CSA Global
Mining Industry Consultants

NI 43-101 PRE-FEASIBILITY REPORT

Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia

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Disclaimers

Purpose of this document

This Report was prepared exclusively for Avesoro Resources Inc. (“the Client”) by CSA Global (UK) Ltd (“CSA Global”). The quality of information, conclusions, and estimates contained in this Report are consistent with the level of the work carried out by CSA Global to date on the assignment, in accordance with the assignment specification agreed between CSA Global and the Client.

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Results are estimates and subject to change

The interpretations and conclusions reached in this Report are based on current scientific understanding and the best evidence available to the authors at the time of writing. It is the nature of all scientific conclusions that they are founded on an assessment of probabilities and, however high these probabilities might be, they make no claim for absolute certainty.

The ability of any person to achieve forward-looking production and economic targets is dependent on numerous factors that are beyond CSA Global’s control and that CSA Global cannot anticipate. These factors include, but are not limited to, site-specific mining and geological conditions, management and personnel capabilities, availability of funding to properly operate and capitalise the operation, variations in cost elements and market conditions, developing and operating the mine in an efficient manner, unforeseen changes in legislation and new industry developments. Any of these factors may substantially alter the performance of any mining operation.

Certificate of Qualified Person – Andrew Bamber

In connection with the Technical Report entitled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia", with an effective date of 31 January 2019, I, Andrew Bamber do hereby certify that:

1. I am an Associate Mining Engineer of CSA Global (UK) Ltd., Springfield House, Springfield Road, Horsham, West Sussex, RH12 2RG, UK (telephone +44 1403 255 969; email: admin@csaglobal.com).
2. The Technical Report to which this certificate applies is titled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia" and has an effective date of 31 January 2019.
3. I hold a Ph.D. in Mining Engineering and an M.Sc. in Mineral Process Engineering from the University of British Columbia, am a registered Professional Engineer with the Association of Professional Engineers and Geoscientists of British Columbia (APEGCBC, reg. no. 159366) and am a member of the Canadian Institute of Mining, Metallurgy and Petroleum Engineers (CIM). I fulfil the requirements of a Qualified Person as defined in NI 43-101. My experience includes over 25 years in mining and mineral processing projects and operations, including the Randfontein Estates, Hartebeestfontein, and Cerro Corona (SA) Gold Mines, and the Kubi, Elk River, Madsen, Dublin Gulch, Alexis New Britannia, Phoenix, Fairview and Cameron Lake gold projects.
4. I have visited the project that is the subject of this Technical Report, between 10 and 14 December 2018 for a total of five days.
5. I am responsible for the following sections of this Technical Report; Sections 1, 18, 19, 21, 22, 24, 25 and 26.
6. I am independent of the issuer as described in Section 1.5 of NI 43-101.
7. I have not had any prior involvement with the property that is the subject of the Technical Report.
8. I have read NI 43-101 and the parts of the Technical Report I am responsible for, and the parts of the Technical Report that I am responsible for have been prepared in compliance with NI 43-101.
9. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the parts of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 1st day of April 2019.

"signed and sealed"

Dr. Andrew Bamber
Associate Principal Engineer
CSA Global (UK) Ltd

Certificate of Qualified Person – Belinda van Lente

In connection with the Technical Report entitled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia", with an effective date of 31 January 2019, I, Belinda van Lente do hereby certify that:

1. I am a Principal Resource Geologist of CSA Global (UK) Ltd., Springfield House, Springfield Road, Horsham, West Sussex, RH12 2RG, UK (telephone +44 1403 255 969; email: admin@csaglobal.com).
2. The Technical Report to which this certificate applies is titled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia" and has an effective date of 31 January 2019.
3. I hold a MSc degree in Geology from the Rand Afrikaans University, South Africa and a PhD degree in Geology from the University of Stellenbosch, South Africa. I am a registered Professional Natural Scientist (Pr.Sci.Nat., 400119/10) in good standing of the South African Council for Natural Scientific Professions. I am familiar with NI 43-101 and, by reason of education, experience in evaluation of gold deposits, and professional registration; I fulfil the requirements of a "Qualified Person" as defined in National Instrument 43-101 Standards of Disclosure for Mineral Projects (NI 43-101). I have been practicing my profession continuously since 2005 and my experience includes over 13 years in the consulting and production environment.
4. I have visited the projects that are the subject of this Technical Report, between 02 and 06 July 2018 for a total of five days.
5. I am responsible for the following sections of this Technical Report; Sections 2.4.2, 12.2.1 and 14.
6. I am independent of the issuer as described in Section 1.5 of NI 43-101.
7. I have had prior involvement with the property that is the subject of this Technical Report, being technical input in to the update of the New Liberty Mineral Resource, reported in 2018.
8. I have read NI 43-101 and the parts of the Technical Report I am responsible for, and the parts of the Technical Report that I am responsible for have been prepared in compliance with NI 43-101.
9. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the parts of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 1st day of April 2019.

"signed and sealed"

Dr. Belinda van Lente
Principal Resource Geologist
CSA Global (UK) Ltd

Certificate of Qualified Person – Clive Brown

In connection with the Technical Report entitled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia", with an effective date of 31 January 2019, I, Clive Brown do hereby certify that:

1. I am an Associate Mining Engineer to CSA Global (UK) Ltd., Springfield House, Springfield Road, Horsham, West Sussex, RH12 2RG, UK (telephone +44 1403 255 969; email: admin@csaglobal.com).
2. The Technical Report to which this certificate applies is titled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia" and has an effective date of 31 January 2019.
3. I hold a B.Sc.. Eng. (Mining) and am a Fellow of the South African Institute of Mining and Metallurgy (SAIMM) and a registered Professional Engineer (Pr.Eng.) with the Engineering Council of South Africa (ECSA). I fulfil the requirements of a Qualified Person as defined in NI 43-101. My experience includes 25 years in the mining industry in various roles including operations, management, technical services and consulting, most of which has been related to underground gold and base metal mines.
4. I have visited the projects that are the subject of this Technical Report, during 10th to 14th December 2019 for a period of five days.
5. I am responsible for the following sections of this Technical Report; Sections 2.4.4, 15.1.2, 15.1.3, 15.1.4, 15.1.5, 15.2 (Underground Mineral Reserves), and 16.2.
6. I am independent of the issuer as described in Section 1.5 of NI 43-101.
7. I have not had any prior involvement with the property that is the subject of the Technical Report.
8. I have read NI 43-101 and the parts of the Technical Report I am responsible for, and the parts of the Technical Report that I am responsible for have been prepared in compliance with NI 43-101.
9. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the parts of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 1st day of April 2019.

"signed and sealed"

Mr. Clive Brown
Associate Principal Mining Engineer
CSA Global (UK) Ltd

Certificate of Qualified Person – David Muir

In connection with the Technical Report entitled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia", with an effective date of 31 January 2019, I, David Muir do hereby certify that:

1. I am a Principal Data Geologist of CSA Global (UK) Ltd., Springfield House, Springfield Road, Horsham, West Sussex, RH12 2RG, UK (telephone +44 1403 255 969; email: admin@csaglobal.com).
2. The Technical Report to which this certificate applies is titled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia" and has an effective date of 31 January 2019.
3. I hold a BSc (Hons) degree in Geology from the University of Natal, Durban, South Africa and am a Member in good standing of the Australian Institute of Geoscientists (MAIG, Membership Number: 9102). I am familiar with NI 43-101 and, by reason of education, experience in exploration, evaluation and data management, and professional registration; I fulfil the requirements of a Qualified Person as defined in NI 43-101. My experience includes eleven continuous years in the exploration and mining industry.
4. I have visited the New Liberty Gold Mine between 14 and 15 March 2019 for a total of two days.
5. I am responsible for the following sections of this Technical Report; Sections 11 and 12.1.
6. I am independent of the issuer as described in Section 1.5 of NI 43-101.
7. I have had prior involvement with the property that is the subject of this Technical Report, being technical input in to the update of the New Liberty Mineral Resource, reported in 2018.
8. I have read NI 43-101 and the parts of the Technical Report I am responsible for, and the parts of the Technical Report that I am responsible for have been prepared in compliance with NI 43-101.
9. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the parts of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 1st day of April 2019.

"signed and sealed"

Mr. David Muir
Principal Data Geologist
CSA Global (UK) Ltd

Certificate of Qualified Person – Galen White

In connection with the Technical Report entitled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia", with an effective date of 31 January 2019, I, Galen White do hereby certify that:

1. I am a Principal Consultant of CSA Global (UK) Ltd., Springfield House, Springfield Road, Horsham, West Sussex, RH12 2RG, UK (telephone +44 1403 255 969; email: admin@csaglobal.com).
2. The Technical Report to which this certificate applies is titled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia" and has an effective date of 31 January 2019.
3. I hold a B.Sc. in geology from the University of Portsmouth, UK and am a Fellow of the Australasian Institute of Mining and Metallurgy (No 226041) and am a Fellow of the Geological Society of London (No 1003505). I fulfil the requirements of a Qualified Person as defined in NI 43-101. My experience includes 23 years of geological experience in the mining industry, of which 14 years have been spent in consulting.
4. I have not visited the projects that are the subject of this Technical Report
5. I am responsible for the following sections of this Technical Report; Sections 2.1, 2.2, 2.3, 2.4.1, 3, 4, 5, 6, 7, 8, 9, 10, 12.2.2, 20, 23, 27 and 28.
6. I am independent of the issuer as described in Section 1.5 of NI 43-101.
7. I have not had any prior involvement with the property that is the subject of the Technical Report.
8. I have read NI 43-101 and the parts of the Technical Report I am responsible for, and the parts of the Technical Report that I am responsible for have been prepared in compliance with NI 43-101.
9. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the parts of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 1st day of April 2019.

"signed and sealed"

Mr. Galen White
Principal Consultant
CSA Global (UK) Ltd

Certificate of Qualified Person – Gary Patrick

In connection with the Technical Report entitled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia", with an effective date of 31 January 2019, I, Gary Patrick do hereby certify that:

1. I am an Associate Metallurgist to CSA Global (UK) Ltd., Springfield House, Springfield Road, Horsham, West Sussex, RH12 2RG, UK (telephone +44 1403 255 969; email: admin@csaglobal.com).
2. The Technical Report to which this certificate applies is titled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia" and has an effective date of 31 January 2019.
3. I hold a BSc. (Chemistry / Extractive Metallurgy) and am a Chartered Professional Member (MAusIMM(CP), No 108090) of the Australasian Institute of Mining and Metallurgy. I fulfil the requirements of a Qualified Person as defined in NI 43-101 by having Chartered Professional (Metallurgy) qualifications. My experience includes 25 years in operations, metallurgical testwork supervision, flowsheet development, and study work.
4. I have not visited the projects that are the subject of this Technical Report.
5. I am responsible for the following sections of this Technical Report; Sections 13 and 17.
6. I am independent of the issuer as described in Section 1.5 of NI 43-101.
7. I have not had any prior involvement with the property that is the subject of the Technical Report.
8. I have read NI 43-101 and the parts of the Technical Report I am responsible for, and the parts of the Technical Report that I am responsible for have been prepared in compliance with NI 43-101.
9. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the parts of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 1st day of April 2019.

"signed and sealed"

Mr. Gary Patrick
Associate Principal Metallurgist
CSA Global (UK) Ltd

Certificate of Qualified Person – Matthew Randall

In connection with the Technical Report entitled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia", with an effective date of 31 January 2019, I, Matthew Randall do hereby certify that:

1. I am an Associate Mining Engineer of CSA Global (UK) Ltd., Springfield House, Springfield Road, Horsham, West Sussex, RH12 2RG, UK (telephone +44 1403 255 969; email: admin@csaglobal.com).
2. The Technical Report to which this certificate applies is titled "NI 43-101, Pre-Feasibility Report, Mineral Resource and Mineral Reserve Update for the New Liberty Gold Mine, Liberia" and has an effective date of 31 January 2019.
3. I hold a BSc (Hons), PhD and CEng and am a Professional Member of Institute of Materials, Minerals and Mining . I fulfil the requirements of a Qualified Person as defined in NI 43-101. My experience includes 35+ years in mining.
4. I have visited the projects that are the subject of this Technical Report, between 10 – 14 December 2018 for a total of five days
5. I am responsible for the following sections of this Technical Report; Sections 2.4.3, 12.2.2, 15.1.1, 15.2 (Open Pit Reserves), 16.1 and 16.3.
6. I am independent of the issuer as described in Section 1.5 of NI 43-101.
7. I have not had any prior involvement with the property that is the subject of the Technical Report.
8. I have read NI 43-101 and the parts of the Technical Report I am responsible for, and the parts of the Technical Report that I am responsible for have been prepared in compliance with NI 43-101.
9. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the parts of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 1st day of April 2019.

"signed and sealed"

Dr. Matthew Randall
Associate Principal Mining Engineer
CSA Global (UK) Ltd

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1 Executive Summary

1.1 Overview

A pre-feasibility study for the Combined Project of the New Liberty Gold Mine and the Ndablama deposit in Liberia has been completed between November 2018 and March 2019. The project contemplates the transition of mining operations at New Liberty from the current open pit to underground, plus the development of a new satellite open pit at Ndablama. The study incorporated Mineral Resource modelling and reporting, mine design and scheduling work, infrastructure design, process testwork, capital cost estimation, operating cost estimation, financial modelling and reporting. Tailings facility design and Environmental studies were the responsibility of the Client. This report documents the outcomes of the pre-feasibility and recommendations for next steps.

1.2 Sources of Information

Various technical reports have been used to support the findings documented here. These are listed in Section 3 (Reliance on Other Experts) and Section 27 (References).

Licence and tenure documents, exploration and resource data, mining data and information, mining costs and financial information were provided via a dataroom and reviewed. Note that no legal due diligence has been undertaken by CSA Global Pty Ltd (CSA Global) to independently verify the status of the Project licences.

Dr Belinda van Lente (Qualified Person for Mineral Resources) and Dr Matthew Randall (Qualified Person for Mineral Reserves) visited the New Liberty and Ndablama deposits during the period 2 July 2018 to 6 July 2018, which allowed for first-hand observations, discussions with site technical staff and data collection activities to be completed. Dr. Matthew Randall, Mr. Clive Brown (Qualified Person for Mineral Reserves) and Dr. Andrew Bamber (Qualified Person) visited the New Liberty Property during the period 10 December 2018 to 14 December 2018 which allowed for first hand observations, discussions with site technical staff, data collection and preliminary design activities to be completed.

Additional information relied upon during the course of the technical work is contained in Section 27 (References) of this PFS Report.

1.3 Project Location, Description and Geology

The Bea Mountain Mining Corporation (BMMC) Mineral Development Agreement (Bea-MDA) property is situated 90 km northwest of the capital, Monrovia, in Grande Cape Mount County, in the north-western portion of the Republic of Liberia. The New Liberty Mine and Ndablama deposit are situated within the Bea-MDA property.

The Bea-MDA property originally covered an area of 478 km^2 with boundaries described as cadastral and cartographic maps at the Ministry of Lands, Mines and Energy of Republic of Liberia. The property, which is covered by the licence, has been reduced from a prior exploration lease which covered a total of 1,000 km^2.

This report relates to both the Northern Block and Southern Block of the Bea-MDA property. The Northern Block boundary with the adjacent Southern Block coincides with Silver Hills Mountains, trends east-west and forms a natural barrier between the blocks.

The mineral exploration and exploitation rights defined by the Bea-MDA originally became effective on 22 April 1998. In April 1998, in anticipation of a new Mining Code, Bea replaced the existing licence and assignment, and entered into a specially-negotiated Exploration Agreement. Upon ratification of the new Mining Code in 2000, BMMC, in keeping with the new law, reduced the size (acreage) of the licence to

457 km^2 and entered into the present governing Bea-MDA. The Bea-MDA came into effect on 28 November 2001 and has an initial term of 25 years, which may be extended for successive 25-year terms.

Due to the civil unrest in the country, the Ministry of Lands, Mines, and Energy suspended the exploration period as from July 2002 until 4 January 2005.

The Bea-MDA provides BMMC the right to free access to public land and will assist BMMC in cases where access to private lands is necessary. BMMC was granted the Licence on the 29 July 2009. The Licence for the Production Area shall remain valid and effective for the unexpired portion of the Bea-MDA and any extensions thereof. The Licence allows BMMC to commercially exploit minerals found in the Production Area and all other activities incidental thereto, including the design, construction, installation, fabrication, operation, maintenance and repair of infrastructure, facilities and equipment and the mining, excavation, recovery, handling, beneficiation, processing, milling, stockpiling, transportation, export and sale of minerals.

BMMC was granted all the normal operating licences and permits for the mining operation, including licences associated with explosive storage and use, abstraction and discharge of water and construction.

All resource and exploration data are projected in WGS1984, Universal Mercator Project (UTM) Zone 29 North.

The New Liberty Project is accessible by vehicle from Monrovia, with approximately 80 km of paved road to the town of Danielstown and a further laterite section of 20 km to the Project. The Ndablama deposit is also accessible from Monrovia by vehicle, with approximately 90 km of paved road to the town of Tubmanburg with a further 40 km of laterite road, which forks after Lofa Bridge provides access to the project.

Within the Bea-MDA property are both primary and secondary forest, as well as some grassland and farmland. In the Southern blocks around the New Liberty project, the topography ranges from around 50 m above mean sea level (amsl) to a maximum of 600 m amsl., with the majority of the licence area being composed of gently undulating plains at less than 200 m amsl., with two prominent east-west ridges of resistant rock units (the Bea Mountain and Tokani ranges). Vegetation consists of tropical trees which attain heights of 30–40 m above the forest floor, with thick undergrowth common. At Ndablama, the surrounding area is dominated by low ridges. Elevations range between 150 m amsl and 350 m amsl. The project itself is located between these ridges overlooking lower terrain to the east. Vegetation is primarily forest, with thick canopy and little undergrowth. Rock outcrops are found mostly in the valleys which run down the ridges caused by water channels, with boulders on some of the valley and hillsides.

The Bea-MDA property contains a sequence of highly-deformed discrete lenses of ultramafics and amphibolites, which represent relict Archean greenstone belts, surrounded by granites and granodiorites. These rocks have been subjected to lower amphibolite grade metamorphism resulting in gneissose or schistose textures, depending on the rock competency.

There are several known areas of gold mineralisation within the Bea-MDA property, located in major imbricate shear zones and possibly associated rotational fold hinges close to greenstone belt contacts, forming coevally with calc-alkaline granitoid intrusions. The shears and associated splays acted as structural channels for hydrothermal solutions, which deposited gold in suitable structures or chemical traps, typical of Upper Archean to Lower Proterozoic styles of metallogeny within greenstone belts.

The east of the Bea-MDA Northern Block is underlain by a granite batholith, bordered on both the north-western and south-eastern sides by two prominent shear zones, respectively the Yambesei and the Lofa. The area immediately west of the batholith represents a pressure shadow zone, along which Ndablama is located. The Ndablama pressure shadow zone and the Yambesei corridor consist of sequences of deformed mafic and ultramafic units which typically host gold mineralisation.

1.4 Project History and Exploration

Gold mineralisation in the area now covered by the Bea-MDA, including New Liberty, Ndablama, Gondoja and Weaju has been known about since 1949 (Thayer *et al.,* 1974), however no systematic work is known to have been undertaken. It is reported (ACA Howe, 2000) that, in the late 1980s, a company, Atlantic Mining, installed a small wash plant, mine buildings and accommodation, and commenced mining for gold from adits and hand-excavated shafts around Weaju. A large area of alluvial ground and swamp close to the mine site was cleared to provide alternative ground for artisanal miners. Larger scale production was due to commence in 1990, but the outbreak of civil hostilities led to the abandonment of the operations and the excavations were filled in. No results are available from referenced drilling.

The Project history can be summarised as follows:

- In 1995, KAFCO received the license for the Mineral Development Agreement area from the then government of Liberia.
- August 1995: KAFCO received the government's approval to assign its rights to the licence to Global Limbo Liberia Ltd (Golden Limbo).
- 18 November 1996: Golden Limbo assigned its new rights to the licence to BMMC, which was subsequently approved by the government on 22 November 1996.
- 22 April 1998: Bea-MDA area is defined by BMMC. In anticipation of a new Mining Code, Bea replaced the existing licence and assignment, and entered into a specially-negotiated Exploration Agreement.
- 2000: Mineral Resource estimate prepared for the New Liberty Project (ACA Howe International Ltd).
- 28 November 2001: Bea-MDA reduction to 457 km^2 came into effect, with an initial term of 25 years, which may be extended for successive 25-year terms.
- July 2002 until 4 January 2005: Due to the civil unrest in the country, the Ministry of Lands, Mines, and Energy suspended the exploration period.
- 2006: Mineral Resource estimate prepared for the New Liberty Project (Lower Quartile Solutions (Pty) Ltd).
- 29 July 2009: BMMC granted a Class A Mining Licence.
- 1 October 2012: DFS completed by Aureus for the New Liberty Project. Mineral Resource and Reserve estimates prepared for New Liberty prepared (AMC).
- 20 May 2013: Mineral Reserve estimate for New Liberty updated (AMC).
- 11 November 2013: Mineral Resource estimate prepared for the Ndablama deposit (AMC).
- 1 December 2014: Mineral Resource estimate prepared for the Ndablama deposit (AMC).
- 19 December 2013: Restated and Amended Mineral Development Agreement.
- 31 July 2017: Mineral Resource Statement prepared for the New Liberty Project (SRK).

1.5 Drilling

Drilling at the New Liberty Project has been conducted periodically between 1999 and 2018 and the total number of diamond drillholes in the database is 607 (121,603 m). Of these, 64 diamond drillholes were completed in 2018 (for 23,753 m). Table 1-1 summarises the drilling (including channels) in the New Liberty database.

Table 1-1: New Liberty – drilling and channel summary (by type) as at November 2018

Hole type	Number of holes drilled	Total metres drilled
DD	607	121,603
RC	1,085	41,997
CH	806	28,856

To date, five phases of exploration drilling have been completed at Ndablama. These are shown in Table 1-2. The fifth drill program carried out by Avesoro in 2018, focussed on testing down-dip mineralisation to the west of the main deposit. Drilling is predominantly oriented to the east, and typically inclined at 55° to 60°.

Table 1-2: Ndablama – drilling summary (by campaign and type) as at November 2018

Campaign	Hole type	Period	Number of holes drilled	Total metres drilled
1	DD	2010	15	2,665
2	DD	Q4 2011 to Q2 2012	21	3,317
3	DD	Q1 2013	18	2,331
4	DD	Q4 2013 to Q2 2014	61	13,020
	RC	Q2 2014	39	5,827
5	DD	2018	117	27,493
Total			**271**	**54,653**

At New Liberty, all drill collars were re-surveyed in August 2010 by DGPS, following a review in 2009 of the existing collar survey coordinates that identified a number of uncertainties. Additional resurveying and validation of accessible pre-2011 collars at New Liberty was conducted in 2011 and all additional collars associated with the 2011 campaign were surveyed with Leica DGPS. For RC drilling at New Liberty, collars were surveyed using a Trimble differential GPS, with downhole surveys typically completed for holes greater than 40 m in length at 10 m increments.

Ndablama collar coordinates were originally surveyed with Garmin handheld GPS, and subsequently picked up by a Sokia Total Station. The points were verified with the contour and DTM data obtained from the LIDAR survey carried out in early 2013.

Core recovery, rock quality designation (RQD) and solid core recovery (SCR) are logged with a mean recovery within mineralised fresh material of 99% at both New Liberty and Ndablama.

1.6 Sample Preparation, Analysis and Security

1.6.1 New Liberty

Prior to October 2015, samples were sent to external laboratories for analysis, usually by fire assay. From October 2015, grade control samples were prepared and analysed at the ALS on-site laboratory by fire assay with an AAS finish. Exploration samples were prepared at ALS Monrovia, Liberia and forwarded from there to ALS Johannesburg, South Africa for Au analysis.

QA/QC procedures have evolved with time, from no QC samples in 1999 and 2000 to a comprehensive program in 2018. However, the procedures do not appear to always have been diligently followed and there are numerous instances of apparent misidentification of CRM and blanks which indicate issues with data management

Sample security appears adequate and sample preparation and analytical techniques for both the pre-2013 drilling (prior to Avesoro’s ownership) and the post-2013 drilling are mostly appropriate with no fatal flaws noted.

1.6.2 Ndablama

Samples were sent to ALS Monrovia, Liberia for preparation and forwarded from there to ALS Johannesburg, South Africa for Au analysis by fire assay and screen fire assay. Sample security appears adequate and sample preparation and analytical techniques are appropriate with Fire Assay (FA) and Screen Fire Assay (SFA) being the industry best practice techniques for gold analysis.

Results of QC samples from drillholes NDD116 onwards were reviewed where numerous CRM identification issues were noted. However, once these were corrected, CSA Global concluded that no significant cross contamination was apparent, and that assay accuracy was acceptable with no significant bias. Assay precision was poorer than expected, indicating the coarse nature of the mineralisation.

QA/QC procedures are acceptable and when followed should provide confidence that there is no significant cross contamination and that acceptable assay accuracy (lack of bias) and assay precision (repeatability of results) have been established.

1.7 Data Verification

CSA Global loaded the New Liberty and Ndablama Microsoft Excel exploration and drill data, respectively, into a Structured Query Language (SQL) relational database, which is an industry standard for exploration project databases. Minor validation issues were noted and resolved during the above process and validated databases were provided for downstream work.

Data verification included spot checks on 13 drillhole collars (seven at New Liberty and six at Ndablama) during a site visit, verification of core, review of core photos for several drillholes and review of core recovery. These checks support the use of the data for Mineral Resource and Mineral Reserve work.

1.8 Mineral Resources

Mineral Resources for New Liberty and Ndablama were estimated during December 2018. The current Mineral Resource update was focused on the re-interpretation, extrapolation and re-estimation of the 2017 New Liberty MRE, and the 2014 Ndablama MRE.

CSA Global considers that data collection techniques are adequate and suitable for use in the preparation of an updated MRE to be reported in accordance with CIM (2014) guidelines. QC data support the integrity of the analytical data which have been utilised.

The MREs compiled by CSA Global have been classified and are reported as Measured Mineral Resources, Indicated Mineral Resources and Inferred Mineral Resources under the guidelines of the CIM Standards on Mineral Resources and Reserves, Definitions and Guidelines prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council (2014), and procedures for classifying the reported Mineral Resources were undertaken within the context of the Canadian Securities Administrators NI 43-101.

The current Mineral Resource inventory is shown in Table 1-3 as at 31 December 2018.

Table 1-3: New Liberty and Ndablama Mineral Resource statement as at 31 December 2018

Mineral Resource estimate for the New Liberty and Ndablama Gold Projects, Liberia, as at 31 December 2018												
Deposit	**Measured**			**Indicated**			**Measured and Indicated**			**Inferred**		
	Tonnes (Mt)	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**
New Liberty OP	0.19	1.82	10.9	4.48	3.49	503.0	4.67	3.42	513.9	0.0	1.7	2
New Liberty UG	0.18	2.85	16.4	5.90	3.32	630.0	6.08	3.30	646.3	2.7	3.0	253
Ndablama OP				9.72	1.88	588.0	9.72	1.88	588.0	0.3	1.6	16
Total	**0.37**	**2.32**	**27.3**	**20.10**	**2.66**	**1,720.9**	**20.47**	**2.66**	**1,748.2**	**3.0**	**2.8**	**271**

Notes:

- *Reporting cut-off for New Liberty is 0.80 g/t Au for Open Pit (OP), reported above a surface based on the shell from a US$1,300 gold price pit optimisation run to support reasonable prospects for eventual economic extraction. The New Liberty Underground Mining (UG) is reported below the US$1,300 shell, within stope volumes based on a US$1,500 gold price optimisation at 1.90 g/t cut-off (reported at no cut-off), run to support assumptions relating to reasonable prospects of eventual economic extraction.*

- *Reporting cut-off for Ndablama Open Pit (OP) is 0.85 g/t Au, reported above a surface based on the NPVS shell from a US$1,500 gold price pit optimisation run to support assumptions relating to reasonable prospects of eventual economic extraction.*
- *The New Liberty MRE has been depleted for mining up to 31 December 2018. The effective date of the New Liberty Mineral Resource is 31 December 2018.*
- *The Ndablama MRE has not been depleted, since there has been no previous mining. The effective date of the Ndablama Mineral Resource is 24 November 2018.*
- *Figures have been rounded to the appropriate level of precision for the reporting of Mineral Resources.*
- *Due to rounding, some columns or rows may not compute exactly as shown.*
- *The Mineral Resources are stated as in situ dry tonnes. All figures are in metric tonnes.*
- *The Mineral Resource has been classified under the guidelines of the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Standards on Mineral Resources and Reserves, Definitions and Guidelines prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council, and procedures for classifying the reported Mineral Resources were undertaken within the context of the Canadian Securities Administrators National Instrument 43-101 (NI 43-101).*
- *Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability. The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, title, taxation, socio-political, marketing, or other relevant issues.*
- *Mineral Resources have been reported inclusive of Mineral Reserves, where applicable.*

1.8.1 New Liberty

A three-dimensional (3D) block model representing the mineralisation has been created for the New Liberty deposit by CSA Global, in collaboration with Avesoro geologists, using Leapfrog™ software. High-quality RC and DD samples were used to estimate grades into blocks using ordinary kriging (OK). The block model was validated visually and statistically.

The total drilling available within the area of the New Liberty deposit for the geological model and MRE update was 561 DD holes for a total of 98,632 m and 53,811 assays; and 1,069 RC holes, for a total of 41,417 m and 41,417 assays. The RC holes constitute the grade control drilling and were included to interpret mineralisation wireframes in addition to being used in grade estimation. Channel samples were used for trend visualisation during geological modelling. However, they were not used in estimation of the Mineral Resource, since there is potential bias in sample data, e.g. the high-grade bias in channel samples relative to RC and DD samples.

A total of 28 mineralised domains were characterised by creating mineable intercepts, based on composites of 0.5 g/t Au with a minimum true thickness of 3 m. Within these 28 domains, a total of 15,244 samples were flagged and composited downhole to 1 m lengths. The resultant 15,516 composite samples were used in the estimate.

In total, 13,884 bulk density (BD) measurements from within the New Liberty MRE are were made available for review by CSA Global. These data were flagged by mineralisation domain, geology unit and the modelled weathering profile (bottom of complete oxidation) and reviewed within each of these domains. There is no significant difference in BD between the mineralisation and waste domains. However, there is a difference in BD between oxidised and fresh material, and between the Silicified Metamorphic Ultrabasic Suite (SMUS) and the surrounding geology. As such, an average BD was assigned per weathering profile and geological unit, as 1.58 t/m^3 for SMUS oxide, 1.40 t/m^3 for non-SMUS oxide, 2.95 t/m^3 for SMUS fresh, and 2.83 t/m^3 for non-SMUS fresh.

Following contact analysis, a decision was made to use hard boundaries between mineralisation domains and soft boundaries across weathering zones for all geostatistical analysis and estimation. Histograms and probability plots were reviewed for Au g/t within each individual estimation domain to determine the top-cut. Variograms were modelled using normal score transform for the largest domains in each area (Marvoe, Kinjor and Larjor) of the deposit for Au using composited, top-cut data. The variogram model was back transformed prior to use in kriging. Variograms from the larger domains were applied to smaller, adjacent domains with similar grade trends.

Grade was estimated into parent blocks using OK, controlled by dynamic anisotropy. Grade estimates were validated against drill data. There is good correlation between the input composites and output model for the estimated Au grade. Generally, the model grade trends follow the pattern of the drill samples grades, with acceptable levels of smoothing of the higher and lower grades.

The MRE at New Liberty satisfies the requirements for Measured, Indicated and Inferred Mineral Resource categories as defined in the NI 43-101 Canadian National Instrument for the reporting of Mineral Resources and Reserves.

The MRE indicates reasonable prospects for economic extraction, where Open Pit (OP) material is reported at a cut-off grade of 0.80 g/t Au above a resource shell produced in NPV Scheduler (NPVS) using a US$1,300 Au prices and basic assumptions regarding costs, and Underground Mining (UG) is reported below the US$1,300 shell, within stope volumes based on a US$1,500 gold price optimisation at 1.90 g/t cut-off (reported at no cut-off), run to support assumptions relating to reasonable prospects of eventual economic extraction.

The OP MRE for New Liberty reports 4.67 million tonnes (Mt) at 3.42 g/t for 513,900 ounces of Au of Measured and Indicated Mineral Resources, and 30 kt at 1.7 g/t Au for 2,000 ounces of Au of Inferred Mineral Resource.

The UG MRE for New Liberty reports 6.08 Mt at 3.30 g/t for 646,300 ounces of Au of Measured and Indicated Mineral Resources, and 2.7 Mt at 3.0 g/t Au for 253,000 ounces of Au of Inferred Mineral Resource.

1.8.2 Ndablama

A 3D block model representing the mineralisation has been created by CSA Global, in collaboration with Avesoro geologists, using Datamine Studio RM™ software.

A campaign of infill and step-out drilling during 2018 demonstrated that even though the predicted volume and mineralisation continuity, as modelled at a 0.1 g/t Au cut-off and guided by the main shear zone, remains reasonable, there is a very high variability in grade within the main mineralised domain, which adds risk to the eventual metal predicted by the estimate.

The lower grade variability at New Liberty is amenable to OK, whereas the high-grade variability at Ndablama would cause overestimation and smoothing of higher grades and a different estimation approach needed to be considered.

High-quality RC and DD samples were used to estimate grades into blocks using the top-cut model with indicator residual (TC estimate). Following the generation of the Ndablama TC estimate, recoverable resources were estimated based on a selective mining unit (SMU) of 5 m x 5 m x 5 m, completed using Uniform Conditioning (UC). The UC estimate was further post-processed to produce single cell grades for each SMU, based on Localised Uniform Conditioning (LUC) where the grade tonnage of the panel is reconstituted in SMU sized blocks. The block model was validated visually and statistically.

The total drilling database as used within the Ndablama MRE area for the MRE update was 225 DD holes for a total of 47,610 m and 25,687 assays; and 33 RC holes, for a total of 4,968 m and 2,900 assays.

Three mineralised domains were characterised by creating mineable intercepts, based on composites of 0.1 g/t Au with a minimum true thickness of 3 m. A total of 10,761 samples were flagged within these domains and composited downhole to 1 m lengths. The resultant 10,713 composite samples were used in the estimate.

A total of 8,148 BD measurements within the MRE area, were coded and reviewed by mineralisation domain and oxidation. There is no significant difference in BD between the mineralisation and waste domains.

However, there is a difference in BD between oxidised and fresh material and as such, average BD was assigned per weathering profile as 1.34 t/m^3 for oxide, 1.99 t/m^3 for transitional and 2.94 t/m^3 for fresh.

Following contact analysis, a decision was made to use hard boundaries between mineralisation domains and soft boundaries across weathering zones for all geostatistical analysis and estimation.

Due to the estimation methodology used (TC estimation), cross-variograms were modelled for MIN(AU,2.5) and IND(AU,2.5) for each of the three domains using 1 m top-cut composites. MIN(AU,2.5) captures the background part of the distribution and is equal to Au if Au is less than 2.5 g/t, and to 2.5 if Au is greater than 2.5 g/t; IND(AU,2.5), the indicator function at 2.5, captures the geometry of the tail of the distribution, and is equal to 1 if Au is greater than 2.5 g/t, 0 otherwise.

Grade was estimated into parent blocks of 25 m x 25 m x 5 m (X Y x Z) using the TC model method, controlled by dynamic anisotropy. This was followed by UC and LUC. Grade estimates were validated against drill data. There is good correlation between the input composites and output model for the estimated Au grade. Generally, the model grade trends follow the pattern of the drill samples grades, with acceptable levels of smoothing of the higher and lower grades.

Due to the high-grade variability within the main mineralisation domain at Ndablama, Conditional Simulation (CS) testwork was completed to assist in assessing grade uncertainty and risk attached to the in-situ resource. As part of this, the CS realisations were used to build a Risk Index to characterise the level of local confidence that could be attached to the local estimates. Analysis of the distribution of the Risk Index showed that the grade estimates are marked with a substantial relative uncertainty and that locally the fluctuations between estimated and realised grades can be very important.

CSA Global notes that the Risk Index is not an absolute measure, but a relative measure of the risk of recovery of the expected value. The Risk Index, in combination with estimation statistics (slope of regression, kriging variance, number of samples used to estimate, search volume), drillholes spacing, data quality and QA/QC, potential for eventual economic extraction, volume and mineralisation continuity (as modelled at a 0.1 g/t Au cut-off and guided by the main shear zone), was used to inform classification decisions made.

The Indicated Mineral Resources for Ndablama were classified taking all the above into account, however, CSA Global stresses that the outcome of the Risk Analysis highlights the high-grade variability nature of the deposit and that selective mining at 5 m x 5 m x 5 m, at a selected cut-off, does carry a high measure of risk.

The Ndablama MRE satisfies the requirements for Indicated and Inferred Mineral Resource categories as defined in the NI 43-101 Canadian National Instrument for the reporting of Mineral Resources and Reserves.

The MRE indicates reasonable prospects for economic extraction, supported by a resource shell produced in NPV Scheduler (NPVS) using a US$1,500 Au price and basic assumptions regarding costs.

The MRE for Ndablama reports 9.72 Mt at 1.88 g/t for 588,000 ounces of Au of Indicated Mineral Resources and 0.3 Mt at 1.6 g/t Au for 16,000 ounces of Au of Inferred Mineral Resources. Mineral Resources are reported at a cut-off grade of 0.85 g/t Au.

1.9 Mineral Reserves

The Mineral Reserves for the New Liberty and Ndablama deposit have been reported using the CIM Code. An optimisation process was used to define the optimal pit limits, based on the parameters described in Section 16.1.1 and 16.3.1. The optimised pit limit was then used as a guide to produce an engineered pit design that incorporates ramps and other practical mining constraints.

The pit design was then evaluated against the block model and the appropriate modifying factors applied to determine the Mineral Reserve.

Pit slopes for New Liberty are 38° for weathered material and 42–48° for fresh material. Pit slopes for Ndablama vary from 43° to 55° depending on orientation according to geotechnical recommendations for the lithology. Metal prices assumptions are for $1,300/oz long term gold price.

Open pit operating costs are $1.71/t material moved (ore and waste) for the pits. A transport cost of $5.95 for the 49 km haul from Ndablama to New Liberty has been estimated. Milling costs for both are per current metrics for the operation $20.38/t, with a G&A applied to all tonnes processed at New Liberty of $7.23/t.

Combined Mineral Reserves for the Project are stated in Table 1-4.

Table 1-4: Mineral Reserve statement – New Liberty Gold Mine and Ndablama Deposit, Liberia

Mineral Reserves estimated for the New Liberty "Combined" Project, Liberia, as at 31 December 2018										
Deposit	Cut-off grade (g/t)	Proven			Probable			Total Ore Reserve		
		Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)
New Liberty Open Pit	0.80	0.216	1.65	11	4.701	3.19	482	4.917	3.12	494
New Liberty Underground	2.00	0.084	3.36	9	4.575	3.07	452	4.659	3.08	461
Ndablama Open Pit	1.00	0.00	0.00	0.0	7.282	1.71	400	7.282	1.71	400
Total (excl. Stocks)		**0.300**	**2.13**	**21**	**16.559**	**2.51**	**1,334**	**16.859**	**2.50**	**1,355**
NL ROM Stockpiles (LG, MG, HG)					0.210	1.47	10	0.210	1.47	10
Total (incl. Stocks)		**0.300**	**2.13**	**21**	**16.769**	**2.49**	**1,344**	**17.069**	**2.49**	**1,365**

Notes:

- *The Mineral Reserves have been depleted for mining up to 31 December 2018 and stated as of the same date.*
- *Figures have been rounded to the appropriate level of precision for reporting.*
- *Due to rounding, some columns or rows may not compute exactly as shown.*
- *The Mineral Reserves are stated as in-situ dry metric tonnes.*
- *The Mineral Reserves were prepared under the guidelines of the CIM, for reporting under NI 43-101.*
- *The Ore Reserve is reported at a US$1,300/oz gold price.*
- *Modifying factors applied:*
  - *New Liberty Open Pit: mining recovery of 95% and waste dilution of 10% at 0 g/t Au.*
  - *New Liberty Underground: pillar loss 17%, ore loss 4%, waste dilution 9%*
  - *Ndablama Open Pit: mining recovery of 95% and waste dilution of 5% at 0 g/t Au.*
- *Proven Mineral Reserves were derived from Measured Mineral Resources and Probable Mineral Reserves from Indicated Mineral Resources.*
- *There are no known legal, political, environmental, or other risks that could materially affect the potential Mineral Reserves.*

1.10 Mining Methods

Mining activity for the combined project will include open pit mining of the New Liberty deposit until the breakeven cut-off for underground mining is reached, a transition to underground mining by portal and ramp access followed by mining of the residual reserves between the $1,300 pit shell (pit 33) and the $1,500 pit shell by long hole open stoping (LHOS) methods, with open pit mining of the reserves at the Ndablama deposit and direct shipping of Ndablama ore to the New Liberty mill later in the life of the project. This section describes mining methods at both deposits.

1.10.1 Pit Design and Inventory

1.10.1.1 New Liberty

There is an existing open pit mine already in operation at New Liberty. Mining has already ceased at the Larjor pit, however current mining plans include operation of the Kinjor and Marvoe pits until 2027 ('Pit 46'). The Project under consideration involves the re-optimisation of the existing pit operation from 2019 onwards in the context of proposed underground operations and the curtailment of open pit operations at the break-even between open pit and underground mining.

The detailed mine design for New Liberty "Combined" was based on the selected pit limit (Pit 33) from the optimisation work and utilised the existing interim pit stages (Stages 1, 2 and 3) that are currently being mined. An additional pit stage (Stage 4) was added to smooth out the waste stripping over the remaining life of the open pit. Initial stages are as at Kinjor and Marvoe presently. Ultimately, mining will be continued until the present planned Pit 33 (Figure 1-1).

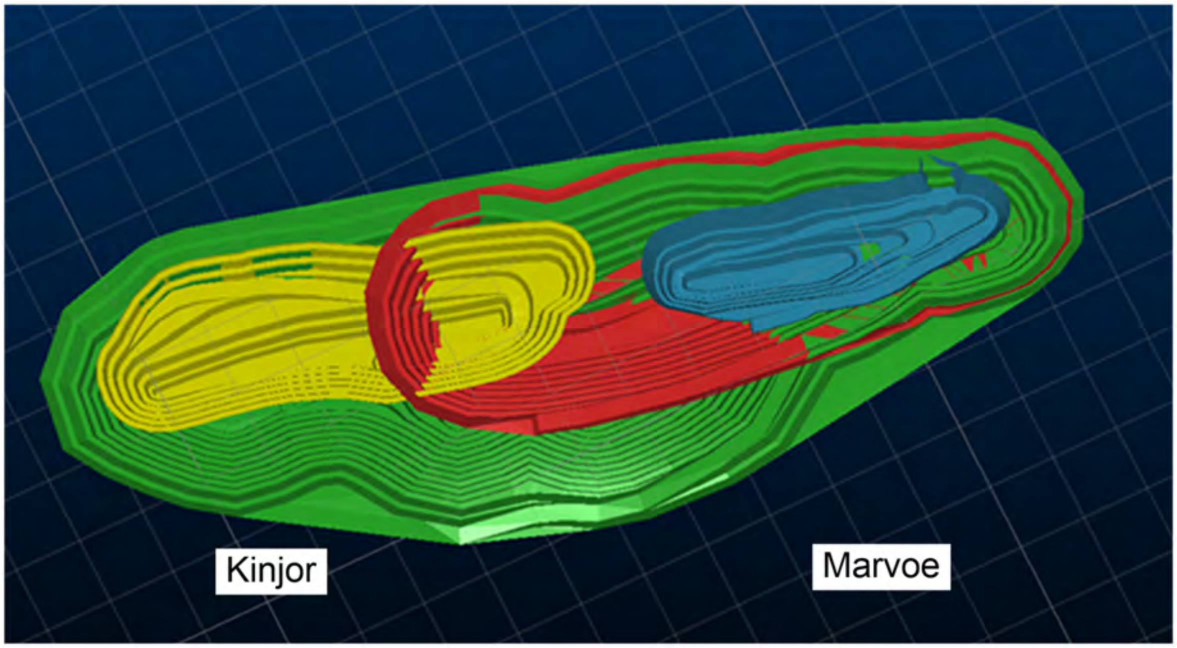


Figure 1-1: Expansion Stage 3 (Pit 33)

To determine this end point it was assessed that at some point it will become more economic to transition to underground mining than continue to expand the open pit. This was studied by looking at the pit increments between Pit 33 and Pit 46. With an assumed mining cost of US$1.9/t, and an underground mining cost of US$45/t, it can be shown that it is more economic to transition to underground mining after Pit 33 than expand the open pit to its limit at Pit 46. Additionally, an overriding factor is the practicality of increasing the mining rate for open pit mining, which is highly restricted by the size of the pit (long, narrow and deep), the resultant stripping ratio which becomes excessive at 20:1, and the acceptable limits on vertical sinking rate, which are exceeded beyond Pit 33. It is this strategy therefore that has been adopted in the PFS.

Reserves for the New Liberty pit by stage design are shown in Table 1-5.

Table 1-5: Reserves for New Liberty pit by stage design

Pit name	Cut-off (g/t Au)	Rock (tonnes)	Waste (tonnes)	Ore Reserve			Marginal Stockpile		
				Tonnes	Ounces	g/t Au	Tonnes	Ounces	g/t Au
New Liberty OP									
Stage 1	0.80	4,925,205	4,463,763	430,335	46,068	3.33	31,107	0.62	0.58
Stage 2	0.80	2,741,529	2,321,476	369,273	26,309	2.22	50,780	1,013	0.62
Stage 3	0.80	26,921,455	25,286,091	1,469,529	130,526	2.76	165,866	3,250	0.61
Stage 4	0.80	21,611,941	20,666,091	849,056	80,304	2.94	96,794	1,894	0.61
Stage 5	0.80	38,763,528	36,854,673	1,799,296	210,636	3.64	109,559	2,143	0.61
Total		**94,963,658**	**89,592,062**	**4,917,490**	**493,844**	**3.12**	**454,106**	**8,300**	**0.61**

1.10.1.2 Ndablama

A pit optimisation for the Ndablama deposit was run using Datamine's NPV Scheduler (NPVS) software. This uses the standard Lerch Grossman (LG) algorithm. The starting surface for pit optimisation was the original surface topography as no mining has taken place in the pit area as yet. The only mining active at this time is the artisanal alluvial workings to the south of the deposit and they do not impact the study. The pit optimisation for Ndablama was run in NPVS with the Price Factor ranging from 2% to 120%. This generates a series of incremental pit shells that simulate a pseudo optimum mining sequence that will generate pit shells in order of maximum cash flow. A total of 60 pit shells were generated using a base price of US$1,300/oz.

A total of four pit stages were designed based on the optimised pit shells generated by NPV Scheduler. Mining methods are by conventional truck-shovel fleet operated by a mining contractor. Each pit stage was designed to have at least 1 Mt of ore and the initial stages target the blocks with the highest value. An expansion (Stage 5) was considered that would take the pit design to the pit final limit (Price Factor of 100%). However, this resulted in a stripping ratio for the increment of 15:1. With an average grade of 1.7 g/t this expansion would be marginally economic when the time lag between the cost of the waste stripping and the revenue from the ore is accounted for. A decision was therefore made to limit the pit designs to the smaller pit and consider this upside expansion potential once in production and there is a better understanding of the costs and the modifying factors for ore loss and waste dilution.

Reserves for Ndablama are laid out in Table 1-6.

Table 1-6: Mineral Reserves by stage at Ndablama Deposit

Pit name	Cut-off (g/t Au)	Rock (tonnes)	Waste (tonnes)	Ore Reserve			Marginal Stockpile		
				Tonnes	Ounces	g/t Au	Tonnes	Ounces	g/t Au
Ndablama									
Stage 1	1.00	4,718,723	2,962,565	1,011,287	51,368	1.58	744,872	16,675	0.70
Stage 2	1.00	18,178,061	14,896,408	1,947,264	105,248	1.68	1,334,389	30,215	0.70
Stage 3	1.00	17,966,375	14,787,517	2,074,477	116,148	1.74	1,104,382	24,855	0.70
Stage 4	1.00	21,433,507	18,106,947	2,249,298	127,370	1.76	1,077,262	24,496	0.71
Total		**62,296,667**	**50,753,437**	**7,282,325**	**400,135**	**1.71**	**4,260,905**	**96,241**	**0.69**

1.10.2 Underground Design and Inventory

A transition to underground mining is considered strategic for the operation in order to overcome limitations associated with the deposit geometry and dip in accessing deeper reserves. The transition to underground mining at New Liberty was determined by assessing the breakeven cut-off between current open pit mining approaches and underground methods. For that assessment, the pit increments between current Pit 33 and Pit 46 shells were studied and traded off versus the cost and outputs of the underground approach. While an economic trade off was performed, using open pit mining costs of US$1.9/t, and underground mining costs of US$45/t, other factors were identified in the trade-off that drive the decision to go underground. The overriding factor was the practicality of increasing the mining rate for open pit mining, which becomes increasingly restricted, as well as practical limits on vertical sinking rate driven by the geometry and orientation of the New Liberty orebody.

The average dip of the orebody is approximately 60°, with local variations in dip ranging from near vertical to around 40°. The orebody consists of a number of veins, generally parallel to each other. Mineralisation can occur in more than one of the veins, creating the potential for multiple parallel stopes in some parts of the deposit. The widths of the mineralised zones range from 2 m to 30 m, with an average width of 10 m. Rock conditions are described as generally good. A range of mining methods were therefore initially considered. However, since sublevel caving has a number of issues which preclude it from being the preferred mining method at New Liberty some form of open stoping was recommended to be used. Additionally, in order to reduce loss of valuable ore to pillars, consideration was given to the installation of a cemented waste rock layer on the floor of the stope to create an engineered sill pillar and thereby negate the need for sill pillars. The inclusion of this engineered, cemented, waste rock pillar reduces the pillar loss in the waste rock fill option from 41% to 27%.

Access to the orebody below the current open pits will be from within the pits. Separate portals will be developed in the Larjor and Kinjor pits providing access to the orebodies. Trucking ramps or declines will be developed from the portals, which will be established on the footwall side of the open pits, into the footwall of the orebody. The ramps will spiral down providing access to all main and sublevels in the mine. In order to access the ore blocks that remain outside strike of the final pit shells, but above the elevation of the portals, ramps will be developed up to the levels above. A crown pillar, suitably augmented by cemented fill in the pit bottoms, will be allowed, supplying ground stability as required to the workings below.

A trucking ramp will be located in the footwall of the orebody, at a minimum of 30 m from the footwall contact, as per the recommendation in the geotechnical report.

Access to the orebody will be established every 20 m vertically, by means of a level crosscut. The dimensions of the level crosscut will be 5.0 m x 5.0 m. Between the decline and the orebody intersection two stub drives of 15 m length will be established, one left and one right. These will initially be used as muckbays and will later be used to house infrastructure such as pump stations, dams and electrical switchgear. A set of return ventilation raises will be established between levels, which link up to an upcast vent raise, holing to surface and which will be equipped with the main fans. The level to level ventilation raises, which will be developed by drop raising techniques, will be located in one of the stub drives. Where required this drive will be extended to provide access to the required location of the ventilation raise. Ore drives will be established in the strike direction from the level access crosscut advancing to the limit of the orebody. Where multiple zones are present, which are separated by a suitably sized pillar (minimum pillar width of 8 m), multiple drives will be established.

Figure 1-2 shows a 3D view of the development layout.

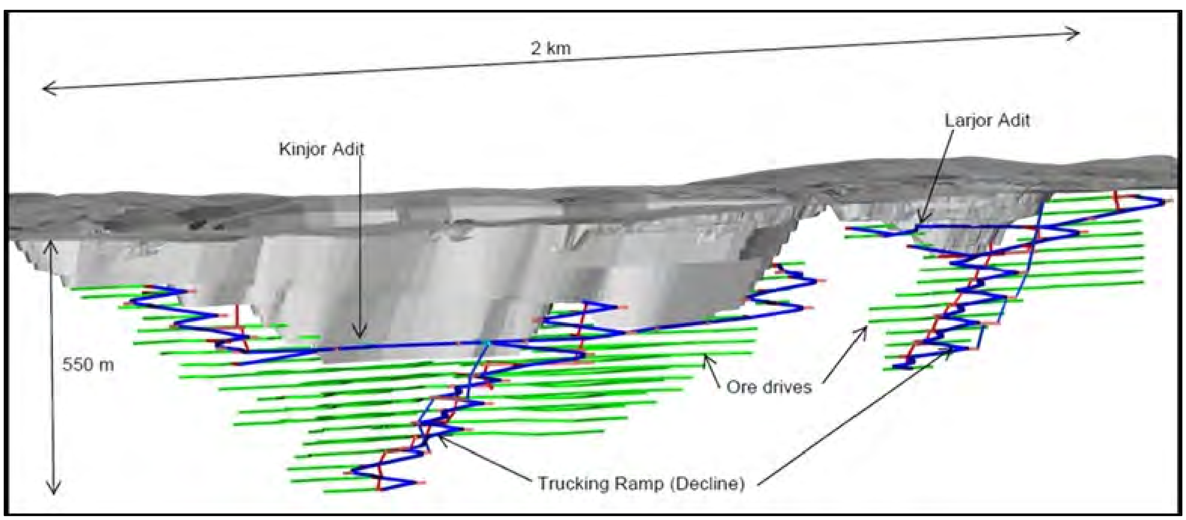


Figure 1-2: Development layout for New Liberty underground

1.10.2.1 Cut-Off Grade

In order to convert the in-situ resources to a mining inventory, appropriate modifying factors need to be applied. The following modifying factors were applied in the mine planning for the New Liberty underground mine (Table 1-7).

Table 1-7: Cut-off grade calculation

	Breakeven	Marginal cut-off (no mining cost)
Gold price (US$/oz)	1,300	1,300
Gold price (US$/g)	41.80	41.80
Refining, transport and marketing (US$/oz)	3.50	3.50
Royalty (% of revenue)	3%	3%
Received gold price	40.43	40.43
Mining cost (US$/t)	40.00	-
Processing cost (US$/t)	20.38	20.38
G&A cost (US$/t)	7.23	7.23
Total operating cost (US$/t milled)	68	28
Breakeven recovered grade (g/t)	1.7	0.68
Gold loss (%)	0%	0%
Metallurgical recovery (%)	92%	92%
Breakeven ROM grade (g/t)	1.8	0.7
Mining dilution (%)	10%	10%
Breakeven in-situ grade (g/t)	2.0	0.8

1.10.2.2 Pillar Losses

An allowance was made for an 8 m pillar every 22 m (skin to skin) along strike. Although an 8 m pillar every 22 m amounts to a pillar loss of 27%, this is not the average as many stopes do not require a pillar, such as stopes at the end of the strike extent of a block, or single stope blocks surrounded by unpay material. The average pillar loss therefore amounted to 17%.

1.10.2.3 Dilution

Two types of dilution are included in stopes. The first is planned dilution. The second category of dilution is a practical result of inaccuracy in mining. It is possible that the dilution tonnage does contain some gold content but since CSA Global cannot say for certain what the source of the dilution will be, CSA Global has assumed it to be at zero grade for conservatism. Unplanned dilution of 10 % at zero grade was therefore applied to the stope tonnage. When the ore development, which has no dilution added to it, is considered, the average dilution is 9%.

Resulting inventory by level for New Liberty underground is too detailed to be shown here, however a summary of resulting Proven and Probable Reserves relating to the underground design is shown in Table 1-8.

Table 1-8: Summary Underground Reserves inventory

Ore Reserve estimated for New Liberty Underground, Liberia, as at 31 December 2018										
Deposit	Cut-off grade (g/t)	Proven			Probable			Total Ore Reserve		
		Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)
New Liberty Underground	2.00	0.084	3.36	9.0	4.575	3.07	451.6	**4.659**	**3.08**	**460.6**

1.10.3 Combined Mine Schedule

The combined annual mining schedule for New Liberty open pit, New Liberty underground and the Ndablama open pit is shown in Table 1-9.

