavenger spirals concentrate	47.8	41.7	48.3	51.5	48.0
Scavenger spirals mids and tails	6.7	8.2	5.8	8.5	6.6
Scavenger-cleaner UCC underflow	65.3	65.8	64.6	65.5	64.8
Scavenger-cleaner UCC overflow	34.8	35.2	35.0	37.0	40.8
SiO_2 Grade					
Scavenger spirals feed	58.1	60.4	59.3	49.1	54.3
Scavenger spirals concentrate	28.0	35.6	28.6	22.7	24.4
Scavenger spirals mids and tails	83.5	81.5	89.7	79.5	77.0
Scavenger-cleaner UCC underflow	6.5	5.5	6.3	5.0	5.1
Scavenger-cleaner UCC overflow	44.0	43.6	46.8	41.0	32.7
Fe Recovery (Stage)					
Scavenger spirals feed	100.0	100.0	100.0	100.0	100.0
Scavenger spirals concentrate	85.8	81.1	89.2	87.4	84.8
Scavenger spirals mids and tails	14.2	18.9	10.8	12.6	15.2
Scavenger-cleaner UCC underflow	58.4	33.2	60.1	64.6	40.6
Scavenger-cleaner UCC overflow	41.6	66.8	39.9	35.4	59.4

The scavenger spiral concentrate grade ranged from 41.7% Fe to 51.5% Fe under the various blends as the result of the variation in the cleaner UCC overflow. Despite that variation, the scavenger cleaner stage gave very consistent grades under all the blends. As can be seen on Figure 13-31, the silica distribution in the scavenger cleaner concentrate is very similar for all the blends. This means that the addition of the scavenger cleaner stage will greatly stabilize the grade of that portion of the final concentrate.

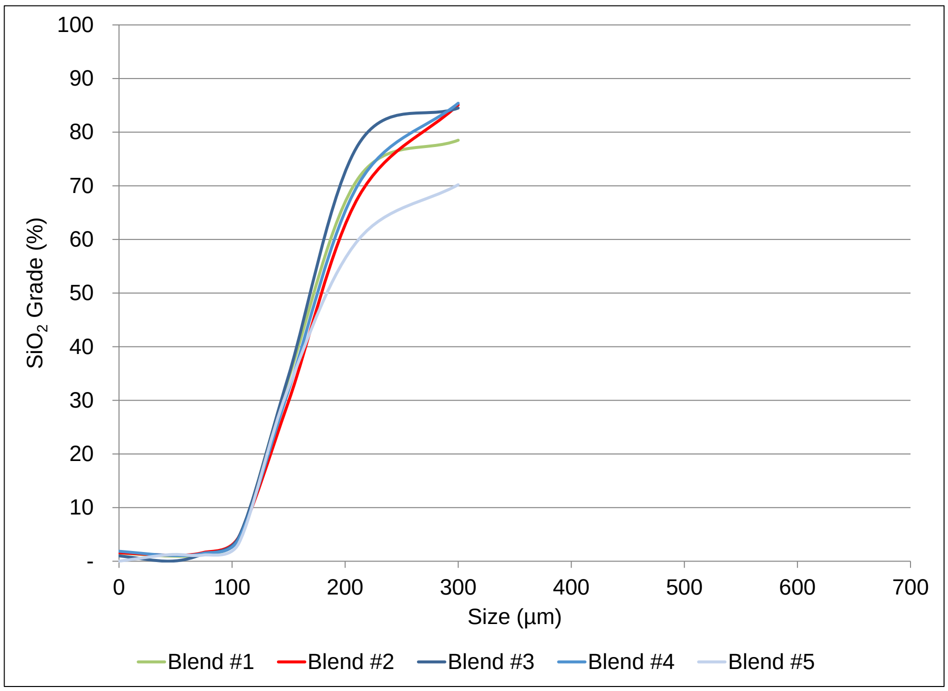


Figure 13-31: Silica grade by size in scavenger cleaner UCC underflow

13.4.5.4 LIMS, WHIMS and Mags Cleaner Stages

The LIMS, WHIMS and mags cleaner stages grades and recoveries for the five blends are shown in Table 13-32.

Table 13-32: LIMS, WHIMS and mags cleaner stages iron and silica grades and recoveries

Stream	Blend #1 (%)	Blend #2 (%)	Blend #3 (%)	Blend #4 (%)	Blend #5 (%)
Fe Grade					
LIMS feed	31.6	30.6	30.2	31.5	31.5
LIMS mag	60.3	59.7	49.9	60.4	63.4
LIMS non-mag	29.3	18.3	30.0	28.8	25.2
WHIMS non-mag	10.7	7.1	13.7	10.1	9.6
WHIMS mag	43.5	31.3	55.3	47.6	46.4
Mag cleaner spirals concentrate	60.7	58.0	63.9	62.3	66.8
Mag cleaner spirals tails	19.2	21.0	27.0	22.3	31.5
SiO_2 Grade					
LIMS feed	48.4	50.2	54.1	48.2	44.5
LIMS mag	12.7	14.8	27.0	13.8	9.0
LIMS non-mag	51.1	65.3	54.3	51.5	51.5
WHIMS non-mag	77.1	81.5	77.5	76.8	70.3
WHIMS mag	31.4	46.3	18.3	26.0	25.7
Mag cleaner spirals concentrate	10.3	14.2	6.6	8.2	3.4
Mag cleaner spirals tails	61.8	62.3	57.1	58.3	43.4
Fe Recovery (Stage)					
LIMS feed	100.0	100.0	100.0	100.0	100.0
LIMS mag	13.7	58.1	1.5	16.9	33.2
LIMS non-mag	86.3	41.9	98.5	83.1	66.8
WHIMS non-mag	15.7	20.8	27.8	17.6	22.1
WHIMS mag	84.3	79.2	72.2	82.4	77.9
Mag cleaner spirals concentrate	84.5	83.4	88.5	85.8	74.2
Mag cleaner spirals tails	15.5	16.6	11.5	14.2	25.8

The magnetic circuit produced a concentrate grade ranging from 58% Fe to 66.8% despite WHIMS magnetic concentrate grade variations from 31.3% Fe to 55.3% Fe.

Results also show that for blend #2 the WHIMS stage generated a concentrate at a much lower iron grade than the other tests possibly caused by a higher proportion of material not sufficiently liberated and by a lower feed grade coming from the LIMS. This caused the mag cleaner feed iron grade to be much lower thus making it more difficult to achieve a high concentrate grade at that stage.

13.4.5.5 Variability Testwork Conclusions

The following conclusions can be drawn from the variability testwork results:

- All the blends except blend #2 allowed for the final concentrate to be on or below the silica target of 4.5%, although the operating parameters of the equipment (wash water, cutters, etc.) were fixed for all the testwork;
- Insufficient liberation in the case of blend #2 may have contributed to the high final silica grade;
- The scavenger cleaner stage gave a very stable underflow iron grades under all the blends proving its benefits to the Phase 2 flowsheet;
- The final iron recoveries for all the blends were consistent with the feed iron grades.

As seen throughout the testwork program, the proposed Phase 2 (QIO) concentrator flowsheet addresses the improvement opportunities of the Phase 1 (QIO) flowsheet and is very robust under various feed conditions. The finer rougher feed particle size distributions in operation as well as the possibility of adjusting the various control parameters will make that flowsheet even more robust.

13.5 Screening Testwork

A composite sample was taken of the classification screen feed on November 24, 2018 between 11:00 am and 2:30 pm (Derrick, 2019).

The sample was sent to Derrick for testing. The test objective was to determine the optimum screen operating conditions for an 850 µm screen opening application. The testing was conducted on a full-scale (1.2 m wide by 1.5 m long) single deck machine.

Derrick concluded that:

- The recommended feed rate for a 5-deck Stack Sizer with a screen opening of 850 µm is 225 tph to 250 tph;
- The recommended feed rate is 275 to 300 tph with a 900 µm screen opening;
- Most efficient separations were achieved with 59% solids (by volume) feed density;
- The re-pulp spray system improved the undersize recovery.

A summary of the screening testwork results are presented in Table 13-33.

Table 13-33: Screening testwork results

Panels	Spray water (m^3/h)	Dry feed (tph)	Efficiency at 850 µm		
			Oversize	Undersize	Overall
850 µm Polyweb	36	228	94.5	97.3	96.7
850 µm Polyweb	-	262	96.3	91.0	92.1
850 µm Polyweb	36	341	97.2	93.2	94.0
850 µm Polyweb	-	341	97.1	90.5	91.9
850 µm Polyweb	36	257	95.9	94.0	94.4
850 µm Polyweb	-	257	96.9	92.4	93.4
850 µm Polyweb	-	257	95.8	91.2	92.2
850 µm Heavy Construction	36	223	91.9	97.4	96.7
850 µm Heavy Construction	-	261	96.2	93.7	94.0
900 µm Polyweb	36	262	94.4	96.3	95.9
900 µm Polyweb	36	341	94.7	95.9	95.7

13.6 Settling Testwork

A confirmatory testing program was carried out by FLSmidth in February 2019 (FLSmidth, 2019). A composite sample was taken November 24, 2018 between 8:50 am and 11:30 am.

The sample consisted of 20 litres of tailings at 38% solids. A 20-litre sample of process water was also sent.

The results from the testing program are similar to the results of 2011:

- A flocculant with a very high molecular weight and very low charge density produced the best settling rates;
- The optimum feedwell densities are in the range of 6% to 8% solids;
- The solids minimum unit area is 0.08 m^2/tpd;
- The thickener can produce an underflow concentration of approximately 60% to 61% solids with two hours of retention time;
- The recommended yield stress for rake design is 30 Pa.

The thickener originally purchased for the Phase 2 (Cliffs) project is appropriate for the expected Phase 2 (QIO) duty.

13.7 Filtration Testwork

A confirmatory test was conducted on new slurry in March 2019 by Bokela (Bokela, 2019).

A 14 kg composite sample of iron ore concentrate was sent to Bokela. The concentrate composite sample was taken November 24, 2018 between 8:40 am and 11:15 am.

The test results confirm that a throughput of 350 tph can be safely achieved with a concentrate moisture content of less than 3% which is sufficient for the Phase 2 duty. The filter has a maximum capacity of 500 tph at a final moisture content of 3.7%.

13.8 Phase 2 Recovery Model

With the information obtained from the testwork program, the variability testwork results in particular, and the operation experience of the Phase 1 (QIO) concentrator; the following recovery equation was determined:

$$\%Fe_{Rec.} = -0.03593Fe^2 + 3.1900Fe - 0.59683MgO - 0.00495MgO^2 + 0.01424FeMgO + 20.678$$

This equation takes into account the magnesium, measured as MgO, feed grade and assumes it as actinolite, which contains iron that is not recoverable. The model is applied on the life of mine annual averages iron feed grades of 27% to 31% and MgO feed grades up to 3.5%. Figure 13-32 shows the comparison of the recovery model developed for Phase 2 (QIO) and the variability testwork results.

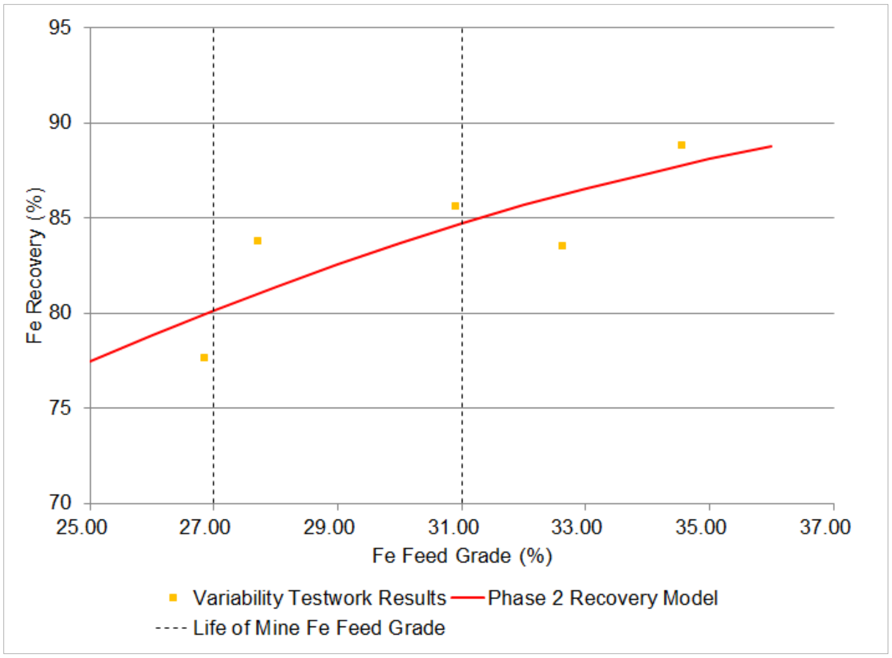


Figure 13-32: Iron recovery vs. iron feed grade

13.9 Mineral Processing and Metallurgical Testing Conclusions

The QIO ore has been extensively tested over the past several decades prior to this current Bloom Lake project throughout these developmental phases:

- Testwork prior to Phase 1 (Consolidated Thompson) (before 2010):
  - A concentrate above 67% Fe grade can be produced at a Fe recovery above 83% for a grinding size of 425 µm;
  - The ore contains actinolite, which can reduce the Fe grade and be a source of MgO and CaO in the concentrate;
  - A three spirals stage flowsheet was developed for Phase 1 and was in operation from 2010 to 2014.
- Original Phase 2 (Cliffs) Testwork (2010 – 2014):
  - West Pit ore was tested and characterized. The ore is softer, well liberated at 850 µm and presented similar metallurgical performances than Chief's Peak Pit;
  - A Phase 2 flowsheet that included rougher spirals, cleaner UCC and scavenger spirals was piloted and presented significant improvement to the Phase 1 flowsheet.

- Phase 1 (QIO) Restart Testwork (2016 – 2017):
  - A flowsheet inspired by the Phase 2 (Cliff) flowsheet was developed by Mineral Technologies and implemented in Phase 1. This flowsheet includes a scavenger circuit using magnetic separators.

Sampling campaigns were conducted in the Bloom Lake Phase 1 (QIO) concentrator. The Phase 1 (QIO) flowsheet audit has allowed valuable information to be gathered, which was used to define the testwork program. The main conclusions are:

- The rougher stage performs well and its concentrate iron recovery is higher than designed;
- The mids stage receives less feed and its concentrate iron recovery is lower than expected but is offset by the higher recovery to rougher concentrate;
- The recovery at the cleaner stage's underflow is lower than expected and result in more material being sent to the scavenger stage:
  - This requires being more aggressive at the scavenger stage to meet final concentrate grade.
- The scavenger stage has been identified as the stage where the most potential gain is possible, both in terms of grade and recovery;
- The magnetic circuit did not perform as expected in the WHIMS stage where the iron recovery was lower than expected.

The objective of the metallurgical testwork program undertook for this study was to improve the Phase 1 (QIO) flowsheet based on the experience acquired and the challenges to come. The testwork has shown that:

- Addition of a cleaner-scavenger UCC to process the scavenger spirals concentrate allows the production of a final grade concentrate at a high iron recovery;
- Reducing the load on the scavenger and magnetic cleaner spirals will improve their performances;
- Sending the middling spirals concentrate to the magnetic scavenging circuit will improve the circuit's robustness;
- Sending the LIMS concentrate to the magnetic cleaner spirals will improve the circuit's robustness.

Phase 2 flowsheet includes those changes. Based on the mine plan developed for this study, at an average feed Fe grade of 29%, the Phase 2 concentrator will allow a Fe recovery of 82.5% while producing an average concentrate grade of 66.2%.

14. MINERAL RESOURCE ESTIMATE

14.1 Introduction

BBA was retained by Quebec Iron Ore (QIO) to audit the updated Mineral Resource Estimate (MRE) for the Bloom Lake project (the "Project") prepared by Jean-Michel Dubé, P. Geo. from QIO. Drillhole information up to 2018 was considered for this estimate with only partial information from the 2018 drilling program used for 3D modelling and classification.

The QP reviewed the resource parameters presented by QIO, including the following items: geological model and domain strategy, statistical study of assays and composites, variography analysis, interpolation and search ellipse settings, estimation process and classification of the resource. During the course of the audit, the QP proposed revising some of the parameters that contributed to establishing the updated parameters.

14.2 Methodology

The herein MRE covers the whole Bloom Lake project with an east-west strike length of 4.6 km and a north-south width of approximately 2.7 km, down to a vertical depth of 400 m below surface. Figure 14-1 shows the location of the Bloom Lake project.

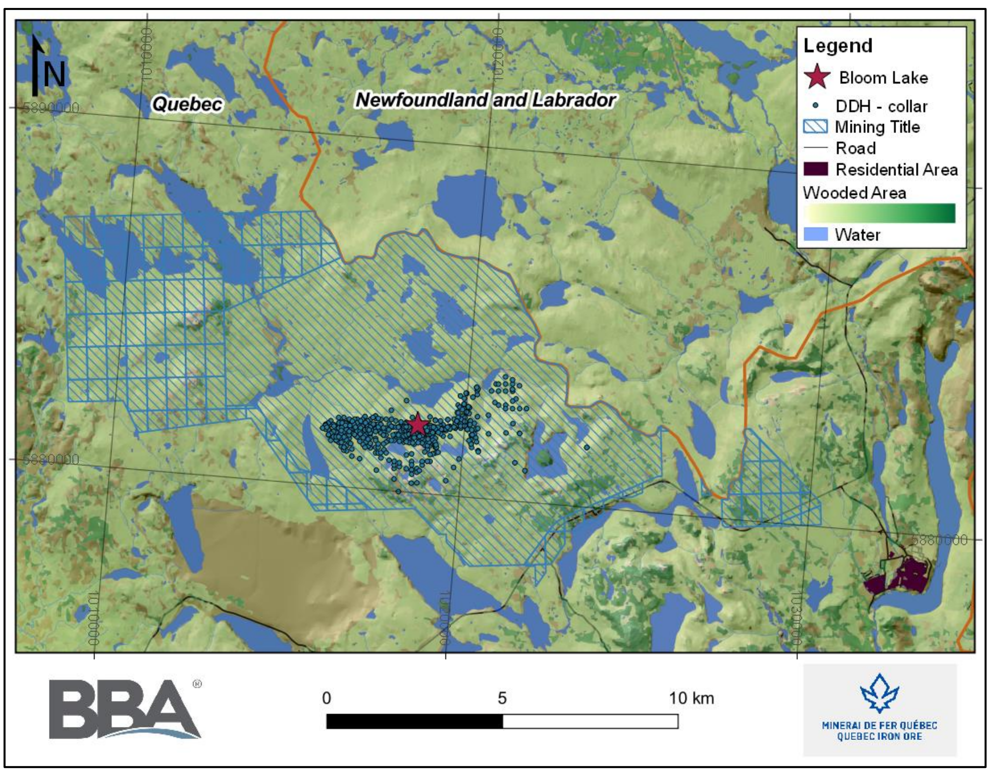


Figure 14-1: Overall plan view for the Bloom Lake project

Geovia Surpac 2019HF1 v.7.0.1949.0 was used for the geological modelling and to generate the drillhole intercepts for each solid, compositing, 3D block modelling and interpolation. Statistical studies were conducted using Excel and Snowden Supervisor v.8.9.

The methodology for the audit involved the following steps:

- Database verification;
- Review of the 3D modelling of the geological and structural models;
- Review of the drillhole composite generating process for each mineralized units;
- Basic statistics;
- High grade value study;
- Geostatistical analysis including variography;
- Review of the block model construction;
- Review of the grade interpolation (including all profiles, scripts and macros);
- Block model validation;
- Review of the Resource classification;
- Cut-off grade calculation and pit shell optimization;
- Review of the mineral resource statement.

14.3 Resource Database

The drilling database consists of 569 surface drillholes from historical and recent drilling programs that occurred between 1957 and 2018 for a total of 141,288 m (Figure 14-2). The average length of a drillhole is 248 m. The database was validated as part of the current mandate.

The modelling and resource estimation focuses on the Bloom Lake project delimited by the block model area and consequently excludes holes located outside the area of interest.

The resource estimation for the Bloom Lake project relies mainly on recent drilling programs as the database includes 165 historical holes (before 2008) and 404 recent drillholes (since 2008). The QP accepted the historical drillhole information into the resource estimation for the following reasons: 1) historical information was verified as part of the mandate and no discrepancies were found; and 2) recent drillholes were drilled in the vicinity of historical drillholes and the results showed comparable geology and mineralization outlines.

From 445 holes, a total of 11,345 sample intervals were analyzed for Fe%, 11,310 for magnetic iron (Mag Fe or Satmagan) and approximately 9,650 for Oxides. The database also includes some 5,250 Heavy Liquid Separation samples (HLS) analyzed for iron recovery (Fe Rec) and silica concentrate (Si Conc). These HLS analyses were not used for the block model, but are of interest for the material characterization to be sent to the process facility.

Figure 14-2 below shows the location of the drillholes that were used for the resource estimate.

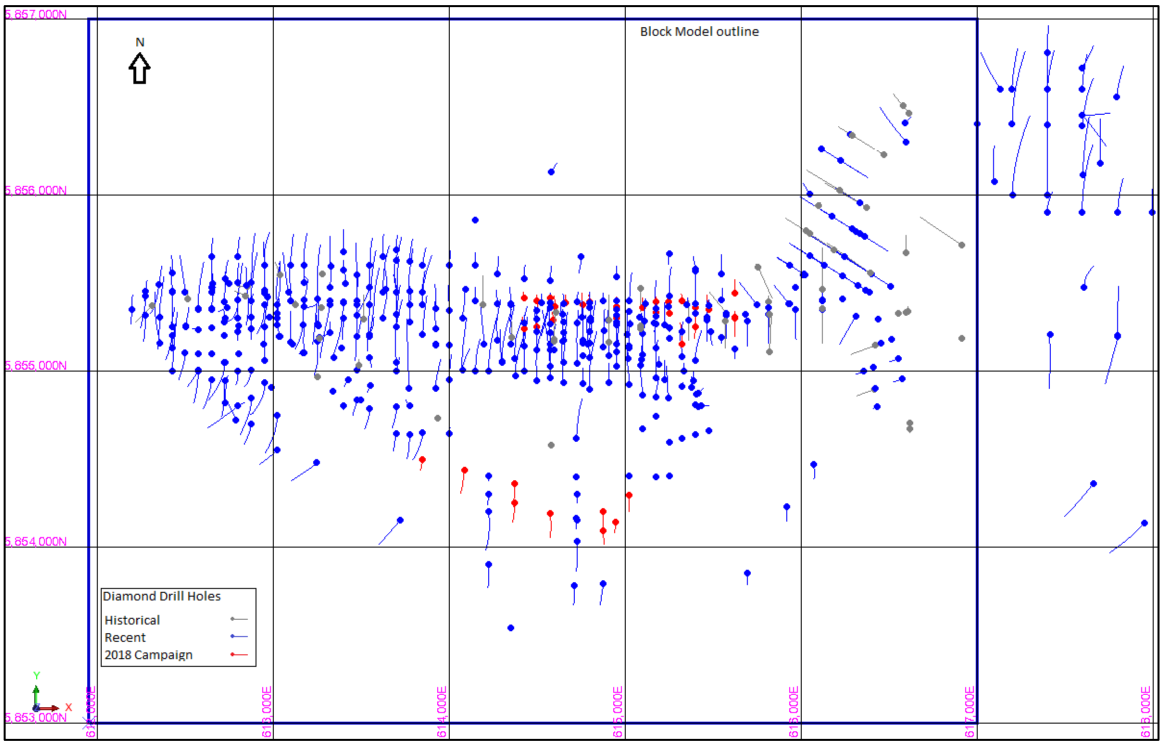


Figure 14-2: Plan view of the diamond drillholes for the Bloom Lake project

The resource database was validated before proceeding to the resource estimation. The validation steps are detailed in Chapter 12 of this report. Minor variations have been noted during the validation process but have no material impact on the 2019 MRE.

The QP is of the opinion that the database is appropriate for the purposes of the mineral resource estimation and that the sample density allows a reliable estimate to be made of the size, tonnage and grade of the mineralization in accordance with the level of confidence established by the mineral resource categories in the CIM Standards.

14.4 Geological Interpretation and Modelling

The Bloom Lake Gems project includes a geological model and structural interpolation domains.

14.4.1 Geological Model

The geological model was initially inherited from Cliffs in 2014 and was reported to be produced in Geovia Gems. The interpretation was based on diamond drillholes (DDH), geological maps, ground magnetic surveys and production data. Cross-sections were generated at 75 m to 150 m spacing, west to east. The geologists at Bloom Lake interpreted two sets of interpretation, vertical cross-section and plan view section.

Eight geological units were modelled:

1- Tabular to folded and anastomosing mineralized bands including:
   a. Hematite Iron Formation (IF)
   b. Magnetite Iron Formation (IFM)
   c. Silicate Iron Formation (SIF)
   d. Waste Silicate Iron Formation (WSIF)

2- Unmineralized units sitting below and above the mineralization as well as intercalated between the mineralized bands, including:
   a. Amphibolite (AMP)
   b. Quartzite (QZ)
   c. Mica Schist (MS)
   d. Gneiss (GN)

Through various steps, vertical cross-section interpretation was converted to plan views every 14 m (upper portion of the model; 410 m and up) and every 28 m (lower portion of the model; below 410 m). The interpretation was created at the centre of each bench and then extruded to the bench height to create solids.

QIO revised the geological model in 2018 and 2019 for some local area using Geovia Surpac. Modifications were brought to the “Patte Pignac” and to the north wall of the Pignac pit based on recent drilling and observations made during operation.

The QP reviewed the geological model in 3D views, plan views, and cross-sections and is of the opinion that the level of detail to which the geology model was constructed represents adequately the complexity of the folded structures and stratigraphy of the Bloom Lake project for the material contained within the resource pit shell. Some sterile units are currently not taken into account in the block model, but it is not believed to be material to the mineral resource estimate. QIO is currently working towards improving the geological model and recommendations were made in order to improve the model for future updates.

In the QP's opinion, the geological model is appropriate for the size, grade distribution and geometry of the mineralized zones and is suitable for the resource estimation of the Bloom Lake project. The model appears to be compatible with the anticipated mining and grade control methods as well as to the size and type of equipment to be used. Figure 14-3 and Figure 14-4 show typical cross-section and plan views of the current model.

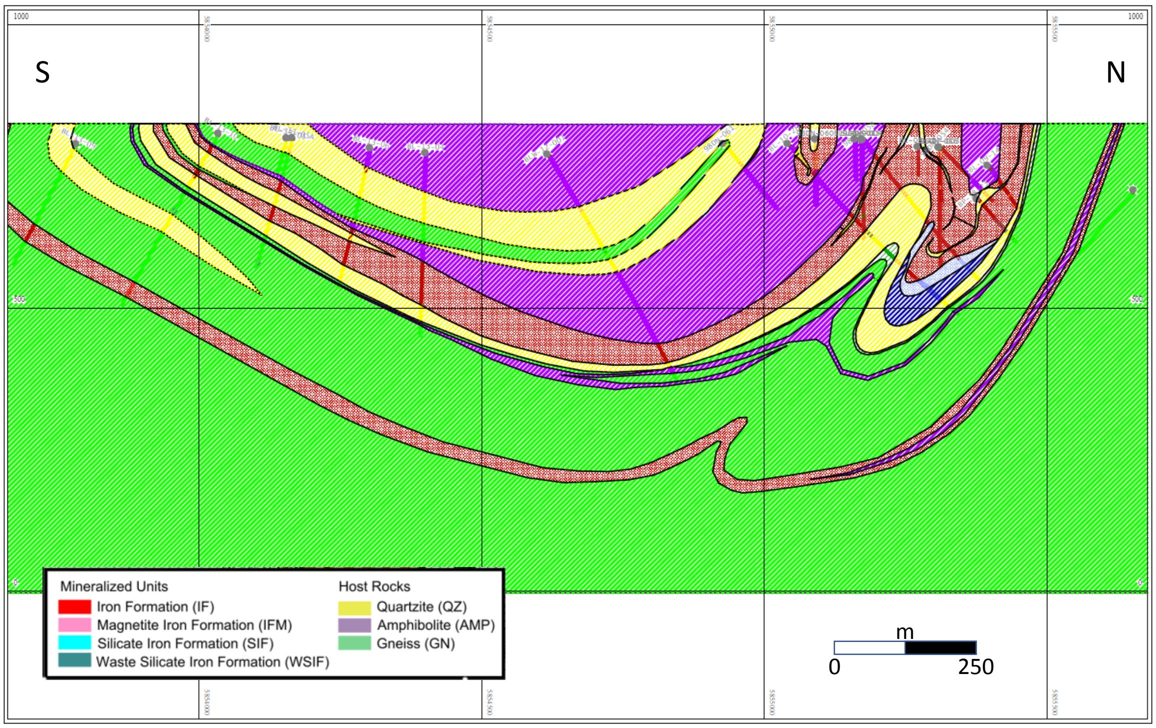


Figure 14-3: Typical cross-section looking west showing the geological interpretation and drillholes

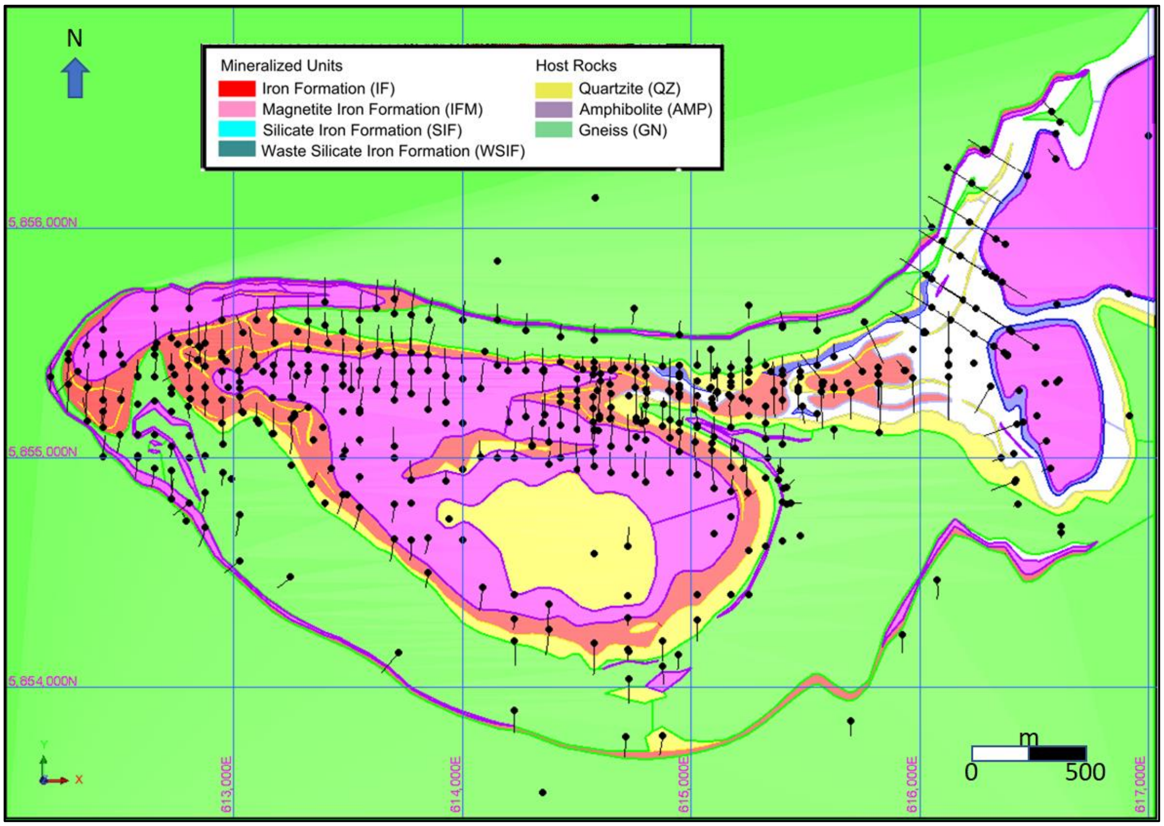


Figure 14-4: Typical plan view (Elevation 620 m) showing the geological interpretation and drillholes

14.4.2 Structural Domains

Because of the folded nature of the deposit, the geological model was divided into multiple structural domains to accommodate grade interpolation. Although domains existed in the previous model, it was necessary to revisit the approach during the course of the current MRE update. A total of 22 domains were created using Geovia Surpac for the current MRE.

Table 14-1 lists the plane attitudes defining each of the structural domains outlined at Bloom Lake.

Table 14-1: List of plane attitudes defining the structural domains

Domain	Plane attitude	
	Orientation	Dip
1000	120	40
2000	105	35
3000	27	25
4000	88	22
5000	90	0
6000	90	0
7000	90	0
8000	95	0
9000	70	0
10000	260	15
11000	90	5
12000	255	55
13000	270	65
14000	240	55
15000	270	35
16000	272	55
17000	268	0
18000	270	15
19000	270	75
20000	225	50
21000	0	70
22000	136	70

The QP reviewed the structural domains and is of the opinion that the wireframes adequately subdivide the geological model into individual orientation subsets of grade continuity. Consequently, the QP considers the structural model to be appropriate for the resource estimation of the Bloom Lake project.

14.4.3 Overburden and Topography

The topographic surface was created by QIO in Surpac and is based on a Lidar flown in 2018 and drillholes collar coordinates. The overburden/bedrock interface is based on downhole descriptions.

14.4.4 Voids Model

There are no underground voids on the Project. Up-to-date open-pit depletion was adequately applied.

14.5 Data Analysis

14.5.1 Assay Statistics

The drillhole intervals intersecting the mineralization wireframes were identified to the corresponding lithological unit and assays were coded accordingly. These coded intercepts were used to produce basic statistics on sample lengths and grades on a per mineralized lithology domains basis (IF_only, IF_QRIF, SIF, LIMO).

Statistics are presented in Table 14-2 to Table 14-5.

Table 14-2: Descriptive statistics for the IF_only assays

Variable	Fe (%)	Al_2O_3 (%)	CaO (%)	MnO (%)	P_2O_5 (%)	TiO_2 (%)	Sat (%)	MgO (%)
Number	8,592	7,321	7,616	7,619	7,256	7,600	8,562	7,621
Minimum	0.310	0.005	0.005	0.005	0.005	0.005	0.010	0.005
Maximum	68.74	22.80	19.30	4.69	1.24	3.61	61.20	12.69
Mean	29.46	0.40	1.07	0.09	0.04	0.05	4.04	0.94
Median	30.40	0.15	0.04	0.02	0.02	0.01	0.90	0.06
Variance	59.70	1.74	5.15	0.05	0.01	0.05	54.41	3.18
Standard Deviation	7.73	1.32	2.27	0.22	0.07	0.22	7.38	1.78
Coefficient of Variation	0.26	3.30	2.12	2.42	1.85	4.45	1.82	1.90

Table 14-3: Descriptive statistics for the IF_QRIF assays

Variable	Fe (%)	Al_2O_3 (%)	CaO (%)	MnO (%)	P_2O_5 (%)	TiO_2 (%)	Sat (%)	MgO (%)
Number	9,312	7,958	8,264	8,270	7,890	8,251	9,280	8,272
Minimum	0.310	0.005	0.005	0.005	0.005	0.005	0.010	0.005
Maximum	68.74	22.80	19.30	4.69	1.75	3.61	61.20	13.10
Mean	28.08	0.43	1.12	0.09	0.04	0.05	3.94	0.96
Median	29.70	0.15	0.05	0.02	0.02	0.01	0.97	0.06
Variance	82.70	1.90	5.39	0.05	0.01	0.05	51.26	3.27
Standard Deviation	9.09	1.38	2.32	0.23	0.08	0.22	7.16	1.81
Coefficient of Variation	0.32	3.24	2.08	2.41	1.90	4.44	1.82	1.88

Table 14-4: Descriptive statistics for the SIF assays

Variable	Fe (%)	Al_2O_3 (%)	CaO (%)	MnO (%)	P_2O_5 (%)	TiO_2 (%)	Sat (%)	MgO (%)
Number	10,232	8,594	8,900	8,906	8,526	8,887	10,200	8,908
Minimum	0.310	0.005	0.005	0.005	0.005	0.005	0.010	0.005
Maximum	68.74	22.80	19.30	4.69	1.75	3.61	61.20	16.20
Mean	27.35	0.44	1.52	0.12	0.04	0.05	4.49	1.34
Median	29.03	0.15	0.05	0.02	0.02	0.01	1.12	0.06
Variance	87.20	2.02	8.82	0.07	0.01	0.05	56.86	5.67
Standard Deviation	9.34	1.42	2.97	0.27	0.08	0.23	7.54	2.38
Coefficient of Variation	0.34	3.23	1.96	2.28	1.89	4.40	1.68	1.78

Table 14-5: Descriptive statistics for the LIMO assays

Variable	Fe (%)	Al_2O_3 (%)	CaO (%)	MnO (%)	P_2O_5 (%)	TiO_2 (%)	Sat (%)	MgO (%)
Number	9,338	7,984	8,290	8,296	7,916	8,277	9,306	8,298
Minimum	0.310	0.005	0.005	0.005	0.005	0.005	0.010	0.005
Maximum	68.74	22.80	19.30	4.69	1.75	4.10	61.20	13.10
Mean	28.09	0.44	1.11	0.09	0.04	0.05	3.93	0.96
Median	29.70	0.15	0.05	0.02	0.02	0.01	0.98	0.06
Variance	82.84	2.06	5.39	0.05	0.01	0.06	51.14	3.27
Standard Deviation	9.10	1.43	2.32	0.23	0.08	0.24	7.15	1.81
Coefficient of Variation	0.32	3.28	2.08	2.40	1.93	4.53	1.82	1.88

14.5.2 Compositing

Compositing of drillhole samples was conducted in order to homogenize the database for the statistical analysis and remove any bias associated to the sample length that may exist in the original database. The composite length (6.0 m) was determined using original sample length statistics, thickness of the mineralized zones, and mining units.

Inside the mineralized zones, 90% of the samples are between 3.0 m and 6.0 m in length. The average sample length is 4.8 m. Composites were generated with a length of 6.0 m, but allowing tail redistribution along the intervals, resulting in 99.25% of the composites being between 3.0 m and 6.0 m.

Missing samples were ignored during the compositing procedure as per QIO protocol. Although BBA made the recommendation to include missing samples with a grade of 0% Fe, unless justification such as sample lost or bad recovery are noted in the logs. That being said, verification was made to make sure ignoring unsampled intervals were not bringing a material bias in the model.

Table 14-6 to Table 14-9 show the basic statistics for the 6.0 m composites.

Table 14-6: Description statistics for the IF_only composites

Variable	Fe (%)	Al_2O_3 (%)	CaO (%)	MnO (%)	P_2O_5 (%)	TiO_2 (%)	Sat (%)	MgO (%)
Number	8,105	7,378	7,543	7,540	7,341	7,503	8,049	7,546
Minimum	1.81	0.01	0.01	0.01	0.01	0.01	0.05	0.01
Maximum	66.80	18.53	16.85	4.24	0.98	3.41	48.92	11.20
Mean	29.32	0.38	1.15	0.10	0.04	0.05	4.12	1.00
Median	30.15	0.16	0.05	0.02	0.02	0.02	1.07	0.06
Variance	49.92	0.80	5.18	0.05	0.00	0.02	49.49	3.13
Standard Deviation	7.07	0.90	2.28	0.23	0.06	0.15	7.03	1.77
Coefficient of Variation	0.24	2.38	1.98	2.36	1.49	3.21	1.71	1.77

Table 14-7: Descriptive statistics for the IF_QRIF composites

Variable	Fe (%)	Al_2O_3 (%)	CaO (%)	MnO (%)	P_2O_5 (%)	TiO_2 (%)	Sat (%)	MgO (%)
Number	8,800	8,021	8,195	8,192	7,983	8,154	8,741	8,198
Minimum	0.32	0.01	0.01	0.01	0.01	0.01	0.05	0.01
Maximum	66.80	18.53	16.85	4.24	1.75	3.41	50.80	12.61
Mean	27.73	0.40	1.21	0.10	0.04	0.05	3.98	1.03
Median	29.38	0.16	0.05	0.02	0.02	0.02	1.13	0.07
Variance	74.06	0.87	5.44	0.05	0.00	0.02	45.51	3.21
Standard Deviation	8.61	0.94	2.33	0.22	0.06	0.15	6.75	1.79
Coefficient of Variation	0.31	2.32	1.93	2.28	1.55	3.16	1.70	1.74

Table 14-8: Descriptive statistics for the SIF composites

Variable	Fe (%)	Al_2O_3 (%)	CaO (%)	MnO (%)	P_2O_5 (%)	TiO_2 (%)	Sat (%)	MgO (%)
Number	8,921	8,031	8,196	8,193	7,994	8,157	8,866	8,199
Minimum	1.36	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Maximum	66.80	18.53	18.70	4.24	0.98	3.41	48.92	15.84
Mean	28.38	0.40	1.61	0.13	0.04	0.05	4.59	1.43
Median	29.48	0.17	0.06	0.03	0.02	0.02	1.26	0.08
Variance	58.69	0.94	8.81	0.08	0.00	0.02	52.04	5.70
Standard Deviation	7.66	0.97	2.97	0.28	0.06	0.15	7.21	2.39
Coefficient of Variation	0.27	2.42	1.85	2.17	1.51	3.20	1.57	1.67

Table 14-9: Descriptive statistics for the LIMO composites

Variable	Fe (%)	Al_2O_3 (%)	CaO (%)	MnO (%)	P_2O_5 (%)	TiO_2 (%)	Sat (%)	MgO (%)
Number	8,141	7,414	7,579	7,576	7,377	7,539	8,085	7,582
Minimum	1.81	0.01	0.01	0.01	0.01	0.01	0.05	0.01
Maximum	66.80	18.53	16.85	4.24	0.98	3.55	48.92	11.20
Mean	29.34	0.39	1.15	0.10	0.04	0.05	4.11	1.00
Median	30.16	0.16	0.05	0.02	0.02	0.02	1.07	0.06
Variance	50.48	0.90	5.16	0.05	0.00	0.03	49.27	3.12
Standard Deviation	7.10	0.95	2.27	0.23	0.06	0.16	7.02	1.77
Coefficient of Variation	0.24	2.45	1.98	2.36	1.53	3.40	1.71	1.77

14.5.3 High Grade Handling

There was no top cutting applied to higher iron grade assays for the Project.

It is common practice to statistically examine the higher grades within a population and to trim them to a lower grade value based on the results of a statistical study. The capping is performed on high grade values considered to be outliers. BBA conducted a basic statistical study to validate QIO's choice of not applying any capping. Figure 14-5 to Figure 14-8 show graphs supporting the absence of capping.

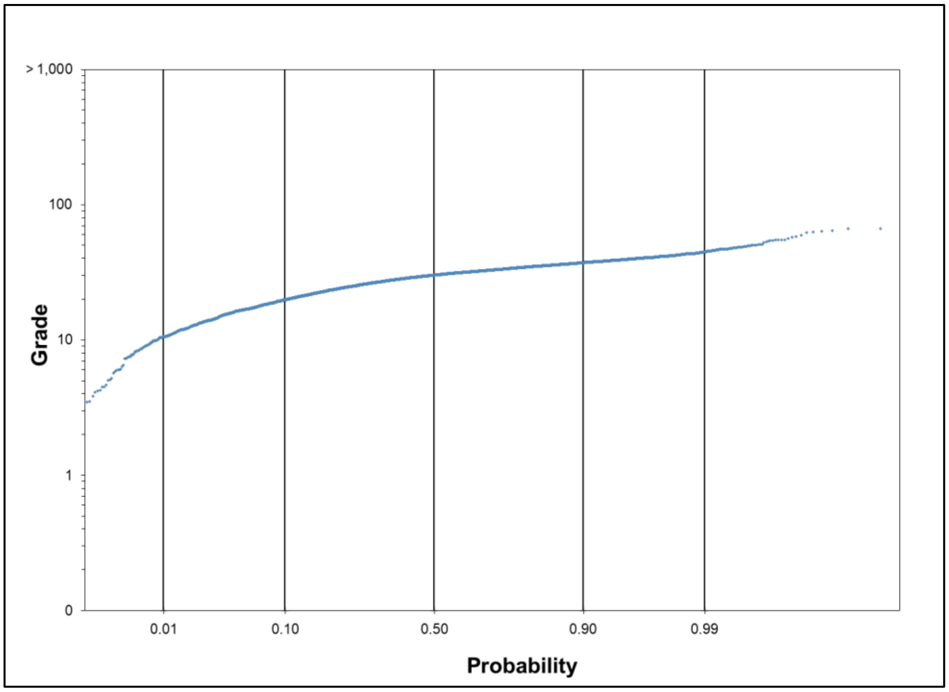


Figure 14-5: Probability plot of grade distribution for the IF_only composites

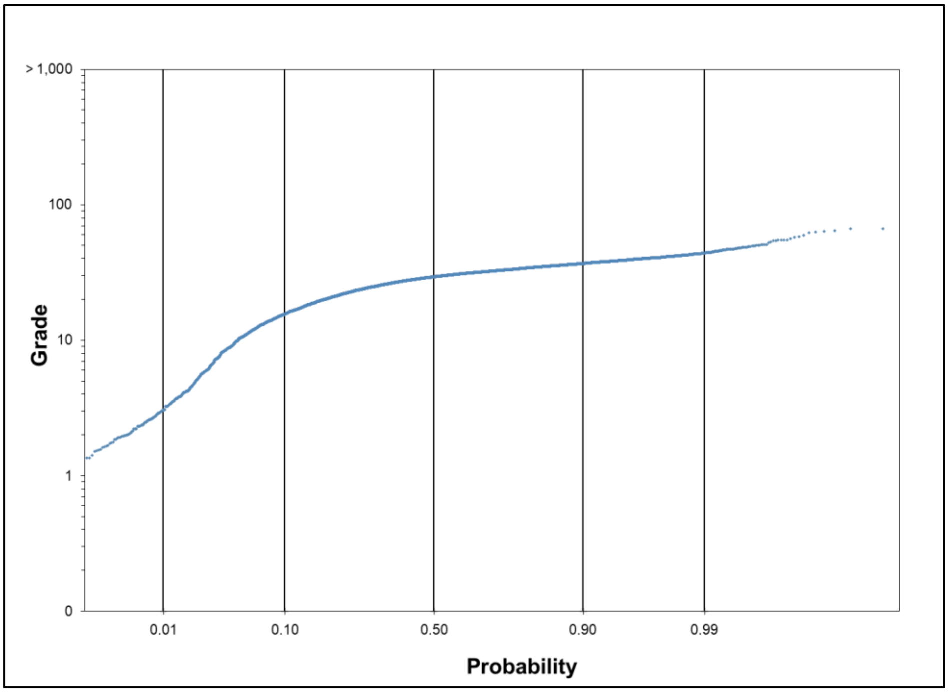


Figure 14-6: Probability plot of grade distribution for the IF_QRIF composites

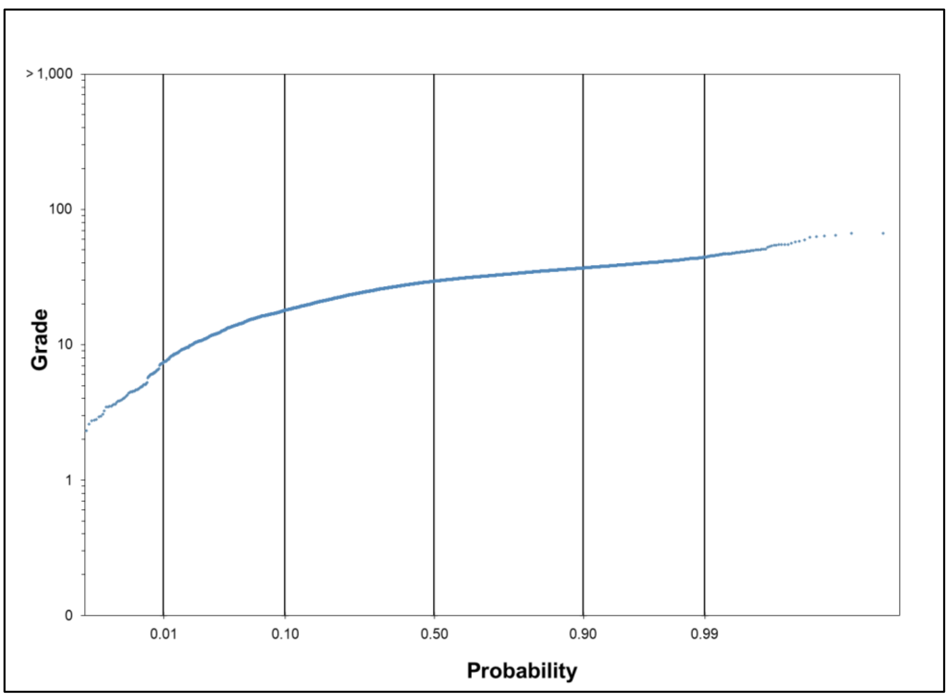


Figure 14-7: Probability plot of grade distribution for the SIF composites

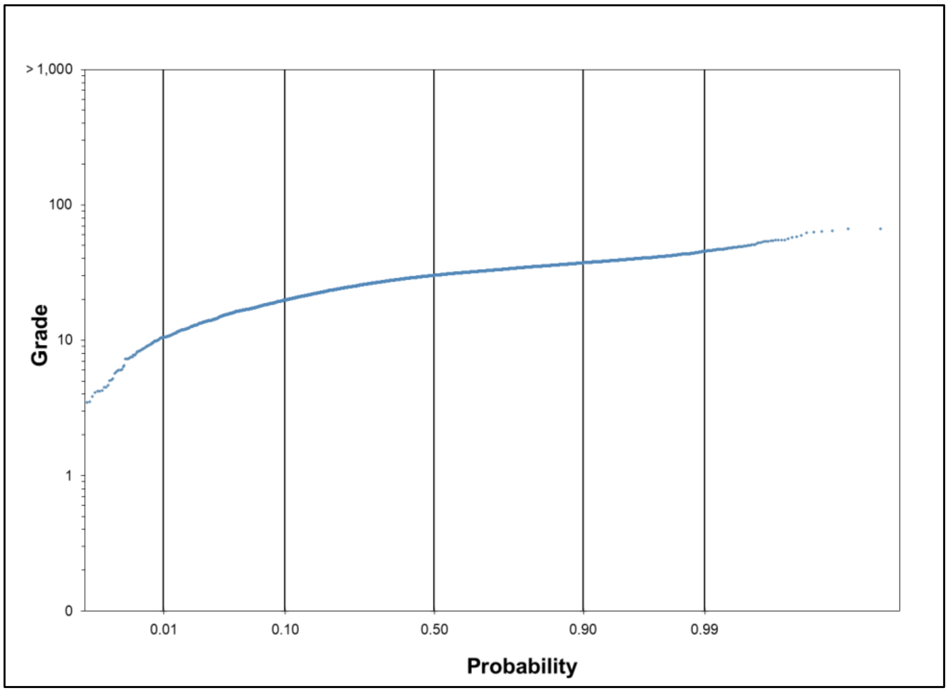


Figure 14-8: Probability plot of grade distribution for the LIMO composites

14.5.4 Density

For mineralized units, density values were calculated based on the formula established and used during the operational period:

$$SG = \text{Fe\%} \text{ x } 0.0284 + 2.5764$$

Density values were calculated from the density of host rock, adjusted by the amount of iron as determined by metal assays. Waste material was assigned the density of porous dolomite (2.71 g/cm^3). The calculation was made on blocks in the block model.

Validations were performed to gain confidence that the formula presented above can be used for the purpose of the current MRE.

Unmineralized material was assigned fixed densities varying from 2.33 g/cm^3 to 3.19 g/cm^3 based on measurements from different laboratories.

It is the QP's opinion that the densities were measured and recorded at appropriate intervals, and in an appropriate manner, for this kind of deposit.

Average and median densities of the mineralized units were tabulated for the entire Project (Table 14-10).

Table 14-10: Descriptive statistics of the calculated density for mineralized units

Geology unit	Lithology code	Rock code	Count	Min	Max	Mean	Median
Iron Formation	IF	200	86,991	2.84	4.09	3.45	3.46
Iron Formation Magnetite	IFM	203	12,242	3.06	3.72	3.44	3.45
Silicate Iron Formation	SIF	210	83,427	2.86	3.66	3.35	3.37
Silicate Iron Formation with actinolite	SIFA	211	3,612	2.83	3.52	3.20	3.19
Orange limonite	LIMO	221	1,458	2.80	2.80	2.80	2.80

14.5.5 Variography Analysis

A semi-variogram is a common tool used to measure the spatial variability within a zone. Typically, samples taken far apart will vary more than samples taken close to each other. A variogram gives a measure of how much two samples taken from the same mineralized zone will vary in grade depending on the distance between these samples, and therefore allowing building search ellipsoids to be used during interpolation.

A 3D directional variography was carried out on the composites using the Snowden Supervisor v8.9 software. Variograms were modelled in the three orthogonal directions to define a 3D ellipsoid for each structural domain. The three directions of ellipsoid axes were set by using the variogram fans and visually confirmed with geological knowledge of the deposit.

Then, a mathematical model was interpreted in order to best-fit the shape of the calculated variogram for each direction. Three components were defined for the mathematical model: the nugget effect, the sill, and the range. After completing the study, it was judged more appropriate to assign the variogram parameters of the iron grade throughout the deposit to all domains and adjust the orientation of the ellipsoids based on the structural planes of each domain. All elements were assigned the same variogram parameters.

The QP participated in the variography study and considers them appropriate to be used in the ordinary kriging (OK) estimation. Table 14-11 presents the chosen variogram model parameters, and Figure 14-9 to Figure 14-11 illustrate the variography results.

Table 14-11: Variogram model parameters

	First spherical structure				Second spherical structure			
Nugget	Sill	Range X (m)	Range Y (m)	Range Z (m)	Sill	Range X (m)	Range Y (m)	Range Z (m)
0.21	0.32	83	33	35	0.47	345	140	60

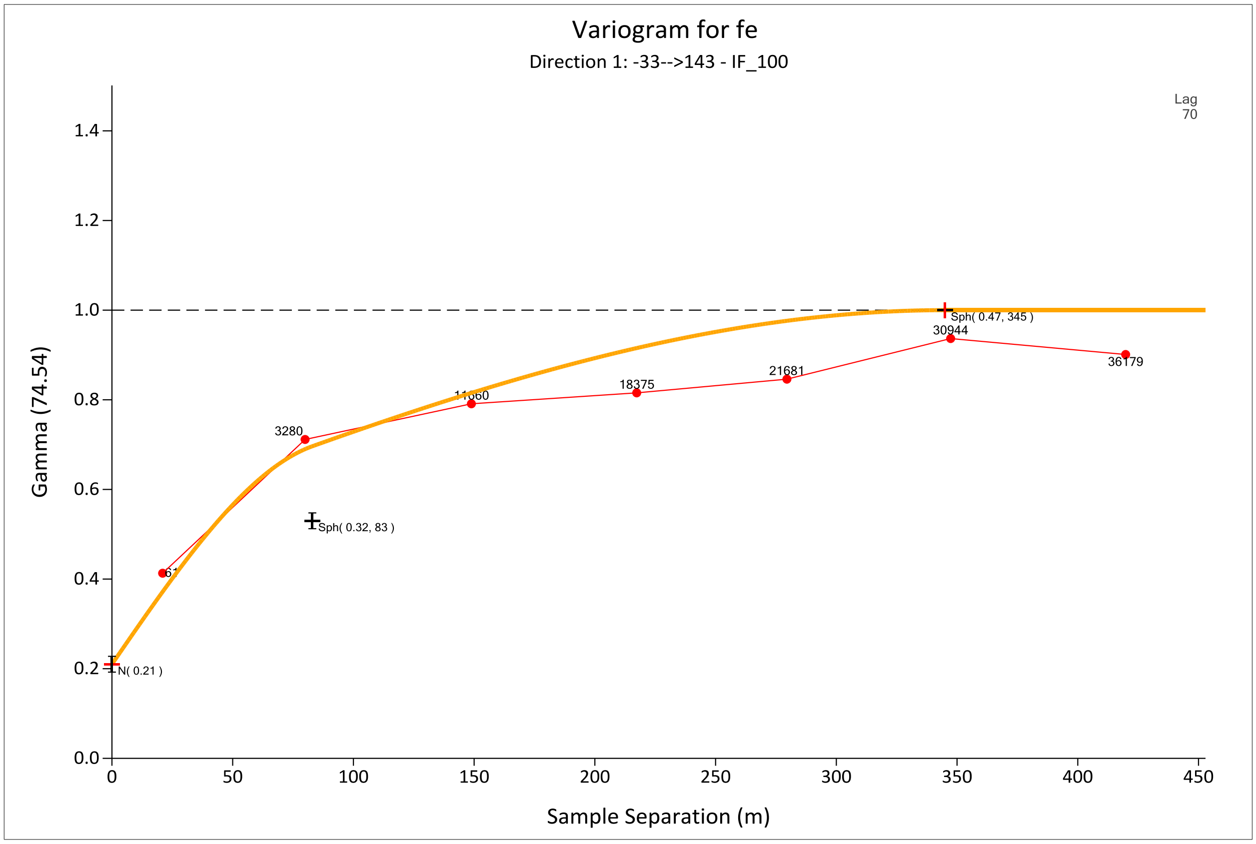


Figure 14-9: Major axis variography study for the iron content

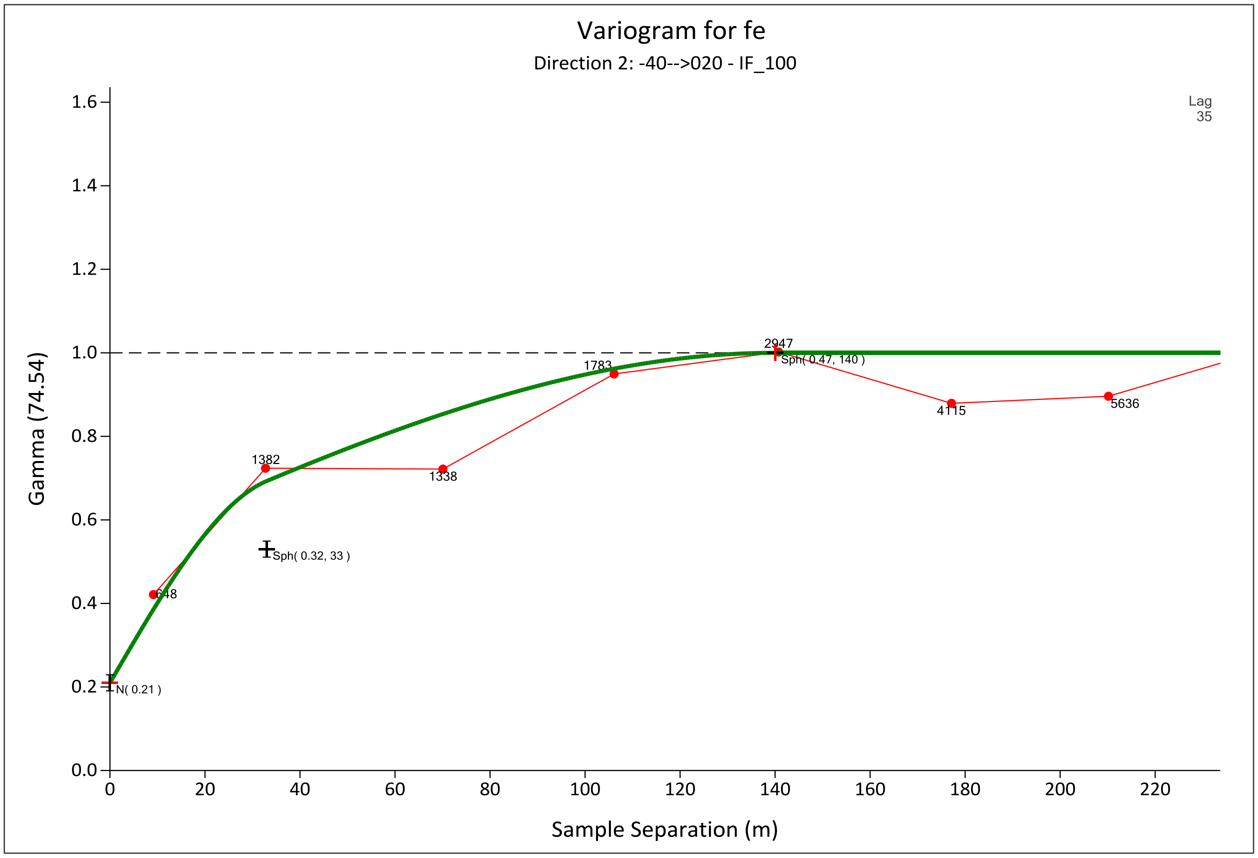


Figure 14-10: Semi-major axis variography study for the iron content

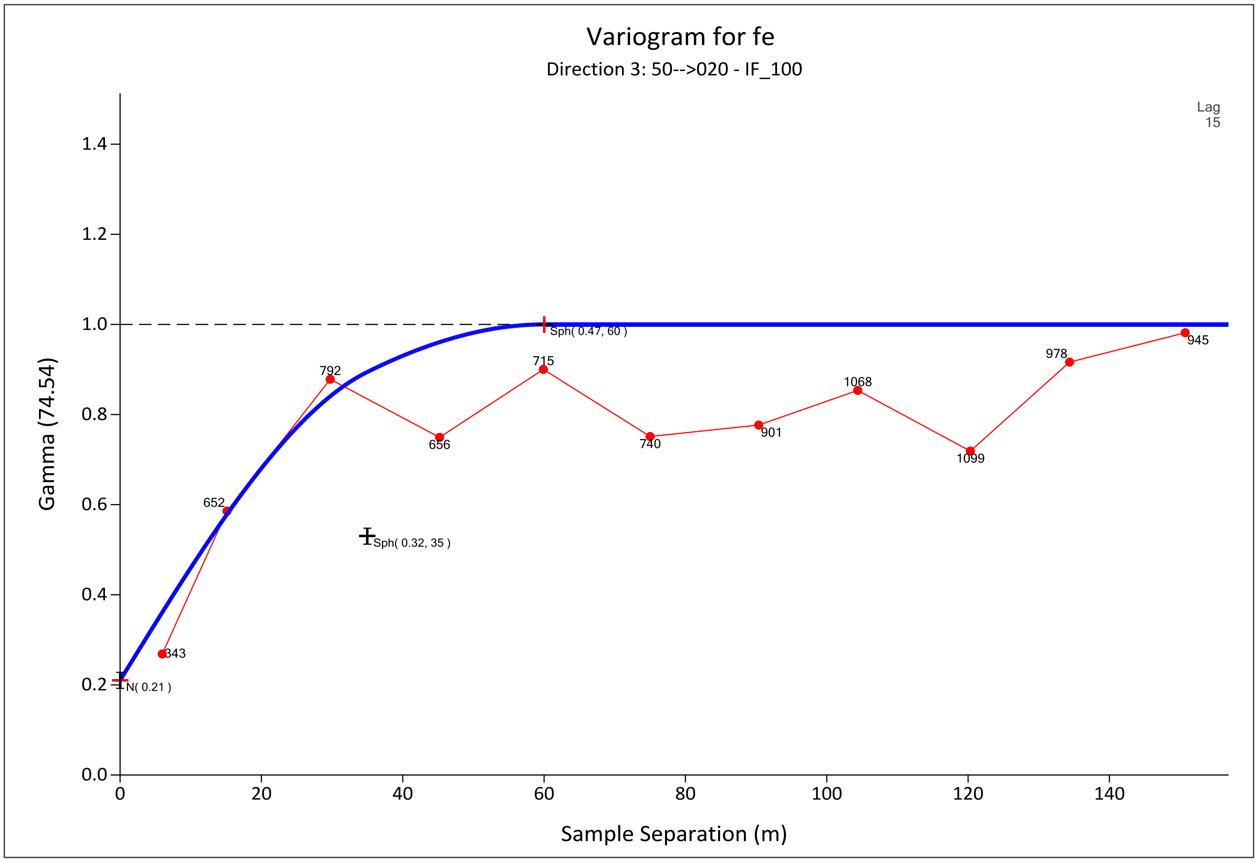


Figure 14-11: Minor axis variography study for the iron content

14.6 Block Modelling

The block model for the Bloom Lake project was set in Geovia Surpac 2019HF1 v.7.0.1949.0.

14.6.1 Block Model Parameters

The size of the blocks were chosen to best match the drilling pattern, the thickness of the zones, the complexity of the geology model and the open pit mine planning. The block model parameters are summarized in Table 14-12.

Table 14-12: Block model parameters

Properties	X (column)	Y (row)	Z (level)
Origin coordinates	611,800	5,853,000	-24
Number of blocks	640	400	72
Block extent (m)	6,400	4,000	1,008
Block size (m)	10	10	14
Rotation	No rotation		

The block model was coded using the 50-50 model method, reflecting the proportion of each wireframe inside every block. Rock codes were attributed to each block according to the highest proportion of lithology included in the block. Additionally, blocks that were located at least 50% inside the overburden solid and at least 99% above the topography surface were identified as overburden and air, respectively.

14.6.2 Search Ellipsoid Strategy

One search ellipsoid was used for each structural domain in the interpolation of all grade attributes. Ranges and orientations of the ellipses are representative of the anisotropy ratios and directions as determined from the variography analysis. Table 14-13 details search parameters by structural domain.

Table 14-13: Search ellipsoid orientation and ranges presented by structural domain

			Pass 1			Pass 2 (mostly for exploration purposes)		
	Orientation		Search ellipsoid ranges			Search ellipsoid ranges		
Blockcode	Azimut	Dip	X (m)	Y (m)	Z (m)	X (m)	Y (m)	Z (m)
1000	120	40	345	138	60	1,035	414	180
2000	105	35	345	138	60	1,035	414	180
3000	27	25	345	138	60	1,035	414	180
4000	88	22	345	138	60	1,035	414	180
5000	90	0	345	138	60	1,035	414	180
6000	90	0	345	138	60	1,035	414	180
7000	90	0	345	138	60	1,035	414	180
8000	95	0	345	345	345	1,035	1,035	1,035
9000	70	0	345	138	60	1,035	414	180
10000	260	15	345	138	60	1,035	414	180

			Pass 1			Pass 2 (mostly for exploration purposes)		
	Orientation		Search ellipsoid ranges			Search ellipsoid ranges		
Blockcode	**Azimut**	**Dip**	**X (m)**	**Y (m)**	**Z (m)**	**X (m)**	**Y (m)**	**Z (m)**
11000	90	5	345	138	60	1,035	414	180
12000	255	55	345	138	60	1,035	414	180
13000	270	65	345	138	60	1,035	414	180
14000	240	55	345	138	60	1,035	414	180
15000	270	35	345	138	60	1,035	414	180
16000	272	55	345	57.5	57.5	1,035	172.5	172.5
17000	268	0	345	138	60	1,035	414	180
18000	270	15	345	345	345	1,035	1,035	1,035
19000	270	75	345	138	60	1,035	414	180
20000	225	50	345	138	60	1,035	414	180
21000	0	70	345	345	345	1,035	1035	1035
22000	136	70	345	138	60	1,035	414	180

14.6.3 Interpolation Parameters

With a large search ellipse within large units, the number of composites to be used during the interpolation becomes a key estimation parameter.

A kriging neighbourhood analysis (KNA) was conducted on the most representative zones with the Snowden Supervisor software. KNA provides a quantitative method of testing different estimation parameters (i.e. block size, discretization and min/max of composites used for the interpolation) by evaluating their impact on the quality of the results.

Following this study, the parameters provided in Table 14-14 were chosen for the interpolation of the Bloom Lake block model.

Table 14-14: Composite constraints used for the estimation of each element

Interpolation parameters	Pass 1	Pass 2
Minimum number of composites used	3	3
Maximum number of composites per drillhole used	4	4
Maximum number of composites used	32	32

14.6.4 Interpolation Methodology

The interpolation was run with the use of two passes on a set of points extracted from the 6.0 m composited data. The block model grades were estimated using OK methods constrained inside the mineralized wireframes.

Hard boundaries between the mineralized zones were used in order to prevent grades from adjacent zones being used during interpolation. Soft boundary was used between structural domains to avoid artificial breaks in the grade distribution. As a block was estimated, it was tagged with the corresponding pass number.

For comparison purposes, additional grade models were generated using 1) inverse distance squared (ID^2); and 2) nearest neighbour (NN).

14.7 Block Model Validation

Every step of the block modelling process was revised to ensure fair representation of the available data in the Bloom Lake resource model.

More specific validations were completed on the block model including visual review of the interpolated grades in relation to the raw and composited data, checks for global and local bias, graphical validation (swath plots), statistical analysis of the model, comparison to other estimation methods and reconciliation with production data.

14.7.1 Visual Validation

Block model grades were visually compared against drillhole composite grades and raw assays in cross-section, plan, longitudinal and 3D views. This visual validation process also included confirming that the proper coding was done within the various domains.

The visual comparison shows a good correlation between the values without excessive smoothing. Visual comparisons were also conducted between ID^2, OK and NN interpolation scenarios. The OK scenario used for the resource estimate produced a grade distribution honouring drillhole data and the style of mineralization observed at Bloom Lake.

14.7.2 Statistical Validation

Grade averages for the OK, NN and ID^2 models were tabulated in Table 14-15. This comparison did not identify significant issues.

The average iron grades generated by the NN and ID^2 interpolation methods are very close to those reported from the OK interpolation method.

Table 14-15: Comparison of the block and composite mean grades at a zero cut-off grade (blocks > 50% inside a mineralized zone)

Unit	Number of composites	Average composite grade (% Fe)	Number of blocks	OK grade model (% Fe)	ID^2 grade model (% Fe)	NN grade model (% Fe)
SIF	8,921	28.38	185,837	29.07	29.26	29.14
LIMO	8,141	29.34	100,256	30.79	30.95	30.94
IF_QRIF	8,800	27.73	98,798	30.78	30.95	30.93
IF_only	8,105	29.32	98,798	30.78	30.95	30.93

14.7.3 Block Model Reconciliation

The previous block model showed local divergence, but it is expected that the current block model will provide better predictions by the fact that:

- Recent modelling updates address local observations allowed by recent mining operation;
- The improved structural domains provide a better control of the orientation of the grade interpolation;
- Grade distribution better honours the drillhole database.

14.8 Mineral Resource Classification

The mineral resources for the Bloom Lake project were classified in accordance with CIM Standards.

14.8.1 Mineral Resource Definition

The "CIM Definition Standards for Mineral Resources and Reserves" published by the Canadian Institute of Mining, Metallurgy and Petroleum for the resource classification clarifies the following:

> *"Inferred Mineral Resource:*
>
> *An **Inferred Mineral Resource** is that part of a Mineral Resource for which quantity and grade or quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade or quality continuity.*
>
> *An Inferred Mineral Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to a Mineral Reserve. It is reasonably expected that the majority of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with continued exploration.*

<u>Indicated Mineral Resource:</u>

*An **Indicated Mineral Resource** is that part of a Mineral Resource for which quantity, grade or quality, densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit.*

Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation.

An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Mineral Reserve.

<u>Measured Mineral Resource:</u>

*A **Measured Mineral Resource** is that part of a Mineral Resource for which quantity, grade or quality, densities, shape, and physical characteristics are estimated with confidence sufficient to allow the application of Modifying Factors to support detailed mine planning and final evaluation of the economic viability of the deposit.*

Geological evidence is derived from detailed and reliable exploration, sampling and testing and is sufficient to confirm geological and grade or quality continuity between points of observation.

A Measured Mineral Resource has a higher level of confidence than that applying to either an Indicated Mineral Resource or an Inferred Mineral Resource. It may be converted to a Proven Mineral Reserve or to a Probable Mineral Reserve."

14.8.2 Mineral Resource Classification for the Bloom Lake Project

The estimated block grades were classified into Measured, Indicated and Inferred Mineral Resource categories using drill spacing, geological continuity, number of holes used and slope of regression (see Table 14-16).

When needed, a series of clipping boundaries were created manually in 3D views to either upgrade or downgrade classification in order to avoid artifacts due to automatically generated classification. All remaining estimated but unclassified blocks were flagged as "Exploration Potential".

It must be noted that the 2018 drill program was used for classification purposes although assay results had not been received. The QP does not recommend doing so, but verifications allowed determining that these drillholes affected a very limited amount of material throughout the deposit (less than 1% of the tonnage). Additional verifications allowed confirming that mineralization was identified in the 2018 drillholes at similar visual content as adjacent holes. Once results are received by QIO and included in a future update of the block model, it is anticipated that tonnage will not be affected, but grade could locally be slightly lower or higher for the limited amount of blocks within interpolation reach of the 2018 drillholes. The anticipated variations are judged non-material by the QP and will have an insignificant impact on the mineral resource estimate Figure 14-12 shows the distribution of the classified blocks within the resource pit shell.

Table 14-16: High level guidelines used to classify resources at Bloom Lake

Parameters	Measured	Indicated	Inferred
Minimum number of holes	6	3	1
Average distance to composites	≤ 150	≤ 250	-
Slope of regression	≥ 0.8	≥ 0.5	-

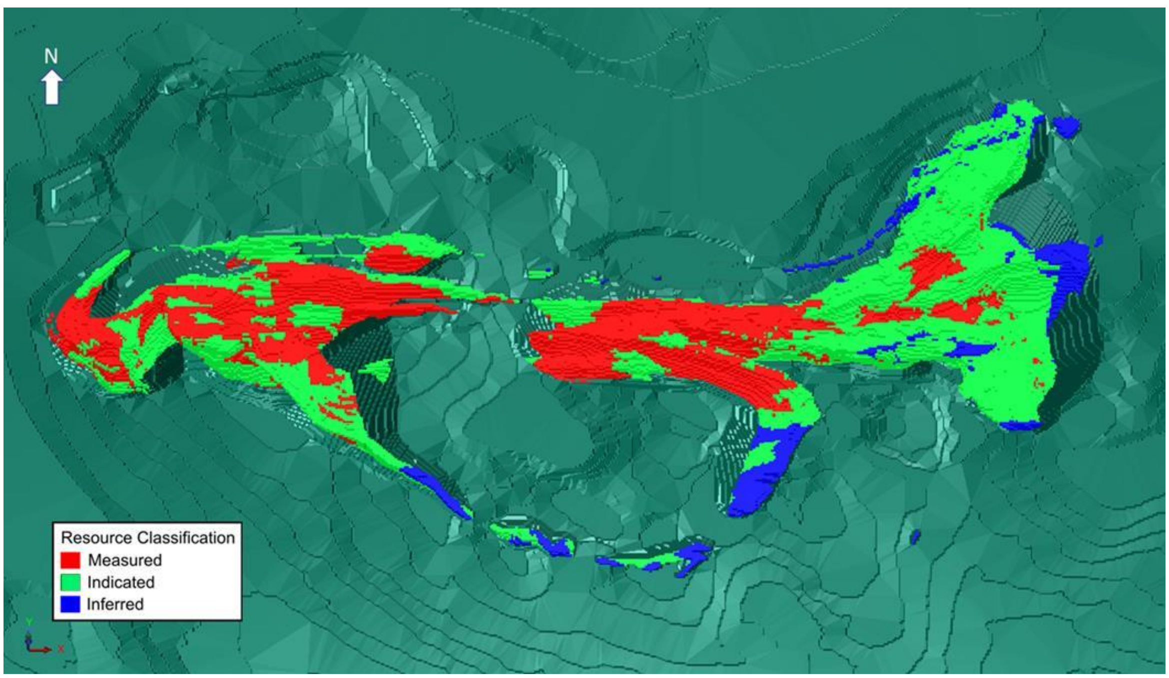


Figure 14-12: 3D view showing block classification

14.9 Cut-off Grade and Pit Optimization

According to CIM's Definition Standards, in order for a deposit to be considered a Mineral Resource it must be proven that there are "reasonable prospects for eventual economic extraction". This requirement implies that the quantity and grade estimates meet certain economic thresholds and that the Mineral Resources are reported at an appropriate cut-off grade that takes into account extraction scenarios and processing recoveries.

In order to determine the quantity of mineralization that shows a "reasonable prospect for eventual economic extraction" using open pits mining methods, BBA carried out a pit optimization analysis using Hexagon MineSight's Economic Planner. This analysis evaluates the profitability of each mineralized block in the model based on its value. The pit optimization parameters are presented in Table 14-17.

It is important to note that the results from the pit optimization exercise are used solely for testing the "reasonable prospects for eventual economic extraction" by open pit mining methods and do not represent an economic study.

The cut-off grade used for the Mineral Resource Estimate is 15% Fe. The pit optimization analysis carried out for the Mineral Resource Estimate used the same parameters as for the pit optimization for the economic study presented in this Report, but allowed for Inferred material to be considered.

Table 14-17: Bloom Lake optimization parameters

Parameter	Base value	Unit
Mining costs		
Mining cost	2.50	CAD/t mined
Incremental bench cost	0.039	CAD/t / 14 m
Processing & G&A costs		
G&A cost	2.76	CAD/t milled
Concentrator cost	3.70	CAD/t milled
Total operating cost	6.46	CAD/t milled
Net value & payment		
CFR 62% iron	61.50	USD/t
Concentrate premium	12.70	USD/t / %
CFR 66.2% iron	74.20	USD/t
Exchange rate	0.81	USD/CAD
CFR 66.2% iron	92.01	CAD/t
Shipping and logistics	18.88	CAD/t
Selling costs	26.04	CAD/t
Iron price FOB Bloom Lake	47.09	CAD/t
Iron recovery	varies	%
Weight recovery	varies	%
Discount rate	8.00	%
Concentrate production rate	15.00	Mtpy

It is the QP's opinion that the calculated cut-off grade is relevant to the grade distribution of this Project and that the mineralization exhibits sufficient continuity for economic extraction under the cut-off applied.

14.10 Bloom Lake Mineral Resource Estimate

The Measured, Indicated and Inferred Mineral Resources for the Bloom Lake project presented herein is estimated at a cut-off grade of 15% Fe, inside an optimized Whittle open pit shell based on a long term iron price of USD61.50/dmt for 62% Fe content, a premium of USD12.7/dmt for the 66.2% Fe concentrate and an exchange rate of 1.24 CAD/USD. The Measured and Indicated Mineral Resource for the Bloom Lake project is estimated at 893.5 Mt with an average grade of 29.3% Fe, and Inferred Mineral Resource at 53.5 Mt with an average grade of 26.2% Fe. Table 14-18 presents the resource estimation tabulation by category. Figure 14-13 shows a 3D view of the grade distribution within the open pit optimized shell.

Table 14-18: Mineral resources estimate for the Bloom Lake project

Classification	Tonnage (dry) kt	Fe %	CaO %	Sat %	MgO %	Al_2O_3 %
Measured	379,100	30.2	1.4	4.4	1.4	0.3
Indicated	514,400	28.7	2.5	7.7	2.3	0.4
Total M&I	893,500	29.3	2.1	6.3	1.9	0.4
Inferred	53,500	26.2	2.8	8.0	2.4	0.4

Notes on Mineral Resources:

1. The independent qualified person for the 2019 MRE, as defined by NI 43-101 Guidelines, is Pierre-Luc Richard, P. Geo, of BBA Inc. The effective date of the estimate is April 19, 2019. CIM definitions and guidelines for Mineral Resource Estimates have been followed.
2. These mineral resources are not mineral reserves as they do not have demonstrated economic viability. The MRE presented herein is categorized as Measured, Indicated and Inferred resources. The quantity and grade of reported Inferred resources in this MRE are uncertain in nature and there has been insufficient exploration to define these Inferred resources as Indicated or Measured; however, it is reasonably expected that the majority of Inferred mineral resources could be upgraded to Indicated mineral resources with continued exploration.
3. Resources are presented as undiluted and in situ for an open pit scenario and are considered to have reasonable prospects for economic extraction. The constraining pit shell was developed using pit slopes varying from 42 to 46 degrees. The pit shell was prepared using Minesight.
4. The MRE was prepared using GEOVIA Surpac 2019HF1 v.7.0.1949.0 and is based on 569 surface drillholes (141,289 m) and a total of 11,397 assays.
5. Density values were calculated based on the formula established and used by the issuer.
6. Grade model resource estimation was calculated from drillhole data using an ordinary kriging interpolation method in a block model using blocks measuring 10 m x 10 m x 14 m (vertical) in size.
7. The estimate is reported using a cut-off grade of 15% Fe. The MRE was estimated using a cut-off grade of 15% Fe, inside an optimized open pit shell based on a long term iron price of USD61.50/dmt for 62% Fe content, a premium of USD12.70/dmt for the 66.2% Fe concentrate and an exchange rate of 1.24 CAD/USD. The cut-off grade will need to be re-evaluated in light of future prevailing market conditions and costs.
8. Calculations are in metric units (metre, tonne). Metal contents are presented in percent (%). Metric tonnages are rounded and any discrepancies in total amounts are due to rounding errors.
9. The author is not aware of any known environmental, permitting, legal, title-related, taxation, socio-political or marketing issues, or any other relevant issues not reported in this Technical Report that could materially affect the Mineral Resource Estimate.

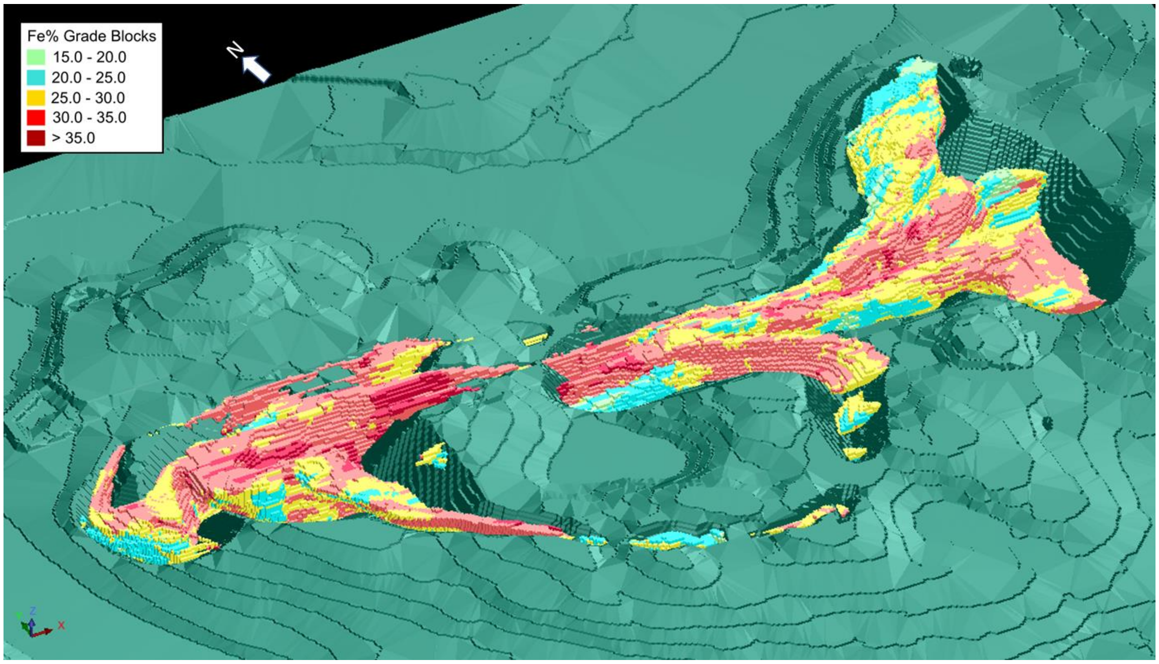


Figure 14-13: 3D view showing Fe grade located inside the open pit optimized shell

Table 14-19 and Table 14-20 show the sensitivity of the block model to the iron cut-off grade for the in situ mineral resource estimate within the MRE pit optimized shell.

The reader is cautioned that the numbers presented in the following tables should not be misconstrued with a mineral resource statement. The reported quantities and grade estimates at different cut-off grades are only presented to demonstrate the sensitivity of the block to the selection of a reporting cut-off grade.

Table 14-19: Grade and tonnage sensitivity to cut-off grade (Measured and Indicated resources)

Cut-off grade Fe	Tonnage (dry)	Fe	CaO	Sat	MgO	Al_2O_3
%	kt	%	%	%	%	%
10%	894,086	29.3	2.1	6.3	1.9	0.4
15%	893,501	29.3	2.1	6.3	1.9	0.4
20%	879,446	29.5	2.0	6.3	1.9	0.4
25%	779,392	30.3	1.7	6.1	1.7	0.3
30%	413,861	32.5	1.0	5.4	1.0	0.3
35%	43,357	36.6	0.3	3.8	0.3	0.3
40%	2,041	42.7	0.1	1.1	0.1	0.3

Table 14-20: Grade and tonnage sensitivity to cut-off grade (Inferred resources)

Cut-off grade Fe	Tonnage (dry)	Fe	CaO	Sat	MgO	Al_2O_3
%	kt	%	%	%	%	%
10%	54,045	26.1	2.8	8.1	2.4	0.4
15%	53,482	26.2	2.8	8.0	2.4	0.4
20%	50,920	26.6	2.8	7.9	2.4	0.4
25%	34,498	28.3	2.3	8.0	2.0	0.4
30%	7,043	32.5	2.7	11.7	2.5	0.3
35%	1,084	36.1	1.2	6.4	1.2	0.4

15. MINERAL RESERVES ESTIMATE

15.1 Introduction

BBA Inc. (BBA) was mandated by Quebec Iron Ore (QIO) to prepare a feasibility study level mining study and Mineral Reserve Estimate for the Bloom Lake Mine Phase 2 project (the Project) located in Quebec.

The Project's objective is to double the throughput capacity of the Bloom Lake Mine, previously started by Cliffs Natural Resources. This Project was placed on hold and eventually in care and maintenance when operations were suspended in December 2014. It was later acquired as a part of the purchase by QIO in April 2016. Phase 2 expansion is based on operating assumptions seen during the Phase 1 ramp-up completed by QIO in 2018 with adjustments for economies of scale.

15.2 Summary

The mineral reserve for the Bloom Lake project is estimated at 807.0 Mt at an average grade of 29.0% Fe as summarized in Table 15-1. The Mineral Resource Estimate (MRE) was prepared by BBA. The resource block model was generated by QIO and reviewed by BBA.

The mine design and MRE have been completed to a level appropriate for feasibility studies. The MRE stated herein is consistent with the CIM definitions and is suitable for public reporting. As such, the mineral reserves are based on Measured and Indicated (M&I) Mineral Resources, and do not include any Inferred Mineral Resources. The Inferred Resources contained within the mine design are classified as waste.

Table 15-1: Mineral reserve estimate

Classification	Diluted ore tonnage (dry Mt)	Fe %	CaO %	Sat %	MgO %	Al_2O_3 %
Proven	346.0	29.9	1.5	4.7	1.4	0.3
Probable	461.0	28.2	2.6	7.9	2.5	0.6
Total Proven & Probable	**807.0**	**29.0**	**2.2**	**6.5**	**2.0**	**0.5**

Notes on Mineral Reserves:

1. The mineral reserves were estimated using the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Standards for Mineral Resources and Reserves, Definitions and Guidelines prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council May 10, 2014.
2. The independent and qualified person (QP) for the mineral reserves estimate, as defined by NI 43-101, is Isabelle Leblanc, P. Eng., from BBA. The effective date of the estimate is May 17, 2019.
3. Inside the final open pit design, all Measured Resources and associated dilution (waste material at 0% Fe) have been converted into Proven Mineral Reserves. Inside the final open pit design, all Indicated Resources and associated dilution (waste material at 0% Fe) have been converted into Probable Mineral Reserves.
4. The reference point of the mineral reserve is the primary crusher feed.
5. Mineral reserves are based on the December 31, 2020 mining surface.
6. Mineral reserves are estimated at a cut-off grade of 15% Fe.
7. Mineral reserves are estimated using a long-term iron reference price (Platt's 62%) of USD60.89/dmt and an exchange rate of 1.24 CAD/USD. An iron concentrate price adjustment of USD12.70/dmt was added.
8. Bulk density of ore is variable but averages 3.40 t/m^3.
9. The average strip ratio is 0.88:1.
10. The mining dilution was calculated using a 1.0 m contact skin.
11. The average mining dilution is 1.18% at a grade of 0% Fe. Dilution was applied block by block and shows a wide range of local variability.
12. The average ore loss is 0.81% at a grade of 31% Fe. Ore loss was applied block by block and shows a wide range of local variability.
13. The author is not aware of any known environmental, permitting, legal, title-related, taxation, socio-political or marketing issues, or any other relevant issues not reported in the Technical Report, that could materially affect the Mineral Reserve Estimate.
14. Numbers may not add due to rounding.

15.3 Resource Block Model

The block model was prepared by Quebec Iron Ore in April 2019 and was named "bm_bl_interp_p2_20190419". The block model framework information is presented in Table 15-2. In addition to the modeled iron grade, other interpolated attributes include calcium oxide (CaO), Satmagan (SAT), Magnesium Oxide (MgO), and aluminum oxide (Al_2O_3), which are tracked in the schedule.

Table 15-2: Block model framework

Model setting	Value
X Origin	611,500
Y Origin	5,852,500
Z Origin	4
Block Size in X Direction	10
Block Size in Y Direction	10
Block Size in Z Direction	14
Number of Blocks in X Direction	600
Number of Blocks in Y Direction	500
Number of Blocks in Z Direction	59

15.4 Pit Optimization

The open pit optimization was conducted to determine the optimal economic shape of the open pit to guide the pit design process. This task was undertaken using the MineSight Economic Planner (MSEP) software that is based on the Lerchs-Grossmann algorithm. The method works on a block model of the ore body, and progressively constructs lists of related blocks that should, or should not, be mined. The method uses the values of the blocks to define a pit outline that has the highest possible total economic value, subject to the required pit slopes defined as structure arcs in the software. This section describes all the parameters used to calculate block values in MSEP.

For this feasibility study, Measured and Indicated Resource blocks were considered for optimization purposes.

15.4.1 Pit Slope Geotechnical Assessment

Golder Associates Ltd. (Golder) carried out a geotechnical review of the planned Phase 2 pit prepared by BBA in 2019. For this review, Golder used the feasibility level pit slope design prepared by Golder (2014) as the basis for comparison. The conclusions of this technical review have been considered as inputs to the pit optimization and design process. The Golder scope included essentially a slope design update and a basic review of waste rock facilities and groundwater.

A total of nine domains were defined according to changes in the rock mass fabric, with separations roughly along the axes of the overall folding structures, by changes in the pit wall orientation, and by available structural data sources.

Groundwater levels generally follow the topography and are found within 11 m from the ground surface following testwork completed by Hydro-Ressources. It has been assessed that the open pit will be developed in a good rock mass where rock mass failure is not a concern. Rather, potential instability will involve structural controls, the most significant being the foliation control on bench face angle and the potential control of flat sets on bench crest backbreak angles. No major fault that would adversely daylight on the final pit walls has been identified.

In overburden, a minimum design slope of 2H:1V with 8 m bench width at each 15 m height was recommended (Golder, 2014). The pit slope recommendations used for pit optimization are presented in Table 15-3. For the purpose of optimization, only the overall slope angles were input. This is due to the fact that nearly all sections in the pit contain a ramp.

Table 15-3: Pit slope design sectors for optimization

Geotechnical pit design profiles	1	2	3
Design sector	I, II, VI, X	III, IV, V, VII, VIII, IX	XI
Bench face angle (^{o})	75.0	70.0	70.0
Avg. catch berm width (m)	14.0	13.3	15.0
Inter-ramp (^{o})	52.5	50.0	48.0
Ramp width (m)	35.0	35.0	35.0
Geotechnical bench width (m)	20.0	20.0	20.0
Overall slope angle (^{o})	45.7	43.7	42.1

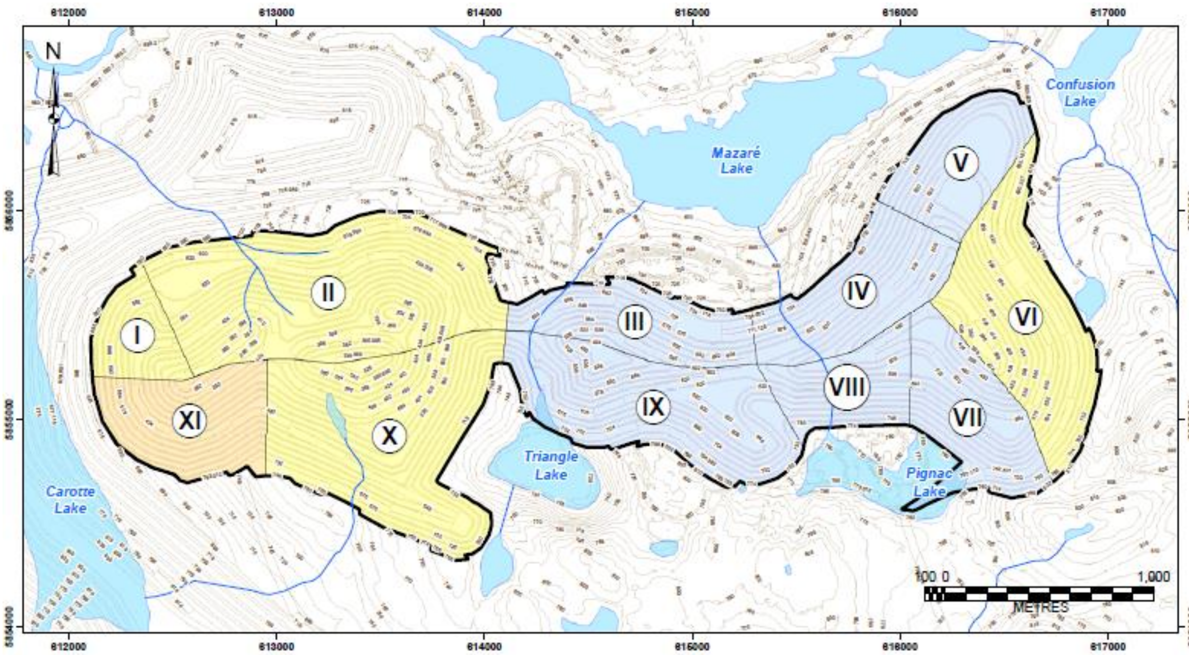


Figure 15-1: Bloom Lake geotechnical zones

15.4.2 Mining Dilution and Ore Loss

A mining dilution assessment was made on a block by block basis prior to applying a cut-off grade. A script was developed to assess if the block was ore, what rock type the neighbouring blocks are, and whether to dilute from neighbouring blocks or lose to neighbouring blocks. The amount that is either lost or gained (diluted) is then the block height x block width x skin thickness.

For this study, the skin thickness was chosen to be 1.0 m. This will be achieved via the purchase of a 140-tonne excavator that will separate material along ore-waste contacts. This material will then be loaded separately by production loaders. While along linear contacts this technique reduces ore-waste misclassification to almost zero, foliated contacts and blast movement will induce misclassification despite best efforts. It is for this reason that 1.0 m was chosen as it adds an average of 6% ore loss and 10% dilution along the ore-waste contact.

For all blocks within the resource model, diluted grade and density are calculated by taking into account the grade, density and rock type of the surrounding blocks. Table 15-4 shows the loss and dilution rock type criteria.

Table 15-4: Ore loss and dilution interactions

		Ore rock types				
		Iron formation	**Magnetite**	**Silicate iron formation**	**Actinolite iron formation**	**Limonite**
Waste rock types	Gneiss	Dilute	Dilute	Dilute	Dilute	Dilute
	Amphibolite	Loss	Loss	Loss	Loss	Loss
	Quartz	Dilute	Dilute	Dilute	Dilute	Dilute
	Overburden	Loss	Loss	Loss	Loss	Loss

The Chief's Peak Pit mineralized formation is embedded in bands of high silicate formation that was previously considered as a waste iron formation. By providing sufficient blending opportunities in the mine, material high in CaO and MgO that was previously classified as waste can now be classified as ore. This has an additional effect reducing the number of ore-waste contacts thereby reducing overall dilution in Chief's Peak.

The average mining dilution is 1.18% at a grade of 0% Fe. The average ore loss is 0.81% at a grade of 31% Fe. Dilution and ore loss were applied block by block and show a wide range of local variability.

For pit optimization in MSEP, diluted grade and tonnes were used. After dilution and loss, a cut-off grade of 15% was applied and only blocks meeting this criteria were available to be sent to the concentrator.

15.4.3 Pit Optimization Parameters

A series of optimized pit shells was generated by varying the base selling price using revenue factors ranging from 0.65 to 1.04.

A summary of the pit optimization parameters is presented in Table 15-5 for a milling rate of 41.9 Mtpy based on a reference iron ore price (Platt's 62% CFR China) of USD60.89/dmt concentrate (Revenue factor = 0.99) and an exchange rate of CAD 1.24/USD. A price adjustment of USD12.7/dmt was applied as a premium for 66.2% iron concentrate. The iron ore price assumption is deemed in line with respect to long-term forecasts. The metallurgical recovery is estimated on a block by block basis using the following formula:

$$Fe\ Rec = -0.0764Fe^2 + 5.5756Fe - 0.8921MgO - 0.0020MgO^2 + 0.244FeMgO - 14.8746$$

The overall effect of the recovery curve is to penalize low grade and contaminated material. Two different formulas were ultimately used in the mill production schedule, the Phase 2 formula being detailed in Section 13.8 of this Report and the Phase 1 (QIO) formula detailed in the previous

Phase 1 (QIO) restart feasibility study. Each updated curves estimate a slightly higher recovery than the curve used in the optimization. The impact of the adjusted curves is non-material on the outcome of the optimization.

The total selling, shipping and logistics cost is estimated at CAD44.92/dmt and is deducted to estimate a FOB Bloom Lake concentrate price of CAD47.09/dmt.

Unit reference mining costs are used for a "reference mining block" located near the pit crest or surface and are incremented with depth, which corresponds to the additional cycle time and resulting incremental hauling cost. The reference mining cost was estimated at CAD2.50/t with an incremental depth factor of CAD0.039/t per 14 m bench.

The overall slope angles utilized in MSEP are based on the overall slope angles recommended by Golder's pit slope study (2014), which include provisions for ramps and geotechnical berms. The overall slope angles are summarized in Table 15-3.

Table 15-5: Optimization parameters

Parameter	Base value	Unit
MINING COSTS		
Mining Cost	2.50	CAD/t mined
Incremental Bench Cost	0.039	CAD/t /14 m
PROCESSING & G&A COSTS		
G&A Cost	2.76	CAD/t milled
Concentrator Cost	3.70	CAD/t milled
Total Operating Cost	6.46	CAD/t milled
NET VALUE & PAYMENT		
CFR 62% Iron	61.50	USD/t (base selling price at revenue factor 1)
Concentrate Premium	12.70	USD/t/%
CFR 66.2% Iron	74.20	USD/t
Exchange Rate	1.24	CAD/USD
CFR 66.2% Iron	92.01	CAD/t
Shipping and Logistics	18.88	CAD/t
Selling Costs	26.04	CAD/t
Iron Price FOB Bloom Lake	47.09	CAD/t
Iron Recovery	varies	%
Weight Recovery	varies	%
Discount Rate	8.0	%
Concentrate Production Rate	15.00	Mtpy

Note: The optimized parameters do not necessarily correspond with the final design parameters used in the FS.

15.4.4 Open Pit Optimization Results

The nested shell results are presented in Table 15-6 using only the Measured and Indicated (M&I) Resource. The concentrate values presented are using the recovery formula applied on a block by block basis. This ensures that the optimization is slightly conservative because blending the ore body is expected to increase overall concentrate production.

Pit Shell 9 is selected, for the M&I optimization, as the optimum final pit shell that corresponds to a CAD46.32/t FOB Bloom Lake pit shell (Revenue Factor 0.99). This selection allows for nearly 20 years mine life without compromising the value of the Project. This shell has a total tonnage of 1.4 Gt including 802 Mt of ore at an average diluted grade of 29.2% Fe. The average strip ratio is 0.75:1.

Table 15-6: Open pit optimization results

Pit	Revenue Factor (RF)	RF Eq. Price (USD/t)	Mineralized Material (kt)	Grade (%Fe)	Fe Concentrate (kt)	Waste (kt)	Total material (kt)	Strip Ratio	INC Strip Ratio	Mine Life (Yrs)	% of Max NPV
1	0.65	39.98	3,936	36	1,829	113	4,049	0.03	0.242	0.1	3%
2	0.75	46.13	182,505	31.25	73,862	43,311	225,816	0.24	0.242	4.3	66%
3	0.80	49.20	380,389	30.12	142,173	115,673	496,062	0.30	0.366	9.1	94%
4	0.85	52.28	523,954	29.62	188,053	215,747	739,701	0.41	0.697	12.5	100%
5	**0.90**	**55.35**	**667,566**	**29.39**	**236,061**	**375,584**	**1,043,150**	**0.56**	**1.113**	**15.9**	**100%**
6	0.96	59.04	761,680	29.25	266,497	518,513	1,280,193	0.68	1.519	18.2	97%
7	0.97	59.66	768,516	29.23	267,604	529,848	1,298,364	0.69	1.658	18.3	95%
8	0.98	60.27	793,910	29.22	276,293	584,025	1,377,935	0.74	2.133	18.9	94%
9	**0.99**	**60.89**	**802,004**	**29.22**	**279,046**	**598,157**	**1,400,161**	**0.75**	**1.746**	**19.1**	**93%**
10	**1.00**	**61.50**	**811,068**	**29.20**	**281,720**	**614,289**	**1,425,357**	**0.76**	**1.780**	**19.3**	**93%**
11	1.02	62.73	844,056	29.14	292,358	674,322	1,518,378	0.80	1.820	20.1	91%
12	1.04	63.96	897,557	29.10	309,516	796,306	1,693,863	0.89	2.280	21.4	86%

Notes on pit optimization:

- These results are not mineral reserves.
- Based on the December 31, 2020 forecasted topographic surface named "Surface_2020-12-31_V3.msr".
- Optimization based on diluted block grades. CoG of 15% Fe applied after dilution and ore losses.
- Highest NPV pit shown in GREEN, RF = 1.0 pit shown in BROWN, BBA selected pit shown in ORANGE.

15.4.5 Slope Design Criteria

The final pit was designed using a double benching configuration to a final height of 28 m. The pit slope profile is based on recommendations by Golder following a slope performance review in 2018. The slope profile is based on recommended batter angles with catch bench width recommendations for an inter-ramp angle (IRA) ranging from 42 to 52 degrees. A 20 m geotechnical berm is introduced at approximately the mid-elevation of the pit or 112 m where ramp segments do not pass in the slope to reduce the vertical stack height. In addition, areas where low rock quality is expected, the design is modified to a single bench design. The criteria are enumerated below where Sector XI refers to the sectors presented in Figure 15-1.

Table 15-7: Pit slope design criteria

Pit	2014 design sector	Bench configuration (elevation (m) and height (m))	Bench face angle (°)	Berm width (m)	Inter-ramp angle (°)
West	II (North Wall)	Single Bench (718-410 m) 14 m	70	9	46
	X (East)	Double Bench (769-410 m) 28 m	70	13.3	50
	X (South)	Double Bench (770-592 m) 28 m	70	13.3	50
		Single Bench (592-410 m) 28 m	70	9	46
West – South Extension	Wall Avg. Dip Direction 005° (355° - 015°)	Double Bench 28 m	70	13.3	50
	Wall Avg. Dip Direction 205° (180° - 225°)	Single Bench 14 m	70	9	46
Chief's Peak	III (North Wall)	Single Bench (726-536 m) 14 m	70	9	42
Chief's Peak – South Extension	Wall Avg. Dip Direction 020° (010° - 030°)	Double Bench 28 m	70	13.3	50
	Wall Avg. Dip Direction 310° (300° - 320°)	Double Bench 28 m	70 (75) (1)	13.3 (14) (1)	50 (52.5) (1)

(1) Upon the excavation and mapping of the first bench, there would be the opportunity to steepen the IRA if there is no major kinematic control

The overburden is sloped at a 2H:1V angle. The overburden is removed 5-10 m back from where the rock crest intersects the pit design. The average depth of overburden over the footprint of the pit averages less than 5 m and consists of a thin layer of top soil covering sandy till with cobbles and boulders. Much of the open pit surface has already been stripped from past operations, however, the push backs of the West Pit will require overburden removal, as will the push backs of the Chief's Peak Pit.

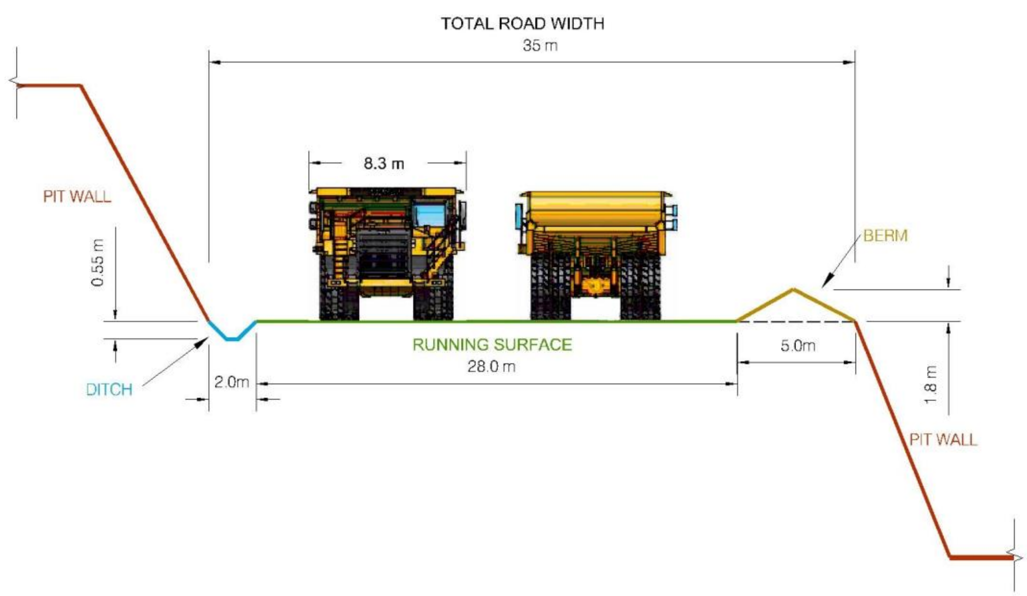
Figure 15-2: West Pit overburden striping

15.4.6 Ramp Design Criteria

The ramps and haul roads are designed for the largest equipment being a 240-tonne class haul truck with a canopy width of 8.3 m. For double lane traffic, industry best-practice is to design a haul road of at least 3.5 times the width of the largest vehicle, in this case at least 35 m. Ramp gradients are designed at 10%.

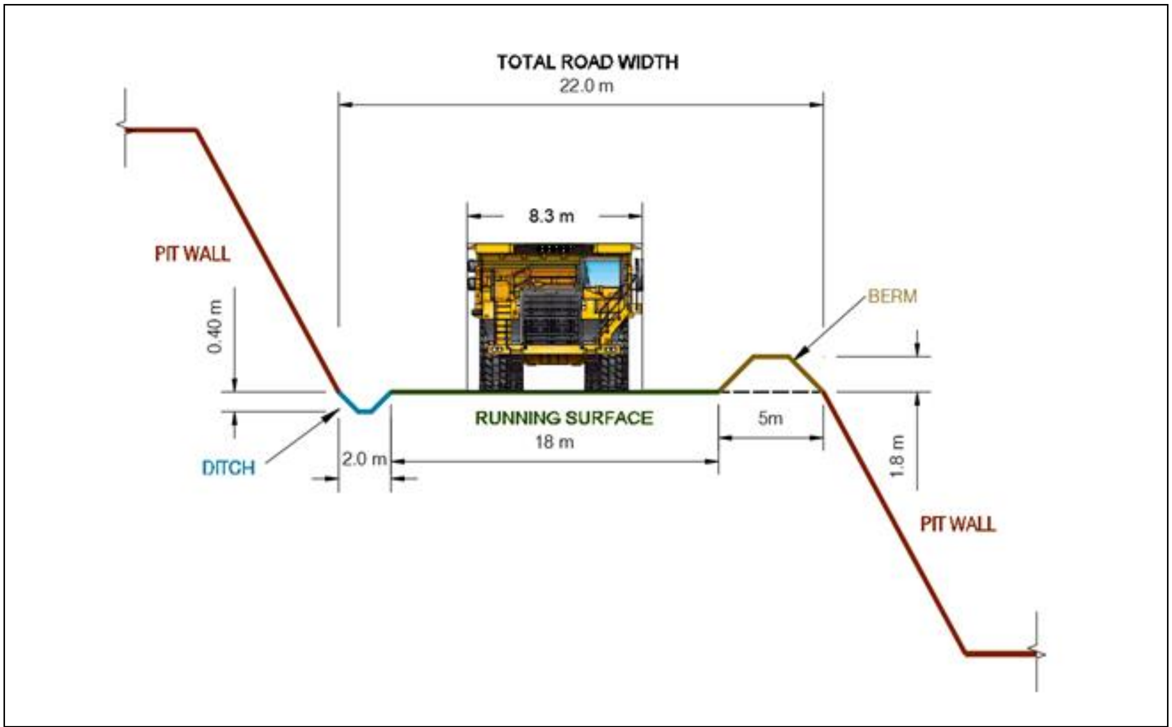
A shoulder barrier or safety berm on the outside edge will be constructed of crushed rock to a height equal to the rolling radius of the largest tire using the ramp. The rolling radius of the truck tire is 1.8 m. These shoulder barriers are required wherever a drop-off greater than 3 m exists and will be designed at 1.1H:1V. A ditch planned on the high wall will capture run-off from the pit wall surface and assure proper drainage of the running surface. The shoulder berm will have a 1 m flat top to allow for the placement of dewatering or other infrastructure. The ditch will be 2 m wide. To facilitate drainage of the roadway, a 2% cross-slope on the ramp is planned.

The double lane ramp width is 35 m wide (Figure 15-3) and the single lane ramp is 25 m wide (Figure 15-4). Single lane ramps are introduced in the pit bottom when the benches start narrowing and when the mining rates will be significantly reduced.



	Double Lane Ramp Profile Design	Author: BBA Date: May 2019

Figure 15-3: Double lane ramp profile design



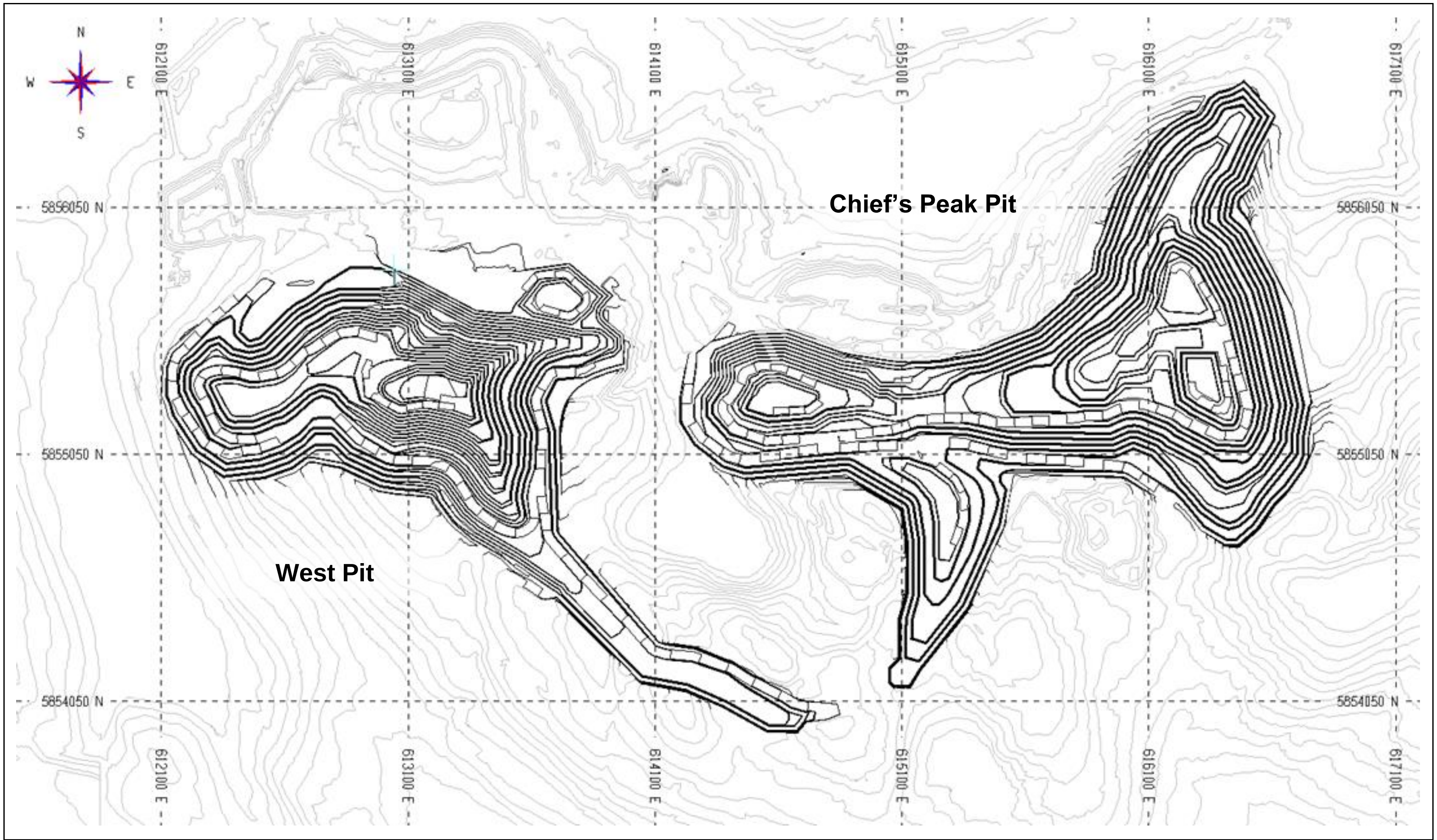
	Single Lane Ramp Profile Design	Author: BBA Date: May 2019

Figure 15-4: Single lane ramp profile design

15.4.7 Open Pit Mine Design Results

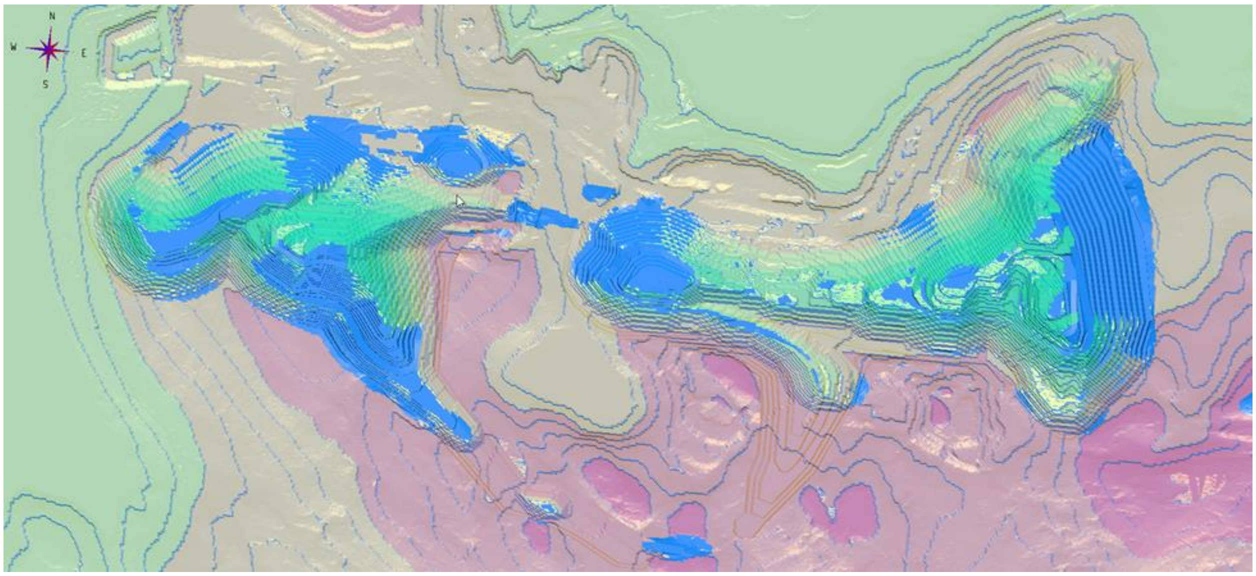
The final pit design is presented in Figure 15-5. The final pit includes a Chief's Peak Pit and a West Pit. The final pit is 4,600 m east-west and roughly 2,700 m north-south and reaches a depth of 320-360 m. The final pit was designed with the current pit position taken into consideration with respect to ramp entrances and road networks.

The West Pit final design has three exits, two to the north and one to the southeast to provide access to the pushbacks and shorten distances to the crusher and waste dumps. The Chief's Peak Pit final design has two pit exits, one in each of the southwest and southeast corner. This is primarily to maximize ore recovery and hauling distance to the new planned waste storage facility to the south. Each of the pit design generally follows the guiding economic pit shell as presented in Figure 15-6. The minor exception to this rule is the ramp exits to the south. The ramps are designed in Inferred Resources and provide a shorter haul path to the new waste storage facility. It is expected in the future that these resources will be converted to reserves with minimal additional drilling. However, these Inferred Resources were not used in the mineral reserves estimate.



	Final Pit Design	**Author: BBA** **Date: May 2019**

Figure 15-5: Final pit design



	Final Pit Design vs. RF 0.99 Shell	**Author: BBA** **Date: May 2019**

Figure 15-6: Final pit design vs. RF 0.99 Shell

The pit design used in this study was completed with the Phase 1 version of the block model. Near the end of the study, a new block model was released re-categorizing some Measured and Indicated material as well as transferring some Indicated material into the Inferred category. Further to these changes, the initial pit optimization was completed prior to the final results from the metallurgical campaign. The final pit optimization presented here was evaluated with the latest block model and recovery curves. It can be noted that further optimization of the ultimate pit design will be necessary in the detailed engineering phase of the Project. With the addition of drillholes on the south extension of the Chief's Peak Pit, some Inferred material can be reclassified as Indicated Resources and used as planned in the ultimate pit design.

The impact of the new model on ultimate pit was approximately 9 Mt or 1.1% and, as such, a redesign was not considered necessary for this study. Additionally, the impacted material is not mined within the first 5 years of the mine plan allowing for ample opportunity to upgrade the resource classifications to allow for their inclusion in the Mineral Reserves.

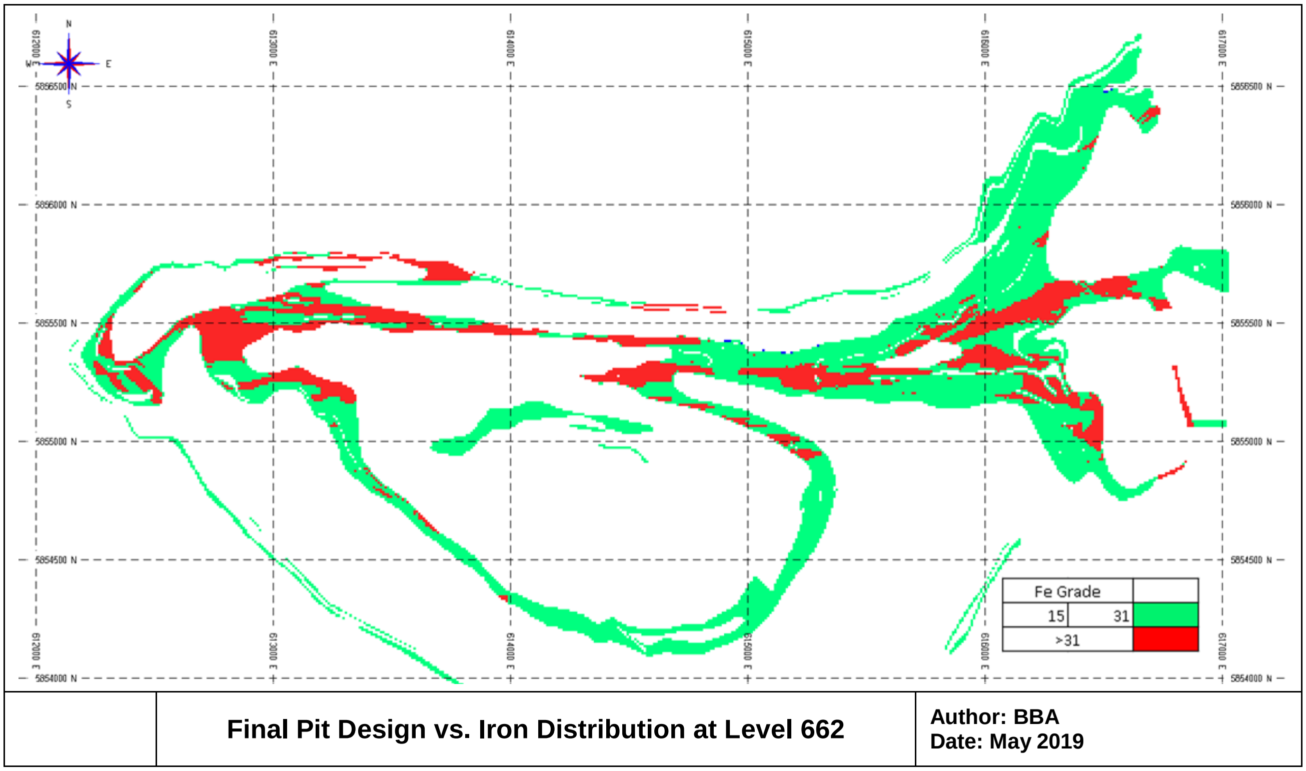


Figure 15-7: Final pit design vs. iron distribution (above 15% Fe) at level 662

15.5 Mineral Reserve Statement

The mineral resources for the Bloom Lake project were classified in accordance with CIM Standards.

15.5.1 Mineral Reserve Definition

The "CIM Definition Standards for Mineral Resources and Reserves" published by the Canadian Institute of Mining, Metallurgy and Petroleum for the resource classification clarifies the following:

Probable Mineral Reserve:

A Probable Mineral Reserve is the economically mineable part of an Indicated, and in some circumstances, a Measured Mineral Resource. The confidence in the Modifying Factors applying to a Probable Mineral Reserve is lower than that applying to a Proven Mineral Reserve.

Proven Mineral Reserve:

A Proven Mineral Reserve is the economically mineable part of a Measured Mineral Resource. A Proven Mineral Reserve implies a high degree of confidence in the Modifying Factors.

15.5.2 Mineral Reserve Estimate for the Bloom Lake Project

The mineral reserve and stripping estimates are based on the final pit design presented in the previous section. The Proven and Probable Mineral Reserves are inclusive of mining dilution and ore loss. The total ore tonnage before dilution and ore loss is estimated at 804 Mt at an average grade of 29.3% Fe. The dilution along gneiss and quartz contacts results in 9.21 Mt of dilution or 1.1%. Ore loss occurs along amphibolite and overburden ore contacts. This procedure aligns with current operating standards at the mine. Overall ore loss is 6.41 Mt at an iron grade of 31.0%. Table 15-8 presents a Resource to Reserve reconciliation.

Table 15-8: Resource to reserve reconciliation

Resource to reserve reconciliation	Tonnage (Mt)	Grade (Fe %)
Mineralized material: before dilution	804.1	29.3
Add: mining dilution	9.4	0.0
Remove: mining ore loss	6.5	31.0
Proven & Probable Mineral Reserve	**807.0**	**29.0**

The Proven and Probable Mineral Reserves total 807 Mt at an average grade of 29.0% Fe. The total tonnage to be mined is estimated at 1,513 Mt for an average strip ratio of 0.88, which includes overburden.

Table 15-9: Final pit mineral reserves and quantities

Classification	Diluted ore tonnage (dry Mt)	Fe %	CaO %	Sat %	MgO %	Al_2O_3 %
Proven	346.0	29.9	1.5	4.7	1.4	0.3
Probable	461.0	28.2	2.6	7.9	2.5	0.6
Total Proven & Probable	**807.0**	**29.0**	**2.2**	**6.5**	**2.0**	**0.5**

Notes on Mineral Reserves:

1. The mineral reserves were estimated using the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Standards for Mineral Resources and Reserves, Definitions and Guidelines prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council May 10, 2014.
2. The independent and qualified person (QP) for the mineral reserves estimate, as defined by NI 43-101, is Isabelle Leblanc, P. Eng., from BBA. The effective date of the estimate is May 17, 2019.
3. Inside the final open pit design, all Measured Resources and associated dilution (waste material at 0% Fe) have been converted into Proven Mineral Reserves. Inside the final open pit design, all Indicated Resources and associated dilution (waste material at 0% Fe) have been converted into Probable Mineral Reserves.
4. The reference point of the mineral reserve is the primary crusher feed.
5. Mineral reserves are based on the December 31, 2020 mining surface.
6. Mineral reserves are estimated at a cut-off grade of 15% Fe.
7. Mineral reserves are estimated using a long-term iron reference price (Platt's 62%) of USD60.88/dmt and an exchange rate of 1.24 CAD/USD. An iron concentrate price adjustment of USD12.70/dmt was added.
8. Bulk density of ore is variable but averages 3.40 t/m^3.
9. The average strip ratio is 0.88:1.
10. The mining dilution was calculated using a 1.0 m contact skin.
11. The average mining dilution is 1.18% at a grade of 0% Fe. Dilution was applied block by block and shows a wide range of local variability.
12. The average ore loss is 0.81% at a grade of 31% Fe. Ore loss was applied block by block and shows a wide range of local variability.
13. The author is not aware of any known environmental, permitting, legal, title-related, taxation, socio-political or marketing issues, or any other relevant issues not reported in the Technical Report, that could materially affect the Mineral Reserve Estimate.
14. Numbers may not add due to rounding.

16. MINING METHODS

16.1 Introduction

The operation consists of a conventional surface mining method using an owner mining approach with electric hydraulic shovels, wheel loaders and mine trucks. The study consists of resizing the open pit based on parameters outlined in this chapter and producing a 20-year life of mine (LOM) plan to feed two plants at a nominal rate of 41.9 Mtpy.

16.2 Mine Designs

16.2.1 Open Pit Phases

Mining of the Bloom Lake project is planned with six phases with a starter phase, intermediary phase and a final pushback in both the Chief's Peak and West pits. In order to clarify the naming convention for use by the operations, the phases were designated PH1A, PH1B and PH2. Phases 1A and 1B correspond roughly to the phases that would have been mined during the Phase 1 project. The Phase 2 designs are the final push backs that correspond with mining activities that will only be undertaken for the purposes of the Phase 2 project. Characteristics of each mining phase are summarized in Table 16-1 and are presented in Figure 16-1 and Figure 16-2.

The Project has two main mining areas, the Chief's Peak and West pits. The Chief's Peak pit is 2,500 m long by 1,850 m wide at the east end. The starting phase of Chief's Peak pit is located on the western end. The West pit is 1,890 m long by 950 m wide; it has a narrow southern limb that is 1,300 m long by 200 m wide.

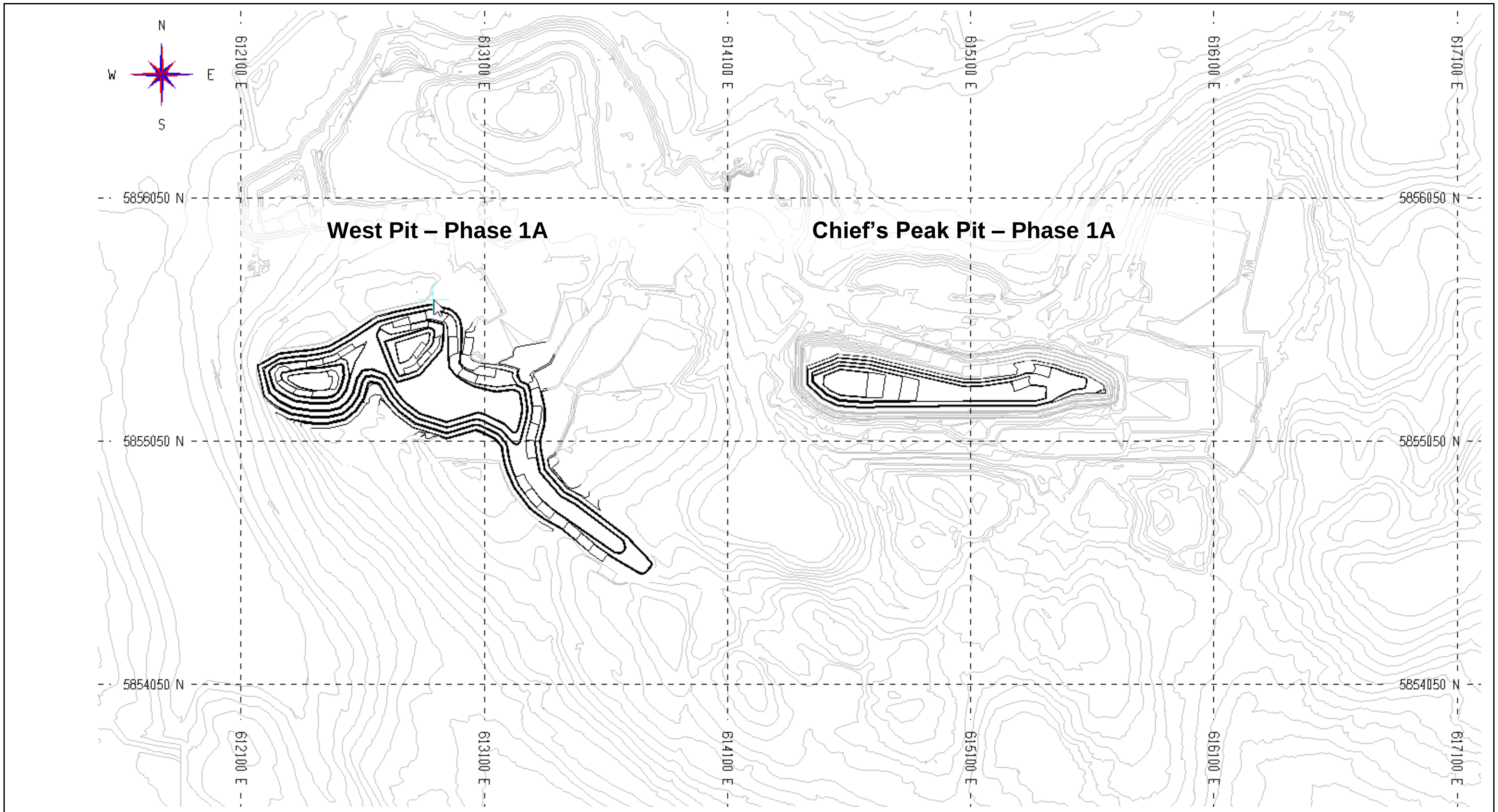
The Chief's Peak pit has one ramp exit to the north and one ramp exit to the south. Until the first two phases of the Chief's Peak pit are complete, there will be an additional ramp exit to the north, close to Crusher 1. The southern ramp will also access to the new waste storage facility as well as alternate access for preliminary stripping activities. The West pit has one ramp exit on the northeast wall, one on the east wall, and one in the southern limb.

The final pit contains 807 Mt of ore at an average grade of 29.0% Fe with an average strip ratio of 0.88:1. This mineral reserve is sufficient for a 20-year mine life. The Chief's Peak pit contains 67% of the ore and has higher levels of contaminants than the West pit. The strip ratio of the Chief's Peak pit (0.68:1) as a whole is lower than the West pit (1.28:1).

Table 16-1: Pit phase design summary

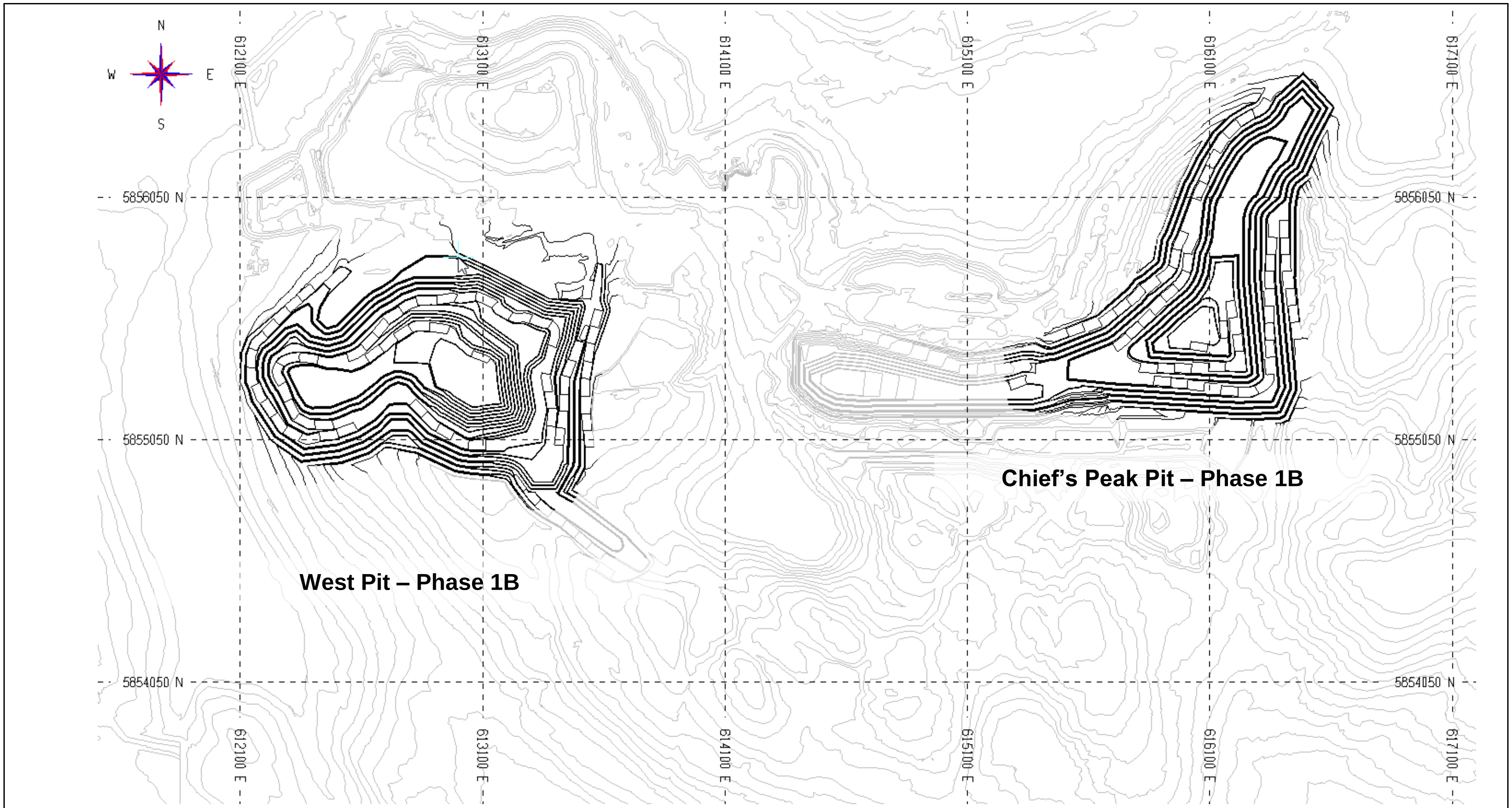
		Chief's Peak Pit			Total	West Pit			Total	Grand total
		Phase 1A	Phase 1B	Phase 2		Phase 1A	Phase 1B	Phase 2		
Total tonnage	**Mt**	**16**	**341**	**556**	**913**	**86**	**310**	**204**	**600**	**1,513**
Overburden	Mt	0	3	12	**15**	1	5	8	**14**	**29**
Waste(1)	Mt	4	92	273	**369**	24	187	126	**337**	**706**
Strip ratio	w:o	0.32	0.37	0.97	**0.68**	0.39	1.51	1.61	**1.28**	**0.88**
Ore tonnage	Mt	12	249	282	**544**	62	123	78	**263**	**807**
Fe%	%	29.5	27.7	28.0	**28.0**	30.5	31.6	30.5	**31.0**	**29.0**
CaO%	%	0.88	3.39	3.09	**3.18**	0.07	0.08	0.06	**0.07**	**2.16**
SAT%	%	3.01	9.49	9.19	**9.19**	0.87	0.94	1.17	**0.99**	**6.51**
MgO%	%	1.24	3.10	2.92	**2.96**	0.08	0.09	0.07	**0.08**	**2.02**

Note: (1) Includes overburden



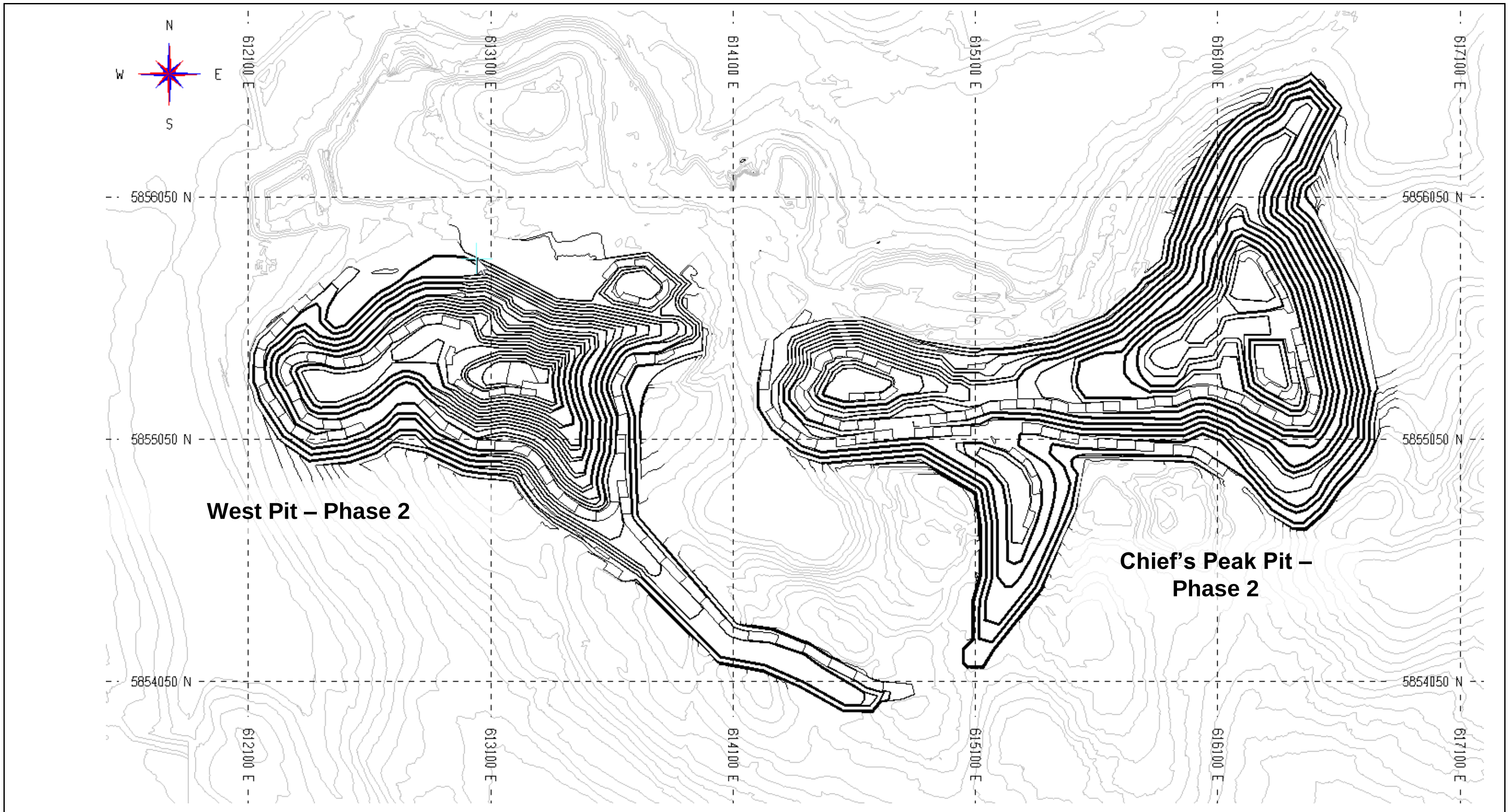
	First Phase Design	**Author: BBA** **Date: May 2019**

Figure 16-1: First phase design



	Second Phase Design	Author: BBA Date: May 2019

Figure 16-2: Second phase design



	Third Phase Design	**Author: BBA** **Date: May 2019**

Figure 16-3: Final pit design

The pit design slope profiles adhere to recommendations generated by Golder Associates Inc. (Golder) stemming from the performance and excavation of the Chief's Peak Phase 1A (Pignac) since the restart of operations. The recommendations are summarized in Table 16-2. The inter-ramp angles (IRA) vary from 42 to 50 degrees depending on the regional RQD and bench height.

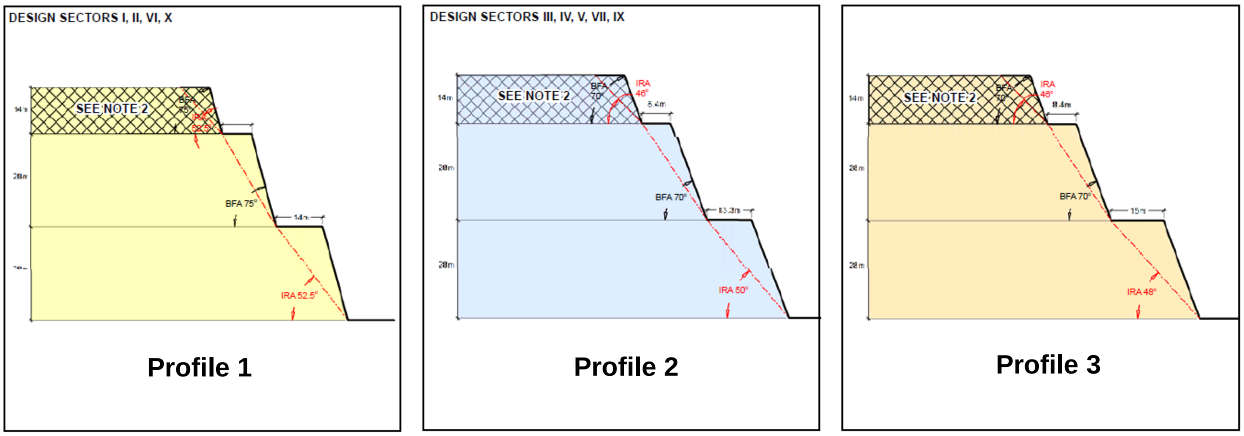
The pit slope profile has a geotechnical catch bench at elevation 585 m. This geotechnical catch bench mitigates risks from overbank hazards on the pit wall. Overbank hazards result from muck spilling down the slope of the previous pit phase filling the catch benches. The design allows the catch bench to be accessed to allow debris removal.

Table 16-2: Pit phase design criteria

<table>
<tr><th>Pit</th><th>2014 Design sector</th><th>Bench configuration (elevation (m) and height (m))</th><th>Bench face angle (°)</th><th>Berm width (m)</th><th>Inter-ramp angle (°)</th></tr>
<tr><td rowspan="4">West</td><td>II (North Wall)</td><td>Single Bench (718-410m) 14m</td><td>70</td><td>9</td><td>46</td></tr>
<tr><td>X (East)</td><td>Double Bench (769-410m) 28m</td><td>70</td><td>13.3</td><td>50</td></tr>
<tr><td rowspan="2">X (South)</td><td>Double Bench (770-592m) 28m</td><td>70</td><td>13.3</td><td>50</td></tr>
<tr><td>Single Bench (592-410m) 28m</td><td>70</td><td>9</td><td>46</td></tr>
<tr><td rowspan="2">West – South Extension</td><td>Wall Avg. Dip Direction 005° (355° - 015°)</td><td>Double Bench 28m</td><td>70</td><td>13.3</td><td>50</td></tr>
<tr><td>Wall Avg. Dip Direction 205° (180° - 225°)</td><td>Single Bench 14m</td><td>70</td><td>9</td><td>46</td></tr>
<tr><td>Chief's Peak</td><td>III (North Wall)</td><td>Single Bench (726-536m) 14m</td><td>70</td><td>9</td><td>42</td></tr>
<tr><td rowspan="2">Chief's Peak – South Extension</td><td>Wall Avg. Dip Direction 020° (010° - 030°)</td><td>Double Bench 28m</td><td>70</td><td>13.3</td><td>50</td></tr>
<tr><td>Wall Avg. Dip Direction 310° (300° - 320°)</td><td>Double Bench 28m</td><td>70 (75)[(1)]</td><td>13.3 (14)[(1)]</td><td>50 (52.5)[(1)]</td></tr>
</table>

[(1)] Upon the excavation and mapping of the first bench, there would be the opportunity to steepen the IRA if there is no major kinematic control.

Figure 16-4 is an excerpt from the 2014 geotechnical investigation completed by Golder. This figure describes the bench profiles for the double bench configurations considered in the Report, with a 28 m bench height and 13.3 m to 15 m catch berm width.