Table 1-9: Schedule of the Combined Project of New Liberty Gold Mine and Ndablama Deposit

Parameter	Unit	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	LOM Total
Mining Physicals													
New Liberty Open Pit													
Ore mined	kt	1,649.3	1,468.9	1,287.3	511.9	-	-	-	-	-	-	-	**4,917.5**
ROM grade	g/t	2.53	3.16	3.65	3.63	-	-	-	-	-	-	-	**3.12**
Waste mined	kt	33,502.2	33,876.3	22,175.0	38.6	-	-	-	-	-	-	-	**89,529.1**
Strip ratio	W:O	18.1	21.1	11.9	0.8	-	-	-	-	-	-	-	**16.7**
New Liberty Underground													
Ore mined	kt	-	41.3	233.3	382.4	552.3	579.4	617.8	613.0	605.6	577.2	456.8	**4,658.9**
ROM grade	g/t	-	2.64	3.21	3.34	3.37	2.93	2.97	3.05	2.98	2.86	3.22	**3.08**
Waste mined	kt	-	119.9	125.7	286.8	208.4	76.8	88.0	2.3				
Ndablama Open Pit													
Ore mined	Kt	-	-	-	1,123.2	873.8	1,430.4	1,484.3	906.1	1,464.5	-	-	**7,282.3**
ROM grade	g/t	-	-	-	1.60	1.60	1.67	1.81	1.66	1.83	-	-	**1,71**
Waste mined	kt	-	-	-	8,307.3	15.926.4	9,620.1	8,410.4	7,081.4	1,407.9	-	-	**50,753.4**
Strip ratio	W:O	-	-	-	4.3	10.0	2.7	6.8	9.2	0.6	-	-	**4.4**
Production													
Tonnes milled	kt	1,576.2	1,453.7	1,602.4	1,794.4	1,800.0	1,800.0	1,800.0	1,800.0	1,800.0	1,185.5	456.8	**17,069**
Milled grade	g/t	2.64	3.04	3.00	3.15	2.06	2.13	2.31	2.06	2.31	2.00	3.22	**2.49**
Recovered gold	koz	123,600	131,100	142,500	167,600	109,900	113,900	123,500	109,900	123,400	70,300	43,700	**1,259,400**

1.11 Mine Water Management

The key objective of the mine water management aspect of the PFS is to develop an appropriate level of understanding of the hydrology, hydrogeology and water management aspects of the New Liberty Combined Project.

The investigations and assessments completed focussed on the key hydrological and hydrogeological aspects of the project relating to the prediction of inflows into the proposed open pits and underground mine for use in the development of appropriate system designs and strategies for both dewatering/depressurisation and surface water management.

The basis for the assessments included the significant amount of hydrological and hydrogeological information collected, collated and analysed as part of previous studies completed between 2011 to 2014; on-going water monitoring programs at the New Liberty site; additional hydrogeological field investigations at the New Liberty site completed in November 2018; and hydrological and hydrogeological investigations at the Ndablama site completed in November 2018.

Precipitation analysis was undertaken on the available site data in order to develop representative annual precipitation for normal, wet and dry years and depth duration frequency analysis was undertaken to develop estimated rainfall depths for a range of storm return periods and durations. These analyses were used as the basis for the prediction of surface water inflows and the development of appropriate surface water management plans for each site.

The principal hydrogeological units were identified in both the New Liberty and Ndablama deposit areas and hydraulic parameters and properties were derived for each unit.

1.11.1 New Liberty

Site investigations indicate that the New Liberty site is underlain by a layer of moderate permeability highly weathered rock (saprolite/saprock) of varying thickness. The weathered rock is underlain by typically low permeability fractured bedrock with localised areas of enhanced permeability where water bearing fractures/faults exist. The permeability of the fractured bedrock appears to decrease with depth. Shallow groundwater flows occur through the saprolite/saprock layer and preferentially through permeable fracture zones within the fresh rock.

The groundwater level is typically less than 10 mbgl and generally 65–75 mRL. The commencement of mining and associated pit dewatering does not appear to have significantly impacted groundwater levels in any of the current groundwater monitoring drillholes. The groundwater is generally acidic with some elevated metals concentrations.

The Marvoe Creek Dam is a large body of water which has the potential to act as a large water source, recharging any zones of enhanced permeability hydraulically connected between the dam and the current open pits and the proposed underground mine.

1.11.1.1 New Liberty Open Pit Inflows

Predicted inflows and dewatering estimates were previously completed for the New Liberty open pits in 2013 (pre-mining) based on the then proposed mine plans and available data. There is currently insufficient data to confirm the current pit dewatering rates/volumes or to validate the previous pit dewatering predictions.

In November 2018, it was observed that the Larjor Pit contained a significant volume of water, while saturated pit floors were observed at both the Kinjor and Marvoe pits. Significant water volumes were observed flowing into the three pits from external pit catchments and/or shallow weathered units. Near surface inflows were particularly prevalent along the entire northern perimeter of the three pits and at the western side of the Larjor Pit. Significant discrete inflows were also observed associated with geological structures evident in the pit walls in each of the three pits (e.g. the main ore bearing shear zone, the Marvoe Creek Fault and numerous other faults/fractures).

Potential groundwater and surface water pit inflows were predicted for the proposed final New Liberty open pit as follows:

- Larjor Pit: Average bulk groundwater inflow rates of 5–10 L/s; structurally controlled groundwater inflow rates of 1–2 L/s for each permeable structure intersected by the pit.
- Main Pit (Pit 33): Average bulk groundwater inflow rates of 10–15 L/s; structurally controlled groundwater inflow rates of 1–2 L/s for each permeable structure intersected by the pit.

Generally, the structurally related inflows will reduce in magnitude rapidly, although long term localised inflows could potentially occur where the open pit intercepts a structure with a direct link to an overlying water body. Localised structurally related inflows may increase during the wet season and may reach the initially encountered higher inflow rates during prolonged wet periods.

Currently two primary diversion drains capture runoff from parts of the waste dump and surrounding area and convey the runoff to the west and south of the pits and waste dumps. The predicted surface water inflows from the remaining surface water catchments that drain into the proposed open pits range from approximately 560,000 m^3 to 715,000 m^3 (dry year to wet year) for Larjor Pit and approximately 1,920,000 m^3 to 2,455,000 m^3 (dry year to wet year) for Pit 33.

The resulting predicted combined inflows for the proposed New Liberty pits are as follows:

- Larjor Pit: Approximately 875,000 m^3 - 1,030,000 m^3 (dry year – wet year)
- Pit 33: Approximately 2,700,000 m^3 – 3,245,000 m^3 (dry year – wet year)
- 24-hour 50-year storm event: Approximately 98,000 m^3 for Larjor Pit and 335,000 m^3 for Pit 33.

1.11.1.2 New Liberty Underground Inflows

The bulk groundwater inflows into the underground mine are predicted to be generally low with average inflows predicted to be in the order of 1–2 L/s for each stage of development (each lobe) of the underground mine. These are average bulk inflow values and inflows will be higher at times of rapid advancement (especially with respect to depth) and lower when the area has been actively mined for an extended period of time.

Structurally related inflows are predicted to be in the order of 2–5 L/s. These structurally controlled inflows are predicted to reduce in magnitude rapidly, although long term localised inflows could potentially occur where the underground mine intercepts a structure with a direct link to an overlying water body or saturated overlying shallow sediments. In the wet season, enhanced localised structurally related inflows into the underground mine may temporarily increase again. The location of these structurally related enhanced inflows will directly correspond with where the underground mine intersects significant structures. Cover drilling ahead of underground mining should be considered in order to provide advanced warning of potential localised structurally controlled inflows.

Dewatering associated with open pit development and the underground mine will result in the water table being drawn down in the vicinity of the pits and underground mine. The cone of depression is predicted to be steep and narrow with its extent constrained to the north and west by the presence of the Marvoe Creek Dam and the Marvoe Creek diversion channel respectively and greater water level drawdown to the east and south where there are no significant recharge sources.

Water levels within the two-mine site water supply wells are predicted to be drawdown as a result of the dewatering from the open pits and underground mine. However, these wells are located close to the Marvoe Creek Dam and so the actual drawdown in the wells is likely to be significantly less than predicted due to recharge from the dam. The water level within the village wells is not predicted to be impacted as a result of the dewatering from the open pits and underground mine. The wetland area down gradient of the TSF is not predicted to be impacted by the groundwater level drawdown as a result of dewatering.

The New Liberty site is an operating mine site, with an existing surface water management plan in place to manage surface water associated with the mine until the cessation of open pit mining. The current design of the southern waste dump appears to encroach on the drainage channel around the eastern pit perimeter but will be redesigned as part of the subsequent Definitive Feasibility Study (DFS).

1.11.2 Ndablama

Site investigations completed at Ndablama pit indicate that the site is underlain by a layer of highly weathered rock (saprolite) and in some area a transition zone consisting of saprock. This weathered zone is underlain by competent bedrock where groundwater flow is predominantly associated with secondary fracturing.

The competent fresh bedrock is considered to generally have a lower average permeability than the weathered material as there are relatively few structures with enhanced permeability within the competent rock.

Measured groundwater levels generally range between artesian and 7 mbgl. Groundwater levels in the Ndablama deposit area mimic topography with groundwater flow generally from the elevated hills towards the low-lying streams and groundwater gradients generally range between 1:15 and 1:40.

The groundwater quality of samples collected within the Ndablama study area indicates exceedances of the World Health Organisation (WHO) drinking water quality guidelines for chloride, nitrate, lead, manganese and mercury.

Shallow groundwater flows will occur laterally down gradient along the weathered/unweathered contact (transition zone) and may discharge as springs or seepage into the various streams and rivers that exist in the Ndablama area. The degree of saturation of the weathered saprolite/saprock will fluctuate seasonally depending on rainfall recharge during the wet season and it is possible that some areas of the weathered zone will be completely dry during the dry season.

Groundwater inflows into the Ndablama open pit were predicted at various stages of mine development and were predicted to vary from approximately 1 L/s (construction) to 8 L/s (end of Stage 4).

Potential annual surface water inflows into the Ndablama Pit for Stage 1 range from approximately 200,000 m^3 to 260,000 m^3 (dry year – wet year) for Stage 4 from approximately 640,000 m^3 to 845,000 m^3 (dry year – wet year).

There is scope to reduce the external catchment area draining to the Ndablama pit in the earlier stages of development and this should be optimised during the DFS in conjunction with the surface water management in the vicinity of the pit.

The resulting combined inflows for the pits were predicted as follows:

- Stage 1: 272,500 m^3 to 335,600m^3 (dry year – wet year); 24-hour 50-year storm – 32,500 m^3
- Stage 2: 728,400 m^3 to 913,100 m^3 (dry year – wet year); 24-hour 50-year storm – 94,000 m^3
- Stage 3: 807,400 m^3 to 999,300 m^3 (dry year – wet year); 24-hour 50-year storm – 100,000 m^3
- Stage 4: 849,200 m^3 to 1,097,300 m^3 (dry year – wet year); 24-hour 50-year storm – 10,600 m^3.

During the construction phase of the mine, the boxcut excavations will extend below the local groundwater level and dewatering will be required to ensure a dry working environment, resulting in localised water level drawdown up to approximately 100 m from the edge of the boxcut excavation. One stream within the pit area will be mined out in the construction phase, thus reducing baseflow contribution to the overall stream flow volume. Drawdown of the groundwater level will cause the local groundwater flow patterns to be changed so that groundwater flows towards the boxcut excavation.

Dewatering will also be required during the operation of the mine resulting in the drawdown in local groundwater levels. The zone of influence of the groundwater level drawdown in the saprolite during the operational phase is predicted to be up to approximately 200 m from the pit crest. A portion of the river that drains the sub-catchment within which the pit will be located will be mined out. The associated average annual decrease stream flow volume in the river draining towards the southern discharge point is predicted to be a maximum of approximately 20%, although the decrease in discharge volume will vary seasonally. There are no privately-owned water supply wells that fall within the predicted zone of influence of the dewatering induced groundwater level drawdown cone.

The local groundwater flow patterns will be directed towards the pit due to mine dewatering. Seepage from the Waste Rock Dump (WRD) into the pit may occur and will be captured within the dewatering system along with the other pit inflows and handled within the mine water management system.

During the decommissioning phase the mine dewatering will stop and the water level within the pit will start to recover. The WRD will be sloped and capped, which will reduce the recharge into the WRD and lead to a lowering of the water level within the WRD area. In the long term, the water level within the pit will continue to recover. The recovering water levels will allow the groundwater flow patterns in the area to recover to near pre-mining levels. It is predicted that water level in the Ndablama pit will recover to approximately 195–200 m amsl within 15–20 years of the end of mine operation. At this level groundwater inflows into the pit will be minimal due to the water level within the pit being at, or even slightly above, the regional groundwater level elevations around the pit. In addition, once water levels reach these levels it is predicted that water discharge from the pit will commence.

A site-specific surface water management plan was developed for the Ndablama site. Proposed channel alignments were developed to divert “clean” surface water runoff around and downstream of the development and to manage the “dirty” water runoff from the impacted catchments. Diversion channel sizing ranges from 1m deep v-shaped channel to 1.5 m deep, 3.0 m base width trapezoidal channels. The proposed stormwater diversion channels with design flows less than 10 m^3/s have a minimum freeboard of 300 mm, while channels with larger design flows have a minimum freeboard of 500 mm. Where mean channels velocities exceed 3.0 m/s, reinforced concrete channels are required and where flow velocities are less than 1.5 m/s, no erosion protection is required. For channels with flow velocities between 1.5 m/s and 3.0 m/s, rip-rap linings are required.

The runoff from the impacted catchments will be collected in channels and discharged to sedimentation ponds, in order to facilitate the settlement of suspended sediment, prior to discharge to the environment. A minimum sedimentation pond depth of 1.2 m is recommended, incorporating a minimum settling depth of 0.6 m with an additional depth provided for the storage of settled sediment between maintenance. Sedimentation pond design will be undertaken as part of the subsequent DFS, when there is more certainty on the project infrastructure design.

1.12 Metallurgy and Process Technology

1.12.1 Metallurgical Testwork

Testing has been carried out on representative samples from the New Liberty underground ore sources, and on samples representing the Ndablama deposit.

The testwork programs included comminution, gravity, flotation, whole ore cyanidation leaching, and gravity tails leaching.

Testing carried out on the underground ore sources from the New Liberty and Ndabalama deposits verified that the optimal process route is that of gravity-intensive cyanidation leach, followed by conventional CIL, and gold recovery on the gravity tail.

The testwork showed that both New Liberty and Ndablama ore sources have a high Gravity Recoverable Gold (GRG) component and warrants the inclusion of a gravity circuit in the flowsheet. Gold extraction on the gravity concentrate are high, and leach kinetics are rapid.

Cyanidation leaching on the gravity tails also demonstrates rapid leach kinetics.

Bond Rod Mill Work Index testing on New Liberty samples showed a Master Composite of the four zones to have a work index value of 15.21 kWh/t which would be considered 'hard' based on standard classification criteria. Bond Ball Mill Index testing of the New Liberty Master Composite showed it to have a work index value of 16.06 kWh/t which would again be classified as 'hard' using standard criteria.

Bond Rod and Ball Mill Work Index tests were carried out on a composite of the fresh ore types at Ndablama. The Bond Rod Mill Work Index at a product size 642 µm was 13.0 kWh/t, whilst the Bond Ball Mill Work Index at a product size P80 of 60 µm was 18.5 kWh/t, which would be considered to be hard.

The results of the separate gravity and cyanide leach tests were used to calculate overall gold and silver recoveries for each sample based on the combined gravity-leach performance. These results are given in Table 1-10.

Table 1-10: Combined gravity-leach test results – New Liberty

Sample	Product	Gravity recovery (%)		Leach recovery (%)		Overall recovery (%)	
		Au	Ag	Au	Ag	Au	Ag
Larjor/Kinjor South	Concentrate	64.0	14.4	97.2	91.9	62.2	13.2
	Tailings	36.0	85.6	85.2	10.4	30.7	8.9
	Total					**92.9**	**22.1**
Kinjor North	Concentrate	57.7	9.7	97.5	86.1	56.3	8.4
	Tailings	42.3	90.3	92.1	5.7	38.9	5.1
	Total					**95.2**	**13.5**

Overall, the results showed that by using a combined gravity-leach methodology, gold recoveries of 92.9% and 95.2% could be achieved for the Larjor/Kinjor South and Kinjor North samples respectively.

For Ndablama ore, the results of the separate gravity and cyanide leach tests were used to calculate overall gold and silver recoveries for each sample based on the combined gravity-leach performance. These results are given in Table 1-11.

Table 1-11: Gravity-leach test results – Ndablama

Comp ID	Test no.	% Au extraction (h)					Au grade (g/t)		Consumption (kg/t)	
		Gravity	2	8	16	24	Calculated head	Residue	NaCN	Lime
Oxide	JR791	33.7	88.49	88.49	88.49	91.89	1.03	0.08	1.28	4.86
	JR792	34.55	91.33	91.33	91.33	92.82	1	0.07	1.39	4.87
Fresh	J3793	70.77	94.02	94.02	95.17	94.9	2.42	0.12	0.8	0.48
	J3794	69.6	92.78	92.78	92.78	94.03	2.46	0.15	1.06	0.48

Results indicate the oxide and sulphide ore types are readily processable using the gravity-leach process flowsheet, with average GRG recoveries for the oxide and sulphide ore types of 34.1% and 70.2% respectively. Gold leach extractions were on average 92.3% and 94.5% for the oxide and sulphide ore composites respectively.

1.13 Ore Processing Facilities

All ores generated in the project will be processed in the existing New Liberty mill. The process flowsheet is an industry-standard arrangement consisting of crushing, ore stockpiling, grinding and classification, gravity gold recovery, thickening and gold extraction by cyanidation in a Carbon-in Leach (CIL) circuit. Gold is recovered from the activated carbon by acid washing, elution and electrowinning, followed by smelting to produce gold doré. The CIL tailings undergo cyanide detoxification followed by arsenic precipitation from tailings solution prior to disposal in the tailings dam.

An overall process flowsheet for the New Liberty treatment facility is shown in Figure 1-3.

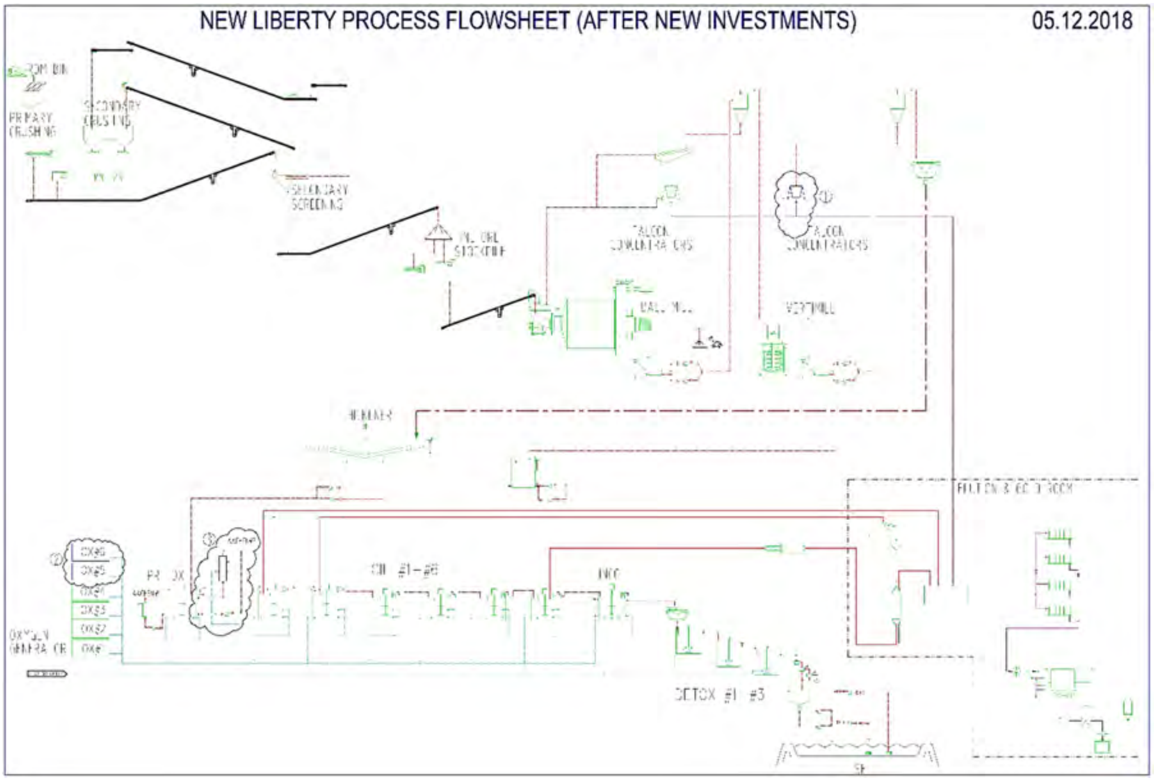


Figure 1-3: New Liberty plant flowsheet

Based on the Bond Rod and Ball Mill Work indices reported, the existing grinding circuit has sufficient installed grinding capacity to process the underground ore sources from the New Liberty mine at an annual production rate of 1.8 million tonnes per annum (Mt/a), targeting a grind size P80 of 75 µm.

Based on the Bond Rod and Ball Mill Work indices reported, a coarser with a reduction in grind size is required to reflect coarser gold mineralisation when processing the at Ndablama ore. The existing grinding circuit has sufficient installed grinding capacity to process ore sources from the Ndablama deposit in combination with ores from New Liberty underground mine at an annual production rate of 1.8 Mt/a, targeting a grind size P_{80} of 106-125µm.

At an annual production rate of 1.8 Mt/a, the current CIL circuit has a calculated leach residence in the range of 19–20 hours. This is on the low side, in the event the Falcon concentrator is offline. To ensure that the target gold recovery of 92% is consistently achieved, it is recommended to investigate the installation of a second Falcon concentrator in the primary grinding circuit to maximise the Gravity Recoverable Gold recovery, and to ensure that the leach tanks are injected with pure dissolved oxygen to increase leach kinetics.

1.14 Tailings

In order to store the life of mine (LOM) tailings the existing Tailings Management Facility (TMF) at the New Liberty Gold Mine will require expansion. The proposed LOM is forecast to produce 18 Mt tailings in 10 years from October 2018 at an average throughput of 1.8 Mt/a. Throughput to the existing facility as of the end of October 2018 was approximately 3.4 Mt, resulting in a total storage capacity requirement of 21.4 Mt within the TMF at closure.

The TMF dam hazard classification has been assessed to be 'high' in accordance with the Canadian Dam Association Regulations 2013 (CDA 2013). This assessment is based on the height, storage, downstream population at risk, as well as key habitats and species at risk and the potential economic consequences of failure.

At the time of writing this report the Phase 2 construction of the TMF was partially complete to a crest elevation of 82.5 mRL with embankments being constructed around the perimeter of the facility crossing the western valley sides wrapping around the southern ridge and abutting high ground to the west. Tailings beaches have inundated the valley up to approximately 78 mRL in the western portion of the site, with the supernatant pond covering most of the middle and eastern portions of the basin area. Phase 2 construction to 82.5 mRL is scheduled to provide at total storage capacity of 9.35 Mt and should be completed by June 2019.

1.14.1 Tailings Characterisation

Geotechnical and geochemical characterisation of the tailings has been undertaken and are reported in detail in this report.

Geochemically, the tailings are classified as non-acid generating and arsenic and cyanide are identified as the primary contaminants of potential concern. Arsenic levels from leach tests exceed the IFC discharge standard of 0.1 mg/L. Furthermore, mercury, nickel, lead and cobalt were elevated in some samples. Kinetic testing was conducted on the tailings samples to assess longer-term drainage water quality and reaction rates. After an initial spike, the arsenic levels in solution fall to low levels after a period of about five weeks.

Operational monitoring programs and engineering studies have advanced the understanding of the geochemical behaviour of the tailings beyond the static characterisation work carried out as part of the ESIA.

Routine environmental monitoring commenced for the mine in 2016, which identified areas of concern not initially considered. These include occasions of elevated concentrations of iron and nickel in surface water discharge and groundwater seepage, as well as some exceedences of copper downgradient of the TMF. Arsenic, iron, nickel, cyanide and possibly copper were occasionally above IFC standards in surface water discharge and boreholes monitoring seepage from the TMF analysed in 2016.

Further static and kinetic testing is recommended on representative tailings samples generated by the updated processing circuit to assess geochemical changes that may inform environmental behaviour and provide an assessment of the long-term leachate conditions.

The waste rock used for construction purposes (i.e. buttressing) is unlikely to be acid generating and it was deemed not necessary to undertake kinetic samples.

1.14.2 Design Criteria

The complete design criteria are summarised in Table 1-12 below.

Table 1-12: Design criteria

Design criteria		Value
General		
Dam classification		High Risk (CDA 2007, 2013, 2014)
Production rates		
LOM		October 2018 – October 2028
Annual tailings production rate		1.8 Mt/a
LOM tailings production		18 Mt/a
Current tailings deposited to October 2018		3.4 Mt
Tailings characteristics		
Current disposal method		Thickened slurry tailings
Average slurry solids concentration % by weight		45%
Specific gravity		2.9
Tailings average in-store dry density		1.25 t/m^3
Tailings beach slope	Sub-aerial	0.5%
Water management		
Storm event	No spill	1:100-year 24-hour flood event during wet year
	Safe conveyance (inflow design flood)	1:3 between 1:1,000-year 24-hour and Probable Maximum Flood (PMF) during wet year event
Annual rainfall rates	Extremely dry year	2,248 mm
	Average year	3,307 mm
	Extremely wet year	4,720 mm
Stormwater runoff management	IDF	1:100-year 24-hour flood event
Rainfall	1:100-year 24-hour event	368 mm
	1:1,000-year 24-hour event	549 mm
	1:10,000-year 24-hour event Probable Maximum Precipitation (PMP)	782 mm
Total freeboard (crest to maximum operating water level (MOWL))		3.5 m
Spillway depth (at embankment crest)		1.5 m*
Total beach freeboard (crest to maximum beach level)		2.1 m
Embankment geometry		
Minimum embankment crest width		9 m
Centerline construction	Maximum slope angles	2.5H in 1V
	Maximum raise height	3 m
	Maximum rate of rise	2.5 m/year
Loading condition		Required factor of safety
Static, end of construction before reservoir filing		≥ 1.3
Static, long-term (steady-state seepage, normal reservoir level)		≥ 1.5
Rapid drawdown		≥ 1.3
Liquified tailings (post-seismic)		≥ 1.2
Pseudo-static (OBE)		≥ 1.0
Pseudo-static (MDE)		≥ 1.0
Seismic criteria		Value
Dam classification		High
Operational Basis Earthquake (OBE)		1,000-year Recurrence interval
		Peak Horizontal Ground Acceleration 0.055g
Maximum Design Event (MDE)		2,475-year Recurrence Interval
		Peak Horizontal Ground Acceleration 0.11g

1.14.3 Water Management

A water impoundment area was developed to collect run-off from a 74 ha catchment to the northwest of the TMF. A northern catchment area of 16 ha is conveyed, by a diversion drain, to the water impoundment area. Non-contact water is then diverted under the TMF via a penstock pipeline to the downstream toe of the TMF valley where it is attenuated, monitored, treated as necessary within a sump pond and released to the natural marsh environment via a series of charcoal filled gabion baskets. The marsh provides further attenuation prior to effluent entering the receiving environment downstream. The proposed expansion of the TMF eventually results in the northern catchment diversion drain being inundated and as such the catchment reports to the TMF, albeit for a significantly reduced area of only 9 ha.

A detailed TMF water balance was developed as part of the Phase 2 design and found that excess flows reporting the TMF would require discharging via the penstock system to be combined with flows from the water impoundment area for dilution and release to the environment. The currently proposed increase in throughput has been calculated to result in an estimated 67,700 m^3 additional process water being retained on the facility annually. Because of the removal of the diversion channel in latter phase of development, the accumulation of additional run-off from the northern catchment area (approximately 9 ha) would result in a further 120,000 m^3 in an average climatic year and 170,000 m^3 in an extreme wet climatic year reporting to the supernatant pond in a given year.

In order to mitigate against operations exceeding the maximum operating pond volume, water will be released to the environment via the penstock system during the wettest months of the year while there is adequate clean water from the water impoundment area to dilute the flows (April through September). In order to provide a more accurate update of the likely excess flows, it is recommended that the full TMF water balance be updated with the revised model parameters.

Records of effluent monitoring at the sump pond for the period April through June 2018 indicate that effluent has been meeting the required discharge limits on total cyanide, WAD cyanide and free cyanide set by the permitting authorities. Furthermore, it has met the additional limits on dissolved arsenic set by the IFC other than on three reported occasions. It is noted that water from the natural environment often exceeds the dissolved arsenic limits due to the naturally occurring base levels of arsenic in soils. It is also noted that monitoring data was provided for samples collected prior to entering the marsh land, and as such had not benefitted from additional attenuation and dilution.

Release of water has been carried out via the penstock system which enables the effluent to be diluted by non-contact water during the wet season during April through September. Additional analyses to assess the likely impact on concentrations from the proposed levels of excess water release should be undertaken.

The rate at which contact water has been released from the TMF has not been recorded and as such there is no way to accurately assess what level of dilution has been occurring. Current WAD cyanide levels in the TMF have been recorded by BMMC at around 0.74 mg/L and the discharge limit is 0 5 mg/L, therefore it can be estimated that a dilution factor of 1.48 would be sufficient to achieve the target levels. Natural breakdown of the cyanide will also occur in the marsh areas prior to entering the downstream environment to the west.

Future studies will establish suitable and cost-effective technologies to remove arsenic from the supernatant water before releasing it into the Penstock and downstream wetland. This should enable water to be pumped off the dam at a higher rate and also during drier months when there is little to no fresh water available for dilution.

For the expansion of the TMF the water impoundment embankment will be raised to retain the tailings and supernatant pond within the TMF. The design storm event does not over top the embankment.

Submersible pumps will be employed to divert non-contact water around the TMF via a pipeline outfalling to the valley south of the TMF.

Operational spillways will be constructed through natural terrain to the eastern most end of the TMF out falling to the valley south of the TMF. The closure spillway will be constructed as part of the closure plan through natural ground in the hillside just above the final operational stage spillway. The spillway design is currently conceptual and will require further consideration through the detailed design phases.

1.14.4 Tailings Deposition Strategy

Tailings will be discharged via spigots placed along the upstream crests of embankments. By depositing from these embankments, the pond will be maintained along the northern perimeter of the facility against the natural ground. Rotational discharge will be carried out with the development of even beaches in 0.3 m thick tailings layers in order to optimise consolidation and beach strength

1.14.5 Embankment Design

The proposed expansion of the facility is based on further staged centreline raises using a zoned earth technique.

1.14.6 Construction Schedule

The TMF will be constructed in phases to provide capacity to store the LOM tailings throughput.

1.14.7 Environment

Updated Arsenic and Cyanide Management Plans were prepared in 2017.

Based on the previously completed flow and transport groundwater modelling and impact assessments, it is concluded that seepage from the TMF could result in COPC entering groundwater and surface water in excess of WHO guidelines and IFC effluent standards. While it is noted that the modelling and impact assessment is sensitive to the assumptions made in the model, the conclusions appear to be supported by the water quality monitoring undertaken to date. It is recommended that additional site-specific data be collected with respect to:

- Hydraulic conductivity (of tailings and in-situ geology)
- Porosity (of the tailings and in-situ geology)
- Soil water characteristic curve analysis for the tailings
- Tailings chemistry (including the pond water chemistry)
- Seepage rates from internal embankment drainage structures
- Groundwater level and quality monitoring data (for model calibration).

Based on the additional data, it is recommended that the seepage modelling and impact assessment is updated based on the currently proposed design of the TMF, and that the water balance for the TMF be updated taking in to account seepage modelling results.

1.14.8 Cost Estimation

Annual capex costs are summarised below in Table 1-13.

Table 1-13: Summarised annual capex costs

Phase	Year	Annual cost	Cumulative cost
Studies, design and water impoundment area preparation	2019	$594,000	$594,000
Phase 3a	2020	$593,558	$1,187,558
Phase 3b	2021	$2,350,756	$3,538,314
Phase 4a	2023	$1,921,276	$5,459,590
Phase 4b	2024	$1,116,386	$6,575,976
Phase 5	2026	$2,514,897	$9,090,873
Phase 6	2027	$1,823,128	$10,914,001
Closure		$4,838,793	$15,752,794
Total (US$ exc. VAT)		**$15,752,794**	

1.14.9 Risk Management

The most significant risks identified are summarised below.

- Safety and environment:
  - Mine waste spillage in to downstream environment and water course causing contamination
  - Leakage through embankment face impermeable liner system allowing contaminated contact water into the environment
  - Seepage of contaminated contact water beneath facility into natural water system.
- Construction and operation:
  - Construction standards are not adequately controlled leading to some form of failure of the dam to safely contain solids and water
  - Insufficient foundation and embankment fill geotechnical data and reliance on the use of published shear strength data
  - Prolonged wet season
  - Extreme rainfall event (above PMP event) or successive events which could flood and overtop the TMF embankments.
- Infrastructure:
  - Failure of the penstock structure through the weight of the tailings or other issue causing the penstock system to become blocked
  - Failure of the decant pumping system resulting in water not being returned to the process
  - Failure of pumping system at Water Impoundment Area.
- Storage:
  - No significant risks identified.
- Foundations:
  - The ground conditions are found to be worse or more areas of concern more extensive than anticipated from the available ground investigations.
- Closure:
  - Long-term seepage from the facility
  - Inappropriate deposition planning resulting in the pond being located in the wrong place at closure
  - Insufficient construction material for capping system (waste rock, fine fill and topsoil)
  - Insufficient time is given for consolidation of tailings prior to construction of capping layer and consolidation characteristics are not well understood.

Majority of these risks have been shown to be adequately mitigated by proposed measures set out in the development of the TMF expansion design and associated recommendations for additional work.

1.14.10 Recommendations

The areas that require further studies and assessments prior to detailed design identified throughout this chapter and the appended report are summarised below:

- An update of the New Liberty Gold Mine water balance to assess excess and deficit flows
- Assessment of the dilution requirements and maximum discharge rates to satisfy effluent discharge limits permitted
- An additional Ground Investigation to improve understanding of the foundation conditions (geotechnical and hydrogeological)
- The installation of vibrating wire piezometers into the tailings to assess water levels and consolidation of the tailings beach
- Additional tailings testwork for strength and liquefaction resistance (CPTU Campaign)
- Additional tailings testing testwork for settlement and beach slope characterisation (also considering the Ndablama resource tailings)
- Additional tailings testwork for geochemistry for assessment of long-term leachate conditions
- Additional tailings testwork for hydraulic characterisation (to inform updates to seepage impact assessments)
- Detailed stability assessment of the slopes following improved geotechnical data from additional ground investigations and testwork
- Update of the seepage impact assessment models
- Carry out HAZOP workshop for tailings management
- Updates to OMS Manuals
- Updates to Emergency Response Plans, including the need to carry out a dam breach assessment.

1.15 On-Site Infrastructure

1.15.1 Roads

No new roads are planned for the New Liberty mine site. Haul trucks exiting the underground workings will dump ROM at the portals, where it will be picked up by front-end loader and loaded on to existing in-pit trucks for haulage to the New Liberty ROM pad.

A new, reliable haul road is required to move direct shipping ore from the Ndablama satellite pit to the New Liberty mill. The distance of the preferred alignment from NLGM to Ndablama is 46.0 km and will pass from northeast to southwest close to the alignment of the existing Tubmanberg road. The road design will be the standard two-layer construction and will be unsealed though, due to the use of rock material from the mining operations, it can be considered as an all-weather road.

New in-pit roads and haul roads to the waste dumps and ROM pad at Ndablama will be constructed. Additionally, a loadout area near the ROM pad and haul road to link with the new Ndablama–New Liberty road will be constructed.

Additionally, a linking road from the Ndablama–New Liberty haul road to the New Liberty ROM pad will be constructed, with an appropriate ROM dump and turning circle for the return of haul trucks to Ndablama.

1.15.2 Utilities

The combined project will utilise local diesel generation plants to supply the operational power requirements. An existing 10 MVA diesel generation facility is already in operation at New Liberty. Extension to the existing New Liberty power plant has been allowed to support the underground mining operation.

An extension to the New Liberty single line diagram is planned, as shown in Figure 1-4.

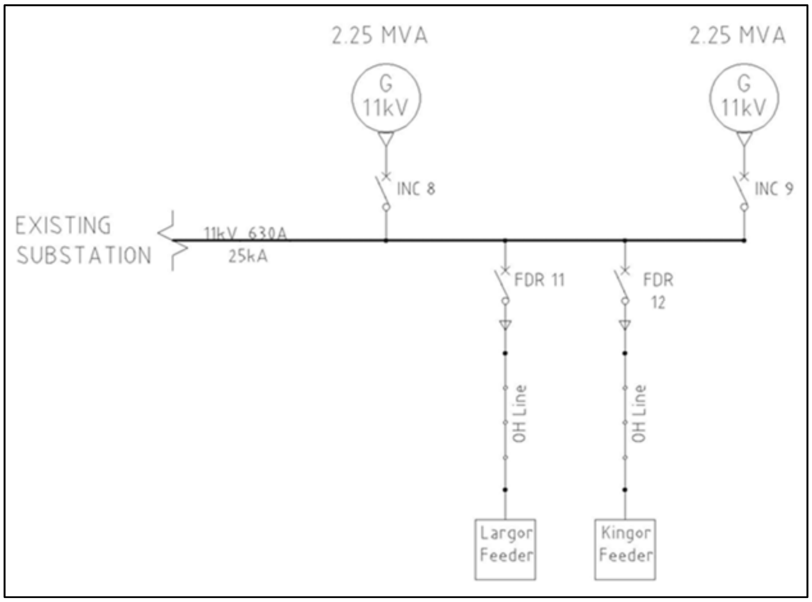


Figure 1-4: New Liberty revised single line diagram

Ndablama is a greenfields site and will include a new diesel power plant in order to supply the electrical requirements (Figure 1-5). Main distribution reticulation will be at 11 kV with equipment operational voltages being 525 V and 400 V.

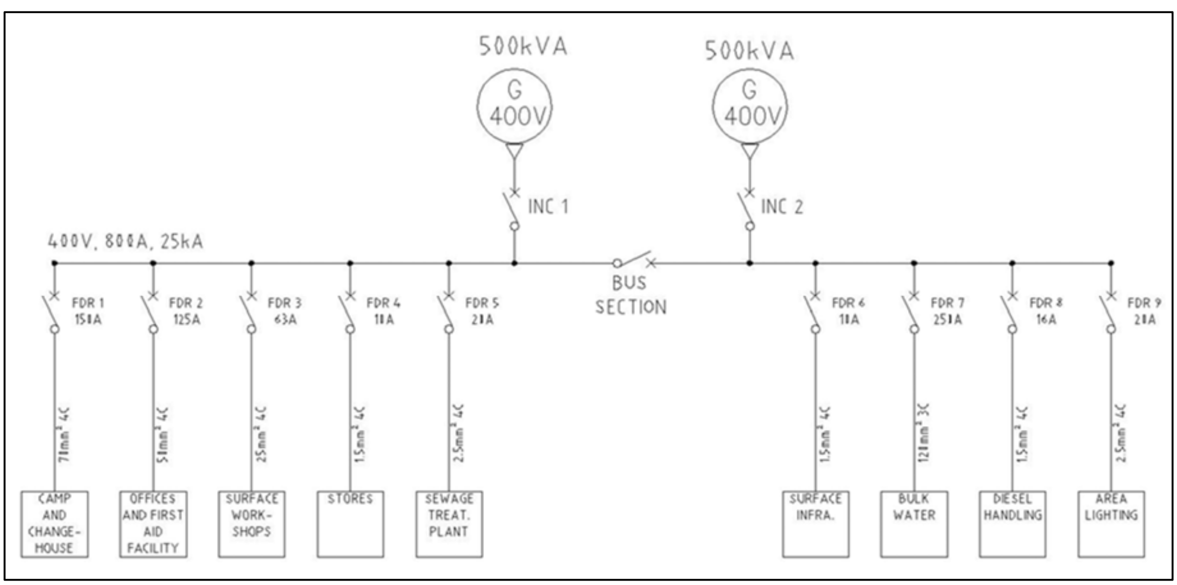


Figure 1-5: Ndablama new generation capacity and single line diagram

Production communication will be generally via a VHF radio system. The mining, engineering and emergency services will operate off different channels of the radio system. The radio system will include an antenna for surface communications and a leaky feeder system for underground. Hand held radio units will be provided to personnel and fixed units installed in vehicles and control rooms as required.

A fibre Ethernet backbone system will be installed underground to provide a data conduit between underground equipment and the surface control room. Non-production communication will be an IP telephone system connecting into the Ethernet backbone system.

Surface communications will be by VHF in the main, with communication from the mine site to Monrovia, Ankara and London via satellite data link. 3G communications are available at New Liberty and will be extended to Ndablama at an appropriate time using the local mobile provider.

1.15.3 Operations Facilities

The layout and provision of surface infrastructure takes into consideration the labour complement and the proposed mining method and the size and type of equipment to be used. It is understood that operation will be by contractor and that no accommodation is to be provided.

The site area will be fenced off with a 1.8 m high, medium security fence with vehicle access via manned gates. The surface infrastructure is planned to be serviceable and fit for purpose, with most of the standard structures being prefabricated and based on typical structures that are provided by a specialised supplier of this type of building, called “Red Sea”, who operate out of Ghana. The structures are designed to provide facilities that are quickly erected and easy to remove at the end of the life of the mine.

The infrastructure and contractor camp that has been planned for the Ndablama operations will include a combined activity site approximately 6 km away from the pit and outside of a 500 m blast radius line, and a small control tower near the pit entrance. The selected area where the surface infrastructure is to be located, is deemed to be the most suitable although the general area is undulating, and typical cut and fill procedures will be required to create the terraced platform.

1.15.4 On-Site Maintenance Facilities

Facilities already exist for maintenance of the New Liberty open pit fleet. An additional 30 m x 30 m trackless workshop located on surface has been planned for underground vehicles. Lubrication, fuelling and minor maintenance will be conducted in lubrication bays constructed underground.

A complete surface fleet workshop has been provided for at Ndablama, including shovel maintenance, bucket maintenance, truck and tipper maintenance, complete with stores and offices.

1.15.5 Other Facilities

Additional facilities, including a contractor’s camp, main office complex, changehouse and laundry room, stores facilities, fuel depot, fire protection, waste and sewage facilities including bio-disc type packaged sewage treatment have been provided for. No provision for additional surface transport other than a haul truck fleet has been allowed for as it is understood that the fleet will be sourced from drawdown at New Liberty as mining operations wind down at that site.

1.16 Project Execution

1.16.1 Introduction

The combined project will include open pit mining of the New Liberty deposit until the break-even cutoff for underground mining is reached, a transition to underground mining by long-hole open stoping methods, and open pit mining of the reserves at the Ndablama deposit with direct shipping of Ndblama ore to the New Liberty mill later in the life of the project.

At New Liberty a new, approximately 600,000 ROM t/a underground mine, will be initially accessed by a portal developed from the old Larjor pit in 2020. An additional portal will be developed at Kinjor pit in

2022. Each portal will have constructed entry, plus support, and services including sumps/pumping and a main ventilation fan (and vent shaft) in the vicinity. Extensive facilities including sumps and pumps to maintain/control water in the final pit (Pit 33) will be provided around each portal. Additionally, an ore transfer station, with a dump for underground ore trucks, and front-end loader to load haul trucks will be provided.

Power generation will be by two new 2.25 MVA diesel generators, with reticulation at 6,000 V to the new pumps, fans and the underground. Additional workshop capacity for planned maintenance of underground fleet will be provided. New/updated roads for mobile fleet to travel from the portal(s) to the plant stockpile and workshops will be constructed.

At Ndablama a new approximately 1,200,000 ROM t/a open pit mine, operated by contractor with conventional truck/shovel fleet will be developed. The pit is to be provided with all relevant infrastructure to support conventional diesel mining fleet plus labour/supervision, including a combined workshop, fuel station and lubrication station, stores, offices, changehouse facilities, and pit dewatering infrastructure. Workshops will be designed for the estimated complement of mobile fleet; offices and changehouse facilities will be designed for the estimated labour complement plus contingency. Roads to connect the ROM pad to the Ndablama–New Liberty haul road must be laid out. A ±46 km haul road from Ndablama mine to New Liberty mine will also be constructed prior to the development and pre-strip of the Ndablama pit. Power generation will be by a single new 400 kVA generator for small power (offices, changehouses, stores) only. Solar generation has been allowed on the changehouse roof to support power requirements.

There is an existing 1.8 Mt/a mill on site at New Liberty therefore no new milling facilities relating to New Liberty underground or Ndablama open pit are contemplated. A new road train side-tip (2 x 90-t cars) will be required in the ROM area to handle ROM coming from Ndablama pit from Year 5.

1.16.2 Project Management

Management of the project will be by a combination of owner's team and consultants. Overall management of the project will be by Avesoro Resources. Domain areas (e.g. underground mine development, open pit mine development, the haul road project, and TSF) will be managed by individual consultants specialising in these areas. All domain project managers will report to the Avesoro Project Manager. The provision of major infrastructure (e.g. power and pumping) is by Avesoro and will be managed by Avesoro.

1.16.3 Health, Safety, Environment and Community

Health, safety and environment (HSE) responsibility will rest with Avesoro for the project. Ongoing HSE management is required for the operating New Liberty Mine. New HSE functions will be initiated in advance of developments at Ndablama, including ongoing community engagement already initiated during exploration phases.

Avesoro has put in place an Environment, Health, Safety and Community Management Plan. The plan focuses on workplace safety, occupational health and safety, active resettlement and community engagement plans with a constructive and consultative approach with all impacted communities, and an active environmental monitoring program focused on major water, air and soil environmental metrics. An active conservation and remediation plan is also in place.

1.16.4 Quality Control and Assurance

A systematic QA/QC program for the project will be set up. For engineering and procurement activities, standards will be agreed, work will be to standard, manufacturing will be managed to standard, and procurement will be to AVS specifications. AVS will provide QA/oversight to all engineering, procurement and construction (EPC) activities under their management. Individual domain consultants will provide QA/oversight to all EPC activities under their management.

1.16.5 Project Schedule

A level 2 project schedule has been developed. Key activities in the project plan are described below.

Operations at New Liberty Open pit are current and will continue until open pit mining is curtailed at pit 33 stage in 2022. Development of the portal at Larjor will commence in Q1 2020, with access ramp development from Q2 2020 until Q4 2021. Surface infrastructure to support underground mining at New Liberty, including new generating capacity, and surface water management facilities are developed in Q1 2020. Development of the portal at Kinjor commences at the end of open pit activity in Q3 2022, with access ramp development from Q4 2022. Footwall development is ongoing from Q4 2021 until end of LOM, with full production achieved circa Q4 2022.

Expansion of the TSF begins in March 2019, with additional phases in March 2020 and a major capital extension in March 2021. Thereafter expansion of the TSF will be incremental with ongoing mining activity.

Development of the New Liberty – Ndablama haul road begins in Q3 2021, with a duration of six months, with surface preparation, haul roads and surface water diversion works developed on site in Q1 2022. Camp, office and workshop facilities are constructed in Q1 2022, with mining commencing in Q2 2022. Due to the outcropping nature of the deposit, and deposit geometry, no significant pre-strip is scheduled and ore production, and waste stockpile construction start immediately.

Closure of both New Liberty mine and surface infrastructure, in line with permitting provisions, and closure of Ndablama is currently planned at the end of LOM in 2029.

1.16.6 Project Controls

No major construction, other than mining development, major capital items, and the haul road previously described, is envisaged. The project will be executed under project procedures that conform generally to ISO 9001 requirements, and embrace cost, time and resource control principles. All equipment and parts required will be purchased against established budgeted estimates that would only be exceeded with prior Avesoro approval. Subcontracts will be awarded against bills of quantity that reflect a completed detail design. Contract management of operating contracts (New Liberty open pit, New Liberty underground and Ndablama open pit mining contracts) will be by Avesoro.

1.17 Environmental and Social Impact Assessment

1.17.1 New Liberty Gold Mine

New Liberty Gold Mine is situated in the north-western portion of Liberia within the Gola Konneh District of Grand Cape Mount County. The climate is equatorial with a wet season extending from May to November. The average annual rainfall recorded at the site during the period November 2010 to August 2017 is 3,387 mm, some 600 mm less than what is typically recorded along the coastal belt. The temperatures on site are generally within the range 20ºC to 35ºC and are generally lower in the wet season than in the dry season. The mine is 40 km from the coast and the topography is gently undulating with occasional small hills. The mine site, including the TSF is in the catchments of the Marvoe Creek and the Wilagea Creek, a tributary of Marvoe Creek, within the Mafa River basin. Baseline water quality studies undertaken prior to development of the mine found that the quality of water in watercourses draining the mine site was generally good, but levels of aluminium, iron and arsenic were elevated in some samples. Historical artisanal mining was found to have had a measurable impact on aquatic habitats and ecological water quality, particularly the Marvoe Creek. However, the diversity of fish and amphibian species was found to be high. Dense tall rainforest surrounds the mine site, which, prior to mining had been somewhat disturbed by past artisanal mining, prospecting, logging and bush meat hunting. Figure 1-6 presents a map of habitats in the BMMC concession that was produced in 2016. Several biodiversity studies have been completed in the vicinity of the mine. In terms of fauna, impacted reptiles identified included the vulnerable African Dwarf Crocodile (Osteolaemus tetraspis). Numerous bird species (139) were recorded, including vulnerable hornbill, parrot and greenbul species (specifically Ceratogymna elata, Psittacus timneh and Criniger olivaceus).

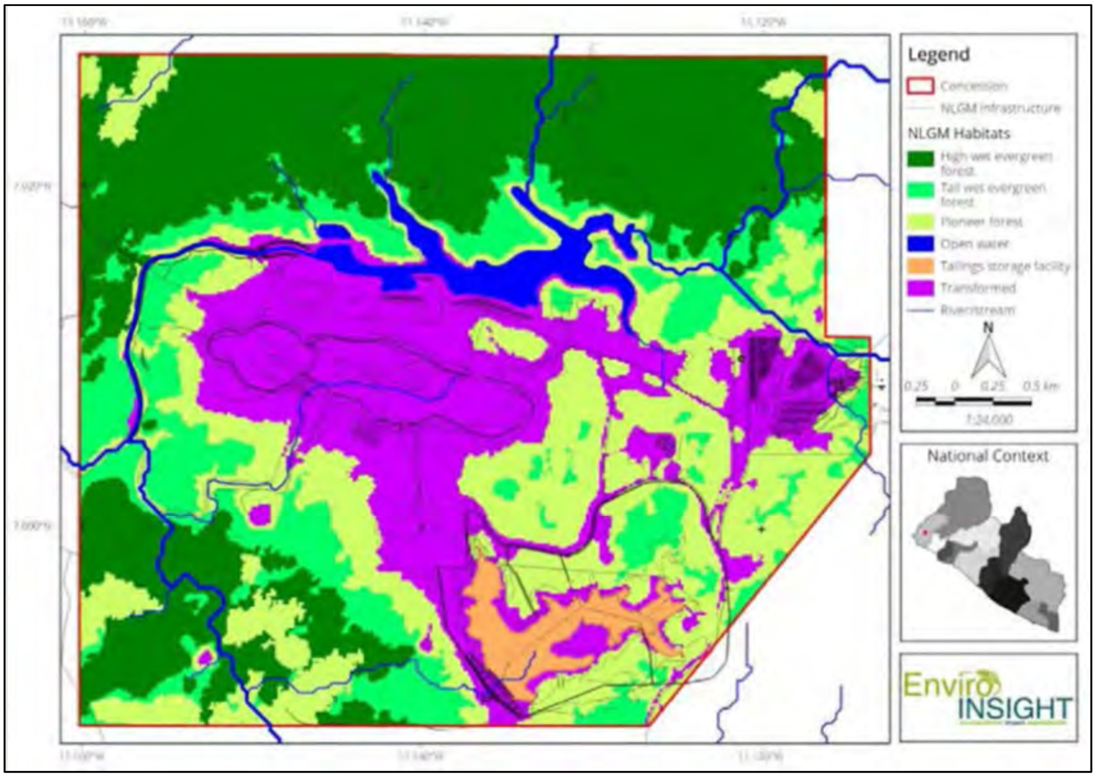


Figure 1-6: Habitat types in the BMMC Concession

The area around the mine is sparsely populated. About one third of Grand Cape Mount County's population is literate and the ratio of literate females to males is low. Education levels are largely are largely influenced by the proximity of households to schools. Kinjor and Larjor settlements were situated in the mine foot print and had to be relocated. Final settlement was completed in 2018 with the completion of the construction of 322 housing units and title certificates handed over to the beneficiaries. Further downstream of the TSF, near the Mafa River are the settlements Magina and Koma about 11km and 12km downstream respectively, not resettled.

The ESIA recorded that inhabitants of the small settlements in the vicinity of the mine site were engaged in livelihood activities such as agriculture, artisanal mining and work associated with mining prospects.

The livelihoods of people living in Kinjor and Lajor were largely based on artisanal mining.

The livelihoods of other villages in the surrounding communities of the mine are largely based on subsistence farming and fishing from streams and rivers.

By 2018, BMMC had installed water pumps in all the communities directly impacted by its operations.

1.17.1.1 Permits and Approvals

The primary approvals for New Liberty Gold Mine take the form of:

- A Mineral Development Agreement (MDA) between the Government of Liberia and BMMC, dated 18 September 2013 and which replaced an earlier MDA dated 28 November 2001
- A Class A Mining Licence granted to BMMC on 29 July 2009

- An environmental permit for the Gold Exploitation granted to BMMC by the Liberian Environmental Protection Agency (EPA) on 4 November 2012, which was renewed as required in December 2015 and in December 2018
- A discharge permit granted to BMMC by EPA for discharges from the TSF, which is renewed on an annual basis and was recently renewed on 07 December 2018.

All the above approvals, with the exception of the Mining Licence, contain environmental and social conditions. In addition to the above approvals, BMMC has approvals for exploration, TSF operation and importation and handling of cyanide permits. A number of the environment and social management plans produced for New Liberty Gold Mine have been formally approved by government, are referred to in the MDA, environmental permit and/or discharge permit, and are in active use by the mine.

1.17.1.2 Key Environmental Issues

Key environmental issues at New Liberty Gold Mine include:

- Compliance with cyanide and arsenic criteria in water downstream of the TSF
- Interpretation of water quality impacts and implementation of pollution control measures
- Management of biodiversity impacts
- Ongoing delivery of social commitments, including support of resettled communities
- Active stakeholder engagement management
- Livelihood restoration and community development.

Ongoing work focuses on management and amelioration of these issues.

1.17.2 Ndablama deposit

BMMC plans to develop the Ndablama Resource Area by means of establishing an open pit and associated waste rock dump in the northeast of the license area. A haul road will be established to connect the Ndablama area to New Liberty Gold Mine which is located approximately 46 km to the west. All ore mined at the Ndablama pit will be processed at New Liberty Gold Mine, making use of the existing plant and associated infrastructure there.

Please refer to Figure 1-7 for the regional locality of the proposed development.

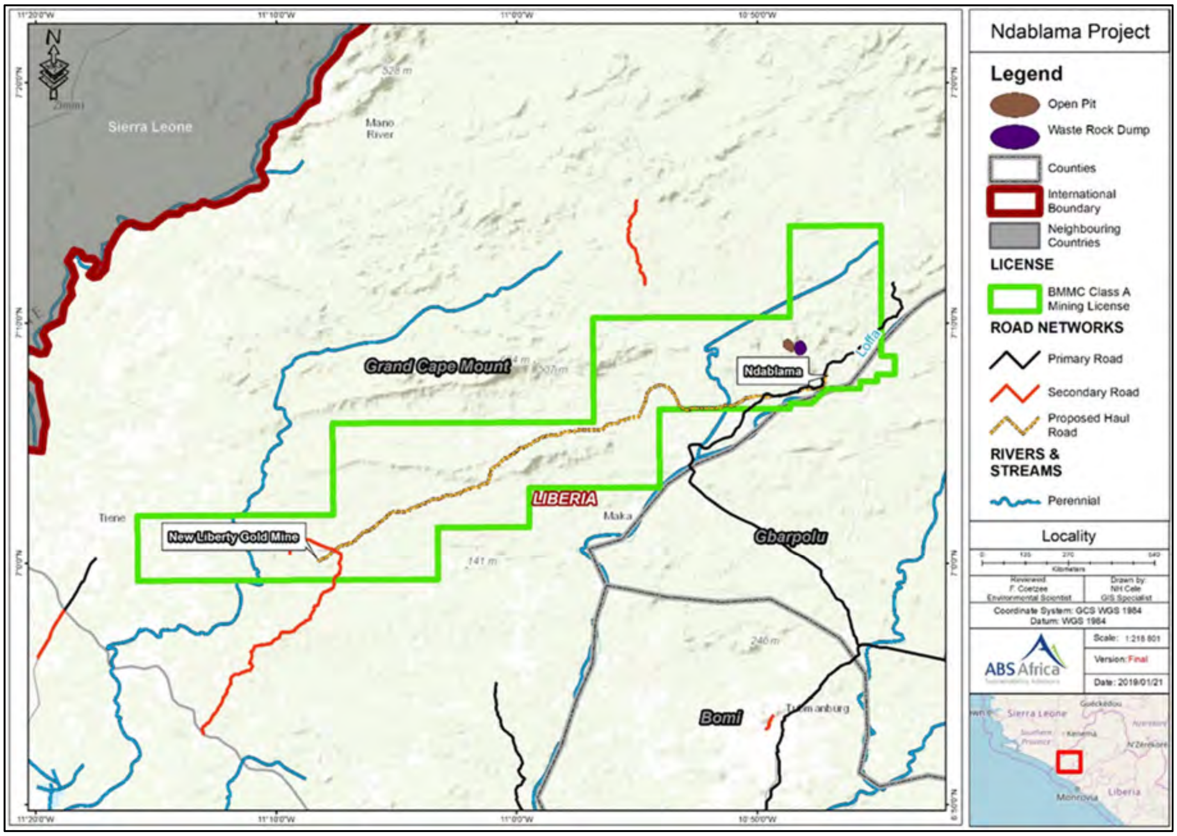


Figure 1-7: Locality and layout of the Ndablama Resource Area and associated haul road

1.17.2.1 Environmental Baseline

The topography ranges from around 50 m amsl to a maximum of 600 m amsl, with the majority of the licence area being composed of gently undulating plains at less than 200 m amsl, with two prominent east-west ridges of resistant rock units (the Bea Mountain and Tokani ranges). The Ndablama and surrounding area is dominated by low ridges. Elevations range between 150 m amsl and 350 m amsl.

The equatorial climate is hot year-round, with heavy rainfall from May to October. During the dry months of November to March, dry dust-laden Harmattan winds blow from the hinterland. Average annual rainfall along the coastal belt is over 4,000 mm and declines to 1,300 mm at the forest-savannah boundary in the north. Temperatures range from the low 20ºC during the rainy season to low 30ºC during the dry season.

The mean annual rainfall for Ndablama is 3,173 mm. The monthly rainfall for the following scenarios was calculated, a normal year, an average wet and an average dry year. The normal year is taken as the statistical average year, the dry year as the 30 percentile values and the wet year as the 70 percentile values.

Mean annual temperatures in Liberia range between 18°C in the northern highlands and 27°C along the coast. The climate is characterised by the constant high temperatures and abundant rainfall. Annual average temperature for New Liberty area is given as 26.3°C. The average daily maximum temperatures for the general project area range from 25.6°C in August and September to 28.2°C in April and May, with daily minima ranging from 24.8°C in July and August to 26.8°C in May.

The Ndablama Resource Area is located within the Lofa River catchment, with a basin area of approximately 10,612 km^2. The river originates in the neighbouring Republic of Guinea and generally flows in a south-westerly direction. Main sub catchments making up the Lofa catchment include Lawa River, Budulu Creek, Yambasei Creek and Mahe River. The key parameters associated with flow in the river is provided in Table 1-14 below:

Table 1-14: Flow data at Lofa Bridge Measuring Station

Description	Value
Mean flow	246 m^3/s
Mean annual catchment runoff	947 mm
Minimum daily flow	12 m^3/s, 16-03-2014
Maximum daily flow	1,401 m^3/s, 08-09-2013

Two aquifers occur in the area. Numerous springs occur in the area where daylighting of groundwater is evident and near the rivers and their many tributaries that drain the study area. Previous groundwater studies in the area, mostly at the New Liberty operations which are located in a similar environment and geological setting; do not provide an indication of the percentage rainfall recharge into the upper weathered material aquifer. For the purpose of this project, it is assumed that recharge will range between 1% and 5 % of the mean annual precipitation after taking into consideration evapotranspiration.

Groundwater flows in the lower aquifer are associated with the secondary fracturing in the competent rock and as such will be along discrete pathways associated with the fractures. Faults and fractures in the host geology (mainly ultramafics, granite, gneiss, and schist) can be a significant source of groundwater depending on whether the fractures have been filled with secondary mineralisation. In summary it can be said that the general transmissivity of this aquifer ranges between 1.4 m^2/day and 2.0 m^2/day.

Chloride concentration was found to exceed the WHO water quality guideline value of 0.7 mg/L. Nitrate concentrations at points PRSBH3 and PRSBH5 also exceed the WHO guideline value of 11.3 mg/L. Lead concentrations in five of the nine boreholes exceed the WHO guideline value. It is possible that these collectively originate from artisanal mining activities in the area.

1.17.2.2 Fauna and Flora

The proposed development is located within the Upper Guinean forests that extend from Senegal to Togo and are regarded as one of the biodiversity hotspots of the world. The Upper Guinean forests have a high degree of plant and animal endemism. Compared to Neotropical and Asian rainforests, African forests are characterised by much lower species richness, and contain fewer palm, epiphyte and understory species.

Approximately 254 bird species are expected to occur in the Ndablama Site, which equates to 41% of the approximate 615 species listed for Liberia as a whole. An estimated 145 mammal species may be expected to occur within the Ndablama Site. During the study, a total of 39 species were observed, with 26 species recorded in the dry season(D) and 32 species recorded in the wet season (W), representing 26% (total), 22% (W) and 18% (D) of the expected species respectively. A total of 26 amphibian species were observed in the dry season and 31 species in the wet season, representing 39% and 46% of the expected species respectively. A total of 11 reptile species were observed in the dry season and 18 species in the wet season, representing 11% and 18% of the expected species respectively. No vulnerable or endangered species were noted in the survey.

All the terrestrial disciplines considered the high and tall wet evergreen forest to be of very high sensitivity. The Lake Piso Multiple Sustainable Use Reserve is located in the Robertsport area approximately 57km from the project boundary. The Bong Mountain National Park is located to the east, with the Kpo Mountains National Park located to the northeast of the proposed development. No protected areas are located within the immediate vicinity of Ndablama.

1.17.2.3 Socio-Economic Baseline

The study area is characterised by several small agricultural villages and artisanal mining communities, with a marked distinction between those found in the north and north-eastern sections, versus those in the central and western corridor. Settlements and towns in the north and north-eastern portions of the study area, notably the villages and communities of Ndablama, Silver Hills, Weaju, and Leopard Rock were documented as predominantly artisanal mining communities.

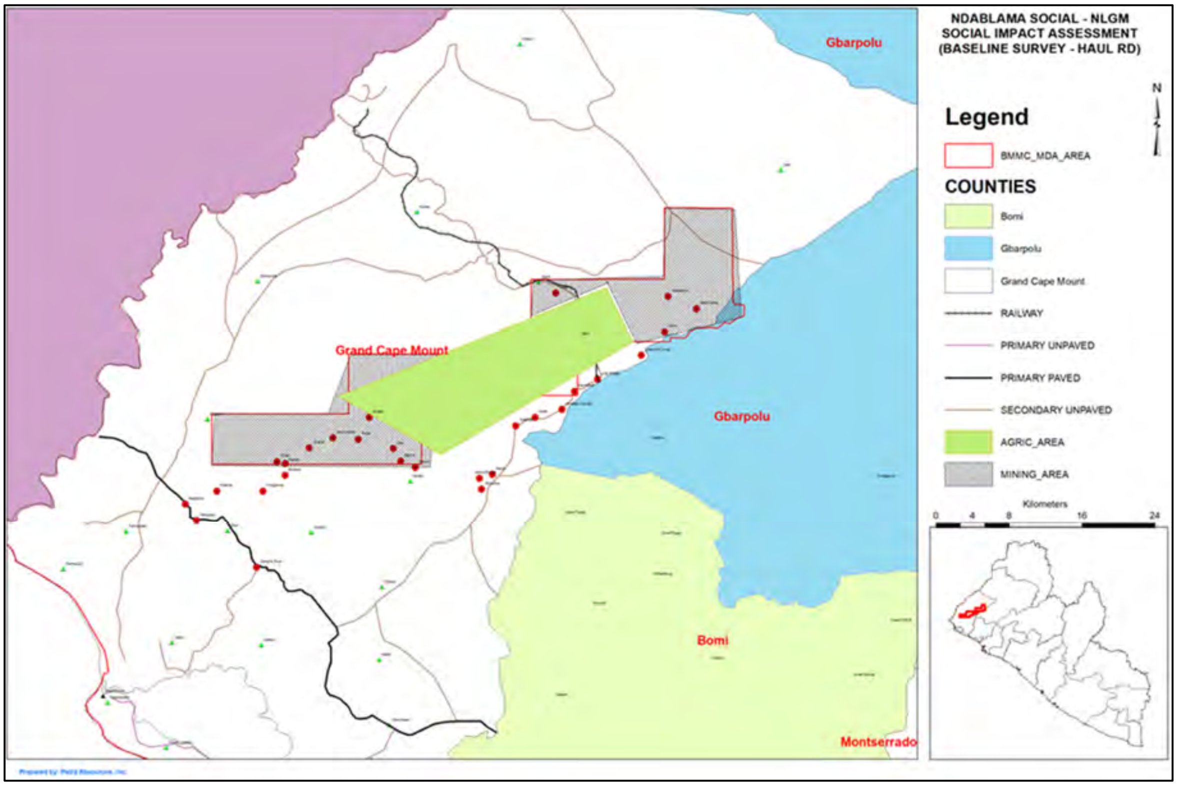


Figure 1-8: Map of study area showing mining and agricultural areas

The north and northeast areas have had a long history of artisanal mining activities which continue to this day as confirmed during the baseline survey. Some of the forest areas traversed during the exercise also reveal indications of ongoing logging and hunting activities for both domestic energy use, local construction, income generation and household dietary consumption. Notably, the artisanal mining villages in the north and northeast were also identified to be predominantly inhabited by Sierra Leoneans from the nearby neighbouring country which forms the western border with Liberia, approximately 45 km northwest of the study area.

Majority of the residents in the area, particularly in the central and western sections are subsistence farmers, with the exception of New Kinjor and Jawaji, where many are contracted or employed by the company.

The land capability rating ranges from moderate to low palatable grazing lands on the lower lying gently undulating to hilly land forms Haplic Alisols and Cambisols, to rough grazing and/or wilderness land on all the steeper and shallow rooting soils associated with the Lithic Leptosols and Regosols.

In addition to artisanal mining and subsistence agriculture, half of the surveyed households run some form of micro/small business. These include the sale of farm produce including rice, vegetables, oil, and fish usually transported via motorbikes to these areas. There are cases where some of these goods are traded in value for gold – especially within the mining villages.

1.17.2.4 Preliminary Assessment of the Environmental Impacts

The environmental and social impact assessment is currently being undertaken, with selected baseline studies completed to inform the engineering studies associated with the project. Studies are ongoing to quantify the environmental and social impacts associated with the proposed development.

Waste rock and ore will be drilled and blasted as part of the mining operations, generating dust and noise. Permanent, localised change in topography will occur due to the development of the open pit and mine residue deposits.

The impact on land use will primarily happen during the construction and operational phases of the project. Re-establishing farm fields in other areas will reduce the amount of other available land, potentially increase land values, and possibly increase pressure on undeveloped areas sources of agricultural land.

The development of the pit and associated WRD is expected to impact on the mean annual runoff of the affected sub catchment by reducing the MAR by approximately 8%.

It is anticipated that between 200 m^3/day and 600 m^3/day of water will be released from the Ndablama pit into the unnamed tributary of the Lofa River, made up of rainfall as well as ground water seeps. The expected discharge of water from the pit is not expected to have a significant impact on the mean annual runoff (MAR) of the affected Lofa River catchment, due to the high MAR of the catchment. The impact is not expected to be significant and will be limited to the immediate sub-catchment affected.

Clearing of vegetation during the construction and operational phase of the project will inevitably disturb the fauna habitat, shelter and food sources. The potential development of settlements along the major roads will result in increased crop cultivation and human-wildlife interactions due to animals raiding these food sources will also increase. The siting of infrastructure away from the natural habitat wherever possible, and progressive rehabilitation and reinstatement of disturbed areas could reduce the spatial scope and severity of the impacts.

The risk of accidents on the various access, haulage and construction roads, as well as increased human-wildlife contact due to improved access into the area, will increase. The potential development of settlements along the major roads could result in an increase in human-wildlife interactions due to animals raiding these food sources. The improved access to the Natural Habitat can also lead to increased hunting activities. Continuous environmental awareness raising, and training should aim at minimizing the impacts on fauna.

The development of various mine access, construction and haul roads, the siting of containment facilities such as the WRDs, as well as the construction of the open pit, will result not only in the loss of flora species and habitat, but also the secondary impacts of fragmenting/splitting habitats and loss of biodiversity.

The impact of the loss of biodiversity and habitat fragmentation will thus be permanent in certain areas. The severity of the impact is moderately significant, the spatial scope area specific. With proper mitigation measures, the overall post-mitigation impact significance can be reduced.

The current layout affects some critical habitat areas to the south of the pit, with design work ongoing to determine if the critical habitat can be avoided without affecting other sensitive receptors and community infrastructure. If the design cannot be changed to avoid affecting the critical habitat, a biodiversity offset would be considered as per the requirements of the Mitigation Hierarchy in Performance Standard 6 of the IFC's Performance Assessment. This offset will be aligned with the current Biodiversity Management Plan that is currently in place.

The development will require the removal of undisturbed vegetation from areas earmarked for infrastructure placement. The impact is expected to be of a moderate to high significance and limited to the project site. With careful infrastructure planning and continuous rehabilitation, the impact significance will be reduced.

The impacts of sediment deposition could affect aquatic habitats downstream of the proposed development. The proposed is likely to increase the pressure on aquatic resources because of increased harvesting of aquatic resources, clearing additional land for cultivation, increased abstraction, sanitation, washing, etc.

The proposed haul road between Ndablama and NLGM will cross several aquatic ecosystems. The impacts at each crossing are expected to have a small footprint, but the cumulative impacts of multiple crossings will have a larger footprint, which was rated as “local” in terms of the scoring system used to assess impacts.

PM and gaseous emissions will be released during the construction, operational and decommissioning phases of the project. Only the operational phase air quality impacts were quantified since construction and decommissioning phase impacts will likely be similar or less significant than the operational phase impacts. The significance of construction-related inhalation health impacts are considered low. Since fugitive dust from construction activities is easily managed, the significance of its impact could be reduced to very low if the management and additional mitigation measures recommended in the EMP are implemented effectively.

Greenhouse gas (GHG) emissions from the project are not likely to result in a noteworthy contribution to climate change on their own.

The increase in noise levels at nearby communities are expected to be limited.

The estimated vibration levels are based on waste blasting, which will generate the highest ground vibration amplitudes because the holes will be deeper than those applied to ore blasting. With proper mitigation measures, the blasting engineer will be able to control the vibration amplitudes so that they are lower than 7.5 mm/s at any building or structure. The project is, therefore, unlikely to impact neighbouring buildings and structures and the impact is, therefore, considered to be negligible.

Dust and fumes from blasting will be carried downwind from the blasting areas. Fumes (mainly nitrous oxides (red in colour) and carbon monoxide) disperse very quickly into the atmosphere, and will not pose a risk to people or animals at distances greater than approximately 1,000 m. At distances closer than this, there is a risk to people’s health, and this will fall into the occupational health category.

The proposed development is not expected to directly impact any of the heritage or archaeological sites, provided that the mitigation measures are implemented effectively.

1.17.3 Preliminary Assessment of the Socio-Economic Impacts

1.17.3.1 Socio-Economic

The following potential social and economic impacts have been identified as part of the assessment and will be confirmed and assessed as part of the Social and Environmental Impact Assessment for the project:

- Migration and urbanisation.
- Increase in social tension/conflict.
- Decrease of cultural cohesion and traditional customs and structures.
- Economic displacement. The loss of gold washing areas in the Ndablama area the impact is considered significant, especially in the areas directly affected by the mine infrastructure and associated facilities. While the artisanal miners do not have a legal right to mine in the Ndablama area, the development of the pit and associated WRD will prevent future access to the current workings. It is anticipated that the majority will relocate to nearby areas not currently earmarked for development.

- Loss of agricultural resources: Along the haul route some cultivated fields and plantations may be affected during the construction phase. The impact is considered limited, provided that mitigation measures are implemented.
- Degradation of conditions of access to natural resources.
- Inequalities in socio-economic structures.
- New economic opportunities.
- Diseases and the risk of transmission of HIV/AIDS.
- Opportunities available via the community development plant.
- Erosion of the traditional culture and loss of identity.
- Local residents will be affected by temporary, and in some cases permanent, elimination of common property resources, including natural resources occurring in the Project area. Elimination of agricultural fields and subsistence produce could threaten food security and place increased pressure on vulnerable populations as well as women to fulfil their expected role within the household, while simultaneously reducing their ability to do so through reduced access to agricultural land. Conflict could arise from increased competition for productive land and common property resources.

1.17.3.2 Resettlement, Economic Displacement and Impact on Agricultural Resources

The development will result in the economic displacement of some artisanal miners that are currently working within the development footprint and associated safety buffer. Farmers whose agricultural assets are affected will be assisted with the obtaining of alternative land to work as well as provided with compensation for the loss of the agricultural assets and cash crops.

An asset survey identified a number of facilities and structure along the haul route corridor that need to be taken into consideration during the detail design and alignment of the haul route from Ndablama to New Liberty Gold Mine.

The main facilities identified within the development footprint area include:

- Pits with associated mini-crushers
- Gold washing facilities in the local drainage lines
- Temporary shelters constructed from wood and tarpaulin
- Hand dug wells
- Cultivated fields.

Mitigation will be undertaken in terms of the relevant Liberian legislation, which includes the following key elements:

- Determining eligibility for compensation and resettlement assistance, including livelihood restoration initiatives.
- Approach to land access and management.
- Establishing rates of compensation. Standard compensation rates (set by the Government) will be used for agricultural crops and trees.
- Establishing mechanisms to resolve grievances among affected persons related to compensation and eligibility.

International best practice guidelines will also be taken into consideration during the detailed planning and implementation phases, which include the IFC's Performance Standards and the World Bank Group's Operational Policies.

1.17.4 Environmental and Social Management Plan

As part of the ESIA for the Ndablama deposit an Environmental and Social Management Plan (ESMP) will be developed. The role of the ESMP is to assist BMMC in reducing potential impacts and risks and achieving its environmental objectives as well as fulfilling its commitment to the environment. The ESMP will be used to ensure compliance with environmental specifications, monitoring and management measures. The ESMP will be implemented from site preparation through to decommissioning and closure.

With the appropriate mitigation measures implemented, impacts associated with the Project can be mitigated to an acceptable level. Social impacts relating to procurement of local goods and services and access and mobility, are considered to be positive impacts. The Project, with suggested mitigation measures, will enhance the socio-economic environment of the Ndablama study area.

A public consultation and disclosure process is currently underway as part of the Environmental and Social Impact Assessment and associated permitting process for the Ndablama deposit. The approach to consultation and disclosure is informed by IFC PS 1 (IFC, 2012) as well as the host country legislation. A Stakeholder Engagement Plan (SEP) was developed as part of the EMS at NLGM by BMMC. A new stakeholder engagement plan (SEP) and a grievance mechanism as implemented by BMMC, and by which stakeholders may communicate their concerns and comments on the project have been issued in 2018 and a recording and tracking system for all engagements and grievances have been implemented. Both the SEP and grievance mechanism have been operationalised and regular planned engagements are taking place.

National and international experience shows that mining communities, such as that will be created by the Project, are vulnerable to socio-economic contraction after mine closure. Negative impacts include loss of employment, decreased demand for goods and services, out-migration of community residents, and potential for reduced community well-being. Many of these impacts are unavoidable, but mitigation measures can reduce the severity, such as proper planning and scheduling, skill transfer and alternative skills development projects, severance packages, and local alternative economic development, all of which are planned for the project.

1.18 Capital Cost Summary

A capital cost summary for costs related to the New Liberty Project, to WBS tier 4, is presented in Table 1-15.

Table 1-15: Capital cost summary – New Liberty

Area	Project capital	Sustaining capital	Total
Site and Local Infrastructure	**1,301,940**	**-**	**1,301,940**
Utilities and Reticulation	1,301,940	-	1,301,940
Permanent Power Supply	*1,301,940*	-	*1,301,940*
Open Pit Preparation	**1,351,851**	**4,465,555**	**5,817,407**
Infrastructure	1,157,046	2,541,556	3,698,602
Pit Dewatering	*917,837*	*2,005,747*	*2,923,584*
Pit Electrical Reticulation	*239,209*	*535,809*	*775,018*
Pit Preparation	194,805	1,923,999	2,118,805
Cemented Crown Pillar	*194,805*	*1,599,999*	*1,794,805*
Pit Backfill	-	*324,000*	*324,000*
Underground Mining	**9,812,859**	**35,813,319**	**45,626,178**
Mining	8,798,161	32,541,813	41,339,973
High Wall Support	*27,975*	*27,975*	*55,950*
Level Development	*2,643,664*	*12,171,812*	*14,815,476*
Portal	*72,342*	*72,342*	*144,684*
Ramp Development	*5,482,403*	*18,398,604*	*23,881,007*
Ventilation Raise Development	*571,777*	*1,871,080*	*2,442,857*
Facilities and Services	653,511	2,059,385	2,712,896
Dewatering Pump Stations	*224,242*	*752,544*	*976,786*
Escape Ladderways	*20,239*	*67,921*	*88,160*
Lubrication Station	*15,134*	*50,788*	*65,922*
Refuge Bays	*11,508*	*38,620*	*50,128*
Ventilation Controls	*6,600*	*22,150*	*28,750*
Ventilation Fans	*375,788*	*1,127,363*	*1,503,151*
Utilities and Reticulation	361,187	1,212,121	1,573,308
Communications, Control and Instrumentation	*62,726*	*210,504*	*273,229*
Dewatering Reticulation	*78,398*	*263,098*	*341,496*
Electrical Reticulation	*10,631*	*35,676*	*46,307*
Fire-Suppression	*63,444*	*212,913*	*276,357*
Potable Water Reticulation	*35,078*	*117,718*	*152,796*
Service Water Reticulation	*110,911*	*372,212*	*483,123*
TOTAL	**12,466,650**	**40,278,875**	**52,745,524**

A capital cost summary for costs related to the Ndablama deposit, to WBS tier 4, is presented in Table 1-16.

Table 1-16: Capital cost summary – Ndablama

Area	Project capital	Sustaining capital	Total
Site and Local Infrastructure	**14,349,973**	**3,000,000**	**17,349,973**
Facilities and Services	**1,875,245**	**-**	**1,875,245**
Changehouse	311,340	-	311,340
Diesel Storage and Dispensing	509,271	-	509,271
Mine Offices	229,322	-	229,322
Mine Workshop	215,986	-	215,986
Sewage Treatment Plant	319,797	-	319,797
Stores	289,529	-	289,529
Site Preparation	**12,253,170**	**3,000,000**	**15,253,170**
Earthworks and Terracing	2,253,170	-	2,253,170
Haul Roads	10,000,000	3,000,000	13,000,000
Utilities and Reticulation	**221,559**	**-**	**221,559**
Site Water Reticulation	221,559	-	221,559

Additionally, Processing and Tailings, Project General & Administration (G&A) (study and engineering cost), plus contingency contribute to a final overall capital cost estimate of $105,996,975 (Table 1-17). All costs are in 2019 US$, estimated to ±25% based on bills of quantities and recent quotations or estimates from similar projects. A contingency of 10% has been allowed.

Table 1-17: Overall capital cost summary

Area	Project capital	Sustaining capital	Total
New Liberty	12,466,650	40,278,875	52,745,524
Ndablama	14,349,973	3,000,000	17,349,973
Processing and Tailings	3,538,314	7,375,687	10,914,001
General and Administration	2,319,046	13,032,342	15,351,388
Contingency	3,267,398	6,368,690	9,636,089
Total	**35,941,382**	**70,055,594**	**105,996,975**

1.19 Operating Cost Summary

1.19.1 New Liberty Operating Costs

Operating costs assessed for New liberty include open pit mining costs, underground mining costs, processing cost (including tailings), and G&A. Costs are summarised in Table 1-18.

Table 1-18: Operating cost summary – New Liberty

Area	LOM operating cost	Cost per tonne milled	Cost per ounce recovered
G&A	**75,095,822**	**4.40**	**59.63**
Tech Services Labour Compliment	4,337,970	0.25	3.44
Open Pit G&A Cost	70,757,852	4.15	56.18
Mining	**341,352,232**	**20.00**	**271.03**
Open Pit	162,387,856	9.51	128.94
Ore Mining	*9,185,429*	*0.54*	*7.29*
Waste Mining	*153,202,427*	*8.98*	*121.64*
Underground	178,964,376	10.48	142.10
Ore Development	*63,606,133*	*3.73*	*50.50*
Stoping	*115,358,244*	*6.76*	*91.59*
Processing	**199,452,977**	**11.69**	**158.37**
Ore Processing	199,452,977	11.69	158.37
TOTAL	**615,901,031**	**36.08**	**489.03**

1.19.2 Ndablama Operating Costs

Operating costs assessed for Ndablama include open pit mining costs, haul costs to New Liberty, processing cost (including tailings), and G&A. Costs are summarised in Table 1-19.

Table 1-19: Operating cost summary – Ndablama

Area	LOM operating cost	Cost per tonne milled	Cost per ounce recovered
G&A	**52,651,213**	**3.08**	**41.81**
Open Pit G&A Cost	52,651,213	3.08	41.81
Mining	**105,904,334**	**6.20**	**84.09**
Open Pit	105,904,334	6.20	84.09
Ore Mining	*19,623,492*	*1.15*	*15.58*
Waste Mining	*86,280,842*	*5.05*	*68.51*
Processing	**191,743,630**	**11.23**	**152.24**
Ore Processing	148,413,793	8.69	117.84
Ore Transportation	43,329,837	2.54	34.40
TOTAL	**350,299,177**	**20.52**	**278.14**

All costs are in 2019 US$. Since a significant portion of the operating cost estimate is based on current or factored operational costs from the New Liberty operations, in addition to contractor quotations for the underground mine, it is accepted that no contingency allowance is required for the operating cost estimate.

1.20 Closure Provisions and Cost

1.20.1 New Liberty

New Liberty is an existing open pit mine with process plant and associated surface infrastructure including waste dumps, tailings dam, offices, stores and camp. Provision for closure is of course a key environmental obligation, for which a closure plan was produced in 2013 by Digby Wells Environmental (2013b). The plan was presented in the ESMP within the 2013 ESIA and has, therefore, effectively been approved by the EPA.

The following closure objectives form part of the conceptual closure plan:

- All structures not desirable or usable post-closure will be demolished and building material removed or disposed of.
- Hazardous material, equipment and contaminated soils and steel structures will be disposed of safely and in an environmentally acceptable manner.
- Areas used for the handling and storage of hazardous materials will be decontaminated.
- Disturbed areas will be rehabilitated to a final land use capability that is practical and best suited for the final landform, taking into consideration the socio-economic activities of the receiving communities.
- At the end of the mine life, the residual facilities will include open pits, WRD, diversion structures and supporting infrastructure.
- The ultimate end use of the rehabilitated areas is considered to have three major objectives:
  - Re-establishment to the greatest feasible degree of vegetation on the disturbed areas within the concession
  - Re-integration of the disturbed areas outside the project footprint into the agricultural and other prevalent economies
  - Re-development of the disturbed land by working with and involving local people to assist them in working towards a more sustainable form of livelihood.

The closure cost estimate based on the 2013 closure plan is US$10.0 million and is provided in the capital estimate above.

1.20.2 Ndablama

During the planning and implementation stages of the mining project, the focus of reclamation and closure planning is to ensure that:

- The proposed post-closure land use(s) for the site are defined and agreed with the regulatory authorities and local communities
- The nature, scale and cost of the works required to return the site to a condition consistent with the requirements of the post-closure land use(s) are defined and understood
- The necessary financial provisions are made for closure and that these are included in the assessment of the project's economic viability
- A plan is developed for the implementation of the reclamation and closure works to ensure that the process proceeds concurrently with mining operations wherever possible
- The build-up in reclamation and closure liabilities over the LOM is limited through appropriate mine planning and concurrent reclamation to mitigate as far as possible the impacts of premature or unplanned closure.

The framework within which the conceptual reclamation and closure plan has been developed is described below in terms of the following:

- LOM plan
- Policy guidelines and legislative requirements
- Post-closure land use objectives.

1.20.2.1 Life of Mine Plan

The study confirms the need to develop the following:

- Open pit
- WRDs
- Stormwater diversions
- Mine Services Area including workshops, offices
- Contractors camp including messing and sanitation facility
- Internal roads and haul road to New Liberty Gold Mine.

Existing infrastructure at New Liberty Gold Mine that will be used include the processing plant, TSF, accommodation camp, offices and workshop, as well as associated structures and equipment.

1.20.3 Post-Closure Land Use Objectives

The following closure objectives form part of the conceptual closure plan:

- All structures not desirable or usable post-closure will be demolished and building material removed or disposed of.
- Hazardous material, equipment and contaminated soils and steel structures will be disposed of safely and in an environmentally acceptable manner
- Areas used for the handling and storage of hazardous materials will be decontaminated.
- Disturbed areas will be rehabilitated to a final land use capability that is practical and best suited for the final landform, taking into consideration the socio-economic activities of the receiving communities.

- At the end of the mine life, the residual facilities will include open pits, WRD, diversion structures and supporting infrastructure.
- The ultimate end use of the rehabilitated areas is considered to have three major objectives:
  - Re-establishment to the greatest feasible degree of vegetation on the disturbed areas within the concession
  - Re-integration of the disturbed areas outside the project footprint into the agricultural and other prevalent economies
  - Re-development of the disturbed land by working with and involving local people to assist them in working towards a more sustainable form of livelihood.

1.20.3.1 Financial Provision for Closure

The financial provision requirements associated with the proposed development were calculated for the concurrent, decommissioning, closure and post-closure phases of the proposed development. The closure cost estimate for New Liberty based on the 2013 closure plan is US$10.0 million. The total financial provision requirements for Ndablama have been estimated at $2,500,000 to cater for closure and remediation task described above. A total closure provision of $12,500,000 for both sites is therefore included in the capital estimate.

1.21 Market Studies

1.21.1 Background

Bea Mountain Mining Corporation is an existing producer and seller of gold. Good historical data for realisable gold prices therefore exists, and no market study specifically for this PFS was undertaken. Avesoro typically sells gold on the spot market, with an average realised gold price in 2018 of $1,275/oz versus an average of $1,268/oz. A flat gold price of $1,300/oz for near-term and long-term future price assumptions is used.

1.21.2 Market Analysis

Analysis of market forecasts supports the price assumptions for the PFS. A recent survey of analysts forecasts by the London Bullion Market Association suggests a 1.8% gain in the gold price in 2019 over 2018 for an average of $1,290/oz in the year (Els, 2019). The London Bullion Market Association itself predicts an average gold price of $1,311, a high of $1,475 and a of $1,150 (LBMA, 2019) The average gold price to date in 2019 was $1,304.11/oz.

1.21.3 Summary

A long-term gold price projection of $1,300/oz for this PFS is considered reasonable on the basis of actual gold prices realised by Avesoro in past periods, and consensus projections for the long-term gold price above this threshold across a range of analyses.

1.22 Economic Analysis

The decision to transition to underground mining operations and incorporate contributions from the satellite deposit at Ndablama shows a significant positive impact on the value of New Liberty and the economics of the Mine.

Table 1-20: Updated Mineral Reserve estimate, prepared in accordance with CIM Standards

Mineral Reserves estimate for the New Liberty Gold Mine Liberia, as at 31 December 2018										
Deposit	Cut-off grade (g/t)	Proven			Probable			Total Ore Reserve		
		Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)
New Liberty Open Pit	0.80	0.216	1.65	11	4.701	3.19	482	4.917	3.12	494
New Liberty Underground	2.00	0.084	3.36	9	4.575	3.07	452	4.659	3.08	461
Ndablama Open Pit	1.00	0.00	0.00	0.0	7.282	1.71	400	7.282	1.71	400
Total (excluding Stocks)		**0.300**	**2.13**	**21**	**16.559**	**2.51**	**1,334**	**16.859**	**2.50**	**1,355**
New Liberty ROM Stockpiles (LG, MG, HG)					0.210	1.47	10	0.210	1.47	10
Total (including Stocks)		**0.300**	**2.13**	**21**	**16.769**	**2.49**	**1,344**	**17.069**	**2.49**	**1,365**

Average forecast annual gold production is approximately 114,500 ounces over an 11-year LOM (2019 to 2029) for total production of 1,200,000 ounces. Mining costs are estimated at $1.71/t for New Liberty open pit, $45/t for New Liberty underground, and $1.71/t for Ndblama, plus processing cost at New Liberty of $20.81/t and G&A of $7.23/t. Resulting average LOM operating cash costs are US$767/oz with all-in sustaining cash costs of US$862/oz. Total development capital cost is US$35.9 million, with sustaining capex of a further US$66 million.

Key LOM financial metrics are shown in Table 1-21

Table 1-21: Key LOM financials

Parameter	Unit	LOM total
Pre-Tax Project NPV[1]	US$M	411
Post-Tax Post Debt NPV[1,2]	US$M	286
Free Cash – LOM [2]	US$M	370
LOM Operating Cash Cost	US$/oz	767
LOM AISC	US$/oz	862

Notes:
[1] At 5% discount rate and US$1,300/oz Au price.
[2] After tax and all debt repayments and associated finance costs.

Post-tax NPV is US$286 million at a 5% discount rate and US$1,300/oz gold price (after debt repayment and associated finance charges). LOM free cash generation is US$370 million.

1.23 Risk Assessment

A risk analysis for the New Liberty 'Combined' Project was carried out between 15 March 2019 and 25 March 2019. Additional risk items and mitigating actions relating to environmental and community issues were drawn in from an independent exercise by ABS Africa, the Environmental Consultant to the client for the proposed open pit at Ndablama as well as the haul road from Ndablama to New Liberty.

Objectives of the risk assessment were to identify and extant risks to the project as described in this Preliminary Feasibility Study, to assign likelihood of occurrence and consequence of occurrence to the risk and therefore assess overall level of risk to the project from Low (1) to High (5).

1.23.1 Risks

Key risks to the project were categorised in the areas of geological/resource risk, risk relating to open pit mining (at New Liberty and Ndablama), risk to underground mining at New Liberty, metallurgical/product risk, and social/environmental risk. Market risk and management risk were identified and quantified as part of this overall process.

1.23.2 Geological Risk

Geological/resource risks assessed included a lack of a structural model or data for the deposits, with risk of additional geological loss over those already assessed, plus additional hydrogeological risk from lack of structural knowledge as well. High levels of spatial grade variability in the Ndblama deposit was flagged as a risk, with risk to the eventual metal produced.

1.23.3 Mining Risk

Mining risk identified included the following:

- Risk that mining dilution and loss factors are higher than those allowed in the modifying factors
- Challenges in grade control, relating to the highly variable, nuggety nature of the deposits
- Risk of delay to the timing of the start of the underground at Kinjor
- Pit slope instability is an identified risk at New Liberty in particular for current open pit operations
- Crown pillar failure, relating to risk of flooding in the underground mine as well as loss of access to the underground mine was flagged as a high-risk item
- Risk that the proposed mining contractor performs poorly was identified as a medium risk.

No material metallurgical or product risk, considering all mitigating factors available, was identified.

One key operational risk not covered in mining was potential for disruption of the haul route between Ndablama mine and New Liberty mill interrupting production.

Several social and environmental risks had already been identified for the New Liberty operation. Additionally, risks relating to mining operations at Ndablama were freshly identified by the environmental consultant, including vulnerable fauna species incident on the property; risk of exceeding other water monitoring parameters downstream of New Liberty; significant stakeholder/community relations risk.

1.23.4 Market Risk

No significant market risk was identified.

1.23.5 Risk Mitigation

Mitigating actions to geological/resource risks identified include additional core logging, structural mapping, and modelling; remodelling of the Ndablama deposit with respect to grade variability in combination with infill drilling to improve confidence; and best practice grade control during operations as already practiced at New Liberty pit.

Mitigating actions to mining risk include validating contractor requirements with close owner supervision of contractors; best practice slope control as well as advanced blast design and explosive selection to reduce overbreak and maintain slope stability; improved modelling of surface flows, as well as geological structure controlling groundwater flows to the pit as well as underground workings; best practice design for artificial support of the crown pillar and appropriate sequencing of stopes. All risks barring crown pillar risk are mitigated to medium-low risk, where risk relating to the crown pillar design remains medium-high.

Mitigating actions for social/environmental risks include continuing existing water quality monitoring and control programs; a well-designed livelihood development plan at New Liberty and a resettlement action plan (RAP) for Ndablama plus best practice stakeholder community relations management; continued implementation and monitoring of the Environmental, Social Health and Safety Management Plan (ESHSMS) further mitigates risk to medium-low.

1.24 Conclusions

1.24.1 Data

Avesoro do not have a robust data management system in place, instead they rely on Microsoft Excel spreadsheets which results in multiple versions of the 'database' with no centralised point of truth. However, once validation issues were resolved, the compiled databases are suitable for downstream work.

Sample security both New Liberty and Ndablama appears adequate and sample preparation and analytical techniques for both the pre-2013 drilling (prior to Avesoro's ownership) and the post 2013 drilling are mostly appropriate with no fatal flaws noted. Implementation of QA/QC procedures could be improved.

1.24.2 Mineral Resources

At Ndablama, there is a very high variability in grade within the main mineralised domain, which adds risk to the eventual metal predicted. The high-grade gold zones contain nuggety gold – which are irregular in occurrence, and difficult to predict. There is a risk that high grade gold continuity has been overstated in the estimate.

For reporting purposes, using reasonable assumptions to support the criteria that Mineral Resources must have the potential for eventual economic extraction, the New Liberty Mineral Resource has been constrained for Open Pit (OP) within a US$1,300 pit shell and reported at 0.80 g/t Au cut-off, and for Underground Mining (UG) below the US$1,300 shell, within stope volumes based on a US$1,500 gold price optimisation at 1.90 g/t cut-off (reported at no cut-off). The Ndablama Mineral Resource has been constrained within a US$1,500 pit shell reported at 0.85 g/t Au cut-off.

1.24.3 Mining and Reserves

Mining activity for the Combined Project will include open pit mining of the New Liberty deposit until the break-even cutoff for underground mining is reached, a transition to underground mining by portal and ramp access followed by mining of reserves between the $1,300 pit shell (pit 33) and the $1,500 pit shell by long hole open stoping (LHOS) methods, with open pit mining of the reserves at the Ndablama deposit and direct shipping of Ndblama ore to the New Liberty mill later in the life of the project.

The detailed mine design for New Liberty pit was based on the selected pit limit (Pit 33) from the optimisation work and utilised the existing interim pit stages (Stages 1, 2 and 3) that are currently being mined. An additional pit stage (Stage 4) was added to smooth out the waste stripping over the remaining life of the open pit. Initial stages are as at Kinjor and Marvoe presently. Ultimately mining will be continued until the present planned Pit 33.

A pit optimisation for the Ndablama deposit was run using Datamine's NPV Scheduler (NPVS) software. This uses the standard Lerch Grossman (LG) algorithm. The starting surface for pit optimisation was the original surface topography as no mining has taken place in the pit area as yet. A total of four pit stages were designed based on the optimised pit shells generated by NPV Scheduler. Each pit stage was designed to have at least 1 Mt of ore and the initial stages target the blocks with the highest value.

A transition to underground mining is considered strategic for the operation in order to overcome limitations associated with the deposit geometry and dip in accessing deeper reserves. The transition to underground mining at New Liberty was determined by assessing the breakeven cut-off between current open pit mining approaches and underground methods. For that assessment, the pit increments between current Pit 33 and Pit 46 shells were studied and traded off versus the cost and outputs of the underground approach. While an economic trade off was performed, using open pit mining costs of US$1.9/t, and underground mining cost of US$45/t, other factors were identified in the trade-off that drive the decision to go underground. The overriding factor was the practicality of increasing the mining rate for open pit mining, which becomes increasingly restricted, as well as practical limits on vertical sinking rate driven by the geometry and orientation of the New Liberty orebody.

Access to the orebody below the current open pits will be from within the pits. Separate portals will be developed in the Larjor and Kinjor pits providing access to the orebodies. Trucking ramps or declines will be developed from the portals, which will be established on the footwall side of the open pits, into the footwall of the orebody. The ramps will spiral down providing access to all main and sublevels in the mine. In order to access the ore blocks that remain outside strike of the final pit shells, but above the elevation of the portals, ramps will be developed up to the levels above.

The trucking ramp will be located in the footwall of the orebody, at a minimum of 30 m from the footwall contact, as per the recommendation in the geotechnical report.

Access to the orebody will be established every 20 m vertically, by means of a level crosscut. The dimensions of the level crosscut will be 5.0 m x 5.0 m. Between the decline and the orebody intersection two stub drives of 15 m length will be established, one left and one right. These will initially be used as muckbays. These will later be used to house infrastructure such as pump stations, dams and electrical switchgear. A set of return ventilation raises will be established between levels, which link up to an upcast vent raise, holing to surface and which will be equipped with the main fans. The level to level ventilation raises, which will be developed by drop raising techniques, will be located in one of the stub drives. Where required this drive will be extended to provide access to the required location of the ventilation raise. Ore drives will be established in the strike direction from the level access crosscut advancing to the limit of the orebody. Where multiple zones are present, which separated by a suitably sized pillar, minimum pillar width of 8 m, multiple drives will be established.

The average dip of the orebody is approximately 60 degrees, with local variations in dip ranging from near vertical to around 40°. The orebody consists of a number of veins, generally parallel to each other. Mineralisation can occur in more than one of the veins, creating the potential for multiple parallel stopes in some parts of the deposit. The widths of the mineralised zones range from 2 m to 30 m, with an average width of 10 m. Rock conditions are described as generally good. The preferred mining method at New Liberty was selected as a variation of long hole open stoping. In order to reduce loss of valuable ore to pillars, consideration was given to the installation of a cemented waste rock layer on the floor of the stope to create an engineered sill pillar and thereby negate the need for sill pillars. The inclusion of this engineered, cemented, waste rock pillar reduces the pillar loss in the waste rock fill option to from 41% to 27%.

1.24.4 Water Management

1.24.4.1 New Liberty

Site investigations indicate that the New Liberty site is underlain by a layer of moderate permeability highly weathered rock (saprolite/saprock) of varying thickness. The weathered rock is underlain by typically low permeability fractured bedrock with localised areas of enhanced permeability where water bearing fractures/faults exist. The permeability of the fractured bedrock appears to decrease with depth. Shallow groundwater flows occur through the saprolite/saprock layer and preferentially through permeable fracture zones within the fresh rock.

The groundwater level is typically less than 10 mbgl and generally 65 mRL to 75 mRL. The commencement of mining and associated pit dewatering does not appear to have significantly impacted groundwater levels in any of the current groundwater monitoring drillholes. The groundwater is generally acidic with some elevated metals concentrations.

The Marvoe Creek Dam is a large body of water which has the potential to act as a large water source, recharging any zones of enhanced permeability hydraulically connected between the dam and the current open pits and the proposed underground mine.

New Liberty Open Pit Inflows

Predicted inflows and dewatering estimates were previously completed for the New Liberty open pits in 2013 (pre-mining) based on the then proposed mine plans and available data. There is currently insufficient data to confirm the current pit dewatering rates/volumes or to validate the previous pit dewatering predictions.

In November 2018, it was observed that the Larjor Pit contained a significant volume of water, while saturated pit floors were observed at both the Kinjor and Marvoe Pits. Significant water volumes were observed flowing into the three pits from external pit catchments and/or shallow weathered units. Near surface inflows were particularly prevalent along the entire northern perimeter of the three pits and at the western side of the Larjor Pit. Significant discrete inflows were also observed associated with geological structures evident in the pit walls in each of the three pits (e.g. the main ore bearing shear zone, the Marvoe Creek Fault and numerous other faults/fractures). Potential groundwater and surface water pit inflows were predicted for the proposed final New Liberty open pit. Generally, the structurally related inflows will reduce in magnitude rapidly, although long term localised inflows could potentially occur where the open pit intercepts a structure with a direct link to an overlying water body. Localised structurally related inflows may increase during the wet season and may reach the initially encountered higher inflow rates during prolonged wet periods.

Currently two primary diversion drains capture runoff from parts of the waste dump and surrounding area and convey the runoff to the west and south of the pits and waste dumps. The predicted surface water inflows from the remaining surface water catchments that drain into the proposed open pits range from approximately 560,000 m^3 to 715,000 m^3 (dry year to wet year) for Larjor Pit and approximately 1,920,000 m^3 to 2,455,000 m^3 (dry year to wet year) for Pit 33.

New Liberty Underground Inflows

The bulk groundwater inflows into the underground mine are predicted to be generally low with average inflows predicted to be in the order of 1–2 L/s for each stage of development (each lobe) of the underground mine. These are average bulk inflow values and inflows will be higher at times of rapid advancement (especially with respect to depth) and lower when the area has been actively mined for an extended period of time.

Structurally related inflows are predicted to be in the order of 2–5 L/s. These structurally controlled inflows are predicted to reduce in magnitude rapidly, although long term localised inflows could potentially occur where the underground mine intercepts a structure with a direct link to an overlying water body or saturated overlying shallow sediments. In the wet season, enhanced localised structurally related inflows into the underground mine may temporarily increase again. The location of these structurally related enhanced inflows will directly correspond with where the underground mine intersects significant structures. Cover drilling ahead of underground mining should be considered in order to provide advanced warning of potential localised structurally controlled inflows.

Dewatering associated with open pit development and the underground mine will result in the water table being drawn down in the vicinity of the pits and underground mine. The cone of depression is predicted to be steep and narrow with its extent constrained to the north and west by the presence of the Marvoe Creek Dam and the Marvoe Creek diversion channel respectively and greater water level drawdown to the east and south where there are no significant recharge sources.

Water levels within the two mine site water supply wells are predicted to be drawdown as a result of the dewatering from the open pits and underground mine. However, these wells are located close to the Marvoe Creek Dam and so the actual drawdown in the wells is likely to be significantly less than predicted due to recharge from the dam. The water level within the village wells is not predicted to be impacted as a result of the dewatering from the open pits and underground mine. The wetland area down gradient of the TSF is not predicted to be impacted by the groundwater level drawdown as a result of dewatering.

The New Liberty site is an operating mine site, with an existing surface water management plan in place to manage surface water associated with the mine until the cessation of open pit mining. The current design of the southern waste dump appears to encroach on the drainage channel around the eastern pit perimeter but will be redesigned as part of the subsequent Definitive Feasibility Study (DFS).

1.24.4.2 Ndablama

Site investigations completed at Ndablama pit indicate that the site is underlain by a layer of highly weathered rock (saprolite) and in some area a transition zone consisting of saprock. This weathered zone is underlain by competent bedrock where groundwater flow is predominantly associated with secondary fracturing.

The competent fresh bedrock is considered to generally have a lower average permeability than the weathered material as there are relatively few structures with enhanced permeability within the competent rock.

Measured groundwater levels generally range between artesian and 7 mbgl. Groundwater levels in the Ndablama deposit area mimic topography with groundwater flow generally from the elevated hills towards the low-lying streams and groundwater gradients generally range between 1:15 and 1:40.

The groundwater quality of samples collected within the Ndablama study area indicates exceedances of the World Health Organisation drinking water quality guidelines for chloride, nitrate, lead, manganese and mercury.

Shallow groundwater flows will occur laterally down gradient along the weathered/unweathered contact (transition zone) and may discharge as springs or seepage into the various streams and rivers that exist in the Ndablama area. The degree of saturation of the weathered saprolite/saprock will fluctuate seasonally depending on rainfall recharge during the wet season and it is possible that some areas of the weathered zone will be completely dry during the dry season.

Groundwater inflows into the Ndablama open pit were predicted at various stages of mine development and were predicted to vary from approximately 1 L/s (construction) to 8 L/s (end of Stage 4).

Potential annual surface water inflows into the Ndablama Pit for Stage 1 range from approximately 200,000 m^3 to 260,000 m^3 (dry year – wet year) for Stage 4 from approximately 640,000 m^3 to 845,000 m^3 (dry year – wet year).

There is scope to reduce the external catchment area draining to the Ndablama pit in the earlier stages of development and this should be optimised during the DFS in conjunction with the surface water management in the vicinity of the pit.

During the construction phase of the mine, the boxcut excavations will extend below the local groundwater level and dewatering will be required to ensure a dry working environment, resulting in localised water level drawdown up to approximately 100 m from the edge of the boxcut excavation. One stream within the pit area will be mined out in the construction phase, thus reducing baseflow contribution to the overall stream flow volume. Drawdown of the groundwater level will cause the local groundwater flow patterns to be changed so that groundwater flows towards the boxcut excavation.

Dewatering will also be required during the operation of the mine resulting in the drawdown in local groundwater levels. The zone of influence of the groundwater level drawdown in the saprolite during the operational phase is predicted to be up to approximately 200 m from the pit crest. A portion of the river that drains the sub-catchment within which the pit will be located will be mined out. The associated average annual decrease stream flow volume in the river draining towards the southern discharge point is predicted to be a maximum of approximately 20%, although the decrease in discharge volume will vary seasonally. There are no privately-owned water supply wells that fall within the predicted zone of influence of the dewatering induced groundwater level drawdown cone.

A site-specific surface water management plan was developed for the Ndablama site. Proposed channel alignments were developed to divert “clean” surface water runoff around and downstream of the development and to manage the “dirty” water runoff from the impacted catchments. Diversion channel sizing ranges from 1 m deep V-shaped channel to 1.5 m deep, 3.0 m base width trapezoidal channels. The proposed stormwater diversion channels with design flows less than 10 m^3/s have a minimum freeboard of 300 mm, while channels with larger design flows have a minimum freeboard of 500 mm. Where mean channels velocities exceed 3.0 m/s, reinforced concrete channels are required and where flow velocities are less than 1.5 m/s, no erosion protection is required. For channels with flow velocities between 1.5 m/s and 3.0 m/s, rip-rap linings are required.

Sedimentation pond design will be undertaken as part of the subsequent DFS, when there is more certainty on the project infrastructure design.

1.24.5 Process Technology

Testing has been carried out on representative samples from the New Liberty underground ore sources, and on samples representing the Ndablama deposit.

The testwork programs included comminution, gravity, flotation, whole ore cyanidation leaching, and gravity tails leaching.

Testing carried out on the underground ore sources from the New Liberty and Ndabalama deposits verified that the optimal process route is that of gravity-intensive cyanidation leach, followed by conventional CIL, and gold recovery on the gravity tail.

The testwork showed that both New Liberty and Ndablama ore sources have a high GRG component and warrants the inclusion of a gravity circuit in the flowsheet. Gold extraction on the gravity concentrate are high, and leach kinetics are rapid.

Cyanidation leaching on the gravity tails also demonstrates rapid leach kinetics.

Bond Rod Mill Work Index testing on New Liberty samples showed a Master Composite of the four zones to have a work index value of 15.21 kWh/t which would be considered ‘hard’ based on standard classification criteria. Bond Ball Mill Index testing of the New Liberty Master Composite showed it to have a work index value of 16.06 kWh/t which would again be classified as ‘hard’ using standard criteria.

Bond Rod and Ball Mill Work Index tests were carried out on a composite of the fresh ore types at Ndablama. The Bond rod mil work index at a product size 642 µm was 13.0 kWh/t, whilst the Bond Ball Mill Work Index at a product size P80 of 60 µm was 18.5 kWh/t, which would be considered to be hard.

Overall, results for New Liberty showed that by using a combined gravity-leach methodology, gold recoveries of 92.9% and 95.2% could be achieved for the Larjor/Kinjor South and Kinjor North samples respectively.

Results for Ndablama indicate the oxide and sulphide ore types are readily processable using the gravity-leach process flowsheet, with average GRG recoveries for the oxide and sulphide ore types of 34.1% and 70.2% respectively. Gold leach extractions were on average 92.3% and 94.5% for the oxide and sulphide ore composites respectively. Recovery rates of 92% used in the study were therefore validated.

All ores generated in the project will be processed in the existing New Liberty mill. The process flowsheet is an industry-standard arrangement consisting of crushing, ore stockpiling, grinding and classification, GRG, thickening and gold extraction by cyanidation in a CIL circuit. Gold is recovered from the activated carbon by acid washing, elution and electrowinning, followed by smelting to produce gold doré. The CIL tailings undergo cyanide detoxification followed by arsenic precipitation from tailings solution prior to disposal in the tailings dam.

Based on the Bond Rod and Ball Mill Work indices reported, the existing grinding circuit has sufficient installed grinding capacity to process the underground ore sources from the New Liberty mine at an annual production rate of 1.8 Mt/a, targeting a grind size P80 of 75 µm.

Based on the Bond Rod and Ball Mill Work indices reported, a coarser grind size is required when processing the Ndablama ore. The existing grinding circuit has sufficient installed grinding capacity to process ore sources from the Ndablama deposit in combination with ores from New Liberty underground mine at an annual production rate of 1.8 Mt/a, targeting a grind size P_{80} of 106-125µm.

1.24.6 Infrastructure

New Liberty is to have a new, approx. 700,000 ROM t/a underground mine, accessed by portals from the old Larjor pit as well as the existing New Liberty pit (Kinjor), with a ramp accessing reserves between the current $1,300 and $1,500 New Liberty pit shell. Each portal will have constructed entry, plus support, and services including sumps/pumping and a main ventilation fan (and vent shaft) in the vicinity. Extensive facilities including sumps and pumps to maintain/control water in the final pit (Pit 33) will be provided around each portal. Additionally, an ore transfer station, with a dump for underground ore trucks, and front-end loader to load haul trucks will be provided at each portal. Water from underground will be pumped to the two in-pit sumps, where this water, plus the pit inflows will be settled, then pumped to the existing water diversion trench to the South of Kinjor pit for discharge.

The underground mine is to be designed with relevant in-mine infrastructure to support conventional diesel mining fleet plus labour/supervision, including fuel stations, lubrication stations, miner's stations, refuge stations, ventilation and pumping infrastructure. Workshops will be on surface. Operations are to be via three shifts of eight hours, plus a spare shift, operating 24/7/365. Main electrical reticulation is at 6,000 V, transformed to 500 V in working sections. Lighting and small power will be provided in stationary working places; in all other locations lighting is to be by cap lamps and lights from mobile equipment. The mine is non-methaniferous, therefore electrics are to be to IP55 and explosion protected standard only (i.e. intrinsically safe not required). Underground communications by radio, with transmission by leaky feeder is assumed. Underground communications will interface via a new digital base station on surface with existing surface radio communications/dispatch and the mine's existing control network.

Power generation by two new 2.25 MVA diesel generators is assumed, with reticulation at 6,000 V to the new pumps, fans and the underground. Additional workshop capacity for planned maintenance of underground fleet will be provided. New/updated roads for mobile fleet to travel from the portal(s) to the plant stockpile and workshops will be laid out.

There is an existing 1.8 Mt/a mill on site at New Liberty therefore no new milling facilities relating to NL underground are contemplated. A new road train side-tip (2 x 90-t cars) will be required in the ROM area to handle ROM coming from Ndablama pit from Year 5.

Ndablama is to be an approx. 1,600,000 ROM t/a open pit mine, with conventional truck/shovel fleet and associated labour/supervision, three shifts of eight hours, plus a spare shift, operating 24/7/365. The pit is to be provided with all relevant infrastructure to support conventional diesel mining fleet plus labour/supervision, including a combined workshop, fuel station and lubrication station, stores, offices, changehouse facilities, and pit dewatering infrastructure. Pit dewatering will be by Global type diesel pumps as at New Liberty, discharging into the surface stormwater diversion trenches as required. Workshops will be designed for the estimated complement of mobile fleet; offices and changehouse facilities will be designed for the estimated labour complement plus contingency. Haul trucks from the pit will dump to a ROM pad, where a front-end loader will load off-highway trucks for the transport of ore to the New Liberty ROM pad. Roads to connect the crushing station to the Ndablama–New Liberty haul road must be laid out. Probably the single biggest item of infrastructure required is the 46 km haul road from Ndablama mine to New Liberty mine. Power generation by a single new 400 kVA generator for small power (offices, changehouses, stores) only is assumed. Solar generation has been allowed on the changehouse roof to support power requirements. Power reticulation will be at 6,000 V, transformed to 500 V in working sections. Communications/dispatch is to be by radio, with an additional 3G tower for cellular and data communications back to New Liberty.