Geotechnical Bench Slope Design Recommendations	Source: Golder

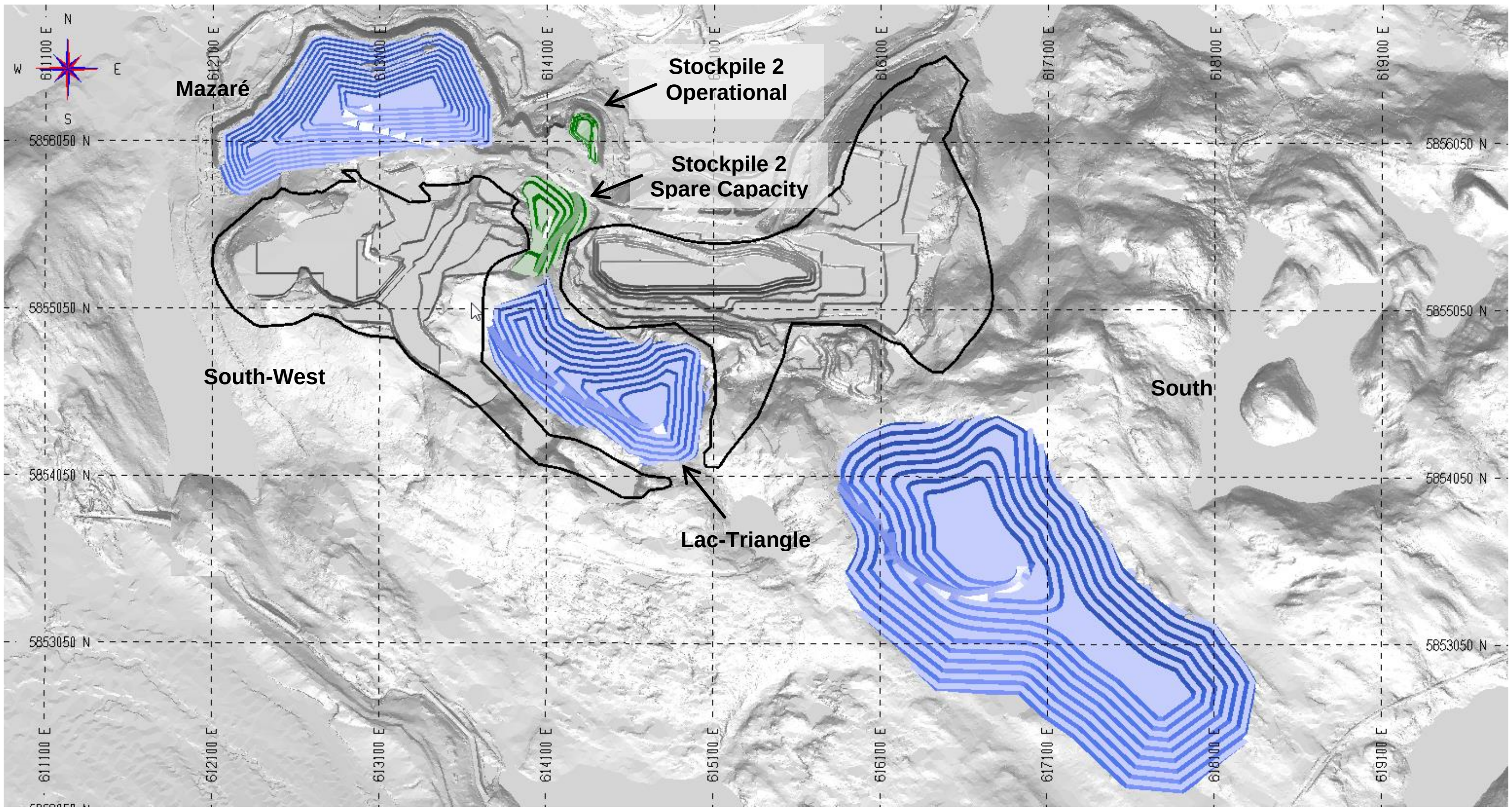
Figure 16-4: Geotechnical bench slope design recommendations

16.2.2 Overburden and Waste Rock Storage

A total of 706 Mt of waste material is mined throughout the life of mine. Available capacity from the start of the Project is approximately 156 Mt and is sufficient for the first 5 years of the mine life. There are three dump locations planned in the first 5 years, one to the north and two to the south. The north dump is an extension of the existing dump and is 90 m high. The waste storage facility located in Lac-Triangle has 70 Mt of capacity at 140 m high. The southwest contingency storage area will be required to satisfy the first 5 years of waste. It has a planned capacity of 30 Mt and a height of 100 m.

To finish the mine life, an additional waste storage area has been planned to the south of the Chief's Peak pit. This site was chosen from a set of three options as a balance of economic, environmental, and social impacts. The area gently slopes to the south and abuts a hill. As such, the ultimate slope height varies and reaches a maximum of 180 m while holding a total of 538 Mt.

Two small stockpiles are maintained at each crusher (maximum of 500 kt) to handle unplanned work stoppages and to provide continuity of feed during white-out conditions.



	Waste Dump Designs	**Author: BBA** **Date: May 2019**

Figure 16-5: Rock storage locations outside the final pit limit

Overburden will be co-located at each of the storage facilities where space is available. Where space isn't available overburden will be stockpiled at the former overburden stockpile located on the south of Chief's Peak pit and be re-handled at the end of the mine life for reclamation purposes.

The dump storage locations were offset 20 m from the pit limit for safety reasons.

During operations an annual allowance for material requirements for tailings management facility (TMF) construction will be placed on the containment dike. It has been assumed that these construction requirements will grow with time. All waste dump capacities are shown in Table 16-3. A density of 2.0 t\m^3 was used for waste material placed in the storage facilities; which is considered to be conservative.

Table 16-3: Waste storage capacities

Waste storage facility	Capacity (Mt)	Capacity (Mm^3)	Surface area (ha)	% Filled
South West	31.3	15.6	48.3	100%
South	576.5	288.2	322.5	94%
Lac-Triangle	69.8	34.9	82.6	100%
Mazaré	55.7	27.8	99.4	100%
Overburden	8.2	4.1	25.5	0%
Total	**741.5**	**370.6**	**481.1**	**94%**

Table 16-4: Waste pile design criteria

Waste storage facility	Avg. catch bench width (m)	Pile face angle (deg)	Overall slope angle (H:V)	Approximate height (m)
Mazaré	15	35	3:1	90
South	36	36	3:1	180
Overburden pile	15	35	4:1	60
South West	15	35	3:1	100
Lac-Triangle	25	36	3:1	140

16.2.3 Ore Stockpiles

Ore stockpiles are located close to Crusher 1 and Crusher 2. The two stockpile locations have an approximate 1.0 Mt total capacity. Ore is stockpiled primarily to provide buffers to over or under production of ore from the pit and to ensure the appropriate blend can be maintained. Throughout the mine life, approximately 1.0 Mt is preserved in stockpile which represents 8 days of feed.

The stockpile capacity mentioned above are for a single lift as this is how the stockpiles are currently operated at the site. An additional lift can be placed on each stockpile if the need should arise to a maximum height of 28 m. Should this route be chosen, a dozer will be required to push the material down to the loading equipment. The combined stockpile capacity is estimated at 1.4 Mt. The design criteria are presented in Table 16-5.

An additional 6 Mt capacity for peak stockpile requirements during the middle of the mine life can be found south of Crusher 2.

Table 16-5: Stockpile design criteria

Ore stockpile characteristics	Catch bench width (m)	Pile face angle (deg)	Overall slope angle (H:V)	Approximate height (m)	Max capacity (Mt)
Stockpile at max. capacity	0	36	1.13:1	28	1.4
South stockpile	24	36	3:1	55	6

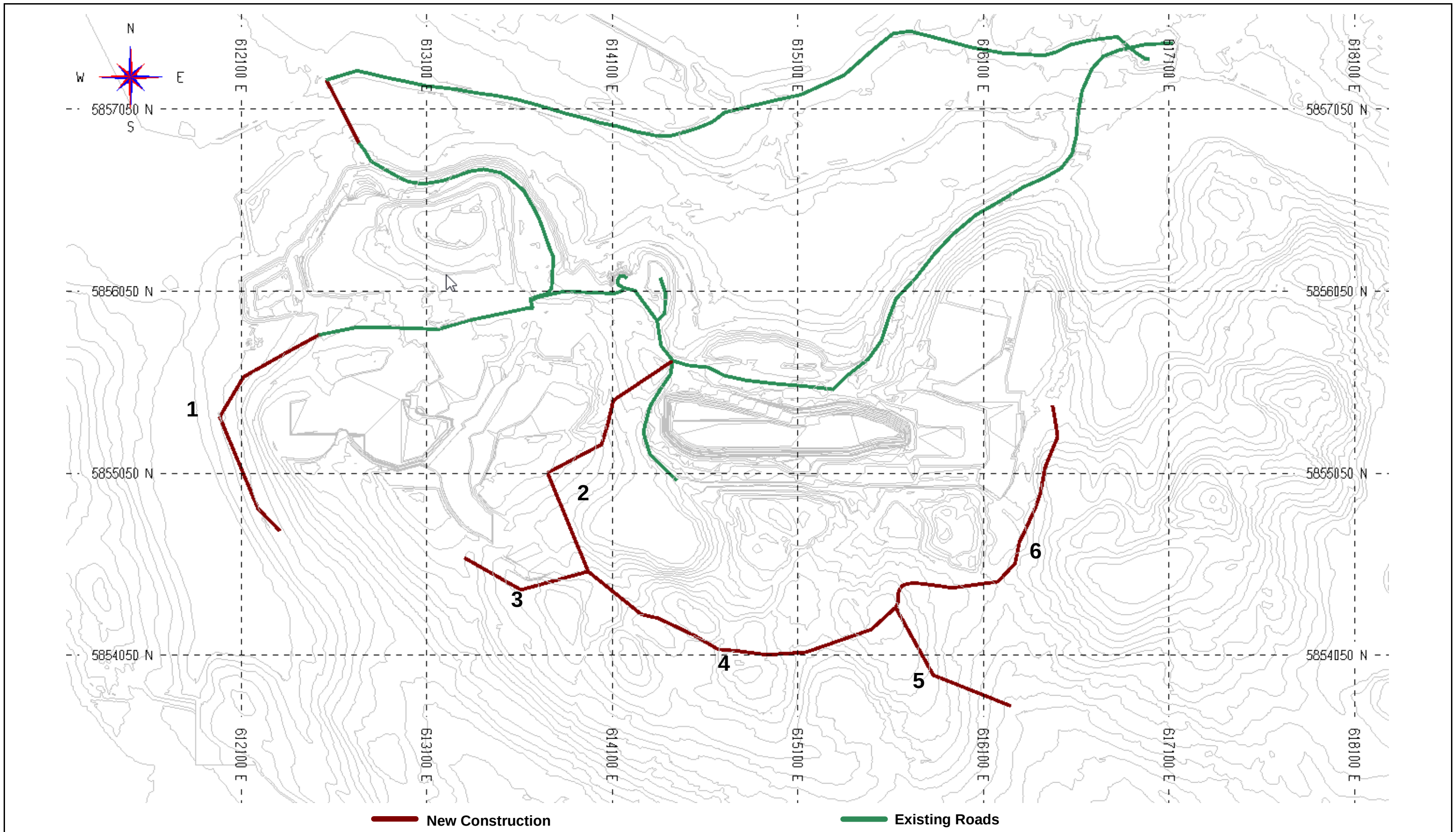
16.2.4 Mine Haul Roads

No new roads are required to start the Project. Access to current infrastructure will be in place for the start of mining. In Year 2, haul road access to the south west waste storage facility (WSF) will be required. An opportunity exists to reinforce the bridge access to the TMF to reduce trucking requirements. To maximise the potential savings, the bridge reinforcement should be completed by Year 4. In Year 5, two additional haul roads will be required to access the South WSF.

Table 16-6: Haul road segments

Haul road Segment number	Length (m)
Mine Road 1	1,400
Mine Road 2	1,544
Mine Road 3	726
Mine Road 4	1,860
Mine Road 5	876
Mine Road 6	1,699
Total	**8,494 m (8.5 km)**

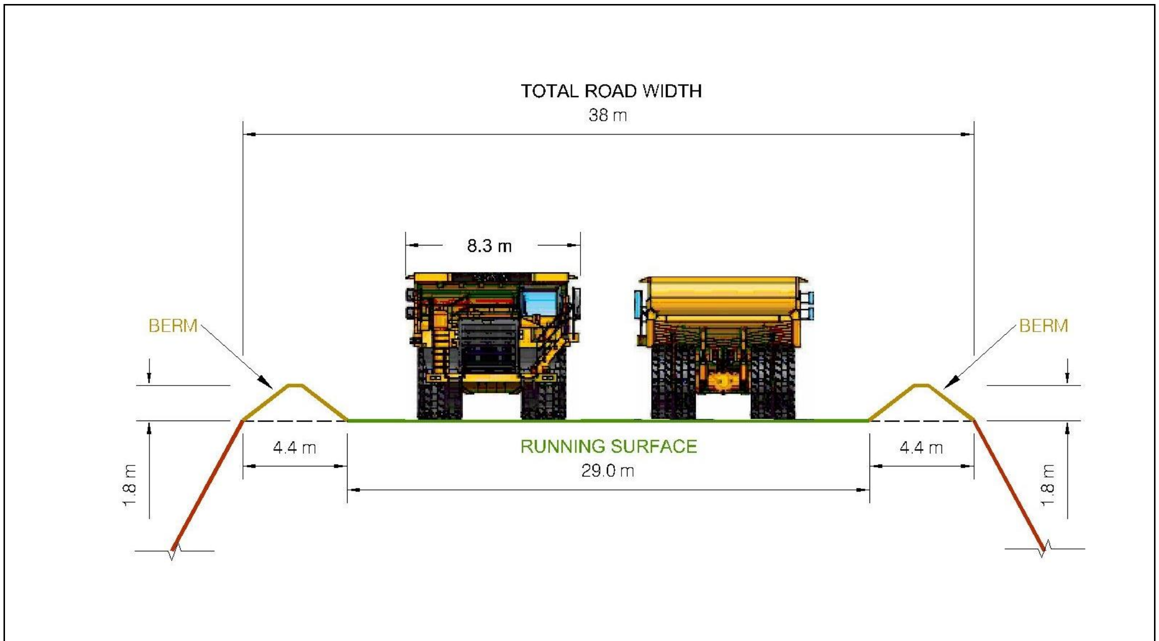
Figure 16-6 below shows the state of the haul road infrastructure at the beginning of the Project. Roads highlighted in green are existing roads used to haul material for Phase 1 of the Project. Roads highlighted in red are roads that will need construction or upgrading to allow the passage of 240-tonne haul trucks. There is approximately 8.5 km of road to be constructed as per Table 16-6, which will be primarily constructed by the pit operations teams. These roads will provide a short haul opportunity for pit operations and as such have not been modelled separately.



	Mine Haulage Roads	**Source: BBA Inc.** **Date: May 2019**

Figure 16-6: Mine haulage roads

Surface roads for mining material movement will be constructed with dimensions described in Figure 16-7. The fill material will be run-of-mine waste rock; a base running layer will be 600 mm thick of 0.25 to 4 inches crushed rock; finally a top-running course will be constructed with 200 mm of approximately minus 0.25 to 1.5 inches crushed rock. This road construction will maximize truck travel speeds on the longer hauls out to the south waste storage facility.



	Out of Pit Haul Road Profile	**Source: BBA Inc.** **Date: May 2019**

Figure 16-7: Out of pit haul road profile

16.3 Production Schedules

16.3.1 Production Schedule Optimization

The life of mine schedule was developed with the Hexagon Mine Plan suite of software. Specifically Minesight Schedule Optimizer (MSSO) was used to optimize the mine plan with a series of production constraints.

The optimization was based on the pit phase designs and related mineral reserves. MSSO integrates load-haul cycle time models which estimates a cycle time from every cut within the reserve to every available destination and seeks to minimize the number of trucks hours required to obtain the required constraints. The constraints are summarized in Table 16-7.

Table 16-7: MSSO Constraints

LOM Targets and Constraints	Unit	LOM Target
Mining Constraints		
Total tonnage mined	Mtpy	100
Number of open phases	year	3
Open benches per phase	unit	3
Maximum Phase 1A tonnage mined	Mtpy	30
Maximum Phase 1B/2 tonnage mined	Mtpy	60
Processing Limits & Recoveries		
Mill feed tonnage	Mtpy	41.9
Annual crusher 1 feed	Mtpy	11.2
Preferred Contaminants Limits in Feed		
Ore Feed – MgO	%	≤ 3.0
Ore Feed – CaO	%	≤ 3.0

16.3.2 Mine Production Schedule

The mine production schedule is completed on a monthly basis during the first year of production, on a quarterly basis for the second year, and annually thereafter. Phase 2 mine plan does not require any pre-stripping other than the stripping already forecasted in the current mine plan. Equipment will need to be commissioned prior to the mill start-up, and some additional drilled inventory should be built up prior to the start of the Phase 2 concentrator. The mine plan for the first year assumes a ramp-up of the concentrator and the attendant increases in total mining rate.

The objectives of the LOM plan are to maximize discounted operating cash flow of the Project subject to various constraints:

- Limit the mining rate to approximately 100 Mtpy;
- The ratio of the Chief's Peak pit to West of less than 4 to 1;
- Ensure sufficient feed to the concentrator to maximise production;
- Limit the vertical drop down rate to 6 benches per phase per year;
- Limit the total mined tonnage from any particular phase;
- Minimize the number of truck hours required;
- Place contaminant level constraints on the mill feed;
- Minimize stockpiling.

The initial ex-pit mining rate is 57 Mtpy and gradually increases until it reaches a mining rate between 91 Mtpy and 99 Mtpy starting in Year 4. The mining rate declines, starting in Year 15, as sufficient ore for the mill is accessible. Stockpiling occurs during the mine life and mainly serves to control the level of contaminants in the mill feed. Stockpiling is primarily limited to 1.1 Mtpy throughout the LOM. This stockpiling level is required to smooth out ore availability in the pit. This limit is relaxed for year prior to the peak material movement to help decrease the peak material movement requirements. The annual mine production and stockpile inventory are presented in Figure 16-8 and Figure 16-9.

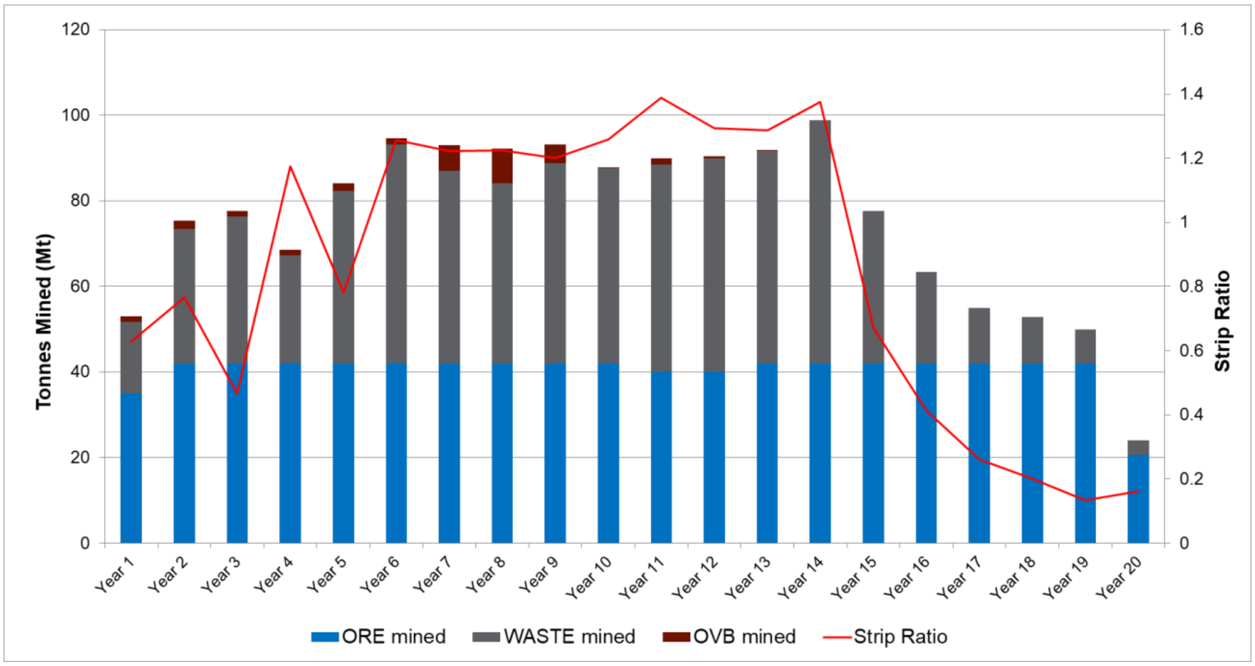


Figure 16-8: Mine production

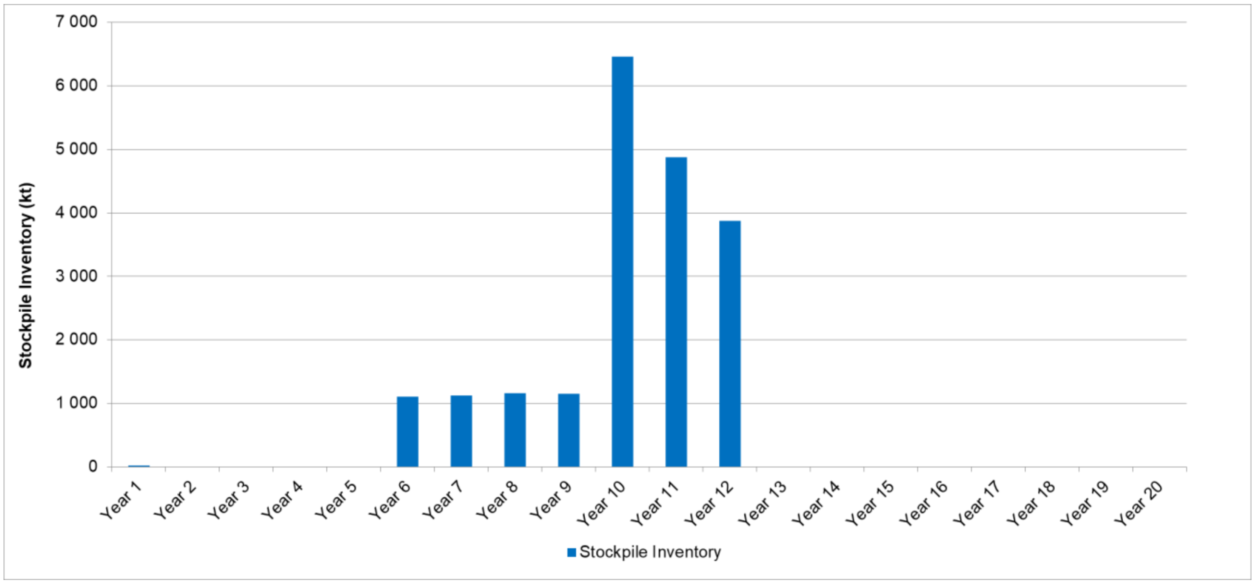


Figure 16-9: Stockpile inventory

Table 16-8 presents the material movement the from mine plan on an annual basis including mill feed contaminants. The first column presents the total ore production from the mine, which will be sent to Crusher 1 (27%) and Crusher 2 (73%). The second section shows the feed tonnage and concentrate production from each phase, given their respective recoveries discussed in Chapter 13. The last sections shows the associated waste tonnage and stockpile re-handling necessary to support the mill feed rates envisaged for the Phase 2 expansion.

Table 16-8: Mine production schedule detail by period

Year	Ore					Phase 1		Phase 2		Total	Stockpile To Mill					Pit to Stockpile					Waste	Grand Total
	Tonnes	Fe	CaO	SAT	MgO	Tonnes	Concentrate	Tonnes	Concentrate	Concentrate	Tonnes	Fe	CaO	SAT	MgO	Tonnes	Fe	CaO	SAT	MgO	Tonnes	Tonnes
1	35,030	29.6	0.8	3.3	0.9	20,150	7,460	14,880	5,590	13,050	90	32.7	0.1	2.1	0.1	110	32.0	0.1	2.7	0.1	17,950	**53,090**
2	41,960	28.5	2.0	7.4	1.9	20,370	7,180	21,590	7,640	14,820	60	27.1	1.9	10.7	2.4	40	26.0	2.9	13.8	3.5	33,490	**75,490**
3	41,960	29.1	1.9	7.5	1.8	20,370	7,380	21,590	7,850	15,230	0					0					35,730	**77,690**
4	41,960	29.6	2.0	8.4	2.0	20,370	7,550	21,590	8,030	15,580	0					0					26,540	**68,500**
5	41,960	27.8	2.5	8.0	2.4	20,370	6,900	21,590	7,340	14,240	0					0					42,140	**84,100**
6	41,960	27.5	3.0	8.4	2.7	20,370	6,820	21,590	7,250	14,070	0					1,110	29.4	3.2	11.9	2.6	52,760	**95,830**
7	41,960	29.0	2.2	5.6	2.0	20,370	7,340	21,590	7,800	15,140	1,110	29.4	3.2	11.9	2.6	1,120	28.6	0.6	3.0	0.6	51,060	**94,140**
8	41,960	28.8	2.6	5.6	2.3	19,940	7,130	21,140	7,890	15,020	1,120	28.6	0.6	3.0	0.6	1,160	29.9	2.0	4.9	1.8	50,290	**93,410**
9	41,960	28.9	2.7	4.8	2.3	20,370	7,320	21,590	7,780	15,100	1,160	29.9	2.0	4.9	1.8	1,150	28.3	1.1	3.8	1.7	51,160	**94,270**
10	41,960	29.7	1.6	6.4	1.6	20,370	7,600	21,590	8,090	15,690	1,150	28.3	1.1	3.8	1.7	6,460	29.9	1.5	12.0	1.7	45,970	**94,390**
11	40,000	31.1	0.4	2.9	0.5	19,420	7,940	20,580	8,000	15,940	1,590	28.4	1.8	6.0	1.6	0					49,950	**89,950**
12	40,000	30.3	0.9	5.2	1.1	19,420	7,650	20,580	7,690	15,340	1,000	31.1	2.5	14.8	2.5	0					50,400	**90,400**
13	41,960	29.0	1.6	5.9	1.6	20,370	7,360	21,590	7,830	15,190	3,870	30.3	1.1	13.6	1.5	0					49,870	**91,830**
14	41,960	29.2	2.4	8.4	2.4	20,370	7,410	21,590	7,870	15,280	0					0					56,960	**98,920**
15	41,960	28.0	3.0	8.2	2.7	20,370	6,990	21,590	7,420	14,410	0					0					35,690	**77,650**
16	41,960	28.1	3.0	5.3	2.6	20,370	7,010	21,590	7,450	14,460	0					0					21,490	**63,450**
17	41,960	28.8	2.3	6.4	2.0	20,370	7,280	21,590	7,730	15,010	0					0					12,970	**54,930**
18	41,960	29.3	2.3	6.4	2.2	20,370	7,450	21,590	7,920	15,370	0					0					10,860	**52,820**
19	41,960	29.2	2.6	6.1	2.3	20,370	7,420	21,590	7,880	15,300	0					0					7,990	**49,950**
20	20,570	26.7	4.5	10.1	3.9	10,410	3,330	11,040	3,250	6,580	0					0					3,470	**24,040**
Grand Total	**806,960**	**29.0**	**2.2**	**6.5**	**2.0**	**394,890**	**142,520**	**412,070**	**148,300**	**290,820**	**11,150**	**29.6**	**1.6**	**9.3**	**1.6**	**11,150**	**29.6**	**1.6**	**9.3**	**1.6**	**706,740**	**1,524,850**

Table 16-9: Mine production – West PH1A – Total tonnage mined by bench (Mt)

West - PH1A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
578	-	-	-	0.4	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
592	-	-	-	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
606	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
620	-	-	-	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
634	-	-	5.0	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
648	-	-	9.0	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
662	-	4.9	6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
676	1.2	12.0	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
690	10.1	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
704	6.9	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
718	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
732	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
746	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
760	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
774	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**30.6**	**20.0**	**22.0**	**10.5**	**2.8**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Table 16-10: Mine production – Chief's Peak PH1A – Total tonnage mined by bench (Mt)

Chief's Peak - PH1A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
578	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
592	0.9	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
606	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
620	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
634	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
648	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
662	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**13.9**	**2.4**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Table 16-11: Mine production – West PH1B - Total tonnage mined by bench (Mt)

West - PH1B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
480	-	-	-	-	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-	0.2
494	-	-	-	-	-	-	-	-	-	-	-	-	4.2	-	-	-	-	-	-	-
508	-	-	-	-	-	-	-	-	-	-	-	0.6	7.5	-	-	-	-	-	-	-
522	-	-	-	-	-	-	-	-	-	-	-	6.8	2.8	-	-	-	-	-	-	-
536	-	-	-	-	-	-	-	-	-	-	-	11.8	-	-	-	-	-	-	-	-
550	-	-	-	-	-	-	-	-	-	-	7.1	6.6	-	-	-	-	-	-	-	-
564	-	-	-	-	-	-	-	-	-	-	16.1	0.0	-	-	-	-	-	-	-	-
578	-	-	-	-	-	-	-	-	-	3.8	12.9	-	-	-	-	-	-	-	-	-
592	-	-	-	-	-	-	-	-	7.1	12.7	-	-	0.1	-	-	-	-	-	-	0.0
606	-	-	-	-	-	-	-	7.6	10.0	3.6	-	-	0.1	-	-	-	-	-	-	-
620	-	-	-	-	-	-	7.5	11.0	4.1	0.2	-	-	-	-	-	-	-	-	-	-
634	-	-	-	-	-	-	19.6	5.0	0.1	-	-	-	-	-	-	-	-	-	-	-
648	-	-	-	-	-	1.9	20.0	0.2	-	-	-	-	-	-	-	-	-	-	-	-
662	-	-	-	-	-	20.6	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-
676	-	-	-	-	6.9	17.9	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-
690	-	-	-	-	14.2	9.5	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-
704	-	-	-	5.2	11.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
718	-	1.2	1.0	5.0	4.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
732	-	0.7	2.8	4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
746	-	-	5.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
760	-	-	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
774	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**1.9**	**12.7**	**15.0**	**37.5**	**50.0**	**50.2**	**23.7**	**21.3**	**20.3**	**36.1**	**25.8**	**17.0**	**-**	**-**	**-**	**-**	**-**	**-**	**0.2**

Table 16-12: Mine production – Chief's Peak PH1B - Total tonnage mined by bench (Mt)

Chief's Peak - PH1B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
494	-	-	-	-	-	-	-	-	-	1.3	-	0.0	-	-	-	-	-	-	-	-
508	-	-	-	-	-	-	-	-	-	2.3	0.2	0.0	-	-	-	-	-	-	-	-
522	-	-	-	-	-	-	-	-	-	3.5	0.0	0.2	-	-	-	-	-	-	-	-
536	-	-	-	-	-	-	-	-	0.0	4.9	0.4	0.3	-	-	-	-	-	-	-	-
550	-	-	-	-	-	-	-	-	4.4	1.3	-	-	-	-	-	-	-	-	-	-
564	-	-	-	-	-	-	-	-	10.1	0.0	-	-	-	-	-	-	-	-	-	-
578	-	-	-	-	-	-	-	1.9	9.0	0.0	-	-	-	-	-	-	-	-	-	-
592	-	-	-	-	-	-	-	10.1	6.0	0.2	-	-	-	-	-	-	-	-	-	-
606	-	-	-	-	-	-	4.0	13.5	0.3	-	-	-	-	-	-	-	-	-	-	-
620	-	-	-	-	-	0.4	12.4	8.3	0.3	-	-	-	-	-	-	-	-	-	-	-
634	-	-	-	-	-	8.7	13.7	0.1	-	-	-	-	-	-	-	-	-	-	-	-
648	-	-	-	-	-	26.2	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-
662	-	-	-	-	17.5	10.0	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-
676	-	-	-	10.9	19.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
690	-	-	3.7	22.2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
704	-	-	23.5	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
718	4.5	17.0	9.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
732	4.1	15.2	6.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
746	-	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
760	-	4.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
774	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**8.6**	**51.2**	**43.0**	**43.0**	**43.0**	**45.8**	**30.9**	**34.0**	**30.1**	**13.5**	**0.6**	**0.5**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Table 16-13: Mine production – West PH2 - Total tonnage mined by bench (Mt)

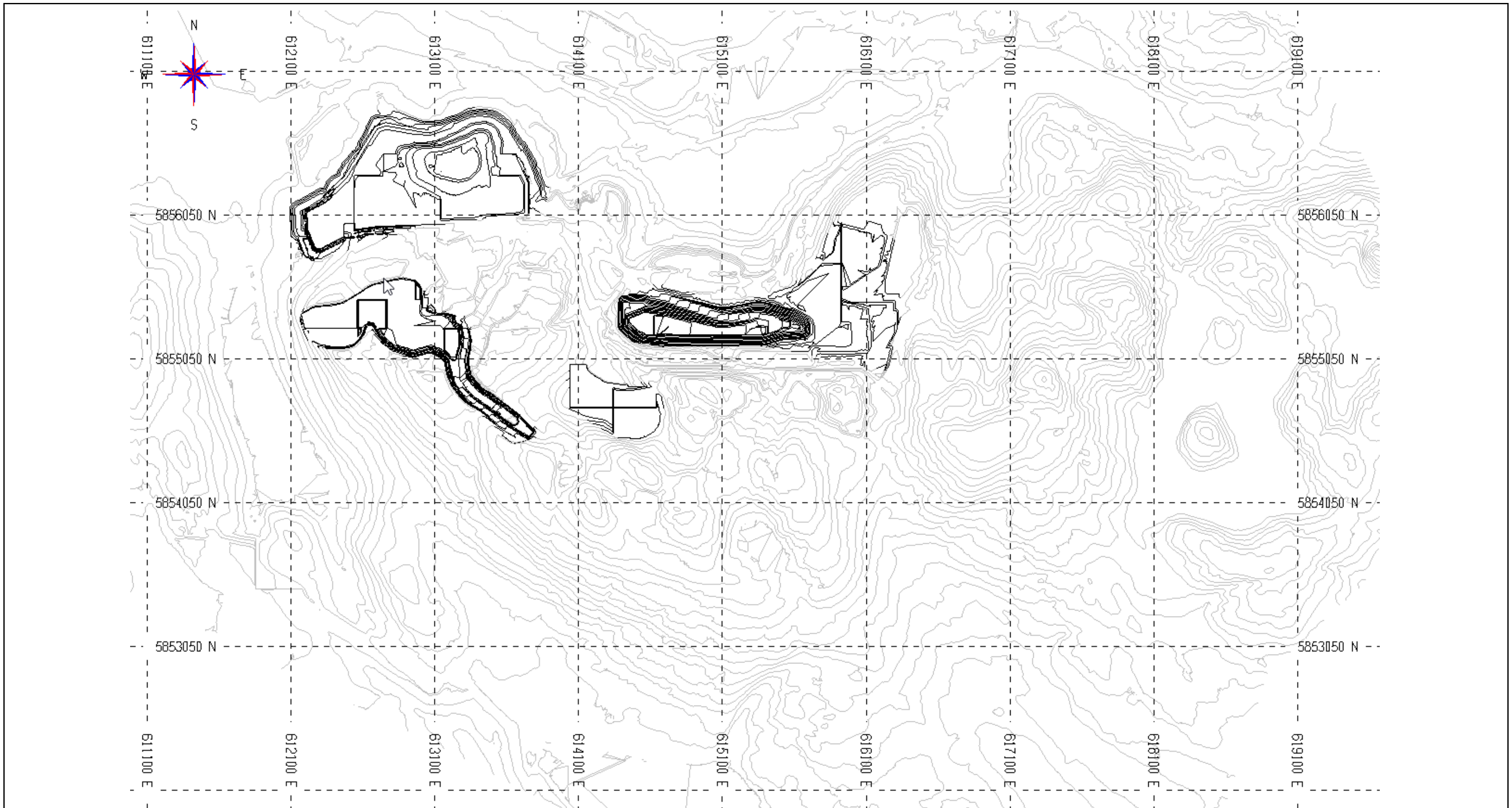
West - PH2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
410	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	0.0
424	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-
438	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.7	-
452	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	-
466	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.9	-
480	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.8	-
494	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.2	4.2	0.1
508	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7	-	-
522	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.0	-	-
536	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.5	-	-
550	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.9	1.6	-	-
564	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	-	-	-
578	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.0	-	-	-
592	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.8	3.3	-	-	-
606	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.1	-	-	-	-
620	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.6	-	-	-	-
634	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	3.5	-	-	-	-
648	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.4	-	-	-	-	-
662	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	7.0	-	-	-	-	-
676	-	-	-	-	-	-	-	-	-	-	-	-	-	5.2	4.1	-	-	-	-	-
690	-	-	-	-	-	-	-	-	-	-	-	-	2.4	8.7	-	-	-	-	-	-

West - PH2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
704	-	-	-	-	-	-	-	-	-	-	-	3.3	2.8	6.2	-	-	-	-	-	-
718	-	-	-	-	-	-	-	-	-	-	4.0	4.1	3.0	2.8	-	-	-	-	-	-
732	-	-	-	-	-	-	-	-	-	4.6	5.6	5.7	0.2	-	-	-	-	-	-	-
746	-	-	-	-	-	-	-	-	6.9	5.7	2.5	-	0.6	-	-	-	-	-	-	-
760	-	-	-	-	-	-	5.8	5.1	1.1	0.0	-	-	-	-	-	-	-	-	-	-
774	-	-	-	-	-	-	5.5	0.3	-	-	-	-	-	-	-	-	-	-	-	-
788	-	-	-	-	-	0.0	1.6	0.1	-	-	-	-	-	-	-	-	-	-	-	-
802	-	-	-	-	0.8	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**-**	**-**	**-**	**0.8**	**0.1**	**13.0**	**5.4**	**8.1**	**10.3**	**12.0**	**13.1**	**9.0**	**23.9**	**22.0**	**22.0**	**22.0**	**22.0**	**22.0**	**0.1**

Table 16-14: Mine production – Chief's Peak PH2 - Total tonnage mined by bench (Mt)

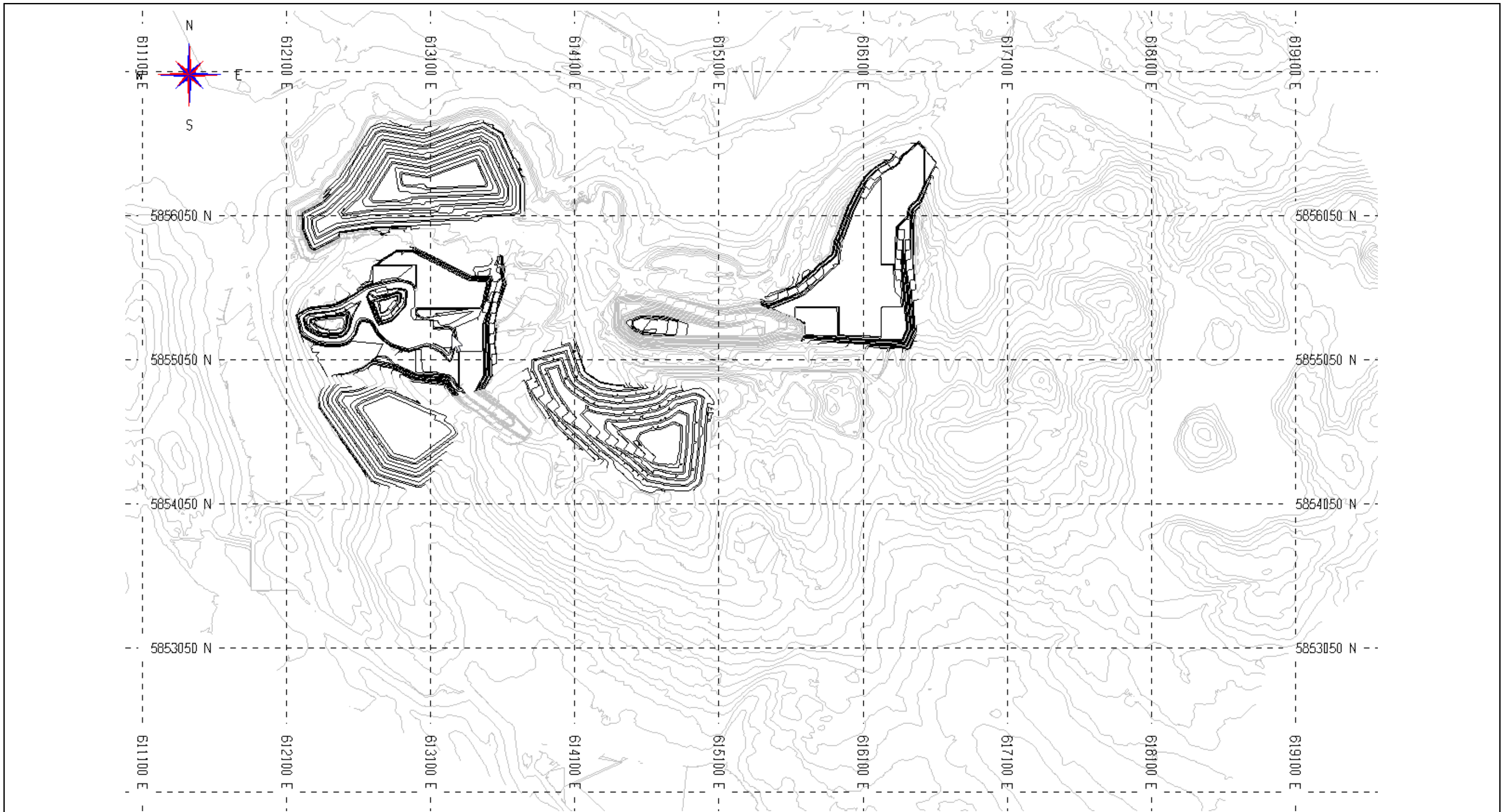
Chief's Peak-PH2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
410	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9
424	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.6
438	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4
452	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.7
466	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.4	3.6
480	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13.9	-
494	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.3	6.6	-
508	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16.0	-	-
522	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.5	7.5	-	-
536	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.7	15.4	-	-	-
550	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.8	9.1	-	-	0.5
564	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	15.9	-	-	-	-
578	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16.3	8.0	-	-	-	-
592	-	-	-	-	-	-	-	-	-	-	-	-	-	7.5	18.1	-	-	-	-	-
606	-	-	-	-	-	-	-	-	-	-	-	-	-	15.6	9.9	-	-	-	-	-
620	-	-	-	-	-	-	-	-	-	-	-	-	4.5	16.3	4.5	-	-	-	-	-
634	-	-	-	-	-	-	-	-	-	-	-	-	7.9	19.1	-	-	-	-	-	-
648	-	-	-	-	-	-	-	-	-	-	-	-	16.2	12.5	-	-	-	-	-	-
662	-	-	-	-	-	-	-	-	-	-	-	10.6	15.6	4.0	-	-	-	-	-	-
676	-	-	-	-	-	-	-	-	-	-	4.0	17.8	12.2	-	-	-	-	-	-	-

Chief's Peak-PH2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
690	-	-	-	-	-	-	-	-	-	0.3	15.2	12.3	6.4	-	-	-	-	-	-	-
704	-	-	-	-	-	-	-	-	-	13.8	12.2	9.9	0.6	-	-	-	-	-	-	-
718	-	-	-	-	-	-	-	-	-	23.2	9.9	0.3	1.5	-	-	-	-	-	-	-
732	-	-	-	-	-	-	-	-	16.7	12.1	0.0	0.1	0.8	-	-	-	-	-	-	-
746	-	-	-	-	-	-	-	3.1	17.4	0.8	-	0.0	-	-	-	-	-	-	-	-
760	-	-	-	-	-	-	-	15.2	0.7	0.1	-	-	-	-	-	-	-	-	-	-
774	-	-	-	-	-	-	-	9.6	-	-	-	-	-	-	-	-	-	-	-	-
788	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**30.3**	**34.8**	**50.4**	**41.2**	**51.0**	**65.8**	**75.0**	**55.6**	**41.4**	**32.9**	**30.8**	**27.9**	**23.7**



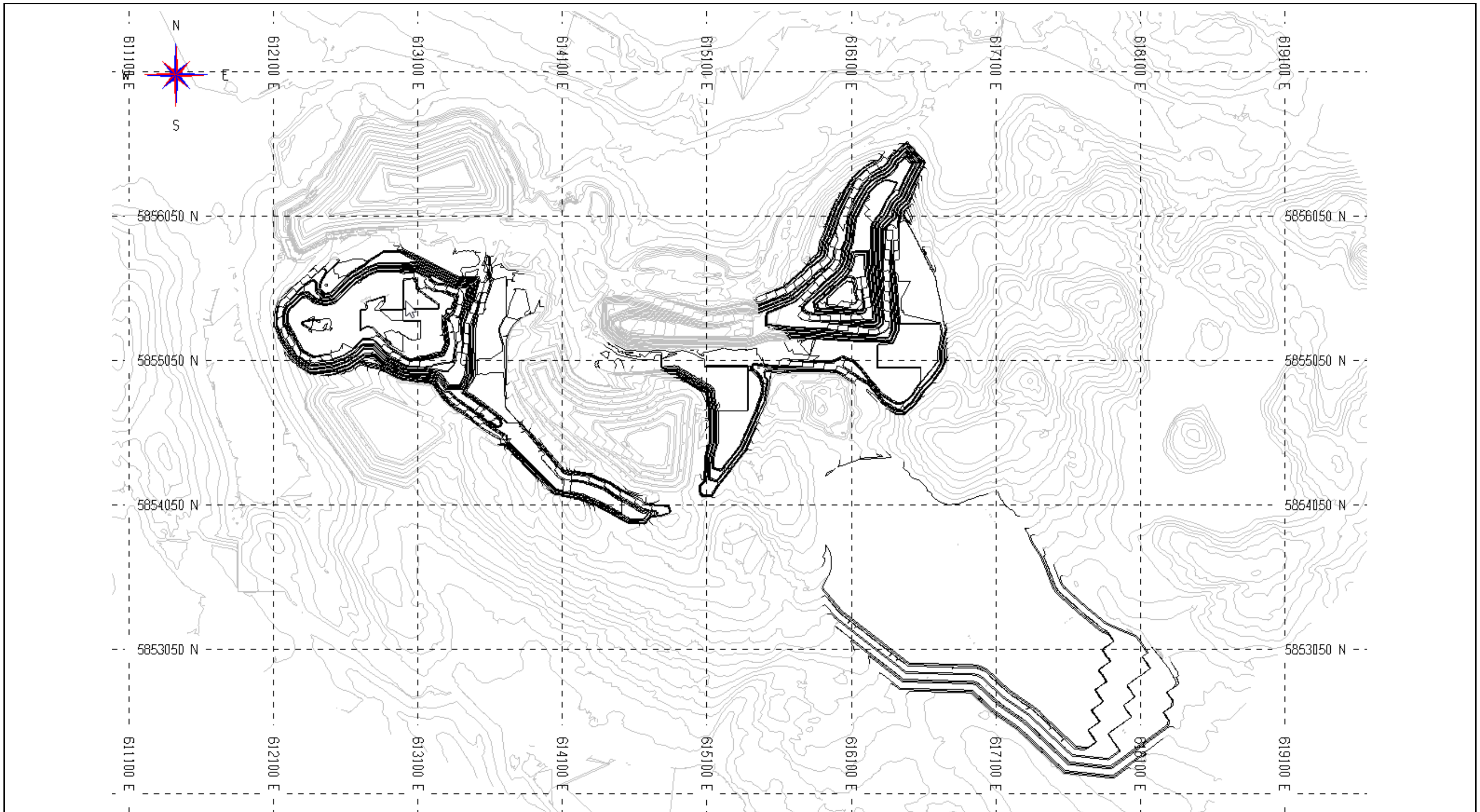
	Pit Schedule – EoY- Year 1	Source: BBA Inc. Date: May 2019

Figure 16-10: Production schedule – Year 1



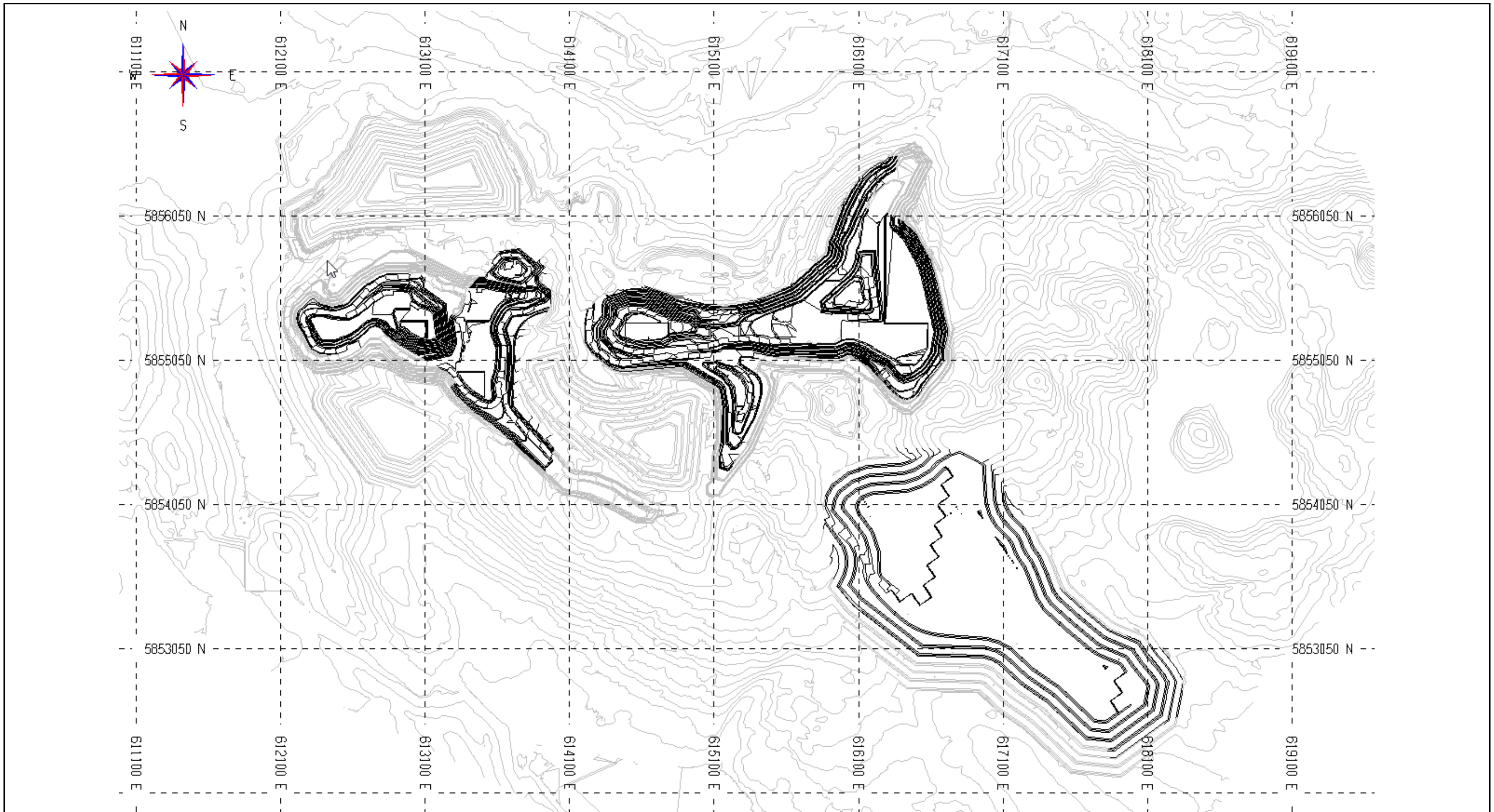
	Pit Schedule – EoY Year 5	**Source: BBA Inc.** **Date: May 2019**

Figure 16-11: Production schedule – Year 5



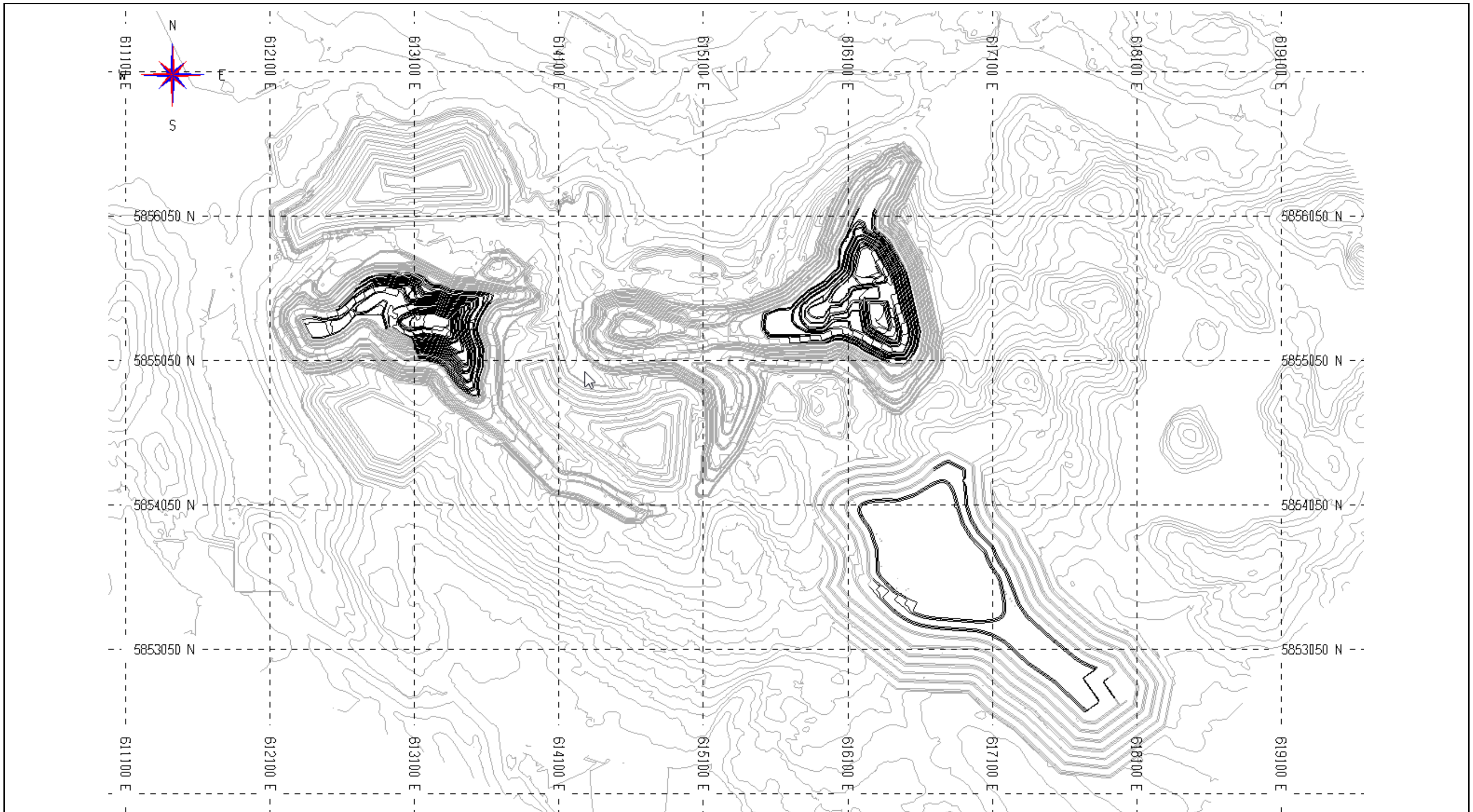
	Pit Schedule – EoY Year 10	**Source: BBA Inc.** **Date: May 2019**

Figure 16-12: Production schedule – Year 10



	Pit Schedule – EoY Year 15	**Source: BBA Inc.** **Date: May 2019**

Figure 16-13: Production schedule – Year 15



	Pit Schedule – Year 20	**Source: BBA Inc.** **Date: May 2019**

Figure 16-14: Production schedule – Year 20

16.3.3 Mill Production Schedule

The mill production schedule is presented in Table 16-15. As a simplifying assumption, the ramp-up and commissioning period has been assumed to be 12 months. The ramp up period calculation is based on a McNulty Series 1 curve considering the implementation of a known process at a currently operating site.

The concentrate production averages 15 Mtpy over the 20-year LOM. The concentrate, at 66.2% iron, is obtained with a combined Phase 1 and Phase 2 metallurgical recovery that averages 82.4% over the same period. The recovery curve detailed in Chapter 17 was applied by scheduling period. The first year monthly weighted average recovery was checked against the annual average and the impact of variability between the two periods was found to be minimal. Consequently, the use of annual average grades to calculate the recovery was considered appropriate.

Table 16-15: Mill production schedule detail by period

Year	Ore					Phase 1		Phase 2		Total
	Tonnes	Fe	CaO	SAT	MgO	Tonnes	Concentrate	Tonnes	Concentrate	Concentrate
1	35,030	29.6	0.8	3.3	0.9	20,150	7,460	14,880	5,590	**13,050**
2	41,960	28.5	2.0	7.4	1.9	20,370	7,180	21,590	7,640	**14,820**
3	41,960	29.1	1.9	7.5	1.8	20,370	7,380	21,590	7,850	**15,230**
4	41,960	29.6	2.0	8.4	2.0	20,370	7,550	21,590	8,030	**15,580**
5	41,960	27.8	2.5	8.0	2.4	20,370	6,900	21,590	7,340	**14,240**
6	41,960	27.5	3.0	8.4	2.7	20,370	6,820	21,590	7,250	**14,070**
7	41,960	29.0	2.2	5.6	2.0	20,370	7,340	21,590	7,800	**15,140**
8	41,960	28.8	2.6	5.6	2.3	19,940	7,130	21,140	7,890	**15,020**
9	41,960	28.9	2.7	4.8	2.3	20,370	7,320	21,590	7,780	**15,100**
10	41,960	29.7	1.6	6.4	1.6	20,370	7,600	21,590	8,090	**15,690**
11	40,000	31.1	0.4	2.9	0.5	19,420	7,940	20,580	8,000	**15,940**
12	40,000	30.3	0.9	5.2	1.1	19,420	7,650	20,580	7,690	**15,340**
13	41,960	29.0	1.6	5.9	1.6	20,370	7,360	21,590	7,830	**15,190**
14	41,960	29.2	2.4	8.4	2.4	20,370	7,410	21,590	7,870	**15,280**
15	41,960	28.0	3.0	8.2	2.7	20,370	6,990	21,590	7,420	**14,410**
16	41,960	28.1	3.0	5.3	2.6	20,370	7,010	21,590	7,450	**14,460**
17	41,960	28.8	2.3	6.4	2.0	20,370	7,280	21,590	7,730	**15,010**
18	41,960	29.3	2.3	6.4	2.2	20,370	7,450	21,590	7,920	**15,370**
19	41,960	29.2	2.6	6.1	2.3	20,370	7,420	21,590	7,880	**15,300**
20	20,570	26.7	4.5	10.1	3.9	10,410	3,330	11,040	3,250	**6,580**
Grand total	**806,960**	**29.0**	**2.2**	**6.5**	**2.0**	**394,890**	**142,520**	**412,070**	**148,300**	**290,820**

16.3.4 Waste Requirements for Civil Work

Waste material will be required for the construction of the TMF and various usages in the mine. The total waste rock required is 7.6 Mt mainly for the TMF. Waste material for stemming and road construction will be sourced from the waste dumps around the site.

16.4 Mine Operations and Equipment Selection

16.4.1 Mine Operations Approach

Mining is to be carried out using conventional open pit techniques with electric hydraulic shovels, wheel loaders and mining trucks in a bulk mining approach with 14 m benches. An owner mining open pit operation is planned with the outsourcing of certain support activities such as explosives manufacturing and blasthole loading.

16.4.2 Production Drilling and Blasting

Drill and blast specifications are established to effectively single pass drill and blast a 14 m bench. For this bench height, a 311 mm blasthole size is proposed with a variable burden and spacing and 1.5 m of subdrill. Because of the changing rock properties and size requirements between waste and ore, powder factors vary between 0.35-0.5 kg/t. Blastholes are initiated with electronic detonators and are double primed with 450 g boosters. The bulk emulsion product is a gas sensitized pumped emulsion blend specifically designed for use in wet blasting applications.

Several rock types are present in the pit including hematite, gneiss, schist, quartzite and amphibolite. The average rock properties based on testing shows a range in hardness between 52 MPa and 119 MPa (Table 16-16).

Table 16-16: Rock properties

Rock properties		Hematite iron formation	Gneiss	Schist	Quartzite	Amphibolite
UCS	MPa	119	67	52	113	80
Young's modulus	GPa	43.95	20.15	11.25	n/a	29.84
Poisson's ratio	%	0.19	0.27	n/a	n/a	0.22
Specific gravity	t/m^3	3.41	2.74	2.77	2.68	3.04

The drilling parameters used in the study are based on data collected from the previous operation at Bloom Lake. The average drill productivity for the production rigs is estimated at 20 m/h instantaneous with an overall penetration rate of 15 m/h. The overall drilling factor represents time lost in the cycle when the rig is not drilling such as move time between holes, moves between patterns, drill bit changes, etc. The average drilling productivity of the drills is estimated at 2,200 tph including the 5% re-drill factor. Drilling requirements are based on the planned rock type movements throughout the LOM. In years when there is more magnetite and silicate material, drilling hours increase.

There are three blasthole rigs in production at the start of the Project. Each drill has a drill bit size range of 244 mm to 406 mm with a single pass drill depth of 21.3 m with a 21.4 m tower configuration. There are two Bucyrus 49HR electric drive and one Caterpillar MD6640. Future drill additions will be required and are planned as the same class of drill.

Blasting activities will be outsourced to an explosives provider who will be responsible for supplying and delivering bulk explosives in the hole. The mine engineering department will be responsible for designing blast patterns and relaying hole information to the drills via the wireless network.

Blasthole loading and firing activities will be performed during day shift only. During full production, the blasting team will consist of 10 individuals. Three of them will be operating the explosive truck (contractor), there will be two blasters and four helpers, as well as one drill and blast supervisor. All accessories and blasting consumables will be purchased through the bulk explosive supplier.

Budgeting of explosive products and services is based on proposals received from suppliers, although no final agreement has been made.

In the current feasibility study, a mobile manufacturing unit (MMU) was chosen. The emulsion truck is a mixing truck that takes bulk explosive components such as ammonium nitrate prill, gassing agents and diesel fuel to form a blasting product as it is distributed into the blast hole. Thus, the provider is not storing a large amount of bulk explosive on site, but ingredients in separate tanks that are not considered as explosives. For this reason, the explosives plant or depot can be located closer to the mining operations. This approach reduces infrastructure construction.

Table 16-17: Drill and blast parameters

Parameter	IF and default	IFM	SIF	Gneiss and default	Quartzite	Amphibolite
Drill specifications						
Hole diameter (inch)	12.25	12.25	12.25	12.25	12.25	12.25
Hole diameter (mm)	311.2	311.2	311.2	311.2	311.2	311.2
Hole area (m^2)	0.076	0.076	0.076	0.076	0.076	0.076
Bench height (m)	14.0	14.0	14.0	14.0	14.0	14.0
Subdrill (m)	1.5	1.5	1.5	1.5	1.5	1.5
Stemming (m)	4.5	4.5	4.5	4.0	4.5	4.5
Loaded length (m)	11.0	11.0	11.0	11.5	11.0	11.0
Hole spacing (m)	6.7	6.7	6.7	6.8	7.9	6.5
Burden (m)	7.7	7.7	7.7	7.8	9.1	7.5
Instantaneous penetration rate (mph)	22.0	17.0	19.0	22.0	22.0	19.0
Re-drill (%)	5	5	5	5	5	5
Rock mass/hole (t)	2,473	2,473	2,473	2,064	2,818	2,184
Stemming mass/hole (t)	0.75	0.75	0.75	0.67	0.75	0.75
Bloom Lake blend						
Usage (by volume) (5)	100	100	100	100	100	100
Density (kg/m^3)	1,200	1,200	1,200	1,200	1,200	1,200
Kg/hole	1,004	1,004	1,004	1,049	1,004	1,004
Blasting specifications						
Powder factor (kg/tonne)	0.406	0.406	0.406	0.508	0.356	0.460

16.4.3 Ore Control

The ore control program will consist of establishing dig limits for ore and waste in the field to guide loading unit operators. A high precision system combined with an arm geometry system will allow shovels to target small dig blocks and perform selective mining. The system will give operators real-time view of dig blocks, ore boundaries, and other positioning information. Physical flagging will be implemented when required in the field.

The ore control boundaries will be established by the technical services department based on grade control information obtained through blasthole sampling with post-blast boundaries adjusted for blast movement measurements made using a BMM® system. An annual charge for ore control services has been budgeted. The blasthole cuttings will be analyzed for half (50%) of the blastholes. An XRF technology will also be utilized for waste ore contact confirmation.

A hydraulic excavator (CAT 6015B or similar) will be used to clean the ore/waste contact to reduce dilution and ore loss.

16.4.4 Pre-split

Pre-split drill and blast is planned to maximize stable bench faces and to maximize inter-ramp angles along pit walls as prescribed by the geotechnical pit slope study. The pre-split consists of a row of closely-spaced holes along the design excavation limit of interim and final walls. The holes are loaded with a light charge and detonated simultaneously or in groups separated by short delays. Firing the pre-split row creates a crack that forms the excavation limit and helps to prevent wall rock damage by venting explosive gases and reflecting shock waves. As a best-practice, it is recommended that operations restrict production blasts to within 50 m of an un-blasted pre-shear line. Once the pre-split is shot, production blasts will be taken to within 10 m of the pre-shear and then a trim shot used to clean the face. Double bench pre-split holes spaced 1.8 m apart will be 36.2 m in length and drilled with a smaller diameter of 127 mm (5.0 in.).

Blasting of the pre-split holes will use a special packaged pre-split explosive internally, traced with detonating cord that ensures fast and complete detonation of the decoupled charge. For our specific application, a 40-mm diameter cartridge, 28 m long will be used. This load factor of 2.37 kg/m allows for a targeted charge weight of 1.02 kg/m^2 of face.

Table 16-18: Pre-split parameters

Pre-split parameters		Pre-split single	Pre-split double
Drill pattern			
Hole diameter	in	5	5
Diameter (D)	m	0.127	0.127
Spacing (S)	m	1.8	1.8
Bench height (H)	m	14	28
Pre-split hole length (L)	m	18.1	36.2
Face Area	m^2	32.58	65.16
Explosives charge	kg	33	66.36
Charge factor	kg/m^2 face	1.02	1.02
Cartridge charge			
Number of cartridges	qty	35	70
Cartridge length	m	0.40	0.40
Cartridge loading factor	kg/m	2.37	2.37
Decoupled charge length	m	14	28
Decoupled charge	kg	33	66

Pre-split drilling is currently completed by a local contractor, and a price per metre has been included for the Phase 2 expansion.

16.4.5 Loading

The majority of the loading in the pit will be done by four electric drive hydraulic face shovels equipped with a 28-m^3 bucket. The shovels are matched with a fleet of 218 t payload capacity mine trucks. The Project already owns three Caterpillar 6060 electric drive hydraulic front shovels. The hydraulic shovels will be complemented by four production front-end wheel loader (FEL). The site already owns two Komatsu WA-1200.and one LeTourneau 1850

The blending strategy at the mine endeavors to provide a consistent feed to the mill, while the local geology varies significantly. Due to this, the loading strategy at the mine requires a shovel and a loader in ore for the majority of the working hours. Fortunately for Phase 2, the increased production requirements will help as 4-6 pieces of loading equipment should be active at all times. The loading productivity assumptions for both types of loading tools in ore, waste and overburden are presented in Table 16-19.

The 28 m^3 shovel is expected to achieve a loading rate of 3,776 tph based on a 4-pass match with the mine trucks and an average load and spot time of 3.4 minutes. The productivity in waste will remain approximately the same due to better bucket filling factors on the lower density material.

The wheel loader is expected to achieve a loading rate of 2,643 tph on a 6-pass match and an average load time of 4.8 minutes in ore. The loading rate in waste is estimated at 2,371 tph, with seven passes per truck.

Table 16-19: Loading specifications

Loading Unit		Shovel (28 m^3)	Shovel (28 m^3)	FEL (12 m^3)	FEL (12 m^3)
Haulage Unit		**Truck (218 t)**	**Truck (218 t)**	**Truck (218 t)**	**Truck (218 t)**
Material		**Ore**	**Wst/Ovb**	**Ore**	**Wst/Ovb**
Bucket capacity	m^3	28	28	16	16
Bucket fill factor	%	73%	83%	84%	84%
In-situ dry density	t/bcm	3.45	3.04	3.45	3.04
Swell	%	30%	30%	30%	30%
Loose density	t/lcm	2.65	2.34	2.65	2.34
Actual load per bucket	t	54.3	54.2	35.8	31.5
Passes (whole)	#	4	4	6	7
Nominal truck payload	t	217	217	215	220
Carry back	%	1.5%	2.5%	1.5%	2.5%
Actual truck payload	t	214	211	211	215
Cycle time					
Truck spotting	min	1	1	1	1
Loading time	min	2.40	2.40	3.80	4.43
Cycle efficiency	%	80%	80%	80%	80%
Number of trucks loaded per shift	#	161.1	161.1	114.1	100.8
Production / Productivity					
Shift production	t/12h	34,472	34,067	24,127	21,648

16.4.6 Hauling

Haulage will be performed with 218-tonne class mine trucks. The existing truck fleet consists of seven Caterpillar 793D and three Caterpillar 793F mechanical drive trucks.

The truck fleet productivity was estimated using the Haulage module within MSSO and verified with the standard Talpac model. Integrating the model within the planning suite allows for cycle times to be generated for every cut to every destination, including an estimate of the waste storage facility geometry at the time of mining.

The assumptions and input factors for the haulage simulations are presented in Table 16-20, Table 16-21 and Table 16-22.

A speed limit of 50 km/h was applied globally. Rolling resistances were also applied globally at 2.2%. The haulage models were calibrated against actual site data by de-rating the trucks performance by 15%. This de-rating covers disruptions that are difficult to model, like the many various yields, stops, truck bunching, slow moving equipment, and other impediments to a perfect cycle time.

Table 16-20: Model parameters

Model input	Values
Rolling resistance (%)	2.2
Global speed limit (km/h)	50
De-rating factor (%)	15

Table 16-21: Cycle time components

Cycle time component	Duration (min)
Truck average spot time at loader	1
Truck average loading time	3.70
Truck average spot time at dump	0.4
Truck average dumping time	1

The fuel consumptions were also estimated manually with a caterpillar table of fuel consumption under various loads. Generally, the fuel burn rate increases with depth as a longer period of time is spent on grade.

Table 16-22 present the results for the haulage study. When cycle times decrease going forward in the schedule it is due to the mining of benches higher in the pit when new mining phases are initiated.

The total haul hours required by period determines the number of trucks required throughout the LOM. The truck fleet will reach a maximum of 34 units in Year 13 and remains at this level until Year 15 before it starts decreasing as a result of a drop in mining rate.

Table 16-22: Haulage results

Year	Distance (km)	Hauling hours (h)	Average cycle time (min)	Average travel velocity (km/h)	Fuel consumption (L/NOH)[1]
1	1,363,145	40,598	10	33.6	146
2	2,183,778	60,658	11	36.0	149
3	1,975,592	60,668	10	32.6	152
4	1,813,348	58,886	11	30.8	155
5	2,424,972	82,202	13	29.5	158
6	3,904,510	131,792	18	29.6	161
7	3,801,326	128,379	18	29.6	164
8	3,598,837	117,840	17	30.5	167
9	3,138,053	108,639	15	28.9	170
10	3,649,073	114,580	16	31.8	173
11	3,571,611	116,619	17	30.6	175
12	3,634,421	119,091	17	30.5	179
13	4,192,866	132,108	19	31.7	181
14	4,571,113	144,333	19	31.7	185
15	3,478,504	118,283	20	29.4	188
16	2,786,547	98,908	20	28.2	191
17	2,548,934	91,165	22	28.0	194
18	2,562,402	96,122	24	26.7	197
19	2,580,161	99,828	26	25.8	200
20	1,417,139	53,519	29	26.5	203
Total	**59,196,332**	**1,974,220**	**17**	**30.0**	**175**

NOH: Net Operating Hour (defined in Table 16-25).

[1] Average cycle time excludes spot, load, dump and bunching time.

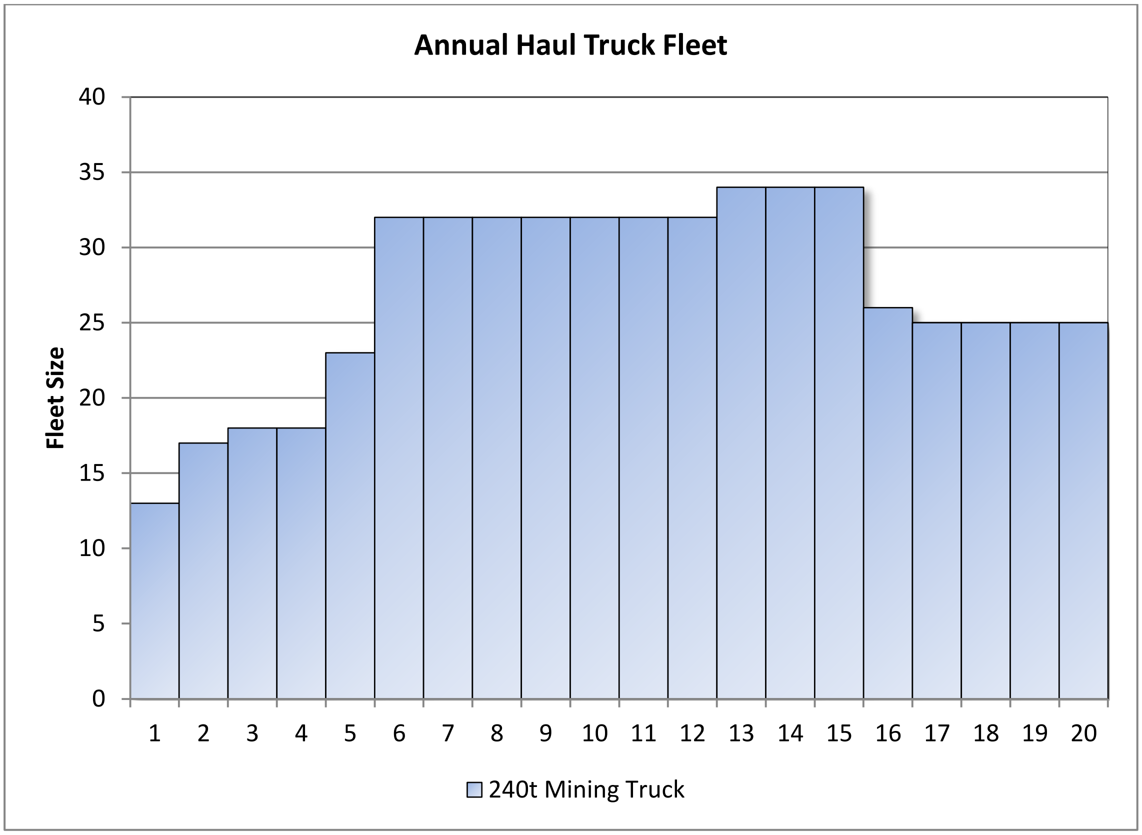


Figure 16-15: Truck requirements

16.4.7 Dewatering

The pumping system is designed to handle a 1 in 10-year event in the pits that are in operation and a 1 in 2-year event when pits are not exploited. The data used for this analysis come from an estimation of the monthly precipitation of this area based on a random generation of the next 30 years. This analysis was also completed with the WSP analysis of seven days rainstorm event. All these data were generated with respect to the ultimate pit design. The pumped water will be sent to sedimentation ponds located southwest of the Mazare Lake. Underground inflows from the Confusion and Mazare lakes are estimated in a 2013 geotechnical Golder report. These flows were only applied to the Chief's Peak pit PH1B and PH2. The pumping system envisioned for this Project has been verified operationally in the Labrador Iron Trough.