1.24.7 Tailings

The proposed LOM is forecast to produce 18 Mt tailings in 10 years from October 2018 at an average throughput of 1.8 Mt/a. Throughput to the existing facility as of the end of October 2018 was approximately 3.4 Mt, resulting in a total storage capacity requirement of 21.4 Mt within the TMF at closure. In order to store the LOM tailings, the existing TMF at the New Liberty Gold Mine will require expansion. To accommodate this requirement a vertical expansion option using the centreline method of construction was selected.

Th dam is located in a basin to the south of the Plant. Presently, the dam is still in Phase 1 operation. Tailings beaches have inundated the valley up to approximately 78 mRL in the western portion of the site, with the supernatant pond covering most of the middle and eastern portions of the basin area. Phase 2 construction to 82.5 mRL is scheduled to provide at total storage capacity of 9.35 Mt and should be completed by June 2019. A Phase 3 design, based on centreline method, to accommodate the full 21.4 Mt over LOM was designed by Golder as part of the study.

Site conditions in terms of topography, ground conditions and seismicity are generally good for impoundment. Tailings characteristics are generally good for deposition, and are not expected to change, except perhaps for a marginal coarsening of particle size in the processing of Ndablama material. Issues in the past with achieving target placed density were noted however have largely been overcome. Water management in tropical, high rainfall conditions for the location is key, however has historically been well managed within a robust dam design.

Majority of risks associated with the impoundment have been identified and have shown to be adequately mitigated by proposed measures set out in the development of the TMF expansion design and associated recommendations for additional work. The highest residual risk is associated with the adopted geotechnical properties of the foundation and embankment materials. This underlines the need for further ground investigation and specifically the requirement to have a better understanding of the ground conditions and the geotechnical behavioural characteristics.

1.25 Recommendations

1.25.1 Data

CSA Global recommend the following for both New Liberty and Ndablama:

- That Avesoro use an 'off-the-shelf' geological database programme (e.g. acQuire or DataShed), which would increase confidence in the data and reduce the time taken to resolve validation issues and to understand the assay results.
- QA/QC procedures should be applied diligently to ensure that adequate controls on cross-contamination, assay bias and assay precision are in place.

1.25.2 Mineral Resources

CSA Global recommends the following actions are completed prior to completing MRE updates in the future.

New Liberty:

- A sound geological and structural model should form the basis of any future MREs, so that faulting and other mineralisation controls are integrated in the model.
- Additional dry BD data should be collected routinely during grade control and/or mine production and reviewed to continue building up the BD database of values that can be used to improve the confidence of the tonnage factors for the MRE.
- The current level of understanding of the Au distribution and geological controls are sufficient for mine planning purposes. CSA Global recommends that instead of additional infill drilling to upgrade Indicated Mineral Resources to Measured Mineral Resources, grade control drilling should be sufficient to delineated blast and dig lines during open cast mining.
- The resource is open down dip, as well as along strike. CSA Global recommends additional drilling for resource delineation at depth to allow current Inferred Mineral Resources to be potentially upgraded to Indicated Mineral Resources. A drill spacing along strike of 30–40 m and downdip of 20–30 m is recommended to potentially allow the classification of Indicated Mineral Resources.
- The QA/QC review showed that assay results are potentially understated, which could be influenced by the assay method (particularly where an aqua regia digest been used). Due to the coarse nature of the gold mineralisation, a Screen Fire Assay (SFA) technique could be used to more accurately determine the gold values.

Ndablama:

- Create a geological model to support and constrain the mineralisation model, to ensure that continuity and the high-grade variability are well understood by correctly interpreting the structural and geological controls on high grades.
- Prior to any mining, conduct a grade control RC drilling program with a close spacing of at least 10 m x 10 m and estimate a grade control model to assist with short-term planning.
- Additional dry BD data should be collected routinely during grade control and/or mine production and reviewed to continue building up the BD database of values that can be used to improve the confidence of the tonnage factors for the MRE.
- CSA Global recommends that instead of additional infill drilling to upgrade Indicated Mineral Resources to Measured Mineral Resources, grade control drilling should be sufficient to delineate blast and dig lines during open pit mining.
- The resource is open down dip, as well as along strike. CSA Global recommends additional drilling for resource delineation to allow Inferred Mineral Resources to be considered for an Indicated Mineral Resources classification level. A drill spacing along strike of 30–40 m and down dip of 20–30 m is recommended to potentially allow the classification of Indicated Mineral Resources.
- The QA/QC review showed that assay results are potentially understated, which could be influenced by the assay method (particularly where an aqua regia digest been used). Due to the coarse nature of the gold mineralisation, a Screen Fire Assay (SFA) technique could be used to more accurately determine the gold values.

1.25.3 Mining and Reserves

Further work on mining would focus on several areas:

- For the residual New Liberty pit, further optimisation of the open pit: underground transition may further curtail the life of the open pit in favour of underground mining. This should be examined in detail.
- Additionally, optimisation of pit slopes as well as advanced blast design to reduce overbreak and improve wall rock control would be recommended.

- For the underground mining, potential new indicated resources developed from additional infill drilling should be considered in an updated design. Additionally, further optimisation of the footwall drive design, as well as the pillar and fill design should be undertaken.
- For mining at Ndablama, a revised geological model is expected, which should allow redesign of the pit for better ore/waste management, and optimisation of the waste dump design. Additionally, extension of resources down dip as well as along strike should be considered in further updates to the mine design and schedule.
- Additionally, further pit geometry and pit slope optimisation for Ndablama may further optimise the design and schedule.

Updated assessment of the Mineral Reserve would be a natural consequence of this work.

1.25.4 Mine Water Management

1.25.4.1 New Liberty

Recommendations for subsequent stage of project development at New Liberty include the following.

Mine inflows:

- A hydrogeological field investigation programme should be completed at New Liberty including the installation and test pumping of large diameter drillholes to confirm:
  - hydraulic properties of both the bulk rock mass
  - hydraulic properties of the main geological structures intersected by the final open pit and the proposed underground mine (including the Marvoe Creek Fault);
  - hydraulic connection between large geological structures intersected by the mine and the Marvoe Creek Dam, Marvoe Creek diversion channel and overlying saturated weathered sediments.
- If significant water yields are obtained from the new hydrogeological test drillholes, then consideration should be given to commissioning these drillholes as long-term dewatering drillholes for the underground mining operation.
- Mine inflow predictions should be updated in accordance with the new hydrogeological data obtained from the site investigation, all new monitoring data available and any updated mine plans as the project progresses.
- Cover drilling ahead of underground mining should be considered in order to provide advanced warning of localised enhanced mine inflows derived from geological structures with enhanced permeability and to advance dewater/depressurise these structures prior to intersection with the main drive/shaft.

Surface water management:

- A review the existing surface water management plan at New Liberty should be competed and a subsequent update of the plan undertaken in order to incorporate any modifications required to effectively manage surface water runoff once final pit, waste dump and associated infrastructure designs are prepared and to minimise external pit catchments draining to the New Liberty pit.

Mine closure:

- Pit lake development and the potential impact of the final open pits and underground mine following cessation of mining should be evaluated once a mine closure plan has been developed for the New Liberty mine site.

Water monitoring:

- Five new groundwater monitoring drillholes should be installed adjacent to the proposed New Liberty final pit crests; including three monitoring points located along the northern side of the pits and two located along the southern edge of the pits, at a distance of approximately 50 m from the final pit crest.

- Groundwater level measurements should be completed manually on a monthly basis at all the existing monitoring drillhole sites and at the five new pit monitoring drillholes. In addition, a groundwater level logger should be installed in one of the pit monitoring drillholes in order to record water levels on a six-hourly basis, with monthly download of the logger. It is recommended that groundwater quality monitoring is completed on a monthly basis at all the existing groundwater monitoring locations and two of the new pit monitoring drillholes.

1.25.4.2 Ndablama

Recommendations for subsequent stage of project development at Ndablama include the following.

Mine inflows:

- Mine inflow predictions should be updated in accordance with any new hydrogeological data obtained from the monitoring program initiated and in accordance with any updated mine plans as the project progresses.

Surface water management:

- The surface water management plan at Ndablama should be updated in accordance with any updated pit, waste dump and associated infrastructure designs in order to ensure effective management of surface water and to minimise external pit catchments draining to the Ndablama pit.
- Sediment settlement pond designs should be undertaken once there is more certainty on pit, waste dump and associated infrastructure designs.
- Future waste dump and surface water management design should be integrated in order to ensure that sufficient space is included in the corridor, between the different waste dumps, for both surface water management infrastructure and other mine associated infrastructure requirements such as haul roads.

Water monitoring program:

- A water monitoring program should be initiated immediately at Ndablama, in order to establish baseline conditions prior to the commencement of mining activities.
- Groundwater level measurements should be completed manually on a monthly basis at the five new hydrogeological drillholes installed in November 2018 (NDB1 to NDB5) and the Hydrocensus points PRSBH8 and PRSBH9, if they can be found. In addition, a groundwater level logger should be installed in one of the new hydrogeological drillholes in order to record water levels on a six-hourly basis, with monthly download of the logger. It is recommended that groundwater quality monitoring is completed on a monthly basis at the seven drillholes identified above.
- Surface water monitoring should include surface water levels, flow and water quality monitoring. The surface water monitoring program should include (as a minimum) the following surface water monitoring points: one point immediately downstream of the open pit, one point immediately downstream of the waste dumps; and one point downstream of entire catchment impacted by all the Ndablama mine infrastructure.
- A water monitoring review should be completed once 12 months of data is obtained.

1.25.5 Process Technology

Several recommendations in respect of process technology have been made:

1.25.5.1 New Liberty

In order to achieve the study throughput rate of 1.8 Mt/a when treating the UG ore types, New Liberty Gold Mine will have to ensure:

- Continuous ore fed from the mine
- Three-stage crushing to achieve a final product size of 100% -10 mm
- Two-stage grinding; primary ball mill, and secondary Vertimill
- Product size P80 of 75 µm reporting to the CIL circuit
- Maintain an overall plant availability of between 95% and 96%.

To achieve this, several areas of process plant operation, including planned maintenance will need attention.

In order to achieve the desired throughput in processing harder ore from Ndablama, it would be recommended to reduce the grind size to reflect the coarser liberation size for gold noted in this ore.

Several other areas of optimisation including additional gravity concentration capacity for recovery of GRG, introduction of an 'Acacia' type leach reactor to increase kinetics in leaching the gravity concentrate, and addition of oxygen to the CIL circuit to increase leach kinetics are being implemented.

The metallurgical testwork recoveries obtained by gravity-leach tests carried out on samples representing underground ore sources from New Liberty and fresh ore from Ndablama are summarised in Section 18.15.

The current process plant configuration includes all the unit processes to ensure that target gold recovery is achieved including; gravity, intensive cyanidation leach, and conventional CIL/ADR circuits.

Testing showed that the New Liberty ore types have a significant GRG component and therefore it will be essential to maximise gravity recovery using the existing Falcon concentrator. It will also be important to ensure that the gold head grade to the CIL circuit does not spike in the event the Falcon concentrator is off-line for maintenance.

At an annual production rate of 1.8 Mt/a, the current CIL circuit has a calculated leach residence in the range of 19–20 hours. This is on the low side, in the event the Falcon concentrator is offline.

To ensure that the target gold recovery of 92–93% is achieved, it is recommended to investigate the installation of a second Falcon concentrator to maximise the GRG recovery, and to ensure that the leach tanks are injected with pure dissolved oxygen to increase leach kinetics.

1.25.5.2 Ndablama

At present, no process stages are included in the design at Ndablama. However, several process stages are recommended for consideration, including:

- Ex-pit crushing of Ndablama ore in order to improve load factors in haul trucks transporting ore to Ndablama as well as improving throughput of the ore through the comminution circuit at New Liberty
- Potential to sort Ndablama ore in order to reject waste inclusions incorporated into planned ore blocks prior to hauling the ore to New Liberty
- Potential to sort Ndablama ore into high-grade and low-grade fractions to facilitate heap leaching of low-grade fractions, and direct shipping of high-grade to New Liberty for processing
- Further investigation of heap leach potential of low-grade ore from Ndablama and appropriate flowsheet development and circuit design.

1.25.6 Water Sources

No specific recommendations with respect to water sources are made.

1.25.7 Tailings

The areas that require further studies and assessments prior to detailed design identified throughout this chapter and the appended report are summarised below:

- An update of the New Liberty Gold Mine water balance to assess excess and deficit flows
- Assessment of the dilution requirements and maximum discharge rates to satisfy effluent discharge limits permitted
- An additional Ground Investigation to improve understanding of the foundation conditions (geotechnical and hydrogeological)
- The installation of vibrating wire piezometers into the tailings to assess water levels and consolidation of the tailings beach
- Additional tailings testwork for strength and liquefaction resistance (CPTU Campaign)
- Additional tailings testwork for settlement and beach slope characterisation (also considering the Ndablama resource tailings)
- Additional tailings testwork for geochemistry for assessment of long-term leachate conditions
- Additional tailings testwork for hydraulic characterisation (to inform updates to seepage impact assessments)
- Detailed stability assessment of the slopes following improved geotechnical data from additional ground investigations and testwork
- Update of the seepage impact assessment models
- Carry out HAZOP workshop for tailings management.

1.25.8 Engineering and Other Technical Studies

Additional stages of engineering study are recommended and have been included in the budget. Additional study work leading towards development of an underground mine at New Liberty and an open pit mine at Ndablama would include:

- Additional process testwork to establish the feasibility of heap leaching of Ndablama ore
- Additional process testwork to investigate the feasibility of sorting Ndablama ore
- Brownfield process design for additional gravity concentration capacity and intensive leach stages at New Liberty mill
- Trade-off studies for process options at Ndablama to confirm options for the DFS
- DFS-level engineering of the underground mine design and associated infrastructure
- DFS-level engineering of the Ndablama pit and associated infrastructure
- Completion of the Ndablama ESIA and implementation of environmental and community management plans at that site
- Detailed design of underground mine development and associated infrastructure
- Detailed design and cost estimation for the Ndablama–New Liberty road including route survey, right of way establishment and permitting.

2 Introduction

2.1 Terms of Reference

A pre-feasibility for the Combined project of the New Liberty Gold Mine and the Ndablama deposit in Liberia has been completed between November 2018 and March 2019. The project contemplates the transition of mining operations at New Liberty from the current open pit to underground, plus the development of a new satellite open pit at Ndablama. The study incorporated mineral resource modelling and reporting, mine design and scheduling work, infrastructure design, process testwork, capital cost estimation, operating cost estimation, financial modelling and reporting. Tailings facility design and Environmental studies were the responsibility of the Client. This report documents the outcomes of the pre-feasibility and recommendations for next steps.

2.2 Cautionary Notes

2.2.1 Independence

Neither CSA Global, nor the authors of this report, have any material present or contingent interest in the outcome of this report, nor do they have any pecuniary or other interest that could be reasonably regarded as being capable of affecting their independence in the preparation of this report. The report has been prepared in return for professional fees based upon agreed commercial rates and the payment of these fees is in no way contingent on the results of this report. No member or employee of CSA Global is, or is intended to be, a director, officer or other direct employee of Avesoro. No member or employee of CSA Global has, or has had, any shareholding in Avesoro. There is no formal agreement between CSA Global and Avesoro as to CSA Global providing further work for Avesoro.

2.2.2 Notice of Third Parties

CSA Global has prepared this report having regard to the particular needs and interests of our client, and in accordance with their instructions and in compliance with NI 43-101 Technical Reporting. This report is not designed for any other person's particular needs or interests. Third party needs and interests may be distinctly different to Avesoro's needs and interests, and the report may not be sufficient, fit or appropriate for the purpose of the third party, other than its prescription in relating to NI 43-101.

2.2.3 Results are Estimates and Subject to Change

The ability of any person to achieve forward-looking production and economic targets is dependent on numerous factors that are beyond CSA Global's control and that CSA Global cannot anticipate. These factors include, but are not limited to, site-specific mining and geological conditions, management and personnel capabilities, availability of funding to properly operate and capitalise the operation, variations in cost elements and market conditions, developing and operating the mine in an efficient manner, unforeseen changes in legislation and new industry developments. Any of these factors may substantially alter the performance of any mining operation.

2.2.4 Element of Risk

The interpretations and conclusions reached in this report are based on current geological theory and the best evidence available to the author at the time of writing. It is the nature of all scientific conclusions that they are founded on an assessment of probabilities and, however high these probabilities might be, they make no claim for absolute certainty. Any economic decisions which might be taken on the basis of interpretations or conclusions contained in this report will therefore carry an element of risk.

2.3 Sources of Information

Sources of information for the PFS are listed in the References section.

2.4 Site Inspections

2.4.1 Overview

CSA Global visited the New Liberty and Ndablama properties from 2 to 6 July 2018. This visit was completed for the purposes of site inspection, ground truthing, review of activities, procedural review and information data collection and collation and to satisfy NI 43-101 "personal inspection" requirements. Mining operations are current at the New Liberty deposit.

Dr Belinda van Lente, Dr Matthew Randall, Mr Clive Brown and Dr Andrew Bamber carried out the site inspections on behalf of CSA Global.

2.4.2 Geology – Belinda van Lente

The following items were inspected, and conclusions made from the site visit:

2.4.2.1 New Liberty Property

- Local company geologists associated with the projects are familiar with the geology, deposit type(s) and mineralisation within the tenements.
- CSA Global verified the locations of seven drillholes with visual inspection and by handheld global positioning system (GPS). These drillholes are located within the Larjor, Kinjor and Marvoe sections of the New Liberty deposit. The collar locations as recorded in the database compare well to the CSA Global GPS readings.
- Drilling, drill core cutting, sampling, logging and density determination procedures were reviewed, and found to be suited to the deposit type and style of mineralisation.
- Drill core and sample storage and security is considered good.
- The mineralisation at the New Liberty property contains elevated gold grades within the identified deposit area, over reasonable strike lengths. The extent of the mineralisation and continuity, along and across strike, was tested by the 2018 infill drilling.
- Mineralisation shows good continuity and drillholes are located at a nominal spacing of 40 m on 40 m sections extending out to 50 m. The drill spacing is sufficient to allow the mineralisation zones to be modelled into coherent wireframes for each domain.
- Drill core from the 2018 drilling campaign was inspected for two drillholes, K501 and K537. The geology is dominated by tremolite-chlorite-actinolite-talc ± magnetite rich meta-ultramafics, sometimes with phlogopite, and flanked by migmatitic gneisses.
- Significant mineralised intercepts within the inspected drillholes were observed:
  - K501: 269–272 m (weighted average 11.99 g/t Au)
  - K537: 155–159 m (weighted average 2.13 g/t Au).
- The New Liberty deposit consists of several steeply, south dipping mineralisation zones that strike east-west. The geology, strike and dip of these zones within the central part of the deposit was observed on surface within the Kinjor open pit.

2.4.2.2 Ndablama Property

- Drilling, drill core cutting, sampling and logging procedures were reviewed, and found to be suited to the deposit type and style of mineralisation.

- Density determination is by the water immersion method, with porous samples wrapped in plastic. The procedure for density measurement was reviewed and witnessed and is considered acceptable.
- Drill core and sample storage and security is considered good.
- The mineralisation at the Ndablama deposit contains elevated gold grades, with high variability, within the identified deposit area, over reasonable strike lengths. The extent of the mineralisation and continuity, along and across strike, was tested by the 2018 exploration and infill drilling.
- Mineralisation shows good continuity, even though gold grades are highly variable with localised instances of visible gold. Drillholes are located at a nominal spacing of 30 m on 50 m sections extending out to 100 m. The drill spacing is sufficient to allow the mineralisation zones to be modelled into coherent wireframes for each domain.
- CSA Global verified the locations of six drillholes with visual inspection and by GPS. The collar locations as recorded in the database compare well to the CSA Global GPS readings
- Drill core from both historical (pre-2018) and 2018 drilling campaigns at Ndablama were inspected for a total of six drillholes, NDD048, NDD059, NDD129, NDD130, NDD162 and NDD189. The host rocks to the gold mineralisation are amphibolite schists with biotite/phlogopite, and ultramafic tremolite-chlorite schists. This sheared package of ultramafic and mafic rocks is intercalated within a gneiss sequence, overlying a granite batholith.
- High-grade mineralised intersects within each of the six inspected drillholes were observed:
    - NDD048: 65–73 m (weighted average 2.38 g/t Au)
    - NDD059: 70–73 m (weighted average 2.26 g/t Au)
    - NDD129: 114–121 m (weighted average 3.95 g/t Au)
    - NDD130: 94–89 m (weighted average 4.07 g/t Au)
    - NDD162: 72–77 m (weighted average 2.33 g/t Au)
    - NDD189: 115–119 m (weighted average 2.58 g/t Au).
- Visible gold was observed in NDD129 and NDD130.
- The Ndablama deposit consists of three shallow westerly dipping domains along a north-south trend. Mineralisation is open along strike and down dip.

2.4.2.3 CSA Global Recommendations

The following risks were noted during the visit, and recommendations made:

- New Liberty property: Grade control is currently through channel sampling and logging. It is recommended that grade control drilling be done by reverse circulation (RC) and that a study be made comparing the grade control and resource definition sampling methods, to see if grade control samples can be used in the grade interpolation.
- Ndablama property: Survey the locations of artisanal workings and mine shafts and attempt to get extent and depth measurements, from which a void model could be constructed. There is a degree of risk in both location of, and extent of, underground voids.

2.4.3 Mining – Matthew Randall

A site visit to review mining and infrastructure aspects on the project was conducted between 5 December 2018 and 10 December 2018. Mining operations, infrastructure, exploration and geotechnical aspects were all reviewed. Based on the review the New Liberty site was considered well set up for continued operation of the pits, and development of an underground extension. Sufficient and sufficient quality indicated resource at New Liberty was identified that could support an underground operation. Good infrastructure already exists on site and will be easily augmented with new infrastructure for underground operations.

A very high-level trade off done during the site visit on the underground option vs. the pit only option confirmed the strategic decision to go underground. A basic plan for the schedule to support the PFS was developed, comprising the New Liberty pit, mined to 2023 as currently modelled, with the New Liberty underground operation initially at Larjor only in 2021, with production at Kinjor developed in 2023, and underground production planned through to 2026. The Ndablama open pit was discussed to start in parallel with underground production at Larjor to provide production flexibility in the plan, and de-risk both the New Liberty underground as well as the New Liberty open pit, which will be very tight and with high strip ratio – albeit with good projected grades - by then. Ndablama pit conceptually runs until 2027.

As most infrastructure is already at New Liberty, no specific site visit was planned for Ndablama, over and above visits that had already happened in 2018. Ndablama is planned to be light on infrastructure, with fresh water from the river, a diesel generator, workshop, store, office, and contractors (labour) camp. Initial "notes for the record" on New Liberty geotech and Ndablama geotech confirm suitable conditions for continued open pit mining (with a focus on pit slope stability) at New Liberty, good conditions for underground portal, ramp and stope development, and good conditions with good slope stability for the Ndablama pit. Observations of core in the core shack bore out these initial geotechnical notes. Initial hydrology and geohydrological data suggested high surface and groundwater flows, data borne out by observations on site.

2.4.4 Mining – Clive Brown

A site visit was conducted the New Liberty Mine between 10th and 14th December 2018. While on site the general infrastructure was inspected with a view to understanding the capacity to support underground mining. Potential site for the locations of mine access portals in the New Liberty open pits were inspected. Drill core containing intersections within the underground target are were inspected to gain an understanding of the geotechnical environment which can be expected underground as well as other aspects of mine design such as grade control. Discussions were held with the mine management and technical teams. During the site visit a contractor submission for underground mining was reviewed together with the mine management and technical team. A high level trade-off between open pit and underground mining at New Liberty was completed to guide the mine planning process. Agreement was reached with the mine management and technical team on the general mine design criteria such as mining method and the use of contractors to perform the underground mining. Besides the specific infrastructure related to underground mining all other mine support infrastructure exists on the site and very little additional surface infrastructure is envisaged to support underground mining.

3 Reliance on other Experts

CSA Global is relying on information provided by Avesoro, concerning legal, political, environmental, or tax matters relating to the New Liberty and Ndablama deposits. CSA Global has been provided scans of tenement/permit documents; however, CSA Global has not independently verified the status of nor legal titles relating to the mineral concessions.

CSA Global has also not independently verified nor undertaken any due diligence regarding the legal and tax aspects relating to the New Liberty and Ndablama deposits.

In addition to this; no warranty or guarantee, be it express or implied, is made by CSA Global or the Authors with respect to the completeness or accuracy of the legal or tax matters relevant to the New Liberty and Ndablama deposits. Neither CSA Global nor the authors accept any responsibility or liability in any way whatsoever to any person or entity in respect to these parts of this document, or any errors in or omissions from it, whether arising from negligence or any other basis in law whatsoever.

Tailings dam design and cost estimation was provided by Golder Associates (UK) Ltd. contracted directly and under the direction of Avesoro Resources. Environmental and social sections are by ABS Africa of Johannesburg, South Africa, contracted directly and operating under the direction of Avesoro Resources.

4 Property Description and Location

This section, in the context of New Liberty and Ndablama, has been modified from AMC (2013a, 2013b, 2014) and SRK (2017). The Qualified Persons take responsibility for the content of this section and believe it is accurate and complete in all material aspects.

4.1 Area of Property

The Bea Mountain Mining Corporation Mineral Development Agreement (Bea-MDA) property is located within the Republic of Liberia, which is situated on the coast of the south-western corner of West Africa and bordered by Sierra Leone, Guinea and Cote d'Ivoire. The country lies between longitude 7°30' and 11°30' west, latitude 4°18' and 8°30' north and covers a surface area of 111,369 km^2. Liberia's Capital is Monrovia and, as of the last census (2008), the country had a population of 3,476,600.

4.2 Location of Property

The Bea-MDA property is situated 90 km northwest of the capital, Morovia, in Grande Cape Mount County, in the north-western portion of the Republic of Liberia, as shown in Figure 4-1. The New Liberty and Ndablama deposits, the subject of this Pre-Feasibility Study, are situated within the Bea-MDA property, the UTM coordinates of which are shown in Table 4-1.

Figure 4-1: Location of the Bea-MDA property in Liberia
Source: BMMC, 2017

Table 4-1: WGS84 UTM Zone 29 N vertices of the Class A mining licence

Boundary	UTM E	UTM N
0	250,035	773,000
1	250,035	778,000
2	265,035	778,000
3	265,003	778,000
4	284,981	785,013
5	284,981	785,013
6	300,035	793,033
7	300,035	800,000
8	307,035	800,000
9	307,035	790,000
10	308,060	790,000
11	308,060	788,600
12	306,700	788,600
13	306,700	788,050
14	305,400	788,050
15	305,400	787,500
16	302,860	787,500
17	301,700	786,400
18	300,035	786,400
19	300,035	786,000
20	209,035	786,000
21	209,035	780,000
22	280,035	780,000
23	280,035	777,000
24	273,035	777,000
25	273,035	773,000
26	250,035	773,000

The Bea-MDA property covers an area of 478 km^2 with boundaries described as cadastral and cartographic maps at the Ministry of Lands, Mines and Energy of Republic of Liberia. The projects are shown in Figure 4-2 along with the New Liberty Gold Mine development site and other targets, which are currently the subject of exploration. The Bea-MDA property, which is covered by the licence, has been reduced from a prior exploration lease which covered a total of 1,000 km^2.

This report relates to both the Northern and Southern Blocks of the Bea-MDA property, the boundaries of which are illustrated in Figure 4-2. The Northern Block boundary with the adjacent Southern Block coincides with the Silver Hills Mountains which trend east-west and form a natural barrier between the blocks.

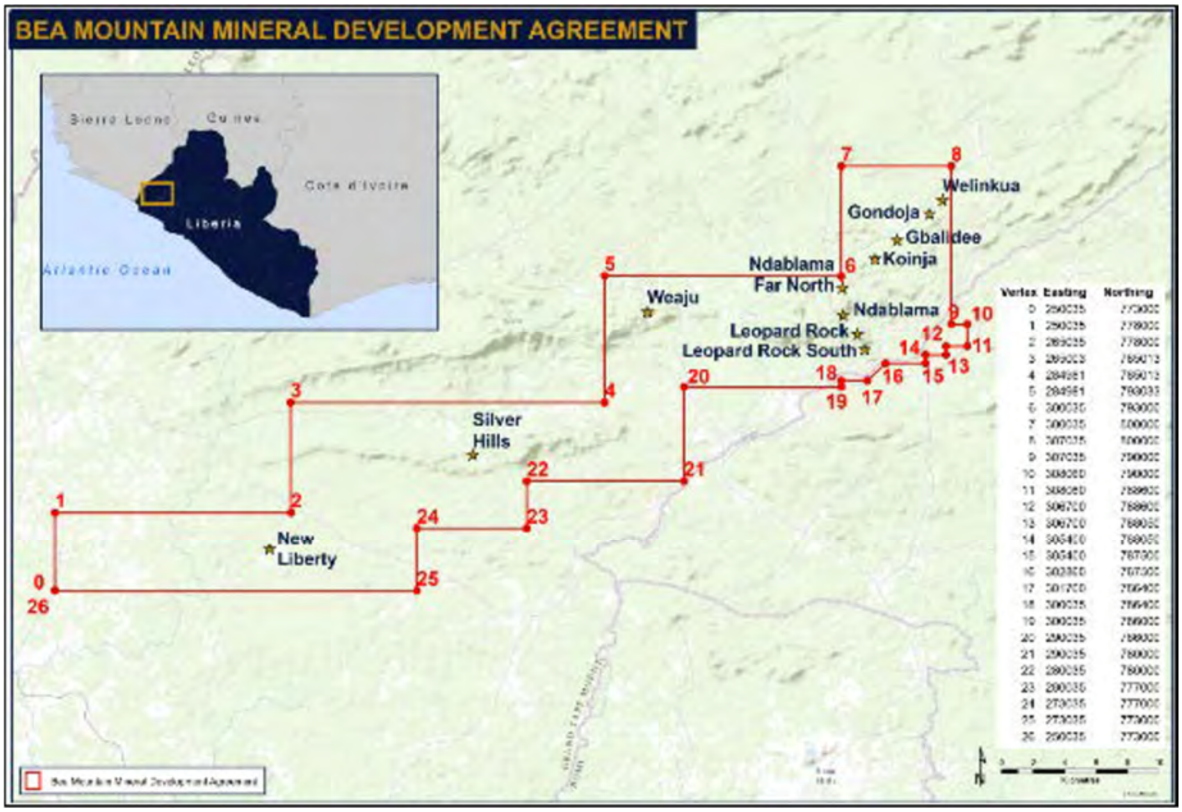


Figure 4-2: Avesoro Class A Mining Licence limits
Source: BMMC, 2017

4.3 Property Ownership

Bea Mountain Mining Corporation (BMMC) has a 100% interest in the current Bea-MDA, which was signed with the Liberian Government in November 2001. Bea Mountain Mining Corporation is a 100% owned subsidiary of Avesoro Resources Inc., dual listed on the Alternative Investment Market (AIM) in London (LSE) and Toronto Stock Exchange (TSX). BMMC was previously a wholly owned subsidiary of African Aura Mining Inc. (African Aura), formerly called Mano River Resources Inc. On 13 April 2011, African Aura completed a Plan of Arrangement ("Arrangement") under the Business Corporations Act (British Columbia) pursuant to which it transferred its gold assets, 30,792,770 shares in Stellar Diamonds plc and US$10.6 million cash (the "Transferred Assets") to Aureus Mining Inc (Aureus) and African Aura was renamed Afferro Mining Inc.

Under the Arrangement, among other things, the Transferred Assets were acquired by Aureus, and each participating shareholder received new common shares in Afferro and Aureus in exchange for the African Aura common shares held by such shareholder on the basis of one new Afferro common share and one Aureus common share for each African Aura common share held by such shareholder.

During 2016, following a period of financial difficulty, Aureus was the subject of a change of control following three equity investments from MNG Gold recapitalising the business. During December 2016, Aureus was renamed Avesoro Resources Inc. (Avesoro), whilst MNG Gold was renamed to Avesoro Holdings Jersey Ltd.

Table 4-2 summarises the ownership history.

Table 4-2: Ownership history

Date	Company	Comments
1995	KAFCO	Receives prospecting rights to future MDA area
Aug-95	KAFCO	Assigned rights in area to Golden Limbo
18-Nov-96	Golden Limbo	Assigned rights to Bea
22-Nov-96	BMMC	Approval received
22-Apr-98	BMMC	Bea-MDA defined
28-Nov-01	BMMC	Bea-MDA reduction to 457 km^2 came into effect
29-Jul-09	BMMC	Granted a Class A Mining Licence
13 Apr-11	BMMC	Transferred from African Aura to Aureus Mining
19-Dec-13	BMMC	Restated and Amended Mineral Development Agreement
Dec-2016	BMMC	Aureus Mining renamed Avesoro Resources Inc.

4.4 Title, Tenure Agreements and Encumbrances

The mineral exploration and exploitation rights defined by the Bea-MDA originally became effective on 22 April 1998. Previously, the ground was held by the Liberian entity known as KAFCO. In August 1995, KAFCO received governments approval to assign its rights to the licence to Global Limbo Liberia Ltd (Golden Limbo). On 18 November 1996, Golden Limbo assigned its new rights to the licence of Bea which was subsequently approved by the government on 22 November 1996. In April 1998, in anticipation of a new Mining Code, Bea replaced the existing licence and assignment, and entered into a specially-negotiated Exploration Agreement. In 2001, BMMC reduced the size (acreage) of the licence to 457km^2. The revised Bea-MDA came into effect on 28 November 2001, and has an initial term of 25 years which may be extended for successive 25-year terms.

Under the terms of the Bea-MDA, there is a 3% royalty to the Republic of Liberia calculated on a production basis. In addition, the Republic of Liberia is entitled to receive, free of charge, an equity interest on BMMC's operations equal to 10% of its authorised and outstanding share capital without dilution (i.e. a 10% "carried interest"). African Aura through its subsidiary was required to pay the Republic of Liberia US$0.08 per acre per year as a rental fee for the exploration licence. Due to the civil unrest in the country, the Ministry of Lands, Mines, and Energy suspended the exploration period as from July 2002 until 4 January 2005.

During the Initial term of the Bea-MDA, BMMC was required to make minimum exploration expenditures of US$1.40 per acre per year. Excess expenditures in a given year can be accredited against succeeding years work requirements. The Bea-MDA provides BMMC the right to free access to public land and will assist BMMC in cases where ace to private lands in necessary. BMMC was granted the Licence on 29 July 2009. Annual licence fees for the Licence, based on the production area of 457 km^2 (the Production Area), amount to US$0.80 per acre, which equates to US$90,146 per annum (1 km^2 = 247.1 acres). The Licence for the Production Area shall remain valid and effective for the unexpired portion of the Bea-MDA and any extensions thereof. The Licence allows BMMC to commercially exploit minerals found in the Production Area and all other activities incidental thereto, including the design, construction, installation, fabrication, operation, maintenance and repair infrastructure, facilities and equipment and the mining, excavation, recovery, handling, beneficiation, processing, milling, stockpiling, transportation, export and sale of minerals.

BMMC was granted all the normal operating licences and permits for the mining operation, including licences associated with explosive storage and use, abstraction and discharge of water and construction.

4.5 Environmental Liabilities

Prior to the commencement of exploration and production on the Bea-MDA property, BMMC was required to provide an Environmental Impact Statement to the Minster, detailing and adverse effects operations may have on the environment and review plans to mitigate such effects. From time to time BMMC is required to submit detailed plans “for the protection, correction and restoration of the water, land and the atmosphere”.

Baseline data collection for the ESIA was initiated in the fourth quarter of 2010 and was conducted during both the wet and dry seasons. The ESIA, as per Liberian legislation, included a Public Participation Process (PPP). An Environmental Impact Statement (EIS) was submitted to the Environmental Protection Agency of Liberia (EPA) in July 2012, which was approved by the EPA in October 2012. The approval of the EIS is required under the terms of the Agreement and is required prior to the commencement of exploitation and production.

Subsequent to the completion of the ESIA and the approval of the EIS by the EPA, a mine optimisation study was conducted in early 2013 for New Liberty. BMMC then commissioned Digby Wells Environmental (Digby Wells) to undertake further detailed specialist studies and update the ESIA report. The updated ESIA report was submitted to the EPA in October 2013 as per the MDA requirements and all permits remained valid. Prior to the investment in the Company by the International Finance Corporation (IFC) in 2014, an addendum to the updated ESIA was also produced and submitted to the EPA during March 2014.

BMMC has commissioned ABS Africa to conduct a new ESIA study for the proposed Ndablama open pit and a connecting haul road running between Ndablama and New Liberty, a study which is currently underway. This ESIA is expected to be completed by mid-2019.

5 Accessibility, Climate, Local Resources, Infrastructure and Physiography

This section, in the context of New Liberty and Ndablama, has been modified from AMC (2013a, 2013b, 2014) and SRK (2017). The Qualified Persons take responsibility for the content of this section and believe it is accurate and complete in all material aspects.

5.1 Access to Properties

The New Liberty Project is accessible by vehicle from Monrovia, with approximately 80 km of paved road to the town of Danielstown and a further laterite section of 20 km to the Project. The laterite section of road has been upgraded and five new culvert-type bridges were installed to facilitate access to site. The Ndablama deposit is also accessible from Monrovia by vehicle, with approximately 90 km of paved road to the town of Tubmanburg, with a further 40 km of laterite road, which forks after Lofa Bridge with the north-east section providing access to the Ndablama deposit. Secondary roads on the licence provide access across the property (Figure 5-1).

Figure 5-1: Road access to the projects

Source: BMMC, 2014

5.2 Topography, Elevation and Vegetation

Within the Bea-MDA property are both primary and secondary forest, as well as some grassland and farmland. In the Southern blocks around the New Liberty project, the topography ranges from around 50 m amsl to a maximum of 600 m amsl, with the majority of the licence area being composed of gently undulating plains at less than 200 m amsl, with two prominent east-west ridges of resistant rock units (the Bea Mountain and Tokani ranges). Vegetation consists of tropical trees which attain heights of 30 m to 40 m above the forest floor, with thick undergrowth common. The primary rainforest is mainly in the mountainous area while the gently undulating plains are mostly covered by secondary forest. In common with the majority of Liberia, deep lateritic soils limit rock outcrop to streams and the more rugged hill areas.

At Ndablama, the surrounding area is dominated by low ridges. Elevations range between 150 m amsl and 350 m amsl. The project itself is located between these ridges overlooking lower terrain to the east. Vegetation is primarily forest, with thick canopy and little undergrowth. Rock outcrops are found mostly in the valleys which run down the ridges caused by water channels, with boulders on some of the valley and hillsides.

5.3 Climate

The equatorial climate is hot year-round, with heavy rainfall from May to October but with peak rainfall occurring between mid-July to August. During the winter months of November to March, dry dust-laden Harmattan winds blow inland from north and east. Average rainfall along the coastal belt is over 4,000 mm and declines to 1,300 mm at the forest-savannah boundary in the north (Bongers *et al.,* 1999). Temperatures range from the low 20°C during the rainy season to warm (low 30°C) during the dry season. Exploration has generally been able to continue throughout the rainy seasons.

5.4 Regional Infrastructure

The 1989–2003 civil wars in the Republic of Liberia had a devastating effect on the country's economy, with neglect and damage resulting in much of Liberia's physical infrastructure being destroyed. Reconstruction began during 2003 and there has since been a recovery in the critical infrastructure sectors such as power, water and transport.

5.4.1 Sources of Power

The Liberian Electricity Corporation currently supplies 10 MW in Monrovia only, with private diesel-powered generators meeting requirements in the rest of the country.

5.4.2 Transport Lines

Liberia has approximately 10,600 km of road networks throughout the country, of which 650 km are paved highway. Some of the dirt roads in the interior of the country were constructed in the 1990s, chiefly by Asian timber companies. These roads were well built and maintained at the time.

The 490 km of rail line in Liberia was primarily constructed to haul iron-ore from interior mining areas to the ports. Much of the Bong Mine rail is still usable, while ArcelorMittal has renovated the Nimba Railway to the port of Buchanan which is located some 250 km to the southeast of the New Liberty Project.

The Freeport of Monrovia, which is privately run under a concession from the government, is one of four main ports in Liberia and is currently the only port with cargo and oil handling facilities. It can accommodate up to third generation container ships.

5.4.3 *Internet*

Internet service is available in Monrovia and in some smaller urban centres. Cellular phone coverage in the Republic of Liberia is good within the major urban areas and is widespread throughout much of the country, with signal available at all Avesoro's main exploration sites.

5.4.4 *Mining Personnel*

The increase in mining operations in the Republic of Liberia is expanding the supply of mining personnel and mining services, such as drilling contractors, equipment rental and services, engineering services and trained labour force. In addition, there is a mobile West African work force in the mining industry.

5.5 New Liberty Project Infrastructure

The construction of the Project infrastructure is complete and in operation, and the infrastructure is adequate to support the ongoing operations at the Project (Figure 5-2).

Figure 5-2: New Liberty site infrastructure
Source: www.avesoro.com, 2019

The mine is well served by road access and road infrastructure and has adequate generation capability by diesel generators and access to water pumped and treated from the Marvoe Creek. Communications by voice and data are by satellite link, with 3G coverage by the local mobile telephony provider. There is a substantial camp at New Liberty accommodating management, technical, and operating personnel on a fly-in/fly-out basis. Some local labour is sourced from and accommodated in villages proximal to New Liberty.

5.5.1 Tailings Storage Facility

The current TSF arrangement has been in operation since July 2015. As of the beginning of August 2017, the TSF has been operated as a self-raising facility, in which deposited tailings material will be reworked to form the main embankment itself.

The configuration of TSF was significantly altered during 2016. This was required due to periodic uncontrolled release of supernatant to the environment which did meet compliance limits (between December 2015 and June 2016). A temporary TSF configuration was constructed to ensure that discharge of excess supernatant to the environment met acceptable discharge limits. This involved segregation of the TSF into a series of compartments or cells, designed to promote a tortuous flow path for supernatant before discharge via the penstock to environment. This, combined with plant modifications, has ensured that discharge water quality has improved and is reported to now be within acceptable limits.

NewFields was commissioned by Avesoro during October 2016 to prepare an alternative TSF design, which would allow safe storage of water on the facility and controlled release of supernatant to the environment. This new design involves conversion of the TSF to a water retaining, downstream raised facility. In addition, a water retaining dam is to be constructed to the east of the TSF, which will divert inflows of fresh water from the upstream catchment during storm events. This fresh water will be routed via the existing penstock arrangement and safely discharged downstream. A new centreline dam design suitable for the project under consideration is being designed by Golder Associates, based largely on the 2017 NewFields design.

5.6 Local Resources

In the area around the Bea-MDA property, covering Grand Cape Mount County between the localities of Gbah and Gbesse, large tracts of land are devoted to rubber farms, however, these are located mainly outside the licence area. Closer to the Sierra Leone border the major farming activity is palm oil cultivation.

There are several small-scale artisanal alluvial diamond and gold operations within the BEA-MDA property.

5.7 Ndablama deposit Infrastructure

The Ndablama deposit is accessible from Monrovia by vehicle, with approximately 90 km of paved road to the town of Tubmanburg, with a further 40 km of laterite road, which forks after Lofa Bridge with the northeast section providing access to the site. There is currently a small artisanal village on site, as well as a small exploration camp with voice and internet access by VOiP. No other project infrastructure (power, water or communications) is available.

6 History

This section, in the context of New Liberty and Ndablama, has been modified from AMC (2013a, 2013b, 2014). The Qualified Persons take responsibility for the content of this section and believe it is accurate and complete in all material aspects.

6.1 Historical Exploration

Gold mineralisation in the area now covered by the Bea-MDA, including New Liberty, Ndablama, Gondoja and Weaju has been known about since 1949 (Thayer *et al.*, 1974); however, no systematic work is known to have been undertaken prior to the 1990's. It is reported (ACA Howe, 2000) that, in the late 1980s, a company, Atlantic Mining, installed a small wash plant, mine buildings and accommodation, and commenced mining for gold from adits and hand-excavated shafts around Weaju. A large area of alluvial ground and swamp close to the mine site was cleared to provide alternative ground for artisanal miners. Larger-scale production was due to commence in 1990, but the outbreak of civil hostilities led to the abandonment of the operations and the excavations were filled in. No results are available from referenced drilling.

Subsequently, the bulk of the work carried out within the Bea-MDA property has concentrated at the New Liberty deposit. The first exploration work at the property was carried out by Golden Limbo and comprised desktop studies, a review of satellite imagery, target selection and acquisition of a portfolio of possibilities. In 1997, Mano River Resources (Mano) collected preliminary channel samples across the artisanal workings, where primary mineralization was exposed. During reconnaissance work, numerous targets for gold mineralisation were identified through geological mapping, supported by soil and stream geochemical sampling programs.

Exploration by Aureus Mining Inc. (Aureus), Bea Mountain Mining Corp. (BMMC) and Avesoro Resources (Avesoro) at the Bea-MDA property since 2011 has followed a systematic process of reconnaissance work, grab-sampling followed by soil geochemistry, mapping, trench sampling and eventually drilling. Aureus completed a feasibility study in October 2012 for the New Liberty Project and subsequent to this carried out additional work with a view to optimising the Project (AMC, 2012).

Since this time, the Company has continued to conduct further evaluation work at New Liberty, including grade control drilling to produce a better geological understanding of the deposit at a mining scale. Exploration has continued across the Bea-MDA property focussing on also, in recent years, the Ndablama deposit.

6.2 Historical Mineral Resource Estimates

The QPs have done insufficient work to classify the historical estimates as current resources. Avesoro is not treating the historical estimates as current.

6.2.1 New Liberty

Prior to completion of the Feasibility Study on the Project in 2012, two previous historical MREs were prepared for the Project, the first by ACA Howe International Ltd (ACA Howe) in 2000 (Table 6-1), and the second by Lower Quartile Solutions (Pty) Ltd (LQS) in 2006 (Table 6-2).

Table 6-1: New Liberty Mineral Resource estimate – ACA Howe (2000)

Mineral Resource category	Tonnes (kt)	Grade (g/t Au)	Gold (koz)
Indicated	1,078	5.23	181
Inferred	3,009	4.02	427

Notes:

- *Cross-section method employed.*
- *No cut-off used, as mineralised zone taken.*

The ACA Howe estimate was prepared to "Australasian Institute of Mining and Metallurgy Joint Ore Reserve Committee's (JORC) code standards" and is presented here as an historical estimate. Estimates were completed for the three principal geological zones, and were based on relatively shallow drilling, with the deepest mineralised intercept reported at 104 m, and the Mineral Resource quoted to a maximum depth of 150 m.

The LQS estimate was produced in support of a study by MDM Engineering Group Limited (MDM), was reported according to CIM Standards and was based on significantly more drillholes than the ACA Howe estimate.

Table 6-2: New Liberty Mineral Resource estimate – LQS (2006)

Mineral Resource category	Tonnes (kt)	Grade (g/t Au)	Gold (koz)
Measured	6,658	3.49	746
Indicated	6,875	2.88	637
Total	**13,533**	**3.18**	**1,383**

Note: A cut-off of 1.0 g/t Au is applied for all zones.

To the extent known, there was no gold production on the Bea-MDA property by the previous licence holders.

Following completion of the Feasibility Study at New Liberty in 2012, AMC (2012, 2013a) derived Mineral Resource and Reserve estimates as presented in Table 6-3 and Table 6-4. These were reported with effective dates of 1 October 2012 and 20 May 2013, respectively and were reported before any mining had commenced and are therefore un-depleted.

Table 6-3: New Liberty Mineral Resource estimate as at 1 October 2012 (AMC, 2012)

Minzone	Measured			Indicated			Measured and Indicated			Inferred		
	Tonnes (kt)	Au		Tonnes (Kt)	Au		Tonnes (kt)	Au		Tonnes (kt)	Au	
		g/t	koz		g/t	koz		g/t	koz		g/t	koz
M401	651	4.77	100	5,468	3.88	683	6,118	3.98	783	3,060	3.2	314
M402				874	2.51	71	874	2.51	71	130	3.6	15
M501				2,317	2.43	181	2,317	2.43	181	1,120	2.6	92
M503				486	6.93	108	486	6.93	108	1,300	3.6	152
M504										120	5.1	20
Total	**651**	**4.77**	**100**	**9,145**	**3.55**	**1,043**	**9,796**	**3.63**	**1,143**	**5,730**	**3.2**	**593**

Key to Minzone codes	
M401	Larjor + Latiff + Kinjor main zone
M402	Kinjor footwall zone
M501	Marvoe main zone
M503	Marvoe western hanging wall zone
M504	Marvoe central hanging wall zone

Notes:

- *CIM definitions were used for Mineral Resources.*
- *A cut-off of 1.0 g/t Au is applied for all zones.*
- *Due to rounding, some columns or rows may not add up exactly to the computed totals.*
- *Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.*

Table 6-4: New Liberty Mineral Reserve estimate as at 20 May 2013 (AMC, 2013a)

Reserve category	Oxide/Fresh	Tonnes (Mt)	Au grade (g/t)	Au ounces (koz)
Proven	Oxide	-	-	-
	Fresh	0.7	4.4	99
Probable	Oxide	0.3	2.3	18
	Fresh	7.5	3.3	806
Total	**Oxide**	**0.3**	**2.3**	**18**
	Fresh	**8.2**	**3.4**	**905**
GRAND TOTAL	**Mineral Reserves**	**8.5**	**3.4**	**924**
Waste	Oxide	13.3	-	-
	Fresh	118	-	-
Total		**131**	**-**	**-**
Strip ratio	(w:o) (t/t)	15.5	-	-

Notes:

- *CIM definitions were used for Mineral Reserves.*
- *A cut-off of 0.8 g/t Au is applied for all zones.*
- *Due to rounding, some columns or rows may not add up exactly to the computed totals.*

6.2.2 Ndablama

In November 2013, an Inferred Mineral Resource of 451,000 ounces at 2.1 g/t Au was estimated, reported using a 0.5 g/t cut-off grade. The Ndablama Mineral Resource estimate was prepared by AMC Consultants (UK) Limited (AMC) in accordance with the requirements of National Instrument 43-101 "Standards of Disclosure for Mineral Project", of the Canadian Securities Administrators ("NI-43-101"). Mineral Resources for Ndablama as of 2013 are presented in Table 6-5.

Table 6-5: Ndablama Mineral Resource estimate as at 11 November 2013 (AMC, 2013b)

Mineral Resource	Tonnes (Mt)	Au grade (g/t)	Au (koz)
Inferred	6.8	2.1	451

Notes:

- *Mineral Resources for the Ndablama deposit are reported at a cut-off grade of 0.5 g/t Au.*
- *The effective date of the Ndablama gold deposit mineral resource estimate is 11 November 2013.*
- *Mineral Resources, which are not Mineral Reserves, do not have demonstrated economic viability. The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, title, taxation, socio-political, marketing, or other relevant issues.*
- *The quantity and grade of reported Inferred Mineral Resources in this estimation are uncertain in nature and there has been insufficient exploration to define these Inferred Mineral Resources as Indicated and Measured Mineral Resources.*

In 2014, AMC carried out a second MRE, comprising 7.6 Mt grading 1.58 g/t for 386,000 ounces in the Indicated Mineral Resources category and 9.6 Mt grading 1.7 g/t for 515,000 ounces in the Inferred Mineral Resources category as at 1 December 2014 (Table 6-6). The Mineral Resources are reported at a 0.5 g/t Au cut-off, constrained within a conceptual pit shell based on a US$1,700/oz gold price assumption (AMC, 2014). The Mineral Resources are reported in accordance with CIM guidelines and disclosed via NI 43-101 Technical Reporting (AMC, 2014).

Table 6-6: Ndablama Mineral Resource estimate as at 1 December 2014 (AMC, 2014)

Mineral Resource	Tonnes (Mt)	Grade (g/t)	Au (koz)
Indicated	7.6	1.58	386
Inferred	9.6	1.70	515
Total Mineral Resources	**17.2**	**1.65**	**901**

Notes:

- *Mineral Resources for the Ndablama deposit are reported at a cut-off grade of 0.5 g/t Au.*
- *Mineral Resources are reported to a conceptual open-pit based on US$1,700/oz gold.*

- *The effective date of the Ndablama deposit MRE is 1 December 2014*
- *Mineral Resources in this Resource Statement are not Mineral Reserves, and do not have demonstrated economic viability. The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, title, taxation, socio-political, marketing, or other relevant issues.*
- *Totals and average grades are subject to rounding to the appropriate precision.*

No mining has commenced at the Ndablama deposit and no Mineral Reserves have been reported to date.

7 Geological Setting and Mineralisation

This section, in the context of New Liberty and Ndablama, has been modified from AMC (2013a, 2013b, 2014) and SRK (2017). The Qualified Persons take responsibility for the content of this section and believe it is accurate and complete in all material aspects.

7.1 Regional Geology

Liberia is underlain by the West African Craton, which has remained stable since about 1.7 Ga. The craton consists of two major basement domains; the Reguibat Shield (in the north and around Mauritania) and the Man Shield (3.0–2.5 Ga) which underlies most of Liberia, and much of Sierra Leone, eastern Guinea and the western edge of Cote D'Ivoire (Figure 7-1). The two shields are separated by the Taodeni basin of Proterozoic to Palaeozoic age, while the Man Shield lies to the west of the Proterozoic Birimian Belts.

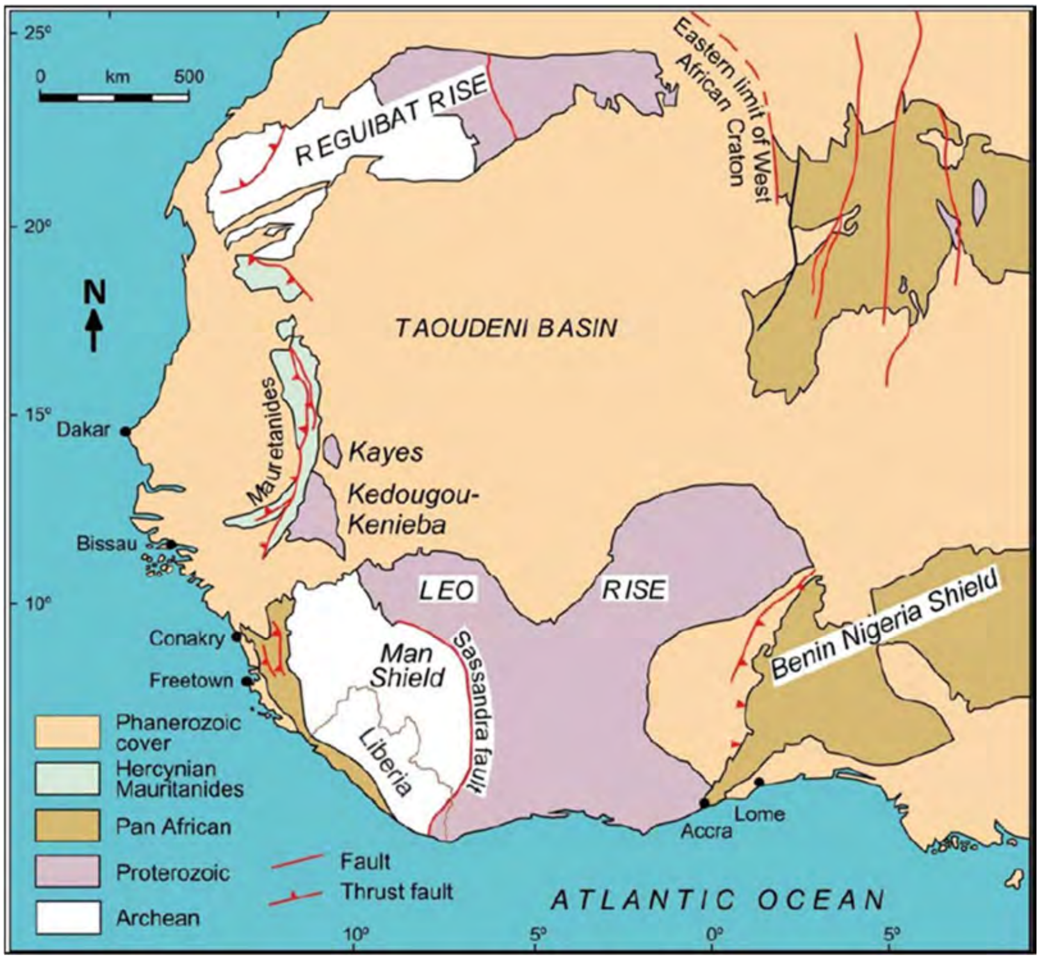


Figure 7-1: Regional geological setting
Source: Milési et al., 1992

To the east of Liberia is a Birimian-age (2.1 Ga) proto-continent that accreted on to Africa during the Eburnean Orogeny (Milési *et al.,* 1992). Along the southern edge of the country, Pan African units represent the formation of Gondwana (500 Ma). The west of Liberia is composed of Archean granites and granitic gneiss, as well as greenstone belts (metamorphosed mafic and ultramafic rocks, bounded by granite and gneiss suites which represent remains of volcanic belts), summarised in Figure 7-2. The Archean rocks have been subjected to deformation and shearing, with major regional structures acting as conduits for mineralising fluids.