Table 16-23: Pumping requirement to keep pit completely dry

West Pit				
Event	**Snow m^3/year**	**Rainfall m^3/year**	**UG Inflow m^3/year**	**Total m^3/year**
1:10 yr	724,025	1,382,400	-	2,106,475
		Maximum hourly flow rate (snow melt period)		1,067 m³/h
Pignac Pit				
Event	**Snow m^3/year**	**Rainfall m^3/year**	**UG Inflow m^3/year**	**Total m^3/year**
1:10 yr	474,671	906,240	-	1,380,911
		Maximum hourly flow rate (snow melt period)		700 m³/h
1:2 yr	319,928	610,805	-	930,733
		Maximum hourly flow rate (snow melt period)		472 m³/h
Chief's Peak Pit				
Event	**Snow m^3/year**	**Rainfall m^3/year**	**UG Inflow m^3/year**	**Total m^3/year**
1:10 yr	712,007	1,359,360	5,475,000	7,546,367
		Maximum hourly flow rate (snow melt period)		1,675 m³/h

For this study, equipment was sized to allow a small accumulation of water at the bottom of the pits in operation and have to be dried in less than a week. The pumping stations considered in this study are typical in mining dewatering and have a capacity of 150 m of head at 750 m³/h flow rate. Pumps and auxiliary equipment are installed in a modified sea container. An intermediate pond with booster pumping station is added at approximately every 125 m drop. Table 16-24 below presents the pumping station required per pit.

Table 16-24: Pumping station and intermediate pond requirements

	West		**Chief's Peak PH1A (Pignac)**		**Chief's Peak**	
	Pump	**Pond**	**Pump**	**Pond**	**Pump**	**Pond**
Year 1	1	0	1	0	0	0
Year 8	2	1	1	0	6	1
Year 20	6	2	4	1	9	2

No system for lowering the water table has been included in this study. In 2018 a report from Hydro-Ressources Inc. (HRI) determined that the lakes south of the Chief's Peak pit do not have significant exfiltration towards the Chief's Peak pit. A ground water model has not yet been elaborated for use in forecasting pit dewatering for the Chief's Peak or the West pit. As such the current pit dewatering quantities in December 2018 and January 2019 were applied as a base load to both the Chief's Peak and West pit dewatering scenarios for forecasting purposes.

16.4.8 Road and Dump Maintenance

Waste and ore storage areas will be maintained by a fleet of four 899 hp and two 630 hp track-type dozers. Also, a 814-hp wheel dozer is available on site with an additional dozer later in the mine life. The wheel dozers will be dedicated to the maintenance of the mine roads and the loading areas.

Mine roads will be maintained by three 16 ft blade motor graders and an 18 ft motor grade later in the mine life. A water/sand truck will be used to spray roads to suppress dust, or spread road aggregate during winter months. Two small water trucks are also available (1 x water truck and 1 x sand truck). They will be used for areas inaccessible to the larger truck.

For snow removal activities, a 230 hp IT loader (tool carrier) will be used either with a snow blade or with a snow blower for cleaning around buildings and in critical areas. If needed, a second IT loader from the maintenance department can give additional support.

16.4.9 Support Equipment

All miscellaneous construction related work, such as water ditch construction and cleaning, will be done by one 49-t excavator. This unit will be equipped with a hydraulic hammer for boulders clearing after blasts. A larger 140 t excavator will be used to clean up the contacts between ore and waste to minimize dilution. As well, a modified 40 t excavator will be used to improve wall scaling.

For open pit service, four mechanic service trucks are planned, two fuel and lube trucks, and one low-boy. Ten light towers are required to illuminate critical workplaces such as at the loading face, stockpile area, and waste dump points. In other locations, the electrical network of the pit could be used for lighting.

Several other pieces of equipment are planned to support the mining activities: A mobile generator for shovel and drill moves; A minibus for shift change; A cable reeler for cable moves; A D10 and D9 operated by remote control for stockpile re-handling in the A-Frame; and two small IT loaders for stemming blastholes.

16.4.10 Mine Maintenance

The Bloom Lake project does not intend to sign for a maintenance and repair contract (MARC) for its mobile equipment fleet. Consequently, the maintenance department has been structured to fully manage this function, performing maintenance planning and training of employees. However, reliance on dealer and manufacturer support for major components is planned through component exchange programs.

Tire services such as tire pressure and wear monitoring, scheduled tire rotation, tire replacement and repairs will be outsourced and has been budgeted as part of the maintenance budget.

A Computerized Maintenance Management System (CMMS) will be used to manage maintenance and repair operations. This system will keep up to date status, service history and maintenance needs of each machine.

16.4.11 Roster Schedules

While some of the workforce is to be sourced locally from neighbouring communities such as Fermont (QC), Labrador City (NL) or Wabush (NL), the rest of the workforce will be hired on a fly-in fly-out basis. Except for some administrative positions on a standard 8-hour shift 5 days on / 2 days off, the rest of the crews will be working 12-hour shifts with a 14 on / 14 off rotating schedule. Four crews will be required to operate on a continuous basis 24 hours per day 365 days per year.

16.4.12 Equipment Usage Model Assumptions

The typical equipment usage model assumptions are established by equipment groupings as presented in Table 16-25. The annual net operating hours (NOH) vary approximately between 5,000 and 6,000 hours per year.

Table 16-25: Equipment usage model assumptions

Equipment usage assumptions		Shovels	Loaders	Trucks	Drills	Ancillary
Days in period	days	365	365	365	365	365
Availability	%	85	85	85	85	85
Use of availability	%	90	90	95	90	85
Utilization	%	77	74	75	72	72
Operating Efficiency	%	85	85	87	85	80
Effective utilization	%	65	63	66	61	58
Total hours	h	8,760	8,760	8,760	8,760	8,760
Down hours	h	1,314	1,314	1,314	1,314	1,314
Delay hours	h	1,005	970	859	949	1,266
Standby hours	h	744.6	744.6	372.3	744.6	1116.9
Gross operating hours (GOH)	h	6,701	6,465	6,605	6,329	6,329
Net operating hours (NOH)	h	5,696	5,495	5,746	5,380	5,063

Time standards used for the Project follow industry standard definitions described in Figure 16-16 below. Standard shift delays have been provided by the operations for use in calculation of the different time components.

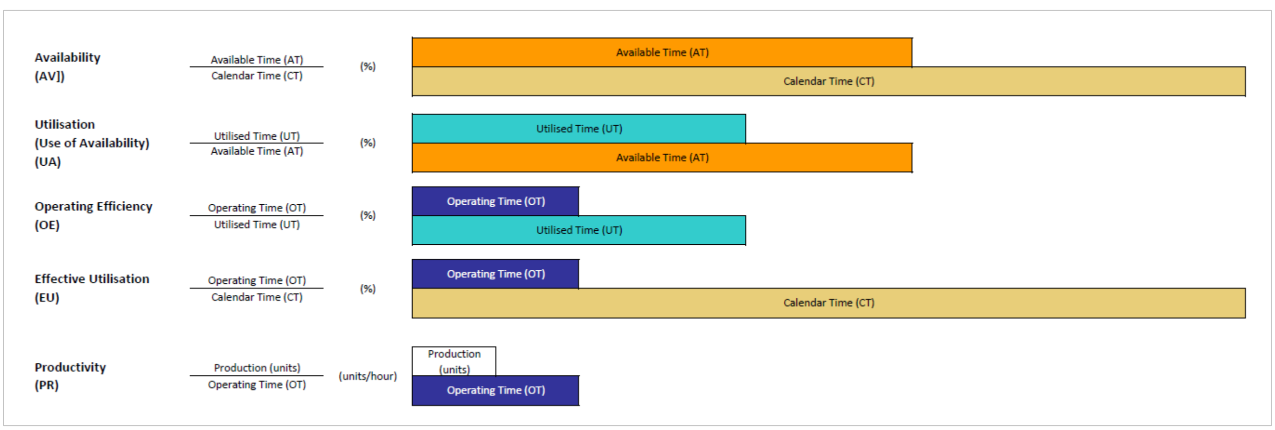


Figure 16-16: Time definitions

16.4.13 Fleet Management

A fleet management system including hardware and software is already implemented to manage in real-time the operation, monitor machine health, and track key performance indicators (KPIs). The system will be managed by a dispatcher on each crew controlling the system that will send operators onscreen instructions to work at peak efficiency. Two system administrators will keep the system functioning at peak effectiveness as well as provide training to users.

The fleet management system on site is by Modular Mining. A provision has been included to install dispatch and provision on new fleet additions.

The shovels are equipped with the Modular ProVision system, which is a high precision global positioning system (GPS). This system improves the productivity and bench grade control, and can be integrated with the mine planning software.

The production drills are also equipped with the high precision ProVision system. This system helps guide rigs into position and assures holes are drilled to the correct depth and location.

16.4.14 Pit Slope Monitoring

Slope movement monitoring is planned for the open pit to gather measurements and confirm assumptions in order to assure safe working conditions. Initial slope movement monitoring will consist of using prisms reading using manual or automated surveys with at least two permanent total stations established in climate controlled enclosures ensuring full coverage of the open pit. The initial prism monitoring will provide movement response data to verify visual observations and confirm if the slope is performing adequately.

A permanent, fully-automated monitoring system using Lidar or radar could be considered for the long term if warranted based on review of prism monitoring results.

The slope movement monitoring data will be important for the calibration of numerical models required for detailed design updates during the mine life. The pit phasing approach will allow for adjustments to the final design based on observations and knowledge gained with the interim pit phases.

16.4.15 Electric Cable Handling

An evaluation of capital and operating costs was made for mining cable management and electrification of the pit since the mine will operate up to four electric front shovels and seven electric drills.

The operation of a 550 hp wheel loader with a removable cable reel attachment has been budgeted to handle the electric cables required for the various production units. A capital expenditure for increasing the electrical grid capacity for the pit has been estimated in the CAPEX of the Project. Two additional substations will be available for the beginning of mining operations with an additional substation added part way through the mine life. At the same time, as the final substation is an addition, a full loop will be completed around the mine to increase system reliability within the mine.

16.4.16 Aggregate Plant

The Project has multiple needs for crushed rock of different granulometry. An external contractor will be hired to supply and operate the aggregate plant, and those costs have been imbedded in the cost per tonne of crushed rock that is produced.

The main usage of crushed rock is for road maintenance, which will be used during winter to help with traction on snowy haul roads and ramps and to maintain all the roads to an acceptable standard throughout the year. The second usage of importance is for stemming material for all blastholes. Finally, the remainder of crushed rock will be for the tailing storage facility (TSF).

16.5 Mine Equipment Requirements

At the start of the Project, the majority of the required equipment is already available in the mine. However, the addition of some equipment will be required for the first year. The required fleet was estimated with material movement requirements and haulage hours from the LOM plan. The equipment requirements are presented in Table 16-26.

Table 16-26: Equipment requirements

	Start	Year1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Haul truck fleet																					
CAT 793F	10	13	17	18	18	23	32	32	32	32	32	32	32	34	34	34	26	25	25	25	25
Shovel fleet																					
Production Electric Shovel CAT 6060FSE	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3
Drill fleet																					
Drill Rig CAT 6640	3	4	6	6	6	7	7	7	7	7	7	7	7	7	7	6	5	4	4	4	4
Loader fleet																					
Production Loader Komatsu WA1200-6	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	2	2	2	1	1	1
Support fleet																					
Grader (18M)		0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Grader (16M)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2
Wheel Dozer (854K)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Dozer (D9)	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Dozer (D10)	2	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	3	3	2	2	2
Auxiliary fleet																					
Wheel Loader (988)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Water Truck (T183) / Sand Spreader Body	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
WA900		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fuel/Lube Truck	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Service Truck	4	4	4	4	4	6	6	6	6	6	6	6	6	6	6	6	6	5	4	4	4
Multi-Tool (IT62H)	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Pick-up Truck	20	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Mini Bus	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lighting tower 4 post of 1000 w. / diesel generator	8	8	8	10	10	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8
CAT 390F for scalling		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Excavator (med size)	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2
Excavator (small size)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2
Haul truck (777)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Fardier (Cat 793)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Genset RH340 and drill moves		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CAT6020B dilution excavator		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Reel loader WA500 + reel		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Wheel Loader (WA600)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CAT D10 REMOTE (A-Frame)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CAT 390 REMOTE (A-Frame)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total																					
Field fleet		7	10	10	10	11	11	11	11	11	11	11	11	11	11	9	8	7	7	7	7
Shop fleet		25	30	31	32	39	48	48	48	48	48	48	48	50	50	48	39	37	34	34	34
Total primary fleet		**32**	**40**	**41**	**42**	**50**	**59**	**59**	**59**	**59**	**59**	**59**	**59**	**61**	**61**	**57**	**47**	**44**	**41**	**41**	**41**
Auxiliary Equipment		65	65	67	67	71	71	71	71	71	71	71	71	71	71	71	71	64	63	63	63
Total mining equipment		**97**	**105**	**108**	**109**	**121**	**130**	**130**	**130**	**130**	**130**	**130**	**130**	**132**	**132**	**128**	**118**	**108**	**104**	**104**	**104**

Note. Equipment detailed in the table are not necessarily those that will be used by the project and are used primarily for costing purposes. Other manufactures and types of equipment will be considered during the project construction phase.

16.6 Mine Manpower Requirements

Figure 16-17 presents the mine manpower requirements over the LOM with a reduction occurring when the tonnage decreases in Year 15. The first and last year are fractional years and explain the reduction in number of employees. The total mine department workforce is 324 the first year of operation and reaches a peak of 480 individuals by Year 14.

The total mine staff is relatively constant over the mine life with 77 people required. Only four administrative contractors are planned for blasting activities.

The mine maintenance group will have a maximum of 120 hourly employees and 24 employees that are staff members and accounted for in the technical services group. The mine geology team maintains its size of 14 employees. The mine engineering group will have a total of 16 employees.

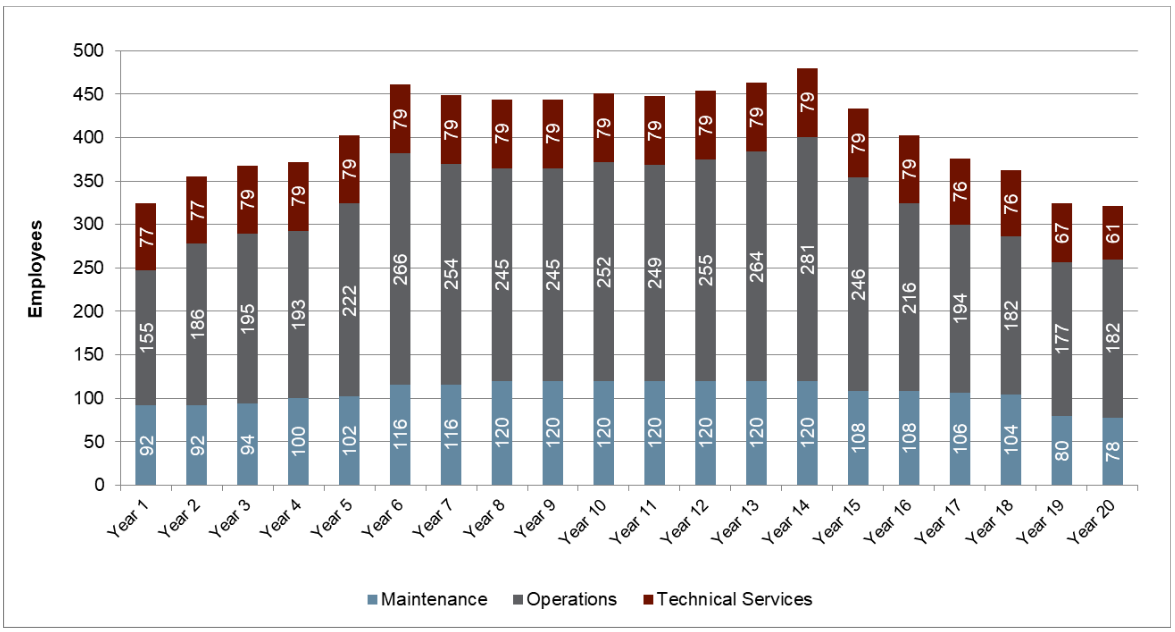


Figure 16-17: Mine manpower requirements

17. RECOVERY METHODS

17.1 Introduction

Quebec Iron Ore (QIO) intends to start-up Phase 2 (QIO) to expand the Bloom Lake concentrator (Phase 1 (QIO)) and double its yearly production to 15 Mtpy of concentrate from the ore mined from the following pits: Pignac, West and Chief's Peak.

The Phase 2 (Cliffs) facility currently exists; however this phase has never been in operation as construction was halted before completion in 2012. Phase 2 (Cliffs) crushing and storage facilities were started-up along with the Phase 1 (QIO) concentrator in the beginning of 2018. Phase 2 (Cliffs) spirals and other equipment were utilized in the Phase 1 (QIO) concentrator.

The Phase 1 flowsheet developed for the start-up by QIO, referred to as Phase 1 (QIO), was based on the initial Phase 2 flowsheet, referred to as Phase 2 (Cliffs), as well as testing and piloting results realized in partnership with Mineral Technologies. The suggested flowsheet for the Phase 2 restart, referred to as Phase 2 (QIO), incorporates further improvements derived from experience with the current operation and using the testwork program results outlined in Chapter 13.

In the following sections, the design basis and criteria of the processing plant are presented together with the description of each of the processing sections. This information, with the general arrangement drawings and plant 3D models, provides the basis for the capital expenditure (CAPEX) and operating expenditure (OPEX) cost estimates.

17.2 Overall Process Design Basis and Design Criteria

Bloom Lake Phase 1 (QIO) was designed to process ore at a nominal rate of 2,500 tph. With the new life of mine (LOM) design, the projected production is 7.29 Mtpy of concentrate at a 29.0% Fe feed grade and concentrate grade of 66.2% Fe with a Fe recovery of 82.2%. The Phase 1 (QIO) capacity is proven by 2018 production.

The Bloom Lake Phase 1 concentrator has been in operation from 2010 to 2014, and has been successfully restarted in 2018, thus providing significant operational data to be used for process design. The Phase 1 operation experience has shown that:

- Installing a larger thickener and maximizing water recirculation will improve the circuit's robustness;
- Increasing the pan filters and classification screens capacities and flexibilities will improve the concentrator's availability and throughput;
- Increasing the AG mill motor power will allow processing hard ore at an increased tonnage.

The Bloom Lake Phase 2 (QIO) is designed to process ore at a nominal rate of 2,650 tph. With the new LOM design, the projected production is 7.75 Mtpy of concentrate at a 29.0% Fe feed grade and concentrate grade of 66.2% Fe. The Phase 2 expected weight recovery is 36.1% and the Fe recovery is 82.5. The combined Phases are designed to produce 15 Mtpy of concentrate with a Fe recovery of 82.4% and a weight recovery of 36.0%.

The overall process and plant design criteria for the Phase 2 (QIO) concentration plant are established on the following bases:

- The life of mine is 20 years at nominal capacity;
- Equipment selection is based on a combination of existing equipment of the original Phase 2 (Cliffs) and new equipment. Original Phase 2 equipment has been reused as much as possible without impeding plant performance. It allows a consistent concentrate quality to be achieved at low capital and operating costs. Table 17-1 presents the list of major equipment that will be used for Phase 2 (QIO) operations and indicates if the equipment already exists or if it is new;
- Only proven and modern technology for processing iron ore is considered in the process design. Variability testing results have been used to support the equipment selection;
- The Phase 2 (QIO) concentration plant is designed as follows:
  - Stochastic simulations have been realized to generate realistic maximum and minimum flow rates for each stream and results from simulations have been used for equipment sizing. Additional safety margins are applied whenever maintenance issues for a given equipment impact downstream operations;
  - Piping is sized in order to respect critical settling velocities at the minimum calculated flow rates.
- Fresh water usage has been minimized by designing a water distribution system that maximizes water recovery and recirculation.

Table 17-1: List of major processing facilities

Circuit	Major processing facilities	Origin
Crushing	Primary crusher	Phase 2 (Cliffs)
	Crushed ore stockpile	Phase 2 (Cliffs)
	Overland conveyor	Phase 2 (Cliffs)
	A-Frame crushed ore stockpile shed	Phase 2 (Cliffs)
	Reclaim apron feeders	Phase 2 (Cliffs)
Grinding & Classification	AG mill	Phase 2 (Cliffs)
	Scalping screens	New
	Static screens	New
	Classification screens	Phase 2 (Cliffs) & New
Separation	Spirals	New
	Cleaner up-current classifier (UCC)	Phase 2 (Cliffs)
	Scavenger cleaner UCC	Phase 2 (Cliffs)
	LIMS	New
	WHIMS	New
Filtration & Load-out	Pan filter	Phase 2 (Cliffs)
	Concentrate storage	Phase 2 (Cliffs) & New
	Load-out	Phase 1 (QIO)
Tailings	Rougher tails dewatering cyclones	New
	Tailings cyclones	Phase 2 (Cliffs)
	Thickener	Phase 2 (Cliffs)

17.2.1 Process Design Criteria

Table 17-2 summarizes the general parameters upon which the concentration plant design has been based. Sizing of the selected equipment is based on these parameters as nominal values. Design values for all the equipment were generated by Monte Carlo simulations, which consist in setting parameters to vary within a specified range according a specified distribution.

Table 17-2: Major design criteria

Parameter	Unit	Nominal value
Operating schedule		
Annual operating time	day	365
Equipment utilization - Concentrator	%	93.0
Annual operating time - Concentrator	h	8,147
Mill feed		
Mill feed annual capacity	tpy	21,589,020
Mill feed rate	tph	2,650
Mill feed rate - Design	tph	3,100
Mill feed iron grade	%	29.0
Mill feed MgO grade	%	2.0
Mill concentrate		
Mill annual concentrate production - nominal	tpy	7,792,400
Mill concentrate iron recovery	%	82.5
Mill concentrate iron grade	%	66.2
Mill concentrate weight recovery	%	36.1
Mill concentrate silica (SiO_2)	%	4.5

17.3 Process Flow Diagrams and Material Balance

The process flow diagram for the processing plant was derived from experience with Phase 1 (QIO) operation, the metallurgical testwork (bench-scale and pilot-scale) and Manufacturers' test results to meet the design criteria. The simplified process flow diagram (PFD) for the new Phase 2 is presented in Figure 17-1.

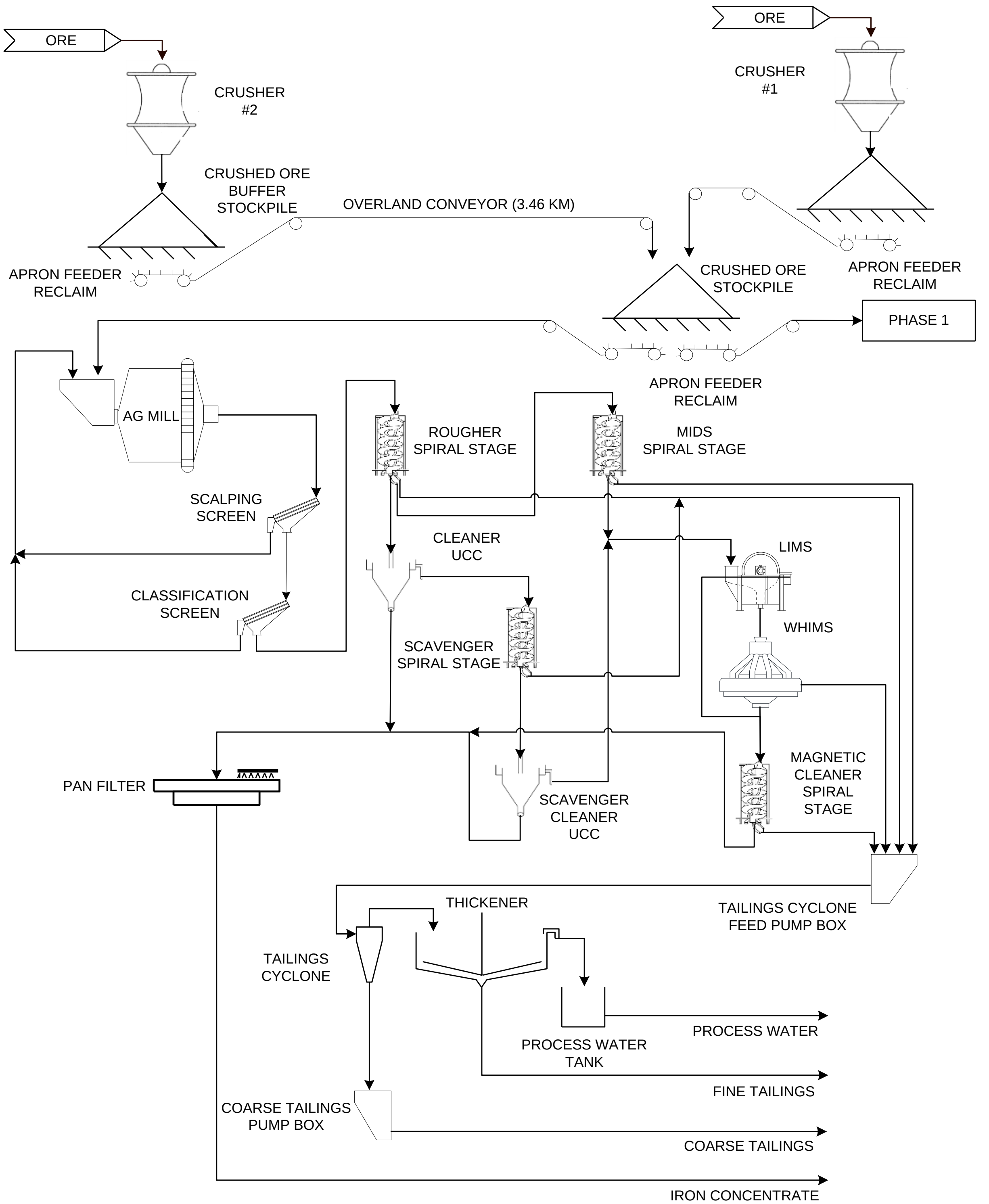


Figure 17-1: Simplified block flow diagram Phase 2 (QIO)

17.4 Crushing Circuit

A basic flowsheet of the crushing circuit is represented in Figure 17-2. The subsections below describe the crushing circuit flowsheet.

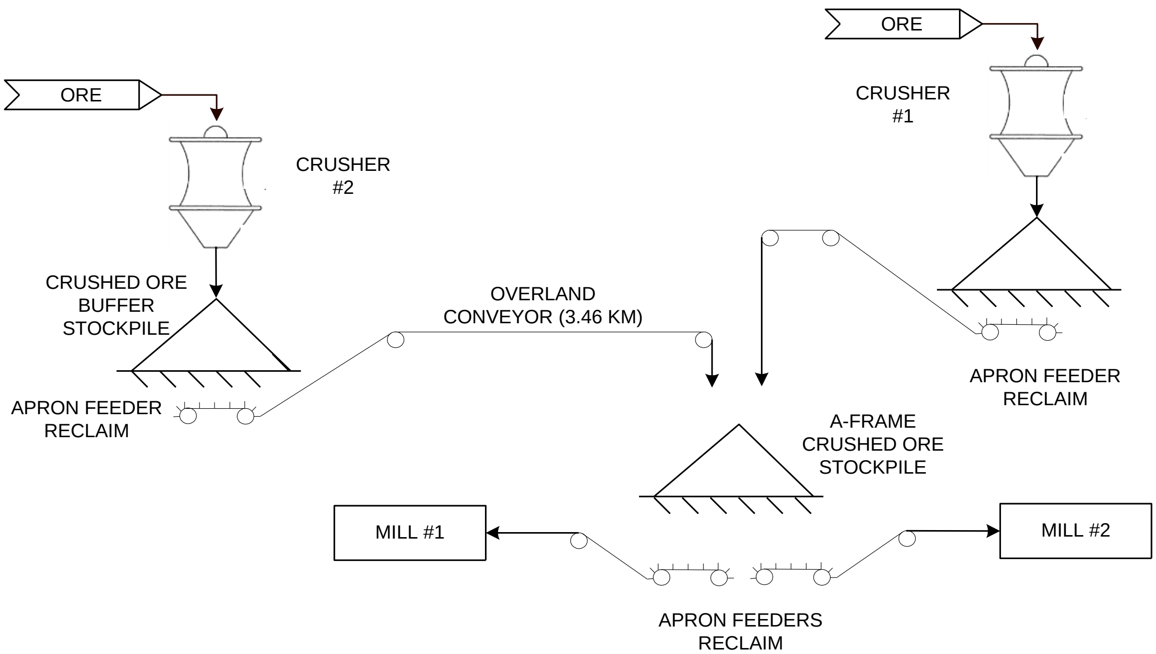


Figure 17-2: Simplified block flow diagram – Crushing circuit

17.4.1 Primary Crushers

The near pit primary crusher (Crusher 2) and overland conveyor built during the Bloom Lake Phase 2 (Cliffs) project have been in operation for Phase 1 (QIO) since its start-up in the beginning of 2018. Crusher 2 and the overland conveyor will be used to provide most of the feed to both Phase 1 and Phase 2 concentrators. The Phase 1 (Cliffs) primary crusher (Crusher 1) will also be operated and provides approximately 27% of the combined feed to Phase 1 and Phase 2 mills. Crusher 1 discharge system will be modified to be able to feed both the Phases 1 and 2 (QIO) concentrators.

Ore from the mine is delivered by 240-tonne trucks to Crusher 1 and Crusher 2, both equipped with two dump points. A hydraulic hammer (rock breaker) is installed adjacent to each crusher to manipulate lumps in the feed pocket and to break the larger ore lumps so they can enter the crusher. The hydraulic hammer is operated from the crusher operator’s room.

Crushed ore from Crusher 2 (<250 mm) falls on a surge conveyor that transports it to the crushed ore buffer stockpile, enclosed in a dome. Ore is withdrawn from the buffer stockpile by an apron feeder to a sacrificial conveyor and is then transferred on the overland crushed ore conveyor.

Crushed ore from Crusher 1 is fed to a surge bin where it is reclaimed via a conveyor system and is transported to the common crushed ore stockpile area

17.4.2 Crusher 2 Stockpile Dome

The stockpile dome is designed to hold approximately 5,800 t of crushed ore and to shelter the stockpile from the wind. The dome is installed at the end of the crusher surge conveyor and is 34 m long by 34 m wide for an inside height of 14 m. This dome is completely enclosed with a wall at each end. There is a large door at one end to allow access by a front-end loader. The dome foundation consists of 92 concrete blocks of 4' x 4' x 8' piled two high and resting on crushed rock.

17.4.3 Overland Conveyor

The overland conveyor transports the crushed ore over a distance of 3.45 km before discharging in the crushed ore stockpile. The overland conveyor was built during the Bloom Lake Phase 2 (Cliffs) project and some modifications to facilitate and improve maintenance operations were made for the Phase 1 (QIO) restart in 2018. The overland conveyor consists of a 1.6 m wide by 3.45 km long belt conveyor running at 4.6 m/s. The conveyor is used for transferring the crushed ore from the Phase 2 primary crushing location to the A-frame crushed ore stockpile. Its original design capacity of 6,000 tph is sufficient for the operation of Phases 1 and 2 with the average throughput considered of 2,500 tph and 2,650 tph respectively.

17.4.4 A-Frame Crushed Ore Stockpile Building

There are three apron feeders installed to withdraw the crushed ore from the stockpile to feed the Phase 2 (QIO) concentrator mill feed conveyor. The apron feeders' configuration makes it easier to withdraw material from the centre or the extremities of the crushed ore stockpile, improving the consistency of the particle size distribution of the AG mill feed. Each apron feeder is equipped with a dust collector to minimize dust emission. Steel rods are inserted through the collar of each apron feeder to shut off the feed when maintenance is being carried out. The mill feed tonnage is controlled by varying the apron feeder speed with a signal from the belt scale. A metal detector is installed on the mill feed conveyor to stop the conveyor when metal pieces are detected in order to protect the conveyor and mill liners. Another separate dedicated set of apron feeders currently reclaims the feed to Phase 1. The existing stockpile feeding system will be modified to allow crushed ore from Crusher 1 and Crusher 2 to be placed over either Phases apron feeders. This will allow for material from either crusher to be used as feed for both Phase 1 and Phase 2.

17.5 Grinding and Classification Circuit

A basic flowsheet of the grinding and classification circuit is represented in Figure 17-3. The subsections below describe the grinding and classification circuit flowsheet.

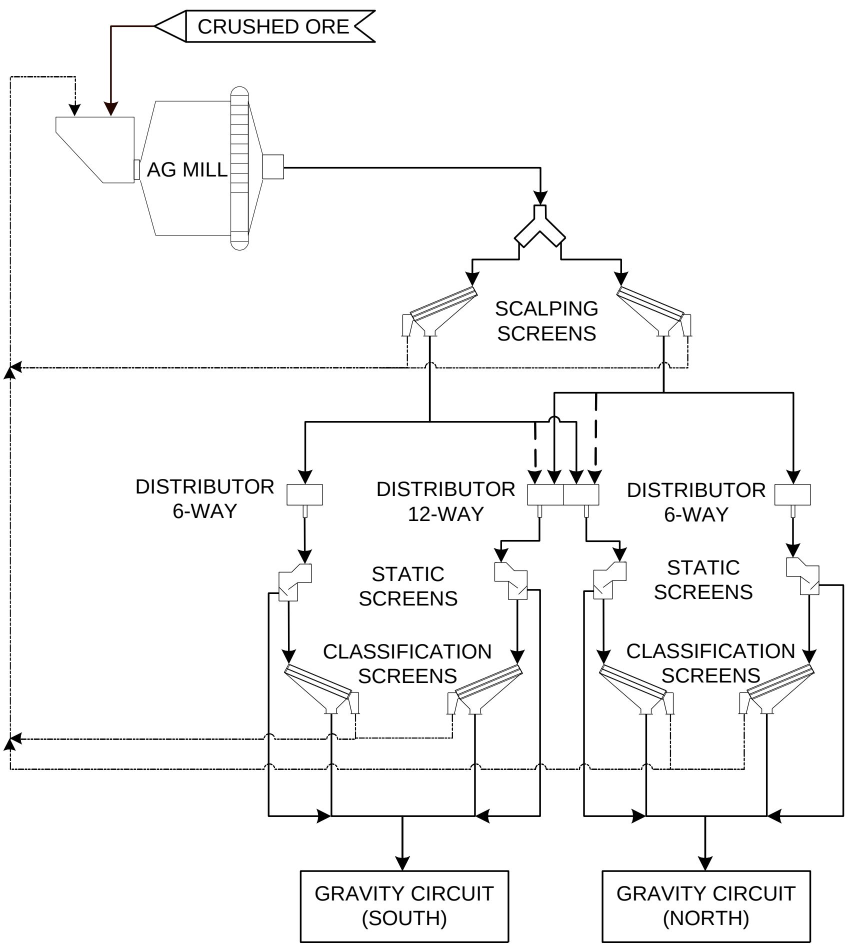


Figure 17-3: Simplified block flow diagram – Grinding and classification circuit

17.5.1 Circuit Description

Crushed ore from the stockpile is fed to an AG mill by means of the mill feed conveyor. Ground ore is discharged from the mill as a slurry to feed two scalping screens. The screens oversize (ore greater than 5 mm) is conveyed back to the mill and the undersize of each scalping screen discharges into its own pump box from where it is pumped to the classification screens' feed distributors. There are three distributors installed, two 6-way and one 12-way fitted with two equal distribution chambers.

From the classification stage, the plant is divided into two production lines, named North and South. Each scalping screen undersize pump feeds one 6-way distributor of one of the production lines and the chamber of the 12-way distributor feeds the other production line. Because of the rotating AG mill load movement, the split in the AG mill discharge chute is not equal and one scalping screen receives more ground material than the other scalping screen (North or South depending on the AG mill rotation side), thus resulting in an unequal split between the lines. The distributor configuration maximises the distribution of the scalping undersize material and the feeding of both production lines with equal tonnage of similar material.

For each production line, the classification stage is composed of ten static screens followed by ten vibrating classification screens. The layout includes room for four additional static screens and classification screens for future capacity increase requirements. The quantity and size of screens selected is meant for an increased screening area and screens' width will promote screening efficiency and reduce overgrinding and recirculation tonnage. Because of the number of classification screens, maintenance on one of them can be done without, or with little, tonnage impact. The distributor system is designed to ensure that both production lines in Phase 2 are fed with a homogeneous mill discharge.

Classification screen oversize is conveyed back to the AG mill while static screens and classification screens undersize is collected in a pump box (one for each production line) to be pumped to the gravity concentration circuit. The classification screens undersize pump boxes dilution water is pumped from the filtrate tank ensuring stable rougher feed density.

17.5.2 Circuit Capacity Validation

QIO will use the existing Phase 2 (Cliffs) 36' by 19'-9" AG mill, which is the same size as the Phase 1 (QIO) AG mill. The nominal feed tonnage of the Phase 2 mill has been set to 2,650 tph. Datamining of the Phase 1 (QIO) for 2018 as well as operational experience showed that this 150 tph increase over the Phase 1 (QIO) is achievable with the available mill.

Figure 17-4 shows the major factors that have limited the AG mill feed tonnage since the restart of operation in the Phase 1 (QIO) concentrator.

This section presents the different factors that have limited the AG mill feed tonnage during the first year of operation in the Phase 1 (QIO) concentrator and the modifications that were implemented in the Phase 2 (QIO) concentrator in order to prevent those limitations.

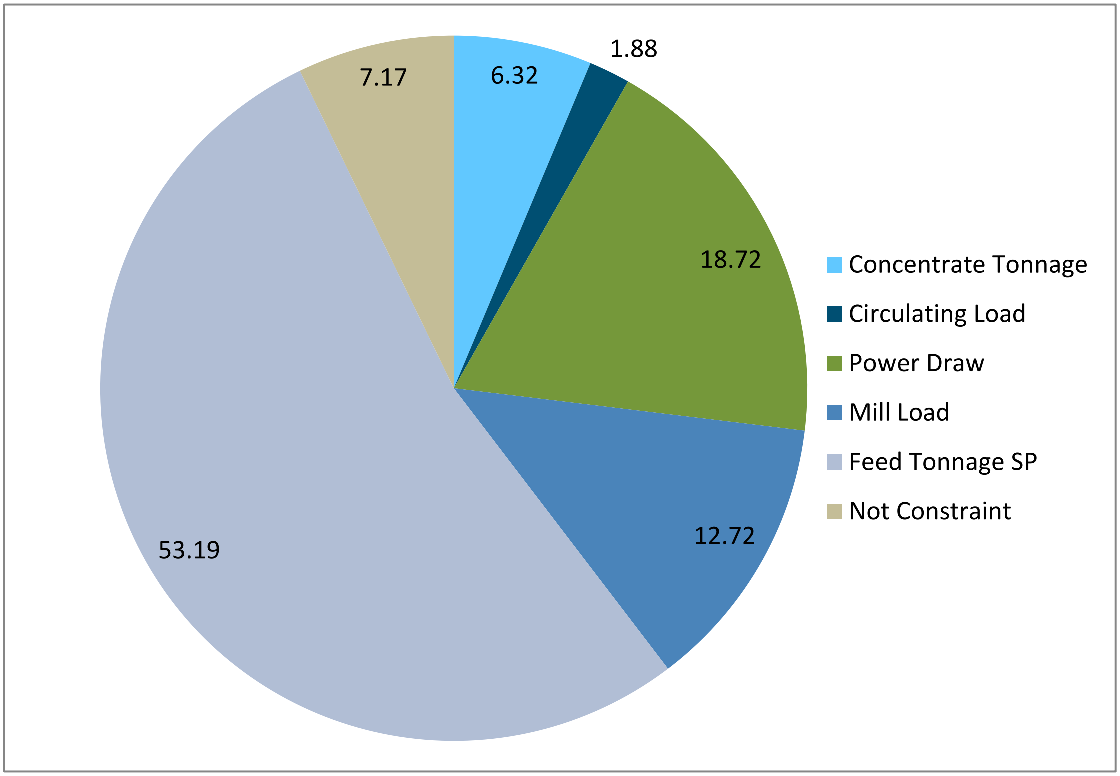


Figure 17-4: Phase 1 AG tonnage constraints – 2018

17.5.2.1 Feed Tonnage Set-point

The most significant reason (more than 50% of the time) for the limitation of tonnage comes from the maximum tonnage set-point entered by the operators. This set-point is used to limit the feed tonnage when constraints, other than those used in the mill control itself (motor power, mill load, circulating load and concentrate tonnage), limit the production throughput. Examples of those limitations in the process plant are: no ore available, pumping limitations in various sectors of the plant, concentrate filtration limitations or fine tailings thickening limitations.

The major limitations observed in the Phase 1 (QIO) process plant are mitigated as follows in Phase 2 (QIO):

- Crushed ore feeding chutes to the concentrator stockpile were the cause of numerous "no feed" occurrences due to blockage. Modification were conducted in February 2019 and occurrence of blockage dropped drastically;
- The simultaneous operation of Crusher 1 and Crusher 2 will provide flexibility, improve crushed ore availability and reduce the "no feed" occurrences;

- The fine tailings thickener surface area is 2.1 times that of the Phase 1 (QIO) thickener, which translates to a much slower rise rate, thus less likeliness of thickener overflow control loss;
- The fine tailings pumping capacity will be increased compared to Phase 1 (QIO);
- The concentrate pan filters area is 1.7 times that of the Phase 1 (QIO) filters meaning that only three filters are required in operation and stopping a pan filter for maintenance will not imply tonnage reduction.

17.5.2.2 Mill Motor Power and Mill Load

The second reason in terms of occurrences (close to 20% of the time) is the power limitations on the AG mill motors. The mill motor power draw is mostly affected by feed tonnage and ore hardness, so tonnage is limited when approaching the motors' power limit.

As a result, the Phase 2 (QIO) project will upgrade the original 7,500 hp (5,593 kW) motors so they can reach up to 8,400 hp (6,264 kW). The additional 12% power available will make it possible to increase tonnage when the power draw is high and no other constraint is active.

The power increase means that ore-specific power can reach 4.7 kWh/t at the design feed rate of 2,650 tph, which is higher than the Phase 1 (QIO) design value of 4.5 kWh/t at 2,482 tph.

The third reason limiting the tonnage is the mill load. In the case where the mill load approaches the maximum load set-point, extra power will be of limited use. However, when the mill power is high and the mill load is normal, having extra power will permit an increased throughput. In 2018, there was room to increase the mill load more than 60% of the time when the mill motor power was a constraint.

Part of the mill load comes from the circulating load, which consists of the scalping screens and classification screens oversize. When screening is not efficient, an increased fraction of undersize material reports to the oversize and the circulating load is increased by the presence of fine material that should not be recirculated to the mill. By increasing the classification screens' surface, the screening efficiency will be increased, thus reducing the impact of the recirculation on the mill load.

17.5.2.3 Concentrate and Circulating Load Tonnages

The fourth and fifth constraints on the mill tonnage in 2018 were the concentrate and circulating load tonnages. Both limitations are due to conveyor capacity. The Phase 2 (QIO) concentrate and recirculation conveyors will have an increased capacity compared to Phase 1 (QIO). The concentrate conveyors will be designed to handle 1,500 tph.

17.5.2.4 Conclusion

The Bloom Lake concentrator Phase 1 has been successfully restarted in 2018, thus providing significant operational data. The Phase 1 operation experience has shown that:

- Installing a larger thickener and maximizing water recirculation will improve the circuit's robustness;
- Increasing the pan filters, classification screens and conveyors capacities and flexibilities will improve the concentrator's availability and throughput;
- Increasing the AG mill motor power will allow processing hard ore at an increased tonnage.

The combination of mitigation actions to be implemented in the Phase 2 (QIO) concentrator will allow the throughput to be increased to 2,650 tph.

17.6 Separation Circuit

The Phase 2 separation circuit developed is, as in Phase 1 (QIO), a multi-stage circuit comprised of spirals (rougher, cleaner, scavenger and middlings (mids) stages), UCCs, LIMS and WHIMS, designed to remove gangue material, mostly silica, from hematite and magnetite to achieve the desired 82.5% iron recovery, with a key difference being the inclusion of up-current classifiers in the scavenger stage. The combination of various pieces of separation equipment in the different stages of the separation circuit is meant to maximize iron recovery while maintaining silica grade control.

A basic flowsheet of the separation circuit is represented in Figure 17-5. The subsections below describe each processing step.

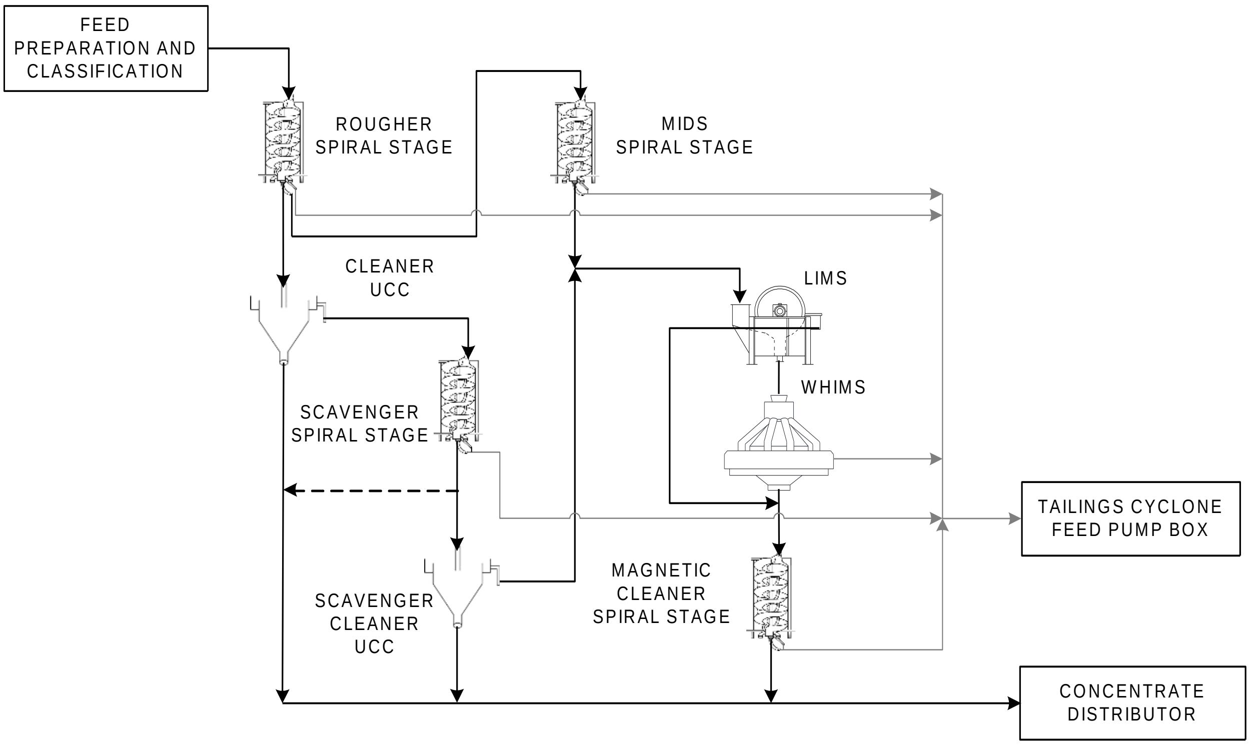


Figure 17-5: Simplified block flow diagram – Separation circuit

17.6.1 Gravity Circuit

In the gravity circuit, the combination of spirals at the rougher stage and UCC at the cleaner stage enables the removal of silica of all sizes. The roughers will be operated with settings that maximize iron recovery while preventing coarse silica from getting to the cleaner stage. The cleaner stage will be operated with settings that remove fine and mid-sized silica to achieve a final concentrate SiO_2 grade lower than the 4.5% target. The mids spirals are used to recover misplaced iron from the rougher stage middlings while removing mid-size to coarse silica; they act as a buffer that absorbs feed grade and liberation variations. Sending the mids concentrate to the magnetic separation circuit stage prevents the reintroduction of coarse silica into the cleaner UCC stage, compared to Phase 1 (QIO) flowsheet.

A combination of spirals and UCC is also used at the scavenger and scavenger-cleaner stages. The scavenger stage role is to absorb the cleaner UCC overflow flow rate variations and stabilize the scavenger cleaner UCC. It is operated so as to maximize iron recovery while removing mid-sized silica. The scavenger cleaner stage is operated so as to remove fine silica. To maximize iron recovery in the event that the scavenger spiral grade is good enough for the final concentrate to meet specifications, the scavenger-cleaner UCC stage can be bypassed.

17.6.1.1 Rougher Stage

The classification screen pumps feed four primary distributors that evenly distribute the feed to each of the 32 rougher spirals feed distributors. The rougher spirals feed distributors then redistribute the feed to each of the 36 spiral starts of each rougher spirals bank.

The rougher spirals act as the first separation stage of hematite and magnetite from gangue material, mostly silica, and produce three products: concentrate, middlings and tails.

The rougher spiral concentrate feeds the cleaner up-current classifiers. The middlings, containing iron are fed to the mids spiral banks for further separation and half of the tails are fed to the rougher spirals dewatering cyclones, the other half are sent to the tailings thickening cyclone cluster pump box.

17.6.1.2 Cleaner Stage

The cleaner up-current classifiers (UCCs) receive the rougher spirals concentrate. Each of the eight up-current classifiers receives feed from four rougher banks. The cleaner UCC underflow is high grade concentrate and is sent to the pan filters while overflow feeds the scavenger spirals. The cleaner UCCs are meant to produce final grade concentrate by removing mid-size and fine silica.

17.6.1.3 Scavenger Stage

The scavengers' role is to recover the fine iron that reports to the UCC overflow. The UCC's overflow is sent to the scavenger spirals distributors to feed the individual scavenger spiral starts. There are 16 scavenger spiral banks, each having 36 starts. The middlings and tailings, almost free of iron at this point, are fed to the tailings cyclone cluster feed pump boxes for disposal while the scavenger spiral concentrate feeds the scavenger cleaner up-current classifiers.

17.6.1.4 Scavenger Cleaner Stage

The concentrate coming from the scavenger spiral banks is collected into four scavenger cleaner up-current classifiers. The underflow is high grade concentrate and is sent to the pan filters. The overflow feeds the magnetic separation circuit. The cleaner up-current classifiers are meant to produce final grade concentrate by removing mid-size and fine silica.

Scavenger spirals recover fine iron that has been lost in the cleaner UCC overflow. When cleaner UCC teeter water is increased to remove mid-size silica in order to meet the final concentrate grade, scavenger spirals receive more feed and the scavenger spirals concentrate grade is low. Adding a scavenger cleaner stage allows the iron recovery at the scavenger stage to be maximized, producing a higher grade concentrate at the scavenger cleaner stage. The scavenger cleaner technology chosen is a UCC, which will remove fine silica that the scavenger spiral is not able to remove. The additional scavenger cleaner stage allows for a better grade control while not impacting the iron recovery.

17.6.1.5 Mids Stage

The mids spiral banks are fed by the rougher spirals middlings through the mids feed distributors, which split the feed evenly to each spiral start. There are 32 mids spiral banks installed, each having 12 starts. The mids spirals act as a scavenger separation stage to recover hematite and magnetite from a low grade feed stream. The mids spiral concentrate feeds the magnetic circuit. Both middlings and tails are fed to the tailings cyclone cluster feed pump boxes for disposal.

Operation experience and sampling campaigns' results have shown that mids concentrate recovery is low and can contain coarse silica that is not removed in the cleaner UCC stage, thus adversely impacting the final UCC concentrate grade or the iron recovery. Sending the mids concentrate to the magnetic circuit enables the recovery of mids concentrate iron without impacting the cleaner UCC performance. This allows for an improved cleaner UCC grade and improved recovery.

17.6.1.6 Rougher Tails Dewatering Stage

The tails coming from the rougher is a high flow/low percent solids stream from which water can be recovered and reused in the process. It is collected through a series of launders that feed two rougher spiral tails dewatering cyclones clusters of six cyclones each. These cyclones allow a large part of the water at the cyclones overflow to be recovered while the solids report to the cyclones underflow. The cyclones overflow is sent to the rougher spirals tails dewatering cyclone overflow pump box. The cyclone underflow is sent to the tailings cyclone cluster feed pump boxes for disposal. These clusters are gravity fed from a height sufficient to maintain adequate pressure.

The rougher spirals tails dewatering cyclone overflow pump box collects both the rougher spirals tails dewatering cyclones overflow and make-up process water. The rougher spirals tails dewatering cyclone overflow pumps take the required quantity of water from the pump box to feed the mill feed chute and the scalping screen pump boxes for density control.

17.6.2 Magnetic Circuit

A combination of LIMS, WHIMS and spirals is used to scavenge iron from the scavenger-cleaner UCC overflow and mids spirals concentrate. The LIMS prevents magnetite from entering the WHIMS stage to ensure the efficient operation and availability of the WHIMS. The WHIMS magnetic intensity is adjusted to maximize iron recovery from paramagnetic minerals. Both LIMS and WHIMS magnetic concentrates are fed to the mag cleaner spiral stage where the settings are adjusted to obtain a concentrate grade good enough to achieve the final concentrate target grade of 4.5% SiO_2.

17.6.2.1 Low Intensity Magnetic Separators Stage

The Low Intensity Magnetic Separators (LIMS) stage is the first stage of the magnetic separation circuit. It is fed by the mids spirals concentrate and the scavenger cleaner up-current classifiers overflow through the LIMS feed pump box and pumps. There are four LIMS installed. The LIMS concentrate goes to the magnetic cleaner spiral banks. The LIMS tails, with almost no magnetite content but still containing hematite, are sent to the Wet High Intensity Magnetic Separators (WHIMS) for further separation.

17.6.2.2 Wet High Intensity Magnetic Separators Stage

There are eight WHIMS installed, two per LIMS. Non-magnetic tails reports to the WHIMS tails discharge point of the machine and is directed to the tailings cyclone cluster feed pump boxes for disposal. The hematite reports to the concentrate discharge point of the machine and is directed to the magnetic (mags) cleaner spirals feed pump box from where it is pumped to the mags cleaner feed distributors.

17.6.2.3 Mags Cleaner Stage

The mags cleaner spirals banks are fed by the LIMS and WHIMS concentrates through the mags cleaner feed distributors which split the feed evenly to each spiral start. There are four mags cleaner spirals banks installed, each having 24 starts. The mags cleaner spirals act as a cleaner separation stage to remove excess silica from high grade feed streams in order to meet the desired final grade. The mags cleaner spiral concentrate is sent to the pan filters while the middlings and tails are fed to the tailings cyclone cluster feed pump boxes for disposal.

17.7 Concentrate Filtration Circuit

The concentrate from the cleaner UCCs, the scavenger cleaner UCCs and the mags cleaner spiral banks is collected into the concentrate collector launders. From there, it goes into a 4-way pan filter feed distributor that splits the feed into four horizontal pan filters, as shown in Figure 17-6 below. The addition of this common 4-way feed distributor results in equal distribution of the concentrate to the operating filters, and in a more stable cake height and moisture on each filter.

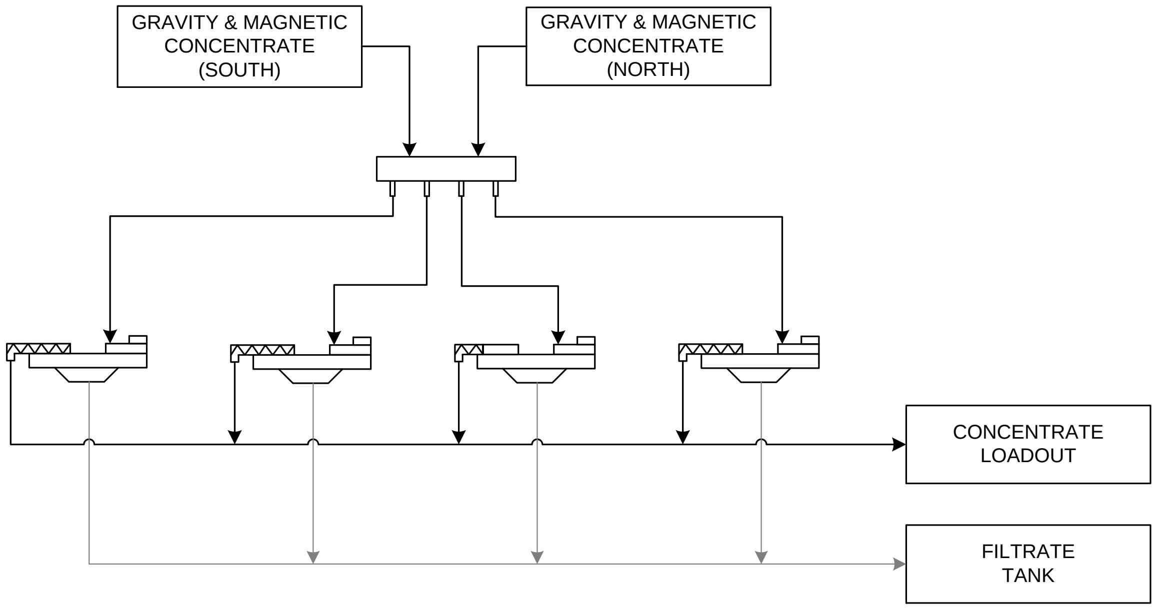


Figure 17-6: Simplified block flow diagram – Concentrate filtration

The filters capacity is 1.7 times the capacity of Phase 1 filters, meaning that three rotary pan filters from a total of four are required for operation at the nominal concentrate tonnage, resulting in no production slowdown when a pan filter has to be stopped for a filter cloth replacement or maintenance.

Vacuum filtration is provided by five rotary-lobe type vacuum pumps (three in operation and two stand-by) connected to a common header. Pressurized air is provided by two dedicated blowers (one in operation and one stand-by). Air goes counter flow to the slurry direction to unclog the pan filter cloths. Each filter is equipped with a steam hood for increased concentrate drying. Rotating screws discharge the concentrate from the filters onto the filter collector conveyor. Filtrate passes through a barometric separation tank (one per filter) and flows by gravity to the filtrate tank. The tank is divided into two sections. The first section separates the water from the iron (iron trap). The iron trap underflow is pumped to the two classification screen pump boxes and is used as dilution water. The iron free water overflow goes into the second filtrate tank section that is used as a buffer to accept process variations. The overflow is converted into process water through the thickener.

There is a by-pass under the concentrate distributor that allows the possibility to send the concentrate onto the floor instead of being filtered. The floor is designed to contain the spill. The floor design collects the solids and redirects the liquid to the main sump nearby. This floor area is used as temporary storage that gives room for material (concentrate or tails) without affecting the normal operation access points.

There is a belt cut sampler installed on the filter collector conveyor. It collects a primary concentrate sample, recovered on the secondary sampler conveyor where a secondary belt cut sampler collects a secondary smaller sample. Material not recovered by the secondary sampler is sent back to the concentrate collector conveyor.

17.8 Load-out Circuit

A basic flowsheet of the load-out circuit is represented in Figure 17-7. The subsections below describe the load-out circuit flowsheet.

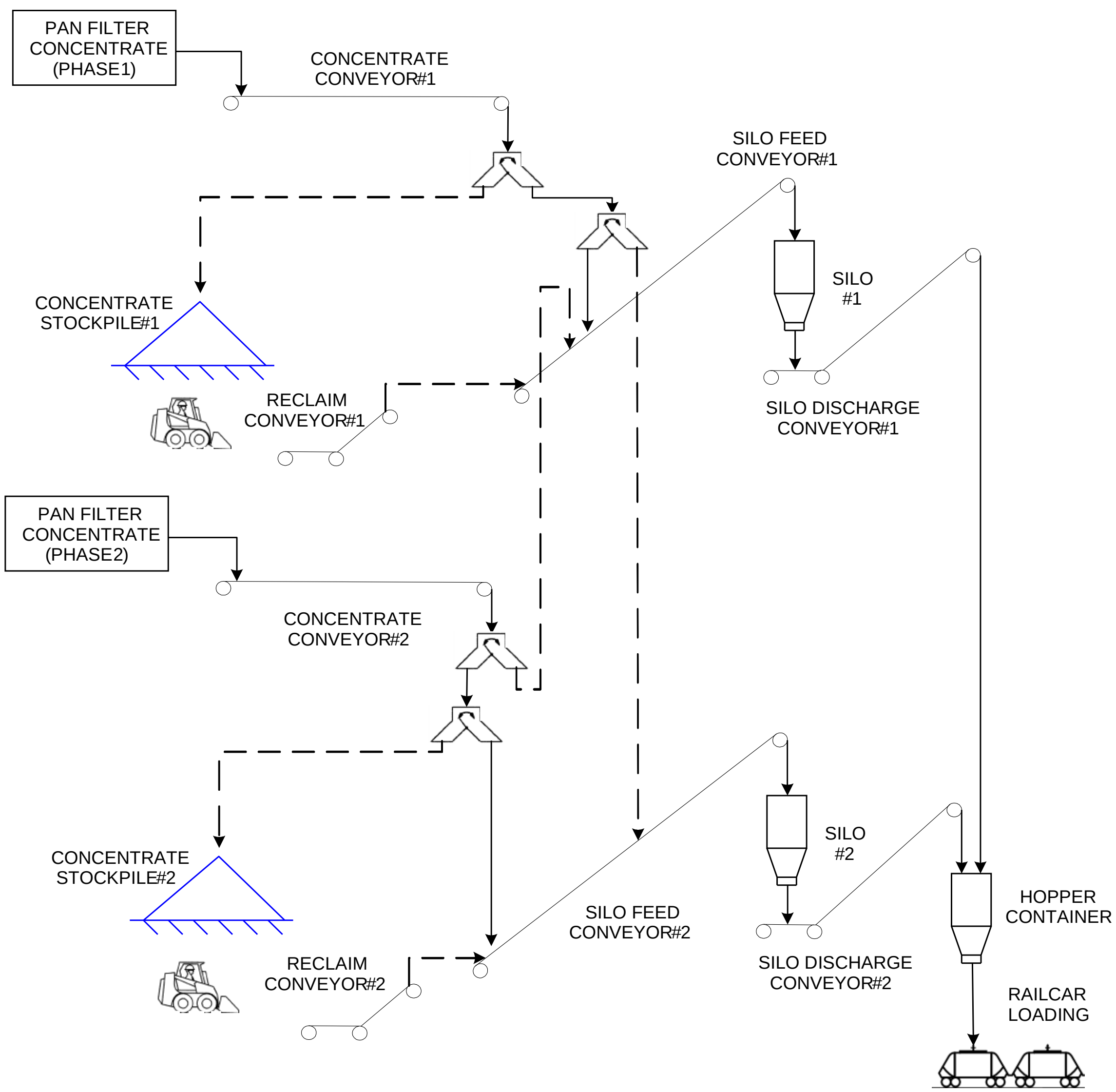


Figure 17-7: Simplified block flow diagram – Load-out circuit

Phase 2 concentrate is transferred from the filter collector conveyor onto the Phase 2 concentrate collector conveyor that leads to the Phase 2 transfer tower. From the Phase 2 concentrate collector conveyor there is a transfer point that enables the transfer of Phase 2 concentrate onto the Phase 1 silo feed conveyor.

From the Phase 2 transfer tower, a diverter box can either send the Phase 2 concentrate to the Phase 2 silo feed conveyor or the emergency stockpile feed conveyor in case the concentrate does not meet the specifications or the concentrate silo is full. Material sent to the Phase 2 80,000 t stockpile can later be reclaimed by feeding it into the reclaim hopper, which feeds the Phase 2 reclaim conveyor that leads to the silo feed conveyor. The Phase 2 concentrate silo, fed by the silo feed conveyor stores the concentrate for later loading onto trains. It has a capacity of 30,000 t. When train loading begins, the four pan feeders located under the silo floor, reclaim the concentrate and transfer it onto the silo discharge conveyor that leads to the Phase 1 hopper and tilt chute for loading into railcars. Calcium chloride is added in the winter months to prevent the concentrate from sticking onto the railcar walls.

17.9 Tailings Circuit

A basic flowsheet of the tailings circuit is represented in Figure 17-8. The subsections below describe the tailings circuit flowsheet.

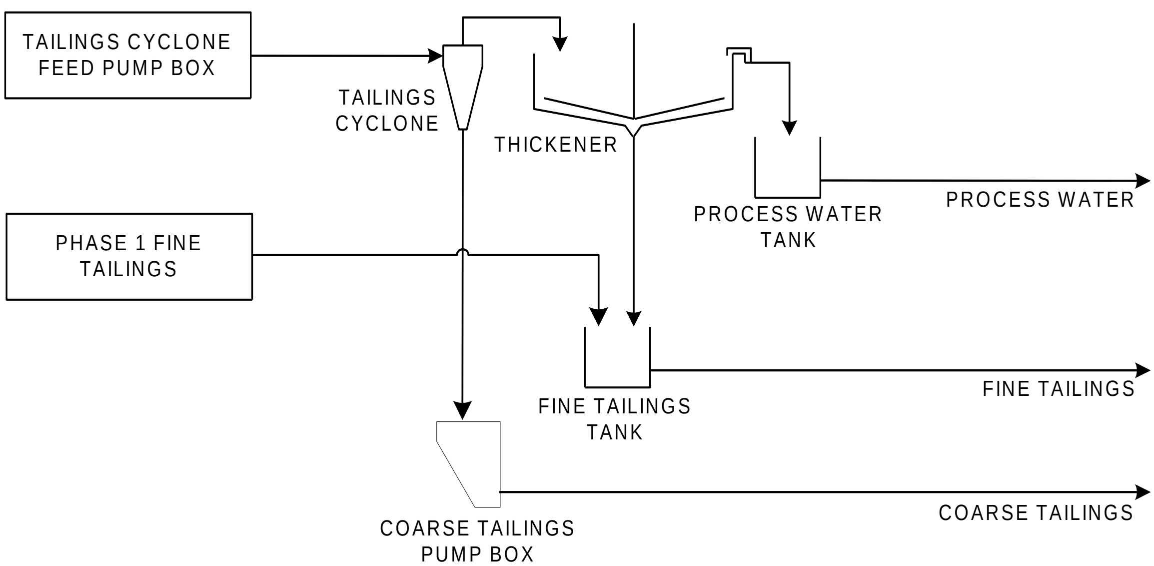


Figure 17-8: Simplified block flow diagram – Tailings circuit

17.9.1 Tailings Thickening Cyclones Stage

The tailings cyclone cluster feed pump boxes receive the rougher spirals banks tails, the rougher tails dewatering cyclone cluster underflow, the mids spirals banks tails, the scavenger spirals banks tails, the WHIMS tails, and the mags cleaner spirals banks tails. From there, the tailings thickening cyclone cluster feed pumps send the slurry to two tailings thickening cyclone clusters. Feed to the cyclone clusters is sampled by primary pressure pipe sampler and a secondary cross-cut sampler. The tailings thickening cyclone clusters are each composed of eight individual cyclones that produce a dense and coarse underflow reporting to the coarse tailings collection box and a fine and dilute overflow that reports to the tailings thickener.

17.9.2 Coarse Tailings Stage

The tailings cyclone cluster underflow (coarse tailings) is gravity fed to a pump box. From here the tailings stream is pumped via a series of coarse tailings pumps to booster stations as it is transported to the coarse tailings storage facility.

17.9.3 Fine Tailings Stage

The tailings thickening cyclone cluster overflow is sent to the tailings thickener feed box where it is mixed with coagulant and the filtrate tank overflow. From there, the slurry flows into the thickener feedwell where it is mixed with flocculant. The tailings thickener's large volume and surface provide time for the fine particles to settle at the bottom of the thickener. The rake mechanism drags the solids towards the centre where it discharges to a series of fine tailings pumps. From there, the material is pumped to the fine tailings tank where it is mixed with Phase 1 fine tailings. The combined fine tailings are pumped through a series of fine tailings pumps to the booster station located a few kilometres away from the concentrator. In the booster station, the material is pumped through a series of fine tails pumps to the fine tailings storage facility.

The thickener overflow, consisting of water containing small quantities of very fine solids, is gravity fed into the process water tank to be reused throughout the concentrator.

The tailings thickener has a surface 2.1 times that of the Phase 1 (QIO) thickener. The increased thickener surface area allows the rise rate to be greatly reduced, which decreases the risk of losing control of the overflow water quality.

Two ramps give access for mobile equipment to the plant main sump (like a Bobcat™ track loader). A designated area beside the main sump (a solids trap) collects the solids from the flush in case of plant shutdown. The trap overflow goes to the main sump. The same concept is applied when the coarse tailings pump box overflows. The solids trap of the filtration area can also be used as a designated area to temporarily store the material when emptying the main sump. These modifications facilitate the removal of material when the main sump is sanded. The trap beside the sump reduces the risk of sanding. The designated temporary storage areas provide room for accumulated material without affecting the normal operation access points.

17.9.4 Tailings Deposition

The fine tailings from the thickener underflow and the coarse tailings from the cyclone underflow are disposed of separately in different settling basins.

17.10 Utilities

17.10.1 Compressed Air

Compressed air required for Phase 2 equipment and services will be supplied by the existing Phase 1 systems via a services pipe-rack connecting the two Phases.

17.10.2 Water Systems

The water distribution system maximizes water recovery and recirculation.

Rougher tails cyclone overflow is recirculated to the grinding circuit to feed the mill feed chute and the scalping screen pump boxes for density control. The number of cyclones in operation is adjusted to the amount of water required. The cyclone by-pass goes to the tailings cyclone cluster feed pump boxes.

Pan filters' filtrate is pumped back to the two classification screen pump boxes and is used as dilution water. The excess filtrate is sent to the thickener.

The rest of the process water is recirculated from thickener overflow. The process water losses are compensated by reclaiming water from the tailings basin overflow. All the process water goes through the process water tank. The tank can be drained and is accessible with mobile equipment if material removal is necessary. The process water is distributed in the plant via two circuits: the low pressure system that feeds the pump boxes and the mill, and a high pressure system that feeds all the other equipment.

The gland seal water tank is fed from the process water tank through water filters. From the gland seal water tank, water is supplied to all the process pumps in the concentrator via three circuits: the low pressure circuit servicing most of the pumps, the high pressure circuit servicing the tailings second and third stage pumps and the booster circuit servicing the process water pumps.

17.10.3 Water Balance

The high level Phase 2 water balance is presented in Table 17-3.

Table 17-3: High level water balance

Parameter	Nominal value	Unit
Input		
AG mill fresh feed	68	m^3/h
Pan filter steam	24	m^3/h
Reclaim water to process water tank	1,072	m^3/h
Output		
Filtered concentrate	35	m^3/h
Thickener underflow (fine tailings)	135	m^3/h
Coarse tailings pump discharge	994	m^3/h
Summary		
Total process water	6,365	m^3/h
Thickener overflow	5,294	m^3/h
Reclaim water to process water tank	1,072	m^3/h

17.10.4 Power Requirements

The peak power requirement for mineral processing of Phase 2 is estimated at 24.9 MW. The major power consumers for the process include the following:

- Gyratory crusher accounts for approximately 2% of the total operating power;
- Conveying accounts for approximately 6% of the total operating power;
- AG mill accounts for approximately 36% of the total operating power;
- Pumping accounts for approximately 49% of the total operating power.

Power requirements including building services are included with infrastructure, as discussed in Chapter 18 of this Report.

17.11 Reporting and Sampling

The sampling strategy is explained as either sampling for:

- Operation monitoring;
- Production reporting;
- Metallurgical performances evaluation.

The use of spot sampling is in response to a specific need to evaluate the efficiency of each piece of equipment or process.

17.11.1 Operation Monitoring

Sampling for operation monitoring purposes is required to estimate the plant production and performance on an hourly basis, and take actions on the process to reach the production and quality target.

The operation monitoring samples are mainly based on three automatic samplers located on the:

- Rougher spiral feed;
- Final concentrate;
- Tailings cyclone feed.

These samplers produce a composite sample every two hours of operation, at which time they are analyzed and provide operators with concentrate quality and plant recovery to guide their actions on the process in order to ensure efficient production of concentrate respecting quality specifications.

Further investigation of the process performance can be achieved using the metallurgical sampling point.

17.11.2 Production Reporting

Sampling for production reporting purposes is required to estimate the plant production and performance on a daily basis. To produce a daily mill report, the information is required from two sources:

- Plant instrumentation;
- Plant automatic sampling.

Plant instrumentation consists of:

- Two weigh scales located on the following conveyors:
  - Fresh feed;
  - Final concentrate.
- One flowmeter on the feed of the tailings cyclone cluster (final tails);
- One density metre on the feed of the tailings cyclone cluster (final tails).

Plant automatic sampling consists of three automatic samplers located on the:

- Rougher spiral feed;
- Final concentrate;
- Tailings cyclone feed.

The plant automatic samples, combined on a 12-hour shift basis, are submitted to chemical assay and results are used in the calculations to produce a shift and daily mill report.

17.11.3 Metallurgical Performance Evaluation

Manual samplers or sampling point accesses will also be installed on critical streams for metallurgy performance evaluation and optimization. Sampling points will be provided on the North and South lines of the plant. These sample points enable the evaluation of:

- North and South lines individually;
- Every separation unit;
- Individual concentrate sources:
  - Cleaner UCC underflow;
    - Scavenger cleaner UCC underflow;
    - Mags cleaner spirals concentrate.
- Other critical streams, such as the rougher spirals concentrate and scavenger spirals concentrate.

The selection of these sample points enables the production of a detailed mass balance of the gravity circuit.

18. PROJECT INFRASTRUCTURE

18.1 Mine Infrastructure

The entire mine infrastructure used for the current mining operations will be upgraded to the new mine plan requirements. Most of the required infrastructure is already constructed with a few new additions/modifications which will be required. The facilities breakdown is detailed in Table 18-1.

Table 18-1: Mine infrastructure

Infrastructure	Condition (existing or new/modified)
Mine maintenance garage (Phase 1)	Existing
Mine maintenance garage (Phase 2) 2023	New
Garage SMS Secondary truck maintenance	New
Truck wash bay	Existing
Fuel storage and distribution system	Existing
Mine electrical infrastructure	New
A cafeteria at the West Pit (to minimize lost time for truck drivers' breaks)	Existing
Spare parts containers located around the site to store drilling equipment, surveyor equipment and environmental equipment	Existing
Mobile shovel bucket repair shop	Existing
Dispatch system, complete with trailers, offices and a cafeteria	Existing
Aggregates crusher plant (contractor)	Existing

18.2 Infrastructure Located on Site

The vast majority of the required infrastructure for Phase 2 is available and currently used for Quebec Iron Ore operations. Figure 18-1, on the following page, shows the location of the major infrastructure located at the Bloom Lake site.

The process plant building required for Phase 2 has already been constructed and certain equipment has already been installed. The structure is complete and the building walls have been closed. The building footprint is 63 m x 138 m and is 58 m at its highest point. The constructed process plant building is shown in Figure 18-2.

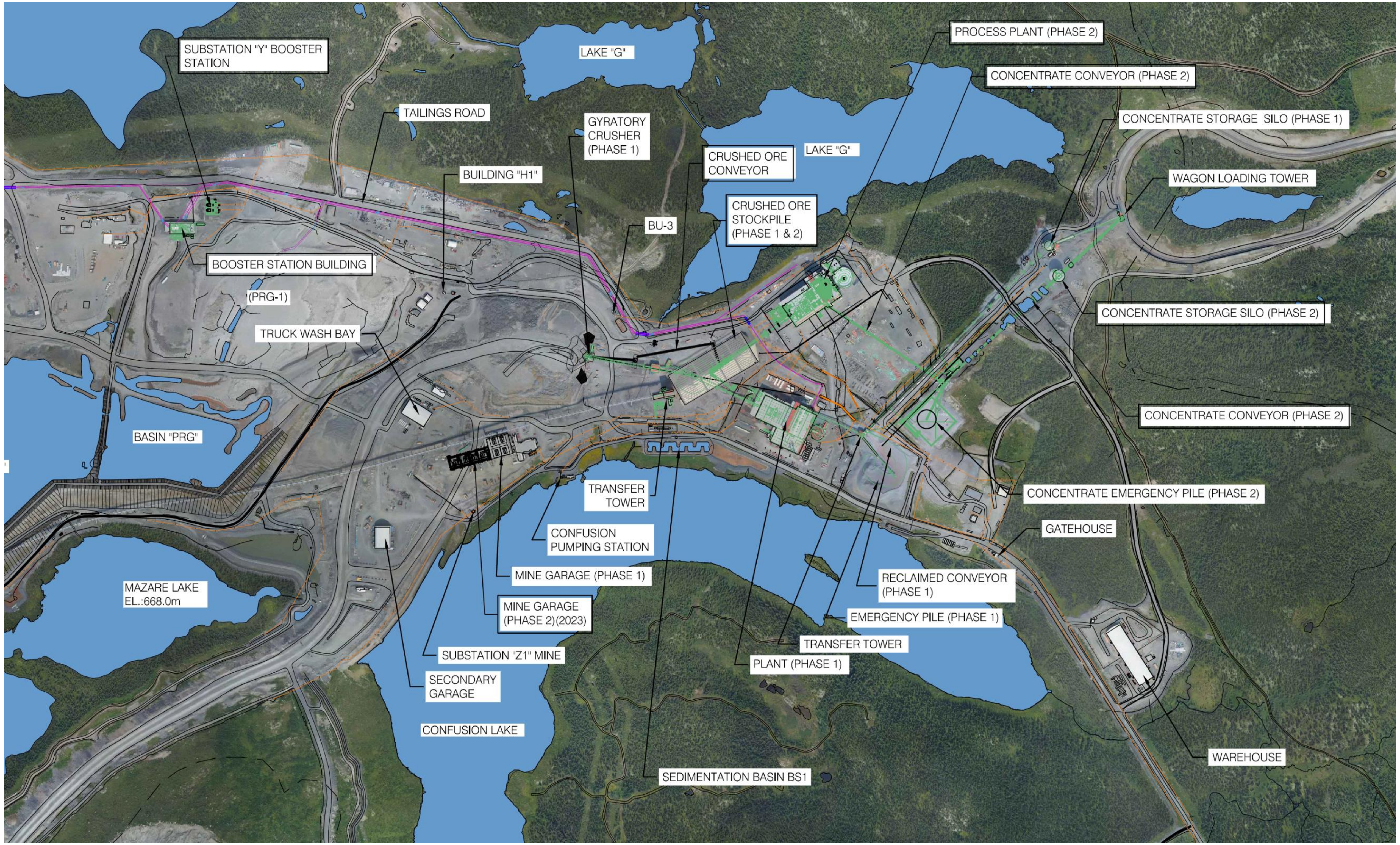


Figure 18-1: Major infrastructure located on the Bloom Lake site

Figure 18-2: Constructed Phase 2 process plant

18.3 Operation Infrastructure

18.3.1 Train Loading Station

Concentrate produced in the Phase 1 plant is currently discharged to a series of conveyors and transported to a 24,000 t silo at the train load-out station. The train loading station will fill one 240-railcar (100 t capacity railcars) train. The Phase 2 expansion will involve the addition of a second silo having a capacity of 30,000 t and linked to the existing load-out station. A series of conveyors will allow both plants to discharge their concentrate in both silos allowing greater operational flexibility.

A dedicated calcium chloride system is in place to store and dose the addition of the freeze protection solution on the bottom and top layer of each railcar. This prevents freezing of the concentrate in the railcar and unloading difficulties in case of an unplanned delay of the rail transport during the winter. The interior of the railcars are also sprayed in order to reduce carry-back of concentrate during the transportation process.

No significant modification is planned for the existing train loading facilities apart from the connection of Silo 2 to the load out, integration of the second silo conveyor inlet and some minor systems improvements to the existing train loading facilities.

18.3.2 Rail Infrastructure

The rail network consists of three separate segments to transport iron ore concentrate from the mine site to the port.

1. **First segment** of rail referred to as the Bloom Lake Railway (BLR) consists of a 32 km long segment that connects the mine site to the Quebec North Shore and Labrador (QNS&L) railway at the Wabush Mines facilities in Wabush, Labrador.
2. **Second segment** uses the QNS&L railway from Wabush to Arnaud junction in Sept-Îles, which has a mainline track of approximately 395 km.
3. **Third segment** is from Arnaud junction to Pointe-Noire (Sept-Îles), which is the property of SFP Pointe-Noire (SFPPN).

The QNS&L railway will also require investments to rehabilitate the existing sidings and procure new locomotives to carry the upgrade train fleet.

The current fleet is composed of 735 insulated ore cars dedicated to move Bloom Lake concentrate. As part of the expansion, QIO will require an extra 450 railcars for a total of four long trains (240 railcars) and one short train (168 railcars). A 5% spare fleet allowance is considered to provide reliable operations.

The proposed changes are summarized as follows:

Pointe-Noire Terminal

An additional rail track is proposed at the Pointe-Noire terminal siding link next to the three existing tracks comprising what is referred to as the "Bloom Yard". This track would be connected, at its southeastern end, to the other yard, called "Wabush Yard". This new siding would mainly be used as a stabling track for other user's trains, before and after unloading at Wabush Yard.

One of the major changes in operations is related to the dumper track at the Pointe-Noire Terminal. The expansion project involves unloading the 240-car train by cuts of 82 cars instead of 55 cars as is currently performed. This modification reduces the unloading cycle time to maximize the car dumper capacity. To achieve this, the existing track must be extended after the dumper and will also be realigned due to stockpile area modifications. This will also require the bypass track to be lengthened on the western side of the dumper. This modification allows empty cars to be moved out of the dumper area while empty cars are sitting before the dumper. The bypass will be extended by a length equivalent to at least 27 cars, and the existing turnout must be relocated.

Arnaud Junction

The three stabling tracks on the southern side of Arnaud junction, which are referred to as the Wabush tracks, have to be extended to be able to hold trains of two locomotives and 164 cars. The current length of these tracks allows only trains of 124 cars, which is not acceptable for future operations.

Bloom Lake Railway

At Bolger Yard there are currently two sidings, one on the west side and one on the east side of Jean River, which can hold, respectively, a train of 76 and 164 cars. To allow stabling trains of 240 cars at this location, which will be necessary when operating the two processing plants, the two sidings will be connected by a bridge over Jean River.

18.3.3 Port Infrastructure

The concentrate is unloaded from railcars at Pointe Noire, which is owned by SFPPN and controlled by the Government of Quebec, and can be either loaded directly onto a vessel or stockpiled to be reclaimed and loaded at a later time. The former Cliffs / Bloom Lake concentrate stockpiling and shipping system is comprised of a rotary car dumper, dump hopper, stockpiling and reclaiming conveyors, a stacker-reclaimer, and ship loaders. Storage capacity is currently 500,000 tonnes of concentrate in the stockpile yard. As part of the expansion project, the infrastructure must be upgraded to accommodate an average yearly throughput of 15 Mt of concentrate. To allow efficient and reliable operations, modifications will be performed to increase the stockpiling capacity, reduce the railcars unloading cycle and increase the stacking and reclaiming performance.

The current Bloom Lake concentrate production is loaded onto vessels using the Port of Sept-Îles' new multiuser terminal linked to the SFPPN terminal. The dock has a capacity of 50 Mtpy via two 10,000 tph travelling ship loaders. Dock 35 is mostly used by QIO to load capesize vessels and will remain the infrastructure commonly used for Phase 2 production. Smaller vessels can be loaded using Dock 36 while Dock 35 can accommodate bigger than capesize vessels, if required, granting flexibility to adapt to customer's needs. The current agreement between Champion Iron and the Port of Sept-Îles allows QIO to load 10 Mtpy of concentrate using the current port infrastructure. Champion Iron is currently negotiating an agreement with another user of the SFPPN terminal in order to acquire an extra 6 Mtpy capacity in order to allow for the additional production from Phase 2 operations.

The infrastructure modifications required for Phase 2 operations can be seen in the port site plan in Figure 18-3. The summary of the port modifications is as follows:

- Dismantling of the existing rail segment located after the rail dumper;
- Excavation, blasting and back-fill to support the new rail segment that will be installed after the rail dumper;
- Move the existing access road for Port de Sept-Îles and Aluminerie Alouette;
- Construction of a new site service road;
- Relocation of the aqueduct network;
- Relocation of the 25 kV electrical line;
- Relocation of the Telus telecommunications infrastructure;
- Construction of new culverts;
- Addition of a new stacker-reclaimer;
- Extension of conveyors CV-2 & CV-3 by 300 m;
- Addition of 600 hp motors on conveyors CV-2 & CV-3.

In order to allow the unloading, handling and storage of two train loads of 240 wagons per day, the existing exit from the rail dumper will be renovated to extend the rail and conveying systems (CV-2 and CV-3). Along with being extended, conveyors CV-2 and CV-3 will require more powerful motors due to the increased duty.

The aforementioned modifications will allow for the current concentrate stockpile to be extended allowing for a total of 94,000 tonnes of concentrate to be stored. In order to obtain the desired minimal storage capacity of 1.5 M tonnes of concentrate (10% of the average yearly production), a second stockpile of 850,000 tonnes will be required for Phase 2. The stockpile will be located to the south of the existing stockpile.

The modifications required for the rail, conveyors and stockpile will also impact several facilities belonging to third parties. A portion of a site access road, aqueduct network, 25 kV electrical line and a telecommunication tower will need to be relocated. Constructing additional access roads, water drainage and installation of protective guard rails will also be required due to site topography.

The new design will allow for ship loading activities to be performed at the same time as fresh concentrate from trains being stacked. This operational flexibility is achieved through the installation of a second stacker-reclaimer at the shipyard. The new stacker-reclaimer bucket angle will reduce the dead zone of concentrate located at the bottom of the pile. This will reduce the current manual manipulation of concentrate and thus facilitate the operability of the stockpiles.

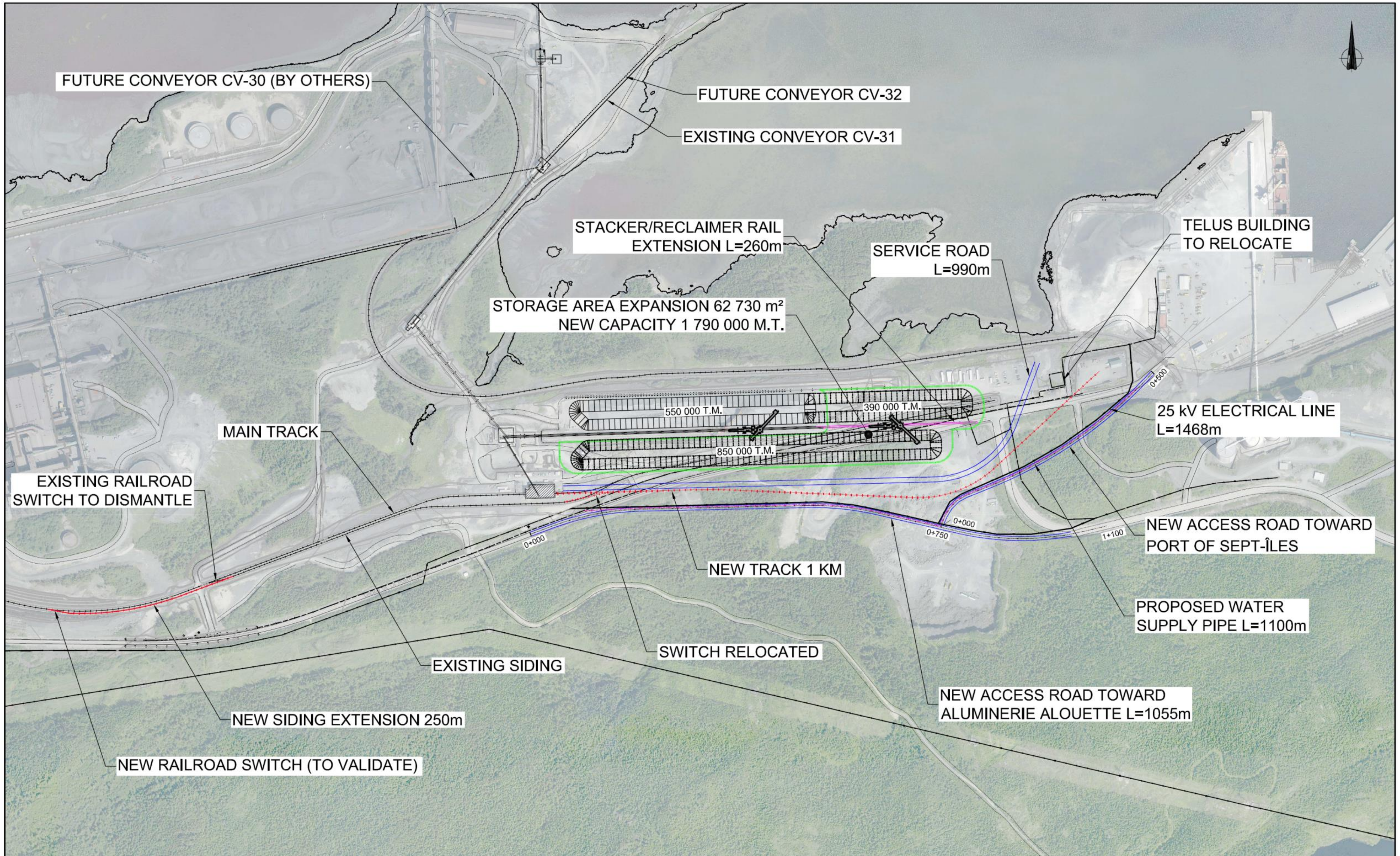


Figure 18-3: Port modifications required for Phase 2

18.3.4 Electrical Substation and Site Power Distribution

The electrical power for the Project is supplied by Hydro-Québec from a T-tap off the 315 kV transmission line L3039 (Montagnais-Normand), which terminates in an existing 315-34.5 kV substation (Substation W) owned by QIO and feeding the existing concentrator plant and mine site.

Substation W is located along Provincial Route 389 and includes two 315-34.5 kV, 48/64/80 MVA oil-filled, power transformers. The power transformers are fed through outdoor-type 315 kV air-insulated disconnect switches and SF6-insulated live-front circuit breakers connected with overhead conductors and busbars in a single-bus configuration. The commercial power metering is done downstream from the incoming 315 kV breaker. A 34.5 kV gas-insulated switchgear (GIS) is used to feed the various 34.5kV distribution lines.

The two 34.5 kV distribution lines will be modified to become two double-circuit overhead lines (circuits A, B, C and D) that connect Substation W to the new and existing concentrator plants. The overhead lines are installed along Provincial Route 389 and main site access road and are approximately 10 km long. Two 34.5 kV distribution overhead lines come from the HQ Normand substation to provide backup power supply to the QIO distribution system, in case of contingency. An additional overhead 34.5 kV distribution line (approximately 5 km long) will derive from Substation W to feed the new and existing electrical installations in the mine area directly and independently from the plant area.

The independent 34.5 kV mine distribution network will be added to provide increased reliability for the mine power supply. It will supply three (one new and two existing) 34.5-7.2 kV, 7.5 MVA fixed mine substations strategically located on the perimeter of the mine pit to supply 7.2 kV power to the mining and pumping equipment in operation. The 7.2 kV network (pit lines and trailing cables) will be designed in compliance with the Canadian Electrical Mining Code CSA M421-16.

The new process plant areas will be fed from a 34.5 kV GIS already installed in the new concentrator main substation (Substation B Area 2600). All other areas will be fed from local substations connected to the 34.5 kV GIS via overhead lines or power cables.

The forecasted peak power demand of the entire installations should not exceed 90 MW, with an average power demand of approximately 70 MW, excluding the 22 MW electrical boiler that will be used on non-firm power.

18.3.5 Non-Process Buildings

The existing 2,485 m^2 (35 m x 71 m) service building attached to the Phase 1 concentrator building provides the following services:

- Maintenance shops;
- Unloading and warehousing completely stocked with parts and supplies;
- Electrical/instrument repair shop;
- Boiler plant to provide steam to both plants for heating and filter cake drying. The boiler plant also hosts the boiler water treatment system;
- Offices for administration, purchasing, human resources, technical services (engineering and geology), training and plant operating personnel;
- Laboratory equipped for metallurgical test work, wet and dry assaying;
- Lunchroom, men and women change rooms, sanitary and locker facilities;
- Communications room;
- Compressor room to provide service air and instrument air to both concentrators;
- Fresh water storage tank and water treatment facilities;
- Electrical room.

Other non-process buildings:

- Eight various utility domes used as warehouses or shops for contractors.

18.3.6 Shop and Warehouse

The service building warehouse floor area covers an area of 630 m^2 (21 m by 30 m) and is 9.5 m high. Trucks to be unloaded will descend a ramp to bring the truck bed level with the loading dock and floor inside the warehouse. Another warehouse is located at the entrance of the mine site. The dome type building covers an area of 5,600 m^2. Half the building is currently insulated and organized to host large parts. The remaining half of the building will be insulated to maximize heat conservation within the warehouse. A fenced outdoor warehouse yard surrounds the dome building and has an area of 20,000 m^2 that is used to store bulk and large materials.

18.3.7 Utilities Area

The 820 m^2 utilities area includes the boiler room, fresh water storage tank and water treatment, blower and compressor rooms and the emergency MCC room. The emergency generator is located outside the service building; in this study, an existing second generator will be overhauled to feed emergency power to the new plant.

Two 50 MBtu/h light fuel oil #2 water tube boilers and one 22 MW electrode boiler supply high pressure steam to the concentrate filters and to the hot water heat exchangers for building heating.

Phase 2 plant services such as steam, compressed air and domestic water will be delivered from the Phase 1 plant through a utility pipe rack. In each plant, two 14 MBtu/h glycol boilers are used to provide heating energy using light fuel oil #2. At peak load, the electrode boiler will provide sufficient process steam for both plants and fuel oil steam boilers will be used as backup.

18.3.8 Emergency Vehicle Station

The emergency vehicle station is sized for an ambulance and one fire truck. The first-aid station is located next to the Phase 1 plant.

18.3.9 Offices, Change Rooms and Lunchroom

An office space of 1,379 m^2 for administration, human resources, accounting, purchasing, engineering, plant operating and maintenance personnel has been provided on the second floor of the service building. Washrooms and a fully equipped first aid room are also located on this floor.

Offices along the outer walls have windows. There is direct access from the offices to the concentrator operating floor. Men's change rooms, showers and toilets are located on the ground floor while women's change rooms, showers and toilets are on the first floor. A lunchroom is located on the first floor.

For Phase 2 operations there will be a dry house and lunch room next to the concentrator in order to minimize transportation time. Phase 1 facilities will be used in the event of peak/unexpected demand.

18.3.10 Laboratory

The processing and analysis from the Phase 2 (QIO) concentrator samples will be shared between Phase 2 (QIO) sample preparation laboratory and Phase 1 (QIO) main laboratory.

The main laboratory is located on the ground floor of the Phase 1 (QIO) concentrator and has 266 m^2 of floor space for the preparation and analysis of samples by wet methods and X-ray fluorescence (XRF). The preparation area is equipped for splitting, drying, crushing, grinding, screening and filtering of samples from both the mine and the concentrator. A dust collection system is provided in the preparation area. Fume hoods are installed in the wet assay room, and a storage room with shelving is provided for samples and supplies. There is also direct access from the laboratory to the Phase 1 concentrator.

The Phase 2 (QIO) sample preparation laboratory is located in the Phase 2 (QIO) concentrator building. Process samples from Phase 2 (QIO) will be prepared in this laboratory and shipped to the main laboratory for analysis by wet methods and XRF using an air tube dispatch system. This preparation laboratory will be equipped for filtering, drying and splitting of samples from the Phase 2 (QIO) concentrator.

18.3.11 Heating, Ventilation and Air Conditioning

Systems are designed for outdoor temperatures of -40°C in winter and 17°C in summer, and inside temperatures of 19-21°C. Fresh air changes vary from one in the offices to ten in change rooms.

The shops, warehouse and concentrator are heated with hot water from the boiler plant by a central system for each sector, which includes a supply fan, return exhaust fan, heating coil, filter and air to air energy recovery system.

The office, laboratory and lunchroom are air conditioned by a variable volume central unit with a 700 kW steam heating coil and a 40-ton roof-mounted cooling unit. Heating of cold perimeter areas is supplemented by using electrical baseboard heaters.

A steam heater is installed near each garage door in the service building and concentrator to compensate for the heat loss through air infiltration in winter.

In the new plant, heating is provided by glycol heaters and some electric unit heaters. Ventilation is supplied by central and local systems, which includes supply fan, return exhaust fan, glycol heating coil and filter.

18.3.12 Water Distribution and Drainage Network

Hot and cold water is distributed to all sanitary facilities in the concentrator building. Cold water is also distributed to the mine offices.

Emergency showers and eye-washes are installed in the laboratory, shops, and at the flocculant preparation area in the concentrator.

Water used for the wash bay operations is recirculated through settling basins with oil skimmers and reused until it allows for good washing operations. Oil and grease are recovered and disposed of off-site on a regular basis by an authorized contractor as it is the case for the non-recyclable oily waters.

Drainage from shop repair bays is collected in a gutter and pumped on a regular basis to be disposed of off-site by an authorized contractor.

18.3.13 Access and Site Roads

The sole access road to the Bloom Lake deposit is from Highway 389. A security station and a barrier gate are located at the end of the 5 km access road leading to the mine site. Other roads have been constructed from the concentrator to the mine, the crusher, along the route of the tailings line and to the freshwater collection point at Bloom Lake.

18.3.14 Fresh Water Supply

Fresh water is required for make-up to the boilers and for domestic consumption. Fresh water is supplied to the fresh water tank at the concentrator by gravity flow from Bloom Lake through a 1.5 km long, 152 mm diameter high-density polyethylene (HDPE) pipe.

18.3.15 Reclaim Water Supply

Reclaim water is pumped from the decanted water into basin *RC-2*. There are three 700 hp pumps mounted on separate barges. Each pump is capable to meet the demand of one concentrator; therefore, two pumps will be used to provide water to Phase 1 and Phase 2 plants and one pump will be on stand-by.

The pipeline is constructed of 610 mm diameter HDPE pipes (approximately 4.5 km long) and is buried. The reclaim water pipeline will terminate at the process water reservoir outside each concentrator.

Reclaim water is also supplied to the booster pumphouse 1 (BPH1) for gland seal and tailings lines flush water. A new dedicated pipeline will be installed between the reclaim water barges and the BPH1 to provide high flow water for rapid tailings line flushing. This dedicated flush water line will use the backup reclaim water pump.

18.3.16 Fire Protection

The fire protection system includes fire water pumps, a fire water distribution network, fire water hose stations and water sprinkler systems.

A water sprinkler system is installed over covered conveyor belts and over the lubrication and hydraulic systems in the process areas.

Fire water pumps are located in a pumphouse and source water from the Confusion Lake. There are three pumps, two main pumps and one jockey pump to maintain the pressure in the fire water pipe network. One of the main pumps is driven by an electric motor and the other by a diesel engine, complete with controls for automatic starting.

Alarm signals are automatically transmitted to the security station in the service building.

18.3.17 Fuel Storage

Number 2 light fuel oil and gasoline is delivered to the site by road tanker and then delivered to one of the six 50,000 L fuel storage tanks.

A 50,000 L gasoline storage tank and fuel station for pick-up trucks and other vehicles is located in the storage tank area.

Fuel for heating of the Phase 2 concentrator will be stored in two new 50,000 L tanks installed beside the plant.

18.3.18 Effluent Water Treatment

A water treatment plant (WTP) is in place and is designed to comply with all regulatory and permitting standards. The treatment plant can treat effluent water from various sources and handle contact water coming from any basins present on the site as well as any type of runoff waters collected and pumped into tailings facility basins. All recirculated water not required for the concentrator process can be discharged to the environment by the WTP at a capacity of 75,000 m^3/day, which is more than adequate to accommodate the needs on a yearly basis. A WTP upgrade is planned to manage extra water from the planned expansion of the tailings deposition area and the south dump.

18.4 Tailings and Surface Water Management

18.4.1 Surface Water Management

18.4.1.1 General Concept

The site's surface water management infrastructure is used to collect the process and run-off waters generated throughout the site, to prevent any unauthorized discharges to the environment and ensure sufficient water supply to the mill. This water is contained in a system of retention basins that is eventually transferred to basins *RC1* and *RC2*. The water is then either recirculated to the mineral processing plants or discharged into the environment after being treated in the water treatment plant. Figure 18-4 and Figure 18-5 present the global water management system with the final deposition areas as planned in operation

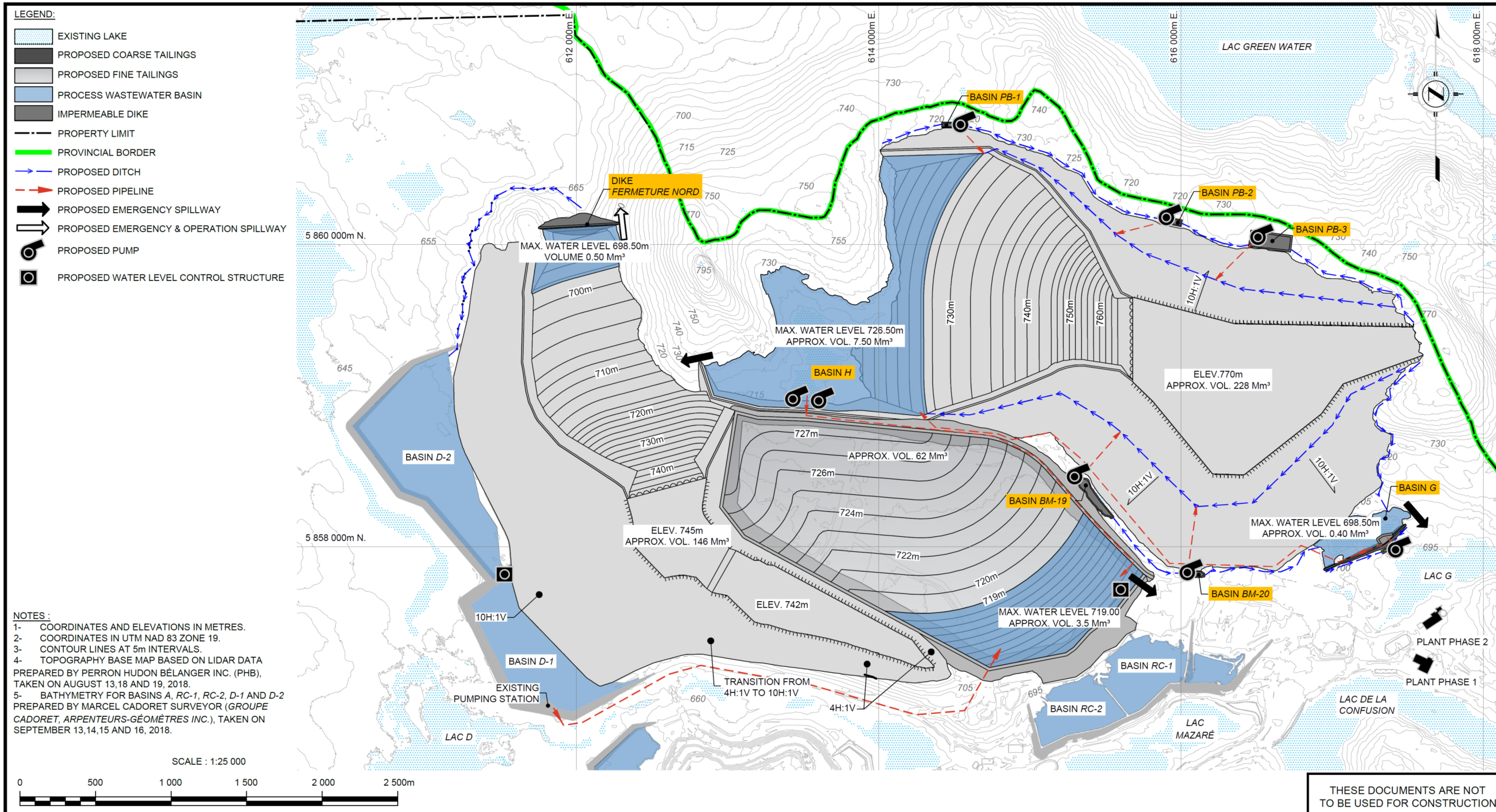


Figure 18-4: Water management infrastructure – Tailings storage facilities

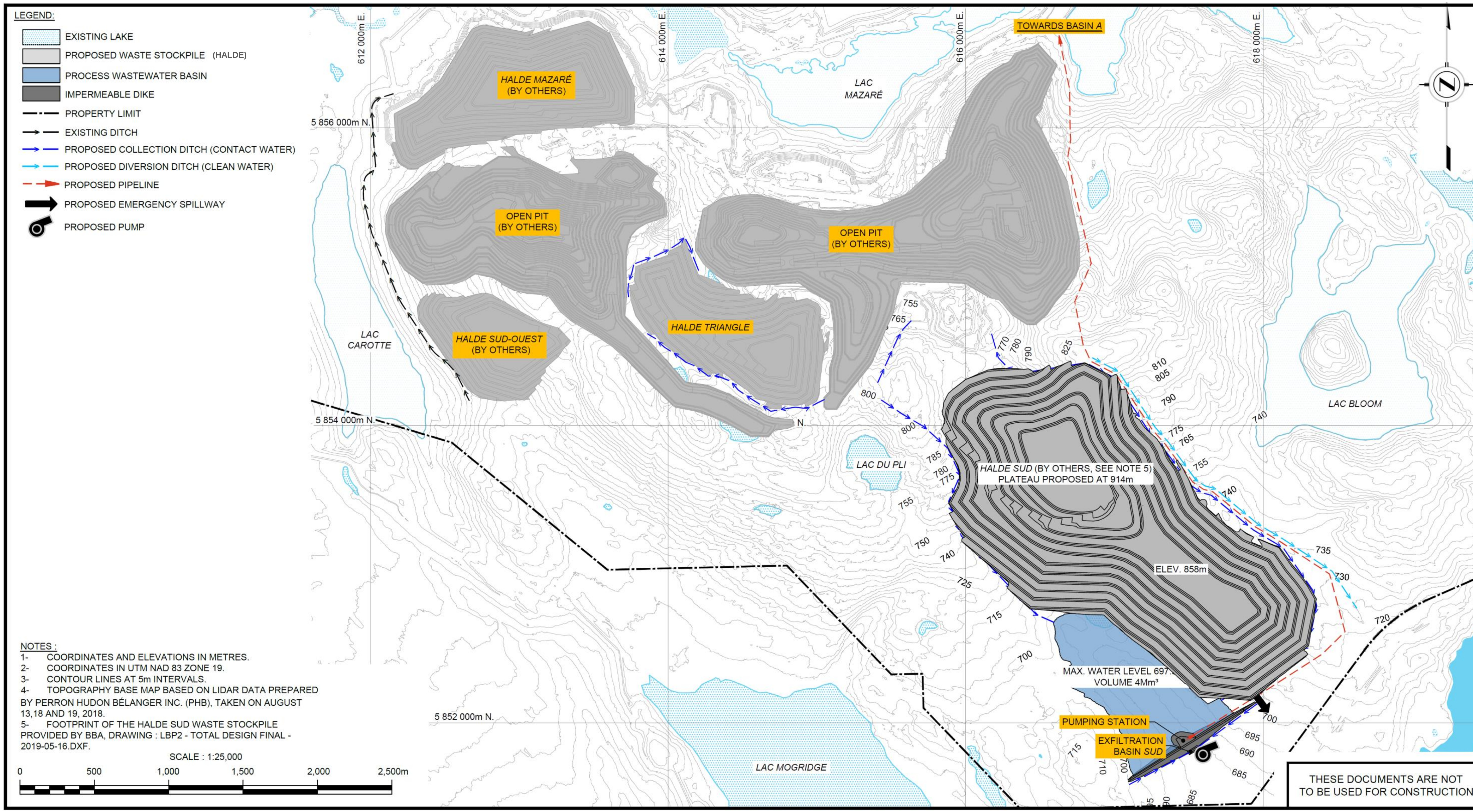


Figure 18-5: Water management infrastructure – Waste rock and overburden facilities

18.4.1.2 Design Criteria

The design criteria for surface water management respect the various laws and regulations in Canada. These laws and regulations, as well as guidelines used to design the water management structures, are listed in Table 18-2.

Table 18-2: Applicable laws, regulations, and guidelines

Item	Laws, regulations, and guidelines	Government division and other associations
1	Loi sur la qualité de l'environnement (April 2019) Specifically: Art. 22 (certificate of authorization) for the construction or modification of a tailings dam	Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC)
2	Directive 019 sur l'industrie minière (2012) Specifically: Section 2.9 regarding tailings confinement	MELCC
3	Guide et modalités de préparation du plan et exigences générales en matière de restauration des sites miniers au Québec	Ministère des Ressources naturelles (MRN)
4	Loi sur la sécurité des barrages (S-3.1.01)	MELCC
5	Règlement sur les effluents des mines de métaux et des mines de diamants (DORS/2002-222)	Environment et Changement Climatique Canada
6	Loi sur les pêches (R.S.C., 1985, c.F-14)	Fisheries and Oceans Canada
7	Code de pratiques écologiques pour les mines de métaux (2009).	MELCC
8	Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities (2011) – Operations guide	The Mining Association of Canada
9	A Guide to the Management of Tailings Facilities (2017)	The Mining Association of Canada
10	Dam Safety Guidelines (2007) Dam safety best practices	Canadian Dam Association

The Bloom Lake iron ore tailings are non-acid generating. As specified in *Directive 019 sur l'industrie minière* (MELCC, 2012), all water management structures associated with non-acid generating tailings and mining waste storage facilities must be designed to manage the project's flood event. Two types of water management structures are defined in *Directive 019*: water-retaining structures (dams or dikes with associated reservoirs) and structures without retention (ditches and small pumping basins). Each type is designed according to a specific project flood.

The project flood, which must be contained by the water-retaining structures, is defined as the contact water volume generated during a 30-day period by a spring melt event, with a 100-year return period, combined with the contact water volume generated by a 24-hour rain event, with a 1,000-year return period.

All non-retention water management infrastructure that do not have a permanent ability to retain significant water reserves must be designed to safely manage and convey the flows generated by the worst case of the two following scenarios: a rain event with a 100-year return period, or a 30-day-snowmelt with a 100-year return period.

In the ensuing decades, Climate Change is expected to increase precipitations in Quebec, particularly in its northern inland regions where the mine is located. The effects are predicted to particularly increase the intensity of short-duration rain events (i.e. less than 1 day), but significant increases to annual precipitation accumulations and snowpack formations will likely occur as well.

To establish the project flood, WSP used climate data published by Environment Canada for the Wabush airport weather station.

The potential effects of Climate Change were therefore factored in when establishing design weather events using mark-up factors. For short-duration events, a mark-up of 18% was used, as recommended by Mailhot et al. (2014). Regional stream flow forecasts, provided by CEHQ (2018), were used to establish mark-ups of 8.0% and 8.7% for snowpack formations and annual precipitations, respectively

Emergency spillways are designed to safely discharge a Probable Maximal Flood (PMF) occurring after a project flood.

Ditches will be built at the toe of each impervious dike, as the dikes are erected. These ditches will collect and convey into pumping basins both the exfiltration and the contact water generated on the downstream slope of the dikes. An adequate pumping capacity is specified for each pumping station to return the water to the main water management system.

To ensure operational performance in all conditions, all pumping stations will be equipped with emergency power generators. In addition, all major pumping stations (basins *Sud*, *G* and *H*) are to be equipped with redundant pumps. This will increase reliability and provide a full robustness to the water management operation. For the other pumping stations, spare pumps will be available in a warehouse to allow for a fast response in cases of unplanned maintenance or emergencies.

18.4.1.3 Design Parameters

The design parameters used to elaborate the design of the water retaining impermeable (dike *Sud*, dike *Fermeture Nord* and dike *G*) and permeable (dike *H*) dikes are specified Table 18-3.

Table 18-3: Design parameters for water retaining dikes

	Impermeable dike	Permeable dike
Freeboard (m)	4.0	3.5
Core composition	Till	N/A
Upstream slope (H:V)	2.5:1	3:1 (excluding coarse tailings beach)
Downstream slope (H:V)	2.5:1	3:1 (excluding coarse tailings beach)
Crest width (m)	10.0	15.0
Emergency spillway	Yes	Yes

18.4.1.4 Existing Water Management Infrastructure

Ditches and Pumping Stations

The existing surface water management system that collects and conveys the contact and process water is currently operational and is considered appropriately designed for current and future conditions. Some minor upgrades will be implemented to improve the reliability and robustness of the system.

Water Treatment Plant

As the site's footprint increases with the expansion, the amount of contact water generated is expected to increase. This necessitates a progressive increase in the site's treatment capability. The existing water treatment plant (WTP) is currently able to treat when the temperature is above 0°C at a rate of 75,000 m^3/day. To be able to manage the extra amount of water coming from the commissioning of the *Halde Sud* waste stockpile, the WTP will first be winterized to be able to treat year-round at the same rate. Once the *HPA-Nord* tailings storage facility (TSF) is commissioned, the treatment rate will need to be doubled (150,000 m^3/day). The existing building, which shelters the treatment plant, was built large enough to accommodate these upgrades.

***HPA-Ouest* and *Sud* TSFs**

As the current *HPA-Ouest* and *Sud* TSFs will expand during the operation, the water management system in this area will also need to be expanded. The construction of an operation ditch is necessary to redirect the reclaim water from the west of *HPA-Ouest* towards the existing basin *D2*. By 2023, to contain the water at the limit of the TSF, the dike *Fermeture Nord* will be constructed. The foundation of the dike's core will be built on injected and treated bedrock. Due to the increases in water and coarse tailings levels, the dike will be raised in two phases with a centreline method. Figure 18-6 presents the typical cross-section of dike *Fermeture Nord.*

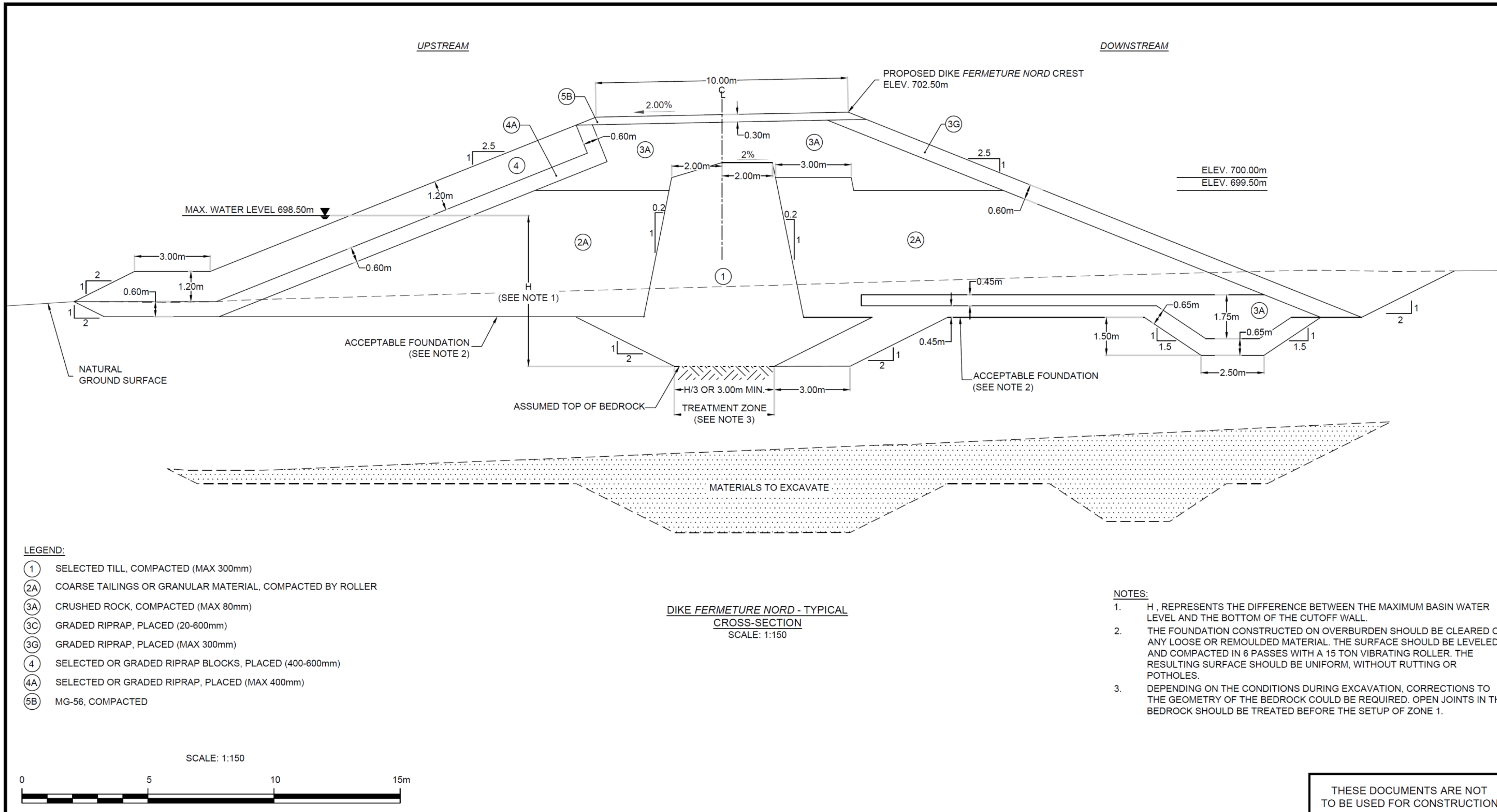


Figure 18-6: Typical cross-section – Dike *Fermeture Nord*

A spillway, designed for both operational and emergency purposes, will be constructed at each phase to allow for controlled gravitational discharges, while protecting the dike from overtopping during extreme weather events. The spillway will lead to the existing ditch, which drains into basin *D2*. Basin *D2* drains towards basin *D1* via a control structure. Basin *D1* is pumped to basin *A*, as is the current protocol.

Basin *A*

The existing water management system within basin *A* is both adequately designed and operational. Due to the deposition of fine tailings, existing dike *A* and its water transfer structure will require raises to increase the maximum water level and thus maintain a design flood storage capacity. The volume of fine tailings to be produced with the expansion will, however, necessitate a final crest elevation of dike *A* higher than what was initially designed. The initial design consisted of a centreline raise of the till core, up to a final elevation of 715 m to 718 m with a width crest of 21 m. To respect this design, the dike will be raised using a centre line raise up to the initially designed maximum crest elevation. To eventually exceed this limit, a subsequent downstream raise method with an inclined till core will be used until the planned final crest elevation of 722 m. This will ensure that the final crest width of 21 m is maintained. A typical cross-section is presented in Figure 18-7.

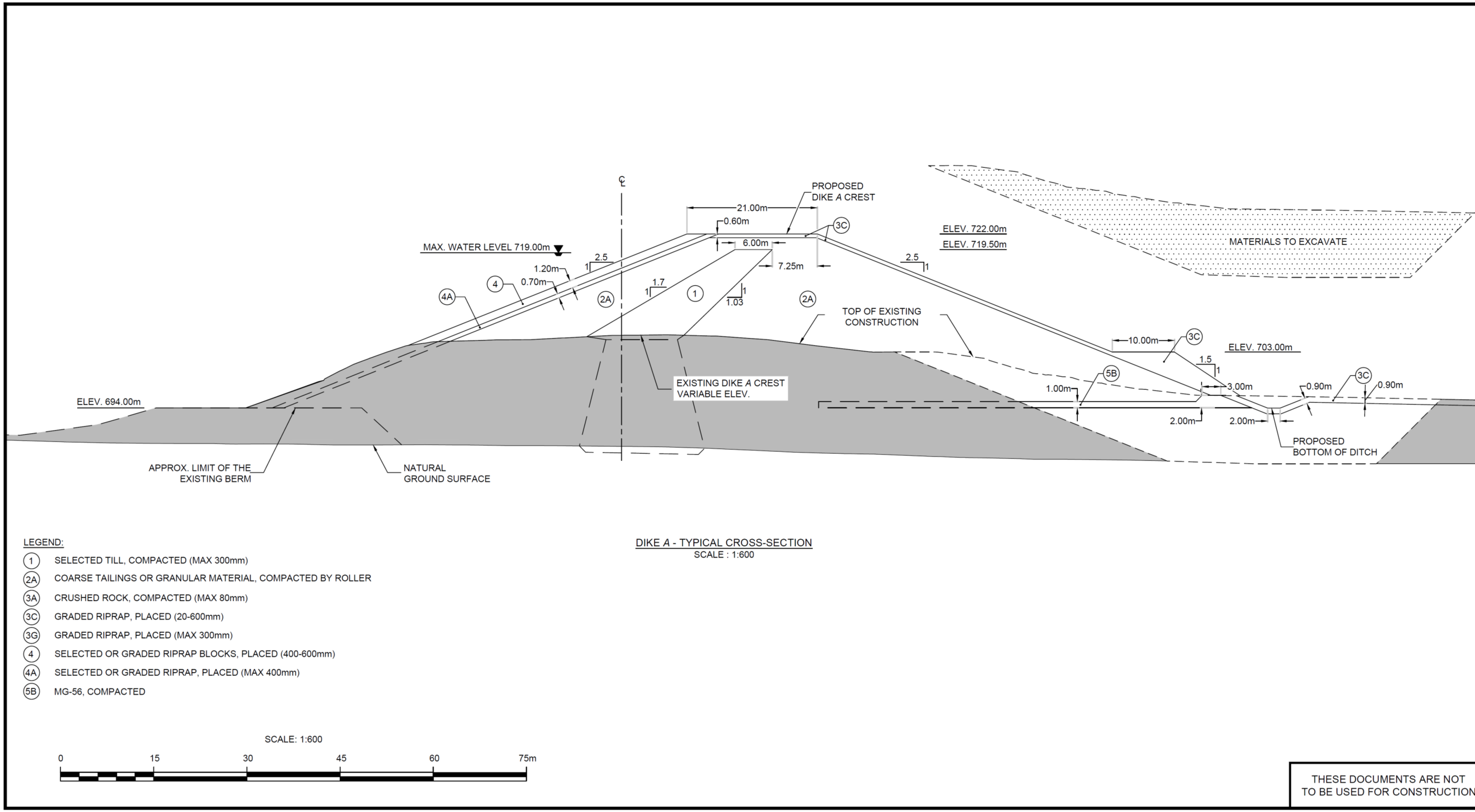


Figure 18-7: Typical cross-section – Dike *A*

The water management strategy of basin *A* implies the collection of reclaim water as well as run-off water generated within its watershed. Basin *A* also receives pumped inflows from the mine sector, basin *D1* and, eventually basin *H*. The water will then be transferred by gravity via the water transfer structure to basins *RC1* and *RC2*.

Waste Stockpile *Sud-Ouest*

The waste stockpile *Sud-Ouest* does not require additional surface water management infrastructure. The run-off water will be conveyed gravitationally towards the existing ditch *F-13* and the existing pumping system will return the water to the basins *RC1* and *RC2*. The existing water management system is both adequately designed and operational.

18.4.1.5 Mine Sector Water Management

The current mine sector surface water management system collects dewatering water from the pit and surface water run-off from waste dumps and other surface infrastructure.

The system conveys water, through pumping stations and ditches, to basins *C*, *D*, *Pignac,* and *Triangle* who then transfer the water by pumping to basin *A*. No upgrade to the existing surface system is required as the full watershed of the mine sector is currently considered in the water management system. Variations of in pit groundwater infiltration and surface run-off reporting to the pit in time based on the pit evolution will be handled by the pit dewatering strategy so not to exceed the current conveying capacity of the mine side pumping stations. The pit dewatering strategy is presented in Chapter 16

18.4.1.6 New Water Management Infrastructure

***HPA-Nord* TSF**

To contain the contact and process water generated on the new *HPA-Nord* TSF, a system of water management infrastructure will be built along the perimeter of the TSF. Ditches and pumping stations will be built in stages with the expanding footprint. Similarly, the storage and pumping capacity of the surface water management basins (basin *H* and basin *G*) will be increased in phases.

The impermeable dike *G* will be constructed with the commissioning of the *HPA-Nord* TSF to block the current eastward water flow direction of the watershed. The foundation of the dike's core will be set on the bedrock or on a layer of impervious till. During operations, basin *G* will collect run-off and exfiltration from the starting dike of *HPA-Nord*.

In 2032, the permeable dike *H* will be constructed to contain the water from the western side of the TSF. This dike will allow managing the spring flood and the process water volumes while the TSF progresses to the west. Dike *H* will be built using trucked and compacted materials. However, its permeable design will require upstream and downstream coarse tailings beach deposited at different times.

The water management system of the *HPA-Nord* is considered isolated and independent from the existing system. This implies that all run-off and reclaim water generated within the limits of the TSF during the design flood event will be directed to and contained entirely within basin *H*. This process ensures that the existing infrastructure will not be affected by the newly developed facility during peak water periods.

Following the spring melt event, water volumes collected in basin *H* can be gradually discharged towards existing basin *A* via a dual barge pumping system. Considering that basin *H* also serves as a sedimentation pond for the TSF, the pumping station is designed to operate year-round. The intakes of both barge systems will require specific positioning throughout the life of the TSF, as such they will be relocated as needed (generally towards the west). They will be anchored to the shore and a walkway will be used for access and maintenance.

The emergency spillway of basin *H* will be excavated in the bedrock on the west end of the TSF and constructed in two phases following the raising of the water level within the basin. The emergency spillway is planned to discharge its water through a conveyance ditch into dike *Fermeture Nord*'s operation and emergency spillway.

Waste Stockpile *Halde Sud*

The new waste stockpile, *Halde Sud*, will require the construction of surface water management infrastructure.

An impervious dike, dike *Sud*, will be erected to contain the water from the design flood. Figure 18-8 presents the typical cross-section of dike *Sud*. The foundation of the dike's core will be built on injected and treated bedrock. A vertical drain will also be constructed and connected to the drainage blanket on the downstream side of the core; this will improve the robustness of the stability.

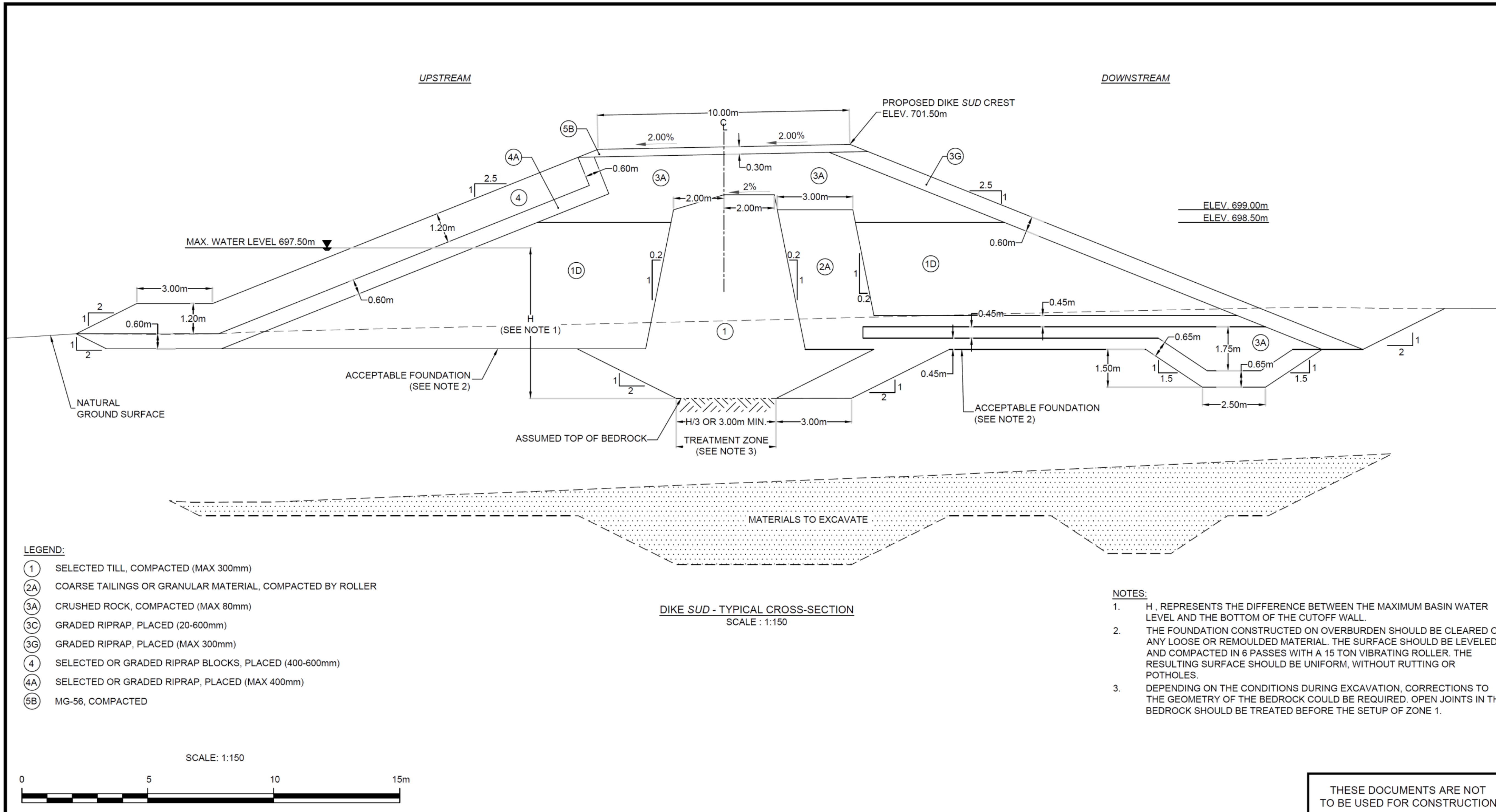


Figure 18-8: Typical cross-section – Dike *Sud*

Peripheral ditches will be constructed to redirect the contact water from the waste stockpile to basin *Sud* or to the existing basins *Pignac Ouest* and *Pignac Est*. To reduce the watershed, a clean water diversion ditch will also be constructed to the east.

The water that is conveyed towards basin *Sud* will be pumped back to basin *A* of the existing water management system, through a 9 km variable thickness pipeline (0.76 m diameter). Considering the topography (elevation gain of +/-130 m) and the distance to the receiving basin, it was not considered economical to winterize the pipeline, therefore the dewatering of basin *Sud* will be limited to the warmer months with above zero temperatures (i.e. roughly half the year). Basin *Sud* was designed considering this limitation, thus it was sized to contain the project flood plus an additional groundwater volume generated during the winter. Furthermore, its pumping station was designed to have the capacity to fully dewater the basin in 6 months (i.e. before the onset of winter) during which wet weather conditions (10-year return period) will prevail. This is considered a conservative approach to respect the Directive 019 regulation, in a case of consecutive spring melt design events.

Waste Rock Stockpile *Lac Triangle*

The waste rock stockpile *Lac Triangle* is planned to be operational at the beginning of the expansion. Basin *Lac Pignac Ouest* is presently pumped to the basin *Lac Triangle.* As the stockpile footprint increases, and the edge of West and Pignac pits develop towards the stockpile, *Lac Triangle* will become filled with waste rock. Peripheral ditches will be constructed to contain and safely convey run-off water towards West and Pignac pits. This water will then be pumped into the existing system via the pit's dewatering infrastructure.

18.4.1.7 Monitoring

As the site's water management system is dependent on numerous pumping stations, to ensure a robust and secure operation, all water management pumping stations are designed with automatic operating system capabilities and remote monitoring systems. This will allow operators to follow basin operation parameters and react diligently to unplanned situations.

18.4.2 Tailings Management

18.4.2.1 Concept

Bloom Lake's tailings management strategy is developed around the hydraulic deposition of separated coarse and fine tailings streams. The coarse tailings account for approximately 85% of the total tailings feed, while fine tailings account for 15% of the total tailings feed. The coarse tailings are a sandy draining, non-liquefiable material while the fine tailings are a silty material, more susceptible to liquefaction. Figure 18-9 presents the layout of the TSFs at the end of mine.

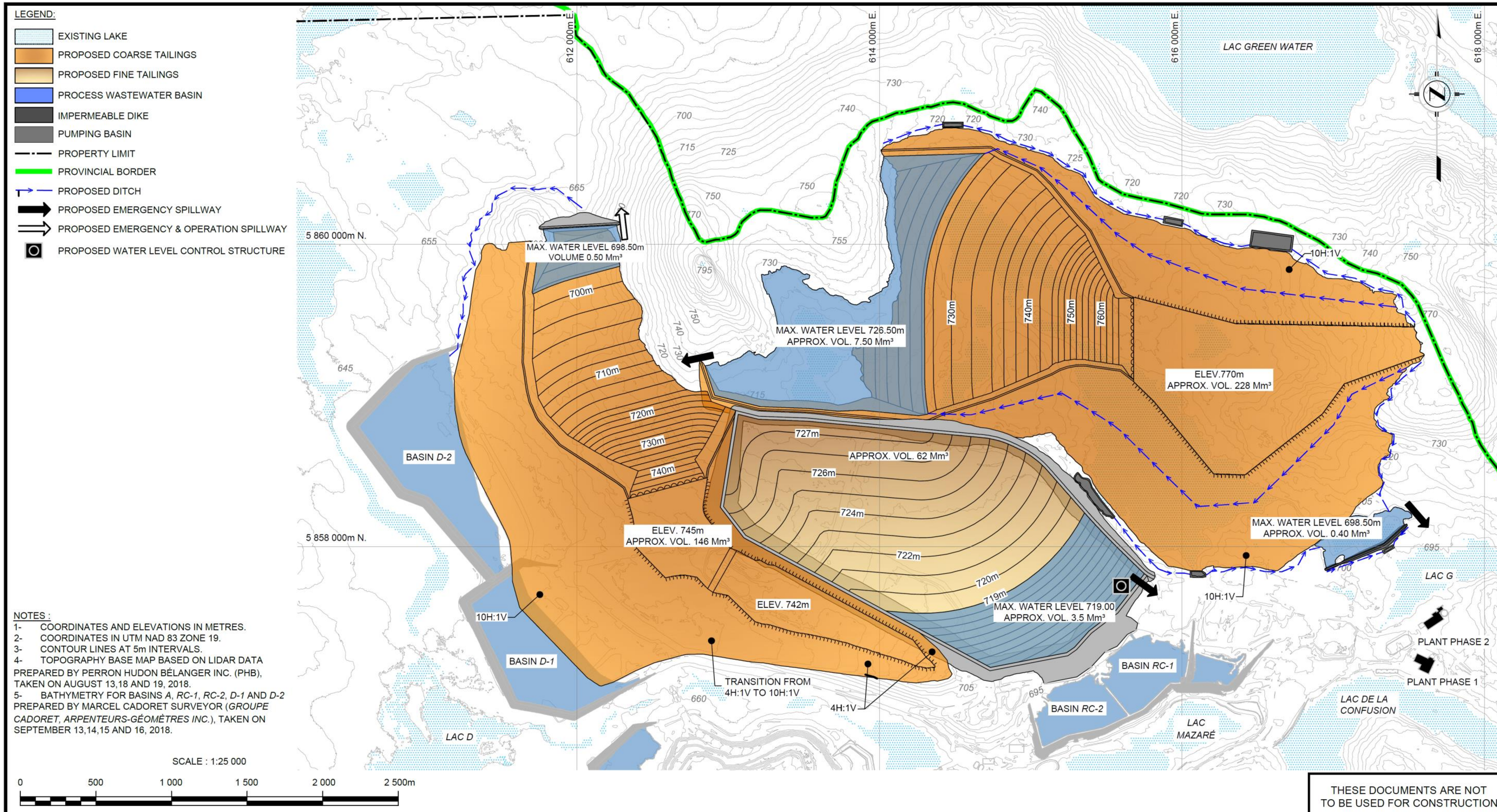


Figure 18-9: Tailings storage facilities – Year 2040

In total, Phases 1 and 2 mills are expected to produce 486.01 Mt of coarse tailings and 85.77 Mt of fine tailings over the 20 years of operation. The coarse and fine tailings have an estimated in-situ density of respectively 1.3 and 1.4 t/m^3, therefore occupying around 373.9 and 61.2 Mm^3 over the life of mine.

The coarse portion of the feed is pumped to three tailings storage facilities (*HPA-Sud*, *HPA-Ouest*, and *HPA-Nord*), where pervious dikes are built to contain tailings and impervious dikes to retain water.

The coarse tailings management strategy is to fill the existing permitted area (*HPA-Sud* and *HPA-Ouest*) up to capacity, and then move operations to the new TSF *HPA-Nord*. This strategy allows deferring capital investments, delay environmental impacts, and decommission and restore portions of the existing TSF while operations are still ongoing.

The fine portion of the feed is pumped during the life of mine to the current containment area, basin *A*, confined by impervious dikes. This containment area also holds a fine particle sedimentation pond.

To achieve this deposition strategy, additional pumping capacity is required for both fine and coarse tailings.

18.4.2.2 Design Criteria

The design of a TSF ensures a safe management of tailings and is based on conservative design assumptions. The containment structures are designed in accordance with industry standards (Canadian Dam Association, Mining Association of Canada, *Directive 019*) and in compliance with current provincial regulations from “Guidelines for preparing mine closure plans in Québec”. The minimum factors of safety, presented Table 18-4 were respected for the design.

Table 18-4: Minimum factors of safety required

Loading conditions	Minimum FS
Slope stability (short-term)	≥ 1.3
Slope stability in stationary conditions (long-term)	≥ 1.5
Pseudo-static analysis	≥ 1.1

18.4.2.3 Storage Facilities

It has been determined that the coarse tailings are non-liquefiable and are safe to use for dike construction. Therefore, the design of the tailings storage facilities utilises the availability of coarse tailings from the process plant.

Basin *A*

Fine tailings are pumped to the existing basin *A*'s TSF throughout the LOM. The deposition points are located on the northern side of the basin, next to dikes *Est* and *Nord.* To ensure the containment of the total amount of fine tailings, it is projected to raise the containment structures of dikes *Est*, *Ouest* and *Nord* to an elevation varying from 721 m to 730.5 m. The design of the dikes is primarily based on the retention of fine tailings. A membrane is added to the design to ensure the continuity of the impervious element throughout basin *A*, at an elevation of 719.5 m, representing the maximum allowable elevation of the design flood event.

Dike *Est* is built using a centreline construction method for most of its operations, and transitioned to a downstream design towards the end of operations, to maintain a final crest width of 21 m. A freeboard of 1.5 m is respected in compliance with *Directive 019*. The dike is composed of coarse tailings with a membrane as the impervious barrier and a riprap on the upstream slope.

Dikes *Ouest* and *Nord* are built using a downstream construction method. A freeboard of 1.5 m is respected in compliance with *Directive 019*. The dike is composed of coarse tailings with an impervious barrier and a riprap on the upstream slope.

***HPA-Ouest* and *Sud* Coarse Tailings Areas**

Coarse tailings are currently pumped to *HPA-Ouest* and *HPA-Sud* TSFs and will be until 2027. For the expansion, the current layout of the TSF is conserved with minor modifications. *HPA-Sud* starter dike is already built. For *HPA-Ouest*, the starter dike will be constructed over the next few years. This pervious dike includes an internal drainage system (finger drains and blanket drains), a rock toe, and is made of trucked, compacted, and controlled coarse tailings.

Once the peripheral starter dikes are built, raising of the containment infrastructure will be done using the hydraulic deposition of coarse tailings combined with mechanical placement. A fleet of dozers and compactors will be operated year-round to ensure proper compaction of the raises and adequate operational reactivity to maintain safe free-board. This method ensures the use of adequate material and meets compaction requirements. The upstream raise of tailings containment dikes will be exclusively done with the coarse fraction, respecting a 10H:1V average slope. This approach provides a safe and stable dike, as the coarse material can easily drain and the 10H:1V slope is conservative in terms of stability against internal erosion and allow for diligent response time in case of unexpected event during operation. Furthermore, these tailings are non-liquefiable, which allows stable conditions under dynamic load. Figure 18-10 presents a typical cross-section of *HPA-Ouest.*

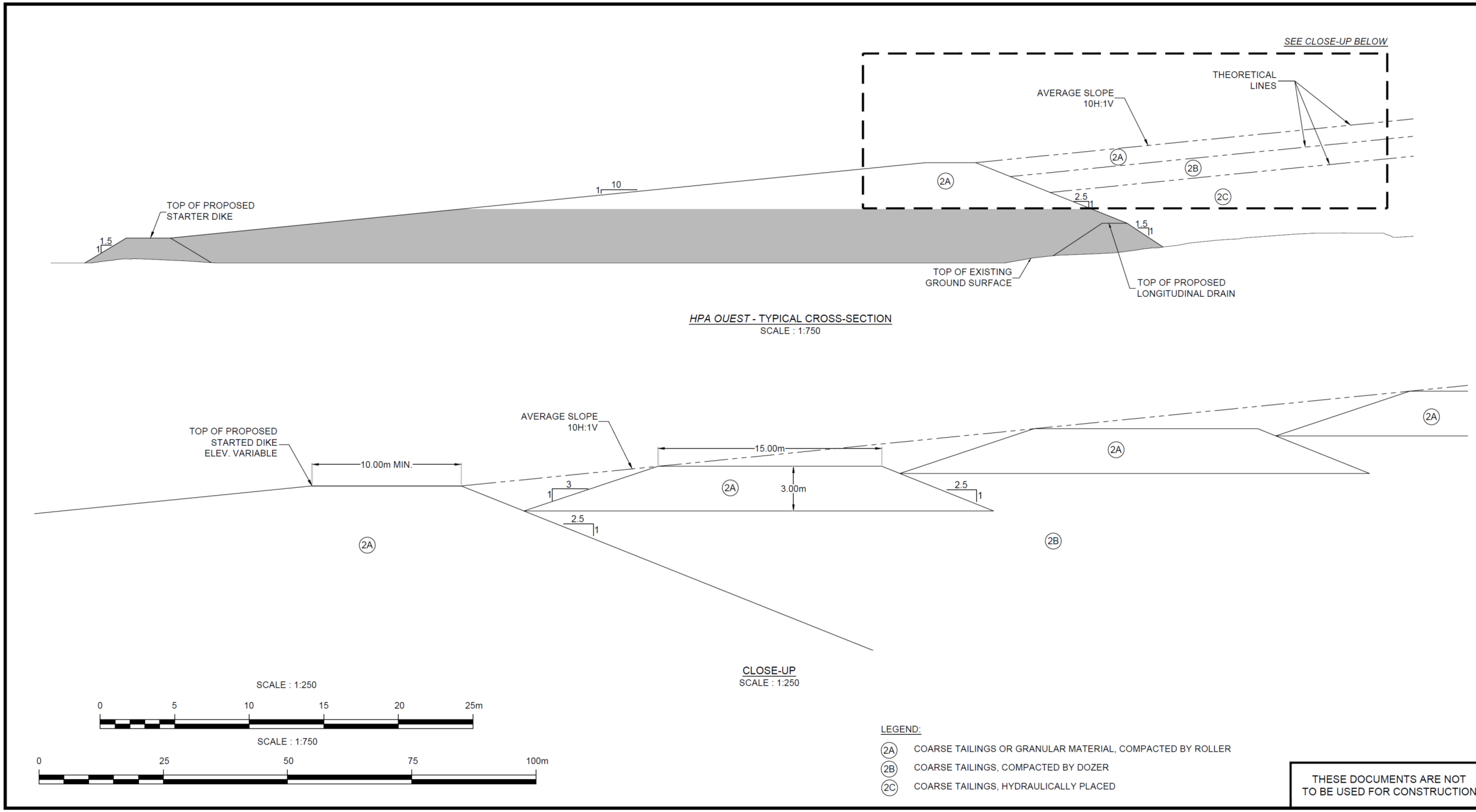


Figure 18-10: Typical cross-section – *HPA-Ouest*

HPA-Nord

Once *HPA-Ouest* and *HPA-Sud* TSFs are filled, a new TSF named *HPA-Nord* will be opened. Coarse tailings will be pumped to *HPA-Nord* from 2028 until the end of the mine life. As it is the case for the existing TSF, peripheric starter dikes need to be constructed prior to, and during, TSF operations. These starter dikes will be pervious and made of coarse tailings including a rock toe with a minimum height of 5 m. The rock toe will assure drainage and stability to the TSF.