An Archean mobile belt along the border between northwest Liberia and Sierra Leone represents a collision orogeny, with a northeast trend and a northwesterly directed closure. Oceanic crust, overlain by sediments, is preserved as tectonic inliers and forms the Bea Mountains, Kpo Range and associated greenstone belts. Later Eburnean (2.15 Ga) deformation is also found to the southeast. A major, crustal scale, northwesterly trending shear zone in the southwestern part of the country cuts across the regional trend of the Archean mountain belt. The interference of these two tectonic elements produced complex structures with a strong rotational component of deformation and formed large and long-lived traps for mineralisation.

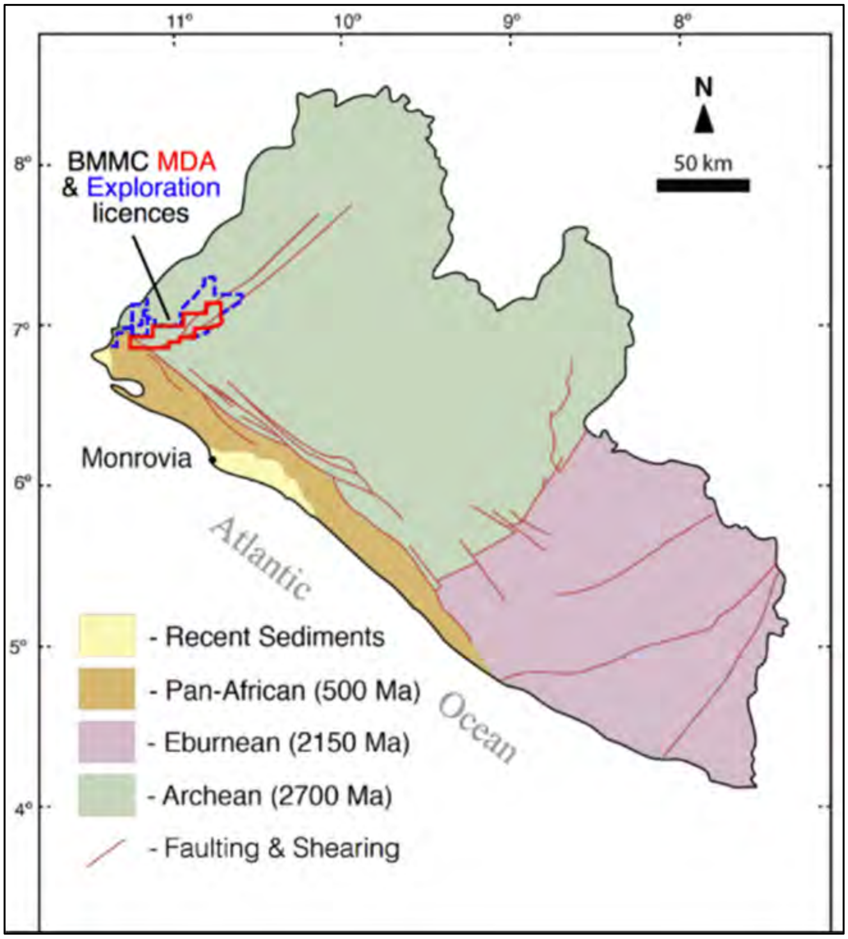


Figure 7-2: Age province map of Liberia
Source: Hurley et al., 2017

7.2 Geology of the Bea-MDA Property

The Bea-MDA property contains a sequence of highly-deformed discrete lenses of ultramafics and amphibolites, which represent relict Archean greenstone belts, surrounded by granites and granodiorites. These rocks have been subjected to lower amphibolite grade metamorphism resulting in gneissose or schistose textures, depending on the protolith.

The greenstone belts are elongated parallel to the regional strike, which is east-trending in the south, swinging to the north-east across a major shear in the north. Two sub-parallel arms of this greenstone unit have been mapped across the entire property; the northern arm represented by the Bea Mountain range and the southern arm the Silver Hills (Figure 7-3). Airborne geophysics has identified other, less clearly defined, east-west trending units which, in the case of New Liberty, have been confirmed by subsequent drilling.

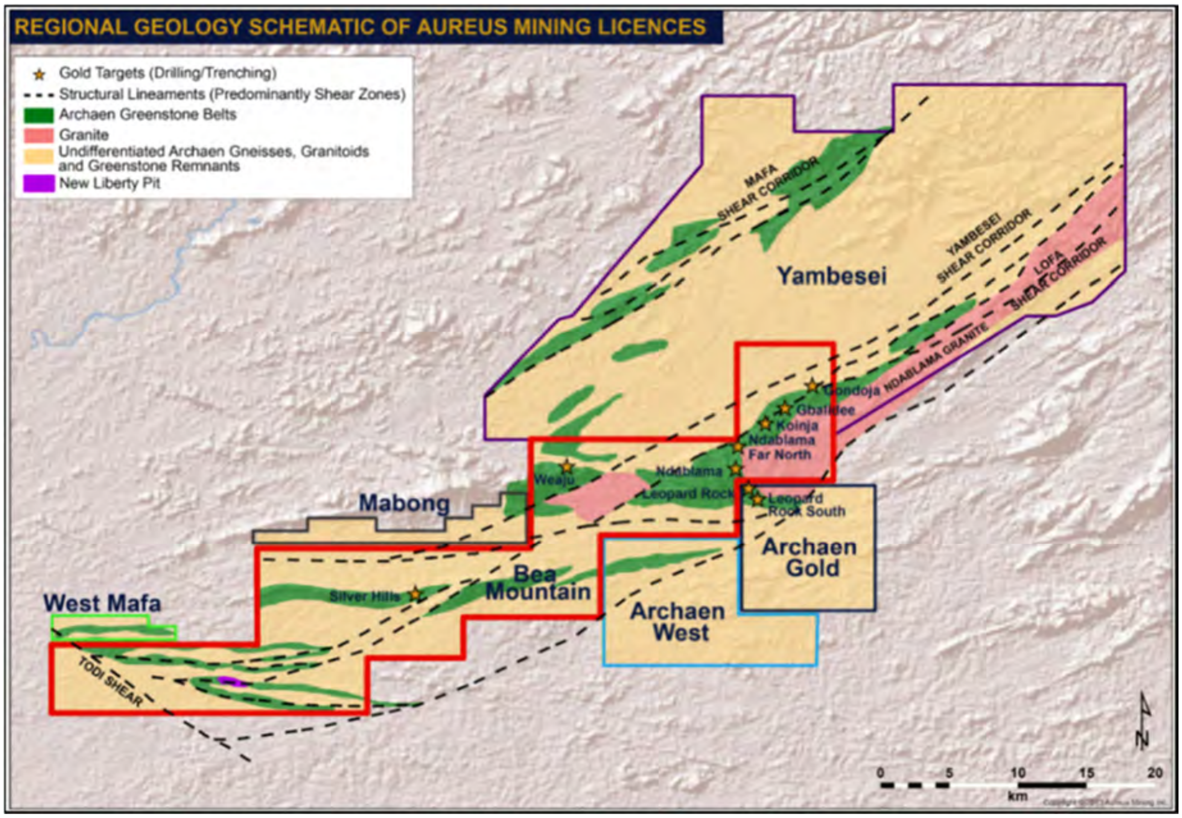


Figure 7-3: *General geology of the Bea-MDA property*
Source: BMMC, 2017

The Bea-MDA property contains several known areas of gold mineralisation; these are located in major imbricate shear zones and possibly associated rotational fold hinges close to greenstone belt contacts, forming coevally with calc-alkaline granitoid intrusions. The shears and associated splays acted as structural channels for hydrothermal solutions, which deposited gold in suitable structures or chemical traps, typical of Upper Archean to Lower Proterozoic styles of metallogeny within greenstone belts.

The east of the Bea-MDA Northern Block is characterised by the presence of a granite batholith, bordered on both the northwestern and southeastern sides by two prominent shear zones, respectively the Yambesei and the Lofa. The area immediately west of the batholith represents a pressure shadow zone, in which Ndablama is located. The Ndablama pressure shadow zone and the Yambesei corridor consist of sequences of deformed mafic and ultramafic units which typically host gold mineralisation. This is highlighted by the continuous 13 km-long zone of soil anomalies extending from the Leopard Rock project (situated south of Ndablama within the adjacent and contiguous Archean Gold Exploration Licence) north to the Gondoja and Welinkua projects.

7.3 Project Geology

7.3.1 New Liberty Stratigraphy

The New Liberty Project is underlain by three main stratigraphic units, which are further subdivided into minor zones of varying mineralogical assemblages. The geology is dominated by tremolite-chlorite-actinolite-talc ± magnetite rich meta-ultramafics, sometimes with phlogopite, and flanked by migmatitic gneisses.

The Hangingwall Complex (HWC) consists of migmatite and gneisses. Amphibolite bands alternate with quartzo-feldspathic gneiss (Figure 7-4), repeating in fractals, from metre through to millimetre scales.

Figure 7-4: Hangingwall gneiss complex (HWC)
Source: BMMC, 2017

The Footwall Complex (FWC) rocks are similarly banded, but the bands have a wider zone of foliated leucoratic gneiss and contain less but larger concentrations of hornblendic gneisses.

The silicified metamorphosed ultrabasic suite (SMUS) is the principal host to the gold mineralisation, and generally contains quartz, chlorite and amphibole, and a host of mafic minerals, including talc.

At the contact separating the HWC and FWC from the SMUS are transitional rocks, named here as garnet phlogopite ± actinolite gneiss, which have a strong schistosity and coarse grain size (Figure 7-5). This unit is also found within the ultramafic sequence. Figure 7-6 shows an example cross section through the New Liberty deposit.

Figure 7-5: Almandine garnet porphyroblasts in HWC
Source: BMMC, 2017

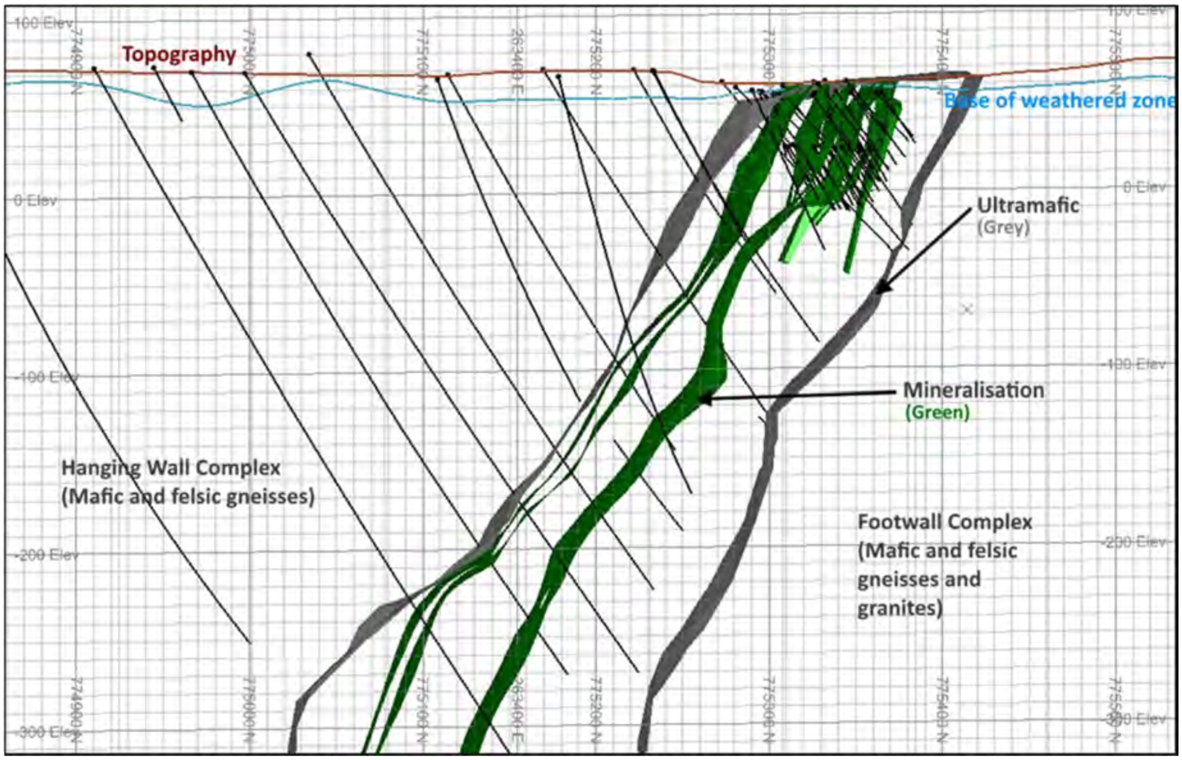


Figure 7-6: Example cross-section through the New Liberty deposit (looking west)
Source: CSA Global, 2018

Syn-to-late tectonic aplites, pegmatites and granitoids that occur within the system are heterogeneous and show significant variations in deformation style relative to the host rocks. Greisens and pegmatitic granites intrude the ultramafics. The variable angles these granite contacts make with the units suggest that they were intruded both along the strike of the zone and into crosscutting fractures, faults and secondary shear zones. The relative ages of these intrusive bodies and their relationships to mineralisation are not known at this stage.

7.3.2 Ndablama Stratigraphy

The Ndablama gold target is underlain by Archean greenstone comprised of amphibolite gneisses and ultramafic rocks.

Geologically, Ndablama is subdivided into three main entities, designated the Northern, Central and South Eastern zones. The general geology of Ndablama consist of mafics and ultramafic rocks. The mafic package consists of amphibolite schists and gneisses which envelope a series of ultramafic schists. The ultramafic rocks have been subdivided into magnetite-rich and magnetite-poor zones. The ultramafic and mafic rocks are located close to the contact with a large granitic batholith to the east. The metavolcanic sequence has been intruded by granitic sills.

A simplified lithological sequence of Ndablama comprises three distinct packages:

- The hangingwall is comprised of a package of amphibolite gneisses sparsely intercalated with granitic gneiss and deformed granitic intrusions. Towards the base of the package bands of magnetite-rich ultramafics can also be found (Figure 7-7).
- The middle package of amphibolite and ultramafic schists. The ultramafics are comprised of tremolite-chlorite with either magnetite of phlogopite, and biotite. Occasionally, this package is intruded by granite breccias and quartz-rich veins usually along the contact zone between the mafic and ultramafic rocks. This package is host to the mineralisation zone (Figure 7-8).

- A lower package (the footwall) which is made up of more amphibolite and granitic gneiss units which are intruded by microcline granite and has weak hematite alteration (Figure 7-9).

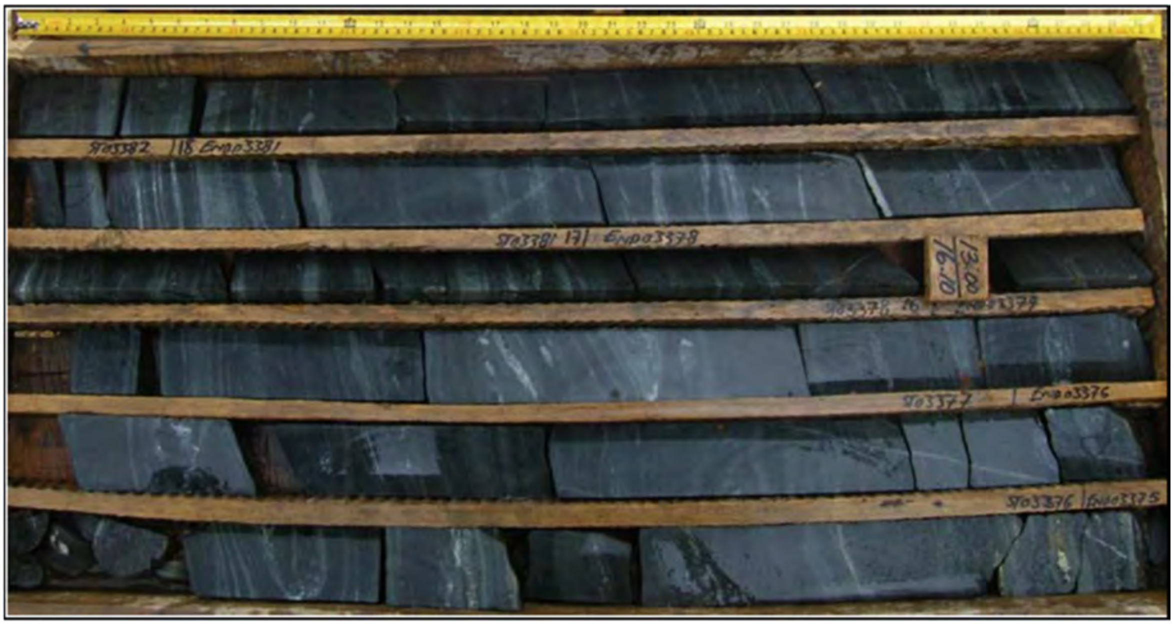


Figure 7-7: Amphibolite gneisses (upper package)
Source: AMC, 2014

Figure 7-8: Sheared ultramafic schists (mineralised zone)
Source: AMC, 2014

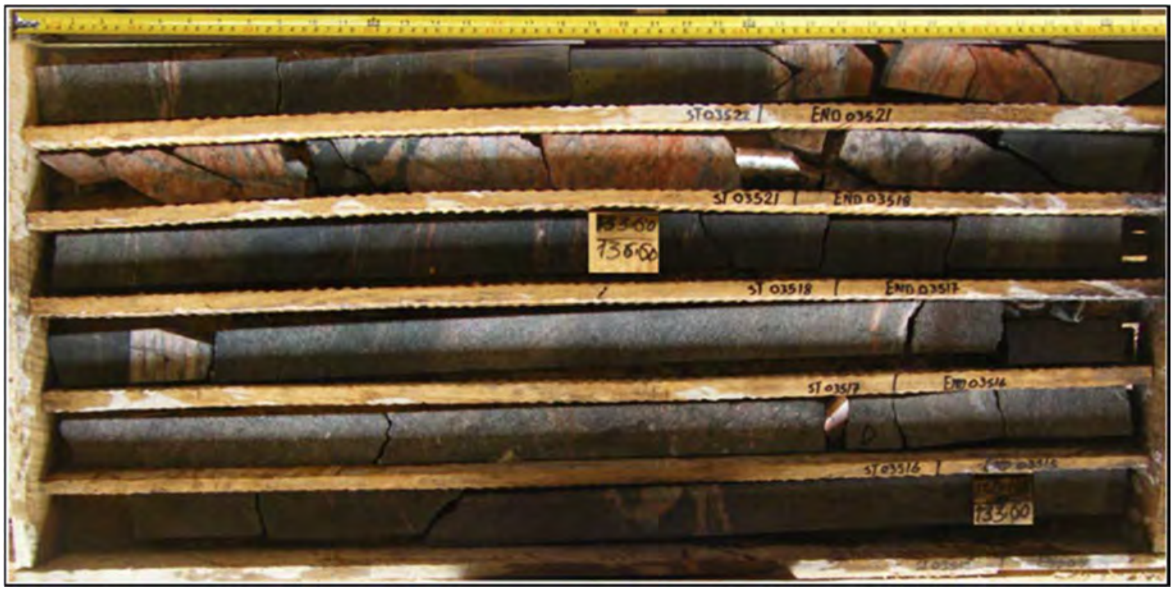


Figure 7-9: Granite gneiss with microcline granite injection (lower package)
Source: AMC, 2014

7.4 Structure

7.4.1 New Liberty Structure

The Project is positioned in a predominantly southerly-dipping schist belt, within a zone of high ductile shear strain oriented 287°/72°, which served as the pathway for the migration of goldu-bearing fluids into the host lithology. The ultramafic unit is layered and cut by brittle faults and dolerite dykes. Parallel bands and linear mafic bodies, interpreted as sills and mafic schists, have also been mapped locally to the north and south of the Project. The ultramafic rocks in sheared regions are characterised by a steeply dipping fabric. Small scale, first-order folds (3–5 cm) are common throughout the system.

Faults are difficult to detect on the surface due to the regolith and because some faults may be parallel to the regional strike, while others could have been annealed by granite veins and intrusions, again parallel to regional foliation. Thrust faults have been identified, with the hanging wall thrusting towards the north. Immediately adjacent to the gold mineralisation shearing increases in intensity until folding is no longer detectable.

7.4.2 Ndablama Structure

Ndablama lies on the western edge of a shallow westerly-dipping shear which lies within a pressure shadow area of the Ndablama batholith to the east. The shear is gently folded around the edge of the batholith forming an open anticline plunging towards the west and hosts the gold mineralisation. It extends over 5 km from Leopard Rock South to Ndablama Far North (Figure 7-10). The resulting shear structure developed mostly in the middle package of amphibolites and ultramafics. The shear dips shallowly westwards varying between 30° and 10°.

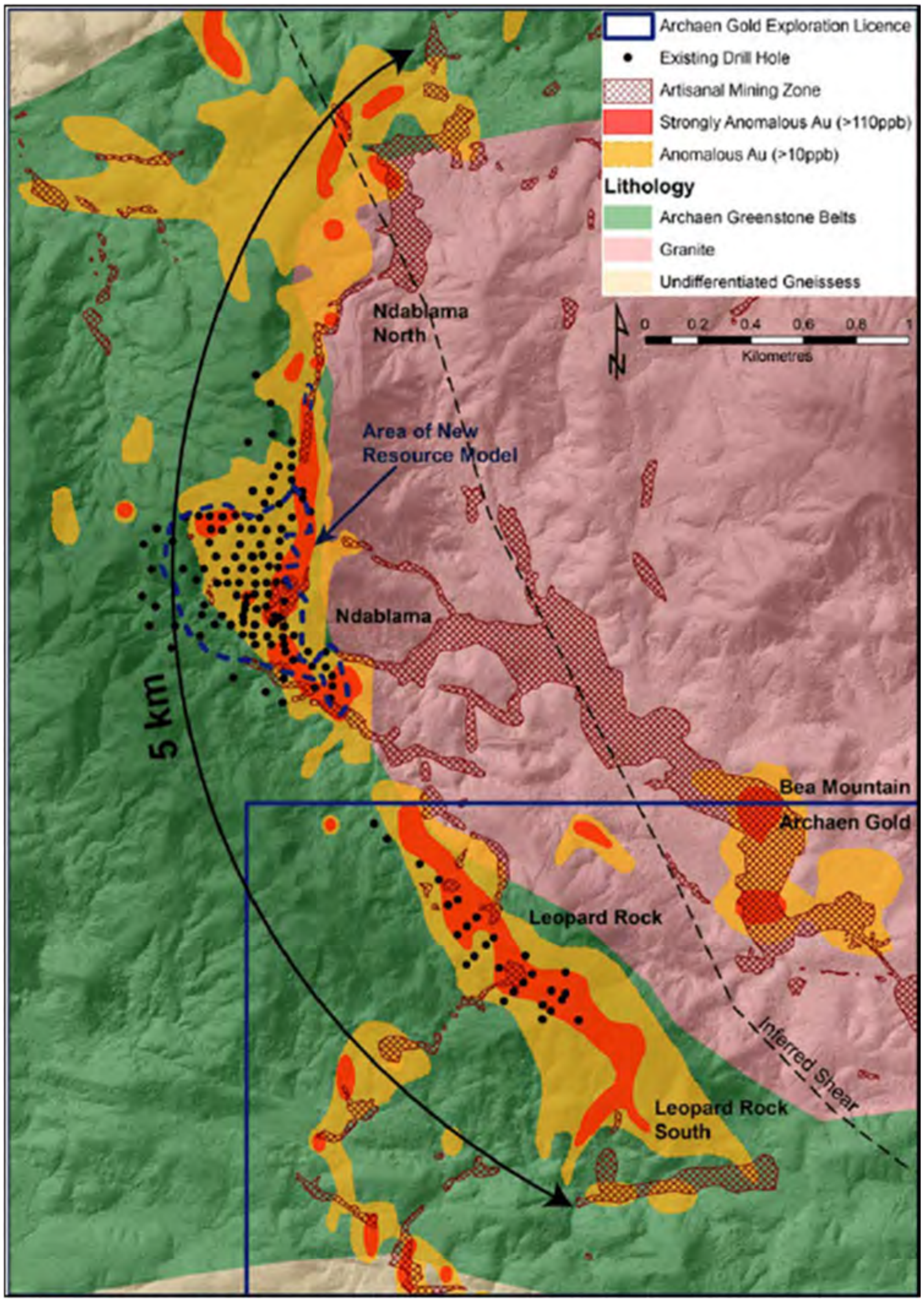


Figure 7-10: Geological map of Ndablama pressure shadow zone
Source: BMMC, 2014

7.5 Alteration and Mineralisation

7.5.1 New Liberty Alteration and Mineralisation

Within the ultramafic unit, silicification is found proximal to the mineralisation, within the immediate hangingwall and rarely in the footwall gneisses. Other alteration styles associated with the mineralisation include the presence of phlogopite as well as chlorite within the mineralised zone, and an associated sulphidic bleaching of the rocks linked with the destruction of magnetite.

These features point to a pathway for the mineralising fluids which was active over a long period of time. The deposit shows the classic signs of sulphidation, with iron sulphides (mainly pyrrhotite) replacing the magnetite and it has a low sulphide content with sulphides forming between 0.1% and 1% of the mineralised zones.

Relationships have been established between magnetite depletion, silicification, phlogopite alteration and gold mineralisation.

Multi element analyses of cores have highlighted a clear association between gold and arsenic, sulphur, nickel and tungsten in the mineralised zones. Enhanced values of magnesium, sodium, potassium, rubidium and barium occur along the margins of the mineralisation. It is hypothesised that the gold-bearing metamorphic fluid may include a granitic component in its evolution.

Vast majority of the mineralisation at the Project is hosted within the altered parts of the sheared ultramafic rocks. Pyrrhotite, gersdorffite and arsenopyrite are the main sulphides with occasional pyrite and rare chalcopyrite or pentlandite. Metallurgical tests of the mineralised sections carried out by Lakefield Research Limited (Lakefield, 1999b) indicated that the gold is free in form. Gold mineralisation occurs in zones of variable thickness, with average widths of 10 m, and is nearly continuous along 2 km of strike.

Through the history of exploration at the Project, particular local concentrations of higher-grade gold mineralisation have been identified, initially on the basis of apparent breaks in strike continuity at surface and subsequently through confirmation of strike discontinuity or at least variation at depth. For convenience, these zones have been named, from west to east as Larjor, Latiff (discovered in 2010 in what had been assumed to be a gap), Kinjor and Marvoe.

7.5.2 Ndablama Alteration and Mineralisation

Gold mineralisation is associated with hydrothermal alteration and disseminated sulphides and is related to shear deformation which follows the granite-metavolcanic contact zone.

Alteration is consistently defined by silicification, magnetite destruction, phlogopite and chlorite, with phlogopite dominating the relationship. Magnetite destruction within the ultramafics has been identified as having a direct relationship with gold mineralisation.

The mineralisation is located within a sheared package of ultramafic and mafic rocks intercalated within a gneiss sequence overlying/adjacent to a granite batholith. The mineralization consists of three bodies; the central zone 430 m long has been drilled to vertical depth of 290 m, southern-eastern zone which has 300 m strike length has been tested to 120 m depth, and the last zone ,along north to south direction, which has about 1300 m strike length has been drilled to 360 m vertical depth. All have shallow westerly-dip (25° on average) and strike north-south (Figure 7-11 and Figure 7-12). The dip of the orebody decreases with depth. Mineralisation continues to the north but at a lower grade.

Sheared amphibolite schists with biotite/phlogopite and ultramafic tremolite chlorite schists host the gold mineralisation at Ndablama, with occasional magnetite-poor ultramafics and intrusive granites also containing mineralisation. Petrography carried out during 2014 shows that the gold is associated with disseminated pyrite and pyrrhotite and trace chalcopyrite (Thatcher, 2014).

Some of the gold mineralisation Is coarse and visible gold is consistently observed in most of the drillholes (Figure 7-13). It occurs mainly within the intensely silicified parts but can also occur within less altered amphibolites or ultramafics.

Gold often occurs at sheared contact zones between ultramafic and mafic rocks that have been intruded by granite dykes and breccias. The breccia often marks the end of the gold mineralisation. Spatially, gold mineralisation remains open in all directions.

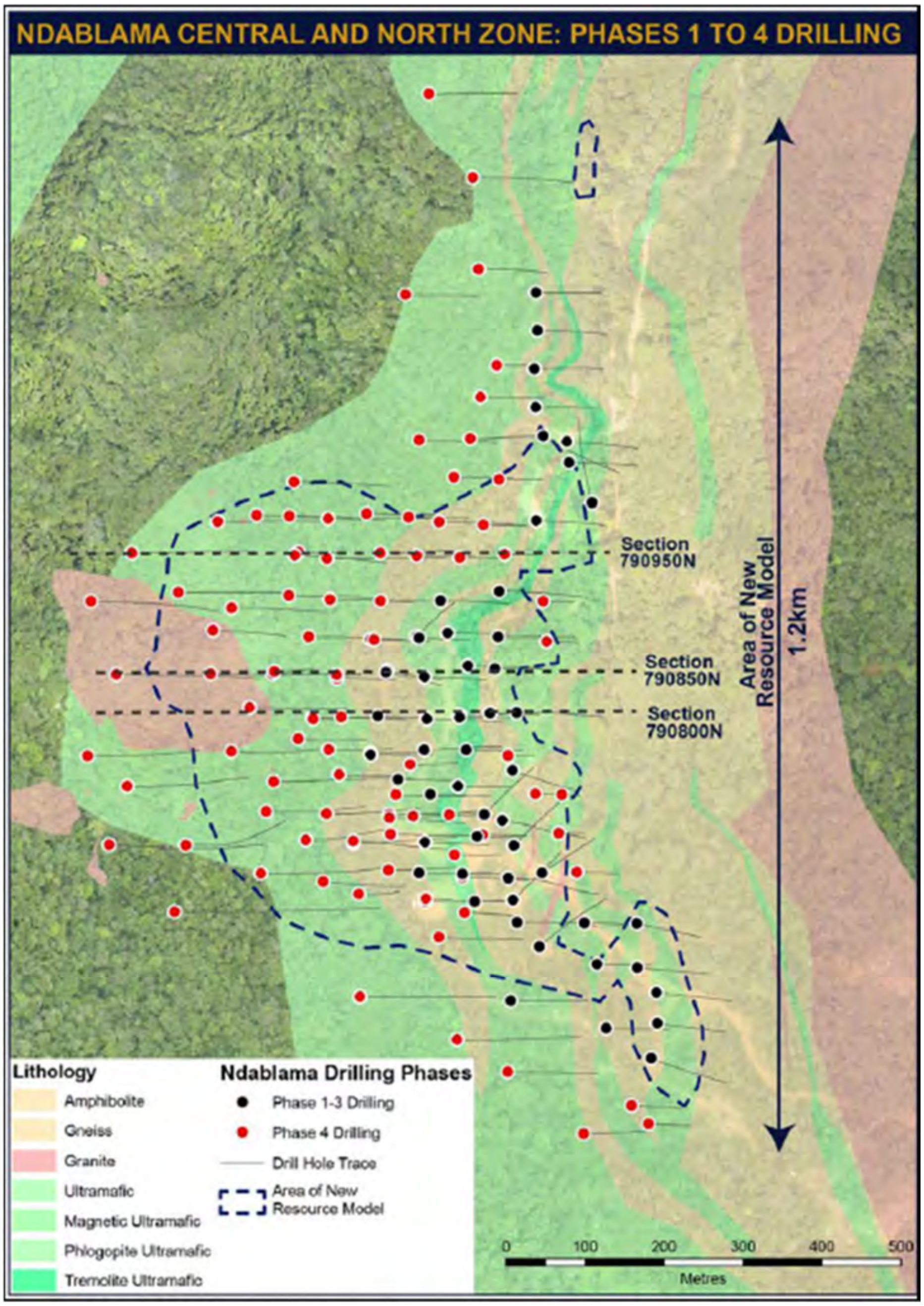


Figure 7-11: Geology of Ndablama (2014)

Source: BMMC, 2014

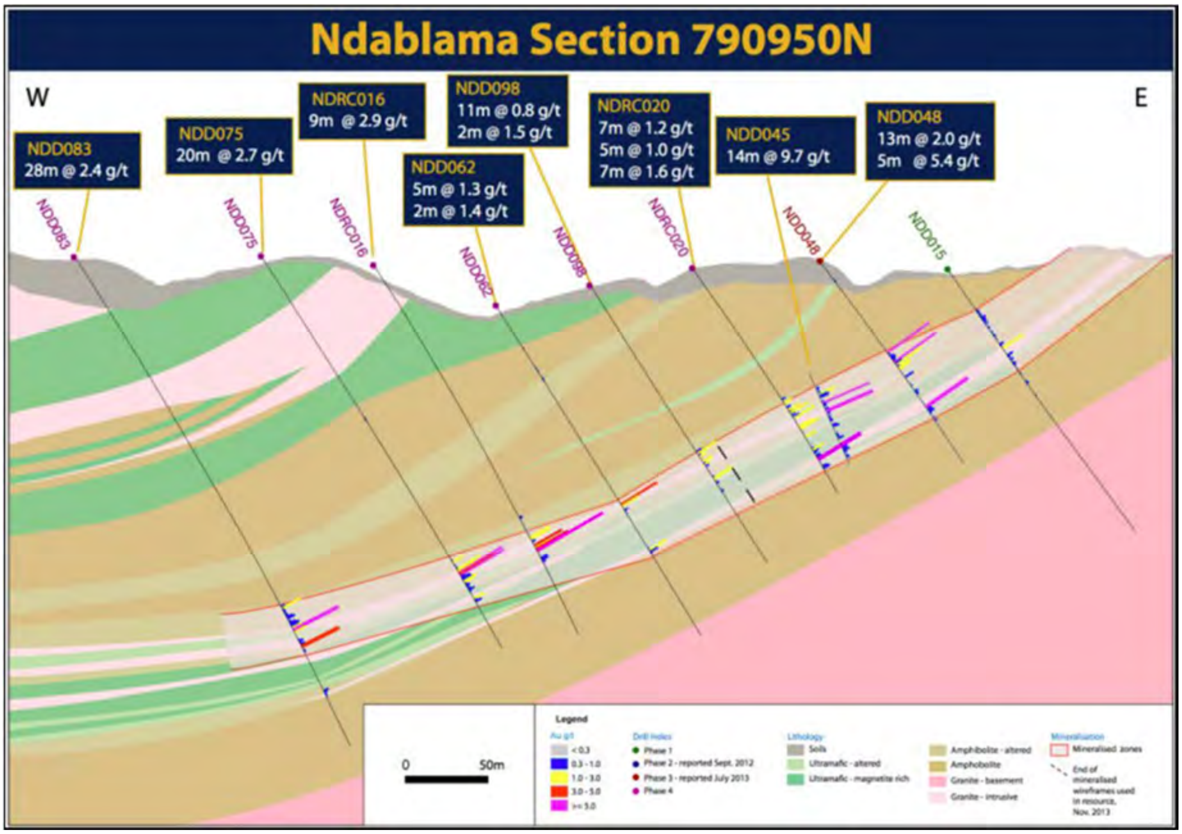


Figure 7-12: *Ndablama example cross section at 790950mN (2014)*

Source: BMMC, 2014

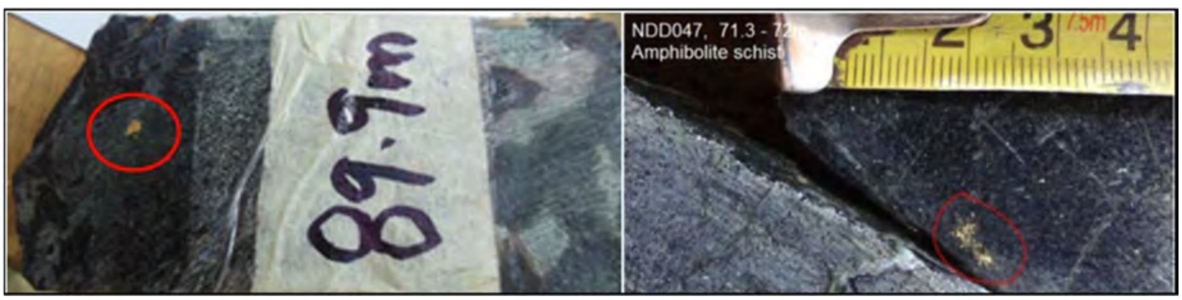


Figure 7-13: *Visible gold in drill core*

Source: AMC, 2014

The mineralised system shows a high-grade plunge (Figure 7-14). This plunge is controlled by the intersection of the axial planar cleavage with the regional foliation. The intersection has been modelled plunging at 13° towards 289°.

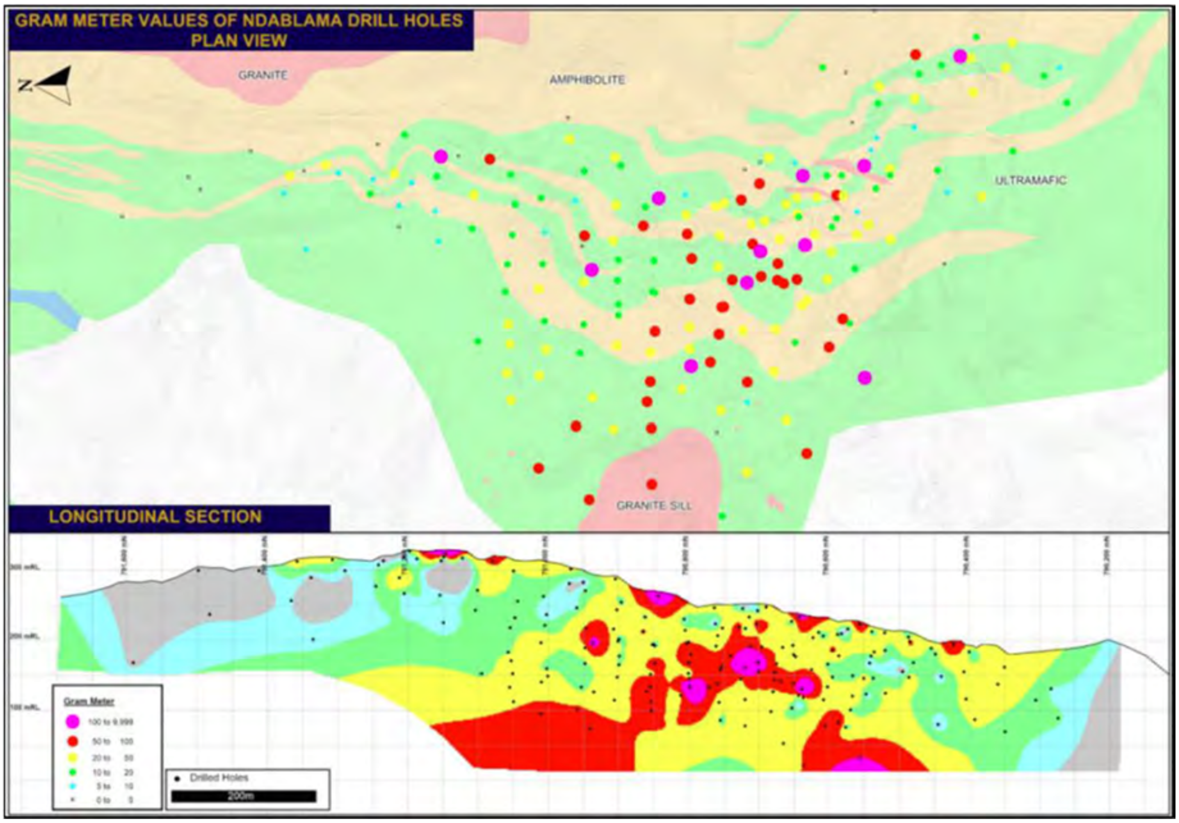


Figure 7-14: Longitudinal plan and section of gold grade (2014)
Source: BMMC, 2014

7.6 Metallogeny and Paragenesis

7.6.1 New Liberty Metallogeny and Paragenesis

Gold at the Project is associated with an assemblage of sulphides and oxides in ultramafics and granite intrusions. Opaque minerals include trace to minor quantities of pyrrhotite, arsenopyrite, chalcopyrite, pentlandite, magnetite, ilmenite and rutile. Sulphide occurs as vein fills, massive aggregates, clusters, blebs, stringers and fine or coarse disseminations in ultramafics or granite veins. There appears to be a progression from syntectonic to late-tectonic growth, with at least two phases of sulphide and oxide growth. The non-opaque minerals are amphibole, chlorite, mica, serpentine, talc and quartz. Pyrrhotite, gersdorffite, arsenopyrite, coarse grained pyrite, chalcopyrite, sphalerite and minor pentlandite are the principal sulphides.

In Figure 7-15, pyrrhotite, arsenopyrite and pyrite are shown in cut ultramafic core, with the bulk of the sulphides aligned to the dominant cleavage.

Figure 7-15: Mineralisation in New Liberty drill core (K501)
Source: CSA Global, 2018

7.6.2 Ndablama Metallogeny and Paragenesis

Gold at Ndablama is associated with an assemblage of sulphide and oxides in ultramafics and amphibolites. Opaque minerals include mainly pyrrhotite and magnetite. There are minor traces of pyrite, chalcopyrite, pentlandite, sphalerite, ilmenite and rutile. Sulphide occurs as vein fills, massive aggregates, clusters, blebs, stringers and fine and coarse disseminations in ultramafics or granite veins. As with New Liberty, there appears to be a progression from syntectonic to late-tectonic growth, with at least two phases of sulphide and oxide growth. The non-opaque minerals are amphibole, chlorite, mica, serpentine, talc and quartz. Pyrrhotite, coarse grained pyrite, chalcopyrite, sphalerite and minor pentlandite are the principal sulphides; the chief observation being (but not always) an increase in grain size and abundance, both absolute and relative, in host rocks near granite veins.

In Figure 7-16, pyrrhotite and pyrite are shown in cut ultramafic core, with the bulk of the sulphides aligned to the dominant cleavage.

Figure 7-16: Mineralisation in Ndablama drill core (NDD189)
Source: CSA Global, 2018

8 Deposit Types

This section, in the context of New Liberty and Ndablama, has been modified from AMC (2013a, 2013b, 2014) and SRK (2017). The Qualified Persons take responsibility for the content of this section and believe it is accurate and complete in all material aspects.

8.1 Mineralisation Styles

The property hosts a typical Upper Archean to lower Proterozoic style of metallogeny, characteristic of greenstone-hosted lode gold mineralisation, where deposits are often referred to as orogenic, and characterised by the presence of gold-quartz veins and disseminated mineralisation. Gold mineralisation is hosted in moderate to steeply dipping quartz-dominated shear zones with associated extensional vein systems. This model is consistent with Archean orogenic gold deposits described by Hagemann and Cassidy (2000), Richards and Tosdal (2001), Goldfarb *et al.* (2001) and Roberts *et al.* (1989).

8.2 Conceptual Models

Archean orogenic deposits are typically hosted in greenstone belts comprised of meta-volcano sedimentary supracrustal assemblages, together with coeval calc-alkaline granitoid intrusions. Gold mineralisation is coeval with the syntectonic stages of the orogeny and is related to periods of crustal shortening at 8–15 km depth. Structures are typically formed at, or close to, contacts between rock types of contrasting competencies, and mineralisation is often localised at bends or splay intersections in the shear system.

Mineralisation in Archean deposits are associated with characteristic alteration styles (quartz-carbonate-sericite-biotite-sulphides) and often enriched in 'lodes' that plunge steeply. Gold deposits may occur in a variety of host rocks, which include granite, meta-volcanic rock (greenstones) and include mafic and ultramafic rock units and associated volcaniclastic, banded iron formations and siliciclastic sediments, as observed within the Bea-MDA licence area. The schematic diagram (Figure 8-1) depicts a typical orogenic lode system with analogous geological settings for the deposit styles found on the property.

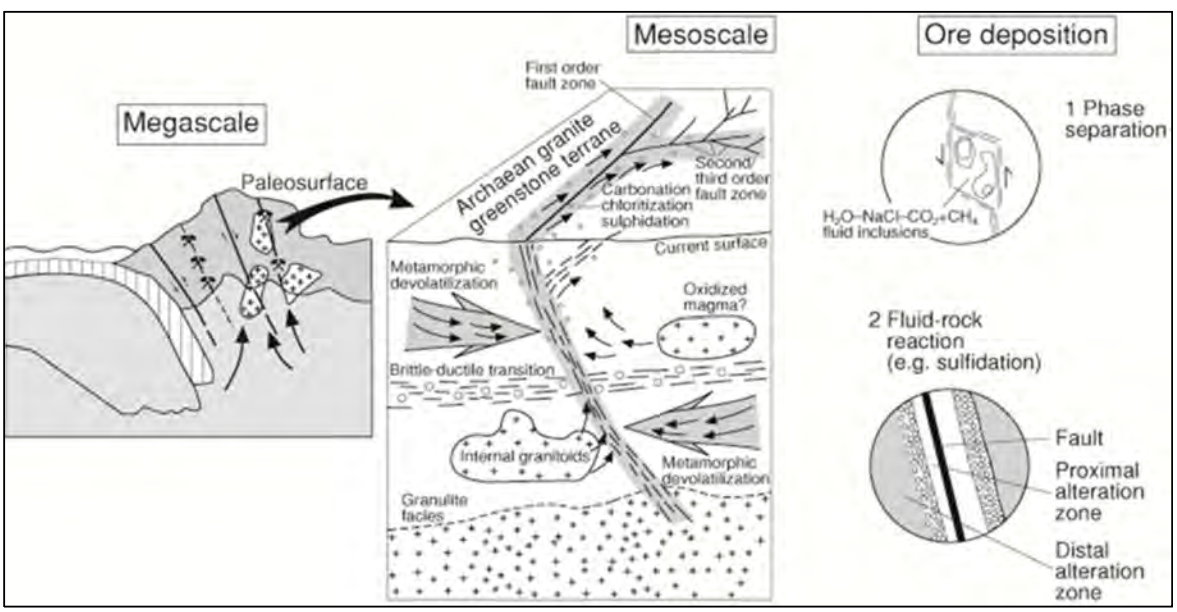


Figure 8-1: Schematic of orogenic gold systems
Source: Hagemann and Cassidy, 2001

The primary targets of Avesoro's mineral exploration program in Liberia are shear-zone hosted gold systems, whether associated with quartz, granite veins, breccia zones, or granite bodies. A structural control to mineralisation is evident with areas of multiple structures intersecting. Gold mineralisation in these deposits is thought to have been emplaced by gold-bearing fluids flowing into dilatational zones formed by faults or fold hinges in high strain zones.

Gold within the system was introduced as gold sulphide complexes in hydrothermal solutions, which may in part have been sourced from underlying granitic plutons. The solutions reacted when they came into contact with the magnetite within the ultramafic rocks, causing the deposition of native gold and sulphide minerals. Prominent examples of such deposits, some of which rank as world class, are: Golden Mile at Kalgoorlie, Australia, Kerr-Addison Mine in Ontario, Canada, Canada and Homestake Mine in the United States, Groves *et al.* (2003) and Robb (2005).

9 Exploration

This section, in the context of New Liberty and Ndablama and relating to pre-2018 exploration and drilling, has been modified from AMC (2013a, 2013b, 2014) and SRK (2017). The Qualified Persons take responsibility for the content of this section and believe it is accurate and complete in all material aspects.

9.1 Methodologies

Exploration at the Bea-MDA property follows a systematic process of reconnaissance work, including grab sampling, followed by soil geochemistry, mapping, trench sampling and eventually drilling. Airborne and ground geophysics have also been conducted, where appropriate.

9.1.1 Coordinates, Datum, Grid Control and Topographic Surveys

At New Liberty, geological and geographical information was first set out on a local grid using a baseline at 285° magnetic, parallel to the strike of the mineralisation. Early mapping of outcrop, trenches and streams was by tape and compass survey. This grid contained several errors, compounded by the magnetic effect of the ultramafic body. In 2009, survey control was re-referenced to UTM Zone 29N coordinates (map datum WGS84), and locations were obtained using GPS. In addition to re-surveying drillholes, a topographic map was created which included streams, roads and outcrop.

Surveys since 2010 for both drillhole collar pickup and topography were undertaken with reference to three control points, with two Trimble R3 receivers used for surveying in 2010. From October 2011, a Leica DGPS survey system was used to resurvey all the drillholes, while a new topographic survey is progressively being updated, with reference to the same three control points.

At Ndablama, in the last quarter of 2012, six control points were set up at locations over Ndablama, Leopard Rock and Gondoja project areas with a Leica DGPS, by consultants from Ghana in collaboration with BMMC surveyors. These points served as references for all spatial data collected within the project areas.

A light detection and ranging (LIDAR) survey was flown during March 2013 over the northern block of the Licence. The survey, by CK Aerial Surveys Inc. of South Africa, produced topographic DTMs and contours, and aerial photographs. A total of 32 km^2 was covered during the survey, including Ndablama, Weaju and Leopard Rock in the Archean Gold Exploration licence area.

Drillhole coordinates have been converted from the historic local grid to UTM29N projected coordinate system, referencing the WGS84 datum. The elevation (RL) was then corrected to the new topographic elevation obtained from the LIDAR survey. Subsequent drillhole and trench collars have been picked up using a SOKIA DGPS using WGS84 datum.

At Ndablama, since 2012, survey pickups for both drillholes and topography have been obtained using a Garmin handheld GPS. Later, all drillhole collars were re-surveyed using a Total Station, with reference to the central points. The LIDAR survey has improved the quality of survey work on the target. All drillhole collars and trenches surveyed with total station matched well with the LIDAR DTM.

9.1.2 Geological Mapping

Company geologists map lithology, mineralisation and structures using outcrop mapping. Outcrop is limited mostly to stream beds, road cuts, artisanal pits and trenches; therefore, maps are progressively updated as more data from trenches and drilling becomes available.

9.1.3 Soil Geochemistry

Soil sampling is undertaken on a set grid, with line spacing determined by the objectives of the individual programme. Samples are positioned using handheld GPS, with 1 kg of soil taken from a depth of approximately 0.5 m, depending on the soil profile. The samples are collected in areas away from drainage channels, then coned and quartered to 1.5–2.5 kg weights and bagged for analysis.

9.1.4 Trenching

Trenches are staked out by geologists at an alignment that intersects the strikes of structures and are then excavated to a depth of 1–4 m, depending on bedrock intersection depth. The trenches are surveyed and logged, followed by continuous channel sampling along each metre of the trench. One-metre-long samples were systematically collected in saprolite material from 10 cm high channels cut into cleaned trench walls near the floor of trenches and across the strike of mapped structures. For consistency, the channels start at the southern ends of trenches. Some trenches (and channels) were excavated in separate segments to traverse around large boulders, trees and unstable artisanal workings, whilst maintaining continuity across the zone.

9.2 Regional Geophysics

In May 2006, a high-resolution helicopter-borne, combined magnetic gradient and gamma-ray spectrometer survey was conducted over the south-west and north-east sections of the licence area by New Resolution Geophysics (NRG). During 2012 a further survey was carried out by Geotech Airborne Limited, covering the remainder of the Bea-MDA property, and the adjacent Archean licence. Sufficient overlap between the old and the new surveys and matching line spacing enabled the surveys to be merged together. The geophysics interpretations are shown in Figure 9-1 and Figure 9-2, and the survey parameters of both are summarised in Table 9-1.

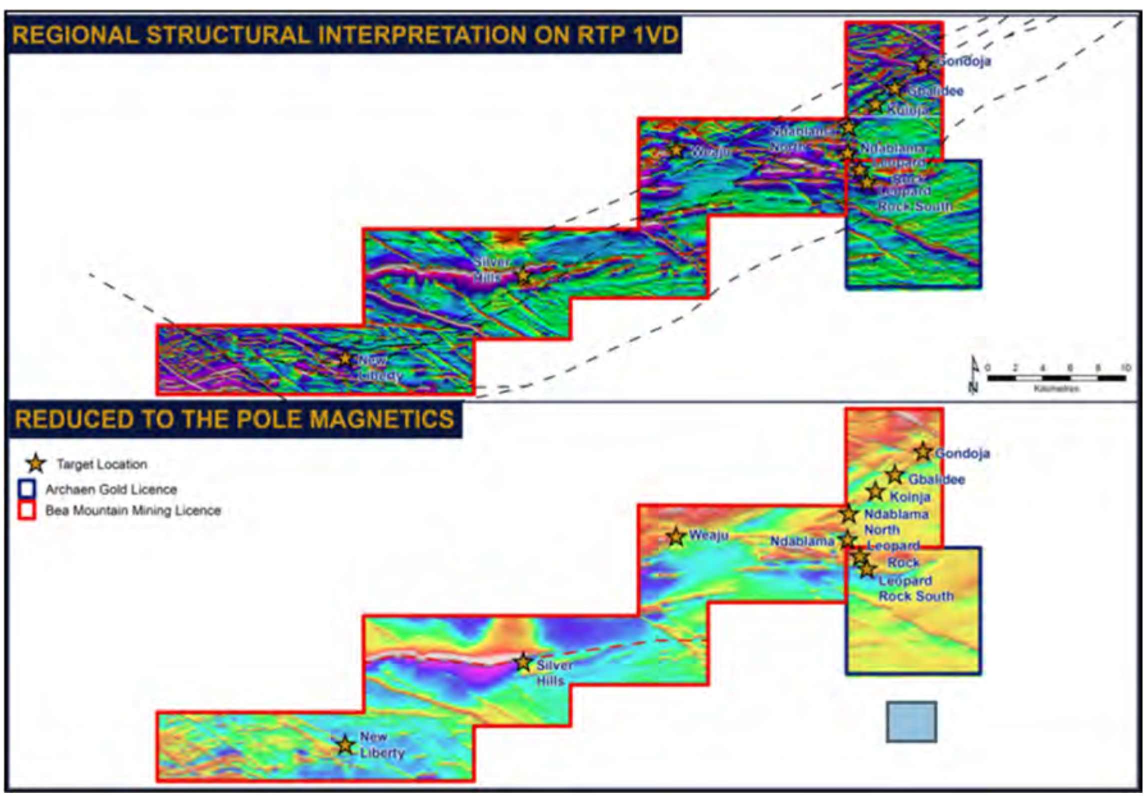


Figure 9-1: Bea Mountain geophysics interpretation
Source: BMMC, 2014

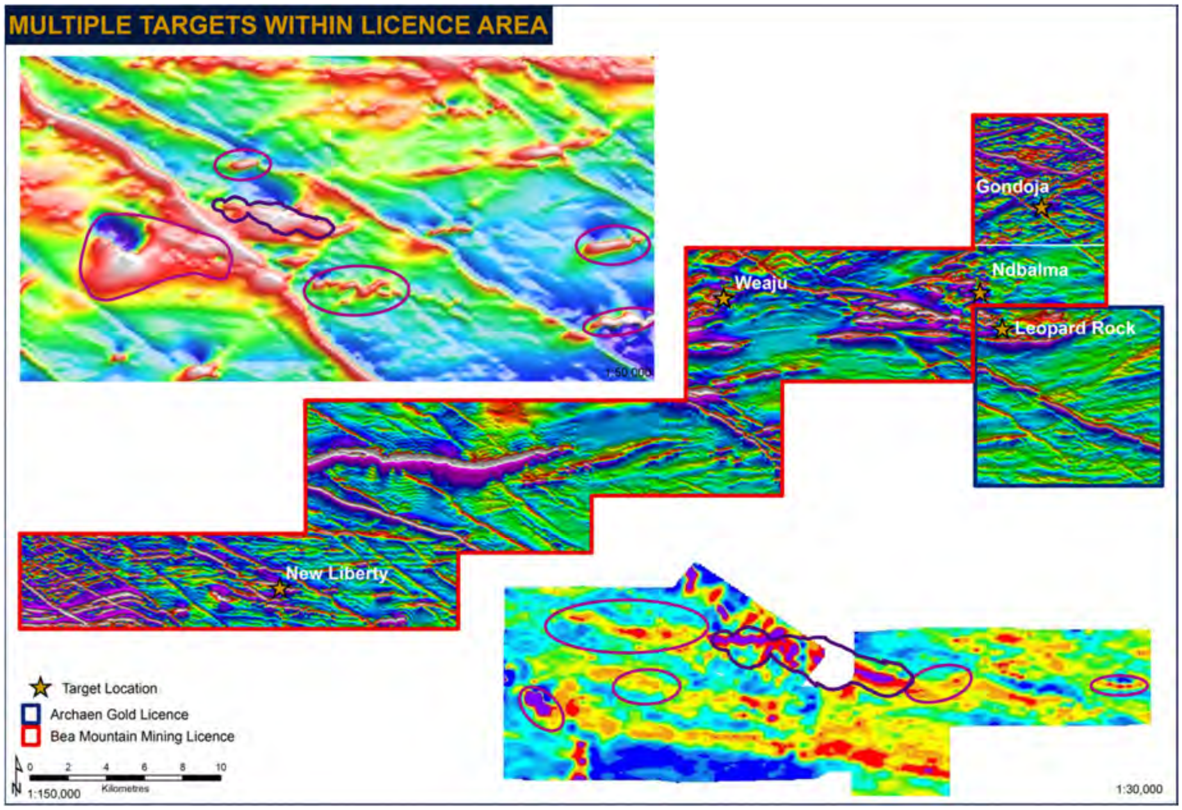


Figure 9-2: New Liberty geophysics interpretation
Source: BMMC, 2012

Table 9-1: Comparisons of the 2006 and 2012 airborne geophysical surveys

Company	Year	Survey method	Data acquired	Flight elevation	Line spacing	Positional system	Line flown (km)
New Resolution Geophysics	2006	Helicopter	Magnetics, spectrometry DTM	30 m	100 m with 1,000 m tie lines	DGPS and radar altimeter	2,200
Geotech Airborne Limited	2012	Fixed wing	Magnetics, spectrometry DTM	100 m	101 m with 1,000 m tie lines	DGPS and radar altimeter	9,631

9.3 New Liberty Exploration

9.3.1 Soil Sampling

Geochemical soil sampling in 1999 on a 100 m x 20 m grid over 1 km each side of the known mineralisation detected a strong anomaly over 200 m to the west and east. Further along-strike soil sampling in 2011 and 2012 extended the areas surveyed to the east and west, in conjunction with geophysics and exploration. During 2013 and 2014, further soil sampling occurred to the both the northeast of New Liberty at the Belgium targets (Silver Hills) and to the north-west at the West Mafa target, with the focus of locating near-mine anomalies for further follow up exploration (Figure 9-3).