Once the peripheral starter dikes are built, an upstream raise, using a coarse tailings deposition and mechanical placement following a 10H:1V average slope, will also be used. As previously discussed, coarse tailings are non-liquefiable and thus are safe for use in dike construction. A fleet of dozers and compactors will be operated year-round to ensure proper compaction of the raises and adequate operational reactivity to maintain safe free-board. The upstream raise of tailings containment dikes will be exclusively done with a coarse portion. As for *HPA-Ouest* and *Sud*, this approach provides a safe and stable dike, as the coarse material can easily drain and the 10H:1V slope is conservative in terms of stability against internal erosion and allow for diligent response time in case of unexpected events during operation. Furthermore, these tailings are non-liquefiable, which allows stable conditions under dynamic load. Figure 18-11 presents a typical cross-section of *HPA-Nord.*

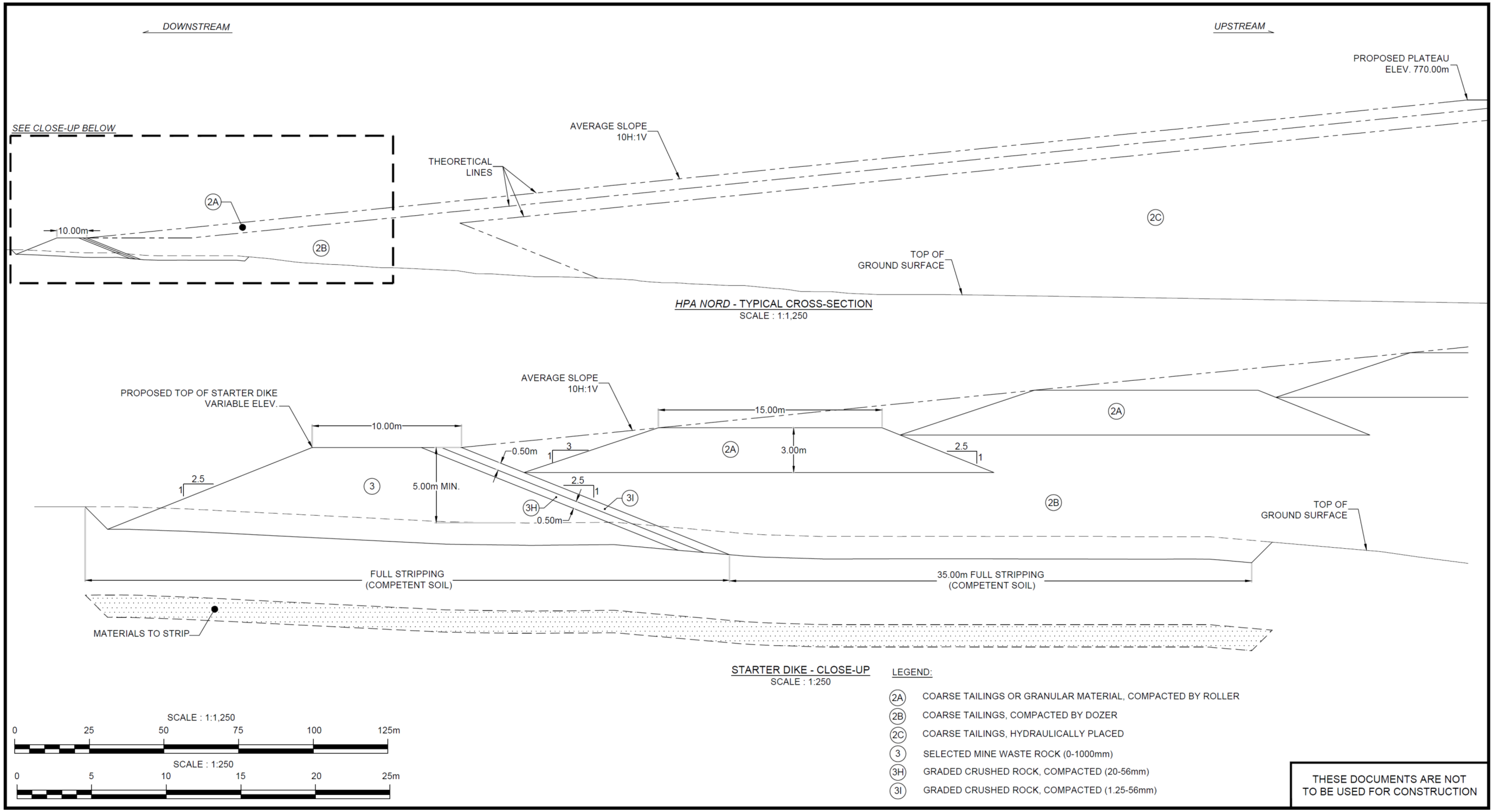


Figure 18-11: Typical cross-section – *HPA-Nord*

18.4.2.4 Monitoring

To make sure the infrastructure is safe and operating within the design parameters, an array of instruments is to be installed. These instruments will be in specific areas to monitor different parameters related to stability and safety of the dikes.

Monitoring is already implemented in the existing infrastructure and additional instruments will be installed in both existing and new infrastructure as well. The instrumentation at Bloom Lake TSFs is currently connected to a telemetry system. This allows for real-time data to be consulted at anytime, anywhere. This system minimizes the dependency towards on-site personnel and, therefore, adds reliability and efficiency to the monitoring.

Annual site inspections and safety reports are also planned. This diligent process is vital to assess the stability and security of the TSF infrastructure throughout the life of mine.

18.5 Waste Stockpile *Halde Sud*

18.5.1 Concept

The expansion of the Bloom Lake Mine requires the development of a new waste rock and overburden stockpile. The location was chosen following a study of numerous locations and configurations. The new stockpile is in a new watershed, south of the projected open pit. Figure 18-12 presents the waste stockpile *Halde Sud*.

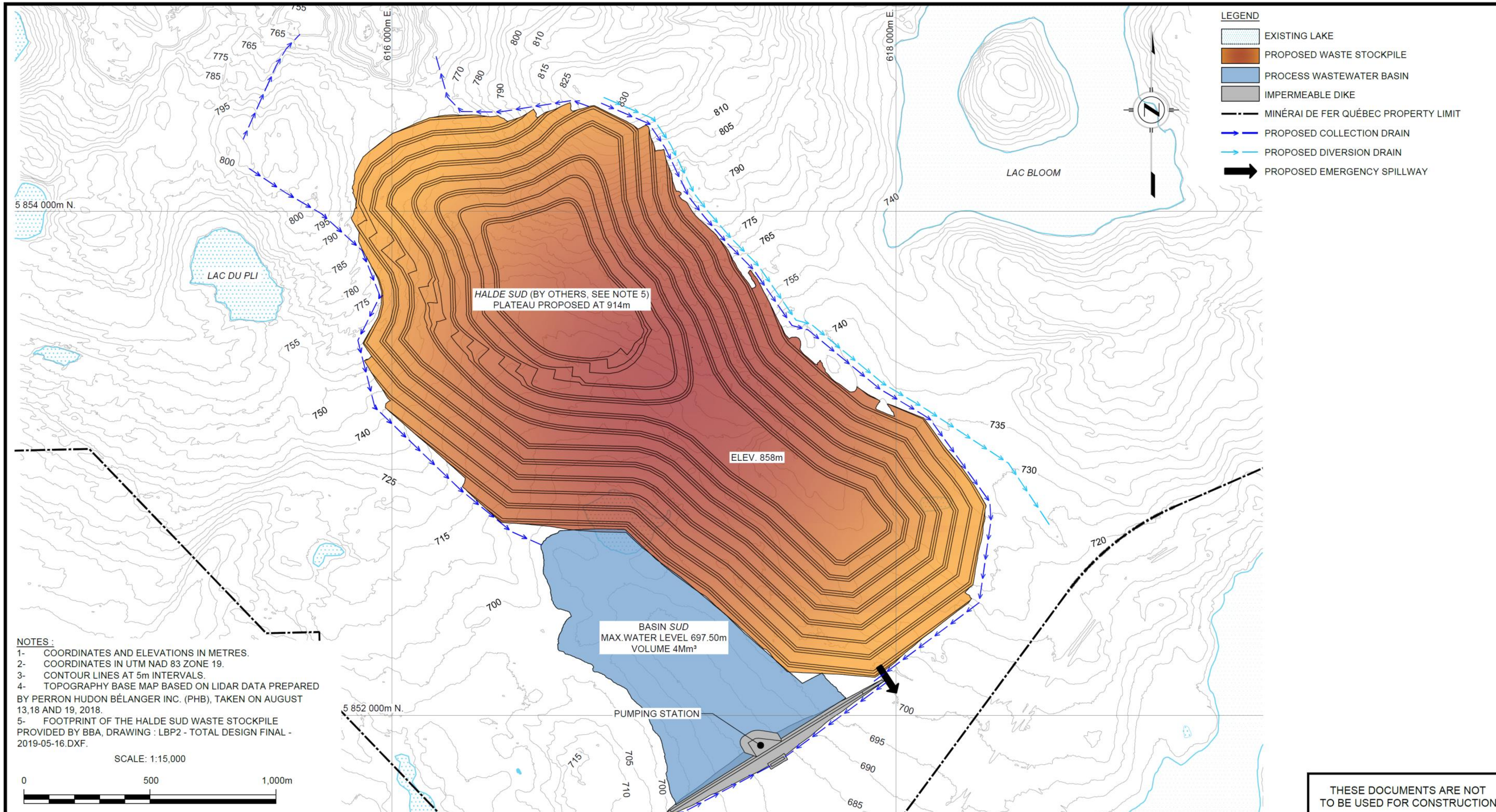


Figure 18-12: Waste stockpile *Halde Sud* – Year 2040

The waste rock and overburden mass balance was provided by BBA. It is planned to store 519.7 Mt of waste rock and 21.9 Mt of overburden in waste stockpile *Halde Sud*, during the life of mine. The overburden coming from the pit's stripping process only represents 4% of the total quantity to be stored and is therefore planned to be stored inside the waste rock pile. The details for the interior layout of the dump, regarding the placement of waste rock and overburden, will be determined in the detailed engineering phases. Depending on the detailed operational overburden and waste rock placement strategy, small cells can be designed in the centre of the dump to avoid any significant impact on the slope's global stability.

18.5.2 Design Criteria

The stockpile was designed to comply with the requirements of Appendix 1 in the MERN (2017) and *Directive 019* of the mining industry. The minimum factors of safety, summarized in Table 18-5, were respected for the design.

Table 18-5: Minimum factors of safety required

Loading Conditions	Minimum FS
Local stability for each bench (short-term and static)	≥ 1.0 to 1.1
Overall stability, for deep slip surfaces or in foundation soil (short-term)	≥ 1.3 to 1.5
Overall stability, for deep slip surfaces or in foundation soil (long-term)	≥ 1.5
Overall stability, for deep slip surfaces or in foundation soil (pseudo-static)	≥ 1.1 to 1.3

The factor of safety for each cross-section analyzed complies with the acceptance criteria mentioned above. To meet the minimum factor of safety, an overall slope of 3H:1V is required with local bench slopes of 2H:1V. The following configuration is proposed:

- Stockpile's maximum elevation: 835 m to 920 m;
- Stockpile's minimum crest width at full development: 50 m;
- Maximum bench height: 10 m;
- Minimum bench width: 20 m;
- Minimum bench offsets: 10 m.

Finally, the proposed configuration will avoid re-profiling the slopes during the closure phase.

18.5.3 Design Results and Limitations

Analyses on configurations of the dump shown in Figure 18-12 and on critical sections of the fully developed dump were done on a proposed LOM layout. Detailed analyses, based on the staging strategy of the operation mine plan including waste rock and overburden placement, will be determined in the detailed engineering phase.

Analyses show that to ensure the stability of the dump on critical peripheral sections, stripping of organic material is required at the toe of the dump on a width varying between 60 m and 300 m depending on the location. The staging strategy during the development of the dump must take this constraint into consideration.

18.5.4 Monitoring

Monitoring of such a large structure is important to ensure that design parameters and limitations are followed during operations. As such, groundwater levels inside and under the waste rock dump will be monitored during operations. Piezometers will be installed during the development of the stockpile. Furthermore, other instruments such as inclinometers and settlement plates will be installed to monitor the stockpile behaviour and the stability of its slope. The stockpile monitoring program will be part of the detailed engineering and operation phases.

18.6 Service and Construction Roads

Three types of roads are meant to be constructed for this Project: 1) service roads for operations and monitoring; 2) construction roads for maintenance and construction; and 3) production roads. The production roads are covered in Chapter 16.

The present section covers the two other types of roads required for the tailings, waste stockpile, and water management operations, monitoring, and construction. The roads' subsoil is assumed to be till or bedrock, depending on the location. The key features of the service and construction roads are defined in Table 18-6 and typical cross-sections are shown in Figure 18-13 and Figure 18-14. The design criteria for serviceability of the roads are to minimize maintenance as they will be used extensively during construction and operation of the facilities. The foundation of the road base will be inclined with an inward slope to redirect run-off water towards the contact water ditches located between the waste or tailings management areas and the roads. The management of the collected contact water is covered in Section 18.4.1 – Surface Water Management

Table 18-6: Key characteristics of service and construction roads

Characteristics	Service road	Construction road
Displayed speed	50 km/h	50 km/h
Vehicle used to design	Legal load truck	CAT 777G
Roadway width	6.0 m	24.0 m (2-way)
Minimum radius of curves	100 m	100 m
Distance of visibility	100 m	100 m
Berm	Yes, if h>3 m	Yes, if h>3 m
Maximum vertical slope	15%	7%

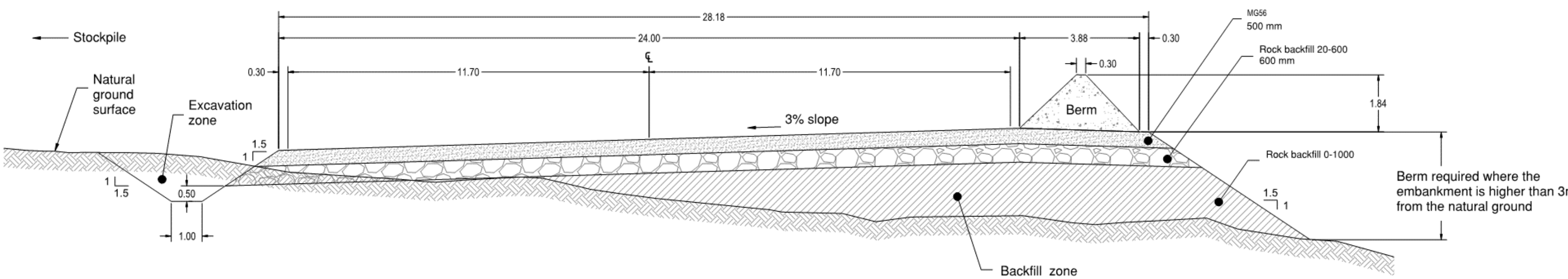


Figure 18-13: Typical cross-section – Construction road

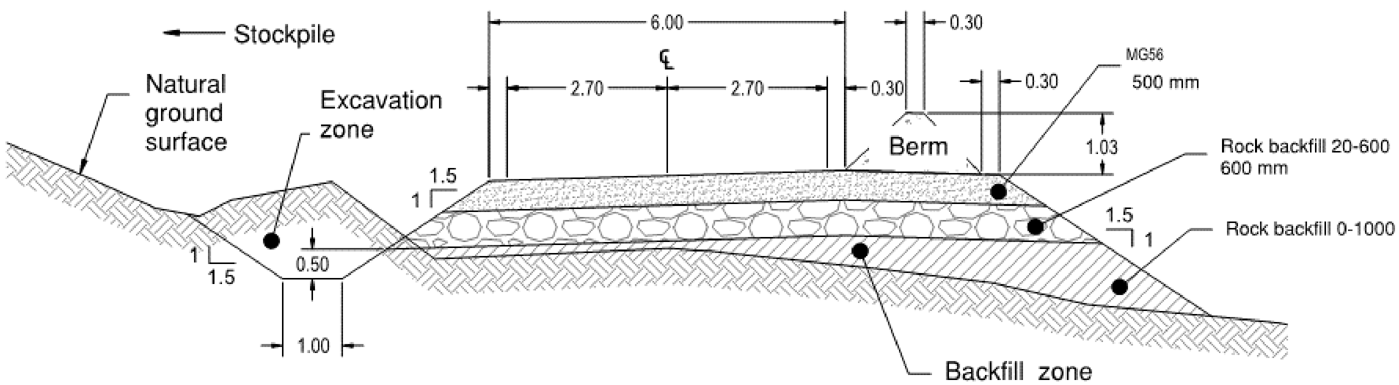


Figure 18-14: Typical cross-section – Service road

18.7 Sanitary Treatment and Waste Disposal

The sewage disposal system is designed to accommodate all sanitary services requirements at the site. The sewage treatment system includes collecting and pumping stations, a septic tank and aerobic treatment stages. The treated water meets the mandatory discharge parameters before it is released to the environment by ground infiltration.

All material that can be recycled will be sent to recycling sites. Solid waste materials that cannot be recycled will be sent to municipal dump located in the Baie-Comeau area.

Used oil and lubricants and all other hazardous wastes will be managed by a recognized waste disposal company in accordance with applicable regulations.

18.8 Accommodations

Lodging for construction workers and permanent workers is accommodated within the town of Fermont. QIO owns the following facilities:

- Four houses located on *rue des Melèzes* (with five rooms each),
- Twenty-two (22) houses, fully furnished, located on *rue des Bâtisseurs* (twelve with eight rooms each, six with seven rooms each and four with five rooms each),
- Two complexes of 99 rooms of lodging located on *rue du Fer.*

The accommodations listed above are fully equipped with furniture, linen and wiring for communications and entertainment. Temporary construction workers will be accommodated in the town of Fermont.

Two new lodging complexes of 99 rooms will be constructed in Fermont to accommodate Phase 2 permanent workers.

Permanent workers will be fed at the QIO cafeteria facility located in Fermont. The QIO cafeteria is a fully equipped industrial kitchen with walk-in freezers and fridges. It has a warehouse and delivery dock. The cafeteria has a seating capacity of 700 people. This new building completed in 2014, has a complete gym, work offices, as well as a playroom with pool tables, golf simulators and other recreational games and is currently used by QIO operations staff.

Temporary workers will be fed at the temporary cafeteria on site; food preparation will be performed at the cafeteria facility in Fermont.

19. MARKET STUDIES

QIO engaged Wood Mackenzie to provide an iron ore market study for use in the Bloom Lake Mine Feasibility Study Phase 2 NI 43-101 technical report.

The market study covered by Wood Mackenzie is described in items 1 to 12, while QIO's input resulting from the market study is provided in item 13 as seen in the following list.

1. Market study executive summary
2. Iron ore market overview
3. Iron ore products
4. Major iron ore markets size and structures
5. Major sources of internationally traded iron ore
6. Iron ore demand evolution: 2000-2018
7. Iron ore supply evolution: 2000-2018
8. Forecast demand of iron ore: 2019-2040
9. Forecast supply of iron ore: 2019-2040
10. Iron ore pricing
11. Iron ore pricing evolution
12. Dry bulk freight outlook
13. QIO's Bloom Lake concentrate price forecast

19.1 Market Study Executive Summary

This report is based on Wood Mackenzie's iron ore industry knowledge, experience, analysis, and on information available to QIO from company, industry, trade, government, and other sources that may be limited or inaccurate. Wood Mackenzie has produced analysis, estimates and projections based upon this information and upon assumptions that are subject to significant degrees of economic, commercial, market, industrial and other uncertainties. Although care has been exercised in preparing this material, Wood Mackenzie makes no warranty of any kind regarding its contents, and shall not be liable in respect to any matter arising from its use without limitation.

Uncertainty over the scale and duration of Brazilian production cuts in the aftermath of the Brumadinho tailings dam tragedy has changed the entire psyche of the iron ore market. Prior to the January 2019 dam failure, the widely held view was for iron ore to enter a period of cyclical and structural weakness that would drive the price of 62% Fe sinter fines towards USD60/t CFR China over the period 2019/20. But that view has now been pushed out by between 1 to 5 years, depending on revised assumptions for Brazilian supply, Chinese demand, and the extent to which other seaborne suppliers can offset the forecast shortfall from Vale.

Wood Mackenzie believes that the seaborne market for iron ore is now finely balanced, with a tendency towards under-supply. The market is clearly vulnerable to further supply side shocks. Cyclone related damage to Australian loading port infrastructure in March 2019 was a clear example of the prevailing market tightness, as subsequent production guidance downgrades from the Australian majors pushed the benchmark 62% Fe index to USD95/t CFR China.

In its Q1-2019 Long Term Outlook, Wood Mackenzie raised its medium term price forecast for iron ore to reflect this changing market dynamic. As of April 2019, the Wood Mackenzie 3-year average price forecast for 62% Fe sinter fines was USD76/t CFR China. The market impact from Vale's supply disruption should have been largely neutralized by 2022/23 and no significant change has been made to the Wood Mackenzie price forecast post 2022.

However, Wood Mackenzie are firm believers that China's steel restructuring programme and rising environmental standards have transformed pricing and demand for iron ore. Wider price spreads based on grade and quality are symptomatic of these structural changes and will remain an important feature of the market for years to come. Wood Mackenzie remains confident that the transition towards a multi-tiered pricing structure based on value-in-use is a long term structural change for the iron ore market.

Wood Mackenzie's long term price forecast for benchmark 62% Fe sinter fines is USD65/t CFR China (real 2019 terms). Wood Mackenzie forecasts that the 65% Fe sinter fines index will trade at a premium of 20% (USD13/t) to the 62% index over the long run, giving a long run price of USD78/t CFR China (real 2019 terms) for 65% Fe sinter fines.

19.2 Iron Ore Market Overview

Iron (Fe) is the world's fourth most abundant element, constituting around 5.6% of the earth's crust. Iron ore is a mineral from which metallic iron can be economically extracted. The iron is most commonly found in the form of iron oxides, either as hematite (Fe_2O_3) or magnetite (Fe_3O_4), but other hydroxide minerals such as goethite and limonite, and carbonate minerals such as siderite are also mined.

Hematite ore generally has higher in situ iron content (commonly up to 65% Fe) and as such, is considered a Direct Shipping Ore (DSO); however, as it only undergoes basic crushing and screening prior to shipping, the final product (in comparison to magnetite) typically contains significantly higher concentrations of impurities (attracting penalties in trade), such as phosphorus, sulphur, moisture, and alumina.

Magnetite normally has a lower in situ iron content (25-40% Fe) than hematite, and consequently typically has to undergo additional processing to produce a high-grade product (>65% Fe), with very low impurities. When magnetite ore is pelletized it has the potential to increase productivity and decrease energy costs in the ironmaking process due to the liberation of the additional oxygen molecule in magnetite (Fe_3O_4) compared to hematite (Fe_2O_3). In addition to superior chemical properties, the regular and consistent shape and hardness of pellets (physical properties) allow for more efficient fluid-flow thermodynamics within the iron blast furnace – further decreasing energy costs.

Most of the world's iron ore resources occur in iron-rich metasedimentary rocks known as banded iron formations (BIFs) in Asia Pacific and taconite in North America. BIFs typically have alternating bands of iron and chert. Itabrites are found in Brazil and are similar to BIFs but typically the chert bands have been recrystallized into quartz. When BIFs have undergone supergene weathering, and the chert bands are no longer present, they are known as bedded iron deposits (BIDs). BIFs can be mined directly as iron ores and are the origin for most of the large deposits being mined today. Generally the most common deposit styles are the following:

i. **Primary BIFs and itabrites** with enriched concentrations of magnetite, similar to the Sino Iron mine in Western Australia and deposits in Minas Gerais, Brazil.

ii. **Bedded iron deposits** (BIDs) from weathered (supergene) enriched BIFs comprising hematite (both martite and microplaty hematite) and goethite. This deposit style is typical of Mt Whaleback and Mt Tom Price (which are Low Phos Brockman ores with Fe units typically circa 75% hematite, 25% goethite) and Mining Area C and West Angelas (which are Marra Mamba ores with Fe units typically circa 75% goethite, 25% hematite) in the Pilbara of Western Australia. It is also typical of the Carajas region in Brazil.

iii. **Detrital low grade iron ore deposits**, including scree and canga deposits, typically found downslope of BIF enriched deposits from which they have been eroded.

iv. **Channel iron deposits** (CIDs) or **paleochannel deposits** formed from accumulations of dense, iron rich pisolites in the base of ancient river channels, typical of Yandicoogina and Robe River in the Pilbara, Western Australia.

v. **Metasomatic skarn and magmatic magnetite deposits**, typical of Kiruna in Sweden and Cairn Hill in South Australia.

vi. **Residual laterites** and **heavy mineral sands**, which can produce large low grade iron deposits. Low grade nickel laterites (<1%) are able to be mined for their enriched iron content.

In the commercial context, iron ore is typically referred to by Fe-content (grade) and physical properties. Iron ore products are typically classified as high grade (>63% Fe), medium grade (58-63% Fe) or low grade (<58% Fe). High iron content is typically preferred as higher Fe reduces transportation costs, measured on a contained Fe unit basis, and increases the iron and steel yield. Very low grade ores need to be further concentrated to achieve the same levels of iron content and production yields. As a result, high grade iron ore can command a 'quality' premium for the higher Fe units compared to medium and low grade ores. Similarly, low Fe-grade iron ores trade at a discount to medium and high grade ores reflecting lower Fe units.

Impurities, such as silica, alumina, phosphorus and sulphur, will affect the iron ore price, together with moisture and loss on ignition. This is because these impurities affect the productivity of the reduction process in the blast furnace. Lower levels of impurities causes a faster reaction rate and greater speed of iron ore conversion. Higher levels of impurities also require increased amounts of consumables, such as flux and coke, and therefore increase steelmakers' costs. For example, increased moisture and loss on ignition will increase the amount of coke breeze required in the sintering process and coke required in the ironmaking process. Likewise, higher levels of silica and alumina increase the amount of slag generated by the blast furnace and therefore reduce the amount of hot metal produced. They also need to be consumed in the correct proportions otherwise this can affect blast furnace productivity. In addition, sulphur and phosphorus have a negative effect on the quality of hot metal and steel produced, and are minimized where possible.

The physical properties of iron ores are equally as important as the chemical properties. Fines used in sintering are required to have an appropriate grain size distribution – the right mix of slightly larger grains that form a nucleus around which smaller grains can agglomerate. Iron ore lump – pebble sized rocks – can be charged directly to the blast furnace and so bypass the sinter process. Lump therefore commands a premium over fines, the value of which roughly mirrors the cost of sintering (about USD10 to USD20 per tonne in China). Concentrates used for pelletizing are required to have a finer grain size than typical sinter fines. Iron ore pellets achieve the greatest physical (and chemical) quality premia as their regular shape and hardness achieve the greatest energy savings during pig iron production.

Steelmakers value consistency and reliability. As iron ore is a differentiated commodity, buyers like to know that cargos reliably have consistent chemical and physical properties. The Australian major iron ore suppliers aim to have mine plans that reduce grade variability throughout the value chain so that the final product on arrival has a consistent quality. Brazil's Vale also supplies products with a consistent grade but, in addition, regularly supply ad-hoc cargos to the market that take advantage of changes in spot quality premia.

Because iron ore is used almost exclusively for steel production, historically the main customers of iron ore have been steel producers. However, iron ore traders have also been an important part of the market since before the year 2000 and have played an increasingly important role over time.

19.3 Iron Ore Products

The diagram below (Figure 19-1) shows the typical iron ore value chain from ore extraction to steel production. The processing paths are largely determined by the ore type. Hematite, with higher in situ iron content, has a simpler, less energy-intensive and less-costly mining and beneficiation process. Magnetite, with lower in situ iron content, is generally more costly to produce and beneficiate, however this cost is often offset by the higher price it attracts from steel mills due to the resultant high iron content, low level of impurities in the concentrate, and energy saving characteristics of magnetite versus hematite.

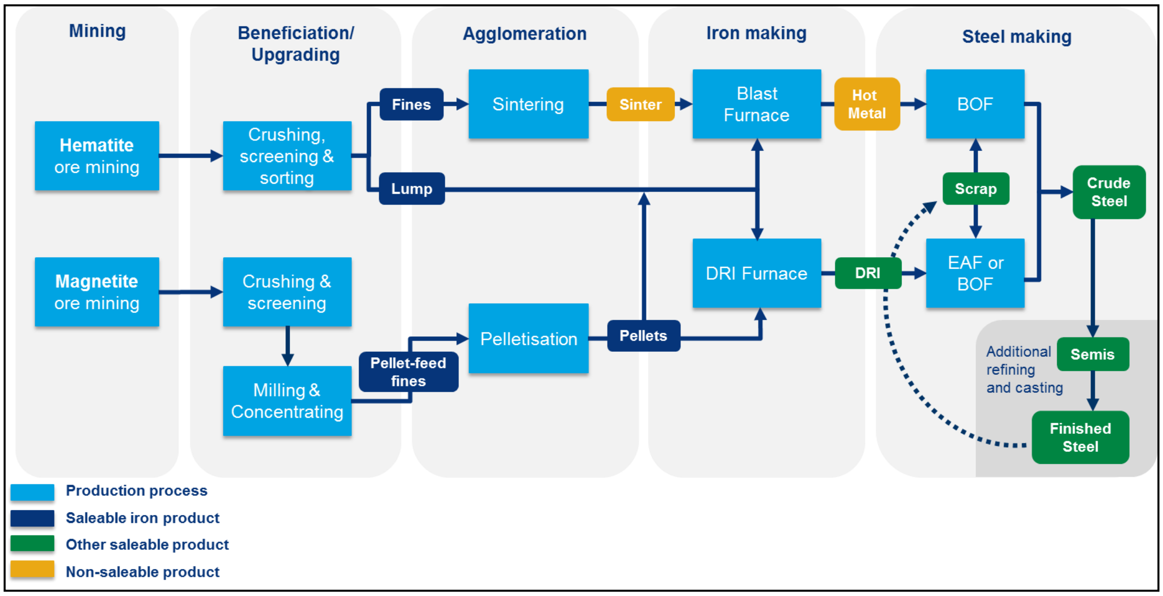


Figure 19-1: The iron ore and steel value chain

Hematite ore is typically crushed then screened into 'lump' and 'fines' material. The majority of the world's iron ore supply is in the form of fines from hematite ore. Fines refer to fine iron ore particles of approximately 1-6 mm diameter. Fines may also be referred to as sinter fines or sinter feed, because they must be fused together in a sintering process in order to form a sinter feedstock suitable for use as a feedstock into the ironmaking process. The additional cost to steel mills from the sintering process means lump ore sells at a premium to fines. Medium and low grade fines can be concentrated to a slightly higher iron content through additional wet or dry processing techniques such as gravity or heavy media separation, screening and flotation, processes that also separate out the iron oxides from the gangue/waste material.

Lump refers to coarse iron ore particles of around 6-30 mm diameter. Lump ore can be used as a direct feedstock in the ironmaking process with only limited processing and, therefore, generally commands a price premium relative to fine ore. The major lump exporting countries include Australia, South Africa, India and Brazil.

Magnetite ore typically requires additional concentrating to increase the grade to commercial levels. Typically, processing for magnetite ore involves crushing, screening, grinding, magnetic separation, filtering and drying, hence magnetite projects generally have capital and production costs that are higher than hematite mines. Processing of magnetite ore is energy intensive so the cost differential with hematite ore is commonly directly related to energy costs.

Pellet-feed fines and concentrates are typically comprised of processed, sub-1 mm magnetite particles and commonly used as a feedstock into the pelletizing process in which these fines/concentrates are agglomerated into balls/pellets of circa 8-20 mm diameter.

19.3.1 Iron Ore Agglomeration

In the blast furnace process, iron ore is consumed in the form of sinter, lump and pellets. Fines particles are too small to be effective within a furnace (they smother the furnace like throwing sand over a fire). There are two methods by which particles can be fused into larger particles and made ready for charging to a blast furnace: pelletizing and sintering. Sintering is a process used to agglomerate fines in preparation for blast-furnace smelting. Sinter can be relatively easily broken back down to fines when crushed or dropped; therefore, it does not travel very well. Because of this, sinter plants are typically integrated with blast furnaces and sinter is not commonly a saleable product.

Pelletizing is a treatment process used for converting iron ore concentrate with particle sizes typically smaller than 1 mm into pellets in a pelletizing plant. Pellets are an ideal furnace feed because they are hard and of regular size and shape, which allows good permeability and gas flow. Pellets are typically between 8 mm and 20 mm in diameter. As well as superior physical properties, pellets typically have a higher and more consistent chemical composition. Pellets command the highest price premium of all iron products due to their higher value-in-use. This means pellets increase blast furnace productivity. Because pellets have a high hardness, they can be transported relatively easily. Therefore, pellets are a saleable product. Pellets are used in blast furnaces and direct reduced iron (DRI) furnaces.

Iron ore is traded at this stage as one of four principal products: lump, sinter-feed fines, pellet-feed fines/concentrate, and pellets.

Of total iron ore imports in 2018, 70% were sinter-feed fines, 15% lump, 9% pellets and 6% pellet feed concentrates.

19.4 Major Iron Ore Markets Size and Structure

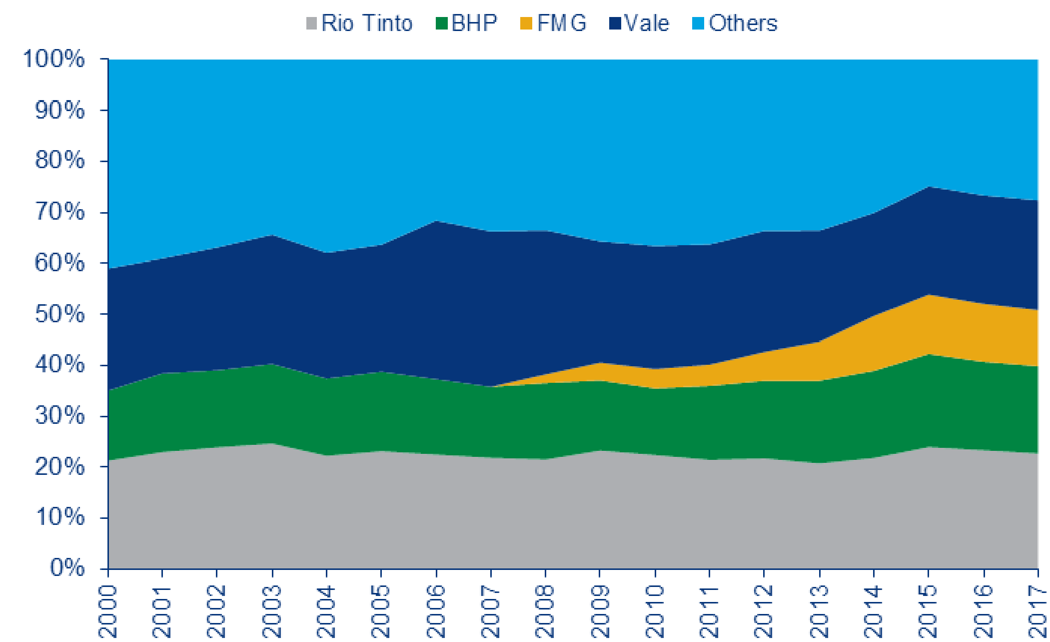
The following definitions of market segments are typically used:

i. Domestic – iron ore produced and consumed within a country.
ii. Export – iron ore that is produced in one country, transported and consumed in another country.
iii. Seaborne – a subset of the export market. It only includes exports that are traded between countries via ocean transport.
iv. Contestable – seaborne market plus China's domestic market competing on cost with seaborne imports.
v. Global – domestic markets plus export market.

Global price assessments are typically discovered in the contestable market segment.

The seaborne iron ore market has a relatively concentrated supply structure. The "big 3" iron ore producers (Vale, Rio Tinto and BHP) have historically contributed more than half of the global seaborne trade. In 2008, Fortescue Metals Group Ltd. (FMG) commenced iron ore shipments and the "big 3" effectively became the "big 4". In 2017, the "big 4" accounted for 72% of global seaborne trade, with some of their market share being taken away by the commencement of shipments from Hancock Prospecting's Roy Hill mine in 2015.

Since at least 2000, there have been numerous companies outside the "big 4" supplying iron ore to the seaborne market. Examples include Anglo American with operations in South Africa and Brazil; ArcelorMittal in Canada, Africa and Europe; Roy Hill in Australia; CSN in Brazil; LKAB in Sweden; Atlas Iron in Australia; Metinvest in Ukraine; and Metalloinvest in Russia. In addition, hundreds of Chinese iron ore companies compete with seaborne iron ore in the Chinese market.



Source: Wood Mackenzie, *Iron Ore Market Service data tool*, accessed September 2018

Figure 19-2: Iron ore share of seaborne supply by the "big 4" producers (marketable basis)

19.5 Major Sources of Internationally Traded Iron Ore

19.5.1 Australia

Australia has been the largest supplier of iron ore into the export market since 2001. The majority of marketable iron ore products from Australia are fines accounting for three quarters of Australia's iron ore exports, on average, between 2000 and 2017. Iron ore fines have seen the largest growth over the past decade, primarily due to FMG's entrance into the iron ore market, but also with BHP Billiton's (BHP) and Rio Tinto's expansion of their respective Yandi and Yandicoogina mines.

The vast majority of iron ore production within Australia is from three companies whose assets are located in the Pilbara region: Rio Tinto, BHP and FMG, which, on a managed basis, accounted for more than 90% of Australian iron ore production and 44% of global exports, on average, between 2000 and 2017. In 2015, Roy Hill (another large integrated mine, rail and port operation), majority owned by Hancock Prospecting, commenced shipments.

19.5.2 Brazil

Brazil has been the second largest iron ore supplier into the export market since 2001. Its iron ore industry is principally made up of three producers: Vale, Companhia Siderúrgica Nacional (CSN), and Samarco, a 50:50 joint venture between BHP and Vale. Samarco's production is currently suspended because of a tailings dam failure in 2015.

Vale is by far the largest producer with 80% of Brazilian production, on average, between 2000 and 2017. In general, Brazil produces high quality iron ore due to its favourable geology and investment in mineral processing infrastructure. The ore is predominantly high grade DSO hematite from the Carajas mine complex in Pará state or itabirite, which is amenable to beneficiation, from the Iron Quadrangle. There is also some lower grade magnetite production. On average, iron ore fines accounted for 66% of Brazil's iron ore export products between 2000 and 2017.

In January 2019, the Córrego do Feijão tailings dam, operated by Vale in Brazil, tragically failed. The subsequent cessation of mining at certain Vale assets reduced iron ore exports from Brazil and significantly tightened the seaborne market.

19.5.3 China

China has abundant iron ore resources but few high-grade deposits. Estimates by the Chinese government placed China's raw iron ore resources at 85 billion tonnes in 2017. Although the majority of iron ore reserves in China are state-owned steel mills, the industry is still highly fragmented with hundreds of individual iron ore mines.

Ownership of Chinese mines is classified into state-owned or private. State-owned mines are owned by state-owned enterprises (SOE) that usually produce steel as well as iron ore. Almost all of China's large steel companies are SOEs. The majority of iron ore produced from SOE mines is consumed by steel plants also owned by the parent SOE. This is referred to as captive supply. As a result, state-owned mines are less sensitive to price movements and will often keep operating even if the mine is losing money to ensure iron ore supply to the associated steel plants and to support employment. Private mines are owned by private companies or investors. These mines are motivated by profit and will alter production accordingly. China's largest and highest quality iron ore deposits were allocated to SOE companies with private mines typically owning smaller, lower grade and higher cost deposits.

The National Bureau of Statistics of China, the official Chinese government statistics agency, only provides China's iron ore production on a run-of-mine basis – that is before the ore is processed into concentrate, and it can be of a variable grade. Using data on hot metal production, iron ore consumption, and iron ore imports/exports, Wood Mackenzie estimates China's domestic iron ore production on a marketable tonne basis (i.e. as sold). This provides a production number for China that can be compared to other countries.

China's annual marketable domestic iron ore production increased rapidly after the global financial crisis (GFC), rising from 242 Mt in 2009 to 431 Mt by 2013. Official Chinese government data for production by company type over this period is not available but Wood Mackenzie estimates private iron ore mines accounted for 60% of China's iron ore output by 2013 - implying private mines accounted for the majority of the rapid post-GFC growth.

By 2017, Chinese iron ore production was estimated by Wood Mackenzie to have fallen to 196 Mt. The decline in Chinese domestic production has been caused by increased availability of lower cost imported iron ore. Much of the closures were from private mines with their share of total Chinese production falling to 31%.

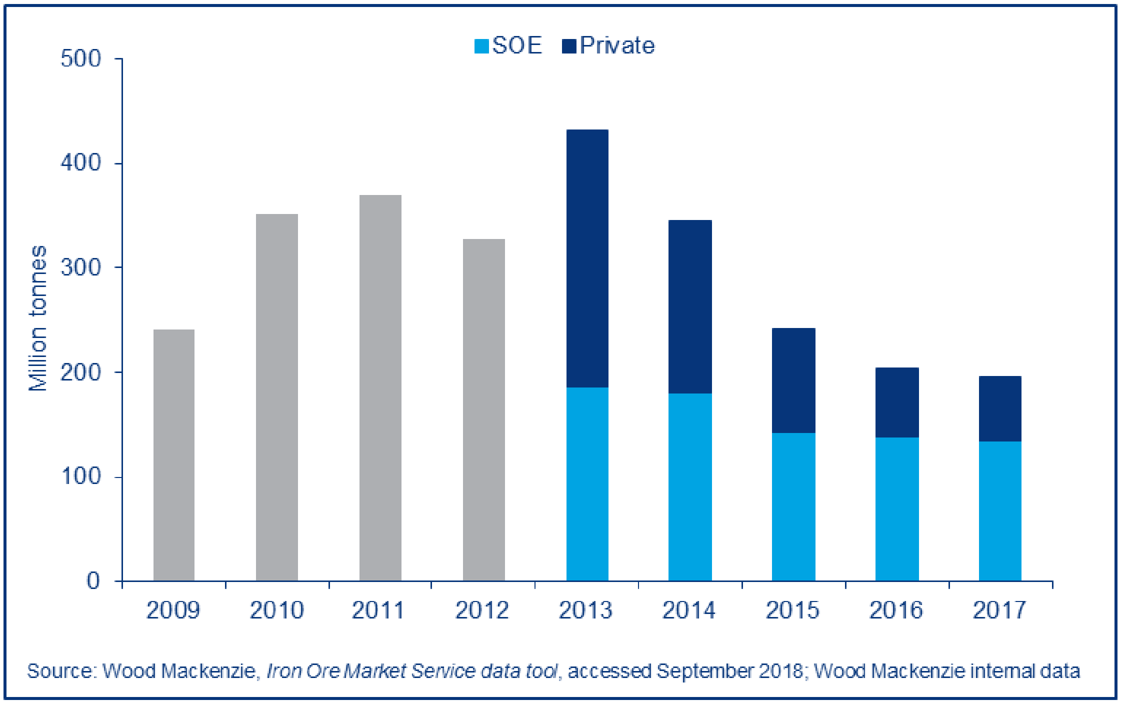


Figure 19-3: Chinese iron ore production (marketable basis)

19.5.4 North America

Total production within North America was flat between 2000 and 2008 averaging 97 Mtpy over the period. The GFC saw production dive to 71 Mt in 2009. After the GFC, North American iron ore production recovered and reached a peak of 124 Mt in 2013, before contracting back to 111 Mt in 2017.

The US accounted for 50% of North American iron ore production, on average, between 2000 and 2017, with Canada accounting for 36% and Mexico the remainder. On average, 30% of North American iron ore production entered the seaborne market between 2000 and 2017. The vast majority of North American seaborne exports are from Canada with smaller volumes from Mexico. Almost all US iron ore production is consumed by steel mills within the US and Canada.

19.5.5 India

India's iron ore production grew steadily from 74 Mt in 2000 to a peak of 209 Mt in 2010. India's Supreme Court imposed mining and export bans in 2010 and 2012 because of illegal mining. These bans caused Indian iron ore production to slump to 136 Mt by 2013. Iron ore production has picked up since 2015, as some mining bans were lifted, some existing mines were expanded and new mines developed to keep pace with India's growing steel production.

Until the 2010 iron ore mining and export ban, Indian suppliers, more so than other key suppliers, were major players in the iron ore spot market, with the majority of exports into the spot market being sourced from Western India. Due to the tightness in the seaborne iron ore markets around 2009, there was a common view that Indian spot sellers were achieving disproportionally higher prices for their products compared to those selling under long-term contracts as customers competed for the limited tonnage available in the spot market. However, even during the height of the boom, questions were being raised within India about the viability of long term iron ore exports from India given its own domestic consumption requirements associated with its growing steel industry.

19.5.6 Europe and CIS

The main iron ore producing countries are Russia, Ukraine, Sweden and Kazakhstan. Combined iron ore production increased from 166 Mt in 2000 to 218 Mt in 2008, with almost all the growth coming from Russia, Ukraine and Kazakhstan. The annual production from EU member countries has increased by only 4 Mt over this period. The GFC caused iron ore output to decline to 199 Mt in 2009. Iron ore output picked up after the GFC and reached a peak of 249 Mt in 2013. From 2014 onwards, lower iron ore prices and conflict in Ukraine saw iron ore output fall to 226 Mt by 2017.

Most iron ore produced in these regions is, and has historically been, consumed within region, with only 47 Mt entering the seaborne market in 2017. The majority of mined iron ore has been low grade magnetite that needs to be processed into high grade concentrate and pellets prior to sale or consumption.

19.5.7 Africa

African iron ore production has grown from 45 Mt in 2000 to 57 Mt in 2007, 71 Mt in 2010, and 112 Mt in 2014. From 2014 onwards, lower iron ore prices and the Ebola outbreak caused production in West Africa, especially Sierra Leone and Liberia, to decline. Total African iron ore production fell to 93 Mtpy by 2017.

Africa has little steel production capacity so most African mines are developed to supply the seaborne market. Between 2000 and 2017, 84% of African iron ore production, on average, was sold into the seaborne market. Of this, the majority was to Asia.

South Africa is the largest iron ore producing country in Africa accounting for three quarters of the continent's output in 2017. Multi-national mining company Anglo American has been the main iron ore producer in South Africa, producing high-grade fines and lump from its Kumba subsidiary. Other key African producers have included SNIM in Mauritania, ArcelorMittal in Liberia, Shandong Iron and Steel, a Chinese state-owned steel producer, in Sierra Leone, and Assore in South Africa.

19.6 Iron Ore Demand Evolution: 2000-2018

19.6.1 2000-2008

Between 2000 and 2008, Chinese steel consumption increased at an average rate of 17% per year. This phenomenal period of demand growth fed directly through to Chinese domestic crude steel production and consumption of iron ore. Over the same period, steel production and consumption in the world ex-China increased by 3% per year. Consequently, China emerged as the dominant force in the world steel industry over this period with its share of global crude steel production rising from 16% in 2000 to 35% in 2008.

Being "structurally short" in iron ore, the "China effect" was even more pronounced on seaborne trade in iron ore. China's share of global iron ore imports rose from 15% in 2000 to 52% in 2008, taking China's import dependency for iron ore from 35% in 2000 to 60% in 2007. While there was growth in iron ore demand and seaborne imports elsewhere in the world during this period it pales in comparison to China's growth.

19.6.2 2008-2009

Chinese steel production continued to grow during the GFC because of the government's fiscal stimulus aimed at steel intensive infrastructure. While the rest of the world's steel output contracted, China's annual steel production growth during this period ensured that global iron ore trade continued to grow.

The GFC saw substantial contraction in steel output in the world ex-China. Global crude steel output excluding China fell by 20% in 2009. Accordingly, between 2008 and 2009, China's share of global crude steel production surged from 38% to 46% and its share of seaborne iron ore imports from 52% to 68%.

19.6.3 2010-2014

After the GFC, Chinese industrial production and fixed investment continued to grow, but at a much slower rate than the industry had become accustomed to during the 2000s.

Between 2010 and 2014, there was a growing divergence in opinion regarding the timing and magnitude of peak steel in China. But there was a growing consensus that the Chinese economy was transitioning away from investment led growth towards a less steel intensive phase of consumption based growth, with negative implications for steel and iron ore demand.

19.6.4 2015-2018

In 2016, Beijing embarked on a comprehensive programme of supply side reforms across key industrial sectors. For steel, this marked the start of the all-important "de-capacity" phase, with the announced closure of 150 Mt of steelmaking capacity by 2020. It was agreed that all induction furnace steel capacity would be permanently closed.

The steel capacity closures and China's ongoing transition to consumer led rather than investment led growth have slowed China's steel production and consequently demand for iron ore. Rising scrap steel availability also affected China's iron ore demand. However, seaborne trade continued to grow during this period by 4% per year, on average, as high cost Chinese domestic mines took the brunt of the impact of slowing steel production growth.

19.7 Iron Ore Supply Evolution: 2000-2018

19.7.1 2000-2008

During the early 2000s, initial phase of the "great bull market" for iron ore, miners struggled to keep pace with rampant Chinese demand. But from 2003/04, the supply side of the iron ore industry started to catch up with (Chinese) demand as investments in new mine/rail/port infrastructure were commissioned.

Global exports of iron ore increased at an annual average rate of 65 Mtpy between 2003 and 2008. This was a major step change for a market that had grown by an average of just 5 Mtpy during the 1980s and 1990s.

19.7.2 2008-2009

The GFC years of 2008 and 2009 saw a decline in global steel production and a rapid fall in iron ore prices to levels below the cost of supply for a large portion of the market. It was mainly high cost Chinese domestic mines that dropped out of the market in response to weaker demand, in turn leading to lower prices.

Seaborne suppliers were also affected. Margins for all producers declined on the back of lower iron ore prices, capital expenditure and growth plans were scaled back as credit dried up and higher cost seaborne suppliers entered into administration or ceased trading.

The effects on supply from the GFC were mostly temporary and growth plans and spending resumed through 2009 into 2010 on the back of China's fiscal stimulus and continued steel consumption growth.

19.7.3 2010-2014

The post-GFC period saw the overall iron ore industry return to growth. Hot metal production during this period rose by 7% per year, on average, almost entirely driven by Chinese growth, and seaborne iron ore trade grew at a trend rate of 8% per year.

Australia was the major driver of increased supply with its seaborne iron ore exports growing by 14% per year. This growth was driven by capacity expansions from Rio Tinto and BHP and the entrance of FMG into the market in 2008.

Brazil was a country that failed to fully capture the benefits of iron ore's "great bull market". Brazilian companies did invest in new iron ore mining capacity during the 2000s but increasingly stringent environmental/permitting restrictions and transportation bottlenecks constrained exports below the country's potential. Brazil's share of global seaborne exports was 37% in 2000 but had fallen to 28% by 2009 and continued to fall to 25% by the end of 2014.

19.7.4 2015-2018

From 2015 onwards, signs emerged that the iron ore market was entering a period of excess supply capability. As prices started falling and margins came under pressure there was a change of strategy amongst the iron ore majors with the focus switching away from growth projects towards balance sheet protection and capital management. Numerous iron ore projects were cancelled, deferred or scaled back during this period, particularly high Capex greenfield projects.

However, Chinese imports of iron ore continued growing strongly in the period 2015–2017. This was largely due to an abundance of supply from the Australian iron ore majors that had invested heavily in their Pilbara systems and were still increasing production towards capacity.

Seaborne supply from the relatively lower-cost iron ore majors has been able to displace China's high-cost domestic iron ore producers who saw operating margins turn negative as iron ore prices declined. This cost disadvantage was exacerbated as Chinese steel capacity increasingly shifted to coastal regions that have easy access to seaborne iron ore.

Since 2016, iron ore suppliers have focused on improving iron ore quality – that is maximizing iron content and minimizing impurities, in response to the changing demand dynamic, in particular from China. The period 2016-18 also saw numerous high-grade projects in Canada, Brazil, Sweden, Ukraine and Australia progress towards financing and construction. Conversely, low grade mines and projects continue to show poor financial returns and risk being forced to withdraw from the market.

19.8 Forecast Demand for Iron Ore: 2019-2040

China will remain the driver of global iron ore demand through to 2022, beyond which, India is primed to take over the baton and keep global iron ore consumption rising. The now well established downward trend in Japanese demand is forecast to continue, while iron ore consumption in Europe, South Korea, Taiwan and the Middle East will enter a period of stagnation.

Global consumption of iron ore is forecast to grow at a CAGR of 1.3% between 2018-2023, falling to 0.5% between 2023 and 2040. Iron ore pellets will be the fastest growing segment of the market, with consumption forecast to grow by almost 2% per annum over the next 20 years. The relative outperformance of iron ore pellets implies strong demand for high grade iron ore concentrate suitable for pelletizing.

Table 19-1: Iron ore consumption by key country/region

Region	Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2025	2030	2035
World		2,058	2,101	2,069	2,058	2,099	2,128	2,182	2,218	2,238	2,259	2,293	2,331	2,373
Asia		1,569	1,605	1,592	1,590	1,613	1,625	1,662	1,688	1,697	1,707	1,718	1,729	1,746
	China	**1,239**	**1,254**	**1,242**	**1,228**	**1,242**	**1,241**	**1,262**	**1,277**	**1,276**	**1,275**	**1,263**	**1,222**	**1,175**
	India	**110**	**118**	**119**	**133**	**141**	**149**	**159**	**166**	**172**	**178**	**201**	**258**	**327**
EU28		135	141	136	133	137	136	136	138	139	140	143	144	146
Other Europe		17	17	19	20	20	20	20	21	23	25	27	27	27
CIS		139	135	132	135	132	135	138	140	144	147	156	167	178
North America		75	79	69	63	66	70	74	75	77	78	78	78	78
South America		56	55	54	48	52	53	56	58	60	62	66	72	78
Africa		17	16	14	14	17	19	22	23	24	26	27	29	30
Oceania		6	6	6	6	6	6	6	6	6	6	6	6	6
Middle East		45	47	47	49	56	64	68	68	68	69	72	78	84

Source: Wood Mackenzie

Note: These data are consumption of fines, lump and pellet.

Table 19-2: Mined iron ore demand by ore type

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2025	2030	2035
Total	**2,084**	**2,116**	**2,085**	**2,072**	**2,114**	**2,141**	**2,184**	**2,217**	**2,239**	**2,264**	**2,297**	**2,327**	**2,350**
Fines	1,316	1,357	1,331	1,328	1,326	1,325	1,353	1,373	1,385	1,396	1,413	1,418	1,421
Lump	269	272	280	289	287	291	299	303	303	304	301	296	292
Pellet feed	500	487	474	455	501	525	532	541	551	564	583	613	637

Source: Wood Mackenzie

19.9 Forecast Supply of Iron Ore: 2019-2040

In January 2019, the Córrego do Feijão tailings dam, operated by Vale in Brazil, tragically failed. The cessation of mining at certain Vale assets reduced iron ore exports from Brazil and significantly tightened the seaborne market. The subsequent finely balanced seaborne iron ore market has come to define iron ore prices, with any potential further reductions in supply causing significant price responses.

Wood Mackenzie's working assumption as of May 2019 is that Vale's Brazilian iron ore production falls to 320 Mt in 2019, 80 Mt below the pre-dam failure forecast for 2019. The impact on seaborne exports should be less severe, as Vale draws down inventory from numerous stocking and blending facilities around the world in its effort to meet customer obligations.

Given the increasingly stringent regulatory environment in the wake of the tailings dam disaster, and the potentially disruptive impact on supply from enforced dam decommissioning, Wood Mackenzie believes the production recovery will be a slow process. Notwithstanding the ramp-up at S11D, Vale is unlikely to return to peak 2018 iron ore production until 2023 at the earliest.

But at a global level, Wood Mackenzie forecast a return to growth in exports from 2020 driven by a gradual return to production at some of Vale's idled assets, ramp-up at Minas Rio, and the completion of expansion programmes at BHP and Rio Tinto. Global exports of iron ore are forecast to peak at 1.66 billion tonnes, but the peak is now expected to occur in 2024, somewhat later than previously forecast.

Table 19-3: Mined iron ore supply by key country/region

Region	Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2025	2030	2035
World		2,198	2,236	2,125	2,163	2,238	2,238	2,237	2,274	2,304	2,343	2,343	2,323	2,305
Asia		612	504	380	380	391	371	389	391	389	385	373	371	371
	China	**431**	**346**	**242**	**204**	**201**	**190**	**194**	**197**	**195**	**188**	**179**	**153**	**136**
	India	**126**	**122**	**115**	**152**	**167**	**154**	**168**	**169**	**170**	**172**	**172**	**196**	**214**
EU28		29	30	27	29	29	29	32	33	34	34	34	34	34
Other Europe		11	14	12	9	9	10	10	10	12	10	10	10	10
CIS		211	205	198	191	191	194	198	200	200	200	200	200	200
North America		126	116	105	103	113	117	125	128	132	132	125	118	105
South America		431	456	466	457	473	478	422	438	468	523	550	540	541
	Brazil	**393**	**423**	**431**	**418**	**436**	**445**	**388**	**398**	**425**	**478**	**505**	**494**	**494**
Africa		104	112	91	88	93	90	92	93	93	93	93	90	79
Oceania		625	751	806	860	882	891	905	923	923	913	905	901	901
	Australia	**623**	**748**	**804**	**857**	**879**	**888**	**903**	**921**	**921**	**911**	**903**	**899**	**899**
Middle East		49	48	39	46	57	60	64	57	53	52	53	59	65

Source: Wood Mackenzie

Note: These data include mined iron ore sinter fines, lump and pellet feed

19.9.1 Forecast Market Balance and Price Outlook (62% Fe sinter fines)

Uncertainty over the scale and duration of Brazilian production cuts in the aftermath of the Brumadinho tailings dam failure in January 2019 has changed the entire psyche of the iron ore market. Prior to the dam failure, the widely held view in the market was that iron ore was entering a multi-year period of cyclical and structural weakness that would drive prices towards marginal cost (around USD60/t CFR China) during the period 2019/20. But this view has now been pushed out by up to five years, depending on revised assumptions for Brazilian supply, Chinese demand, and the extent to which other seaborne suppliers can offset the forecast shortfall from Vale.

Forecasts and assumptions on Brazilian iron ore supply are subject to a higher than normal degree of uncertainty in the wake of the Brumadinho tailings dam failure. Wood Mackenzie's working assumption is that Vale's iron ore production is unlikely to return to the record 2018 level until 2023. This will have a significant impact on the global supply/demand balance as it occurs at a time when there is limited "spare capacity" within global iron ore supply chains.

Wood Mackenzie forecasts global exports to fall in 2019, but not to the same extent as Vale's production, as high seaborne prices will provoke a supply response from incumbent producers, aspiring miners, and high cost swing suppliers to the seaborne market. Wood Mackenzie also forecast significant stock drawdown from within Vale's own system and from Chinese portside inventory. The net impact on global exports in 2019 will be a year-on-year fall of 25 Mt, a swing of almost 50 Mt from Wood Mackenzie's previous forecast for a year-on-year rise of 20-25 Mt.

This major forecast adjustment results in a global seaborne market that is closely balanced, with a tendency towards under-supply. Industry participants will not risk being short while the market is so finely balanced and vulnerable to further supply side shocks. Cyclone damage to key iron ore loading port infrastructure in March 2019 was a clear example of the prevailing market tightness: all three Australian majors announced cuts to production guidance due to the cyclone and prices responded swiftly, with the 62% Fe fines index rising to USD95/t CFR China.

In view of the potential scale and duration of the Brazilian production cuts and the broader implications for industry costs and investment that might follow as a result of regulatory changes relating to iron ore processing and tailings storage, Wood Mackenzie has raised their medium term price forecast for iron ore. The benchmark 62% Fe fines index is forecast to average USD71/t CFR China (in real 2019 US dollar terms) during the five year period 2019-2023.

Recent events discussed above have not triggered a change to Wood Mackenzie's long term (post 2025) view of the market. Supply and demand for iron ore will become more closely aligned in the period 2025-27, followed by the emergence of a notional "supply gap" post-2027. This "gap" needs to be filled by greenfield projects and/or brownfield expansions that currently fall outside of the Wood Mackenzie base case.

The incentive price approach indicates a long run price of at least USD65/t CFR China (real 2019 US dollars) will be required to balance the market over the long term. Wood Mackenzie applies a long run price in real terms from 2025.

Table 19-4: Seaborne imports

Region	Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2025	2030	2035
World		1,217	1,354	1,369	1,433	1,488	1,491	1,500	1,520	1,544	1,553	1,584	1,608	1,663
Asia		1,039	1,168	1,189	1,254	1,301	1,304	1,309	1,329	1,351	1,356	1,375	1,393	1,431
	China	806	916	940	1,011	1,059	1,050	1,052	1,069	1,085	1,085	1,086	1,071	1,042
	India	1	7	10	7	5	16	14	16	18	20	39	75	148
EU28		121	124	119	114	118	115	118	119	120	121	123	125	127
Other Europe		8	9	10	10	11	11	12	12	14	16	18	18	18
CIS		0	0	0	0	0	0	0	0	0	0	0	0	0
North America		7	9	8	12	11	10	10	7	6	6	12	15	29
South America		6	6	5	4	5	5	5	6	6	6	6	7	7
Africa		7	6	5	5	8	10	11	12	13	13	15	16	17
Oceania		0	0	0	0	0	0	0	0	0	0	0	0	0
Middle East		29	33	33	34	34	35	35	35	34	34	34	34	34

Source: GTT, Wood Mackenzie

Table 19-5: Seaborne exports

Region	Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2025	2030	2035
World		1,244	1,384	1,400	1,481	1,529	1,521	1,500	1,526	1,553	1,578	1,592	1,572	1,561
Asia		56	35	12	30	44	34	35	27	23	20	13	13	13
	China	**0**	**0**	**0**	**0**	**5**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
	India	**16**	**10**	**4**	**22**	**28**	**18**	**20**	**15**	**13**	**10**	**3**	**3**	**3**
EU28		23	24	20	23	23	23	25	26	27	27	27	27	27
Other Europe		5	5	4	2	3	3	2	3	4	3	3	3	3
CIS		26	29	28	25	22	15	15	15	14	13	13	12	12
North America		51	42	37	43	45	49	55	57	60	60	60	56	56
South America		358	374	398	409	415	416	369	387	417	461	493	485	484
	Brazil	**330**	**345**	**365**	**374**	**383**	**388**	**338**	**353**	**378**	**420**	**453**	**444**	**444**
Africa		96	102	85	86	89	85	85	86	86	85	85	82	71
Oceania		605	750	801	845	868	879	897	916	916	906	898	894	894
	Australia	**604**	**748**	**799**	**842**	**865**	**877**	**895**	**914**	**914**	**904**	**896**	**892**	**892**
Middle East		24	23	15	18	22	17	17	10	6	4	1	1	1

Source: GTT, Wood Mackenzie

Table 19-6: Seaborne market balance

Region	Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2025	2030	2035
World		27	30	31	49	41	30	0	7	9	24	8	-36	-102

Source: Wood Mackenzie

19.10 Iron Ore Pricing

19.10.1 How is Iron Ore Priced?

Pricing mechanisms for iron ore have evolved over the past 15 years with the industry moving from an annually negotiated benchmark system to index linked pricing. Despite the evolution in pricing mechanisms, the basic principle of pricing has remained the same where iron ore is priced based on the cost of the iron units and adjustments for physical properties, impurities and other steelmaking related characteristics.

Different types and qualities of iron ore will be priced depending on their value to particular steel mills. That is, depending on how the iron ore performs in a steel mill in terms of its impact on steel plant productivity, energy consumption and the quality of steel produced. Steel mills will value identical iron ore differently depending on the steel products being produced; the specifications of each individual steel plant; the composition of the blend, and the location of the steel plant, which can determine alternative sources of supply.

The discounts or premiums received for iron ore products are frequently referred to as "value-in-use" adjustments. Technical marketing teams (internal or external to the iron ore miner) play an important role in ensuring price discounts are minimized and premiums maximized for the iron ore products sold by each company. This is achieved by selling iron ore products to those customers that value the products the most.

In addition to the 'value-in-use' factors, a range of economic and market factors also influence price, including:

- Global and regional balance between demand and supply;
- Cost of production, including exchange rates, freight and location of the customer;
- Steel prices and margins;
- Terms and volumes of the sales contracts;
- Relationship between the buyer and seller;
- Market strategy of the seller.

19.11 Iron Ore Pricing Evolution

Pricing mechanisms and pricing points for iron ore products have matured and become more sophisticated over time. Iron ore pricing has transitioned from the annual benchmark price system through to index linked pricing that is widely used today in annual and long term contracts. This has occurred alongside the emergence of the spot market.

19.11.1 The Annual Benchmark Price Era

From the 1970s up to 2010, iron ore was traded under long term volume contracts with annual price negotiations. Iron ore prices were set through bi-lateral negotiation between suppliers and steel mills. Japanese and European steel companies were the main price negotiators on the buy side with China's influence increasing in the second half of the 2000s. Rio Tinto, BHP and Vale led the negotiations on the sell side.

19.11.2 Breakdown of the Benchmark System

Rapid growth in China's steel output in the 2000's saw global demand for iron ore surge and supply from the traditional exporting countries of Australia, Brazil and South Africa was unable to keep pace. In response, a nascent spot market began to develop from 2003 outside of the benchmark system.

The breakdown of the benchmark system started when Rio Tinto and BHP failed to accept Vale's initial settlement for a 65% year-on-year price increase in February 2008. In a radical break from tradition, Rio Tinto held out for a further four months after the Vale settlement and eventually agreed an 80% price increase with Chinese steelmaker Baosteel. BHP followed suit and also announced that it would no longer enter new contracts based on the annual benchmark system. Existing long-term volume contracts would be allowed to expire and new supply contracts would have prices adjusted more frequently, initially quarterly based on a published index.

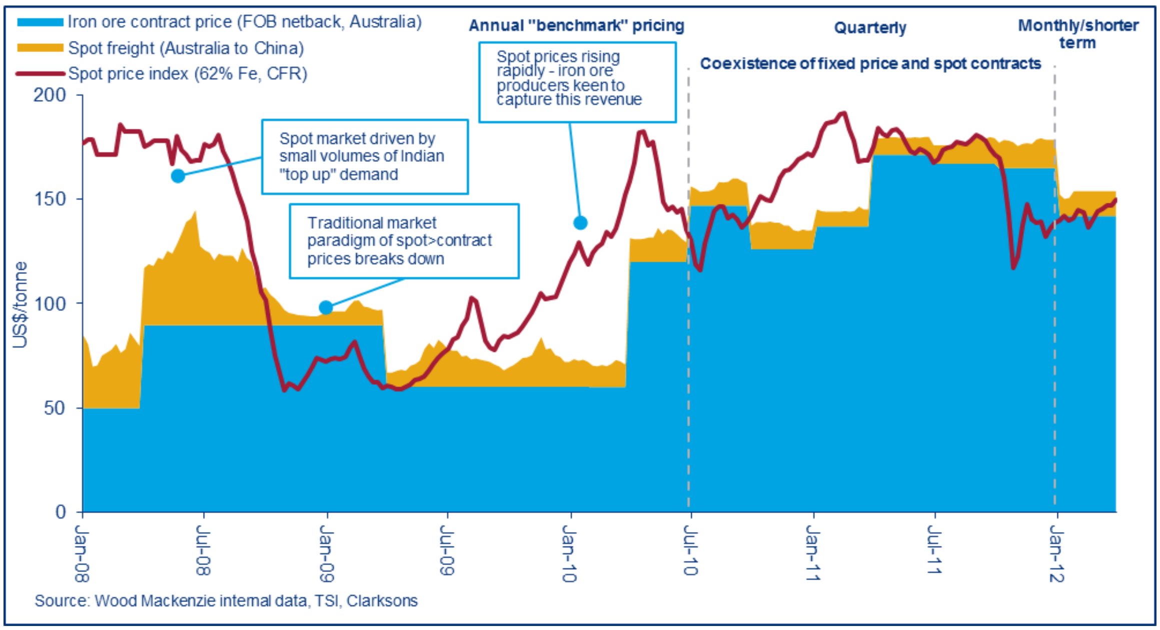


Figure 19-4: Transition from annual benchmark to index linked pricing

19.11.3 "Benchmark" or "Reference" Iron Ore Price

The primary reference for pricing internationally traded iron ore is the price of 62% Fe fines delivered to China. There are several price reporting organizations that track spot prices and compile iron ore price indices for this benchmark and other iron ore products.

One of the most commonly referenced indices is Platts' IODEX 62% Fe CFR China index. CFR China indicates cost and freight. Platts assesses trading transactions, bids and offers for iron ore fines grading between 60% Fe and 63.5% Fe, and then adjusts (or normalizes) the price information to align it to a base standard specification.

Platts has set the quality specification for the IODEX 62% Fe index as follows: 62% Fe, 4.0% silica, 2.25% alumina, 0.09% phosphorus, 0.02% sulphur, and 8% moisture.

19.11.4 Demand and Pricing for High Grade Iron Ore (Fines and Concentrates)

In addition to the "benchmark" or "reference" 62% Fe fines index, there are a range of indices for lower and higher Fe-grade iron ore, for example, 58% Fe and 65% Fe (Platts commenced publishing these in 2009). Indices also exist for adjusting iron ore with different levels of impurities, such as phosphorus and alumina.

High-grade iron ore can reduce blast furnace fuel rates and increase furnace productivity. Price premiums for high grade fines and concentrates vary with market conditions and are influenced by many factors, including: the steel market and mill margins; coal and coke prices; scrap prices; supply and demand of different grades of iron ore; and whether iron ore prices are rising or falling, as well as the absolute price level.

Productivity has emerged as a key driver of iron ore pricing since 2017. However, this was not the case for the previous 10 years, when the Chinese steel industry was struggling with overcapacity and low or negative steel margins. China closed approximately 115 Mtpy of steel capacity between November 2016 and December 2017 when it initiated a programme of supply-side reforms to rationalise its steel industry. In addition, China removed more than 140 Mtpy of illegal induction furnace capacity in 2017/18. In conjunction with the "de-capacity" programme, environmental restrictions to cut air pollution in China's industrial hubs further constrained utilization of the remaining steel capacity. All these factors have encouraged the remaining capacity to run at a higher productivity level.

In response to these developments, steel producers have moved in favour of high-grade fines and concentrates over low grade iron ore. This was most apparent during 2017/18 when steel margins increased sharply, leading to wider discounts for low grade ore, while the premium for high grade (low impurity) fines and concentrates rose sharply.

Wood Mackenzie's view is that the transition towards a tiered pricing structure for iron ore is a structural change that will persist in the long term. Environmental policies and safety checks in China will continue to restrict the industry from fully utilizing remaining steel capacity. Therefore, steel companies will likely keep pursuing high productivity, with a preference for high grade iron ore. This productivity focus favours suppliers of high-grade sinter fines and concentrates.

Wood Mackenzie forecast that the reference index for 65% Fe sinter fines will trade at a premium of 20% (USD13/t) to the 62% index over the long run. Wood Mackenzie's long run price premium forecast for 65% Fe fines is narrower than the record high premiums seen in 2017/18, but is higher than the circa 10% price premium that prevailed before China's steel supply-side reforms began in 2016.

19.11.5 Wood Mackenzie's Methodology for Forecasting Premiums for High Grade Concentrates

There are various qualities and types of iron ore available to a steel company, with different Fe grades and various levels of impurities (gangues). In the sintering process, low grade ore brings in more impurities – mainly acid oxides such as silica or alumina. This consumes more alkaline flux to neutralize acid oxides, and ultimately requires more coke breeze to heat the sinter blend. Low grade ore also results in a lower Fe grade in the sinter produced, because a greater portion in every tonne of sinter is taken by the impurities and residuals of flux and coke breeze after sintering.

Low grade ore also consumes more coke (and consequently coking coal) in the ironmaking process, because of its lower Fe grade and higher impurities. The ironmaking process consumes more sinter to produce every tonne of hot metal when using low grade ore. This means that more impurities are brought into the blast furnace and consequently more slag is generated. Heating up the impurities to form the molten slag consumes fuel, and so low grade ore uses up more coke in the ironmaking process.

In order to better understand the pricing mechanism for various iron ore brands, Wood Mackenzie takes a quantitative approach to assess the theoretical discount or premium that should be applied to a specific ore brand against a benchmark brand. The Wood Mackenzie price spread model uses Pilbara Blend fines as the benchmark specification.

The Wood Mackenzie quantitative model finds the price of varying iron ore grades that would make a typical Chinese steel mill indifferent to switching between them. The model finds the 'indifferent' price by calculating the price for each iron ore grade needed to make the same gross cash margin for the steel mill.

Wood Mackenzie uses the model results, in conjunction with analysis of future supply/demand trends in the seaborne market, to forecast price spreads for high and low grade sinter fines and concentrates.

The spread calculation is achieved by assuming that the price paid for a certain iron ore brand should reflect all costs (including the opportunity cost) with a condition that steel companies can make the same gross margin regardless of which iron ore brand they buy. The model uses gross margin rather than per tonne margin because of the productivity effects of switching iron ore grades. For example, switching to low grade iron ore means a blast furnace of fixed size will produce less hot metal.

Wood Mackenzie's price forecast for the 62% (benchmark) price and the 65% (high grade) price for sinter fines is presented in Table 19-7.