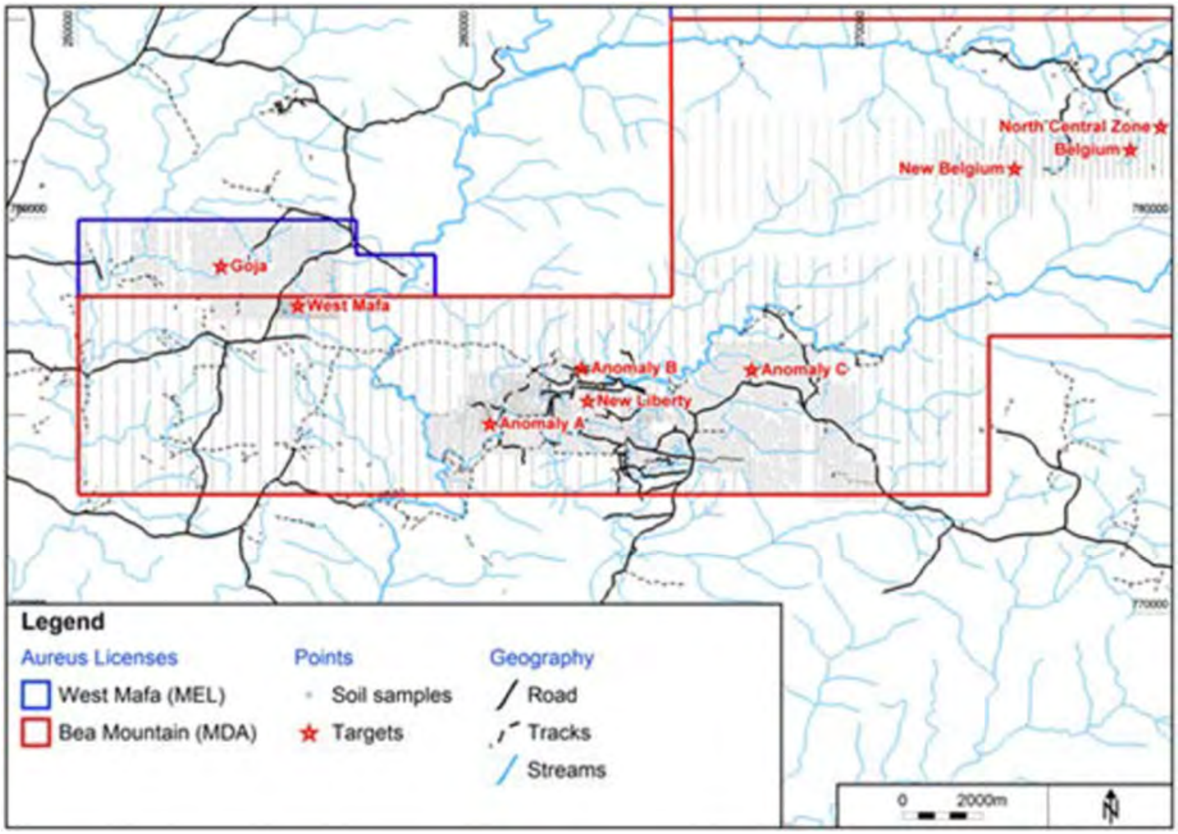


Figure 9-3: Soil sampling coverage over the New Liberty area showing targets identified
Source: BMMC, 2015

9.3.2 Trenching

In 1997, following an encouraging channel sample program over artisanal workings (Figure 9-4), which yielded intersections including 19.95 m at 4.06 g/t Au in the west and 13.1 m at 4.56 g/t Au in the centre of the system, trenches T1 to T12 were excavated. Each 3 m deep trench was aligned approximately perpendicular to the east-west strike of the mineralisation. This covered an along-strike extent of 1,800 m. During 1998, trenches T13 to T24 were completed at intervals of 100 m along the geological strike and 20 m to 80 m long to depths ranging from 2.0 m to 4.0 m into saprolitic material (Figure 9-5). Later trenching (T27 and T28) was used for outcrop demarcation to assist in the positioning of drillhole collars in poorly exposed terrain beyond the ultramafics and mineralisation.

Further to this, during the 2012/2013 field season, a total of 29 trenches were dug across four key sites (totalling 3,241 m, Figure 9-6). The trenches targeted anomalies represented by elevated soil gold and arsenic values coincident with geophysics anomalies.

All trenches were geologically mapped and channel sampled (metre-length samples). All samples were despatched to the SGS Laboratory in Monrovia for analysis for gold, and results were assessed as they were received.

Figure 9-4: Artisanal workings in Larjor
Source: BMMC, 2012

Figure 9-5: Exploration trench
Source: BMMC, 2012

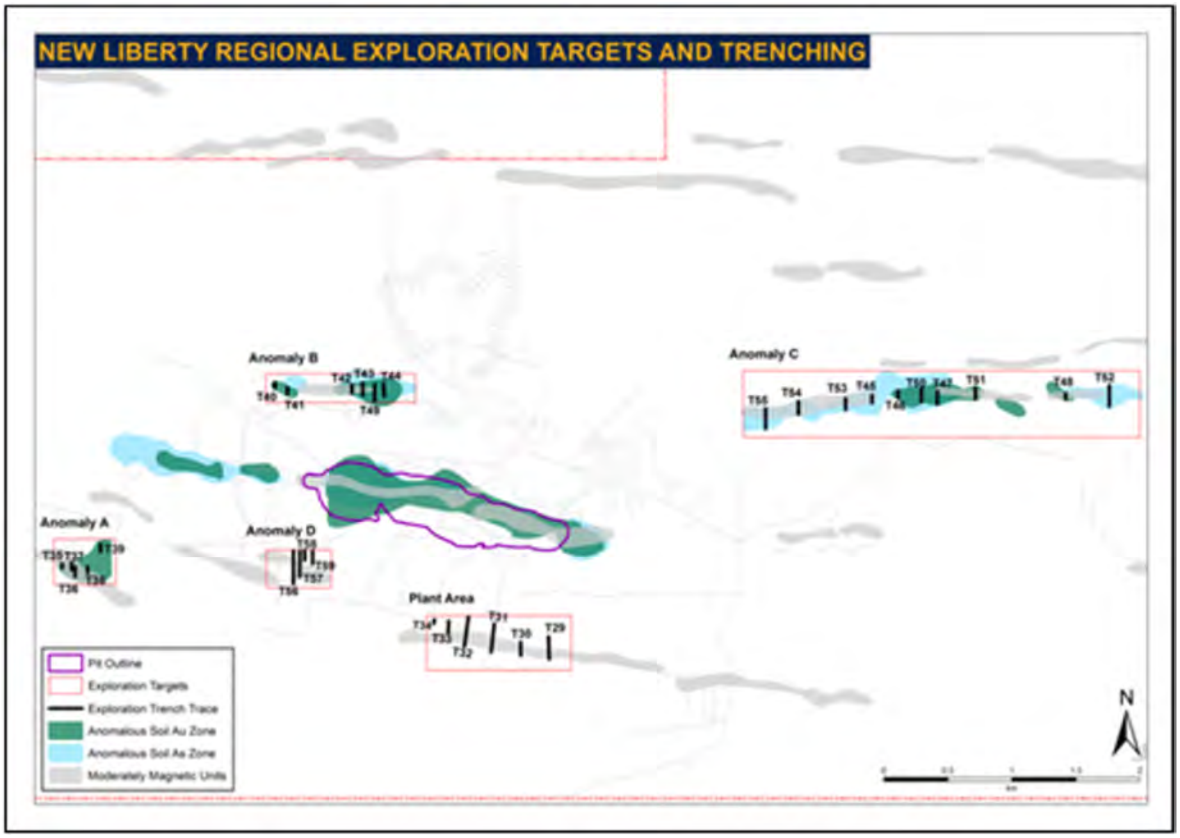


Figure 9-6: Trench coverage around the New Liberty Project
Source: BMMC, 2013

9.3.3 Pitting

Following up from mapping and a revaluation of soil sampling, 1 m x 1 m wide pits were dug over several near-mine targets during the 2015/2016 field season, to a depth of 3–4 m. These were then geologically mapped and sampled from pit floor to surface at intervals accordant with regolith and lithology. Samples were dispatched to ALS laboratory in South Africa for gold analysis, and results were assessed as they were received.

Information gathered from pitting was used to enhance the geological interpretation of near mine targets, including regolith and structure.

9.3.4 Geophysics

Following from the airborne survey, ground magnetic, induced polarisation (IP) dipole-dipole lines and gradient array surveys were undertaken by international geophysics survey company, Fugro, in 2011 and 2012. Initially, the areas of known mineralisation were surveyed to gain an understanding of the signature of mineralisation, with areas outside then used to extrapolate to other features. Further investigation is based on the airborne magnetic data, and along strike from the mineralisation. A total of 52 line km of survey were completed for the ground magnetics and a further 15 km^2 for the IP grid and dipole-dipole. The IP detected a low resistivity corridor thought to represent a continuation of the mineralisation within the ultramafic unit (Figure 9-7).

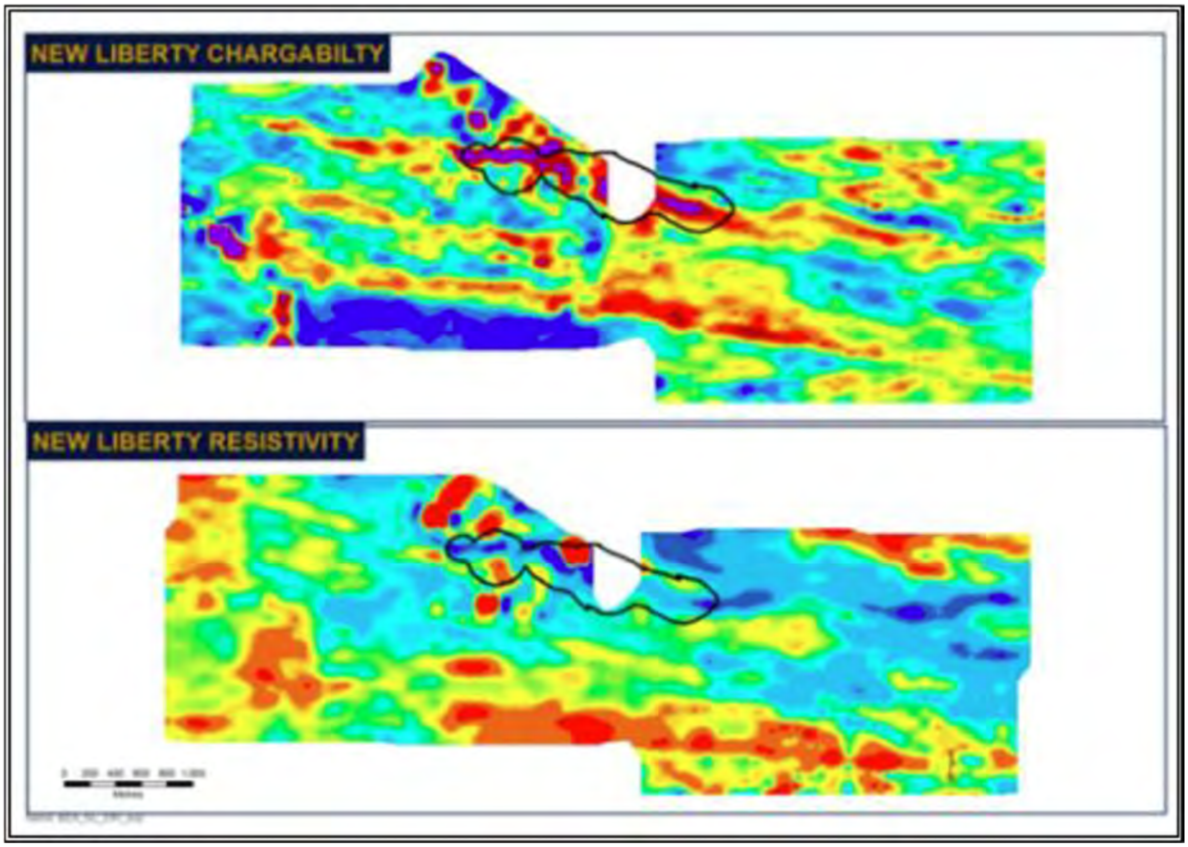


Figure 9-7: IP corridor at New Liberty
Source: BMMC, 2012

9.4 Ndablama Exploration

Exploration in Ndablama started in 2007–2008 with channel sampling. Results for the channel samples are not available, even though they have been mentioned in some reports. African Aura carried out a soil sampling program in 2010, followed by two trenching campaigns between 2010 and 2011, excavating 47 and 16 trenches respectively. Geological mapping and extension of the soil sampling were carried out alongside trenching by Aureus between 2011 and 2013.

Avesoro recommenced diamond drilling at Ndablama in 2018, totalling 117 drillholes for 27,492.9 m.

9.4.1 Soil Sampling

Exploration work at Ndablama was initially started from reconnaissance work at artisanal mining sites. Between 2009 and 2010, a soil sampling program was carried out on a 50 m x 100 m grid spacing. A total of 1,331 soil samples were collected and analysed for gold. This program, covering an area of approximately 6 km^2 between Ndablama Far North and Leopard Rock, detected a 1.2 km long, north-south trending zone of gold enrichment, up to 100 m wide, over the Ndablama prospect. This anomaly is part of a continuous anomaly covering the whole 5 km of the pressure shadow area (Figure 9-8).

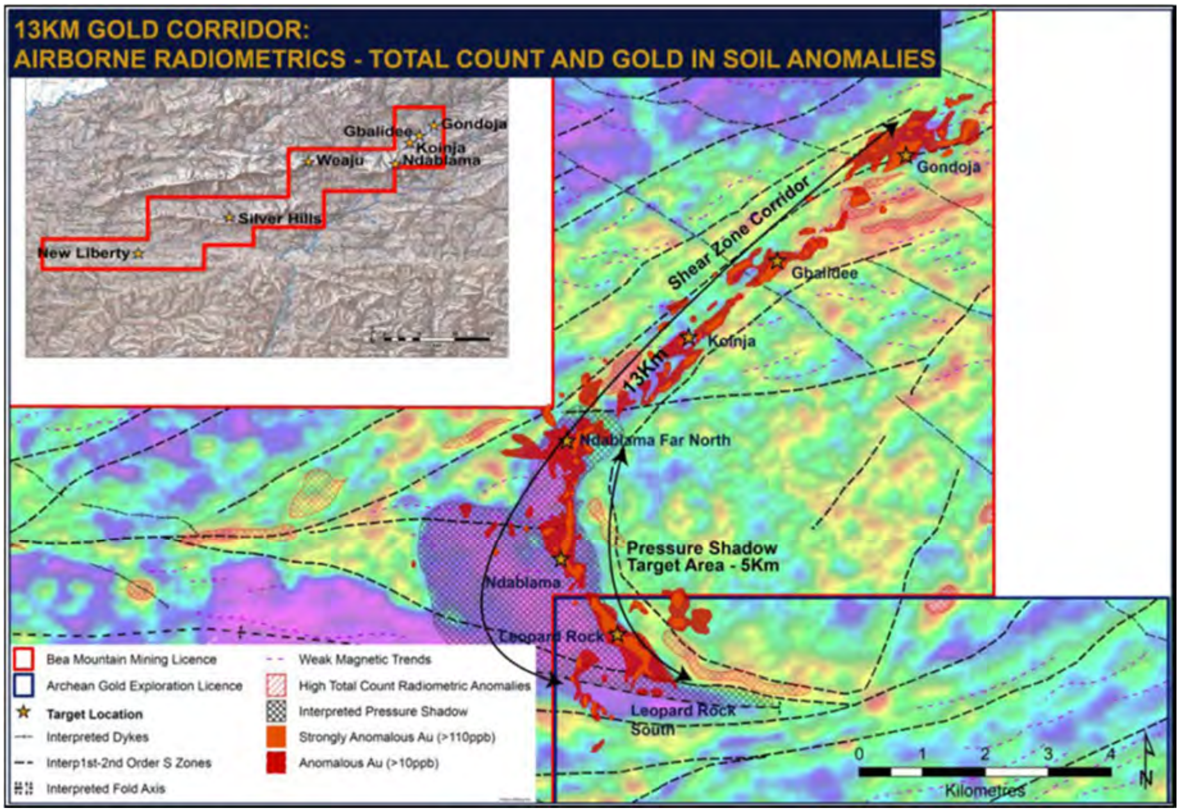


Figure 9-8: Ndablama 13 km soil anomaly

Source: BMMC, 2014

In 2011, the soil grid was extended, with 1,256 samples (Table 9-2) taken west of Ndablama over an area called the Parallel Zone, to cover an additional 6.05 km^2. The soil results provided additional targets further west of the main Pressure Shadow Zone anomalies.

Table 9-2: Soil sampling at Ndablama

Project	Year	Company	Number of soil samples
Ndablama	2010	African Aura	1,331
	Q3 2011	Aureus	1,256
	2014	Aureus	147

In 2014, small soil programs were carried out to fill the gap between Ndablama and Leopard Rock prospects and confirm the anomalous zone in Ndablama North. A total of 98 and 49 samples, respectively have been collected in Ndablama North and Ndablama South. These activities confirmed an anomalous trend and enabled to set targets for trench and channel programs.

9.4.2 Trenching

A summary of all trench sampling performed at Ndablama is presented in Table 9-3.

A follow-up trenching program was undertaken at Ndablama along a 400 m north-south anomaly with 31 trenches completed in 2010 for a length of 2,521 m. This was then followed up with detailed mapping and a subsequent round of trenching in 2011, with 32 trenches excavated for 2,845 m.

A total of 63 trenches were completed at Ndablama for 5,366 m. Significant intercepts were found in majority of the trenches, and results confirm the soil anomalies. The trench results paved the way for the first campaign of drilling in 2011, followed by campaigns two and three during 2012 and 2013 respectively.

During 2012–2014, an additional 10 trenches were excavated, five at Ndablama North and five at Ndablama – Leopard Rock gap area. Trench length excavated were 666 m and 1,043 m respectively. Aureus excavated an additional eight trenches in 2014.

Table 9-3: Trench sampling at Ndablama

Project	Year	Company	Number of trenches
Ndablama	2010	African Aura	NT001–NT047
	Q1 2011	African Aura	NT047–NT063
	2012	Aureus	NNT01–NNT05
	2013	Aureus	LNT01–LNT05
	2014	Aureus	NNT06–NNT11; LNT6–LNT7

9.4.3 Geophysics

An IP ground geophysical survey (Figure 9-9) was completed in this area in 2012 by Fugro to define the mineralisation from Ndablama, through Ndablama South to Leopard Rock. The survey covers an area of 1.8 km^2. The work shows a 500 m northwest-southeast trending sulphide mineralisation zone which appears to form a continuation of the main mineralised Leopard Rock to Ndablama shear zone.

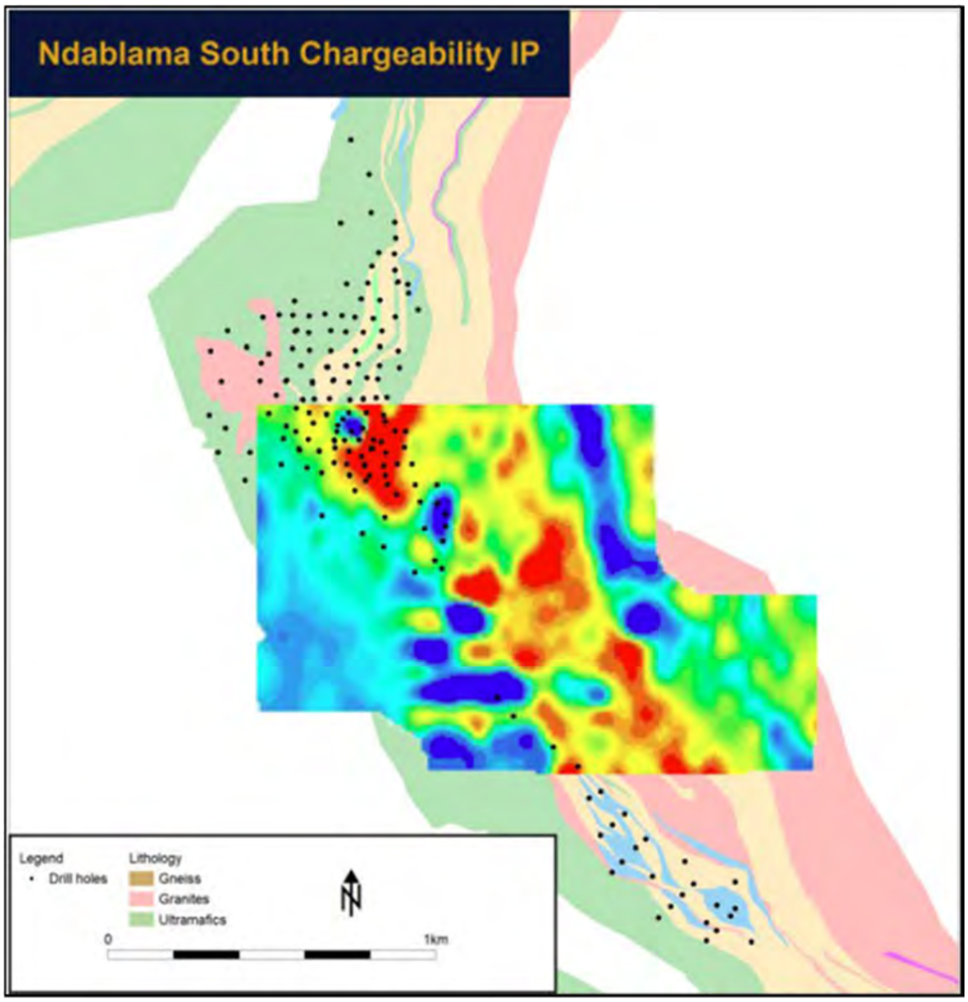


Figure 9-9: Leopard Rock–Ndablama gap ground IP survey 2014
Note: Hole collars are as of December 2014. Source: BMMC, 2014.

9.5 Exploration of Other Main Targets

The information has been included here in the context of disclosing other activities on the Bea-MDA property, but these are unrelated to the purpose of this report.

9.5.1 New Liberty Area

Analysis of both the IP and the re-analysed airborne magnetic data has identified several targets around the Project worthy of further investigation (Figure 9-10). These are undergoing investigation with soil sampling, outcrop mapping and surveys to delineate potential targets for drilling.

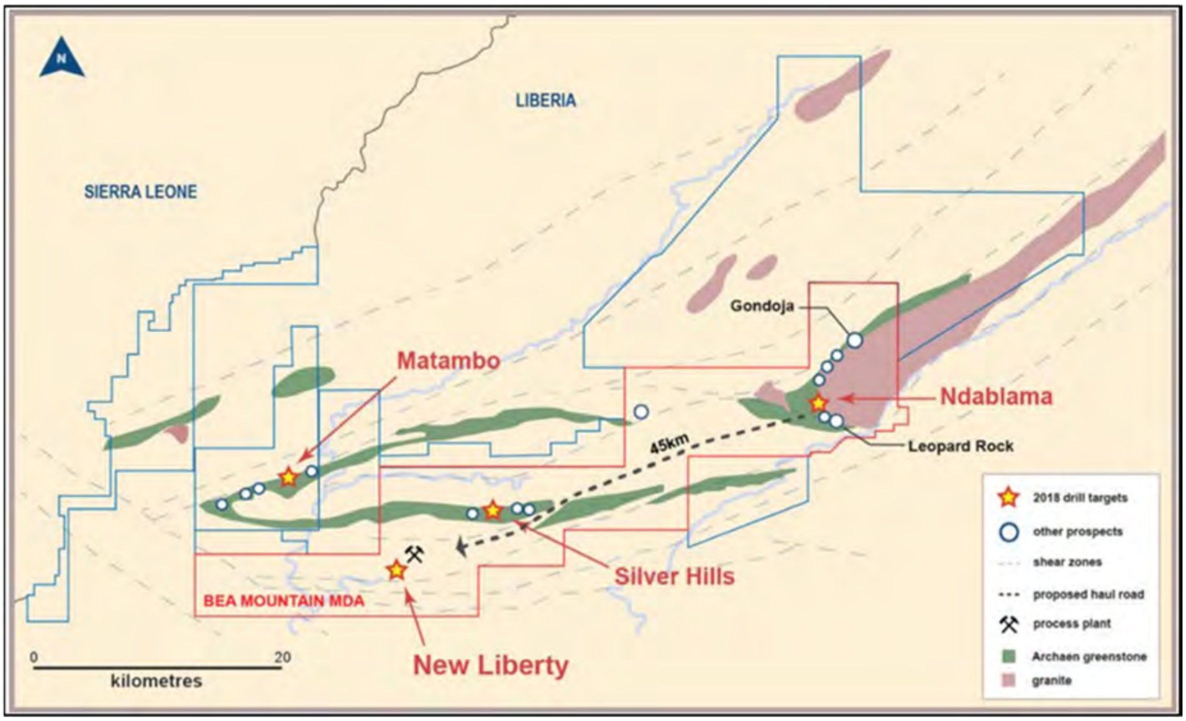


Figure 9-10: Further targets in the Southern Block area
Source: www.avesoro.com, 2019

There are various other targets at the on the Bea-MDA property which are currently subject to exploration at various stages.

9.5.1.1 Silver Hills

Silver Hills is situated approximately 13 km northeast of the New Liberty Project. Soil sampling, trenching, pitting, and detailed mapping results have highlighted a zone potentially 3 km long within a 15 km soil corridor. Channel samples have shown narrow, but high-grade mineralisation. Avesoro commenced drilling at the Silver Hills prospect in 2018, and drilling is still ongoing.

9.5.1.2 Regional Targeting

As part of an ongoing exploration program, a geochemical and structural study of known areas of mineralisation is underway. This data will be merged with regional airborne magnetics and radiometrics datasets to identify structures and settings within the Bea-MDA property.

9.5.2 Ndablama Area

9.5.2.1 Ndablama Far North

Five trenches were excavated at Ndablama Far North in early 2013. These returned wide gold intercepts that have north-south strike continuity over 1 km. The geology is similar to Ndablama and comprises mainly sheared amphibolite and ultramafic rocks located within packages of granitic gneisses.

9.5.2.2 Ndablama North

In 2014, six additional trenches were excavated in North Ndablama for a total of 708 m. These showed the continuation of the mineralisation from the pressure shadow to the north of Ndablama.

9.5.2.3 South Ndablama

Five trenches were excavated in 2012 between Ndablama and Leopard Rock. One out of the five trenches returned significant gold mineralisation. Two additional trenches were completed in 2014, which along with the soils in the area, showed the continuation of the mineralised system between Ndablama and Leopard Rock.

9.5.2.4 Leopard Rock

Situated in the southern portion of the Ndablama Pressure Shadow Zone (Figure 9-11). Soil and trench channels data highlight a northwest-trending mineralised zone. Highlights of the initial 24 drillhole program include 17.6 g/t Au over 4 m and 9.4 g/t over 6 m. Trenching and channel sampling highlights include 6.4 g/t Au over 11 m and 6.9 g/t Au over 4 m.

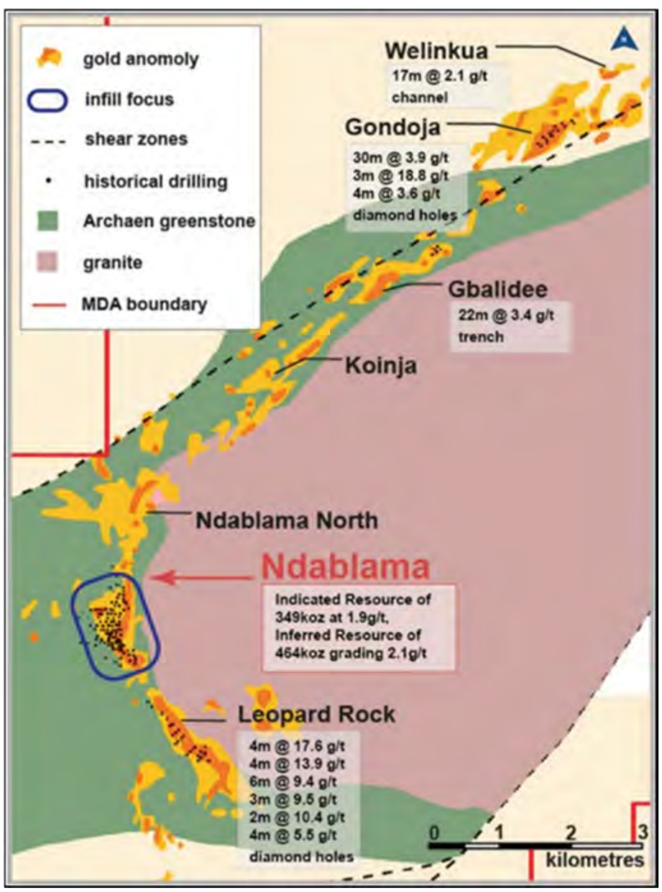


Figure 9-11: Ndablama area exploration targets
Source: www.avesoro.com, 2018

10 Drilling

This section, in the context of New Liberty and Ndablama, unless otherwise stated (i.e. reference to works completed by CSA Global), has been summarised from AMC (2013a, 2013b, 2014) and SRK (2017). The Qualified Persons take responsibility for the content of this section and believe it is accurate and complete in all material aspects.

10.1 Exploration Drilling

10.1.1 New Liberty

Diamond drilling at the Project has been conducted periodically between 1999 and 2018 (Table 10-1). The total number of exploration metres drilled is 121,603 m which was completed in seven campaigns and then additional ongoing drilling by Avesoro from 2012 to 27 November 2018 (data cut-off for this report). Significant drill intersections are summarised in Table 10-3.

Table 10-1: Summary of diamond drilling campaigns at New Liberty as at 27 November 2018

Campaign	Hole numbers	Year	Number of holes	Metres
1	1-19	1999-2000	19	1,949
2	20-26	2000	7	792
3	27-61	2005	35	3,027
4	62-114	2006	53	5,069
5	115-130	2008	16	4,487
6	131-184	2009-2010	54	14,556
7	185-441	2011-2012	248	38,118
8 (ongoing)	442-649	2012-2018	175	53,605
Total			**607**	**121,603**

Note: Drilling totals exclude all hydrogeological, geotechnical, metallurgical and sterilisation holes completed at the Project.

Campaign 1 comprised 19 holes drilled at HQ (68 mm), with the exception of hole K16, which was started in HQ and reduced to NQ (48 mm). The holes were drilled on 50 m centres and intersected mineralisation at depths ranging from 20 m to 30 m below surface along the length of the two mineralised zones. One hole, K10, was drilled some 500 m to the east of the Kinjor excavation to intersect mineralisation identified in trench T-11, in the area termed the Marvoe Zone.

In early 2000, a second campaign of drilling was undertaken, with the aim of testing the mineralisation at greater depth under the Kinjor and Larjor artisanal workings, and to investigate the mineralisation in the Marvoe Zone. K20 and K23 were drilled in the central part of the Larjor orebody and intersected mineralisation at some 50 m and 100 m below surface respectively. K21 and K22 were drilled on the Marvoe Zone near hole K10.

The third diamond core drilling campaign, designed to close along-strike inter-hole distances to a maximum of 25 m, started in January 2005. At the same time, selected holes were drilled at steeper angles in order to intersect the mineralisation at depth, as the deepest intersection at the time was 80 m below surface. The program also aimed at further evaluating the eastern extremity of the Marvoe Zone, which is indicated by aeromagnetic data to continue to the southeast.

A hiatus in drilling followed due to a period of unrest in the country.

Campaign 5 was completed between January and May 2008 and consisted of 16 NQ core drillholes, inclined at between -60° and -70°, drilled under the three known zones. Fourteen of these holes tested the gold mineralisation at 300 m below surface elevation while two (both in Larjor) investigated and demonstrated that the Larjor zone mineralisation persists to -600 m level.

In 2009 (Campaign 6), a 10,730 m definition and extension drilling program was initiated to satisfy two primary objectives:

- To better understand the local geometry of the mineralisation and confirm or otherwise the continuities implied in the interpretations then held.
- To assess the extent and continuity of the mineralisation down dip of the limits of the higher density drilled areas.

The drilling program was flexible and dynamic, allowing changes to be implemented during the program based on feedback from site, assay results received and to account for practical issues such as positioning of drill pads. One outcome of this was the discovery of the Latiff Zone from wildcat drillhole K144 in the gap between the Larjor and Kinjor zones, which led to the revised drilling across the gap.

Four additional holes were drilled in the Latiff Zone through to August 2010 with all holes confirming continuity at depth of the mineralisation.

Campaign 7 was completed between 2011 and 2012. During the campaign, 248 diamond drillholes were drilled for a total of 38,118 m. The drilling was undertaken by Boart Longyear, with aims to increase definition within the orebody at all zones as well as to test for extensions along strike. During the drilling, Aureus used the results from logging and assaying to update the mineralisation model in order to optimise the drill program. PQ drilling was used in the oxide, followed by HQ and then reducing to NQ in fresh material and at greater depths.

Additional exploration drilling from 2012 to 2018 by Avesoro has included 175 holes for 53,605 m. The aim of the drilling was to continue to test down dip and along strike of the current mineralisation wireframes and to improve resource definition.

10.1.2 Ndablama

A total of five phases of exploration drilling has been carried out at Ndablama. Drilling commenced in 2010 and the most recent phase was completed in 2018 and the total drilling inventory comprises 232 DD holes and 39 RC holes for a cumulative meterage of 54,562,9 m. The first phase was conducted by African Aura in 2010, for a total of 15 DD holes. Aureus then conducted two drilling campaigns with 21 DD holes completed in 2012, and a further 18 DD holes completed in 2013. A fourth campaign comprising 62 DD and 39 RC holes was completed in 2013 to 2014. Avesoro carried out the fifth drill program in 2018, totalling 117 DD holes focusing on testing the potential for down-dip extensions of mineralisation to the west. Most of the drilling has comprised holes typically inclined at 55° to 60° to the east, to generate near-orthogonal intersections with the westward-dipping mineralised zone.

Most of the drillholes were drilled along the 1,050 m strike length of the Central and South East zones. The current Ndablama Mineral Resource has been defined based on the holes drilled within these two zones. Ndablama North has been drill tested along 450 m of its strike length.

Details of drilling at the Ndablama target are shown in Table 10-2 and Figure 10-1. Significant drill intersections are summarised in Table 10-4.

Table 10-2: Ndablama drilling campaign details (2010–2018)

Campaign	Period	Number of holes drilled	Total metres drilled	Total samples taken	Total samples sent to laboratory	Results received
1	2010	15	2,665	2,390	2,390	2,390
2	Q4 2011 to Q2 2012	21	3,317	3,646	3,646	3,646
3	Q1 2013	18	2,331	2,579	2,579	2,579
4 (DD)	Q4 2013 to Q2 2014	61	13,020	9,574	9,574	8,131
4 (RC)	Q2 2014	39	5,827	3,917	3,917	3,577
5	2018	117	27,492.9	9,558	9,558	9,558
Total		**271**	**54,652.9**	**31,664**	**31,664**	**29,881**

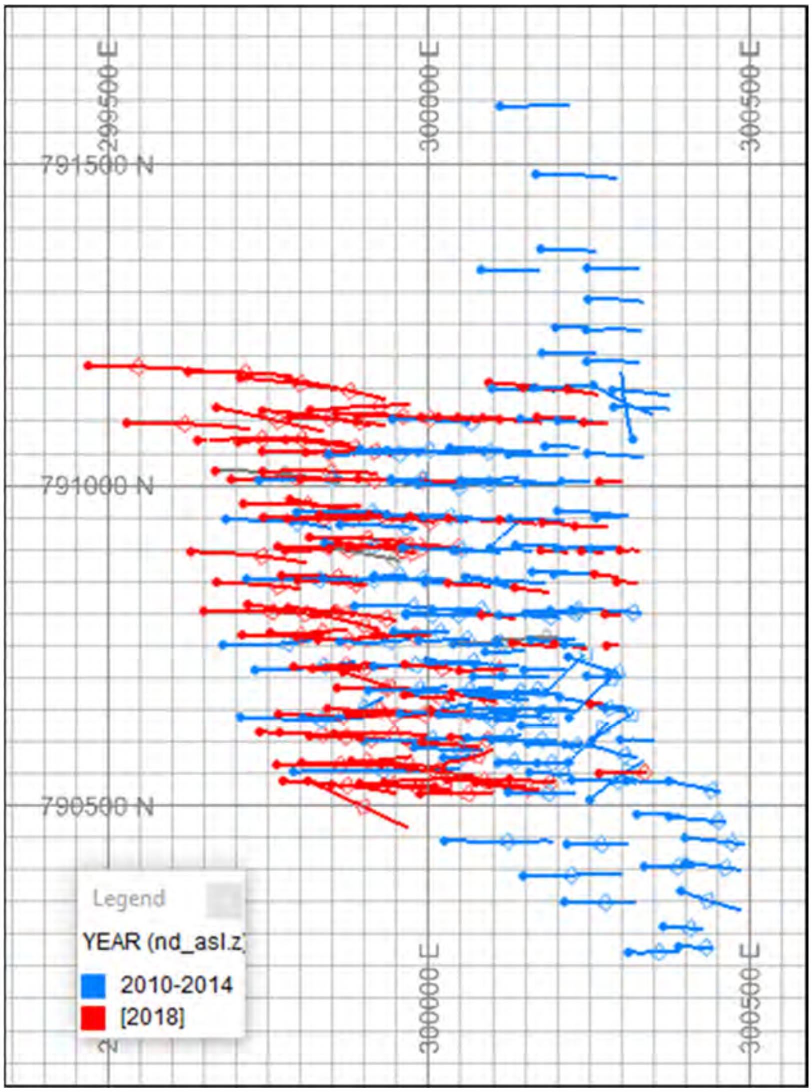


Figure 10-1: Plan of Ndablama drilling phases, showing hole traces (blue = pre-2018; red = 2018 drilling)
Source: CSA Global, 2019

10.2 Significant Intercepts

10.2.1 New Liberty

Significant gold mineralisation drillhole intercepts for the 2018 New Liberty infill drilling campaign for holes K552 to K620 (available results as at 27 November 2018 – data cut-off for MRE and this report) are indicated in Table 10-3.

Table 10-3: New Liberty drilling intersections, holes K552-K620

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
K552	231	249	18	1.83
Including	231	232	1	3.46
	241	242	1	6.72
	243	244	1	7.76
And	262	284	23	1.73
Including	264	265	1	3.79
	266	267	1	6.08
K554	237	238	1	2.24
K555	273	281	8	0.94
Including	276	277	1	3.53
K556	318	334	16	1.63
Including	324	326	2	4.91
K557	259	269	10	1.34
Including	261	262	1	3.06
And	279	289	10	1.04
Including	280	281	1	4.36
K558	264	268	4	1.16
K559	233	255	22	1.23
Including	245	246	1	3.63
	248	249	1	6.37
And	259	286	27	1.64
Including	267	268	1	3.70
	277	278	1	5.31
And	323	342	19	3.76
Including	329	335	6	9.04
	338	339	1	4.22
And	352	357	5	3.12
Including	353	354	1	8.35
And	361	365	4	2.02
Including	362	363	1	3.92
K560	236	248	12	1.30
And	252	273	21	2.48
Including	257	260	3	4.44
	261	263	2	4.37
	265	268	3	5.06
And	318	332	14	3.45
Including	319	322	3	5.86
	325	326	1	5.90
	327	329	2	6.90
And	353	365	12	1.86
Including	355	356	1	4.00
	357	358	1	7.16

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
K561	352	378	26	4.02
Including	357	360	3	5.97
	368	373	5	12.64
K562	415	428	13	2.94
Including	415	417	2	3.87
	420	423	3	8.03
K563	442	464	22	1.44
Including	461	463	2	8.96
K564	407	425	18	3.20
Including	408	409	1	12.3
	417	418	1	4.37
	422	425	3	8.44
And	440	455	15	1.46
Including	441	442	1	4.66
And	463	475	12	2.02
Including	473	475	2	5.65
And	525	533	8	1.85
Including	528	529	1	3.92
K565	400	409	9	2.16
Including	407	408	1	8.70
And	413	426	13	2.07
Including	416	418	2	6.39
And	448	454	6	1.33
And	460	466	6	1.36
Including	465	466	1	3.52
K566	391	436	45	6.73
Including	391	392	1	3.54
And	397	400	3	5.38
And	415	428	13	15.55
And	433	435	2	8.43
K567	353	366	13	2.47
Including	355	359	4	5.99
K569	289	293	4	18.07
K571	283	288	5	8.54
Including	283	286	3	13.23
And	351	363	12	3.79
Including	351	353	2	5.56
	355	356	1	6.00
	361	362	1	14.7
K572	324	336	12	1.03
And	395	402	7	2.58
Including	395	396	1	9.46
	397	398	1	4.73
K574	318	326	8	2.85
Including	319	320	1	5.18
	321	322	1	5.49
	324	325	1	4.84
K576	326	335	9	6.66
Including	328	330	2	17.53
	331	332	1	6.72
	333	334	1	7.89

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
K577	361	373	12	5.32
Including	364	365	1	9.59
	368	371	3	12.27
And	427	433	6	1.17
K578	283	301	18	4.48
Including	283	291	8	6.50
And	295	300	5	4.88
K580	314	324	10	1.53
Including	317	318	1	3.99
K581	236	248	12	5.00
Including	237	239	2	11.42
	241	245	4	7.58
K582	249	253	4	3.39
Including	250	251	1	8.13
K583	140	147	7	1.03
And	151	158	7	2.63
Including	155	157	2	5.60
K602	272	281	9	4.40
K608	242	245	3	9.28
Including	242	243	1	12.45
K609	291	294	3	1.87
Including	293	294	1	3.71
K620	384	394	10	5.34
Including	385	386	1	5.61
	387	392	5	8.35

10.2.2 Ndablama

Significant gold mineralisation drillhole intercepts for the 2018 Ndablama drilling campaign for holes NDD116 to NDD230, and NBDGT03 (available results as at 24 November 2018 – data cut-off for MRE and this report) are indicated in Table 10-4.

Table 10-4: Ndablama drilling intersections, holes NDD116 to NDD230, NBDGT03

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
NDD116	106	111	5	3.61
NDD117	92	94	2	1.57
And	110	112	2	1.74
NDD118	47	52	5	1.32
NDD119	130	138	8	0.63
NDD120	120	127	7	1.01
And	169	170	1	2.79
NDD121	111	117	6	1.02
And	135	137	2	2.48
And	144	145	1	2.29
And	160	162	2	13.47
Including	160	161	1	22.20
NDD122	98	104	6	0.506
Including	139	140	1	1.61
NDD123	94	98	4	2.89
Including	94	95	1	5.32
NDD124	72	76	4	1.20

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
NDD125	45	50	5	1.87
And	45	46	1	3.93
And	49	50	1	4.34
NDD126	208	217	9	10.26
Including	212	215	3	25.90
NDD127	153	156	3	5.46
Including	153	154	1	13.80
NDD128	153	156	3	1.74
NDD129	114	123	9	3.58
Including	118	119	1	13.75
And	126	127	1	3.74
And	132	135	2	1.26
NDD130	83	89	6	3.50
Including	84	85	1	10.50
NDD131	37	47	10	1.42
And	73	74	1	14.85
NDD132	12	17	5	0.76
And	46	47	1	4.80
NDD133	173	188	15	1.44
Including	181	182	1	9.23
And	203	212	9	9.11
Including	203	204	1	73.10
NDD134	170	194	24	2.59
Including	178	179	1	22.90
NDD135	122	123	1	3.28
And	133	136	3	2.79
And	146	151	6	1.62
NDD136	119	121	2	1.59
And	129	135	6	7.91
Including	132	134	2	16.05
NDD137	70	78	8	1.52
NDD138	17	19	2	5.48
NDD139	174	179	5	1.15
And	182	187	5	4.65
Including	186	187	1	18.8
And	191	201	10	1.26
NDD140	164	183	19	1.42
Including	169	170	1	12.05
And	187	191	4	2.84
Including	190	191	1	8.89
NDD141	85	87	2	1.70
And	91	103	12	1.80
Including	94	95	1	12.35
NDD142	42	59	17	1.08
Including	42	43	1	6.31
And	110	112	2	1.52
NDD143	187	192	5	1.66
Including	191	192	1	6.40
And	201	208	7	1.53
And	217	218	2	2.54

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
NDD145	172	175	3	9.04
Including	174	175	1	22.2
And	179	180	1	3.58
And	183	196	13	2.05
And	203	209	6	0.72
NDD146	158	165	7	1.65
Including	163	164	1	6.58
And	182	183	1	2.39
NDD147	143	150	7	0.88
Including	149	150	1	3.19
And	155	167	12	2.27
And	171	180	9	9.87
Including	171	173	2	38.05
NDD148	52	66	14	2.70
Including	54	55	1	10.3
And	63	66	3	5.06
And	69	81	12	1.56
Including	71	74	3	3.40
NDD149	225	228	3	3.69
NDD150	170	175	5	0.78
And	186	195	9	1.41
Including	191	192	1	7.58
NDD151	159	162	3	0.89
And	172	188	16	2.77
Including	174	175	1	31.10
NDD152	130	146	16	1.53
Including	130	131	1	5.46
And	136	137	1	5.92
And	155	157	2	1.10
And	171	177	6	2.09
NDD153	89	124	35	1.40
Including	97	105	8	2.37
And	108	112	4	2.74
And	118	123	5	1.77
NDD154	31	36	5	0.60
And	45	46	1	5.26
And	54	57	3	4.43
NDD155	1	5	4	0.88
And	8	22	14	1.14
Including	17	19	2	5.21
NDD156	181	187	6	1.63
And	196	204	8	1.22
Including	196	197	1	5.48
And	209	221	12	1.27
Including	210	211	1	7.40
NDD157	178	181	3	1.62
And	200	203	3	1.04
NDD158	148	158	10	1.02
And	175	184	9	1.18
Including	180	181	1	4.21

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
NDD159	88	93	5	8.83
Including	88	89	1	30.2
	89	90	1	5.61
	92	93	1	5.52
And	102	108	6	1.95
Including	105	106	1	5.30
And	117	128	11	1.57
Including	127	128	1	7.99
NDD160B	161	164	3	5.70
Including	161	162	1	11.60
And	197	202	5	0.67
NDD161	108	110	2	1.18
And	117	123	6	0.96
And	127	131	4	1.13
And	134	140	6	1.17
Including	135	136	1	4.31
NDD162	67	77	10	1.45
Including	75	76	1	4.94
And	92	96	4	3.41
Including	92	93	1	8.93
And	110	114	4	0.95
And	119	125	6	1.37
Including	122	123	1	3.90
NDD163	271	274	3	3.23
And	286	289	3	0.87
NDD164	186	187	1	3.90
And	217	228	11	1.17
Including	221	222	1	4.04
	226	227	1	3.76
NDD165	203	208	5	1.35
And	212	218	6	1.25
Including	217	218	1	3.77
And	223	225	2	2.51
NDD166	135	137	2	1.97
And	156	159	3	0.86
And	168	174	6	1.09
NDD167	98	101	3	2.86
And	111	114	3	1.08
And	126	137	11	1.21
NDD168	244	254	10	1.86
Including	246	247	1	5.27
And	282	285	3	4.18
Including	284	285	1	9.35
And	305	310	5	0.76
NDD169	272	284	12	1.85
Including	282	284	2	7.52
NDD170	269	273	4	2.16
Including	272	273	1	5.58
And	283	284	1	11.65
And	299	301	2	14.59

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
NDD171	226	228	2	1.64
And	246	261	15	1.52
Including	246	247	1	5.43
	257	258	1	7.60
NDD172	226	230	4	0.82
NDD173	130	140	10	2.04
Including	131	132	1	16.05
And	160	166	6	1.08
NDD174	96	98	2	6.77
Including	97	98	1	10.10
And	137	147	10	3.28
Including	139	140	1	19.55
NDD175	257	263	6	2.05
Including	257	258	1	6.86
And	324	329	5	1.28
NDD176	248	250	2	2.35
And	290	291	1	4.98
And	308	310	2	0.76
NDD177	248	250	2	1.87
And	263	264	1	3.83
And	274	277	3	5.87
NDD178	215	220	5	1.94
NDD179	111	118	7	1.20
Including	117	118	1	4.99
And	124	129	5	1.09
Including	127	129	2	1.96
NDD180	314	315	1	11.60
NDD181	319	320	1	9.00
NDD182	242	250	8	2.25
Including	242	243	1	4.72
	249	250	1	7.54
And	277	302	25	0.80
And	314	318	4	29.20
Including	315	316	1	21.30
	316	317	1	88.10
NDD183	222	231	9	1.17
Including	222	223	1	4.12
And	257	264	7	0.93
NDD184	231	233	2	0.81
NDD185	157	168	11	2.53
Including	157	158	1	19.45
And	192	193	1	3.26
NDD186	122	124	2	1.50
And	135	137	2	1.88
And	158	159	1	29.7
NDD187	108	110	2	2.06
And	128	135	7	1.47
Including	132	133	1	4.04
NDD188	106	107	1	5.18
And	127	129	2	1.25
NDD189	115	119	4	2.58
Including	118	119	1	8.48

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
NDD190	227	233	6	1.35
Including	228	229	1	3.65
NDD192	159	161	2	7.58
Including	160	161	1	12.2
And	168	170	2	1.47
And	187	188	1	4.26
And	211	213	2	1.70
NDD193	225	232	7	1.13
Including	225	226	1	3.24
NDD194	244	251	7	3.74
Including	244	245	1	26.79
NDD195	259	260	1	3.87
Including	265	269	4	0.95
NDD196	296	304	8	0.90
Including	303	304	1	3.18
NDD197	222	231	9	1.00
Including	226	227	1	4.17
And	238	244	6	2.25
Including	240	241	1	7.41
And	255	263	8	1.32
Including	258	259	1	5.60
NDD198	260	261	1	10.85
NDD199	283	297	14	0.67
Including	295	296	1	2.09
NDD200	152	156	4	2.14
And	175	178	3	2.62
NDD201	229	231	2	11.89
Including	230	231	1	22.60
NDD202	246	267	21	3.60
Including	257	258	1	7.51
	261	262	1	22.10
	265	266	1	30.70
NDD203	224	241	18	1.68
Including	231	234	3	5.40
NDD204	243	256	14	4.07
Including	248	249	1	19.60
	255	256	1	24.20
NDD205	195	200	5	4.16
Including	198	200	2	8.22
NDD206	274	277	3	1.80
And	284	288	4	2.13
Including	286	287	1	4.85
NDD207	313	321	8	1.64
Including	317	318	1	10.10
And	330	332	2	1.17
NDD208	302	308	6	0.92
NDD209	59	62	3	3.79
And	71	77	6	1.50
And	87	88	1	4.35
And	94	104	10	2.40
Including	94	95	1	7.66
NDD210	21	24	3	1.02

Hole ID	From (m)	To (m)	Length (m)	Au (g/t)
NDD211	20	23	3	3.08
NDD216	8	12	4	0.79
And	17	19	2	1.41
And	26	30	4	0.98
NDD217	25	26	1	10.65
NDD218	202	205	3	1.84
NDD219	233	240	7	0.95
And	250	251	1	4.24
And	257	259	2	1.08
NDD221	268	270	2	1.16
NDD222	201	207	6	1.29
And	213	214	1	4.94
NDD223	234	244	10	0.73
And	247	249	2	1.32
NDD224	212	227	15	4.49
Including	217	218	1	13.10
	223	224	1	31.70
	225	226	1	9.72
NDD225	213	221	8	14.68
Including	218	219	1	112.00
And	225	235	10	4.73
Including	230	232	2	16.30
And	238	241	3	1.06
NDD226	180	181	1	3.62
And	187	205	18	1.48
Including	187	188	1	4.79
	191	192	1	10.25
	201	202	1	4.20
NDD228	190	196	6	1.00
And	200	203	3	1.38
And	213	214	1	12.00
NDD229	201	209	8	2.22
Including	207	208	1	6.07
And	221	232	11	1.80
Including	221	222	1	3.42
	228	229	1	9.56
NDD230	135	155	20	4.68
Including	136	137	1	30.50
	145	155	10	5.50
And	158	160	2	0.97
NBDGT03	228	229	1	0.98
And	238	241	3	1.99
Including	240	241	1	4.26
And	248	249	1	3.15

10.3 New Liberty Grade Control Drilling

RC grade control drilling was conducted during 2014 and 2015 by Ore Search Drilling and from 2016 to date this has been undertaken in-house by the Company. Grade control drilling is used by the Company to update short-term grade control models for short-term mine planning purposes.

To date, the drilling has been undertaken in three phases, the first of which focused on bringing the drillhole spacing in the upper levels of the Larjor pit profile down approximately 12 m x 12 m. The second phase was undertaken in the Kinjor area of the main pit, in order to provide both 12 m x 12 m infill information and also to address any gaps in the resource model that may have arisen due to access issues with Diamond Rigs in the past, due to the presence of the Marvoe Creek running through this area of the pit. The third and most recent phase of grade control drilling has been completed in the Marvoe area, which has resulted in a sample coverage of approximately 10 m x 10 m.

A summary of the grade control drilling completed as at 25 June 2018 is provided in Table 10-5, with the positions of the grade control and diamond drillhole collars available for the current MRE illustrated in Figure 10-2.

Table 10-5: Summary of grade control drilling as at 25 June 2018

Drilling type	Period	Number of holes	Metres
Grade control (RC)	2012 to August 2017	723	29,251
	August 2017 to June 2018	362	12,746
Total		**1,085**	**41,997**

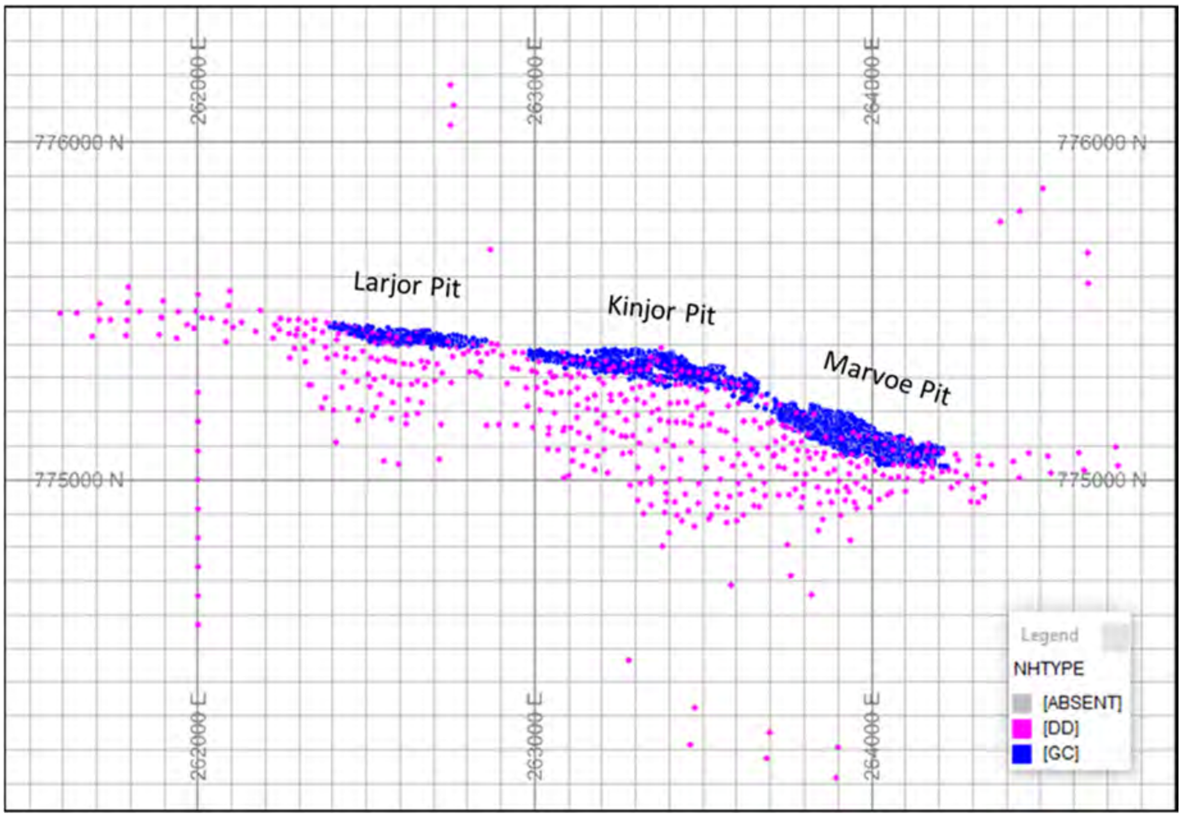


Figure 10-2: New Liberty – location of drilling completed up to 27 November 2018 (blue = grade control collars; pink = diamond drill collars)

Source: CSA Global, 2018

10.4 Drilling Procedure

10.4.1 New Liberty

Drilling was conducted on a grid, with holes generally drilled on a 015° azimuth (magnetic) and inclined at between minus 45° and 70° to intersect the southward-dipping zones. During drilling campaigns 6 and 7, a grid pattern was used. At times, exceptions to the default azimuth were introduced because of inaccessibility due to swampy conditions or because the distance to the target depth exceeded the capability of the rigs. This occurred in the case of six drillholes, K10, K32, K34, K55 in the Marvoe zone and K36 and K38 in the Kinjor zone. In these cases, the back bearing of 195° was used.

The core sizes drilled varied over time as well as within holes, typically HQ (63 mm) or NQ (47 mm) but also ranging from AQ/DT48 (27 mm) to HW/T6116 (90 mm). The quarter core from the first 27 diamond drillholes and half core for the remaining holes are stored on site.

Core runs and core blocks were placed in boxes by the drillers and verified by the BEA Mountain Corp. geologists at the drill rig. As a general practice, core orientations were measured at the drill site by the drillers and checked by the geologists, who then drew orientation lines on the core. Upon receipt in the site core shed, core was cleaned or washed (if required) and core blocks were re-checked by BEA Mountain Corp. staff. Orientation lines were also cross-checked at the core yard by the logging crew.

The core was photographed, wet and dry, using a camera mount in a framed structure to ensure a constant angle and distance from the camera. Magnetic susceptibility readings were taken every metre. For unconsolidated core this is measured in situ and results recorded, in SI units, in the assay log sheet.

10.4.2 Ndablama

At Ndablama all phases until Phase 4 were diamond core drilling, then both diamond and RC drilling were undertaken. Phase 5 consisted of diamond drilling only. All drilling was performed by external contractors. Diamond drilling was undertaken using industry standard methods with geologists and technicians at the rig supervising the drilling activities. Drillholes that were abandoned due to location errors or technical issues were redrilled as closely as possible to the original drillhole collar location.

Drilling was conducted on a grid, with holes predominantly oriented to the east, and typically inclined at 55° to 60°. Most of the holes were planned on 90° azimuth and inclined at -45°, -50° and -60°.

Core sizes varied over time as well within holes. HQ followed by NQ core sizes were drilled from 2010 to 2012. From 2012 onwards, PQ triple tube (PQ3) was drilled in the oxide zone to promote good recoveries, followed by HQ till base of saprock, then NQ to the remainder of the hole.

As with New Liberty, the core was photographed, wet and dry, using a camera mount in a framed structure to ensure a constant angle and distance from the camera (Figure 10-3). Magnetic susceptibility readings were taken every metre. For unconsolidated core this is measured in situ and results recorded, in SI units in the assay log sheet.

Figure 10-3: Ndablama drill core photograph structure
Source: CSA Global, 2018

10.5 Logging

10.5.1 Core Logging

Geological logging has and continues to use a from-to format to record depths, rock codes and brief descriptions of the lithological units and angles of contacts.

Lithological logging records the lithology, alteration and mineralisation and is done by the geologists. Lithology and alteration are logged consistently by using type samples to avoid ambiguity. Along with lithological logging, cross sections are plotted, and interpretation/validation done for both lithology and alteration.

Geotechnical logging records the casing size, bit size, intervals, core recovery, weathering index, RQD, fracture index, jointing and joint wall alteration and a simple geological description. All core was oriented, with alpha and beta angles of fabrics recorded at point depths (Figure 10-4).

Figure 10-4: Structural core measurements
Source: AMC, 2014

10.5.2 RC Logging

Percussion chips are sieved and washed before adding to chip trays. BEA Mountain Corp. geologists inspect the washed chip samples and describe the geology briefly on the log sheet noting; oxidation type, rock type, structure, veining, alteration, sulphides, and moisture content (Figure 10-5).

Figure 10-5: Chip tray and logging sheet

10.6 Surveying

10.6.1 Collar Surveying

At New Liberty, in 2009, a review of existing collar survey coordinates identified a number of uncertainties, and a full resurvey of collars was commissioned. The results of the subsequent August 2010 (differential GPS) survey of all drill collars (described in Section 9.1.1) have not been directly verified by CSA Global. However, accumulated information regarding instrument quality and field procedures has indicated that the resurveyed drill collar coordinate data can be accepted with confidence for the purposes of Mineral Resource estimation.

Additional resurveying and validation of accessible pre-2011 collars at New Liberty was conducted in 2011 and all additional collars associated with the 2011 campaign were surveyed with the Leica differential GPS survey procedures described in Section 9.1.1.

For grade control drilling at New Liberty, collars were surveyed using a Trimble differential GPS, with downhole surveys typically completed for holes greater than 40 m in length at 10 m increments.

Ndablama collar coordinates were originally surveyed with Garmin handheld GPS, and subsequently picked up by a Sokia Total Station. The points were verified with the contour and DTM data obtained from the LIDAR survey carried out in early 2013. To date, all drillholes and collars have been properly surveyed and are well positioned on the LIDAR DTM.

10.6.2 Downhole Surveying

Downhole surveying procedures were similar throughout all phases of the drilling. The equipment used was Reflex Gyro downhole survey tool and core orientation was done with the Gyro ACT II orientation tool. The equipment was supplied by the drilling companies and operated by the BEA Mountain Corp. geology field crew.

At New Liberty, the average recorded dip deviation over the full length of each hole is around 10°, but some deeper holes (more than 400 m) deviate more than 15°. Average azimuth deviation is around 5°, but some deeper holes deviate by more than 10°.

At Ndablama, deviations in azimuth generally average ± 4° for both diamond drillholes and RC holes. Downhole survey intervals were 10 m in most cases and 5 m where applicable. Actual azimuth and inclination deviations were very minimal.

10.7 Core Recovery

At New Liberty, drill core recovery was not recorded during the 1999/2000 drilling campaign but records from subsequent campaigns reveal very high recoveries, with most intervals returning values well above 90%. These recovery values are consistent with site observations of stored core (Figure 10-6) as well as core photographs.

Figure 10-6: New Liberty drill core recovery
Source: CSA Global, 2018

At Ndablama, core recovery data had significant errors that were corrected by BMMC by re-examining core and rechecking logging data for intervals of poor recovery and unusually high recovery. The average core recovery for the Main Zone was 97% and 97% for the South West Zone. Although the average core recoveries were relatively high, significant intervals with low recoveries from 70% to 10%, some over contiguous lengths of over 30 m, were a concern. While poor recovery can be expected in the weathered portion of the deposit, significant core loss occurred in the unweathered portion of the mineralised units.

Subsequent campaigns reveal much better recoveries, with most intervals returning values well above 90%. These recovery values are consistent with site observations of stored core (Figure 10-7) as well as core photographs.

Figure 10-7: Ndablama drill core recovery
Source: CSA Global, 2018

11 Sample Preparation, Analysis and Security

This section, in the context of New Liberty and Ndablama and relating to pre-2018 exploration and drilling, has been modified from AMC (2013a, 2013b, 2014) and SRK (2017) and has been updated to include work that postdates these reports. The Qualified Persons take responsibility for the content of this section and believe it is accurate and complete in all material aspects.

11.1 New Liberty Deposit

11.1.1 Soils and Trenches

Soil samples have been collected from 0.5 m below the surface, in areas away from drainage channels, then coned and quartered to 1.5–2.5 kg weights and bagged for analysis.

In the trenches, 1 m-long samples were systematically collected in saprolite material from 10 cm square channels cut into cleaned trench walls near the floor of trenches and across the strike of mapped structures. Some trenches (and channels) were excavated in separate segments to traverse around large boulders, trees and unstable artisanal workings, to give continuity across the zone.

All work has been carried out by Project crews and supervised by Avesoro geologists.

11.1.2 Diamond Drill Samples

Diamond-drilling activity at the Project was also supervised by Avesoro geologists. Core and core blocks were placed in core boxes by the driller. Upon reception in the core shed on site, core was cleaned or washed (if required) and core blocks checked by Avesoro staff. The core was then photographed, wet and dry, in a frame to ensure a constant angle to and distance from the photographer. Magnetic susceptibility readings were taken every metre. For unconsolidated core this was measured in situ and results recorded, in SI units (kappa), in the assay log sheet.

Sample intervals were measured-off by the project geologists and a line drawn along the length of the core to indicate where the core must be cut. This line was chosen to be at 90° to the predominant structure so that each cut half of the core was a mirror image.

Core cutting by diamond saw was conducted in a dedicated core saw shed while unconsolidated material was split using spoons or trowels, with half the diameter of the sample being removed for assay. Each sample interval was placed in a plastic bag with a sample ticket. The bag was labelled with the hole and sample numbers using a marker pen.

Early exploration samples were 2.0 m in length (holes K1-K18). For holes K21-K27, the 2 m sampling interval over suspected mineralised zones (rich in arsenopyrite and pyrrhotite) was maintained but sampling adjacent to the mineralised zone was extended to 4 m. Subsequently, from K27 to K40, 1 m samples were introduced for target intersections, retaining 2 m intervals over suspected weakly mineralised material. Thereafter, the adopted norm was to sample drillholes uniformly at 1 m intervals for the entire ultramafic unit and within 20 m selvedges into the hanging wall and footwall gneisses.

11.1.3 RC Drill Samples

Reverse circulation drilling was supervised by an Avesoro geologist. Each metre of drilling was collected in separate sample bags which had been pre-labelled with the drillhole ID and interval metre. These bags were then weighed to check the recovery.

For exploration drilling, zones for sampling were selected by the geologist based on the geological logging with help from the drawn geological sections. For grade control drilling, the entire hole is sampled. During drilling, sampling is completed at 1 m intervals with each sample recorded using hole ID, sample ID, start and end depth. Samples are weighed, logged in terms of moisture content, split using a riffle splitter and then geologically logged. The cyclone is inspected and cleaned typically every three to five (3 m) drill runs, with cleaning of the sample splitter completed using compressed air between each 1 m sample. Samples of the mineralised zone were then brought back to the core yard to have QA/QC inserted and be packed into batches and dispatched to the lab.

For exploration drilling, the bulk sample was brought back to site later and stored for future use. Only the mineralised zones and the immediate wall rocks were sampled and sent to the lab. Whilst on the rig, a small portion of each metre from the bulk rejects was sieved and washed to be logged by the geologists and stored in a chip tray.

11.1.4 Bulk Density Measurements

Bulk density readings were taken at 2 m intervals within the same lithology and on every lithological break. This was carried out by weighing samples in air and water with a balance. Porous samples were first wrapped in plastic. For drillholes K1-130, measurements were carried out on half core, i.e. post-sampling, but for subsequent holes whole core was used. Measurements were recorded using a balance with top and under-slung measuring capabilities with detection limit of ±1 gm.

The balance was regularly checked (recalibrated using certified weights). In lithological units of less than 1 m thickness, a single sample was measured, while in thicker units, one sample every 2–3 m was measured. Density measurements were carried out using Archimedean principles for consolidated fresh core and mass/volume determinations on loose granular material. Density was computed from weights of small pieces of core (10–15 cm).

For unconsolidated material, density was measured by filling to the brim a container of volume 180 cm and the density is the weight of the sample divided by 180.

11.1.5 Sample Security

Field samples collected from various projects are stored in a secure facility at the New Liberty camp guarded by a private security firm (SOGUSS) prior to dispatch to the sample preparation laboratory where retained un-assayed duplicates are stored.

11.1.6 Analytical Method

11.1.6.1 2018 Drilling

Samples were sent to ALS Monrovia, Liberia and forwarded from there to ALS Johannesburg, South Africa for Au analysis. Preparation was completed at ALS Liberia. Neither of these laboratories have any relationship (other than at standard commercial terms) with the issuer.

Preparation was by standard ALS crushing and pulverisation techniques; the sample was crushed to 70% passing 2 mm and then a 500 g subsample pulverised to 85% passing 75 µm. Samples were assayed by 50 g fire assay (FA) and samples >5 ppm Au also by an ore grade method also (Au-AA26). Laboratory sample preparation and analytical methods are summarised in Table 11-1. Both FA methods are accredited by the South African National Accreditation System (SANAS).

Table 11-1: ALS sample preparation and analytical methods (New Liberty)

ALS code	Lower detection limit (LDL)	Description
CRU-31		Fine crushing to 70% <2 mm
PUL-32m		Pulverise 500 g split to 85% <75 µm
Au-AA24	0.005 ppm	Au 50 g FA AA finish
Au-AA26	0.01 ppm	Ore grade Au 50g FA AA finish

11.1.6.2 Grade Control Drilling (2014 to 2017)

Prior to October 2015, laboratory samples were sent for sample preparation and analysis for gold to SGS in Monrovia and ALS Johannesburg. Samples were dried using an electric drying oven, crushed using a Boyd crusher to 85% passing 2 mm sieve and pulverised with a Labtech Essa LM2 mill to a size of 90% passing 75 µm with a 50 g split sent for analysis. All samples were analysed for gold by FA with an AAS finish.

After October 2015, all sample preparation and analysis for grade control drilling has been completed at the ALS on-site laboratory (ALS NLGM). At the on-site facility, samples are dried at a temperature of 105°C in an electric drying oven, crushed using a terminator crusher to a size of 75% passing a 2 mm sieve and pulverised to a size of 85% passing 75 µm using a Labtech Essa LM2 mill. A 50 g split is subsequently analysed for gold by FA with AAS finish. The on-site laboratory is managed by ALS (Armitage *et al.,* SRK 2017).

11.1.6.3 Pre-2013 Drilling

The following is described in the 2017 SRK report (Armitage *et al.,* 2017).

In 1999–2000, core samples were despatched to the SGS laboratory in Abidjan, Ivory Coast for assay. Sample pulp check assaying was conducted through the OMAC laboratory in Ireland (OMAC).

In August 2005, a sample preparation facility managed by the Alex Stewart Group (OMAC) was opened in Monrovia, and from that point samples from the project (2005–2006 and 2008) were crushed, pulverised and split in Monrovia, and sample splits shipped by DHL to OMAC.

At the Monrovia sample preparation facility, the total sample (±3.5 kg) was dried to a core temperature of 110°C, jaw crushed to a nominal 2 mm, riffle split to 1 kg, then milled in an LM2 mill to a nominal 95% passing 75 µm. An analytical pulp of approximately 200 g was subsampled, of which a 100 g subsample was sent to Ireland for assay pulp and fusion in a lead collection FA. The resulting prill was dissolved in aqua regia, followed by an AAS finish.

Between 2009 and 2012, samples were sent from site directly to the OMAC preparation facility in Monrovia and sent from there to the OMAC laboratory in Ireland. On arrival of the prepared pulps at the laboratory, samples were checked against the submission sheet, logged into LIMS, and homogenised to prevent segregation that might have occurred in transit. Large consignments of samples (>300) were split into smaller sub-batches of 200 samples for convenience of processing.

Samples were weighed, mixed with flux and fused in clay crucibles. Lead buttons produced after fusion were cupelled, forming dore prills that were digested in aqua regia, and digests were analysed for gold using a Varian AA Spectrometer. Samples were analysed in lots of 50 and include 44 original samples, four duplicates, one CRM and a blank.

OMAC was accredited by the Irish National Accreditation Board to ISO 17025 and FA was included in the Schedule of Accreditation. OMAC participated in inter-laboratory proficiency testing and certification programmes (round-robins).

During 2011, the same sample preparation protocol was applied; however, following the merger between OMAC and the ALS Group, ALS Chemex was no longer eligible for use as a referee company. Consequently, SGS Canada Inc. (SGS) was commissioned as a reference lab. OMAC, ALS Chemex and SGS, including the Monrovia sample preparation facility, are independent of Avesoro.

For umpire assaying, pulps were taken from coarse rejects stored in the sample preparation laboratory of OMAC located in Liberia. Dry rejects were crushed entirely to 80% passing 2 mm using terminator jaw crusher. One-kilogram crushed material splits were taken using a riffle splitter and milled using a LM2 mill to 90% passing 100 µm. Fifty-gram portions of prepared pulp were packed in plastic mini-grip bags and couriered to the ALS Chemex laboratories in Canada. ALS Chemex is part of the ALS Minerals Group which "maintains ISO 9001:2008 and ISO/IEC 17025:2005 certifications" and operates a laboratory quality management system (QMS) involving both internal and external controls (e.g. round-robin programs and proficiency tests).

Sample decomposition was again by FA fusion (FA-FUS03 and FA-FUS04 in the method coded Au-AA25), utilising 30 g of sample followed by atomic absorption spectroscopy (AAS) finish.

11.1.7 QA/QC Procedures

11.1.7.1 Diamond Drilling (2018)

Cross contamination is monitored with coarse blanks, assay accuracy by inserting Certified Reference Material (CRM) samples with known concentrations of the relevant elements and precision by analysis of various duplicate sample analyses. QA/QC procedures are described in the Avesoro document "006_SOP NDD_DD Logging & Sampling". QC material should be inserted as per the following:

- Blanks: Two in 30 samples including one near the beginning of the sampling.
- CRM: Three CRM per 20 samples.
- Field duplicates: Minimum of two quarter-core field duplicates per batch.
- Pulp duplicates: These are done at the laboratory under the supervision of an Avesoro geologist or geological technician at a rate of two per 30 samples.

11.1.7.2 Grade Control Drilling (2014 to 2017)

Pre-generated sample IDs and Standard QA/QC inserts were developed on 1 m intervals for all holes. Standards, field duplicates and blank samples were also taken within the mineralised zone to monitor analytical performance at the laboratory (Armitage *et al.,* 2017).

11.1.7.3 Campaigns (2009/2010 and 2011/2012)

Prior to shipment, final checking was carried out in the presence of a senior geologist and two field assistants to ensure sample identities were correct, samples intact and there were no omissions. Quality control standards and blanks samples were inserted at pre-determined intervals at this point. Samples were analysed in lots of 50 and include 44 original samples, four duplicates, one CRM and a blank.

For umpire assaying, pulps were taken from coarse rejects stored in the sample preparation laboratory of OMAC located in Liberia. Dry rejects were crushed entirely to 80% passing 2 mm using a terminator jaw crusher. One-kilogram crushed material splits were taken using a riffle splitter and milled using a LM2 mill to 90% passing 100 µm. Fifty-gram portions of prepared pulp were packed in plastic mini-grip bags and couriered to the ALS Chemex laboratories in Canada (Armitage *et al.,* 2017)

11.1.7.4 Campaigns (2005 to 2006, 2008)

During the 2005 to 2006 and 2008 drilling campaigns, some additional QA/QC procedures were introduced. Notably blanks andCRMs were together inserted into the sample stream at a rate of one in 10. The 19^{th} and 20^{th} samples were QA/QC samples, in which the 19^{th} sample was a blank (1 kg of Monrovia sand) and the 20^{th} was either an assay pill or Rocklab Ltd standard (as 50 g sealed sachets). Assay pills were crushed and inserted into a bag of 1 kg of Monrovia sand to make up a sample (Armitage *et al.,* 2017).

11.1.7.5 Campaigns (1999 to 2000)

No standard or blank sampling was undertaken, nor any standard QA/QC procedures implemented with these samples (Armitage *et al.,* 2017).

11.1.8 Analysis of QA/QC Data

11.1.8.1 Introduction

CSA Global reviewed the results for the QC samples for Au included with the primary samples as well as the laboratory internal duplicate results. QC results were reviewed separately for channel, pre-2013 drilling (prior to Avesoro), RC (grade control), 2018 infill drilling (up to July 2018) and drilling from July 2018 to the end of 2018. Results of this review are discussed below.

11.1.8.2 Cross Contamination

Drilling (July 2018 to December 2018)

Pulp blanks but no preparation blanks were included with samples in this phase of drilling and therefore the control on potential cross contamination is inadequate. In addition, 6% of pulp blanks had Au values >3 x the Lower Detection Limit (LDL).

2018 Infill Drilling (up to July 2018)

A coarse blank was used in these samples and 98% of the blanks had Au values within 10 x the LDL. Two blank results had significantly elevated Au values.

Grade Control Drilling (2014 to 2017)

A pulp blank was included with these samples, but no preparation blank was used. Numerous failures (8% of blanks >10 x LDL) were noted.

Pre-2013 Drilling

Three blanks were used (AUB0, AUB1, AUB2). Failures were noted in these blanks (7%, 1% and 1% respectively).

Channel Samples

No blank samples included.

11.1.8.3 Assay Bias

CRM results were merged into the SQL database and Shewhart control plots produced in QAQCR. In addition, mean bias was calculated for each CRM.

Drilling (July 2018 to December 2018)

CRM was obtained from Ore Research and Exploration (OREAS) in Australia and inserted with the primary samples sent to the laboratory. Results were reviewed and are summarised below.

Table 11-2: Au CRM data – New Liberty drilling, July to December 2018 (absolute bias >5% highlighted in red)

Standard code	Expected value Au (ppm)	Number of samples	Mean Au (ppm)	Mean bias	Number of failures (>10 x LDL)
OREAS209	1.58	34	1.557	-1%	1
OREAS214	3.03	20	2.685	-11%	4
OREAS218	0.531	33	0.529	0%	1
OREAS220	0.866	16	0.837	-3%	4
OREAS221	1.06	29	1.048	-1%	1
OREAS224	2.15	20	2.133	-1%	5
OREAS252	0.674	24	0.733	9%	2
OREAS254	2.55	21	2.463	-3%	4

Numerous failures and some bias.

Many of the apparent failures appear to be due to misidentified or mislabelled CRM samples. The table below has the obvious misidentified CRM removed and it can be noted that accuracy is acceptable, but precision is still poor.

Table 11-3: Au CRM data (corrected) – New Liberty drilling, July to December 2018 (absolute bias>5% highlighted in red)

Standard code	Expected value Au (ppm)	Number of samples	Mean Au (ppm)	Mean bias	Number of failures (>10 x LDL)
OREAS209	1.58	34	1.557	-1%	1
OREAS214	3.03	16	2.951	-3%	0
OREAS218	0.531	33	0.529	0%	1
OREAS220	0.866	16	0.837	-3%	4
OREAS221	1.06	29	1.048	-1%	1
OREAS224	2.15	16	2.127	-1%	1
OREAS252	0.674	22	0.666	-1%	0
OREAS254	2.55	18	2.538	0%	1

The obvious misidentified CRM have been removed from this table. Bias is between 0% and -3% indicating that the results could have been slightly understated.

Once obvious misidentified CRM were removed from the results, assay accuracy was acceptable with a small negative bias (between 0 and -3%). CRM precision was poor with multiple failures and CSA Global recommends that the failed CRMs are investigated and where possible corrected in the database.

2018 Infill Drilling (up to July 2018)

Table 11-4: Au CRM data – New Liberty 2018 infill drilling, up to July 2018 (absolute bias >5% highlighted in red)

Standard code	Expected value Au (ppm)	Number of samples	Mean Au (ppm)	Mean bias	Number of failures (>10 x LDL)
G308-2	1.11	36	1.10	-1%	0
G313-3	0.51	137	0.52	1%	1
G907-1	0.79	97	0.77	-2%	1
G910-1	1.43	16	1.40	-2%	1
G912-6	4.08	19	4.05	-1%	0
G913-6	2.19	22	2.09	-4%	1
G999-4	3.02	16	3.06	1%	0
GLG913-3	0.0026	3	0.008	211%	2

Numerous failures and some bias (apart from pulp blank, all bias between -4% and 1%).

The apparent failures appear to be due to misidentified or mislabelled CRM samples. The table below has the obvious misidentified CRM removed and it can be noted that accuracy and precision are acceptable.

Table 11-5: Au CRM data (corrected) – New Liberty 2018 infill drilling, up to July 2018 (absolute bias >5% highlighted in red)

Standard code	Expected value Au (ppm)	Number of samples	Mean Au (ppm)	Mean bias	Number of failures (>10 x LDL)
G308-2	1.11	36	1.10	-1%	0
G313-3	0.51	136	0.50	-1%	0
G907-1	0.79	96	0.77	-2%	0
G910-1	1.43	16	1.41	-1%	0
G912-6	4.08	19	4.05	-1%	0
G913-6	2.19	22	2.19	-1%	0
G999-4	3.02	16	3.06	1%	0

GLG913-3	0.0026	3	0.008	211%	2

The obvious misidentified CRM have been removed from the above table. Bias is between 1% and -2% indicating that the results could have been slightly understated.

Grade Control Drilling (2014 to 2017)

Multiple failures of CRM results were noted in the Grade Control drilling results; many of which appear to be a result of misidentified or mislabelled CRM.

Table 11-6: Au CRM data – New Liberty grade control drilling, 2014 to 2017 (absolute bias >5% highlighted in red)

Lab	Method	Standard code	Expected value Au (ppm)	Number of samples	Mean Au (ppm)	Mean bias	Number of failures (>10 x LDL)
ALS Johannesburg	AU_AA26	G303-8	0.26	63	0.24	-7%	0
	AU_AA26	G306-3	8.66	69	8.45	-2%	55
	AU_AA26	G310-6	0.65	68	0.60	-8%	1
	AU_AA26	G900-5	3.21	65	3.21	0%	0
	AU_AA26	G910-1	1.43	63	1.46	2%	5
ALS New Liberty	Au-AA26	G308-2	1.11	162	1.11	0%	8
	Au-AA26	G310-6	0.65	15	0.50	-23%	5
	Au-AA26	G310-8	7.97	429	7.21	-10%	56
	Au-AA26	G312-7	0.22	311	0.43	95%	14
	Au-AA26	G313-4	2	460	1.84	-8%	81
	Au-AA26	G313-6	4.94	435	4.46	-10%	94
	Au-AA26	G900-5	3.21	14	2.96	-8%	5
	Au-AA26	G910-1	1.43	21	1.40	-2%	5
	Au-AA26	G912-2	2.51	47	0.26	-90%	47
	Au-AA26	G912-6	4.08	74	3.63	-11%	16
	Au-AA26	G913-6	2.19	93	2.08	-5%	9
	Au-AA26	G998-3	0.81	225	0.80	-2%	23
	Au-AA26	G999-4	3.02	112	2.73	-10%	16
	Au-AA26	GLG912-2	0.00254	422	0.11	4,302%	n/a
Korkoya Laboratory	Aqua regia	G313-3	0.49	8	0.46	-7%	0
	Aqua regia	G907-1	0.77	86	0.79	3%	1
	Aqua regia	G910-1	1.4	28	1.49	6%	2
	Aqua regia	G912-6	4.05	21	3.68	-9%	2
	Aqua regia	G913-3	2.21	20	0.33	-85%	19
	Aqua regia	G913-6	2.13	51	2.11	-1%	3
	Aqua regia	G999-4	2.93	76	2.84	-3%	6
SGS Monrovia	FAA505	G303-8	0.26	24	0.25	-6%	1
	FAA505	G306-3	8.66	27	9.14	5%	24
	FAA505	G310-6	0.65	28	0.65	0%	1
	FAA505	G900-5	3.21	27	3.15	-2%	2
	FAA505	G910-1	1.43	26	1.40	-2%	1

Multiple failures noted. Bias often as a result of these failures.

Pre-2013 Drilling

CRM material was obtained from Rocklabs, which although their certificates do not stipulate an assay digest and method, generally use a FA technique. Samples digested with an aqua regia digest often under report when compared with results from a FA technique.

Table 11-7: Au CRM data (corrected) – New Liberty grade control drilling, 2014 to 2017 (absolute bias >5% highlighted in red)

Standard code	Expected value Au (ppm)	Number of samples	Mean Au (ppm)	Mean bias	Number of failures (>10 x LDL)
SE44	0.606	81	0.591	-3%	1
SE58	0.607	41	0.574	-5%	4
SF45	0.848	17	0.809	-5%	1
SG40	0.976	36	0.95	-3%	1
SG56	1.027	39	0.935	-9%	3
SI54	1.78	222	1.647	-7%	105
SJ53	2.637	254	2.487	-6%	85
SK52	4.107	79	4.045	-2%	5

Multiple failures noted as well as a systematic negative bias.

Some of the failures appear to be misidentified CRM or blanks.

The systematic negative bias could be at least partly due to the assay technique used not being the same as the assay technique used for the certification of the CRM.

Channel Samples

Multiple failures of CRM results were noted in the channel sample results; many of which appear to be a result of misidentified or mislabelled CRM.

Table 11-8: Au CRM data – New Liberty channel samples (absolute bias >5% highlighted in red)

Standard code	Expected value Au (ppm)	Number of samples	Mean Au (ppm)	Mean bias
G308-2	1.11	58	1.15	4%
G313-3	0.51	55	0.49	-4%
G313-6	4.94	7	4.79	-3%
G907-1	0.79	78	0.79	0%
G910-1	1.43	43	1.4	-2%
G912-6	4.08	95	3.69	-10%
G913-3	2.36	7	0.41	-83%
G913-6	2.19	62	1.93	-12%
G999-4	3.02	43	2.84	-6%

11.1.8.4 Assay Precision

Methodology

Precision error can be estimated by measuring the precision error at each stage of the sampling and assay process. Field duplicates contain all sources of error (sampling error, sample reduction error and analytical error), laboratory duplicates contain sample reduction error and analytical error, pulp duplicates contain analytical error only.

The data were assessed using average coefficients of variation (CV_{AVR}% = std dev/average – also known as relative standard deviation) calculated from individual duplicate pairs and averaged using the RMS (root mean squared) approach. This approach is recommended by Stanley and Lawie (2007) and Abzalov (2008) as a way of defining a fundamental measure of data precision using duplicate paired data.

Precision errors (CV_{AVR}(%)) were calculated for duplicates with mean values ≥10 times the analytical detection limit and compared to acceptable limits. Acceptable and best practice limits are obtained from Abzalov's 2008 paper, "Quality Control of Assay Data: A Review of Procedures for Measuring and Monitoring Precision and Accuracy". Scatterplots, relative difference plots and quantile-quantile (Q-Q) plots were produced.

Drilling (July 2018 to December 2018)

Field duplicate and laboratory pulp split results were compared, and results summarised in Table 11-9 below.

Table 11-9: Duplicate data – New Liberty, July 2018 to December 2018 (including acceptable and best practice limits)

Duplicate type	Element	Pairs (total)	Count of pairs (>10 x DL)	CV(AVR) %	CV(AVR) best	CV(AVR) acceptable	Mean original (ppm)	Mean duplicate (ppm)	Bias
Field duplicate	Au	198	96	38	20%	40%	0.75	0.84	12%
Pulp split	Au	129	60	27	10%	20%	0.48	0.50	3%

Field duplicates have a bias of 12% to the duplicates and acceptable repeatability for a nuggetty orebody. The bias is disproportionately influenced by three pairs with significant differences.

Laboratory pulp splits have poor precision with no significant bias.

Field duplicate results had acceptable precision (for a very nuggetty orebody) with a bias to the duplicate samples. Laboratory pulp splits had poor precision and no significant bias.

2018 Infill Drilling (up to July 2018)

Field duplicate and laboratory pulp split results were compared, and results summarised in Table 11-10.

Table 11-10: Duplicate data – New Liberty 2018 infill drilling (including acceptable and best practice limits)

Duplicate type	Element	Pairs (total)	Count of pairs (>10 x DL)	CV(AVR) %	CV(AVR) best	CV(AVR) acceptable	Mean original (ppm)	Mean duplicate (ppm)	Bias
Field duplicate	Au	229	109	34	20%	40%	0.42	0.51	20%
Pulp split	Au	230	103	28	10%	20%	0.62	0.58	-6%

Field duplicates had acceptable precision and a significant bias of 20% to the duplicates.

Laboratory pulp splits have poor precision and a 6% bias to the original samples.

Grade Control Drilling (2014 to 2017)

Field duplicate and laboratory pulp split results were compared, and results summarised in Table 11-11.

Table 11-11: Duplicate data – New Liberty grade control drilling (including acceptable and best practice limits)

Duplicate type	Element	Pairs (total)	Count of pairs (>10 x DL)	CV(AVR) %	CV(AVR) best	CV(AVR) acceptable	Mean original (ppm)	Mean duplicate (ppm)	Bias
Field duplicate	Au	777	504	34	20%	40%	0.96	1.08	12%

Field duplicates have a bias of 12% to the duplicates and acceptable repeatability for a nuggetty orebody. The bias is disproportionately influenced by a few pairs with significant differences.

Pre-2013 Drilling

No Duplicate data provided for review.

Channel Samples

No Duplicate data provided for review.

11.1.9 Author's Opinion on Sample Preparation, Security and Analytical Procedures

Sample security appears adequate and sample preparation and analytical techniques for both the pre-2013 drilling (prior to Avesoro's ownership) and the post 2013 drilling are mostly appropriate with no fatal flaws noted. Due to the coarse nature of the gold mineralisation, a Screen Fire Assay (SFA) technique could be used to more accurately determine the gold values.

QA/QC procedures have evolved with time, from no QC samples in 1999 and 2000 to a comprehensive program in 2018. However, the procedures do not appear to always have been diligently followed with no preparation blank being used in the most recent campaign of drilling (July to December 2018) or in the grade control drilling. Therefore, there is no adequate control on potential cross-contamination in these samples. Numerous instances of apparent misidentification of CRM and blanks are apparent which indicate issues with data management.

Precision is acceptable for the grade control and 2018 drilling, and once errors corrected, the 2018 samples indicate acceptable levels of assay accuracy. Bias is noted in many of the pre-2018 CRM results, but this is usually a negative bias, indicating that results are potentially understated (not overstated) which could be influenced by the assay method (particularly where an aqua regia digest been used).

Overall, there are issues with many of the QC results and implementation of procedures could be improved.

11.2 Ndablama Deposit

11.2.1 Soils and Trenches

Soil samples were collected from 0.5 m below surface, in areas away from drainage channels, then coned and quartered to 1.5–2.5 kg weights and bagged for analysis.

For trenches, 1 m-long samples were systematically collected in saprolite material from 10 cm-high channels cut into cleaned trench walls near the floor of trenches and across the strike of mapped structures. For consistency the channels start at the southern ends of trenches (and channels) were excavated in separate segments to traverse around large boulders, trees and unstable artisanal workings, whilst maintaining continuity across the zone.

All work has been carried out by project field crews and supervised by BEA Mountain Corp. geologists.

11.2.2 Diamond Drill Samples

Core sample intervals are measured-off by the project geologists and a line drawn 90° clockwise from the orientation line along the length of the core to indicate where the core must be cut. This is to ensure that each half of the core will be a mirror image of the other. Where there is no orientation, a line is chosen to be at 90° to the prominent structure so that each cut half of the core will be a mirror image.

Core cutting by diamond saw is conducted in a dedicated core saw shed (Figure 11-1), while unconsolidated material is split using spoons or trowels. Core is cut in half, or in the case of unconsolidated material, half is removed from the core box for assay. Each sample interval is placed in a plastic bag with a simple ticket. The bag is labelled with the hole and sample numbers using a marker pen.

Figure 11-1: Core cutting shed at Ndablama
Source: CSA Global, 2018

At Ndablama, all samples were cut at 1 m lengths, except for a limited number of holes in Campaign 2 drilling, where samples were cut according to specific lithologies to determine which lithologies were hosts to mineralisation. In such cases, average core lengths for samples fell about 0.7 m. During Campaign 4, the ore zone and nearby wall rock was cut in 1 m samples with the material either side on 2 m lengths or not sampled depending on the area and lithology.

11.2.3 RC Drill Samples

RC drilling was supervised by a BEA Mountain Corp. geologist. Each metre of drilling was collected in separate sample bags which had been pre-labelled with the drillhole ID and interval metre. These bags were then weighed to check the recovery.

For exploration drilling, zones for sampling were selected by the geologist based on the geological logging with help from the drawn geological sections. For grade control drilling, the entire hole is sampled. During drilling, sampling is completed at 1 m intervals with each sample recorded using Hole ID, sample ID, start and end depth. Samples are weighed, logged in terms of moisture content, split using a riffle splitter and then geologically logged. The cyclone is inspected and cleaned typically every three to five (3 m) drill runs, with cleaning of the sample splitter completed using compressed air between each 1 m sample. Samples of the mineralised zone were then brought back to the core yard to have QA/QC inserted and be packed into batches and dispatched to the lab.

For exploration drilling, the bulk sample was brought back to site later and stored for future use. Only the mineralised zones and the immediate wall rocks were sampled and sent to the lab. Whilst on the rig, a small portion of each metre from the bulk rejects was sieved and washed to be logged by the geologists and stored in a chip tray.

11.2.4 Bulk Density Measurements

Bulk density readings are taken at 2 m intervals within the same lithology and at every lithological break, based on weights from 10 cm to 20 cm lengths of core. Measurements are carried out by weighing samples in air and water with a balance (Figure 11-2), with porous samples wrapped in plastic. For some drillholes in Ndablama (Campaign 2), measurements were carried out on half core (i.e. post-sampling), but currently whole core is used.

Figure 11-2: Bulk density measurements at Ndablama
Source: CSA Global, 2018

11.2.5 Sample Security

Field samples collected are stored in the secure exploration camp at Ndablama and guarded prior to dispatch to the sample preparation laboratory where retained un-assayed duplicates are stored.

11.2.6 Analytical Method

Samples were sent to ALS Monrovia, Liberia and forwarded from there to ALS Johannesburg, South Africa for Au analysis. Preparation was either completed at ALS Liberia or at ALS Johannesburg. Neither of these laboratories has any relationship (other than at standard commercial terms) with the issuer.

Preparation was by standard ALS crushing and pulverisation techniques; the sample was crushed to 90% passing 2 mm and then a 1 kg subsample pulverised to 95% passing 106 µm. Samples were assayed by fire assay (FA) as well as by screen fire assay (SFA). Laboratory sample preparation and analytical methods are summarised in Table 11-12. Method Au-SCR24 is not accredited by the South African National Accreditation System (SANAS), but the laboratory operates under the ALS Group international procedures and standards.

Table 11-12: ALS sample preparation and analytical methods (Ndablama)

ALS code	Lower detection limit (LDL)	Description
CRU-32		Fine crushing to 90% <2 mm
PUL-35a		Pulverise 1 kg split to 95% <106 µm
Au-SCR24	0.05 ppm	Au Screen Fire Assay Double Minus 50 g
Au-AA26	0.01 ppm	Ore grade Au 50 g FA AA finish.
Au-AA26D	0.01 ppm	Ore grade Au 50 g FA AA duplicate.

Assay results were prioritised such that the Au Total (SFA) was assigned a higher priority in the assay flat table than the 50 g FA results and therefore the SFA results were used in downstream work.

11.2.6.1 Screen Fire Assay vs Fire Assay

Results for 335 samples analysed by both SFA and FA were reviewed and results for 68 pairs compared. Assay results <0.5 ppm Au were excluded from the comparison as these values were within 10 x the SFA LDL. SFA assay results were significantly higher (more than double) than the FA results for these samples, indicating the influence of coarse Au in the samples.

11.2.7 Quality Assurance and Quality Control Procedures

Cross contamination is monitored with coarse blanks, assay accuracy by inserting CRM samples with known concentrations of the relevant elements and precision by analysis of various duplicate sample analyses. QA/QC procedures are described in the Avesoro document "006_SOP NDD_DD Logging & Sampling". QC material should be inserted as per the following:

- Blanks: Two in 30 samples including one near the beginning of the sampling.
- CRM: Three CRM per 20 samples.
- Field duplicates: Minimum of two quarter-core field duplicates per batch.
- Pulp duplicates: These are done at the laboratory under the supervision of an Avesoro geologist or geological technician at a rate of two per 30 samples.

11.2.8 Analysis of QA/QC Data

11.2.8.1 Introduction

CSA Global reviewed the results for the QC samples for Au included with the primary samples as well as the laboratory internal duplicate results. Results of this review are discussed below. QA/QC data were only available for the diamond core drillholes from NDD116 onwards (i.e. drillholes NDD001 to NDD115 had no QC samples and therefore no controls on cross contamination, assay bias or assay precision).

11.2.8.2 Cross Contamination

The Avesoro procedures describe the use of a coarse (preparation) blank ('AUSP-LF001'). There were three out of 435 blank samples that had assayed Au values >0.5 ppm Au (10 x SFA LDL), but most of the blank samples did not indicate any significant cross contamination in drillholes NDD116 onwards.

Table 11-13: Blank failures – Ndablama

Sample ID	Standard ID	Element	sysResult	Unit code
AuNDD20038	AUSP-LF001	Au	100	ppm
AuNDD24098	AUSP-LF001	Au	1.43	ppm
AuNDD26195	AUSP-LF001	Au	0.82	ppm

Failures should be investigated. Sample AuNDD20038 is >100 ppm Au.

11.2.8.3 Assay Bias

CRM was sourced from Australian based companies, OREAS and Geostats. Due to its nature, CRM was only analysed by FA, not SFA. **Error! Reference source not found.** below summarises the average bias as well as the number of failures for each CRM.

Table 11-14: CRM results – Ndablama (failures and bias <-5% and >5% are highlighted in red)

CRM	Count	Au ppm	Expected value	Bias	Failures
G303-8	16	0.248	0.26	-5%	0
G308-2	92	1.090	1.11	-2%	0
G310-6	14	0.687	0.65	6%	1
G313-2	13	2.078	2.04	2%	0
G313-3	43	0.513	0.51	1%	1
G900-5	19	3.196	3.12	2%	0
G907-1	39	0.771	0.79	-2%	2
G910-1	46	1.403	1.43	-2%	2
G912-6	4	3.918	4.08	-4%	0
G913-6	37	2.237	2.19	2%	1
OREAS209	9	1.533	1.58	-3%	0
OREAS218	33	0.576	0.531	8%	3
OREAS220	35	0.858	0.866	-1%	2
OREAS221	20	1.047	1.06	-1%	0
OREAS252	1	0.710	0.674	5%	0
OREAS254	11	2.496	2.55	-2%	1

Most of the failures (and associated bias) can be attributed to misidentification of CRMs (e.g. Figure 11-3).

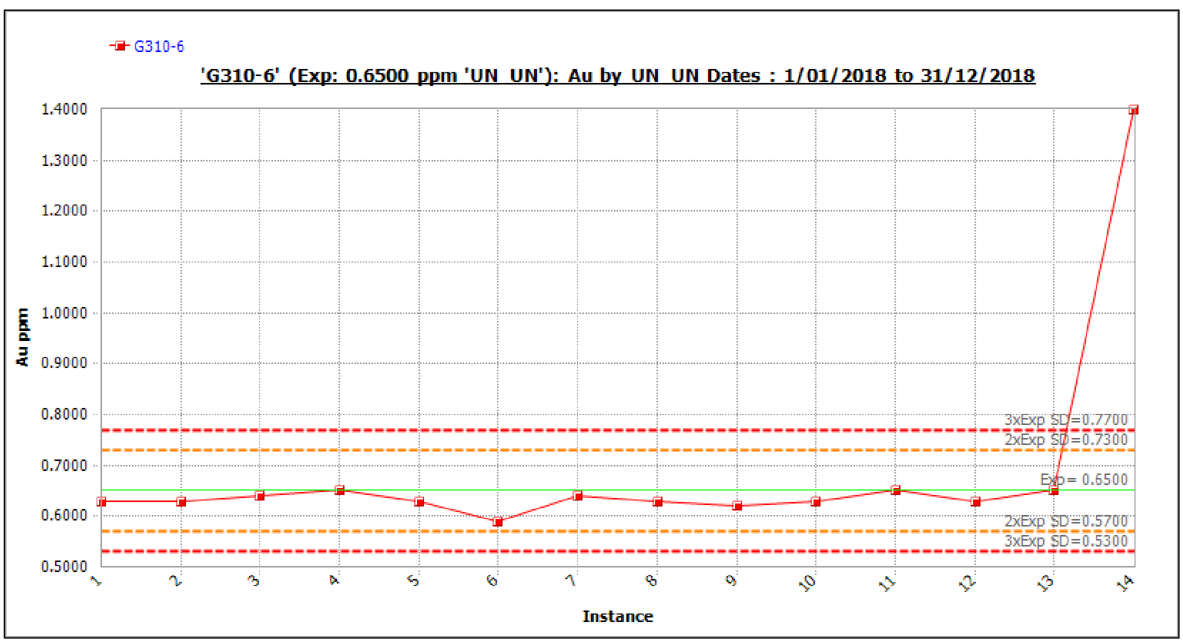


Figure 11-3: Ndablama – CRM G310-6 showing apparent misidentified CRM G910-1 (expected value 1.418 ppm Au)
Source: CSA Global, 2018

Once the obvious misidentified CRM were removed, there was no bias exceeding the 5% tolerance and all except three of the failures were corrected (Table 11-15). Bias is mostly negative, ranging from -5% to 2% (excludes CRM with only one instance), but is positive in two of the higher-grade CRMs.

Table 11-15: Corrected CRM results – Ndablama (failures and bias <-5% and >5% are highlighted in red)

CRM	Count	Au ppm	Expected value	Bias	Failures
G303-8	16	0.248	0.26	-5%	0
G308-2	92	1.090	1.11	-2%	0
G310-6	13	0.632	0.65	-3%	0
G313-2	13	2.078	2.04	2%	0
G313-3	42	0.508	0.51	0%	0
G900-5	19	3.196	3.12	2%	0
G907-1	37	0.771	0.79	-2%	0
G910-1	44	1.418	1.43	-1%	0
G912-6	4	3.918	4.08	-4%	0
G913-6	36	2.188	2.19	0%	0
OREAS209	9	1.533	1.58	-3%	0
OREAS218	31	0.531	0.531	0%	1
OREAS220	35	0.858	0.866	-1%	2
OREAS221	20	1.047	1.06	-1%	0
OREAS252	1	0.710	0.674	5%	0
OREAS254	10	2.545	2.55	0%	0

Once the issues with apparent misidentified CRM are corrected, there are no fatal flaws with assay accuracy and assay bias is not expected to be a significant concern.

11.2.8.4 Assay Precision

Precision error can be estimated by measuring the precision error at each stage of the sampling and assay process. Field duplicates contain all sources of error (sampling error, sample reduction error and analytical error), Laboratory duplicates contain sample reduction error and analytical error, pulp duplicates contain analytical error only.

The data were assessed using coefficients of variation (CV = standard deviation/average – also known as relative standard deviation) calculated from individual duplicate pairs and averaged using the RMS (root mean squared) approach. This approach is recommended by Stanley and Lawie (2007) and Abzalov (2008) as a way of defining a fundamental measure of data precision using duplicate paired data.

Precision errors (CV_{AVR}(%)) were calculated for duplicates with mean values ≥10 times the analytical detection limit and compared to acceptable limits. Acceptable and best practice limits are obtained from Abzalov's 2008 paper, "Quality Control of Assay Data: A Review of Procedures for Measuring and Monitoring Precision and Accuracy". Relative difference plots for each duplicate type are shown below.

Table 11-16: Precision results for each duplicate type – Au (Ndablama)

Duplicate type	Pairs (total)	Count of pairs (>10 x DL)	Best practice	Acceptable practice	$CV_{(AVR)}$ %	Mean original (ppm)	Mean duplicate (ppm)	Bias
Field duplicate	216	22	20	40	63	1.77	1.28	-28%
Pulp split	218	26	10	20	37	2.45	2.49	2%
Lab replicate	349	171	10	20	17	1.24	1.27	2%

Field duplicate (Figure 11-4) and pulp splits (Figure 11-5) have poor precision and therefore repeatability of these results could be of concern, but CSA Global notes that the datasets of duplicates >10 x LDL are small and therefore the poor precision could be a function of small datasets. Lab replicates have an acceptable precision (Figure 11-6).

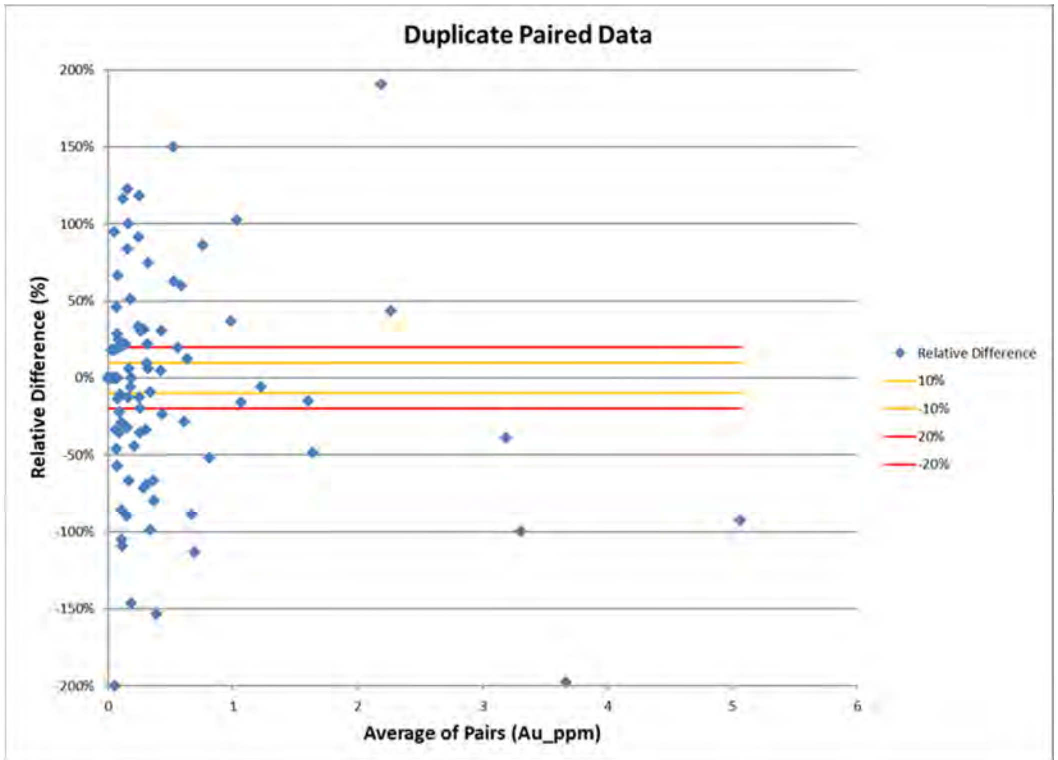


Figure 11-4: *Ndablama – relative difference plot for Au field duplicates*
Source: CSA Global, 2018

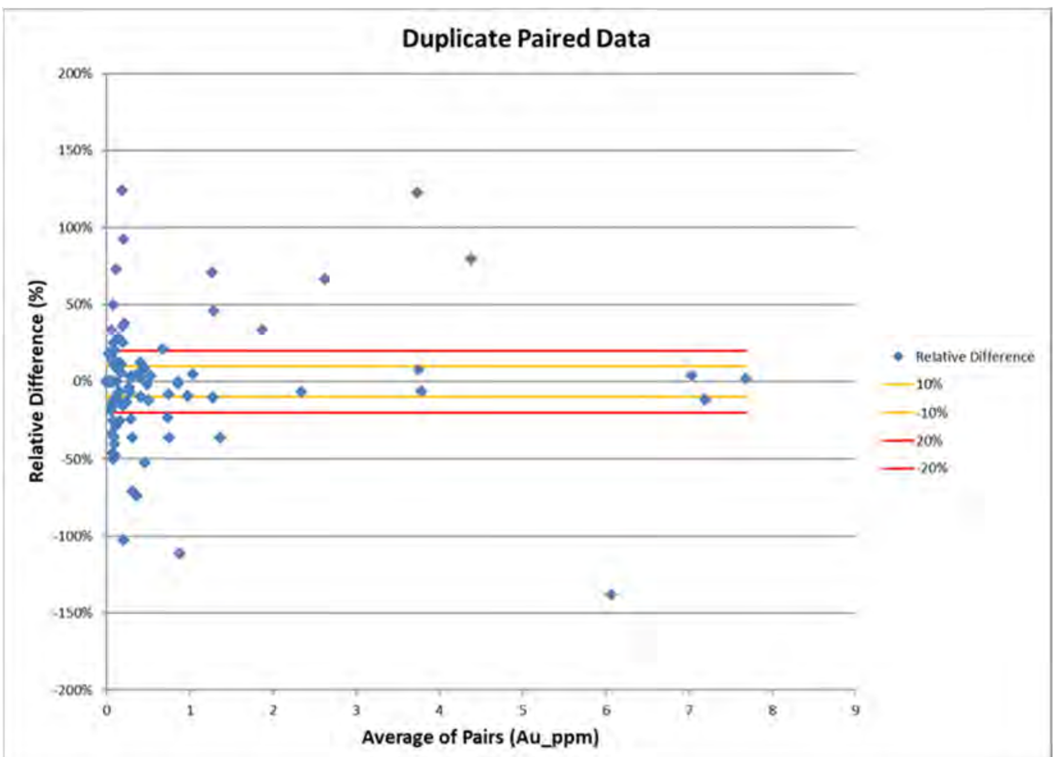


Figure 11-5: *Ndablama – relative difference plot for Au pulp splits*
Source: CSA Global, 2018

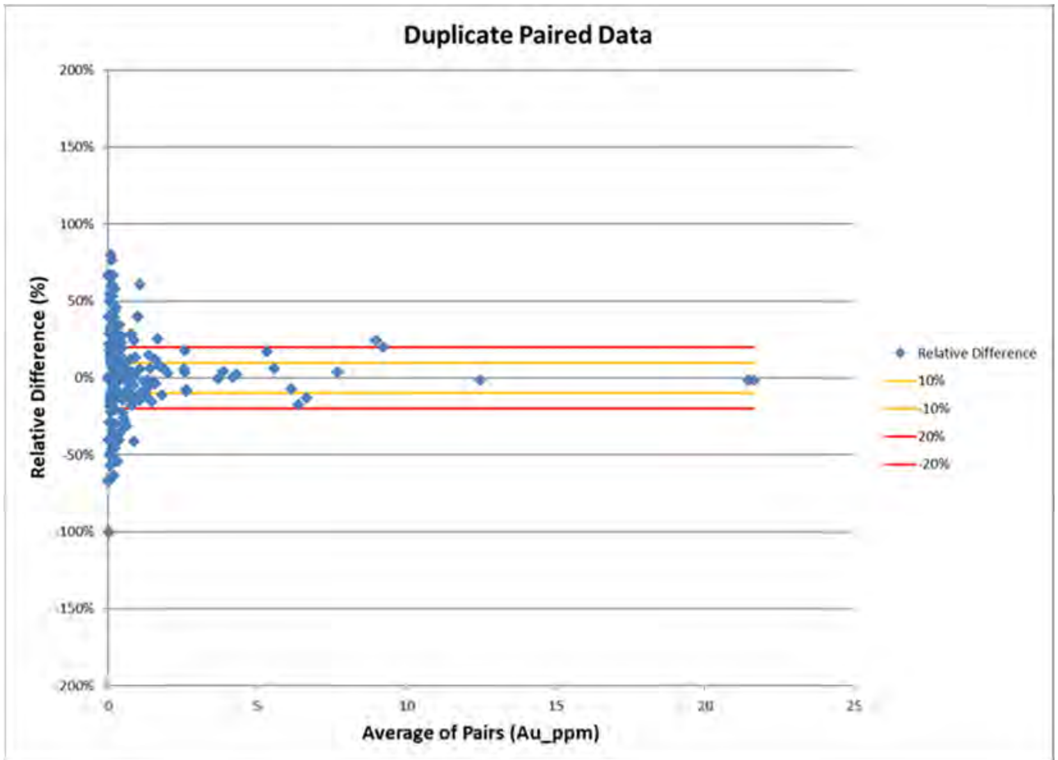


Figure 11-6: Ndablama – relative difference plot for Au lab replicates
Source: CSA Global, 2018

Repeatability of assay results could be an issue, but the dataset analysed is small and therefore any conclusion is inconclusive.