Table 19-7: Wood Mackenzie price forecast (USD/t)

Sinter Fines CFR China	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
62% Fe Nominal	90.8	80.0	75.0	72.0	72.0	72.0	73.2	74.7	76.2	77.7	79.3	80.9	82.5	84.1	85.8	87.5	89.3	91.1	92.9	94.7	96.6	98.6
62% Fe Real (2019$)	90.8	78.4	72.1	67.8	66.5	65.2	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
65% Fe Nominal	105.3	96.0	90.0	86.4	86.4	86.4	87.9	89.6	91.4	93.3	95.1	97.0	99.0	100.9	103.0	105.0	107.1	109.3	111.5	113.7	116.0	118.3
65% Fe Real (2019$)	105.3	94.1	86.5	81.4	79.8	78.2	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0

Source: Wood Mackenzie

19.12 Dry Bulk Freight Outlook

Freight costs were in decline for the first quarter of 2019 following the Vale dam incident and cyclone disruptions to Western Australia. Capesize time charter rates were hit hard following the slowdown of iron ore exports, particularly from Brazil, and bottomed out at the end of March and early April 2019 at around USD3,900 per day. Sentiment is improving following news on Vale's Brucutu mine restart but the modest improvements seen through to May 2019 are by no means a signal that the market has turned. Given Wood Mackenzie's view that Vargem Grande will be much slower to restart than market expectation and much of the concentrate feed from Brucutu redirected to fill the gap at the Tubarao pellet plant, this will lead to a much slower recovery in actual tonne mile demand for dry bulk freight. Any further delay to the restart of Vale's idled operations will result in downside risk for Capesize time charter rates.

Compliance to meet new IMO 2020 regulations will see an increase in freight costs next year. Wood Mackenzie's view is that given the low scrubber installation rate and limited supply of very low sulphur fuel oil, the majority of the dry bulk fleet will switch to very low sulphur marine gasoil to meet sulphur emission requirements. This means that not only will vessels switch to a higher cost fuel, but demand and price for marine gasoil will also increase, compounding the effect. The impact of this fuel cost increase will be felt most on longer routes and for exporters of lower value goods, who will be weighing up these increases relative to the price of the commodities they are shipping.

Table 19-8: Freight rate Brazil-China Route (C3 Index)

	2018	2019	2020	2021	2022	2023
Tubarao-Qingdao Freight (USD/t)	18.40	15.70	19.7	20.40	21.10	22.10

Source: Wood Mackenzie

19.13 QIO's Bloom Lake Concentrate Price Forecast

The following sections describe the QIO concentrate specifications as well as the methodology retained by QIO for determining the Base Case Price Estimate

19.13.1 QIO Concentrate Specification – November 2018 to April 2019

A product specification for Bloom Lake iron concentrate (Table 19-9) was developed based on the Phase 1 (QIO) concentrator's first year of operation, project's life of mine plan and testwork undertaken at COREM from November 2018 to April 2019. These specifications are described as "typical". Iron ore producers commonly quote "typical" or "expected" specifications for their products; guaranteed or minimum/maximum levels of various components are also separately specified in sales contracts.

Table 19-9: Bloom Lake concentrate typical specifications
Chemical composition and particle size distribution from QIO Bloom Lake FS

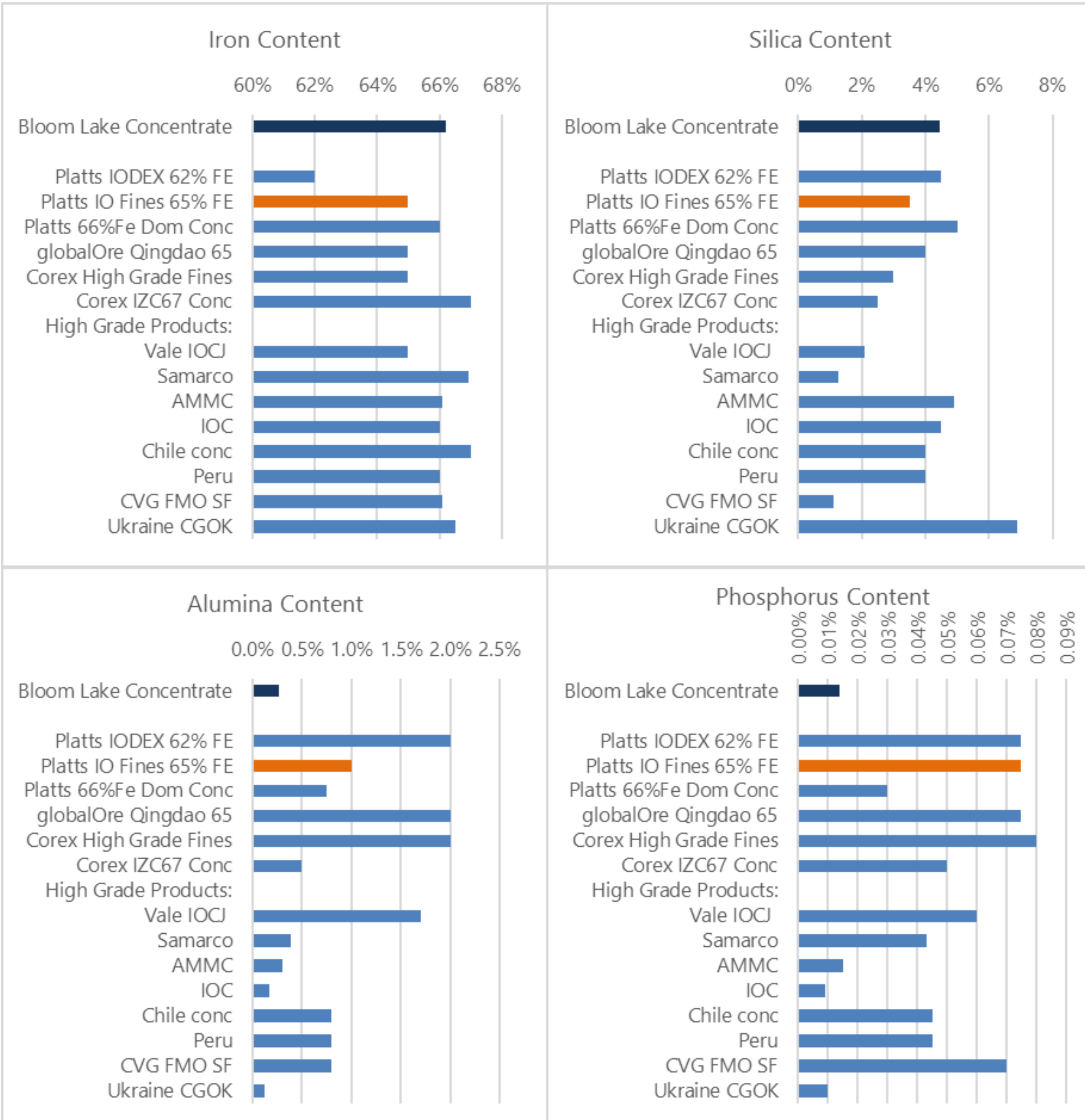
Content	Fe	Silica	Alumina	Phos.	Sulphur	MnO	CaO	MgO	Na_2O	K_2O	TiO_2	LOI
%	66.2	4.50	0.27	0.023	0.01	0.14	0.40	0.40	0.01	0.003	0.07	0.18

Table 19-10: Typical particle size distribution

Size (microns)	850	600	425	300	212	150	106	75	-75
% Retained	2.8	7.7	12.7	17.1	19.2	16.3	12.4	6.8	5.1

The particle size distribution positions the Bloom Lake product as coarse-grained concentrate suitable for use as a sinter feed product and falls within the general sizing range of Canadian concentrates. Bloom Lake concentrate has successfully sold into global markets for several years with sales exceeding 6 Mt in 2014 and nearly 7 Mt in its first year of operations after re-commissioning in February 2018.

Figure 19-5 was originally published in the NI 43-101 technical report on the Bloom Lake Mine Re-Start Feasibility Study by Ausenco March 17, 2017, and compares the Bloom Lake concentrate analysis with the chemistries of some reference index and trading platform specifications, along with those of some potentially competing high-grade products. Note that this is only a generalised comparison as some product specifications may have been superseded and, if current, may change. Moreover, companies often offer variations on product specifications at different times as operational and market circumstances change. Within those limitations, it is clear that the Bloom Lake product's iron content is competitive in the high-grade fines market.



Source: Ausenco (Bloom Lake concentrate), Platts, The Tex Report, COREX, globalORE, companies, Metalytics

Figure 19-5: Bloom Lake chemistry comparison
These charts are only suitable for generalized comparison and should not be relied upon

Notes:

- Product chemistries are charted for indicative comparison purposes and may not be current.
- The specifications of actual products traded may differ materially from those shown above.
- Index, trading platform, and company product specifications are subject to change at any time.

At 4.50%, the silica level is similar to other Canadian (Labrador Trough) concentrates, higher than Brazilian and other South American products, but lower than competing products from CIS sources. It also sits below the Platts index base specification for Chinese domestic concentrate. The decline in China's iron ore production – which is generally characterised by higher silica levels – has to some extent required a rebalancing of silica in sinter feed blends, but this is generally the role of low to medium grade products.

Bloom Lake concentrate has a very low alumina level, also characteristic of traditional Canadian concentrates. It could therefore be used in a blend to correct for high alumina in lower-priced ores. Phosphorus and sulphur, which are generally deleterious contaminants, are also present at very low levels – this can be quite beneficial in reducing the total load of those elements in a blast furnace raw material mix.

Geographically, Eastern Canada is at a logistical disadvantage to Brazil, the main source of high-grade products into Asian markets. On the other hand, it is well-placed to supply Europe and other Atlantic markets. Prior to Bloom Lake's shutdown in 2014, it mainly supplied China and so has a previously-established position in that market. The typically low Canadian concentrate moisture level in the Bloom Lake product is a benefit in reducing effective transport costs, when considered on a dry basis.

19.13.2 Bloom Lake Base Case Price Estimate – CFR China Basis (QIO)

Iron ore is commonly sold on a Cost and Freight (CFR) or Fee on Board (FOB) basis. Under a CFR sale, the product changes hands as it is unloaded at the arrival port and the pricing includes shipping costs. In recent years, there has been a strong trend to CFR sales, as this gives sellers control over shipping. A FOB sale is for iron ore delivered on board a vessel at the loading port, and the price is usually determined by netting back the cost of ocean freight (to China) from the CFR price.

The following represents QIO's base case price forecasts from 2020 to 2038 for medium grade (62% Fe) and high grade (65% Fe) iron ore fines on a CFR China basis and corresponding estimates for 66.2% Fe Bloom Lake concentrate, also on a CFR China basis. All prices are in real 2019 terms.

Table 19-11: Bloom Lake concentrate base case price estimates
Prices in USD/dry metric ton (dmt) and in real 2019 terms

Year	62%Fe Index CFR China (3-year moving avg)	62%Fe Index CFR China + 15% (3-year moving avg)	65%Fe Index CFR China analyst consensus	Realized price 66.2% CFR China net of marketing fees	Freight	Net realized price 66.2% FOB
2021			91.36	91.56	22.27	69.29
2022			88.07	88.26	21.61	66.65
2023			84.24	84.42	20.85	63.57
2024 and +	71.54	82.27	84.24	83.43	20.65	62.78
Average LOM		**83.90**		**84.10**	**21.54**	**62.56**

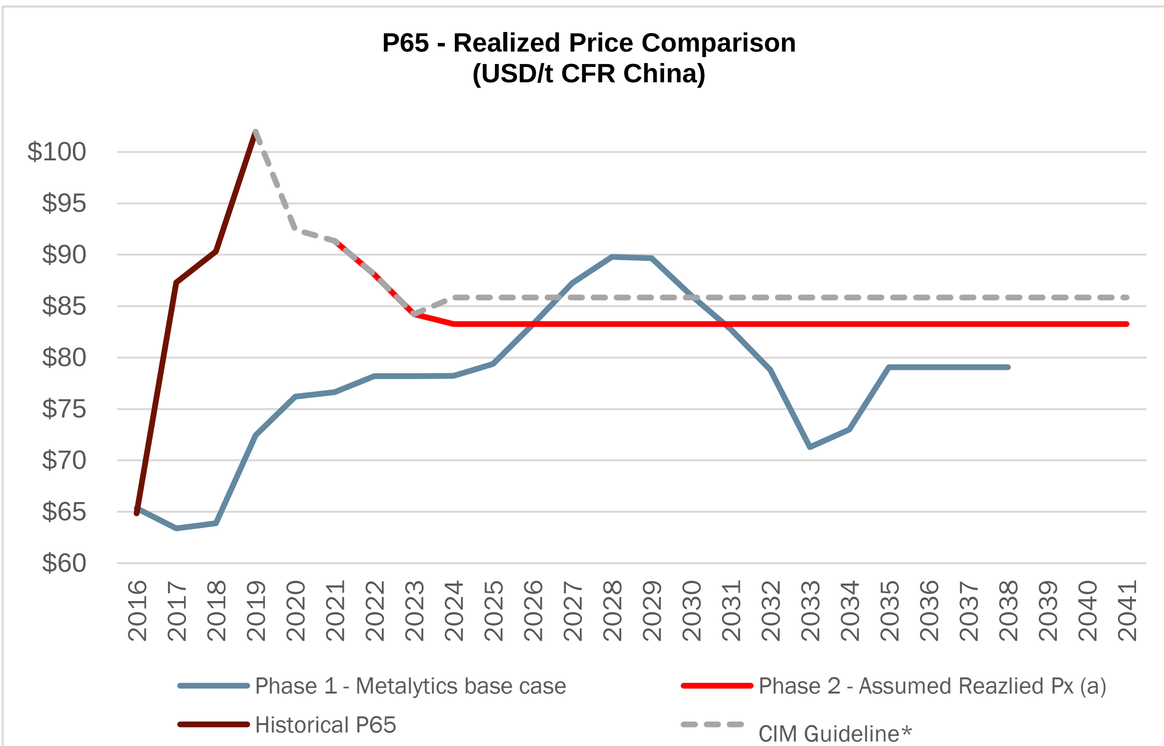
Source: PLATTS

The future Bloom Lake concentrate prices were estimated based on the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) guidance on commodity pricing adopted on November 28, 2015. It is understood that the US Securities and Exchange Commission (SEC) accepts, as a maximum price allowed, the lesser of the 3-year moving average and current spot price. CIM acknowledges many Canadian mining companies using this method and recognize that it has become a common industry standard. Consensus prices obtained by collating the prices used by peers or provided by industry observers is also said to be used as common practice and generally accepted for most common commodities.

The base case economic assumption utilizes a conservative blended average gross realized price of USD84.1/t (66.2% Fe CFR China) for the LOM. Given recent events in Brazil fail to be recognized in the 3-year moving average as suggested by CIM, the base case price assumption also incorporates analyst consensus to capture the short-term pricing dynamic in the industry. The P65 analyst consensus of 9 well recognized global research firms was utilized for the basis of the price for Years 1 to 3. For the remaining LOM, the P65 iron price is based on the average of the P65 analyst long-term consensus and the P62 3-year trailing average with a 15% premium, being a discount to the estimated long-term premium of P65 to P62 of 20% by Wood Mackenzie. Such estimates for P65 then receives a pro-rata adjustment for premium at 66.2% and marketing fees to arrive at a net realized price for the concentrate of 66.2% produced at Bloom Lake.

The average LOM base case P65 price assumption of USD83.9/t compares with a spot price at P65 of USD124.7/t as of June 13, 2019, of which Bloom Lake's 66.2% Fe material receives a premium. The base case P65 price assumption of USD83.9/t also proves to be conservative when compared to CIM guidelines of USD86.1/t, derived using the 3-years average of P65 on long-term basis rather than 3-years average of P62 + 15% used in the study. The average LOM base case realized price of USD84.1/t also compares to the Metalytics estimates for the same period of USD80.5/t used in the FS to re-commission Bloom Lake Phase 1 published in March 2017, which occurred prior to significant events impacting the iron ore industry early 2019.

Given the importance of iron ore in the global freight industry, an historical relationship exists between iron ore price and freight rate. As of June 13, 2019, the 5-year average for C3 freight rate as a percentage of the P62 iron ore price was 20.9%. The estimated freight rate used for the life of mine is derived from a 20% premium to the P65 iron ore price and an additional premium of USD4/t for distance. This premium to the trailing 5-year average is considered to reflect the incremental distance to the C3 freight index, servicing Tubarao to Qingdao, to better estimate the Sept-Iles to Qingdao route, which would be considered the farthest delivery point for Bloom Lake's concentrate.



** CIM Guideline: Average of P65 analyst consensus & trailing 3-years P65*

20. ENVIRONMENTAL STUDIES, PERMITTING, AND SOCIAL OR COMMUNITY IMPACT

The following chapter presents the Project's regulatory environment. It details the applicable laws and regulations, and lists the principal permits that were obtained and those required to complete the Project. The ongoing Environmental Impact Assessment (EIA) is associated to processes for increasing waste rock and tailings storage capacities. This EIA requires that data be gathered on many biophysical components and that consultations be held to inform the Project relevant stakeholders, such as First Nations and the local community. The main results and outcomes are also documented in this chapter. The environmental issues, mitigation measures and compensation projects are also outlined. Finally, the mine's restoration plan is presented at the end of this chapter.

20.1 Related Information

The following information was summarized in NI 43-101, a compliant Technical Report prepared for Quebec Iron Ore (QIO) and issued on March 17, 2017 (Ausenco, 2017), and has been updated with more recent information developed since that time, such as the ongoing EIA for the new Tailings Storage Facility (TSF) and waste piles.

In the present NI 43-101 report, environmental concerns and permitting statuses will focus on the new infrastructure required, which needs to be authorized.

20.2 Required Permits and Status

Several permits and authorizations have already been obtained, which secured the beginning of the Project. Section 20.2.1 lists the permits that were obtained and that are relevant to the expansion Project. Section 20.2.2 identifies the gaps in the authorizations required up to mine closure.

20.2.1 Obtained Permits

20.2.1.1 Provincial

The construction of the Bloom Lake Iron Mine project was initiated in 2008 (production of 8 Mtpy) and operation was launched in March 2010. The Project was subject to an EIA and review process under Section 31 of the Environment Quality Act (EQA), which led to the first decree (137-2008) issued by the Quebec government in 2008 (Table 20-1). The increase in production to 16 Mtpy was approved by the *Ministère de l'Environnement et Lutte contre les changements climatiques* (MELCC) (Ministry of Environment and Climate Change Control) in a decree modification (849-2011) in August 2011. In addition, two subsequent decrees (608-2012 and 764-2012) modifying decree 137-2008 were issued in 2012 to expand the pit(s) and the Tailings Management Facilities (TMF).

In 2011, an environmental impact statement (EIS) was prepared to build a 315 kV-34.5 kV electrical power station to provide power to the mine. The Project was authorized by decree in 2012, and built the same year.

Certificates of authorization, in compliance with sections 22 and 32 of the EQA, were approved for the construction of various infrastructure facilities and the certificate of authorization for the mine exploitation, ore treatment, waste rock and tailings disposition was granted in March 2010.

The mine has also received operational permits for the mine, dust collection systems, railroad and the wastewater treatment systems (Table 20-1). With the infrastructure already authorized, the expansion Project can go forward in 2021 without delays. The storage capacity for waste rocks and tailings is secured by permits up to 2024 at a production rate of 16 Mtpy.

Table 20-1: Main environmental permits obtained in the past

Permit name and description	Agency	Date authorized
Certificate of authorization for Bloom Lake Iron Mine, 8.5 Mtpy, (Decree 137-2008)	Government of Quebec	20/02/2008
Certificate of authorization for operation of Bloom Lake Iron Mine	MELCC (Quebec)	02/03/2010
Certificate of authorization for the railway	MELCC (Quebec)	20/04/2010
Certificate of authorization to operate six dust collectors	MELCC (Quebec)	20/09/2010
Certificate of authorization for the construction and operation of two wastewater treatment systems related to the plant	MELCC (Quebec)	24/01/2011
Certificate of authorization to modify Bloom Lake Mine operation, 16 Mtpy, (Decree 849-2011)	MELCC (Quebec)	15/09/2011
Certificate of authorization to build new structures	MELCC (Quebec)	15/09/2011
Decrees 608-2012 and 764-2012 modifying decree 137-2008, issued on February 20, 2008, to expand the pit(s) and the TMF	MELCC (Quebec)	06/2012 & 07/2012
Certificate of authorization to install and build a boiler, water-glycol heater, conveyors and transfer tower, storage silo and a new water treatment plant	MELCC (Quebec)	21/11/2012 18/06/2013
Certificate of authorization to operate with production increase	MELCC (Quebec)	04/09/2013
Certificate of authorization to modify the tailings pond	MELCC (Quebec)	26/02/2014
Certificate of authorization to create a new borrow pit	MELCC (Quebec)	04/07/2014
Authorization of work or activity that results in serious harm to fish	DFO (Federal)	20/07/2016

QIO has all the provincial permits secured to operate a second concentrator plant and can increase the annual ore production to 16 Mtpy immediately.

20.2.1.2 Federal

The current mine has already been authorized for operation under the federal environmental authority, including the Department of Fisheries and Oceans Canada (DFO), Transport Canada, Natural Resources Canada, and Environment and Climate Change Canada (ECCC).

No other federal authorizations are required to operate the second concentrator plant and can increase the annual ore production to 16 Mtpy immediately.

20.2.2 Legal Context and Permits to Obtain

In the Project, the following infrastructure will require authorizations at both provincial and federal levels:

- *HPA-Nord* TSF;
- *Halde Sud* waste stockpile;
- Increase in storage capacity of Triangle waste rock pile;
- *Halde Sud-Ouest* waste rock pile (within the boundary of a previous authorized pit);
- Increase in storage capacity for basin *A*;
- Two pit extensions south of the mine;
- Increase in the water treatment plant capacity.

The infrastructure listed above will be presented in the updated EIA, which will be submitted by QIO in July 2019. The EIA submitted is an update of the documentation presented in 2014 by the former owner of the mine (WSP, 2014). The QIO Project was improved compared to the Cliffs' design, it now has a lower impact on the environment (fish habitat and wetlands), a better social acceptability and is technically robust. The pursuance of the permitting process was the best approach to secure the permits required.

Beyond the EIA, the Project design must comply with the applicable provincial and federal regulations regarding planned equipment and infrastructure. Numerous laws, regulations, policies and directives are applicable to the Project; the most relevant are detailed hereinafter.

20.2.2.1 Provincial Level

Environment Quality Act (EQA)

The Project is subject to a procedure, as it will require filling, or levelling, of work for any purpose whatsoever, within the 2-year flood line of a river or lake, over a cumulative distance equal to, or greater than, 500 m, or over a cumulative area equal to, or greater than 5,000 m^2, for a same river or lake. The updated EIA will be submitted to the MELCC in July 2019. Several meetings were held with provincial authorities since June 2018 to pinpoint the important features that need to be addressed in the revised documentation. Table 20-2 presents the steps leading towards delivering the decree.

Table 20-2: Steps leading to the authorization of new infrastructure

Step	Timeline
Issuing of an Instruction by the MELCC	August 2012
EIA submission (former version of the Project)	February 2014
1st series of questions and comments from MELCC	August 2014
Revised EIA submission (QIO Project)	June 2019
Notice of receivability (EIA and answers to MELCC questions completed)	Q1 2020
Public Consultations	Q1 2020
Public Hearing – BAPE (if necessary)	Q2 2020
BAPE Report	Q3 2020
Analysis by the MELCC	Q3 2020
Decision by the Government (decree)	Q4 2020
Certificate of authorization for infrastructure associated with EIA processes (in accordance with Section 22 of the EQA)	Required by:
Triangle waste rock stockpile	2021
Sud-Ouest waste rock stockpile	2024
Halde Sud waste stockpile	2025
Basin *A* increased capacity	2032
Pit extensions	2025
Increase in the water treatment plant capacity	2027
HPA-Nord TSF	2027
A forest intervention permit from the *Ministère des Forêts, de la Faune et des Parcs* (MFFP) for deforestation activities	From 2024 to 2025

Once the required environmental impact assessment and review procedure for QIO's Project have been completed, and the decree obtained from the provincial government, the Project's detailed engineering will be finalized. This step shall consider the environmental mitigation measures associated with equipment and infrastructure, as presented in the EIA and incorporated by the government in the decree. It shall also consider all applicable environmental standards included in other relevant provincial laws and regulations.

Certificates of authorization are prescribed under the EQA, Section 22, to allow construction and operation of the new infrastructure. The issuance of these authorizations will be possible only after the delivering of the governmental decree. A timeline is presented in Table 20-2 for these authorizations. There is no specific issue with Section 22 authorizations. Fish habitat compensation plans and wetlands' compensations (if required) will also be approved by the ministry during the process of EQA Section 22 authorizations, listed in Table 20-2. Forest intervention permits will also be required for deforestation activities that will occur before construction of the infrastructure or deposition of tailings and waste rocks.

Directive 019 on the Mining Industry

The operation (re-use, extraction and treatment) and closure activities are subject to Directive 019 pertaining to the mining industry, the guideline currently used to analyze mining projects requiring a certificate of authorization under the EQA. In addition to the information required for the certificate of authorization request, Directive 019 includes standards for the safe management of tailings and water retention conception criteria, as well as the MELCC's broad guidelines regarding environmental protection and monitoring.

The directive was considered during the design of the Project, most notably regarding water retention capacity, safety of the retention structures, and the dikes design.

20.2.2.2 Federal Level

Canadian Environmental Assessment Act

The Canadian Environmental Assessment Act (CEAA, 2012) (L.C. 2012, ch. 19, art. 52; last amended on June 22, 2017) and its regulations establish the legislative basis for federal environmental assessments in most regions of Canada.

The CEAA (2012) applies to projects designated by the Regulations Designating Physical Activities. A project may also be designated by the Minister of the Environment if it believes that the implementation of the Project could cause significant environmental effects or public concern about these effects.

The QIO Project is not subject to a federal environmental assessment under the CEAA (2012) and the Regulations Designating Physical Activities. According to the federal agency, the Project was initiated with provincial authorities before the legislation was modified in 2013 and therefore is not subject to a federal EIA.

The Fisheries Act (Sch. I, P.I, It.6 and Sch. II, It. 5)

Metal and Diamond Mine Effluent Regulation (MDMER)

Under the Fisheries Act, the MDMER (SOR/2002-222) provides the framework for mining activities regarding the protection of fish habitats and resources through Environmental Effects Monitoring (EEM). It also sets thresholds that mining effluents must comply with, for the following parameters: Suspended Matter (SM), pH, metals (arsenic, copper, lead, nickel, and zinc), cyanides, radium, and toxicity. The Project will not affect the monitoring at the effluent because the same discharge point (EFF-REC2) will be maintained. The EEM program and results are detailed in Section 20.5.

Fish habitats (lakes, ponds and streams) are present within *HPA-Nord* TSF and the *Halde Sud* waste stockpile locations. Under Section 36(3) of the Fisheries Act, it is forbidden to deposit deleterious substances such as tailings and waste rock in water frequented by fish. However, the MDMER includes provisions (regulatory amendment) allowing the use of a natural water body frequented by fish for mine waste disposal.

QIO conducted a robust assessment process for alternatives to mine waste disposal in fish habitats. This assessment aims at selecting the best Mine Waste Disposal Site (MWDS) making it the most environmentally, technologically and socio-economically sensible solution. A total of 13 alternatives were analyzed at first, and seven of them (three for waste rock and four for TSFs) were included in the quantitative analysis. For this analysis, 20 sub-accounts, with 40 indicators for waste rock stockpiles and 53 indicators for TSF, were analyzed to select the best alternative. Furthermore, a sensitivity analysis including 12 different scenarios was conducted and concluded that the *HPA-Nord* TSF and *Halde Sud* waste stockpile proposed for the Project were the best alternatives. The detailed list of water bodies and watercourses frequented by fish within the boundaries of both disposal sites is currently in preparation but the impact on fish habitats is approximately 155 ha. A fish habitat compensation plan was developed and its content is summarized in Section 20.3.2.3.

The assessment of alternative reports is currently reviewed by ECCC. Upon acceptance, the process of amendment of Schedule 2 of the MDMER will be initiated. The list of impacted fish habitats and the compensation plan was sent to DFO and ECCC in May 2019. The amendment of Schedule 2 is planned to be completed in 2022. According to the Project development schedule, disposal of tailings in *HPA-Nord* TSF and waste rocks in *Halde Sud* stockpile will not be required before 2026, thus allowing more time than required to QIO to complete the federal permitting process.

The Migratory Birds Convention Act (Sch. I, P.I, It.7.1)

The Migratory Birds Convention Act, 1994, provides for the implementation in Canada of the 1916 Convention between the United Kingdom and the United States of America for the Protection of Migratory Birds in Canada and the United States. The Convention may be amended from time to time. Under Section 12 (1) (h) of the Act:

> *"for prohibiting the killing, capturing, injuring, taking or disturbing of migratory birds or the damaging, destroying, removing or disturbing of nests"*

QIO will conduct deforestation operations outside the breeding season of migratory birds to respect the migratory bird convention Act.

The Species at Risk Act (S.C. 2002, c. 29)

The Species at Risk Act (SARA) was created to prevent wildlife species from becoming extinct. The Act protects species at risk and their critical habitats. SARA also contains provisions to help manage species of special concern to prevent them from becoming endangered or extinct.

Once a species is listed under the Species at Risk Act, it becomes illegal to kill, harass, capture or harm it in any way. Critical habitats are also protected from destruction. The Act also requires that recovery strategies, action plans, and management plans be developed by the competent minister for all listed species. Under Section 33:

> *"No person shall damage or destroy the residence of one or more individuals of a wildlife species that is listed as an endangered species or a threatened species, or that is listed as an extirpated species if a recovery strategy has recommended the reintroduction of the species into the wild in Canada."*

The Project will not affect species at risk based on surveys conducted.

20.3 Environmental Studies and Issues

The following section describes the main results of the environmental baseline studies and discusses the Project's main issues and apprehended impacts.

In 2006, Consolidated Thompson Iron Mines Ltd. (Consolidated Thompson) conducted an EIA study for the mine development project (GENIVAR, 2006). Since then, several other studies were conducted due to project changes and these studies were intended to support the modification of the provincial authorization. The other studies conducted were required as per provincial and federal authorizations. The main studies used are summarized below:

- Environmental and social impact assessment (GENIVAR, 2006);
- The request for modification of the Project, the mine expansion (GENIVAR, 2011a);
- Environmental and social impact assessment (WSP, 2014);
- Previous technical reports prepared by the former owners of the mine (Consolidated Thompson and BBA Inc., 2008; CIMA, 2010; SRK, 2011 and 2013);
- Technical reports prepared for QIO (Ausenco, 2017);
- Assessment of alternatives for mine waste disposal in fish habitat for the new waste pile and the TSF for the amendment of Schedule 2 of the MDMER (WSP, 2018).

QIO updated the EIA study, which was submitted in June 2019, from the 2014 document and various field surveys were conducted since that period.

As stated in Section 20.2 of this report, most of the components required for the Project are already authorized which minimizes the potential environmental permitting issues. Therefore, issues presented below are mostly related to the new TSF (*HPA-Nord*) and *Halde Sud* waste stockpile that will be developed on un-impacted areas.

20.3.1 Physical Components

20.3.1.1 Surficial Deposit

Rock outcrops are mainly present on the top of the principal hills around the mine site. Till is the principal surficial deposit on bedrock but the thickness varies depending on the topography.

In the Project area, ground movement and skin flows are unlikely to occur, especially because hill slopes are not steep. Few signs of erosion were noted on river and stream shorelines around the mine. The vegetation in place combined with a low bank height contributes to maintaining soil cohesion.

Sporadic permafrost can be found in the Fermont area, mainly in peat bogs and under islands of forest tundra on mountain summits (Allard and Seguin, 1987). The various surveys conducted for the Project development revealed no evidence of permafrost. There are no specific issues regarding surficial deposits.

20.3.1.2 Rock Geochemistry

A geochemical study was performed on waste rocks and tailings (Golder, 2014a). According to this study, the waste rock and tailings from Bloom Lake do not shed any leachate and have no acid mine drainage potential (sulphur below 0.3%) based on Directive 019 criteria. Therefore, no specific containment methods are required to store tailings and waste rock.

20.3.1.3 Hydrology

Mining infrastructure has been present in the study area since 2010 and natural conditions have been modified since that period.

Various hydrological studies have been carried out to characterize flows throughout various periods (flood flow, monthly average flow and minimum water flow). Fresh water withdrawal and mining effluent were also considered. The Project will increase the annual volume of contact water to the water treatment plant and release it to the effluent. All the contact water on the site will be collected and directed to the existing effluent (EFF-REC2). A study will be conducted in 2019 (from June to October) to determine the effect of the increased flow of the effluent on the rivers and lakes downstream. The drainage of *Halde Sud* waste stockpile is naturally heading towards the Rivière aux Pékans watershed. However, as it is a protected area (aquatic reserve), the water collected into the basin will be pumped towards the existing system to avoid the creation of a new effluent and potential impacts in the aquatic reserve. Consequently, a flow reduction is apprehended downstream of *Halde Sud* waste stockpile water management system but it will affect only 10.5% of the Mogridge Lake watershed, which will have limited impact on the lake. Surveys will be conducted in 2019 to gather relevant information with this regards but the impacts on the hydrology are not presumed to be important and the forth coming work will help to quantify it.

20.3.1.4 Surface Water and Sediment Quality

The baseline conditions on surface water and sediments were conducted in 2006 before the mine was in operation (Genivar 2006). The surface water quality is not problematic for aquatic life. Nonetheless, pH tends to be lower than 6.5 and aluminum, barium, cadmium and copper concentrations are exceeding governmental criterions. However, these exceedances are associated to the natural background level in the region and not the mining operations. Concerning sediment quality, chromium and zinc can be found in certain areas exceeding criteria but these values are associated to the natural background level.

Effluent quality is regulated by requirements from Directive 019 and the MDMER. Section 20.6 in this report presents a summary of the monitoring ongoing at the effluent. The Project will not impact effluent quality significantly. The water treatment plant will be upgraded for the additional incoming flow.

20.3.1.5 Groundwater

Monitoring of groundwater quality has determined that the water in the sector is of calcium bicarbonate type in the bedrock unit and mainly of calcium or sodium bicarbonate type in the till layer. Natural background levels of groundwater were assessed from groundwater samples taken. Groundwater quality is characterized by occasional exceedances of the criterion for barium, copper, manganese and zinc, which are related to the natural background level of the region and not the mining operations.

20.3.1.6 Air

Currently, there are no National Air Pollution Surveillance Program stations near the study area that could provide data on the amount of particulate matter, NOx and ozone. Also, the MELCC does not have any air quality measurements that have been done in this region or in a comparable environment.

In the study area, meteorological data show a strong convergence of winds from the northwest with a predominance of high velocity winds from the west and north-northwest. The town of Fermont, located 13 km southeast of the Bloom Lake Mine site, is partially downwind of the Bloom Lake Iron Mine and the Mont-Wright Mine (ArcelorMittal).

Potential sources of dust include the TSF, the waste rock piles and the ore and concentrate stockpile areas. The mine has dust mitigation measures to prevent fine particle emissions like dust collectors at the facilities and conveyors. In addition, dust control (water spreading) is ongoing on the roads of the mine. In the TSF as well as the waste rock stockpiles, areas that become inactive are gradually re-vegetated to avoid wind erosion and dust dispersion. Note that some waste rock piles and TSF dikes have already been re-vegetated on the site. The air modelling study was completed and allowed for documentation of particle dispersion associated with the Project.

20.3.1.7 Noise

An evaluation of the existing sound climate in populated areas was carried out around the QIO facilities and included in the EIA study. This assessment was made during the actual operation of the mine in 2018. The measurements were made close to the nearest residential properties.

Noise from the mine site was inaudible at all receiving points. The sound environment was thus dominated by public road traffic, particularly for homes near Daigle Lake. The regulation is currently respected. The noise modelling analysis aimed at documenting the Project impacts and that the regulations in place will be respected.

20.3.2 Biological Components and Species at Risk

20.3.2.1 Terrestrial Wildlife

Birds

The surveys revealed a total of 66 bird species within the study area. The densities of land birds in the study area are low, but they are average for such ecosystems. Field surveys have identified the presence of two species at risk, the bald eagle and the rusty blackbird. None of those species will be affected by the Project. The availability of similar undisturbed habitats in the region of the Project limits the impact of new TSFs and waste rock piles area.

Amphibians and Reptiles

The well-developed hydrographic network of the study area offers good habitat potential for herpetofauna. The consultation of the Atlas of Amphibians and Reptiles of Quebec (AARQ, 2019) made it possible to identify the species recorded at this latitude. According to this information, seven species of amphibians and reptiles are likely to be present in the study area. Of these, four species have been confirmed by surveys. The Project, as currently designed, has a reduced footprint on wetlands compared to other scenarios investigated. Therefore, the impact on amphibian habitats will be limited.

Mammals

Nearly 43 mammal species are likely to frequent the study area. The various field campaigns confirmed the presence of 18 species. From those detections, the rock vole, eastern red bat, northern long-eared bat and little brown bat are species at risk observed near the mine. However, the Project will unlikely affect significantly those species.

The Bloom Lake Mine is in an area where the range of woodland caribou (boreal) and migratory ecotype (tundra) caribou of the George River herd is overlapping (Couturier et al., 2004). However, George River caribou are no longer frequenting the Fermont area. Woodland caribou can occupy the study area throughout the year but in very low densities. The future infrastructure will intentionally be concentrated near existing anthropic features (Bloom Lake Mine, Mont-Wright Mine), which will reduce the habitat disturbance for this species.

20.3.2.2 Vegetation and Wetlands

Black spruce, the most common forest species in the study area, is occasionally accompanied by balsam fir on mesic sites and tamarack at the edge of wet depressions. Mineral or woody bogs occupy poorly drained depressions. The wetlands in the study area are primarily peatlands, riparian habitats (marshes and swamps) and some shallow water areas. Peatlands are ubiquitous where the topography is flat. The Project will affect approximately 75 ha of wetlands for the development of the *HPA-Nord* TSF and *Halde Sud* waste stockpile. The assessment of alternatives conducted showed that the selected locations are impacting less wetlands than other alternatives analyzed. According to the regulation, financial compensation for wetland losses is not in force in the Project area because it is located outside of the area of application. However, during the EIA process, the provincial government will require that a compensation project be realized (wetland restoration or creation). Compensation projects will be presented during the EIA ongoing process.

20.3.2.3 Aquatic Fauna and Habitats

The main species found in lakes and streams in the area are: Red sucker, Black sucker, Lake whitefish, Lake chub, Northern pike, Burbot, Brook trout, Round whitefish, and Pearl dace.

The lakes in the study area have variable morphometric, physicochemical and ichthyological characteristics from one water body to another. Many of them are deep enough to house a population of lake trout or lake whitefish. Some, on the other hand, do not provide sufficient depth for thermal stratification to take place during the summer. The pH is usually close to 7.0 while the conductivity is low in most lakes. Rivers and lakes that will be affected by the new infrastructure will be compensated. The *Halde Sud* Waste Stockpile location is one of the options analyzed where impacts on fish habitats were the lowest. On the other hand, the *HPA-Nord* TSF will be in a sector where there are several lakes. Approximately 155 ha of fish habitat will be impacted by the Project. However, it was the best alternative based on environmental, socio-economic and technical indicators through the robust assessment of alternative study. Impacted fish habitats will be compensated through projects aiming at restoring or creating new fish habitats.

The fish habitat compensation plan development was initiated in June 2018 by a research of potential sites/projects. Many stakeholders were consulted and an extensive research on the field was realized, where 131 sites were evaluated. Nearly one third of those were close to the Fermont community. The conceptual plan was developed with a subset of projects that were the most promising and that fit needs and concerns of local communities, especially First Nations. QIO involved First Nations and provincial authorities early in the process (meetings, consultations, and documentation revision) to produce a compensation plan that would fulfill their requirements. Furthermore, the Innu Nations of Matimekush Lake-John and of Uashat mak Mani-Utenam were involved and consulted during that process. Future steps will be to obtain comments from DFO and to conduct further surveys in Q3 2019.

20.4 Social and Community

The Bloom Lake property is in the northeastern part of the province of Quebec, adjacent to the Labrador/Newfoundland border, in Normanville Township, Caniapiscau County. The property is centered at approximately latitude 52° 50' north and longitude 67° 16' west. The Bloom Lake property is located 13 km west of the town of Fermont and 30 km southwest of the municipalities of Wabush and Labrador City.

All surface rights are property of the Crown. The Bloom Lake property is in the Labrador Trough area, which straddles the border between Quebec and Labrador. There are several iron ore mines in the area including Mont-Wright owned by ArcelorMittal and, in Labrador various mines are active, expanding, becoming or possibly reopening, particularly in the cities of Wabush and Labrador City (Scully Mine, Wabush Mine 3, Kami Mine project, Carol Lake Mine). The entire Project is located within the boundaries of Bloom Lake Mine's mining lease.

According to Statistics Canada (2017), the population in the Regional County Municipality (RCM) of Caniapiscau included 4,066 inhabitants in 2016, of which 2,474 were from Fermont. Fermont counted 2,874 in 2011, 2,633 inhabitants in 2006, and 2,918 inhabitants in 2001. First Nations Uashat mak Mani-Utenam is 3,134 inhabitants according to the 2016 Canadian census data. Population fluctuations are highly correlated to mining activities in the Côte-Nord region.

The surrounding area is used for limited recreational activities. During its previous operation, the mine operator had made agreements with different users to compensate for impacts on community use of the lands within the mining lease. In 2017, QIO concluded an Impact Benefit Agreement (IBA) with the First Nations using the territory (Innu Takuaikan Uashat Mak Mani-Utenam and Matimekush-Lac John communities).

No archaeological or historic resources are known within the mine site. Moreover, during the past operational years, no archaeological or historic resources were found on the site. There is very low chance of finding any artefacts.

20.4.1 Information, Consultation and Collaboration

QIO conducted an extended public consultation program with the community and the stakeholders. Consultations served many objectives:

- Provided information to the community and stakeholders about the Project and its impacts;
- Offered the opportunity to the community to express concerns and questions;
- Obtained information from the community to adjust the Project and apply mitigation measures, if required.

From December 2018 to March 2019, the Project was presented and discussed with nearly 60 people, including municipal and regional socio-economic stakeholders, and First Nations of Uashat mak Mani-Utenam and Matimekush – Lake-John.

20.4.1.1 First Nations

Main concerns

A first information meeting on the Project was organized with the First Nations Uashat mak Mani-Utenam and Matimekush – Lake-John in winter 2019.

The Impact Benefit Agreement (IBA), which is a confidential agreement, was discussed during these meetings, as well as training and employment, relationship of the Innus with the land, and fish habitat compensation projects. Table 20-3 outlines the key concerns and actions proposed by QIO.

Table 20-3: Main concerns, mitigation and commitments – First Nations

Main concerns	Mitigation measures / Commitments
Training and employment	The IBA includes : ▪ Working committee with First Nations specifically dedicated to training and employment issues ▪ Innu training initiatives offered by QIO to develop Innu talents and increase Innu hiring at the site
Environment	The IBA includes a working committee specifically dedicated to environmental issues raised by First Nations
Fish habitat compensation projects	Fish habitat compensation projects are planned with Uashat mak Mani-Utenam and Matimekush – Lake-John Nations

Collaboration and involvement

To help First Nations representatives to learn more about QIO's activities in the territory, the company organized site visits in October 2018 (Matimekush – Lake-John), and April 2019 (Uashat mak Mani-Utenam). These visits provided good opportunities to discuss the expansion project at the Bloom Lake Mine.

As part of the IBA, working committees on specific topics (training and employment, and environment) were created with the First Nations to discuss and answer questions that affects them. Committees ensure that QIO maintains an excellent relationship with the First Nations in the territory.

According to First Nations of Uashat mak Mani-Utenam and Matimekush – Lake-John representatives, QIO has become a reference for them in terms of training, employment and environment towards other mining companies with whom they are involved and they appreciate the relationship with QIO.

20.4.1.2 Municipal and Regional Socio-Economic Stakeholders

Main concerns

With recent consultations, in general the participants met were in favour of the increased storage capacity for tailings and waste rock project. Among the concerns often mentioned was the distance of 700 m between the waste rock pile area limit and the permanent or casual residents on the shores of Daigle Lake. The main anticipated impacts related to this are the modifications regarding air quality, sound climate, quality of water and landscape. Furthermore, stakeholders would like that the community life does not get weakened by the presence of workers in Fermont during construction and that QIO gets involved in the community and keep them informed about the Project's progress and manpower requirements. Questions were also gathered from regional environmental organizations regarding fish habitat compensation projects for which they would like to be consulted to convey their opinion on this subject. Mitigation measures or commitments from QIO have been planned within the Project to address the stated concerns, as presented in Table 20-4.

Table 20-4: Main concerns, mitigation measures and commitments – Municipal and regions social economic stakeholders

Main concerns	Mitigation measures / Commitments
Distance of 700 m between the waste rock pile area limit and permanent or casual residents on the shores of Daigle Lake (air quality, sound climate, quality of water, and landscape).	An information and consultation strategy will be developed specifically for permanent and occasional residents of Daigle Lake to fully understand and respond to their concerns. Mitigation measures will be implemented to limit the impact on air quality, noise, water quality, and landscape.
Potential deterioration of community life by the presence of construction workers in Fermont.	Concerns about community life will be considered in the choice of a site for the construction workers camp. Specific communication measures will be provided to respond quickly to complaints related to community life.
Continued involvement of QIO in the community, and collaboration, to share information of the Project's progress and manpower requirements.	QIO will keep its monitoring committee active, where updated information on project progress and staffing needs will be provided on a regular basis (see next section).
Consultations regarding fish habitat compensation projects.	QIO has completed a consultation process with various stakeholders concerned before submitting the final version of these projects to the agencies.

Social Environment Monitoring Program

A Social Environment Monitoring Program is already implemented by QIO. This program aims to evaluate the effectiveness of the proposed measures to mitigate impacts on the social and human environment during mine operations. Monitoring results will, if necessary, adjust the program to better respond to identified impacts.

The monitoring approach is essentially based on the committee formed with municipal and regional stakeholders. The purpose of this committee is to provide all key players in the Fermont community with a platform for exchange and consultation to:

- Share and better understand the issues of the community and the impacts they have on all stakeholders, whether environmental, social, or economic;
- Identify existing or potential opportunities that can benefit the community;
- Stimulate the development of multi-stakeholder initiatives that would meet common goals for sustainable development;
- Ensure a regular and continuous cycle of communication and exchange.

The relationship with the Fermont community is excellent and QIO will continue to include the expansion project in its follow-ups with the community to maintain this relationship.

20.4.2 Other Communications and Visibility Initiatives

Stakeholders, populations and any other group or individual seeking up-to-date information on the QIO project can send an email to: expansion@mineraiferquebec.com.

In the fall of 2019, QIO will hold an Open House event to share the results of the EIA with stakeholders.

20.5 Operation Monitoring Requirements

Monitoring is an important operational aspect for QIO, and Project follow-ups required by regulatory agencies will be in line with the ongoing monitoring on site.

The same mining effluent will be maintained with the expansion, and the requirements (Directive 019 and MDMER) will remain unchanged. According to the MDMER, a biological monitoring (Environmental Effects Monitoring - EEM) is conducted on the basis of a 36-month cycle. The objective of EEM is to determine the effects of mining effluent on the receiving aquatic environment, specifically about impacts on fish, fish habitat, and the use of fisheries resources.

The EEM Program is conducted in accordance with regulation requirements since 2010 at the Bloom Lake mining site. The third cycle of the EEM Program was conducted in September 2017. The study of benthic invertebrate communities and the study of fish communities were conducted in Mazaré Lake (exposed area) and Daigle Lake (reference area). The third cycle study confirmed that the effluent induces an effect on the benthic invertebrate communities. Regarding fish communities, differences were observed between the exposed and reference areas during the third cycle study, but no impacts were confirmed. The next study will be carried out in 2020 to determine the cause, if any, of the effect observed on the benthic communities and to confirm if the effluents also induce an effect on the fish communities. The conclusion of the study will have no impact on the expansion project because no modification to the effluent quality is expected.

Other monitoring programs are ongoing on the site with regards to groundwater and air quality. No specific concerns were raised whatsoever. QIO also puts a high importance on the follow-ups with First Nations and the local community, as resumed in Section 20.4.

20.6 Water Management

Water management at Bloom Lake Mine involves intake of fresh water, collection and recycling of contact water, and treatment and discharge of water surplus at the final effluent.

Bloom Lake Mine has the authorization to pump fresh water from Bloom Lake for domestic use and for boiler make-up water. There is no restriction regarding the volume extracted. The process water used at the mill is recycled but Confusion Lake water can be used during system maintenance. It can also be used for the fire suppression system.

Contact water is collected at the TSF where it is decanted from tailings through successive basins. Runoff water in contact with waste rock at stockpile locations is also collected by a network of ditches and basins where it is pumped to be recycled at the mill. The excess quantity of water is sent to the water treatment plant before discharge at the effluent. The current water treatment unit has a capacity of 75,000m^3/day. After the expansion, the capacity will be up to 150,000m^3/day.

20.7 Hazardous Materials Management

Hazardous materials at Bloom Lake include used oil, used antifreeze, oil filters, oil canisters, hydraulic hoses, aerosols, absorbents, and soiled clothes. This material is collected in wheeled carts, barrels, or various containers identified and dated. Used oil tanks are also present on site in several locations. Hazardous material stored in carts, barrels, or tanks are disposed of by a specialized company on a regular basis. The hazardous material management must continue to be carried out according to the regulation respecting hazardous material. In addition, hazardous material transportation must comply with the Transportation of Dangerous Substances Regulation as it currently is.

Fuel oil tanks have integral holding sections to retain leakage and prevent contamination to the ground. Used oil and lubricants, and oil skimmed from ponds, are disposed of off-site by a contractor. Petroleum products must continue to be stored and disposed of in compliance with the provincial Petroleum Products Regulation, as it currently is.

20.8 Mine Closure

According to Section 232.6 of the Québec Mining Act (L.R.Q., c. M 13.1), QIO shall submit a revised closure plan to the Minister for approval every 5 years or whenever amendments to the plan are justified by changes in the mining activities. QIO must also provide a financial guarantee covering the closure plan cost to the provincial government in accordance with Section 111 of the Regulation Respecting Mineral Substances other than Petroleum, Natural Gas and Brine (Chapter M-13.1, r. 2).

The objective of the mine site restoration is to bring the site back to an acceptable state, ensuring that the environment can eventually take back its course. The closure plan focuses on the restoration of areas affected by mining activities, i.e. roads, traffic and work areas, buildings, water ponds, TSF, dikes, waste rock dumps, and overburden.

It is expected that the restoration works will be carried out progressively. The most important closure activities are as follows:

- Sale of salvageable mobile equipment or disposal at authorized recycling/disposal facilities;
- Dismantling of buildings and infrastructure, except for those required for monitoring during the post-closure period. Salvageable materials and equipment will be sold or transported to a recycling/disposal facility. Waste from dismantling operations will be transported to authorized sites for disposal;
- On-site treatment of contaminated soil or off-site disposal in accordance with regulations;
- Leveling of the area of the site affected by mining and industrial activities and revegetation of the surface;
- Scarification and revegetation of access and mining roads (except for an access to the site to allow monitoring in the post-restoration period) as well as dismantlement of bridges;
- Securement of the open pit mines and of the accesses to critical mine facilities (tailings management area, waste rock stockpile) with waste rock / boulder berms. Hazard warning signs will be installed every 25 m around the mine pits and at blocked accesses;
- The pumping will stop and the open pit mines will be naturally flooded;
- Progressive pumping and treatment of the water from the accumulation and treatment basins. The dikes will be breached and vegetated. The sludge accumulated in the ponds will be excavated, transported, and put in place on the TSF. Finally, the surfaces of the empty basins will be vegetated;
- The TMF and the waste rock piles will be progressively vegetated as sections become ready for closure.

Several follow-up activities are planned once the mining is complete (post-operation) and once the closure work is completed (post-closure). Each of these two periods will span over five years. Monitoring is planned for the integrity and stability of the structures, for the agronomic performance of the re-vegetated areas and for the environmental quality of the effluent and groundwater. The water treatment plant will be maintained operational as required during the post-mining period.

21. CAPITAL AND OPERATING COSTS

The Bloom Lake Phase 2 project scope covered in this feasibility study (FS) report is based on the construction required for the expansion of the existing project. The cost estimate, presented herein, is calculated and presented in Canadian (CAD) dollars and is dated Q2 2019 unless otherwise stated. Capital costs, sustaining costs and mining operating costs for this FS were developed by BBA and the methodology for their development is described further in this chapter. Operating costs for crushing, processing, concentrate transport and G&A were developed by QIO. Capital and operating costs for tailings and surface water management, excluding tailings pumping, were developed by WSP. Table 21-1 presents a summary of the total estimated initial capital cost and LOM sustaining capital cost for the Bloom Lake Phase 2 project. The capital and operating costs values shown in this chapter detail the combined Phase 1 and Phase 2 operations.

Table 21-1: Estimated pre-production capital costs

Category	Pre-production M$
General	$28.2
Mine – Phase 2	$37.6
Crusher and stockpile	$24.3
Concentrator	$165.0
Tailings and water management	$50.2
Services	$30.5
Rail and Port	$73.4
Owner’s Costs (all-inclusive indirect costs)	$105.1
Contingency	$75.5
Total	**$589.8M**
Deposits	$44.0
Total including deposits	**$633.8M**

The total initial Project capital cost, including the Project construction costs, mine pre-stripping, pre-operational capitalized costs as well as indirect costs, deposits and contingency is estimated at **$633.8M.**

The total sustaining capital costs is estimated at **$4.4/t** over the life of mine (LOM) (capital expenses incurred from Year 1 of production to the end of the mine life), which includes items such as mine equipment fleet additions and replacements, facilities additions, rail car leasing, improvements and costs related to phasing of the TMF.

Table 21-2 presents a summary of the operating costs for the average LOM operating cost in CAD/t of dry concentrate produced.

Table 21-2: Total estimated average LOM operating cost ($/t dry concentrate)

Category	Avg. (LOM)
	$/t conc.
Mining	$13.4
Crushing and Conveying	$1.7
Process Plant	$7.9
Concentrate Shipping	$16.8
Water and Tailings Management	$2.1
General and Administrative	$4.7
Total OPEX (cash cost)	**$46.6**
Sustainability	**$1.3**
Sustaining Capital	**$4.4**
All-in Sustaining Cost	**$52.3**

Sustainability expenses and sustaining capital have been estimated at **$1.3/t and $4.4/t** respectively over LOM for a total all-in sustaining cost of **$52.3/t FOB Sept-Îles**. Working capital is not included in the operating cost estimate presented, but are treated separately in the Economic Analysis in Chapter 22 of this Report.

21.1 Capital Cost Basis of Estimate and Assumptions

The capital cost estimate was based on the detail engineering material take-offs, bids received from vendors and contractors from the previous study phase, and some data from historical projects. As the project was under construction and 65-70% complete, parts of the estimate are based on advanced detailed engineering. The initial capital cost estimate does not include taxes, replacement capital or additional working capital requirements after commissioning and start-up.

The cost estimate, presented herein, is calculated and presented in Canadian (CAD) dollars and is dated Q2 2019. The conversion rates used to transfer foreign currencies to CAD are shown in Table 21-3.

Table 21-3: Currency conversion rates

Country	Currency	Equivalent
United States	1.00 USD	1.32 CAD

21.1.1 Type of Estimate and Accuracy

The present capital cost estimate reflects a Class 3 study as defined by the Association for the Advancement of Cost Engineering (AACE) as described in Recommended Practice N° 18R-97 about Cost Estimating Classification System. The expected accuracy for this study should be in the range of -10% on the low side to +15% on the high side. By default, the Class 3 estimate becomes the first of the project phase *"control estimates"* against which all actual costs and resources will now be monitored for variations to budget, until superseded by the updated project control estimate (Class 2).

The study includes the cost associated to the complete design, procurement, construction, management and commissioning of all commodities and facilities.

21.1.2 General Direct Capital Costs

The following elements were considered in the capital cost estimate for the various Project areas.

- Site Works (Civil): Civil quantity and take-offs are based on design developed up to May 2019 by all parties involved. Unit rates were based on a combination of previous project data, budget quotes obtained during the course of the Project, and BBA's in-house database;
- Concrete works: Concrete quantities were estimated based on updated design calculations, 3D model, drawings and sketches. The unit rates are based on BBA's in-house database;
- Metal works: Structural steel quantities were calculated from updated design, drawings and sketches. Prices are developed from budget quotations received for recent projects in the region from fabricator/erector contractors;
- Architectural finishes: The architectural quantities were calculated by the estimators based on the 3D model and their unit rates were based on internal database;
- Mechanical: A detailed equipment list, including plate works, was compiled based on the process flowsheets and mass balance, and comprises capacities, weights and sizing as issued for design. The remaining equipment was estimated using recent in-house historical data. Heating, ventilation and air conditioning (HVAC) and other building mechanical services, were priced based on quotes and on project historical data factored to the new Project scope;
- Vendor's budgetary prices were obtained for several other pieces of equipment including but not limited to:
  - AG Mill;
  - Scalping and Classification Screens;
  - Filters;
  - Conveyors;
  - Magnetic Separators;
  - Hydrocyclones;
  - Feeders.

- Piping: Large and small bore process piping quantities were estimated based on P&IDs, layout drawings and 3D model. The cut-off diameter for piping estimates is 0.75 inch. The cost includes a calculated ratio of fittings, valves and supports based on congestion and priced according to historical data, adjusted for this Project;
- Electrical: The electrical power lines, main substation and electrical distribution quantities and costs were estimated based on overall operational power requirements obtained from the Project equipment list, layout drawings of the site and plant, and previous project data adjusted for this Project;
- Automation: Instrumentation quantities were evaluated by engineering based on marked-up PFDs, instrument lists, network drawings and G&A's.

Labour

Workweek: All estimated labour costs are based on 10 hours per day, 7 days per week for a workweek total of 70 hours. Rotation is on a 2 to 1 week basis. There is no allowance for a second working team (night shift).

The present estimate is structured and based on the philosophy that contracts will be awarded to reputable contractors on a lump sum basis.

The hourly crew rates used in the present estimate are built-up based on data published by the "Association de la construction du Québec" (ACQ), the "Commission de la construction du Québec" (CCQ), the "Commission des normes, de l'équité, de la santé et de la sécurité du Québec" (CNESST) and by the "Direction générale des acquisitions du Centre des services partagés du Québec".

Table 21-4 provides a summary of the blended crew rates per discipline.

Table 21-4: Summary of blended crew rates per discipline based on "ACCQ - Annexe B2"

Crew rates based on 70 hours/workweek ACCQ-B2				
Typical crew	Labour rate		Construction equipment	Total
	Direct	Indirect		
Site works – Civil	$80.82	$56.52	$74.55	$211.90
Concrete works	$78.07	$58.49	$18.95	$150.29
Metal works	$83.74	$58.09	$30.35	$172.20
Architectural finishes	$80.58	$56.52	$11.95	$146.30
Mechanical – Process	$83.93	$57.75	$19.42	$161.10
Mechanical – Building	$83.85	$57.65	$18.71	$160.21
Piping	$84.05	$58.09	$22.51	$164.65
Insulation	$77.95	$49.30	$6.26	$133.51
Electrical	$84.50	$58.13	$20.72	$163.35
Automation/Telecom	$82.45	$55.68	$4.24	$142.37

In the Table 21-4 above, the Crew Rates are composed of direct and indirect labour rates, as well as the required construction equipment per trade to accomplish the tasks that are considered as a Heavy Industrial Construction Site, as per the "Québec Construction Collective Agreement, Annexe B2" definition.

The Direct Costs for the work to be performed on site are calculated on an assumption of 70 hours per week. The first 40 hours are paid at the standard single rate, the following 5 hours are paid with a premium factor of 1.5 and the following 25 are paid with a premium factor of 2.

Rates presented in Table 21-4 include a mix of skilled, semi-skilled and unskilled labour for each trade, as well as the fringe benefits, that are added to the gross wages. The supervision by the foremen and surveyors is built into the direct costs with a typical ratio seen on union jobs according to each discipline and type of work (roughly 8 workers per supervisor).

For all figures, the Indirect Costs consist of small tools, consumables, supervision by the general foremen, management team, contractors on site, temporary construction facilities, mobilization/demobilization, and contractor's overhead and profit.

In summary, the Crew Rates are developed for each discipline (by speciality) and are established based on the fact that all workers are unionized; they are all-inclusive.

The labour productivity factors were reviewed based on recent projects and construction performance in the area. Construction project performance is an important concern for project owners, constructors and cost management professionals. Project cost and schedule performance depend largely on the quality of project planning, work area readiness preparation, and the resulting productivity of the work process made possible during project execution. Labour productivity is often the greatest risk factor and source of cost and schedule uncertainty to owners and contractors alike.

Many terms are used to describe productivity in the construction industry: performance factor, production rate, unit person-hour rate, etc. Traditionally, productivity has been defined as the ratio of input/output, i.e., the ratio of the input of an associated resource (usually expressed in person hours) to real output (in creating economic value). To restate this definition for use in the construction industry: labour productivity is the physical progress achieved per person hour, e.g., person hours per linear metre of conduit laid, or person hours per cubic metre of concrete poured.

The two most important measures of labour productivity are:

- The effectiveness with which labour is used in the construction process;
- The relative efficiency of labour: doing what is required at a given time and place.

A study carried out by Optima Engineers and Constructors for the Alberta Economic Development reveals 208 irregularities affecting the labour productivity on a construction site.

The following items were considered when developing the labour productivity factors:

- Site location
- Extended overtime
- Access to work area
- Height – Scaffolding
- Availability of skilled workers
- Labour turnover
- Inspection + QA/QC
- Sophisticated specifications
- Materials + Equipment – Handling
- Weather conditions
- Scattered items of work
- Complexity
- Overcrowded / Tight work areas
- Efficiency
- Supervision
- Revamps / Connections / Tie-ins
- Fast-track requirements
- Safety / Security

As described in the paragraphs above, Table 21-5 reflects the numbers affecting the labour productivity on all construction crews:

Table 21-5: Labour productivity loss ratio

Activity	Factor
Site works – Civil	1.425
Concrete Works	1.467
Metal Works	1.527
Architectural Finishes	1.481
Mechanical Works	1.448
Piping/Insulation	1.475
Electrical	1.454
Automation/Telecom.	1.442

21.1.3 Indirect Capital Costs

The indirect capital costs for the Project were estimated based on values provided by QIO, in-house estimates and factors as well as calculations based on anticipated production.

- Owner's costs provided by QIO include all costs related to project and operating manpower involved before the beginning of operations including the procurement and construction management portion of the EPCM mandate. This evaluation is based on an integrated-management team assembled by the owner together with the external management resources chosen for this Project;
- Engineering and support for procurement and construction management costs were developed using the "Manpower Forecasting and Levelling Method". Hours were evaluated for each assignment based on the anticipated engineering scope and allocations for procurement and construction management support;
- Construction indirect costs include the construction of temporary accommodation complexes, offices, guardhouse, warehouse, laydown areas and the cost to maintain and operate all utilities;
- Freight/Transportation: A factor of 6.5% was applied on the value of the remaining process and electrical equipment costs to cover the freight and transportation fees;
- Spare Parts: To cover the process equipment spares, an amount of $2.51M, representing ±4.5% of the remaining process equipment value, is accounted for;
- Vendor Representatives: To cover vendor assistance in construction, pre-operational verifications and commissioning, an estimated lump sum price of $1.116M, representing 2% of the remaining process equipment value, is accounted for to accomplish this task;
- Initial Fill: In order to operate the plant, a sufficient inventory level of key consumables is required during the commissioning and start-up phases of the Project. As the mine site is currently in operation and because most consumables are already in stock on site, an estimated **$100k** was allocated for the initial fill and includes key consumables such as: Reagents; Lubricants; and Fuel oil #2.

21.1.4 Contingency

Approximately $75.5M in contingencies, representing 15% of the pre-production capital costs, was incorporated to the capital cost estimate and includes contingencies on the indirect costs. This contingency will provide an allowance to the Capital Cost Estimate for undeveloped details within the scope of work covered by the estimate. The contingency amount was calculated using the Palisade *@Risk* software following best practice methodologies. The input data was used based on the confidence level of the equipment costs from the budgetary quote, previous project data and BBA's in-house database. Using the P80 for both risk and contingency a total project contingency of roughly 10% was calculated. Contingency is not intended to take into account items such as labour disruptions, weather-related impediments, changes in the scope of the Project from what is defined in the study, nor does contingency take into account price escalation or currency fluctuations. It was decided to use a design contingency value of 15% to provide for a conservative estimate and to ensure, as much as possible, that the target budget is not surpassed.

21.1.5 Exclusions

The infrastructure initial capital cost estimate does not include taxes, replacement capital or additional capital requirements after commissioning and start-up.

Provisions for escalation and provisions on currency risk were excluded, as the estimate is expressed in constant dollars as of Q2 2019.

21.1.6 Assumptions

The Direct and Indirect cost evaluation was based on the assumptions that:

- The market will be conducive, considering industrial construction labour will be available and qualified;
- One construction team will be assigned based on work conventions, without any risk of schedule or hourly rate impacts, based on a good labour relationship management;
- The foundations of the concentrator will be able to handle the load of the structural changes;
- Civil work is priced based on a high percentage of drill & blast, excavation and backfill work;
- The mechanical equipment items are estimated based on the mechanical engineers' account of modifications to existing equipment and the new equipment required for Phase 2;
- This estimation is based on the scope of work developed until May 10, 2019. Changes in the scope are not accounted for;
- Allowances given by QIO for out of scope evaluation are legitimate and have backup data;

21.2 Estimated Capital Costs

21.2.1 General Capital Costs

General capital costs include equipment and work related to the 315kV-34.5kV electrical station and electrical line including connections and supporting structures. General costs also include modifications to existing Phase 1 facilities as dictated by Phase 2 logistical requirements. These modifications are primarily focused on train loading and material handling. The estimated capital cost is **$28.2M.**

21.2.2 Mining Capital Costs

The mining initial capital costs are mainly comprised of the purchase of additional mining equipment required to support the higher annual production rates. These items typically have one or more year long delays between purchase and operation. Thus, equipment required for the first year is included in the pre-production costs of **$37.6M**. Equipment unit prices came primarily from vendor quotations. BBA estimated the requirements for primary production equipment while support equipment requirements were developed largely by QIO. The initial haul truck fleet, shovel fleet, drill fleet and loader fleet, along with certain equipment in the support and auxiliary fleet, will be leased. It is estimated that leases will be on a 5-year term at an interest rate of 5%. Down-payments and first year payments are captured in the mining capital costs.

21.2.3 Crusher and Stockpile Capital Costs

The crusher area includes A-Frame modifications, new galleries as well as new conveyors. The stockpile area includes the creation of a permanent enclosure of the stockpile (for dust prevention) as well as related HVAC requirements around the stockpile and tunnel. The estimated capital cost for the area is **$24.3M.**

21.2.4 Concentrator Capital Costs

The concentrator area includes all the work and equipment needed to finish the Phase 2 concentrator. It includes the modifications to the structure and concrete to accommodate the new equipment, it also includes the completion of the concrete work on the silo. The estimated capital cost for this area is **$165.0M**.

21.2.5 Tailings, Waste Rock and Surface Water Management Capital Costs

The tailings, waste rock and surface water management CAPEX includes the construction cost associated with the initial investments required prior to the start of Phase 2. The capital cost estimate for the tailings and surface water management is **$29.2M** (excluding tailings pumping). The basis of estimate has been included below.

Earthworks cost estimates are based on historical costs for similar earthworks on the site before 2014 and the latest unit costs established by the different contractors who have been solicited to bid on the TSF earthworks since 2017. The water treatment plant upgrade and the barge (including delivery and installation) were estimated based on manufacturers' estimates.

Indirect costs for the construction, such as the engineering works, the fixed fees of the contractor and the mobilization fees were established as a ratio of the earthworks costs. Each of these ratios is calculated based on the historical costs on the site.

Travelling, food and lodging costs were treated together with the other project sectors as per the methodology described in Section 21.1.

21.2.6 Tailings Pumping

The capital cost estimate for the tailings pumping includes tailings pumps at the concentrator, the booster station as well as pipe routing to the TMF. The estimated capital cost for this area is **$21.0M** and the total cost for Tailings and Water Management, including tailings pumping, is **$50.2M**.

21.2.7 Services Capital Costs

Capital costs for the services area account for all additions or modifications to administrative functions: dry house, laboratory, warehouse, offices, shop, etc. Costs also include the installation of a new permanent camp as well as an allocation for the purchase of the housing site. The estimated capital cost for the area is **$30.5M.**

21.2.8 Rail and Port

The port sector area includes the costs associated with modifications and additions to the rail and the port material handling systems. Information regarding the required modifications is detailed in Chapter 18. The estimated capital cost for the area is **$73.4M.**

21.2.9 Indirect Costs

These have been described earlier in this chapter and have been estimated at **$105.1M** for the Project.

21.2.10 Contingency

This has been described earlier in this chapter and has been estimated at **$75.5M** for the Project.

21.2.11 Risk

During the feasibility study, a risk review session was held to identify risks and quantify their impact and probability based on a 5x5 matrix.

The risk reserve requirement integrated in the contingency calculation was calculated using a Monte-Carlo probabilistic analysis from the evaluated impact and probability of occurrence of each risk. Ten thousand (10,000) simulations were run resulting in the following probability of risk cost expenditure (see Figure 21-1).

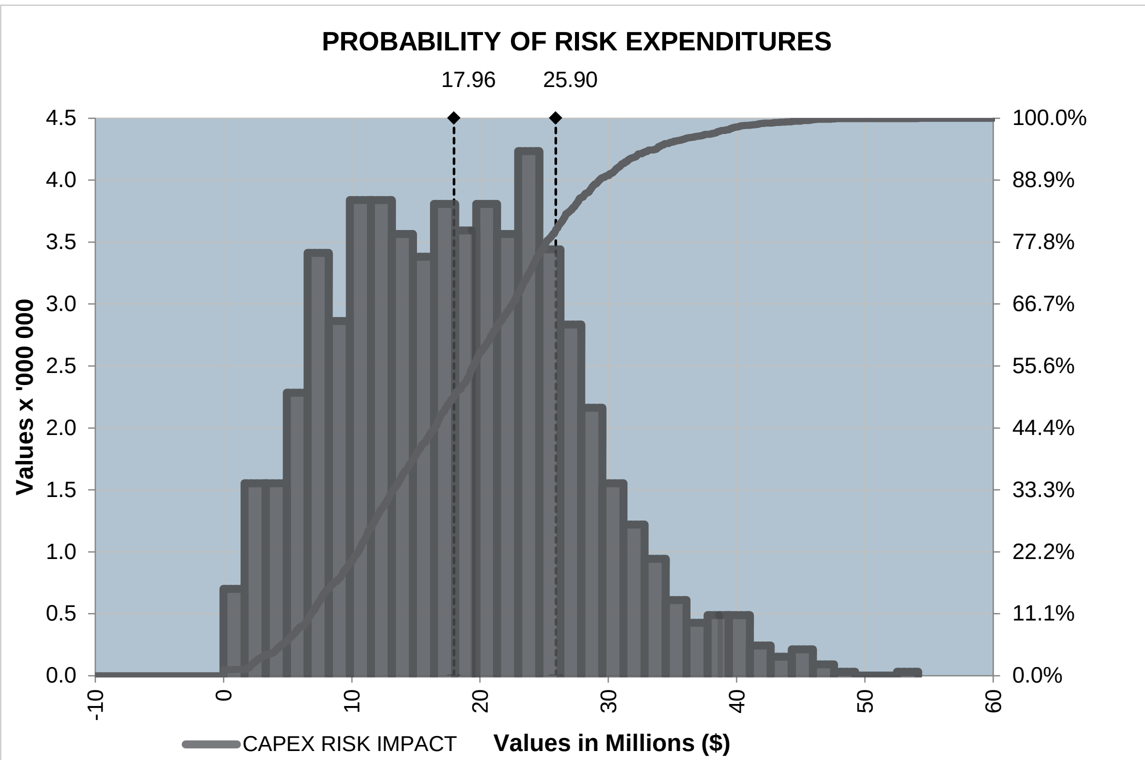


Figure 21-1: Risk expenditure probability curve

As shown in Figure 21-1, the P_{50} of risk expenditure is CAD17.96M and the recommended reserve at P_{80} is of CAD25.9M.

21.2.12 Residual Value

An allocation of **$6.7M** was taken for the residual value of salvaging infrastructure and non-process related equipment and is credited at the end of the mine life. The allocation is equivalent to approximately 5% of the project equipment cost.

21.2.13 Closure Costs

Closure cost estimates have been completed in the past for previous development phases of the Project; they were based on smaller and fewer mine infrastructure facilities as they were planned then. The current mine closure cost estimate was developed for the LOM, which includes more mining infrastructure (concentrator, tailings storage facilities, waste dumps, basins, dikes, etc.).

To develop the closure costs, WSP used a conservative approach generally in line with the concepts of the ministry's guide on mine closure and restoration (MERN, 2017). However, this cost estimate was not developed as a closure plan destined to the ministry as it would not be realistic in the context of this feasibility study. Notable differences include the fact that a conservative value was accounted for the remaining mobile equipment at the end of mine life as well as for some of the salvageable fixed mineral processing equipment. Another important difference is that the usual 15% contingency is excluded from this cost estimate.

Direct costs include (not exhaustive) dismantlement of buildings and infrastructure, on-site treatment of contaminated soils, restoration and revegetation of disturbed areas (mining, industrial, roads, etc.), securement of open pit mines, restoration and revegetation of basins and dikes as well as revegetation of tailings storage facilities and waste rock dumps. The indirect costs include engineering, post-operation monitoring and water treatment as well as post-closure monitoring.

Consequently, the total mine closure and restoration costs include direct costs of **$68.5M**, and indirect costs of **$31.4M,** for a total of **$99.9M**.

21.3 Operating Costs

Estimated average operating costs over the LOM for the Bloom Lake project are summarized in Table 21-6.

Table 21-6: Total estimated average LOM operating cost ($/t dry concentrate)

Category	Avg. (LOM) $/t conc.
Mining	$13.4
Crushing and Conveying	$1.7
Process Plant	$7.9
Concentrate Shipping	$16.8
Water and Tailings Management	$2.1
General and Administrative	$4.7
Total OPEX	**$46.6**

21.3.1 Mine Operating Costs

Table 21-7 shows the breakdown of the estimated mining operating costs for the average over the LOM (Years 1 to 20). The mine operating costs were developed from first principles based on the mine plan and production schedule, distances to the waste piles, crusher and TMF drop points, re-handle, equipment operating parameters from vendors and internal information for similar projects.

Table 21-7: Average LOM mining operating costs

Category	$/t mined	$/t milled	$/t conc.
Labour	$0.83	$1.56	$4.34
Electrical	$0.03	$0.06	$0.18
Fuel	$0.43	$0.81	$2.23
Maintenance	$0.87	$1.64	$4.54
Blasting	$0.42	$0.79	$2.20
Total Mining	**$2.59**	**$4.86**	**$13.48**

Labour: Labour requirements have been estimated to support the mine plan developed in this Study, as outlined in Chapter 16 of this Report. In the initial Project phase, it is estimated that 324 supervisory and hourly personnel will be required to operate the mine. A peak of 480 supervisory and hourly personnel will be required by Year 14.

Fuel: The entire fleet of mining equipment will be operated using diesel fuel. Fuel consumption was estimated for each year of operation based on equipment specifications and equipment utilization. Costs are based on a diesel fuel price of $1.016/litre, delivered to site. Electricity costs are assumed to be $0.049/kWh.

Maintenance: Hourly operating costs were developed for each piece of mining equipment using vendor pricing for preventative maintenance, parts replacement, wear and tear on ground engaging tools, and tire pricing. The hourly operating costs were provided by QIO based on the maintenance cost averages by equipment for the first year of production. The operating costs were then estimated based on the hours of operation and the hourly operating cost provided by QIO.

Blasting: Explosives costs for ore and waste rock have been estimated based on the parameters and powder factors presented in Chapter 16 of this Report and on pricing received from several vendors.

Other: Additional items are included in the mine operating cost such as an allowance for mine dewatering accessories, ore grade control, and miscellaneous items.

21.3.2 Energy Rates

Energy rates were defined using QIO current operations one-year trailing average. Electrical rates are based on Hydro-Quebec L Tariff calculated with a usage factor of 75%, which is realistic considering the use of an off-peak electrode boiler for process steam production. All electrical costs except for steam production are calculated at $0.049/kWh. A special electrical tariff of $0.0466/kWh is used for the electrode boiler under the additional electricity for large-power customers program from Hydro-Quebec.

Light fuel oil #2, diesel and gasoline prices were established based on the one-year trailing average cost paid by the current mine operations and are net of taxes deductions.

Table 21-8: Electrical fuel and diesel rates

Category	Value	Unit
Electrical rate	$0.049	$/kWh
Electrical rate steam production	$0.0466	$/kWh
Light fuel oil #2	$1.03	$/L
Diesel mining fleet and fixed equipment	$1.016	$/L
Diesel support equipment	$1.18	$/L
Gasoline	$1.03	$/L

21.3.3 Crushing and Conveying Operating Cost Estimates

Operating costs for the crushing plant for the Bloom Lake Phase 2 project is shown in Table 21-9. These costs were derived by QIO based on actual operation costs and other study parameters such as labour cost, energy rates and assumptions. QIO currently uses crusher 2 in its current operation of Phase 1. Crusher 1 is used strictly as a backup while maintenance activities are performed on crusher 2.

Table 21-9: Crushing plant operating costs

Period	Avg. LOM ($/t conc.)
Energy	$0.31
Consumables & Maintenance	$1.26
Labour	$0.14
External Consultants/Contractors	$0.01
Total ($/t dry conc.)	**$1.71**

21.3.3.1 Energy

Energy consumption was calculated using a bottom-up approach based on installed power, efficiency and usage assumptions of equipment and compared to actual consumption of current operations.

21.3.3.2 Consumables and Maintenance

Consumables and maintenance costs are based on historical costs, FY19 operation budget and prorated for wear associated to throughput increase. The prorated calculation accounts for the ratio between fixed and variable costs of consumables. Shutdown costs are based on actual budget and frequency was adjusted considering future tonnage.

21.3.3.3 Labour

Labour cost is based on the assignment of personnel dedicated to operation and maintenance of crushing. Salaries are based on actual collective agreement conditions and effective remuneration policy. A total of 16 labourers are assigned to the operation and maintenance of the crushing plants.

21.3.3.4 External Consultants/Contractors

External consultant cost was established using a ratio of the labour cost. The percentage allocated for external consultant is 5% and is linearly decreased to 3% over the life of mine to account for the gain in maturity of the organization.

21.3.4 Process Plant Operating Cost Estimates

Operating costs for the processing plant of the Bloom Lake Phase 2 project is shown in Table 21-10. These costs were derived by QIO and have been compiled from a variety of sources and are mainly based on historical data and operating budgets.

Process plant operating costs were estimated based on recommendations for labour rates, fuel costs and electricity as well as reagent and consumable consumptions.

Table 21-10: Process plant operating costs

Period	**Avg. LOM ($/t conc.)**
Energy	$2.21
Reagents, Consumables and Maintenance	$2.68
Labour	$2.74
Building Maintenance	$0.15
Laboratory Services	$0.05
External Consultants/Contractors	$0.10
Total ($/t dry conc.)	**$7.92**

21.3.4.1 Energy

Energy consumption was calculated using a bottom-up approach based on installed power, efficiency and usage assumptions of equipment and compared to actual consumption of current operations.

21.3.4.2 Reagents, Consumables and Maintenance Materials

Processing plant reagent and consumable costs were estimated based on the annual plant throughput. The costs were based on calculated consumption rates and unit costs from actual operating budget. Reagent and consumable costs include transport to site. Shutdown costs are based on actual operating budget and adjusted with plant throughput without any volume effect cost reduction.

AG mill maintenance cost is based on actual budget and prorated with future tonnage. A service agreement with Metso is currently in place for Phase 1 mill maintenance and the continuation of this agreement was assumed to define the maintenance and shutdowns' costs.

21.3.4.3 Labour

Labour cost is based on the assignment of personnel dedicated to operation and maintenance of the plants. Salaries are based on actual collective agreement conditions and effective remuneration policy. A total of 288 labourers are assigned to the plant operation and maintenance including supervision, engineering, coordination and technical support.

21.3.4.4 Building Maintenance

Annual process plant building maintenance was established using the maintenance costs from the current operations budget.

21.3.4.5 Laboratory Services

Operating costs of the on-site laboratory were estimated based on the current operations budget for consumables and adjusted with the increased samples to analyze. These costs included consumables, reagents and maintenance of the laboratory. Laboratory labour is included in the process plant labour costs.

21.3.4.6 External Consultants/Contractors

External consultant cost was established using a ratio of the labour cost. The percentage allocated for external consultant is 5% and is linearly decreased to 3% over the LOM to account for the gain in maturity of the organization.

21.3.5 Concentrate Transportation

Costs for concentrate transportation were established by QIO based on agreements with the rail transport providers. The cost of concentrate transportation is variable according to the wet tonnage of concentrate produced and does not consider transport and handling losses. Costs provided are based on average concentrate moisture of 3.5%.

The 32 km rail link between the mine and the Quebec North Shore & Labrador (QNS&L) is currently operated by Genesee & Wyoming Inc. and governed by a service contract. Discussions are ongoing with Genesee & Wyoming Inc. but terms have been provided to QIO for the service related to extra tonnage and these terms were used for the operating costs calculations.

QIO currently has a rail transportation contract with QNS&L for the Phase 1 tonnes and future rail costs were derived from this agreement on a per tonne basis. Contract negotiations are currently ongoing to secure future Phase 2 tonnes. QNS&L is defined as a "common carrier" and its services are governed by the Canadian Transport Act (CTA).

An additional operating cost for the railcar maintenance was added to this transport cost. The cost of railcar maintenance was established at $3,476 per car annually.

21.3.5.1 Port Facilities

Costs for port services were established based on actual contracts with SFP Pointe-Noire (SFPPN) and the Port of Sept-Îles. The cost of port services is variable, according to the wet tonnage of concentrate produced and does not consider handling losses. Costs provided are based on average concentrate moisture of 3.5%. QIO is currently negotiating with the SFPPN and the Port of Sept-Îles to finalize operating terms. Services costs were established using reasonable assumptions on fixed and variable costs portions of the actual contracts in place to derive future costs of operation.

21.3.5.2 Total Cost for Rail and Port Facilities

The average annual concentrate land logistics, port and berth cost was established at $16.78 per tonne of dry concentrate.

21.3.6 Tailings, Waste Rock and Surface Water Management

Operating costs for both tailings and surface water management for the Bloom Lake Phase 2 project were derived by WSP with the exception of certain items detailed below. The results displayed in Table 21-11 are for a production of approximately 16 Mt per year. The OPEX includes the operating costs, required each year, during the mine operation. It covers the equipment, personnel and subcontractor support to operate Bloom Lakes' water management and tailings management.

Table 21-11: Water and tailings management operating costs

Period	Avg. LOM ($/t conc.)
Energy	$0.37
Reagents, Consumables and Maintenance	$0.82
Labour	$0.58
External Consultants/Contractors	$0.02
Water Management	$0.20
Engineering	$0.08
Total ($/t dry conc.)	**$2.07**

OPEX costs were established based on the actual operation costs and budget, adjusted to the future operational mode. This adjustment covers the surveillance of the extended storage areas, of the new contact water management systems and of the earthworks required to confine the increased production of tailings.

Heavy equipment fleet is assumed to be rented from a sub-contractor who will also maintain them. Fuel and maintenance costs were calculated by QIO using the mobile equipment list estimated by WSP (includes fuel consumption and work hours).

Electricity costs for surface water pumping effort were estimated by QIO based on actual budget and experience.

External consultant cost was established by QIO using a ratio of the labour cost. The percentage allocated for external consultant is 5% and is linearly decreased to 3% over the life of mine to account for the gain in maturity of the organization.

Labour cost is based on the assignment of personnel dedicated to operation and maintenance. Salaries are based on actual collective agreement conditions and effective remuneration policy for the actual QIO operation.

Travelling, food and lodging costs are assumed as calculated in Section 21.1.

The yearly snow removal contract has not been included into the OPEX estimate in this section but costs are included in the mine OPEX for main roads or in the site support OPEX for smaller roads.

No contingency has been applied to the OPEX presented in this chapter.

21.3.6.1 Surface Water Management and Tailings and Water Management Team

This section includes operating costs for the surface water management; they are divided into two categories: operation and maintenance.

Operation costs are based on the assumptions and data described hereafter:

- Project Management: Cost is provided by QIO and includes all QIO management teams on site;
- Workforce: Cost is provided by QIO and includes all QIO personnel to operate the tailings management areas, the surface water management, and the water treatment plant;
- Water treatment plant: Costs include the annual operation costs for the water treatment plant, estimated with the actual costs on site. These costs exclude the workforce since it is included in the Workforce;

Maintenance costs are based on the assumptions and data described hereafter:

- Pump maintenance: Costs include all the surface water management pumps on site. The costs represent the purchasing of replacement parts as well as general maintenance;
- Pump replacement: Costs are related to replacement of pumps for surface water management. The study considers the probable lifetime of pumps and budgets for replacement. It is estimated that all surface water management pumps will be replaced once during the mine life;
- Control structure maintenance: Costs include the annual preventive maintenance costs for both water level control structures;
- Ditch maintenance: Costs include an average annual maintenance cost;
- Booster station evacuation canal maintenance: Costs include the annual preventive maintenance costs for the booster station evacuation canal.

21.3.6.2 Fine Tailings Management

Operational costs for fine tailings are related to the management of basin *A*'s area. Costs are for rental equipment and include the following works:

- Management of line ends with a CAT 345 DL excavator;
- General maintenance of the area with a CAT D9T dozer and a CAT 988H wheel loader.

21.3.6.3 Coarse Tailings Management

Operational costs for coarse tailings are related to the management of *HPA-Ouest, HPA-Sud,* and *HPA-Nord* areas. Costs are for rental equipment and include the following works:

- Dozing and compacting tailings inside *HPA-Sud*, *HPA-Ouest,* and *HPA-Nord* areas, each year for raising dikes with a fleet of two CAT D9T dozer and one HAMM 3520 compactor during the summer;
- Management of line ends with a CAT 345 DL excavator.

General TSF operation costs include the following works:

- Equipment transportation with a Flatbed;
- Fueling of all mobile equipment with a Fuel Truck.

General TSF maintenance costs include the following works:

- Road maintenance with a CAT 16M grader and a water truck (snow removal not included as costs are already considered in the mining and G&A operating costs based on the area of snow removal activities);
- Transport of granular material and overburden for the various punctual construction needs with Volvo A35 articulated haulers and CAT 777D haul trucks.

General water management infrastructure maintenance costs include the following works:

- Pump handling and maintenance with Terex Stinger 492 boom truck in the various pumping stations;
- General maintenance of the water management infrastructure with a Liebherr A20 Litronic hydraulic excavator;
- Handling of pumps and consumables in the water treatment plant and the warehouse with a Takeushi TW65 wheel loader;
- Other response vehicle and equipment.

21.3.6.4 Recurring Engineering

Annual recurring engineering costs for tailings and surface water management, including but not limited to annual and monthly inspection, operation support, recurring and punctual engineering, are included to ensure proper operation of the tailings storage facility.

21.3.7 General Site Services and Administration Operating Costs Estimate

21.3.7.1 Summary

The G&A costs include camp operations, G&A personnel, health, safety and environmental programs as well as miscellaneous project costs. Costs are summarized by category in Table 21-12.

Table 21-12: General and administration (site support) operating costs

Period	Avg. LOM ($/t conc.)
Energy	$0.24
Mobile Equipment	$0.19
Labour	$1.04
Accommodations and Transportation	$1.48
External Consultants/Contractors	$0.04
Building Maintenance	$0.12
Health and Safety excl. PPE & Labour	$0.05
IT Software and Licenses	$0.19
Snow Removal Contract	$0.27
Insurance	$0.22
Telecommunications Costs	$0.30
Environmental Monitoring and Programs	$0.41
Other G&A Costs	$0.13
Total ($/t)	**$4.68**

The majority of G&A costs are based on costs being incurred by QIO currently or during the previous year's operations, as well as suppliers' proposals. The following sections describe the build-up of operating costs in the site support (G&A) area.

21.3.7.2 Electricity and Heating

Power costs for heating were established based on a rate of $0.049/kWh. Power requirements for the site support and administration buildings were calculated using the installed power taken directly from the existing mechanical equipment list. Operating hours per year, equipment utilization and load factors were used to calculate the total power usage in kWh per year.

Electrical costs associated to the operation of the housing complexes (camp) were determined based on the previous year's operating costs and current operation budget for these facilities.

Finally, light fuel oil #2 is used to heat a number of buildings. The fuel consumption was derived for the current and historical operations.

G&A building maintenance costs were established based on the current cost incurred during the operation.

21.3.7.3 Mobile Equipment

Costs were estimated for the concentrator and infrastructure light vehicle and mobile equipment fleet for site operations and maintenance. They include mobile equipment, such as front end loaders, graders, bulldozers, tanker truck, boom truck and service trucks that are required for operations, maintenance, and service and support activities. A list of the mobile equipment already at site was established along with operating hours per day for each vehicle, in order to determine operating costs of the fleet.

The fuel consumption rate was calculated for vehicles in the fleet according to manufacturers' information. An average maintenance rate per engine hour was established and applied to the vehicles in each category to generate maintenance costs.

Costs for the transportation of personnel from the airport to lodging in Fermont and from Fermont to site as well as transportation on-site are included in the accommodations and transportation section of the G&A costs, based on actual contracts and prorated with the future staffing needs.

Costs associated with the mining mobile equipment and light vehicles are included in the mining cost estimate. The mining operating costs include the operation of all site pick-up trucks as well as the snow removal equipment for the mine sector.

21.3.7.4 Labour (G&A)

Labour costs for all general and administration positions are based on the effective collective agreement and remuneration policy. These positions include the general manager, human resource staff, transportation and logistics personnel, health, safety and security employees, finance and IT staff and warehouse and purchasing departments.

No personnel were considered for the operation of the housing complexes, cafeteria and personnel transportation, as these positions will be contracted out to external service providers.

Labour auxiliary costs were estimated as a separate item based on actual operating budget. The auxiliary costs include a yearly allowance per employee for general consumables and health and safety equipment. Operating materials, office supplies and employee training and induction programs were estimated as a percentage of yearly labour costs.

21.3.7.5 Accommodations and Transportation

The accommodations and transportation cost category includes costs associated with transporting personnel to, and on, site, housing, and cafeteria operations.

Plant operations will be on a two-week rotating schedule, with personnel flying to and from site bi-monthly. The annual cost of flights was established on the basis of the annual employee roster and current operation flight costs without volume savings.

A bus transport schedule is established in collaboration with the local service provider to account for personnel transport between the plant site and the housing complex, as well as to and from the airport. The service provider will supply its own bus fleet and employees.

Camp lodging and catering costs were calculated based on the organizational structure and rosters. A service provider is contracted in the current operation to provide the following services:

- Camp management;
- Room maintenance;
- Room management and help desk;
- Catering.

The service provider will supply its own equipment, consumables, food and labour (bedding will be provided by QIO). The cost of the service is based on the current operating budget on a per person-day basis.

21.3.7.6 External Consultants/Contractors

External consultant cost is established using a ratio of the labour cost. The percentage allocated for external consultant is 5% and is linearly decreased to 3% over the LOM to account for the gain in maturity of the organization.

21.3.7.7 Health & Safety

The cost for health and safety expenditures includes an annual allowance for general safety equipment, an allowance for medical supplies and an allowance for supplemental training related to health and safety concerns. An allowance was also made for various medical fees related to the new employee hiring.

21.3.7.8 Environment Monitoring and Programs, Leases and Claims

The detailed environmental services budget is based on current operations and adjusted for future needs. It includes the following cost items:

- Chemical analysis of mining effluents, surface, ground and potable water, sanitary water and contaminated soils;
- Environmental chemical results management software licence;
- External support for groundwater sampling;

- Equipment and consumables such as pumps, filters, weather station maintenance;
- Annual reporting and environmental obligations;
- Environmental effects monitoring study (federal requirement);
- Permitting and external support such as fuel storage tanks permitting and restoration plan updates;
- Spill/leak prevention and management;
- Waste management, such as septic tank pumping;
- Hazardous waste management, such as waste and soil disposal;
- Environmental programs such as community involvement projects, eco-toxicological studies and environmental training.

21.3.7.9 Information Technology, Telecommunications and Site Security

Information technology (IT), telecommunications and site security cost categories include:

- Information technology costs such as software licenses and IT management tools;
- Annual allowance for security systems and security contracts;
- Annual telecommunications costs;
- Radio services.

Costs for information technology, security systems and radio services were based on the actual operating costs and prorated based on the future staffing needs.

Telecommunications costs, such as internet connection, land lines and cell phone services, were established with the local service provider according to the site requirements.

21.3.7.10 Other G&A Expenditures

Various other G&A expenditures based on current budget were accounted for in the plant operating cost estimate. These expenditures include the following items:

- Annual marketing allowance;
- Professional membership and association dues;
- Radio services;
- Head office monthly allowance;
- External communications, promotional material and publicity allowance.

The annual marketing allowance includes the cost of business travel for promotional purposes. This allowance, as well as the allowance for external communications, promotional material and publicity allowance, was established in conjunction with QIO and is based on their requirements.

21.3.8 Sustainability

Operating costs have been estimated for sustainability and community expenses, which include QIO's IBA, various taxes and other costs. Sustainability costs have been estimated at **$1.28/t** over the life of mine.

22. ECONOMIC ANALYSIS

The economic/financial assessment of the Bloom Lake project of Quebec Iron Ore Inc. (QIO) was carried out using a discounted cash flow approach on a pre-tax and after-tax basis, based on consensus equity research long-term commodity price projections as of Q2-2019 in United States currency and cost estimates in Canadian currency. An exchange rate of 0.76 USD per CAD was assumed to convert USD market price projections and particular components of the capital cost estimates into CAD and forward exchange rate estimates were used to convert USD market price projections into CAD. No provision was made for the effects of inflation. Current Canadian tax regulations were applied to assess the corporate tax liabilities, while the regulations in Québec were applied to assess the mining tax liabilities.

The internal rate of return (IRR) on total investment was calculated based on 100% equity financing, even though QIO may decide in the future to finance part of the Project with debt financing. The net present value (NPV) was calculated from the cash flow generated by the Project, based on a discount rate of 8%.

The payback period, based on the undiscounted annual cash flow of the Project, is also indicated as a financial measure. Furthermore, a sensitivity analysis has been performed for the after-tax base case to assess the impact of variations in the commodity pricing, USD:CAD exchange rate and freight costs, as well as operating and capital costs.

The NPV, IRR, payback period and sensitivity analyses were calculated taking into account the planned Phase 2 project expansion only. The cash flow table presented represents the complete financial model for both current and planned Bloom Lake operations.

The economic analysis presented in this section contains forward-looking information with regard to the mineral reserve estimates, commodity prices, exchange rates, proposed mine production plan, projected recovery rates, operating costs, construction costs and Project schedule. The results of the economic analysis are subject to a number of known and unknown risks, uncertainties and other factors that may cause actual results to differ materially from those presented here.

This Project is not subject to any royalty agreement. However, the Project is subject to an Impact and Benefit Agreement with local First Nations communities.

22.1 Assumptions and Basis

The economic analysis was performed using the following assumptions and basis:

- Commercial production start-up is scheduled to begin in 2021. This will be the first year of production. Operations are estimated to span a period of approximately twenty years;
- The price for 66.2% iron ore concentrate is USD87.9/tonne for the first 3 years and USD84.1/tonne over the LOM. An Iron Ore Market Study was prepared by Wood Mackenzie, a United Kingdom based research and consultancy group, to assess the market trends for global iron ore supply and demand, projected steel demand and production and freight rate. The analysis can be found in Chapter 19;
- Following detailed review of the Market Study delivered by Wood Mackenzie, the Company has opted for a more conservative iron ore price assumption as determined by the Canadian Institute of Mining, Metallurgy and Petroleum (CIM). The short term realized iron ore price assumption for the years 2021 to 2024 is derived from the P65 analyst consensus as of June 7, 2019, while the long-term iron ore price assumption is derived from the average of the P65 analyst consensus as of June 7, 2019, and the 3-year trailing average price for the PLATTS-62 (P62) plus 15% premium which better estimates the realized price of the 66.2% Fe concentrate produced at Bloom Lake.
- The United States to Canadian dollar exchange rate has been assumed to be 0.76 USD: 1.00 CAD over the life of mine (CAD:USD exchange rate of 1.32);
- All cost and sales estimates are in constant Q2 2019 Canadian dollars with no inflation or escalation factors taken into account;
- All metal products are assumed sold in the same year they are produced;
- Class specific Capital Cost Allowance rates are used for the purpose of determining the allowable taxable income;
- All Project-related payments and disbursements incurred prior to the effective date of this Report are considered as sunk costs. Disbursements projected for after the effective date of this report, but before the start of construction, are considered to take place in the preproduction period;
- Final rehabilitation and closure costs will be incurred in 2040 (Year 20);
- Project revenue is derived from the sale of iron ore concentrate into the international marketplace. Pricing was estimated on a CFR China basis;
- This Project is not subject to any Net Smelter Return (NSR) royalty agreement.

This financial analysis was performed on both a pre-tax and after-tax basis. The general assumptions used for this financial model, LOM plan tonnage and grade estimates are outlined in Table 22-1.

Table 22-1: Financial model parameters

Description	Unit	Value[1] Phase 1+2
Long Term Iron Ore Price	USD/tonne	84.1
Exchange Rate	USD:CAD	0.76
Discount Rate	%	8
Discount Rate Variants	%	4,6
Mine Life	year	20
Total Mined and Milled	k tonnes	806,898
Design Processing Rate	k tonnes/year	41,956
Average Stripping Ratio	W:O	0.88
Head Grade at Process Plant	%	29.0
Concentrate Grade	%	66.2
Concentrate Production	k tonnes	290,801
Mining Costs	$/tonne conc.	13.4
Crushing and Conveying Costs	$/tonne conc.	1.7
Process Plant Costs	$/tonne conc.	7.9
Concentrate Shipping Costs	$/tonne conc.	16.8
Water and Tailings Management Costs	$/tonne conc.	2.1
General and Administrative Costs	$/tonne conc.	4.7
Corporate Social Responsibility (CSR)	$/tonne conc.	1.3
Total Operating Cost including sustainability	$/tonne conc.	47.9
Pre-production Capital Cost (including deposits)	$M	633.8
Sustaining Capital Cost	$/tonne conc.	4.4
Reclamation and Closure Cost	$M	99.0

[1] Values shown for reference purposes, financial analysis and sensitivity performed using Phase 2 data only.

22.2 Capital and Sustaining Costs

All capital costs (preproduction, sustaining, reclamation and closure) for the Project have been distributed against the development schedule to support the economic cash flow model. The yearly capital cost profile (excluding pre-production) is displayed in Figure 22-1. The sustaining cost table does not include residual values nor does it include reclamation payments.

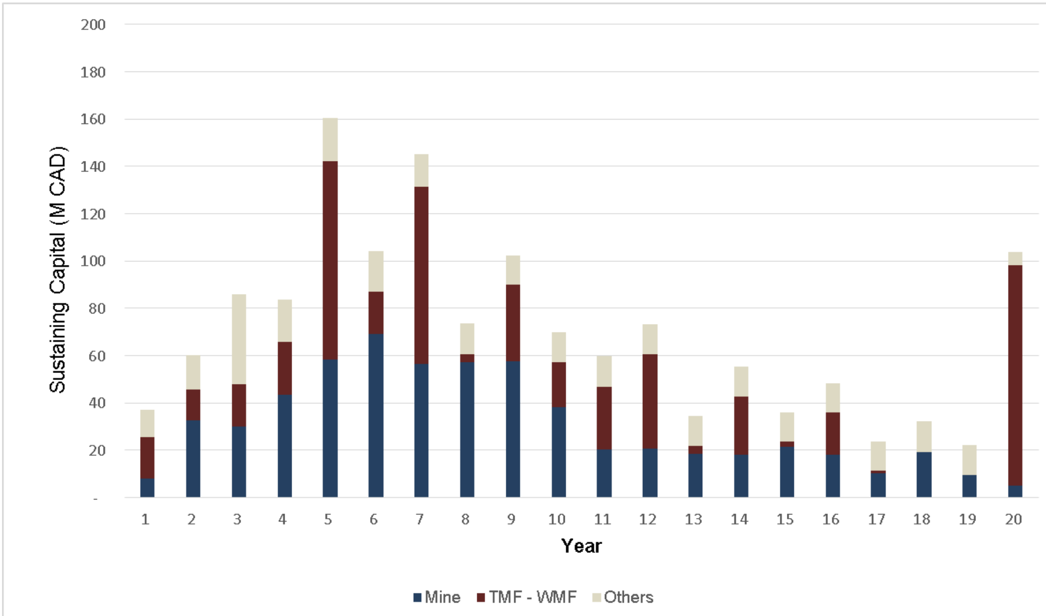


Figure 22-1: Sustaining capital per year

22.3 Taxation

The Bloom Lake Project is subject to three levels of taxation, including federal income tax, provincial income tax and provincial mining taxes. QIO compiled the taxation calculations for the Bloom Lake Project with the assistance of third-party taxation experts; however, this information was not verified by the QPs.

The current Canadian tax system applicable to Mineral Resources Income was used to assess the annual tax liabilities for the Project. This consists of federal and provincial corporate taxes, as well as provincial mining taxes. The federal and provincial corporate tax rates currently applicable over the Project's operating life are 15.0% and 11.5% of taxable income, respectively. The marginal tax rates applicable under the recently adopted mining tax regulations in Québec (originally proposed as Bill 55, December 2013) are 16%, 22% and 28% of taxable income and depend on the profit margin. As the Project concerns the production of iron ore concentrate at the mine site, a processing allowance rate of 10% was assumed.

The tax calculations are underpinned by the following key assumptions:

- The Project is held 100% by a corporate entity and the after-tax analysis does not attempt to reflect any future changes in corporate structure or property ownership;
- Assumes 100% equity financing and therefore does not consider interest and financing expenses;
- Actual taxes payable will be affected by corporate activities, and current and future tax benefits have not been considered.

The combined effect on the Project of the three levels of taxation, including the elements described above, is an appropriate cumulative effective tax rate of 36%, based on Project Earnings. It is anticipated, based on the Project assumptions, that QIO will pay approximately $2,862M in tax payments over the life of mine for both phases of the project.

22.4 Financial Model and Results

An 8% discount rate was applied to the cash flow to derive the NPV for the Phase 2 expansion Project on a pre-tax and after-tax basis. Cash flows have been discounted to 2019 under the assumption that major Project financing would be carried out at this time. The summary of the financial evaluation for the Project is presented in Table 22-2.

Table 22-2: Financial analysis summary (pre-tax and after tax)

Description		Unit	Base Case
Pre-Tax	Net Present Value (8% disc)	$M	1,531.8
	Internal Rate of Return	%	42.4%
After-Tax	Net Present Value (8% disc)	$M	955.7
	Internal Rate of Return	%	33.4%
	Simple Payback Period	Years	2.4

The pre-tax base case financial model resulted in an internal rate of return of 42.4% and a net present value of $1,531.8M with a discount rate of 8%. On an after-tax basis, the base case financial model resulted in an internal rate of return of 33.4% and a net present value of $955.7M with a discount rate of 8%. The simple after-tax payback period is 2.4 years.

The summary of the Bloom Lake Project discounted cash flow financial model (pre-tax and after-tax) is presented in Table 22-3.

Table 22-3: Bloom Lake Project financial model summary

Year	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Production Summary																						
Total Tonnes Mined (kt)	-	52,983	75,451	77,691	68,501	84,095	94,713	93,014	92,245	93,115	87,926	89,953	90,397	91,829	98,913	77,649	63,447	54,930	52,817	49,943	24,044	**1,513,656**
Total Tonnes Milled (kt)	-	35,032	41,956	41,956	41,956	41,956	41,956	41,956	41,956	41,956	41,956	40,000	40,000	41,956	41,956	41,956	41,956	41,956	41,956	41,956	20,570	**806,898**
Concentrate Grade (%)	-	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	66.20%	**66.20%**
Concentrate Production (k tonnes)	-	13,050	14,821	15,227	15,574	14,241	14,073	15,134	15,021	15,096	15,698	15,940	15,341	15,183	15,275	14,413	14,463	15,009	15,375	15,292	6,575	**290,801**
Revenue																						
Exchange Rate (USD:CAD)	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	**0.76**
Gross Revenue ($M)	-	1,577	1,727	1,697	1,715	1,568	1,550	1,667	1,654	1,663	1,729	1,756	1,690	1,672	1,682	1,587	1,593	1,653	1,693	1,684	724	**32,281**
Ocean Transport Costs ($M)	-	(397)	(437)	(433)	(440)	(402)	(398)	(428)	(424)	(427)	(444)	(451)	(434)	(429)	(431)	(407)	(409)	(424)	(434)	(432)	(186)	**(8,267)**
Net Revenue ($M)	-	1,180	1,290	1,264	1,275	1,166	1,152	1,239	1,230	1,236	1,285	1,305	1,256	1,243	1,251	1,180	1,184	1,229	1,259	1,252	538	**24,014**
Operating Expenditures																						
Mining ($M)	-	130	167	174	167	196	233	243	240	235	222	226	233	236	256	215	187	166	164	156	75	**3,921**
Crushing and Conveying ($M)	-	26	27	27	27	26	26	27	27	27	27	26	26	27	27	26	26	24	22	19	9	**499**
Process Plant ($M)	-	115	119	121	121	118	117	120	120	120	121	122	120	120	120	118	118	115	113	108	57	**2,303**
Concentrate Shipping ($M)	-	219	249	255	261	239	236	254	252	253	263	267	257	255	256	242	243	252	258	256	113	**4,880**
Water & Tailings Management ($M)	-	26	26	29	28	26	27	30	33	33	33	32	32	32	32	32	32	33	32	35	19	**602**
General & Administration ($M)	-	69	69	69	70	69	69	70	70	70	70	70	70	70	70	70	70	70	70	73	34	**1,362**
Onsite Operating Costs ($M)	-	585	657	675	674	674	708	744	742	738	736	743	738	740	761	703	676	660	659	647	307	**13,567**
CSR ($M)	-	21	18	18	18	18	18	18	18	18	18	18	18	18	19	19	19	19	19	19	19	**370**
Capital Expenditures																						
Pre-production ($M)	590	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**590**
Sustaining ($M)	-	32	55	81	79	155	99	141	69	98	65	54	68	29	50	30	43	19	28	17	8	**1,220**
Deferred CAPEX - Train ($M)	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	**98**
Reclamation and Closure ($M)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	**100**
Logistic Deposit ($M)	44	(13)	(15)	(11)	-	1	1	-	-	-	3	1	1	1	1	1	1	-	-	(47)	-	**(31)**
Residual Value ($M)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(7)	**(7)**
Total Capital Costs ($M)	**634**	**24**	**45**	**75**	**84**	**161**	**105**	**146**	**74**	**103**	**73**	**60**	**74**	**35**	**56**	**36**	**49**	**24**	**33**	**(25)**	**104**	**1,970**
Changes in Working Capital ($M)	-	(44)	(56)	0.4	(11)	39	14	(20)	(2)	(8)	(21)	(7)	12	4	3	3	(12)	(23)	(13)	(4)	144	**-**
Interest on Capital Lease ($M)	2	1	4	4	4	7	8	7	5	4	2	1	1	1	1	2	2	2	-	-	-	**58**
Pre-Tax Cash Flow																						
Pre-Tax Cash Flow ($M)	(636)	592	619	490	506	266	299	344	392	380	477	489	413	445	412	417	451	549	561	616	(35)	**8,048**
Cumulative Pre-Tax Cash Flow ($M)	**(636)**	**(44)**	**576**	**1,066**	**1,571**	**1,838**	**2,136**	**2,480**	**2,872**	**3,253**	**3,729**	**4,219**	**4,632**	**5,076**	**5,488**	**5,905**	**6,356**	**6,905**	**7,467**	**8,083**	**8,048**	

Year	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Taxes and Duties																						
Federal Corporate Income Tax ($M)	-	30	59	56	58	41	35	42	43	45	53	56	51	50	49	48	53	62	65	67	6	**969**
Provincial Corporate Income Tax ($M)	-	23	45	42	45	31	27	31	33	34	41	43	39	39	37	37	40	47	50	51	4	**739**
Québec Mining Duties ($M)	-	53	57	57	63	42	38	46	50	53	64	68	61	61	58	58	63	77	84	87	13	**1,153**
Total Taxes and Duties ($M)	**-**	**106**	**161**	**155**	**166**	**114**	**100**	**119**	**126**	**132**	**158**	**167**	**151**	**150**	**144**	**143**	**156**	**186**	**199**	**205**	**23**	**2,861**
After-Tax Cash Flow																						
After-Tax Cash Flow ($M)	(636)	486	458	335	340	153	198	225	266	248	318	322	262	295	267	274	295	364	362	412	(57)	**5,186**
Cumulative After-Tax Cash Flow ($M)	**(636)**	**(150)**	**308**	**644**	**983**	**1,136**	**1,334**	**1,559**	**1,825**	**2,073**	**2,391**	**2,714**	**2,975**	**3,270**	**3,537**	**3,812**	**4,107**	**4,470**	**4,832**	**5,244**	**5,186**	

22.5 Sensitivity Analysis

A financial sensitivity analysis was conducted on the base case after-tax cash flow NPV and IRR of the Project, using the following variables: USD:CAD exchange rate(FX Rate), price of iron ore (selling price), freight cost (freight), pre-production capital cost (CAPEX) and operating costs (OPEX). The graphical results of the sensitivity analysis are depicted below in Figure 22-2 for the Project's NPV and in Figure 22-3 for the Project's IRR.

The sensitivity analysis reveals that the iron ore price has the most significant influence on both NPV and IRR compared with other parameters, based on the range of values evaluated.

After the iron ore price, the NPV is most impacted by changes in the USD:CAD exchange rate and the OPEX. The NPV was least affected by CAPEX. After iron ore price, the IRR is most impacted by changes in the USD:CAD exchange rate and then to a lesser extent CAPEX and OPEX. The IRR was least affected by freight costs.

A negative NPV is recorded when iron ore price is decreased by approximately 20% or more. The other parameters caused positive NPV and IRR results within the range of values used for sensitivity analysis.

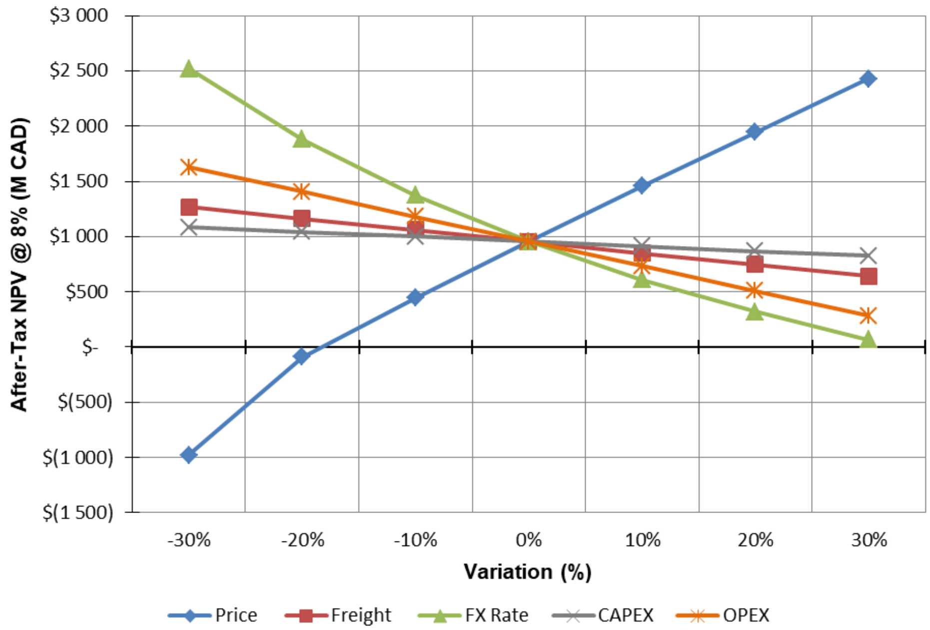


Figure 22-2: Sensitivity of the net present value (after-tax) to financial variables

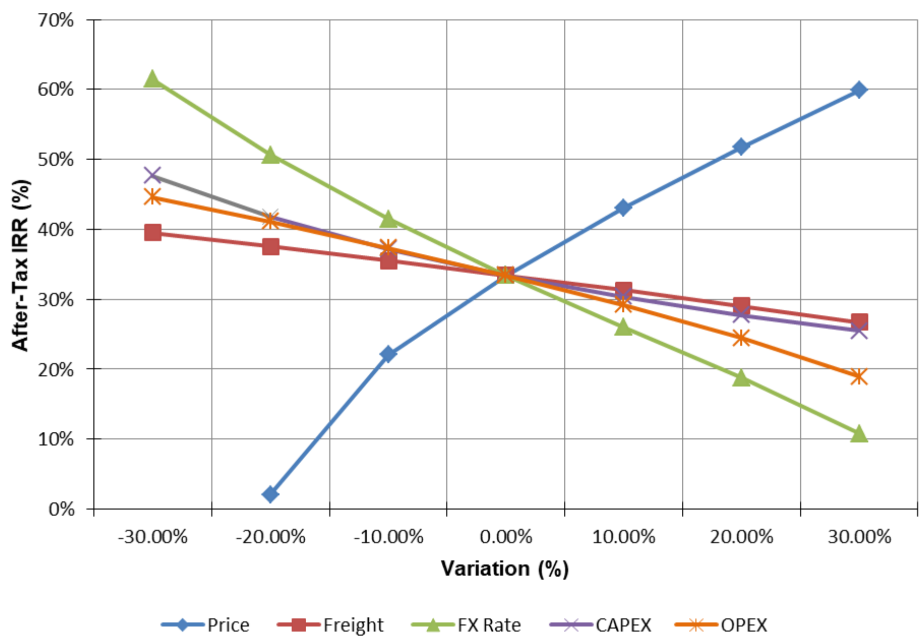


Figure 22-3: Sensitivity of internal rate of return (after-tax) to financial variables

23. ADJACENT PROPERTIES

The Bloom Lake project is situated in an active iron ore mining district, as illustrated in Figure 23-1.

The Mont-Wright Mine owned by ArcelorMittal is 1 km south of the Bloom Lake Property. Further south, the Fire Lake project is also operated by ArcelorMittal Canada. Both mines have a combined production of 26 Mt of concentrate per year.

Approximately 30 km northeast of the Bloom Lake Project is the Iron Ore Company of Canada (IOC) whose major shareholder is the international mining group Rio Tinto. IOC has recorded production rates for a combination of concentrate and pellets of 15.1 Mt and 19.2 Mt in 2017 and 2018 respectively (LIORC, 2019). IOC has also completed the permitting of its latest open pit mine location; Wabush 3. Ore is sent to a concentrator for upgrading to 65-67% iron. Upgrading takes three processes involving the spiral, magnetite and hematite plants. The majority of the concentrate is pelletized with the remainder sold as concentrate.

Also located approximately 30 km northeast, near the town of Wabush, is the Scully Mine owned by Tacora Resources (Tacora). Tacora has recently reactivated operations at Scully Mine; the first train of concentrate from the concentrator arrived in Pointe Noire at the end of June 2019.

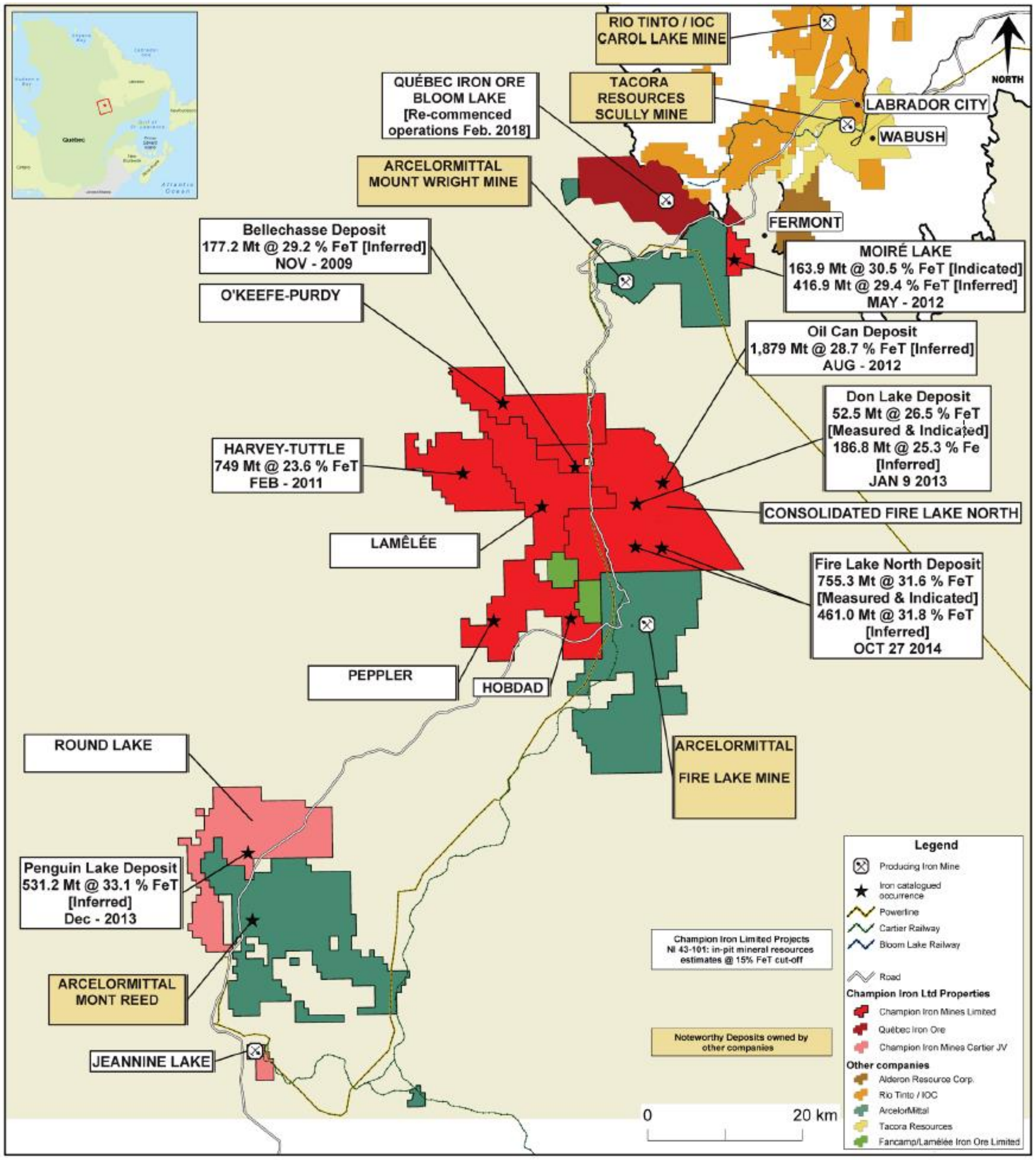


Figure 23-1: Location of adjacent properties

24 OTHER RELEVANT DATA AND INFORMATION

After successfully restarting the existing operation of the Lac Bloom Mine in 2018, Quebec Iron Ore (QIO) is planning the completion of the Phase 2 expansion project started by the previous owner in 2011.

QIO has a very good understanding of the challenges involved in the Phase 2 project, which are quite different from Phase 1. The success of the Phase 2 project requires an effective execution strategy from the Project kick-off to the full production ramp-up. In this regard, QIO has started the preparation of a Project Management Plan (PMP) with the related execution plans (Health, Security and Environment (HSE), Project Execution, Engineering, Procurement, Construction, Project Services and Operational Readiness).

This chapter presents the main highlights from these execution plans under preparation.

24.1 Health, Safety & Environment

QIO is committed to excellence in Occupational Health, Safety (OHS) and Environment, and it is a continuous commitment. Policies, procedures and systems already in place, and the following will be applicable to the Project:

- Work supervision in confined spaces;
- Strict padlocking system throughout the plant;
- Continuous OHS training in the field;
- Additional health and safety measures.

In Environment, QIO has a strong policy based on the following four pillars:

- Continuous improvement of our environmental performance;
- Advocacy towards the respect of our environmental values;
- Respect for local communities;
- Exemplary environmental protection.

The Phase 2 project will be executed in respect of QIO's HSE requirements. The Project key managers will work with QIO, the project team, consultants, vendors, contractors, workforce and the community toward achieving the following objectives:

- Integrate HSE delivery into all project disciplines;
- Align all parties to a common set of goals and objectives;
- Identify HSE issues as early as reasonably practicable in the project life cycle;
- Manage the identified HSE risks by avoidance, prevention, control, and mitigation;

- Manage risks to personnel to a level "As Low As Reasonably Practicable" (ALARP);
- Pursue zero damage to the environment and challenge any deviations;
- Promote awareness and manage health issues.

24.2 Project Implementation and Execution

24.2.1 Project Schedule

The preliminary project schedule is developed to a feasibility study level and will be further defined during the baseline definition exercise which started in July 2019. Pursuant to the strong economics outlined in this Study, QIO's board has approved an initial budget of $68M to advance the Project during the remainder of 2019. This budget will serve for early works during the summer of 2019, definition and procurement work for long-lead items and advancement of detailed engineering to respect the Project's major milestones. The preliminary schedule covers the period from the kick-off up to the commercial operation of the Phase 2 project. The schedule has been provided in terms of reference months compared to the project start pursuant to board approval for the remaining project budget. The major milestones of the Project are listed in Table 24-1.

Table 24-1: Phase 2 project schedule milestones

Milestone Month	Description
June 2019	Phase 2 Feasibility Study completion
July 2019	Phase 2 Project kick-off, start of early works and detailed engineering
M0	Board approval for remaining project budget
M9	Start of pre-commissioning activities
M12	Start of commissioning activities
M14	Start of operation and ramp-up
M19	Phase 2 commercial operation

24.2.2 Project Scope of Work

The Project scope of work consists of the following activities:

Mine

The mining operation will require three new mine trucks and one new drill to supply the increased production capacity along with additional mine dewatering equipment. Existing garage facilities will be upgraded to facilitate maintenance activities of the increased mine truck fleet.

A new 34.5 kV electrical line will be installed between the main electrical Substation W nearby Road 389 and the mine site. Once this new electrical line is operational, the mine network will be disconnected from the process electrical substation.

Ore Stock Pile

The construction of the material handling equipment feeding the Concentrator 2 will be completed and existing equipment will be optimized to facilitate the transfer of Crusher 1 production to the Concentrator 2.

Concentrator 2

The main services (electrical distribution, HVAC and glycol heating loop) will be completed and commissioned during the summer 2019 to facilitate future construction activities inside the building.

Modifications to the building and already installed equipment will be done due to improvement to the process flow sheets along with installation of new spirals, LIMS, WHIMS and screens, and completion of remaining construction activities.

Load-out

The installation of conveying equipment will be done for Silo 2. Additional material handling equipment will be installed to enable the ore transfer from Concentrator 1 to Silo 2. The train loading station building will be upgraded to accept the ore transfer from Silo 2 and the winterizing protection over the train entrance and exit will be added to the building.

Tailings Management

The pumping capacity of the existing Booster Pumphouse will be optimized to handle the additional tailings reject from Concentrator 2. The water flushing system of the tailings piping lines will also be optimized.

Dikes HPA South and HPA West will be upgraded to meet the future tailings deposition plan requirements.

Other Major Scope of Work Items

- Specific engineering activities will be done just after the Project kick-off for the early procurement of items identified in the critical path like spirals and stacker/reclaimer;
- The 34.5 kV electrical overhead lines between Substation W nearby Road 389 and the process main electrical substation will be upgraded to improve reliability. Once this new electrical line is operational, the mine network will be disconnected from the process electrical substation;
- A second bridge will be added over the Jean River to optimize train traffic cycle time;
- Railroad modifications will be done at the SFP Pointe-Noire installations to accept future train traffic increase. Additional material handling and storage capacity will also be installed;
- A new permanent housing camp will be built in the city of Fermont nearby existing ones for the additional manpower required in the course of the Project construction and operations.

24.2.3 Project Organization

QIO's objective is to execute the Project in the form of an EPCM with a Project Integrated Team composed of experienced multidisciplinary personnel from QIO and consulting firms selected by QIO for their specific expertise. QIO's intention is to have its own personnel filling most of the Project Management key roles.

The Organizational Chart of the Project is presented in Figure 24-1.

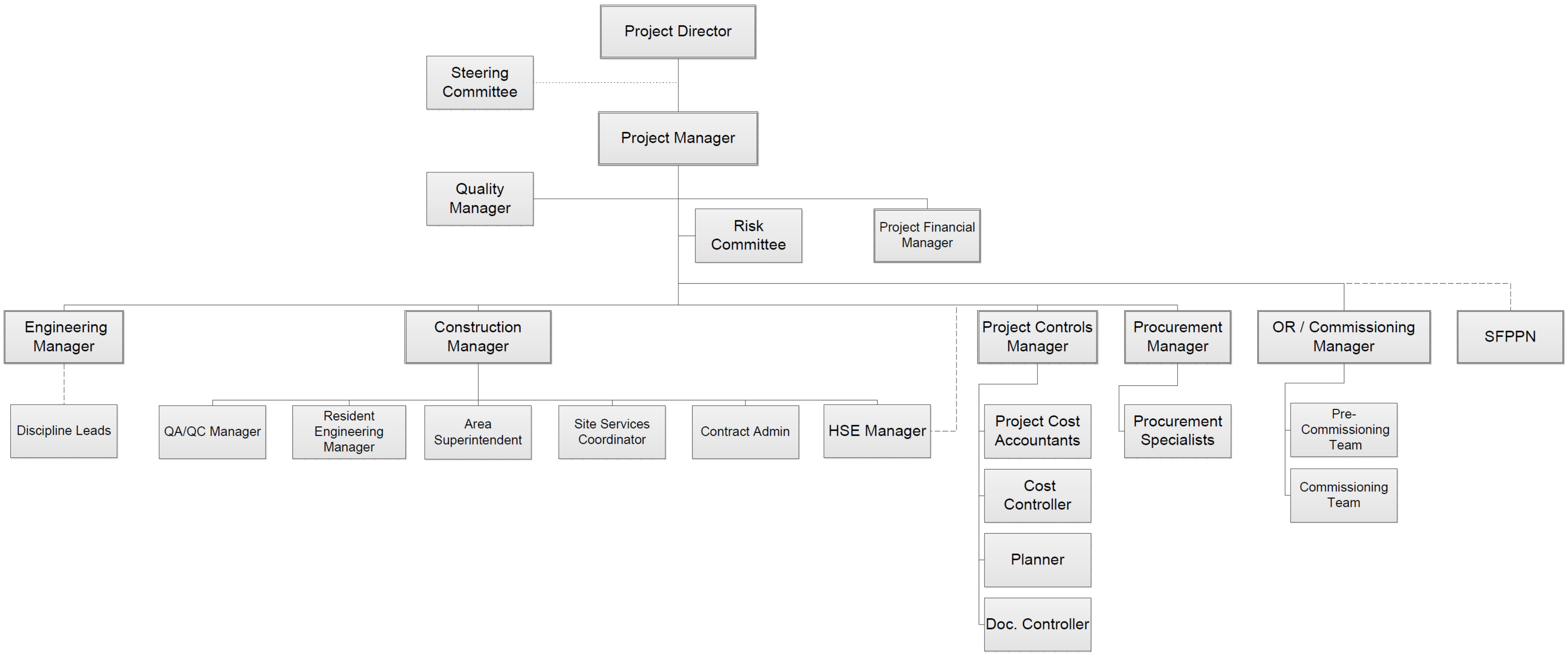


Figure 24-1: Project organizational chart

24.2.4 Baseline Definition

After completion of the FS and the Phase 2 project approval by QIO, the Project Integrated Team will complete a baseline definition exercise where the results of the FS will be integrated to plan the Project execution phase. Upon completion of the baseline definition, the following main deliverables will be completed and ready to use for the execution of the Project:

- Project Management Plan (PMP) and related execution plans (HSE, Project Execution, Engineering, Procurement, Construction, Project Services and Operational Readiness);
- Project baseline schedule;
- Project progress control estimate with key quantities;
- Project control budget cost;
- Project budget hours and Project staffing plan with Manpower Forecasting and Levelling (MFL);
- Engineering deliverables list;
- Procurement package dictionary;
- Project instruction/procedures manual.

24.2.5 Risk Management

Several risk identification workshops were held during the FS to identify and manage the potential risk exposures of the Bloom Lake Phase 2 project. The attendances were stakeholders from Quebec Iron Ore and the different partners collaborating to the FS. The findings of those workshops were compiled in a risk register followed by an assessment of the frequency and consequence of an item in order to get a risk priority number using a risk priority matrix. The risk register and the risk priority matrix are similar to the ones used for the restart of Bloom Lake Mine in 2017. After an exercise of mitigation done during the last workshop, the resulting material and main risks are reported in Figure 24-2 and Table 24-2.

The Project risk register will be revisited, reviewed and updated regularly during the Phase 2 project. Each risk owner will be responsible to provide any update to the mitigation action items and to re-assess the risk as the Project develops.

Additional risk workshops will be scheduled during the Project in different forms (e.g., HAZOP, HAZID, etc.) to address specific aspects in HSE, Engineering, Procurement, Construction, Commissioning and Operation.

Assessment Levels

The pie chart in Figure 24-2 indicates the risk division in the different category of the Project risk register after mitigation:

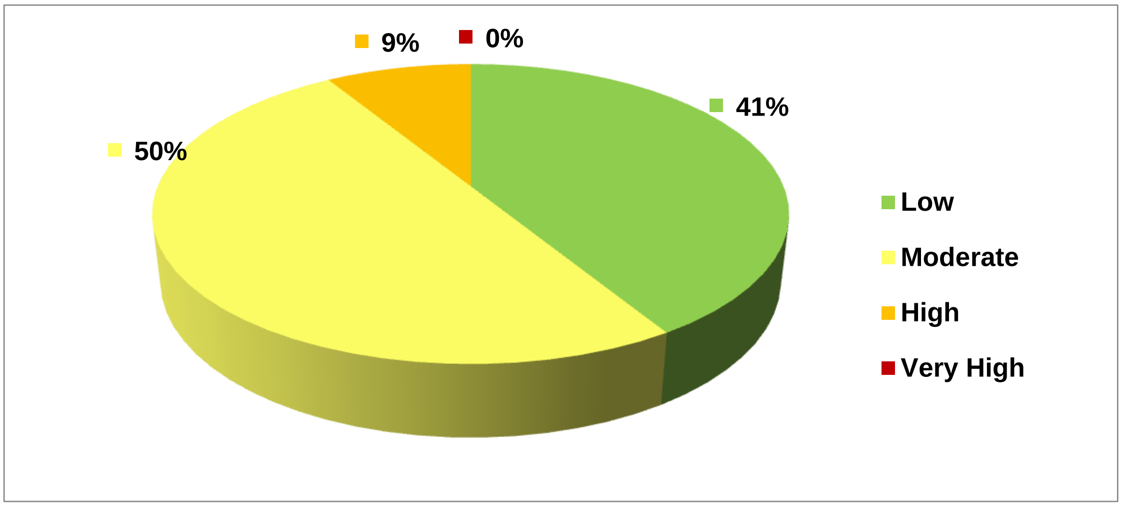


Figure 24-2: Risk register assessment levels

Relevant Risks

The relevant risks for the Project are as follows:

Table 24-2: Summary of the Phase 2 project top risks

Risk ID	Assessment	Description
1	20	A construction site working environment is prone to hazardous situations that can be very dangerous at times. Construction health and safety management is different than a mine site in production.
Consequence		
Construction workers health and safety could be at risk resulting in injury or even death; construction works could be stopped.		
Assessment after mitigation	**Mitigation actions**	
15	▪ Preparation and implementation of a Project HSE execution plan; ▪ Proper HSE budget to hire competent resources to execute the HSE plan and manage the risks; ▪ Evaluation of contractors' OHS performance before contract award; ▪ Implementation of adequate OHS management tools and practices on a construction site (site committees, lockout, work permit).	

<table>
<tr><th>Risk ID</th><th>Assessment</th><th colspan="2">Description</th></tr>
<tr><td>5</td><td>16</td><td colspan="2">Availability of skilled labour for start-up and operation ramp-up.</td></tr>
<tr><th colspan="4">Consequence</th></tr>
<tr><td colspan="4">Impossible to ramp-up the plant due to lack of manpower.</td></tr>
<tr><th colspan="2">Assessment after mitigation</th><th colspan="2">Mitigation actions</th></tr>
<tr><td colspan="2">12</td><td colspan="2">▪ Preparation of an Operational Readiness and Commissioning Plan;
▪ Setting up a committee to address this situation with concrete actions;
▪ Discussions with labour training centres and technical schools;
▪ Review recruitment criteria to ease the hiring of candidates that have recently immigrated to Canada;
▪ A trainee program is now in place to facilitate recruiting of required resources;
▪ Ordering new trucks and drills with “autonomous ready” features is considered.</td></tr>
</table>

<table>
<tr><th>Risk ID</th><th>Assessment</th><th colspan="2">Description</th></tr>
<tr><td>26</td><td>20</td><td colspan="2">Construction of the expansion project at the SFP Pointe-Noire site will be managed by a third-party.</td></tr>
<tr><th colspan="4">Consequence</th></tr>
<tr><td colspan="4">Delays or costs over-run.</td></tr>
<tr><th colspan="2">Assessment after mitigation</th><th colspan="2">Mitigation actions</th></tr>
<tr><td colspan="2">12</td><td colspan="2">▪ Implementation of new governance rules with the arrival of the new General Director at the SFP Pointe-Noire;
▪ Establishment of a project management structure through which QIO will be involved;
▪ An integrated project team will be put in place with SFP Pointe-Noire and QIO.</td></tr>
</table>

24.2.6 Quality Management

The Project Integrated Team will implement a Quality Assurance Program in accordance with QIO quality requirements that includes the PMP and the related execution plans with the relevant Project procedures and instructions covering the Project execution activities.

The quality objectives for the Bloom Lake Phase 2 project are to:

- Meet QIO’s quality requirements;
- Comply with all relevant regulatory body requirements;
- Achieve the Project value objectives and Project schedule objectives;
- Follow approved procedures as defined by the PMP and the related execution plans.

To support the quality objectives, each execution plan will specify the applicable quality requirements like design review in engineering, level of quality control for vendor supplied equipment, review of contractor quality plan by the construction management team, etc.

24.2.7 Change Management

The control of changes for the Phase 2 project will be based on the use of a Project Change Notice (PCN) procedure to document the need for, approval of, and implementation of changes to the Project.

Project key managers will be made fully aware of the scope of work baseline and the project execution plan as well as the criteria that constitute a change. Identifying, communicating and managing changes to the project control base will be the responsibility of all members of the Project Integrated Team including vendors and contractors.

24.3 Operational Readiness (OR)

QIO has been in operation for more than a year and are now working on improving production capacity of Phase 1. As an example, during the fourth quarter of the fiscal year ending March 31, 2019, the optimization of the recovery circuit continued, resulting in record monthly recovery of 81.7% in February from a 31.0% head grade. An average recovery rate of 80.4% was achieved during the fourth quarter.

This is a relevant indicator that QIO's operation team is in control and has sufficient capabilities to prepare itself with the required OR activities for the increased production capacity to come in 2021. Similar to the restart of Phase 1, an OR plan will be prepared to define all necessary activities to be performed during OR execution and the necessary control to be put in place to successfully start Phase 2 production.

The OR plan will be managed by an external consultant specialized in OR planning and execution. The OR plan will be defined, planned and tracked by the OR manager. Most OR planned activities will be done by QIO and external services will be retained for specific activities as required.

Maintenance and operation personnel will be part of the pre-commissioning and commissioning activities to gain as much experience as possible from those activities and be more efficient in the coming operation and maintenance activities.

24.4 Pre-commissioning

The pre-commissioning team will be made of experienced multidisciplinary personnel from QIO and consulting firms selected by QIO for their expertise in pre-commissioning supported by QIO's maintenance personnel to gain experience and become familiar with the process and the different technologies used.

24.5 Commissioning

The commissioning phase, which includes the execution of the dry and wet commissioning activities before ore is introduced into the process, will be performed by QIO's operation personnel supported by the pre-commissioning team.

24.6 Production Ramp-up and Normal Operation

During this phase, ore will be introduced gradually in the process until targeted production rates are achieved. Control strategies will be optimized to help reaching the expected process performance.

The production ramp-up and normal operation phase will be performed by QIO's operation personnel supported by the pre-commissioning team.

25. INTERPRETATION AND CONCLUSIONS

The Bloom Lake Phase 2 project is financially and technically feasible with an estimated initial capital cost of $589.8M and initial deposits of $44M. The economic analysis of the Project shows an IRR of 33.4% and a simple payback period of 2.4 years after taxes.

The expected level of accuracy of the capital and operating cost estimates for this study should be in the range of -10% on the low side to +15% on the high side. The capital cost estimate includes a 15% contingency on the pre-production capital costs and includes contingencies on the indirect costs.

25.1 Geology and Mineral Resources

- The geological interpretation for the Bloom Lake deposit is based on different data sources such as mapping (1998), multiple diamond drilling programs (from 1956 to 2018) and ground magnetic surveys (1967,1971-1972, 2008). The geology and controls on the mineralization is well understood.
- The mineralization is found in bands of iron formations of different composition including hematite, magnetite and silicate iron formations.
- The QP is of the opinion that the database is appropriate for the purposes of the mineral resource estimation and that the sample density allows a reliable estimate to be made of the size, tonnage and grade of the mineralization in accordance with the level of confidence established by the mineral resource categories in the CIM Standards.
- The geological model was initially inherited from Cliffs in 2014 and was reported to be produced in Geovia Gems. The interpretation was based on diamond drillholes (DDH), geological maps, ground magnetic surveys and production data. QIO revised the geological model in 2018 and 2019 for some local area and revised the structural domains using Geovia Surpac. Modifications were brought to the “Patte Pignac” and to the north wall of the Pignac pit based on recent drilling and observations made during operation. In the QP’s opinion, the geological model is appropriate for the size, grade distribution and geometry of the mineralized zones and is suitable for the resource estimation of the Bloom Lake project.
- The estimated block grades were classified into Measured, Indicated and Inferred Mineral Resource categories using drill spacing, geological continuity, number of holes used, and the slope of regression. When needed, a series of clipping boundaries were created manually in 3D views to either upgrade or downgrade classification in order to avoid artifacts due to automatically generated classification. All remaining estimated but unclassified blocks were flagged as “Exploration Potential”.

- The Mineral Resources for the Bloom Lake project is estimated at a cut-off grade of 15% Fe, inside an optimized Whittle open pit shell based on a long term iron price of USD61.50/dmt for 62% Fe content, a premium of USD12.7/dmt for the 66.2% Fe concentrate and an exchange rate of 1.24 CAD/USD.
- The Measured and Indicated Mineral Resource for the Bloom Lake project is estimated at 893.5 Mt with an average grade of 29.3% Fe and Inferred Mineral Resource at 53.5 Mt with an average grade of 26.2% Fe.

25.2 Mining and Mineral Reserves

- Open pit optimization was conducted using MSEP software to determine the optimal economic shape of the open pit to guide the pit design process. Pit optimization is based on a reference iron ore price (Platt's 62% CFR China) of USD61.50/dmt concentrate and an exchange rate of 1.24 CAD/USD. A price adjustment of USD12.70/dmt for 66.2% concentrate was added during the revenue calculation.
- The mine design and Mineral Reserve estimate have been completed to a level appropriate for feasibility studies. Definitions for Mineral Reserve categories used in this report are consistent with the CIM definitions as adopted by NI 43-101.
- At a cut-off grade of 15% Fe, Proven and Probable Mineral Reserves are estimated to be 807 Mt with an average grade of 29.0% Fe for 290.8 Mt of iron concentrate at 66.2% Fe.
- Most of the major mining equipment is ready to start the project. Three additional trucks and one drill will be required to start the Project.
- The majority of the loading in the pit will be done by three electric drive hydraulic face shovels and three front-end-loaders. The loading fleet is matched with a fleet of 218 t payload capacity mine trucks.
- The Project already owns three Caterpillar 6060 electric drive hydraulic front shovels. Two Komatsu WA1200-6 units and a LeTourneau L1850 are available on site. The existing truck fleets consist of seven Caterpillar 793D and three Caterpillar 793F mechanical drive trucks.
- Mining of the Bloom Lake project is planned with six phases with a starter phase and two pushbacks in both the Chief's Peak and West pits.
- Waste rock will be disposed of in four distinct waste dumps. One dump north of the Chief's Peak and West pits and three to the south.
- The life of mine (LOM) plan details 20 years of production, with an 8-month ramp-up and commissioning period followed by a mining rate of 41.9 Mt per year of ore for the remainder of the mine life. The peak mining rate of approximately 100 Mt will be reached in 2034. The mining rate declines, starting in 2035, as sufficient ore for the mill is accessible.
- The open pit generates 707 Mt of overburden and waste rock for a strip ratio of 0.88:1.

25.3 Mineral Processing and Metallurgical Testing

Extensive metallurgical testwork was historically performed on the Bloom Lake mine ore. Furthermore, the Bloom Lake concentrator Phase 1 has been in operation from 2010 to 2014, and has been successfully restarted in 2018, thus providing significant operational data.

The objective of the metallurgical testwork program undertook for this study was to improve the Phase 1 (QIO) flowsheet based on the experience acquired and the challenges to come.

The testwork has shown that:

- Addition of a cleaner-scavenger UCC to process the scavenger spirals concentrate allows the production of a final grade concentrate at a high iron recovery;
- Reducing the load on the scavenger and magnetic cleaner spirals will improve their performances;
- Sending the middling spirals concentrate to the magnetic scavenging circuit will improve the circuit's robustness;
- Sending the LIMS concentrate to the magnetic cleaner spirals will improve the circuit's robustness.

The Phase 1 operational experience has shown that:

- Installing a larger thickener and maximizing water recirculation will improve the circuit's robustness;
- Increasing the pan filters and classification screens capacities and flexibilities will improve the concentrator's availability and throughput;
- Increasing the AG mill motor power will allow processing hard ore at an increased tonnage.

Phase 2 flowsheet includes those changes. Based on the mine plan developed for this study, at an average feed Fe grade of 29%, the Phase 2 concentrator will allow a Fe recovery of 82.5% while producing an average concentrate grade of 66.2%.

25.4 Environmental

The mine has been authorized for operation under the federal environmental authorities and provincial governments (decree and numerous certificate of authorizations) at a production rate of 16 Mtpy. Waste rocks and tailings storage capacity is secured by permits up to 2024 at the maximal production rate. Then, a new tailings storage facility and waste rock stockpile will need to be authorized by a provincial governmental decree. At the federal levels, fish habitats that will be impacted by the Project will need to be compensated and the process of amendment of Schedule 2 of the MDMER is already initiated. The permitting process is ongoing and there are no issues with the deliverance of the authorizations. The mine conducts routine monitoring of water, waste water and air as part of their decrees and authorizations.

A revised closure plan was submitted to the MERN in 2018, which covered five years of mining operations. According to Section 232.6 of the Quebec Mining Act (L.R.Q., c. M 13.1), QIO shall submit a revised closure plan to the Minister for approval every 5 years or whenever amendments to the plan are justified by changes in the mining activities. QIO must also provide a financial guarantee covering the closure plan cost to the provincial government in accordance with Section 111 of the Regulation Respecting Mineral Substances other than Petroleum, Natural Gas and Brine (Chapter M-13.1, r. 2).

26. RECOMMENDATIONS

Given the positive financial results from the economic analysis of the Study, it is recommended that the Project advance to the next phase. The following general recommendations are put forward for the continuation of this Project into the next phases, which are: detailed engineering, procurement, and construction. It is QIO's intent to start commissioning in Month 14 of the proposed schedule and be in commercial operation by Month 19. In order to make this possible, it is imperative that a focus be placed on critical path purchase orders (long-lead items) and begin early works and detailed engineering in the summer of 2019.

26.1 Geology and Mineral Resources

- Silica blanks and standard reference material of industry standards, as well as detailed descriptions of the QA/QC procedures should be introduced in future drilling programs.
- Some sterile units are currently not taken into account in the block model, but it is not believed to be material to the mineral resource estimate. QIO is currently working towards improving the geological model and recommendations were made during the course of this mandate in order to improve the model for future updates.
- The geological model should be re-interpolated to include the 2018 drilling program, which was still pending during the course of this mandate. This is not expected to be material to the project, but could help improve reconciliation locally.
- Comparison analysis (reconciliation) between the resource and grade control block models (blast holes) should be routinely produced to test the performance of the resource block model.

26.2 Mining and Mineral Reserves

- Hydrogeological investigations are recommended for the West Pit, in particular to investigate groundwater infiltration and any incidences on the pit slope performance. The current pit elevation is above the water table.
- Additional waste rock storage options should be investigated. In the event of expanded larger open pit limits optimized for higher iron ore prices, additional waste dump storage capacity will be required.
- Investigation into fleet automation should be undertaken. The fleet size increases dramatically in Year 6 and provides a good opportunity to realize a transition to a smaller, automated fleet instead.

26.3 Mineral Processing and Metallurgical Testing

- The Cleaner Scavenger UCC performances used for the establishment of the flowsheet performances are very conservative due to limited testwork being conducted. Piloting of the Cleaner Scavenger UCC in Phase 1 (QIO) could lead to additional improvements of the flowsheet performances.
- The Cleaner Scavenger Reflux™ classifier showed promising performances, but present a significant risk as limited testwork was performed and as its performance in an industrial iron ore concentrator has not been validated. Extensive piloting of the Cleaner Scavenger Reflux™ classifier in Phase 1 (QIO) could lead to significant improvement of the flowsheet performances.

26.4 Permitting

- The current tailings, waste rock, Phase 2 concentrator, water management structures as well as the water treatment plant have all been authorized. However, authorizations will be required at provincial and federal levels for the following: *Halde Sud-Ouest* waste rock stockpile, *HPA-Nord* TSF, and *Halde Sud* waste rock stockpile. Permits are required for 2024 and, therefore, the permitting process should continue as a high priority component.

26.5 Tailings and Water Management

- As the current TSF will be used to store tailings at an increased rate, the development of the current *HPA-Sud* and *HPA-Ouest* TSF will accelerate. Further, the new *HPA-Nord* TSF is based on design and operating principles used in the current storage area. Engineering, construction, investigations, and monitoring should continue as a high priority component of the Project.

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