11.2.9 Author's Opinion on Sample Preparation, Security and Analytical Procedures

Sample security appears adequate and sample preparation and analytical techniques are appropriate with Fire Assay (FA) and Screen Fire Assay (SFA) being the industry best practice techniques for gold analysis.

Results of QC samples from drillholes NDD116 onwards were reviewed where numerous CRM identification issues were noted. However, once these were corrected, CSA Global concluded that no significant cross contamination was apparent, and that assay accuracy was acceptable with no significant bias. Assay precision was poorer than expected, indicating the coarse nature of the mineralisation.

QA/QC procedures are acceptable and when followed should provide confidence that there is no significant cross contamination and that acceptable assay accuracy (lack of bias) and assay precision (repeatability of results) have been established.

12 Data Verification

12.1 Database Verification

Data were provided by Avesoro in Microsoft Excel spreadsheets and the 2018 assay results in laboratory assay certificates. All data provided were compiled into a SQL database, with inbuilt constraints and triggers, ensuring that data adhered to standard validation criteria such as unique sample IDs, no overlapping intervals, no zero length or negative length intervals, etc. Assay results for the 2018 data were loaded directly from the laboratory assay certificates.

Once validation issues were corrected, a clean export was provided for downstream work. Apart from loading the 2018 assay results directly from the laboratory assay certificates and verifications completed during the CSA Global site visits (discussed in the following section), no other verification of the database was completed.

Once the database validation issues described above were resolved, the compiled databases are suitable for Mineral Resource Estimation and Mineral Reserve Estimation.

12.2 Site Visit Verification

CSA Global staff visited the New Liberty properties from 2 to 6 July 2018.

These visits were required for the purposes of inspection, ground truthing, review of activities, procedural review and information data collection and collation and to satisfy NI 43-101 "personal inspection" requirements.

Dr Belinda van Lente (CSA Global Qualified Person, Mineral Resources) and Dr Matthew Randall (CSA Global Qualified Person, Mineral Reserves) carried out the site inspections on behalf of CSA Global, as described in Section 2.4.

12.2.1 Geology and Mineral Resources

The following was completed as part of the data verification:

- Ground truthing the deposit locations and layouts for New Liberty and Ndablama
- Verification of drillhole collar locations with survey coordinates in the drill database
- Inspection of drill core
- Discussion of drilling, sampling and density determination procedures.

CSA Global inspected the core yards at New Liberty and Ndablama and viewed core for the New Liberty deposit from holes, K501 and K537, and core from the Ndablama deposit from holes NDD048, NDD059, NDD129, NDD130, NDD162 and NDD189. Photographs for K501 and K537 (New Liberty) and NDD059 and NDD129 (Ndablama) showing mineralisation styles and host lithologies are presented in Figure 12-1 to Figure 12-4.

Figure 12-1: *K501 – drill core shown with locations of samples N55921, N55922 and N55923 (269–272 m, weighted average grade 11.99 g/t Au)*

Note: The host rock is magnetite-tremolite-chlorite schist within the SMUS.
Source: CSA Global, 2018

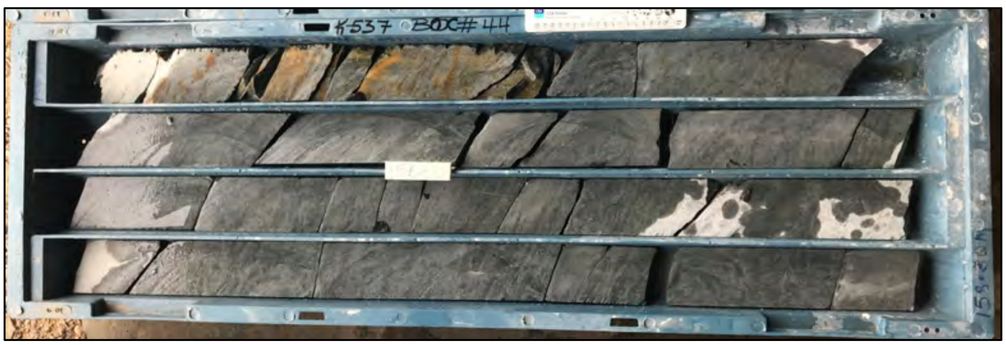


Figure 12-2: *K537 – drill core shown within 155–159 m, with an average weighted grade of 2.13 g/t Au*

Note: The host rock is tremolite-chlorite-talc schist within the SMUS.
Source: CSA Global, 2018

Figure 12-3: *NDD059 – drill core shown within 70–73 m, with an average weighted grade of 2.26 g/t Au*

Source: CSA Global, 2018

Figure 12-4: NDD129 – drill core shown within 117–122 m, with an average weighted grade of 4.64 g/t

Note: Host rock is phlogopite-tremolite-chlorite schist.
Source: CSA Global, 2018

CSA Global verified the location of seven collars at New Liberty and six collars at Ndablama. The handheld GPS coordinates are presented with those recorded in the databases in Table 12-1.

Table 12-1: GPS and database collar surveys verified during the site visit (WGS1984, Zone 29N)

Project	BHID	Avesoro database		CSA Global GPS		Difference (m)	
		Easting	Northing	Easting	Northing	Easting	Northing
New Liberty	K513	263485	774931	263490	774932	4.8	1.1
	K521	263345	775006	263345	775006	0.0	-0.2
	K523	263313	774991	263313	774991	-0.4	0.5
	K530	263932	774964	263933	774964	0.9	-0.1
	K534	263871	774966	263872	774969	1.2	3.1
	K541	263796	774949	263799	774951	2.9	2.4
	K549	263206	775090	263207	775092	0.6	1.7
Ndablama	NDD115	300023	790575	300023	790575	0.3	-0.2
	NDD174	300034	790607	300035	790607	0.7	0.1
	NDD179	300024	790567	300023	790575	-0.8	7.8
	NDD186	300028	790540	300021	790541	-7.3	0.7
	NDD187	300072	790536	300068	790537	-4.2	0.8
	NDD189	300126	790542	300120	790544	-5.8	2.5

CSA Global ground truthed the mined deposit at New Liberty (Figure 12-5) and exploration target at Ndablama, inspecting the open pits, drill collar locations (where preserved) and having geological discussions with the client representatives.

CSA Global considers the data being relied upon, to be adequate for the purposes of downstream evaluation.

Figure 12-5: Location of New Liberty deposit – Larjor, Kinjor and Marvoe (www.earth.google.com)
Source: CSA Global, 2018

12.2.2 Mining and Mineral Reserves

The Mineral Reserve estimate is based on the Mineral Resource models created by CSA Global. Where possible, these were compared to previous estimates to ensure that they were similar and to highlight and explain any significant differences.

13 Mineral Processing and Metallurgical Testing

13.1 Introduction

Testing was performed on samples from four areas of the New Liberty gold deposit, along with a Master Composite, and investigated the potential to recover gold by means of cyanide leaching both with and without gravity pre-concentration. Comminution testing was also undertaken to provide an indication of grinding characteristics and ore hardness.

Testing was conducted by Wardell Armstrong International (WAI) between December 2018 and January 2019.

Testing of representative oxide and fresh samples from the Ndablama deposit was carried out by ALS Ammtec (Ammtec) in November 2013, and again in 2015.

13.2 New Liberty Testwork

Material representing four different ore sources from the New Liberty project was submitted for testing at WAI. The four main ore sources were:

- Larjor
- Kinjor South
- Kinjor North
- Marvoe.

Due to low sample masses, two of the areas (Larjor/Kinjor South) were combined to form a single metallurgical composite. Each sample was then crushed and subsampled to produce material suitable for testing. A separate Master Composite sample was also prepared for comminution testing and grind calibration.

13.2.1 Composite Sample Preparation

Samples were taken from quarter cores. Each drillhole was tagged with a unique ID. Sample details are shown in Table 13-1.

Table 13-1: Sample details

Pit/Zone	Batch no.	BHID	Sample no.	Selected sample from (m)	Selected sample to (m)	Sample length (m)	Sample weight (kg)
Larjor	NL-UG-L-CSA-001	K120	NLMET0001	518.10	520.00	1.90	1.78
		K136	NLMET0002	381.00	383.00	2.00	3.26
		K602	NLMET0003	276.00	279.00	3.00	4.16
		K134	NLMET0004	340.00	343.00	3.00	4.58
		K133	NLMET0005	454.00	456.00	2.00	2.60
Kinjor South	NL-UG-KS-CSA-001	K560	NLMET0006	242.50	244.00	1.50	2.22
		K508	NLMET0007	337.00	338.50	1.50	2.92
		K146	NLMET0008	470.50	473.50	3.00	3.52
		K150	NLMET0009	320.30	322.30	2.00	2.68
		K571	NLMET0010	285.50	287.00	1.50	2.32
		K576	NLMET0011	328.00	329.46	1.46	2.60
		K350	NLMET0012	259.00	261.00	2.00	2.14
Kinjor North	NL-UG-KN-CSA-001	K562	NLMET0013	421.00	422.50	1.50	2.32
		K402	NLMET0014	276.00	277.50	1.50	3.12
		K508	NLMET0015	369.00	370.50	1.50	3.34
		K566	NLMET0016	426.00	427.50	1.50	2.46
		K521	NLMET0017	354.50	356.00	1.50	2.70
		K304	NLMET0018	256.00	258.00	2.00	2.78
		K574	NLMET0019	386.00	387.50	1.50	2.98
		K582	NLMET0020	251.00	252.50	1.50	2.64
		K419	NLMET0021	294.00	296.00	2.00	2.28
Marvoe	NL-UG-M-CSA-001	K556	NLMET0022	341.50	342.84	1.34	2.44
		K154	NLMET0023	434.00	436.00	2.00	2.30
		K559	NLMET0024	353.00	354.50	1.50	2.56

13.2.2 Sample Receipt and Preparation

13.2.2.1 Sample Receipt

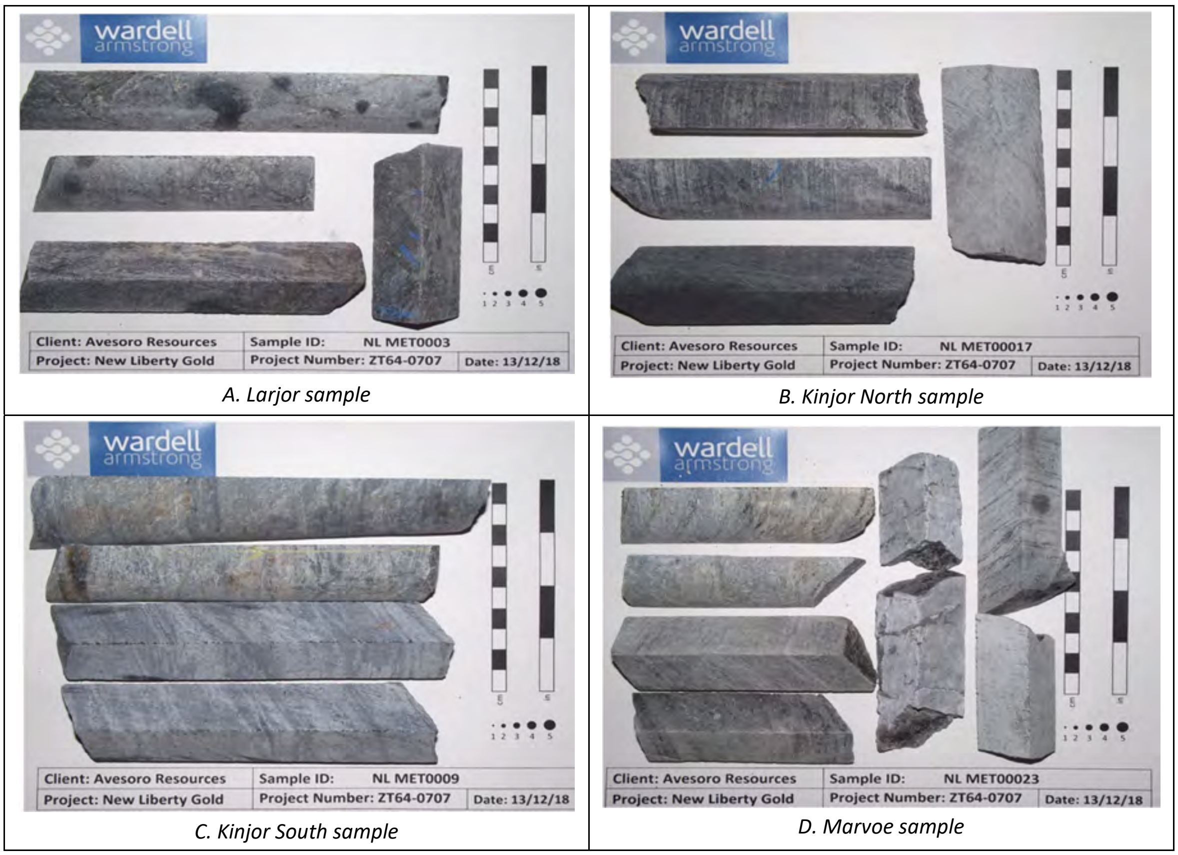
A total of 24 samples of quarter core, representing four different areas of the deposit and weighing a total of 66.0 kg was submitted to WAI in December 2018 for testing.

A summary of the samples received is given in Table 13-2.

Table 13-2: Sample receipt summary

Zone	Number of intervals	Mass (kg)
Larjor	5	16.14
Kinjor North	9	24.21
Kinjor South	7	18.46
Marvoe	3	7.18

Upon receipt, each sample was weighed, photographed and logged into the laboratory sample tracking system. Indicative photographs of the as-received material are shown below in Figure 13-1.



A. Larjor sample

B. Kinjor North sample

C. Kinjor South sample

D. Marvoe sample

Figure 13-1: Example photographs of received samples

13.2.2.2 Sample Preparation

The Larjor and Kinjor South samples were blended to form a single metallurgical composite. This sample, along with the Kinjor North and Marvoe samples were then individually crushed to 100% passing 12.5 mm and a subsample removed from each in order to produce a Master Composite sample weighing 28 kg.

The Master Composite was prepared by blending 55.0% Larjor/Kinjor South with 26.5% Kinjor North and 18.5% Marvoe. From this sample, an initial 15 kg was removed for Bond Rod Work Index testing after which, the remaining material was crushed to 100% passing 3.35 mm and a 10 kg sample extracted for Bond Ball Mill Work Index testing. The remaining 3 kg was then crushed to pass 2.0 mm in preparation for a grind calibration.

Further preparation was also undertaken on the individual metallurgical samples with each sample crushed to 100% passing 2.0 mm and riffled into 1 kg charges in preparation for testing.

A summary of the sample preparation methodology is shown in Figure 13-2.

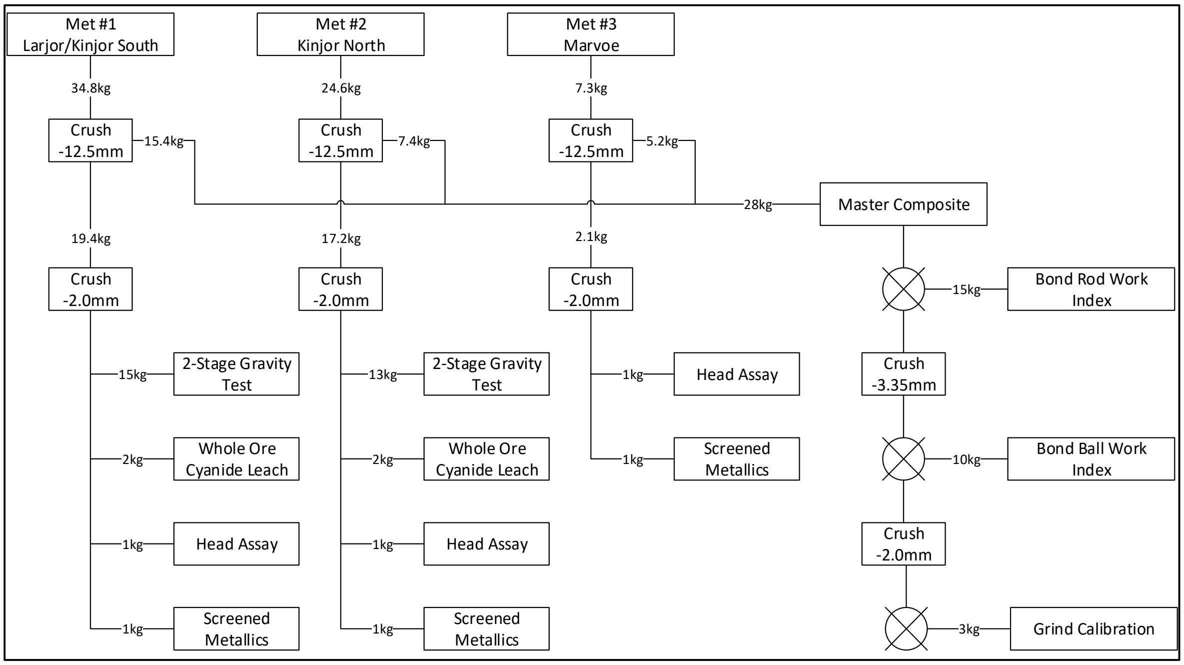


Figure 13-2: Sample preparation methodology

13.2.3 Head Assay

Detailed chemical head assay was performed on each of the individual metallurgical samples submitted for testing. The analyses were performed on a representative subsample of -2.0 mm material which had been further crushed and pulverised to 100% passing 75 µm.

Samples were analysed for gold using the screened metallics protocol along with separate assay for a range of base metals and sulphur as summarised in Table 13-3 and Table 13-4. Each sample was also submitted for multi-element analysis by ICP for a range of trace elements.

Table 13-3: Screened metallics assay results

Sample	+75µm fraction		-75µm fraction		Au distribution (%)		Calculated head assay, Au (ppm)
	Wt. (%)	Au (ppm)	Wt. (%)	Au (ppm)	+75 µm	-75 µm	
Larjor/Kinjor South	7.2	16.25	92.8	4.76	20.85	79.15	5.58
Kinjor North	9.0	16.25	91.0	7.73	17.13	82.87	8.49
Marvoe	8.7	2.19	91.3	3.77	5.22	94.78	3.63

Table 13-4: Head assay results

Element	Units	Assay		
		Larjor/Kinjor South	Kinjor North	Marvoe
$Au_{(Scr\ Met)}$	ppm	5.58	8.49	3.63
$Au_{(FA)}$	ppm	4.76	7.73	3.77
$Au_{(AR)}$	ppm	6.00	8.59	3.60
Ag	ppm	<0.5	<0.5	<0.5
Cu	%	0.009	0.010	0.010
Pb	%	<0.001	<0.001	<0.001
Zn	%	0.006	0.004	0.004
Fe	%	3.62	4.18	2.58
As	%	0.28	0.38	0.12
$S_{(TOT)}$	%	1.38	1.45	0.69

The results showed the level of gold present, as determined using the screened metallics method, to range from 3.63 ppm Au for the Marvoe sample to 8.49 ppm Au for the Kinjor North sample. In terms of coarse gold distribution (+75 µm), the analysis also showed levels to range from 5.2% for the Marvoe sample to 20.9% for the Larjor/Kinjor South sample.

Analysis for gold by Fire Assay showed slightly lower levels of gold for all three samples from 3.77 ppm Au for the Marvoe sample to 7.33 ppm Au for the Kinjor North sample. This slight reduction in gold values is likely due to the presence of coarse gold in the samples resulting in increased assay variance combined with the lower trial size for fire assay. Silver levels in all three samples was <0.5 ppm.

13.2.4 Communition Tests

The Master Composite was subjected to a short program of comminution testing consisting of Bond Rod and Bond Ball Work Index testing.

13.2.4.1 Bond Rod Mill Work Index Test

Bond Rod Mill Work Index testing was undertaken to determine the energy required to grind the Master Composite from a feed size distribution of 100% passing 12.5 mm (F100) to a product size distribution of 100% passing 1.18 mm (P100) using a standard laboratory Bond Rod Mill.

The resulting data can then be used to calculate the net power requirements for the sizing of rod and ball mills. The result of the test is summarised below in Table 13-5.

Table 13-5: Bond Rod Mill Work Index test results

Sample	80% passing size (mm)		Bond Rod Mill Work Index (kWh/t)
	Feed	Product	
Master Composite	9.98	0.81	15.21

Standard classification criteria for Bond Work Index results are shown below in Table 13-6.

Table 13-6: Standard grindability classification criteria

Grindability criteria	Bond Work Index (kWh/t)
Soft	7–9
Medium	9–14
Hard	14–20
Very hard	>20

Based on the criteria detailed above, the Master Composite was classified as being “hard” with respect to rod/ball mill grinding characteristics.

13.2.4.2 Bond Ball Mill Work Index Test

Bond Ball Mill Work Index testing was conducted to determine the energy required to grind the Master Composite from a feed size distribution of 100% passing 3.35 mm (F100) to a product size distribution of 100% passing 106 µm (P100) using a standard laboratory Bond Rod Mill.

As with the Bond Rod Mill Work Index data, the resulting value can be used to determine the net power requirements for the sizing of ball mills. The result of the test is summarised in Table 13-7.

Table 13-7: Bond Ball Mill Work Index test

Sample	80% passing size (µm)		Bond Rod Mill Work Index (kWh/t)
	Feed	Product	
Master Composite	2,132	85	16.06

Using the same classification criteria outlined in Table 13-6, the sample was again classified as "hard" with respect to ball mill grinding characteristics.

13.2.5 Gravity/Leach Testing

Gravity-leach testing was undertaken to investigate the total amount of gold recoverable through the application of gravity preconcentration followed by separate leaching of the gravity concentrate and tailings products.

Testing was performed on both the Larjor/Kinjor South and Kinjor North samples.

13.2.5.1 Gravity Pre-Concentration Tests

Bulk gravity preconcentration was conducted to generate samples of gravity concentrate and tailings for subsequent leach testing.

Each sample was subjected to two stages of processing at target grind sizes of 80% passing 212 µm and 75 µm respectively.

Once complete, the concentrates from each stage were combined and submitted for leach testing. A subsample of the gravity tailings were also submitted for separate leach testing.

The results of the bulk gravity preconcentration are summarised below in Table 13-8.

Table 13-8: Bulk gravity results

Sample	Product	Mass (%)	Assay (ppm)			Distribution (%)		
			Au	Ag	Cu	Au	Ag	Cu
Larjor/Kinjor South	Concentrate	1.49	307.97	6.18	206.87	64.0	14.4	3.9
	Tailings	98.51	2.63	0.56	76.43	36.0	85.6	96.1
	Feed	100.00	7.19	0.64	78.38	100.0	100.0	100.0
Kinjor North	Concentrate	1.56	322.68	3.59	231.49	57.7	9.7	3.9
	Tailings	98.44	3.75	0.53	91.25	42.3	90.3	96.1
	Feed	100.00	8.73	0.58	93.44	100.0	100.0	100.0

The bulk gravity results showed a gold recovery of 64.0% to a concentrate grading 308.0 ppm Au for the Larjor/Kinjor South sample after two stages of gravity concentration. Results for the Kinjor North sample showed the gold recovery to be slightly lower at 57.7% but at a higher grade of 322.7 ppm Au after the same number of concentration stages.

Silver recoveries were low in both samples ranging from 9.7% at 3.6 ppm Ag for the Kinjor North sample to 14.4% at 6.2 ppm Ag for the Larjor/Kinjor South sample.

13.2.5.2 Gravity Concentrate Leach Tests

The gravity concentrates produced during bulk gravity preconcentration were subjected to cyanide leach testing to establish the amount of gold and silver that could be recovered.

A single cyanide leach test was conducted on each sample on the "as is" particle size and leached for 48 hours at 20 g/l cyanide and at pH 10.5 to 11. Both gravity concentrates were tested in their native form with no size reduction or pre-treatment prior to leaching.

The results of both tests are summarised below in Table 13-9 and Figure 13-3.

Table 13-9: Gravity concentrate cyanide leach test results

Sample	Reagent consumption (kg/t)		Recovery (%)		
	Lime	Cyanide	Au	Ag	Cu
Larjor/Kinjor South	0.53	46.70	97.2	91.9	27.0
Kinjor North	0.40	49.90	97.5	86.1	18.8

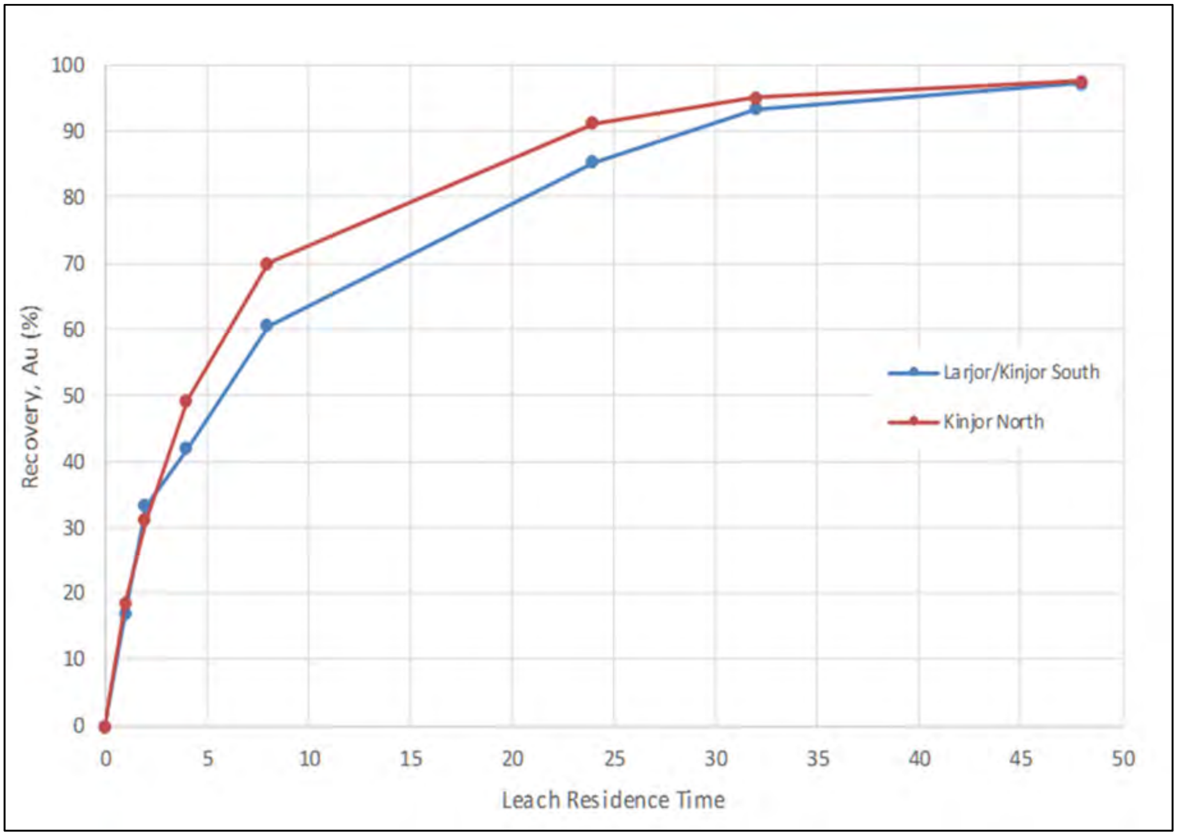


Figure 13-3: Gold leach profiles, gravity concentrate leach tests

The results showed near total extraction of the gold after 48 hours of leaching with recoveries of 97.2% and 97.5% for the Larjor/Kinjor South and Kinjor North samples respectively. Silver recoveries were also high with 86.1% recovered from the Kinjor North sample and 91.9% recovered from the Larjor/Kinjor South sample.

Although both samples achieved similar total gold recoveries, the data showed the Kinjor North sample to exhibit slightly faster leach kinetics demonstrated by the Kinjor North sample having achieved a total gold recovery of 91.3% after 24 hours of leaching, compared with 85.3% for the Larjor/Kinjor South sample.

The amount of lime consumed during testing was low, ranging from 0.40 kg/t to 0.53 kg/t; however, cyanide consumption was high, ranging from 46.7 kg/t to 49.9 kg/t for the Larjor/Kinjor South and Kinjor North samples respectively. The high cyanide consumption is likely attributable to the high cyanide concentration in the leach.

13.2.5.3 Gravity Tailings Leach

A single cyanide leach test was performed on a subsample of the bulk gravity tailings to determine the amount of gold and silver that could be recovered from each sample. Tests were conducted using the "as is" particle size and leached for 24 hours at 1 g/l cyanide and at pH 10.5–11.0.

Results of the tests are summarised in Table 13-10 and Figure 13-4.

Table 13-10: Gravity tailings cyanide leach test results

Sample	Reagent consumption (kg/t)		Recovery (%)		
	Lime	Cyanide	Au	Ag	Cu
Larjor/Kinjor South	0.38	1.50	73.9	10.4	7.3
Kinjor North	0.32	1.17	83.6	5.7	6.3

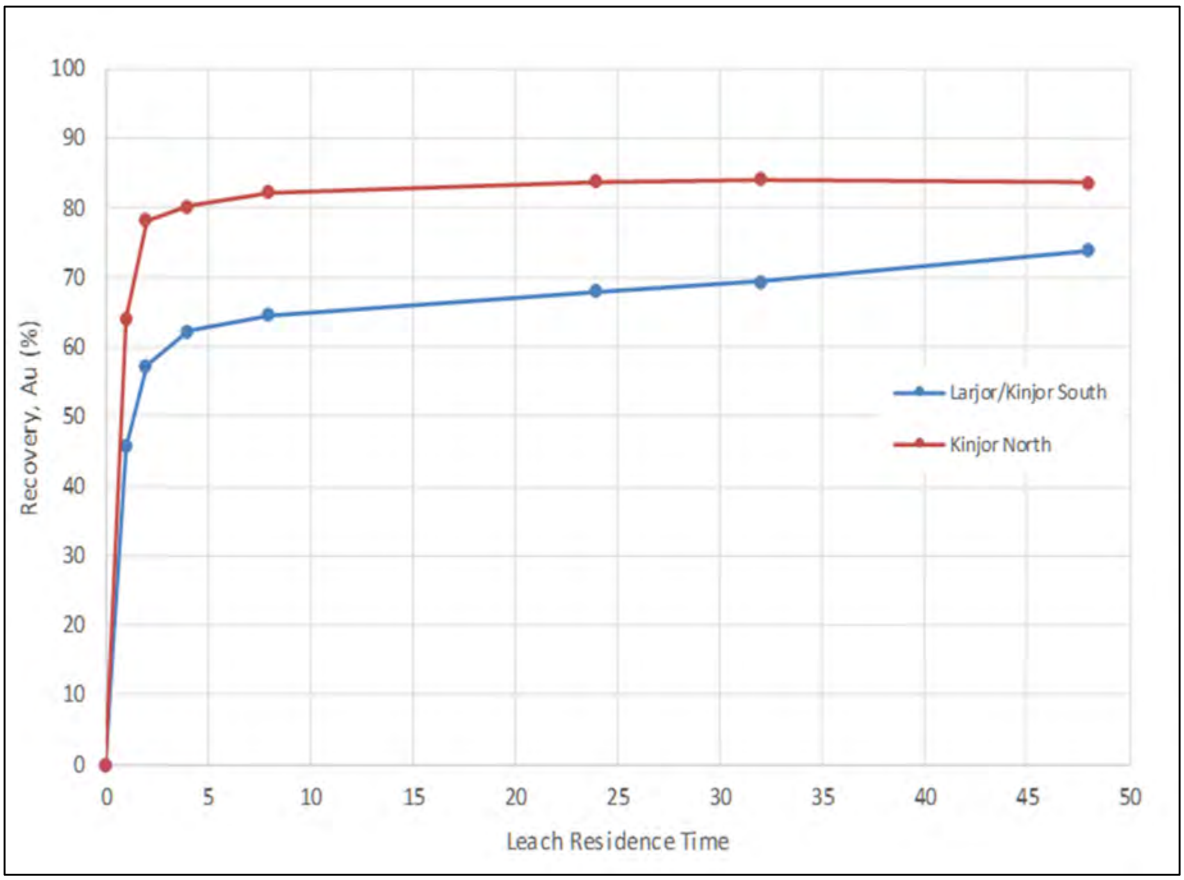


Figure 13-4: Gold leach profiles, gravity tailings leach tests

The data showed the amount of gold recovered from the gravity tailings after 48 hours of leaching to range from 73.9% for the Larjor/Kinjor South sample, to 83.6% for the Kinjor North sample. Silver recoveries were 10.4% and 5.7% respectively.

For both samples, the results showed relatively fast leach kinetics with a large proportion of the total gold recovered extracted during the first four hours of leaching. After four hours of leaching, the results showed that 87.5% of the total gold recovered from the Larjor/Kinjor South sample, and 96.1% of the total gold recovered from the Kinjor North sample, had been extracted into solution.

The amount of lime consumed during testing remained was low for both samples, in the order to 0.32–0.38 kg/t with cyanide consumption also low ranging from 1.17 kg/t for the Kinjor North sample to 1.50 kg/t for the Larjor/Kinjor South sample.

Analysis of the back-calculated head assay for the gravity tailings leaches showed good reconciliation against measured values for the final Knelson tailings (leach feed) for both samples. A summary of the measured and back-calculated head assays for both samples is given in Table 13-11.

Table 13-11: Comparison of measured and back-calculated head assays, Knelson tailings

Sample	Head assay, Au (ppm)	
	Knelson tailings (Measured)	Leach feed (back-calculated)
Larjor/Kinjor South	2.26	2.63
Kinjor North	3.52	3.75

13.2.6 Metallurgical Recoveries

The results of the separate gravity and cyanide leach tests were used to calculate overall gold and silver recoveries for each sample based on the combined gravity-leach performance. These results are given in Table 13-12.

Table 13-12: Combined gravity-leach test results

Sample	Product	Gravity recovery (%)		Leach recovery (%)		Overall recovery (%)	
		Au	Ag	Au	Ag	Au	Ag
Larjor/Kinjor South	Concentrate	64.0	14.4	97.2	91.9	62.2	13.2
	Tailings	36.0	85.6	85.2	10.4	30.7	8.9
	Total					**92.9**	**22.1**
Kinjor North	Concentrate	57.7	9.7	97.5	86.1	56.3	8.4
	Tailings	42.3	90.3	92.1	5.7	38.9	5.1
	Total					**95.2**	**13.5**

Overall, the results showed that by using a combined gravity-leach methodology, gold recoveries of 92.9% and 95.2% could be achieved for the Larjor/Kinjor South and Kinjor North samples respectively.

Combined silver recoveries were 22.1% and 13.5% respectively.

13.2.7 Whole Ore Leaching

Whole ore cyanide leach testing was undertaken to determine the total amount of gold and silver that could be recovered from the Larjor/Kinjor South and Kinjor North samples through direct cyanide leaching of the feed.

Whole ore cyanidation leach tests were undertaken at a grind size P80 of 75 µm, for a leach residence time of 48 hours, adopting a cyanide concentration of 1 g/l NaCN, and pH 10.5–11.0.

The results of the whole ore cyanide leach tests are summarised in Table 13-13 and Figure 13-5.

Table 13-13: Whole ore cyanide leach test results

Sample	Reagent consumption (kg/t)		Recovery (%)		
	Lime	Cyanide	Au	Ag	Cu
Larjor/Kinjor South	0.35	1.88	88.9	22.9	14.9
Kinjor North	0.33	2.18	95.8	13.0	12.3

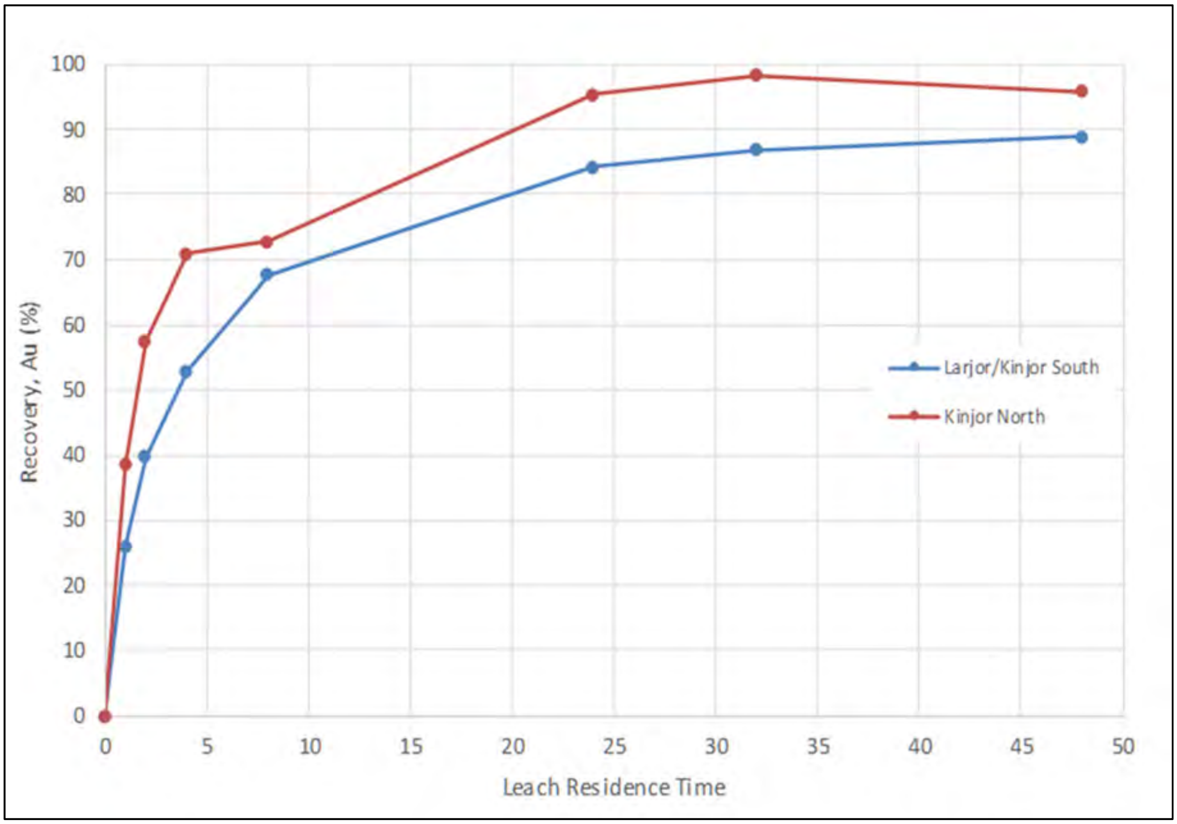


Figure 13-5: Gold leach profiles, whole ore leach tests

The test results showed final gold recoveries of 88.9% and 95.8% for the Larjor/Kinjor South and Kinjor North samples after 48 hours of leaching. Silver recoveries were 22.9% and 13.0% respectively.

Analysis of the rate at which the gold was leached into solution showed moderate leach kinetics with the Kinjor North sample displaying a faster rate of leaching than the Larjor/Kinjor South sample. After the first 24 hours of leaching, 94.6% of the total gold recovered from the Larjor/Kinjor South sample had been extracted increasing to 99.5% for the Kinjor North sample.

The amount of lime consumed in both tests was similar and relatively low at 0.33–0.35 kg/t whilst the amount of sodium cyanide consumed was moderate ranging from 1.88 kg/t for the Larjor/Kinjor South sample to 2.18 kg/t for the Kinjor North sample.

13.3 Ndablama Testwork

Historical Testwork – ALS Ammtech, 2013.

13.3.1 Head Assays

Representative Oxide and Fresh Composite sub-samples were submitted for head assay. Results are shown in Table 13-14.

Table 13-14: Head assays

Comp ID	Au_1 (g/t)	Au_2 (g/t)	Au_3 (g/t)	Au_4 (g/t)	Au_4 (g/t)	Au_4 (g/t)	Au_{Avg} (g/t)	SFA 75 µm (g/t Au)	Ag (g/t)	C_T (%)	C_{Org} (%)	S_T (%)	S^{2-} (%)
Oxide	0.8	0.84	0.7	0.78	1.76	0.76	0.94	0.67	0.9	0.09	0.09	0.18	0.09
Fresh	1.75	1.36	2.47	1.77	3.93	1	2.05	3.37	0.6	0.03	0.03	0.18	0.14

The gold assays for the sulphide ore would tend to indicate the processed of free gold resulting in a “nugget effect”.

13.3.2 Gravity-Leach Testwork

The Oxide Composite and Sulphide Composite subsamples were submitted for gravity separation/cyanidation leach testwork to investigate gold extraction via a conventional gravity-CIL process route. The sample was ground in a laboratory stainless steel rod mill, at 50% solids (w/w), to a P80 of 75 µm. Results of the gravity-leach tests are shown in Table 13-15.

Table 13-15: Gravity-leach test results

Comp ID	Test no.	% Au extraction (h)					Au grade (g/t)		Consumption (kg/t)	
		Gravity	2	8	16	24	Calculated head	Residue	NaCN	Lime
Oxide	JR791	33.7	88.49	88.49	88.49	91.89	1.03	0.08	1.28	4.86
	JR792	34.55	91.33	91.33	91.33	92.82	1	0.07	1.39	4.87
Fresh	J3793	70.77	94.02	94.02	95.17	94.9	2.42	0.12	0.8	0.48
	J3794	69.6	92.78	92.78	92.78	94.03	2.46	0.15	1.06	0.48

Results in Table 13-15 indicate the oxide and sulphide ore types are readily processable using the gravity-leach process flowsheet, with average gravity recoverable gold recoveries for the oxide and sulphide ore types of 34.1% and 70.2% respectively. Gold leach extractions were on average 92.3% and 94.5% for the oxide and sulphide ore composites respectively.

Both pairs of duplicate tests showed reproducible leach results for each composite. Both composites also displayed rapid leach kinetics with close to or above 90% total gold extraction after two hours and no significant increases in extraction after that time.

Cyanide consumption for the Oxide Composite ranged between 1.28–1.39 kg/t and 0.80-1.06 kg/t for the Fresh Composite. Lime consumption was considerably higher for the Oxide Composite at 4.86–4.87 kg/t versus 0.48 kg/t for the Fresh Composite.

13.3.2.1 Historical Testwork – ALS Ammtec, 2015

The testwork program was undertaken by the Australian, Perth based, ALS Laboratories (ALS). Material representing four different ore types was submitted for testing including:

- Low grade
- Medium grade
- High grade
- Oxidised ore.

13.3.3 Composite Sample Preparation

Samples were taken from quarter cores of the second phase of drillhole sampling. Each drillhole was tagged with a unique ID and the relevant location is illustrated in Figure 13-6.

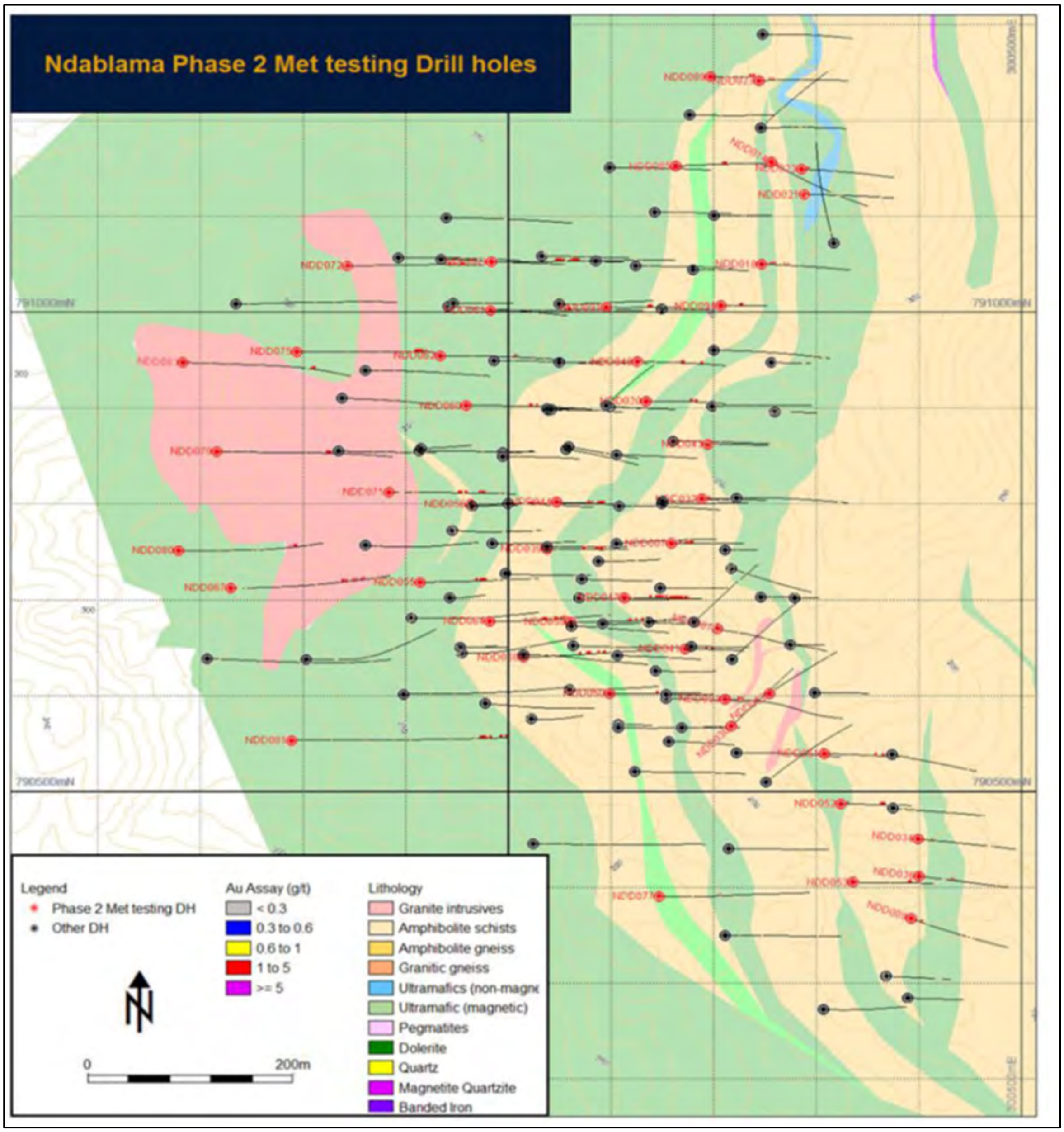


Figure 13-6: Ndablama Phase 2 drillhole locations

Four samples were composited based on requirements from Aureus, with the intent of having a 1 g/t gold variation between three of the fresh composited samples, as well as an oxidised composite sample. The identity of the various drill cores utilised during the make-up of the composites is shown in Table 13-16.

Table 13-16: Whole ore cyanide leach test results

Composite	Low grade	Medium grade	High grade	Oxidised ore
Sample ID	LG	MG V3	HG	OX
Drill Core	NDD 007	NDD 003	NDD 003	NDD 001
	NDD 020	NDD 007	NDD 030	NDD 009
	NDD 041	NDD 020	NDD 037	NDD 014
	NDD 044	NDD 036	NDD 039	NDD 018
	NDD 051	NDD 044	NDD 048	NDD 021
	NDD 056	NDD 048	NDD 050	NDD 023
	NDD 058	NDD 050	NDD 053	NDD 028
	NDD 060	NDD 052	NDD 059	NDD 032
	NDD 061	NDD 055	NDD 067	NDD 034
	NDD 062	NDD 056	NDD 081	NDD 037
	NDD 063	NDD 059	NDD 083	NDD 043
	NDD 067	NDD 060		NDD 052
	NDD 071	NDD 064		
	NDD 080	NDD 072		
	NDD 085	NDD 075		
	NDD 089	NDD 077		
	NDD 091	NDD 079		
	NDD 094			
Head grade (g/t Au)	1.40	1.83	2.70	0.82

It should be noted that the blending of the composites to achieve a targeted Au grade proved difficult due to the inherent “nuggety” nature of the ore. The distribution and analysis of the course gold makes the compositing process difficult.

13.3.4 Screen Fire Assays

A screen fire assay (SFA) was conducted on a +75 µm and -75 µm set of six subsamples for LG, MG V3 and HG composites, with a single SFA conducted on the OX composite. Summaries of the totals are shown in Table 13-17.

Table 13-17: Screen FIre Assay results

Composite ID	+75µm		-75µm	
	Weight (g)	Au (g/t)	Weight (g)	Au (g/t)
Oxide	17.52	13.1	942.75	0.89
LG	104.00	26.2	5869.85	0.98
MG	131.93	28.7	5825.18	1.30
HG	99.54	52.9	5867.76	1.97

For each of the composites, the following comments apply:

- A “nugget” effect is evident;
- There is upgrading of the +75 µm screen fraction, confirming the “nugget” effect. The nugget nature of the ore should allow for effective gravity concentration ahead of the leach. It may prove challenging to provide accurate metal accounting during the testwork and later in the processing plant due to this “nugget” effect. Furthermore, it may make the resource estimation challenging.

13.3.5 Mineralogy

One gold-bearing sample was submitted to ALS Metallurgy for quantitative mineralogical analysis by QEMSCAN (quantitative evaluation of minerals by scanning electron microscopy), XRD (x-ray diffraction) and optical examination.

The sample was sourced from the HG composite and was separated into gravity concentrate ("Pan Con") and gravity tail ("Tail") fractions using a Knelson concentrator and hand-panning before being submitted for mineralogy. The mineralogy of the gravity concentrate was characterised by QEMSCAN and that of the gravity tail by XRD (Table 13-18).

Table 13-18: Mineralogical analytical methods

Sample	%Wt.	Analytical method
Pan Con	4.78	PMA/TMS
Tail	95.22	XRD

Pyrrhotite is the dominant sulphide mineral, accounting for 4.5% by mass in the Pan Con and less than 1% in the Tail. Traces of other sulphides such as pyrite, pentlandite, chalcopyrite, sphalerite and galena are present.

Silicates dominate the sample making up 91% of the Pan Con and 98% of the Tail. The main silicate is amphibole, followed by micas, feldspars, chlorites and quartz.

Other minerals detected in minor to trace proportions were magnetite, ilmenite, sphene, apatite and calcite.

The Pan Con QEMSCAN observed the presence of major amounts of amphiboles (72.8%), minor amounts of micas (6.9%), pyrrhotite (4.5%) and feldspars (4.3%) and trace amounts of other elements. The QEMSCAN TMS also identified two grains of gold encapsulated in silicate material with respective grain compositions of Au 80% + Ag 20% (native gold) and Au 39% + Ag 61% (electrum).

The tails XRD results show the presence of major amounts of amphiboles (76%), moderate amounts of mica (13%) and trace amounts of other elements.

Mineral liberation data from QEMSCAN PMA analysis showed that 85% of sulphides were well liberated, 6% were high grade middlings, 5% low grade middlings and 4% locked.

13.3.6 Communition Testwork

The three composite samples (LG, MG and HG) were combined in an equal ratio and were submitted for preliminary comminution and ore competency characterisation. The Bond Rod and Ball Work Indices were determined for the single composite sample. The BBWi was conducted twice, targeting a P80 of 75 µm and 212 µm on -3.35 mm feed material. The BRWi was conducted on a -12.7 mm feed sample

Results of the comminution tests are shown in Table 13-19.

Table 13-19: Bond Rod/Ball Mill Work Index results

Bond test		$BBWi_{75}$	$BBWI_{212}$	$BRWi_{1180}$
	kWht	18.5	12.8	13
F80	µm	2,696	2,738	11,154
P80	µm	60	175	642

The Bond Work Index test for carried out at a product size P80 of 60 µm was 18.5 kWh/t which would be considered to be hard. The Ndablama ore would appear to be harder than that of the New Liberty fresh ore.

A single abrasion test was conducted and the Bond Abrasion Index (BAi) for the sample was determined as 0.1338, and the material is considered to have relatively low abrasiveness.

13.3.7 SMC and DWI Tests

Ndablama ore can be characterised as being of "hard" competency with a summary of the main test parameters as reported by JKTech shown in Table 13-20.

Table 13-20: SMC and DWi tests

DWi (kWh/m^3)	DWi (%)	Mill parameters			A	B	A x b	SG	ta
		Mia	Mih	Mic					
5.41	46	14.8	10.5	5.4	69.7	0.79	55.1	2.98	0.48

In terms of the measure of an ore's resistance to impact breakage and based on the single composite sample, the Ndablama ore can be categorised as moderately soft.

13.3.8 Sighter Flotation Tests

Sighter flotation testwork was conducted on the LG, MG and HG composite samples. A five-stage rougher flotation bank was utilised and the conditions for each test were kept the constant with the following reagent additions:

- 60 g/t $CuSO_4$
- 40 g/t Aero 6697
- 40 g/t MX Gold 900
- 140 g/t PAX.

The concentrate mass pulls, gold recoveries and sulphide recoveries for the combined concentrates 1 to 5 are summarised in Table 13-21.

Table 13-21: Sighter flotation test results

Comp ID	Test ID	Mass pull (%Wt.)	Au		Sulphide	
			ppm	% recovery	%	% recovery
HG	JR1325	7.86	13.33	91.1	5.52	97.9
	JR1326	7.62	14.93	91.1	5.69	97.9
	JR1327	6.28	15.38	62.6	6.62	93.7
MG V3	JR1360	6.31	8.11	91.5	7.27	92.3
	JR1361	7.89	6.82	92.8	6.30	93.8
	JR1362	10.29	5.67	93.1	6.96	91.4
LG	JR1328	6.18	8.95	90.2	6.01	91.00
	JR1329	6.66	7.50	90.5	5.04	97.7
	JR1330	5.74	8.00	89.5	3.86	97.8

Gold recoveries were generally >90%. The HG composite test JR 1327 is seen as an outlier and could result from a problem with the assay. This is evident as the sulphide recovery for this test is within the expected range, but the gold recovery is far lower than would be anticipated.

13.3.9 Gravity-Leach Testwork

The sulphide HG, MG V3 and LG composites and the oxide composite were subjected to gravity separation testwork utilising laboratory scale Knelson apparatus.

The cyanidation testwork was conducted in order to better understand the leachability of the ore, with particular reference to the following parameters:

- Grind size optimisation

- Effect of pre-oxygenation with shear
- Evaluation of preg-robbing
- Cyanide consumption optimisation.

A total of three separate gravity recovery tests were performed on the OX composite at the optimum grind of P80 75 µm with results as indicated in Table 13-22.

Gravity recoveries for the OX composite were generally lower than those observed for the sulphide composites below and ranged between 41% and 42.5%. No oxide testwork was conducted at ConSep and discount factors were not available for this composite, therefore the gravity recoveries indicated in Table 13-22 represent total GRG.

Table 13-22: Oxide gravity test results

Comp ID	Test ID	Grind size (P80)	Gravity recovery (%)	Total extraction (%)
OX	JR1266	75µm	42.53	96.34
	JR1267		41.17	97.04
	JR1268		41.06	96.46

The recovery of gravity gold from the sulphide composites was tested at both ALS Laboratories and ConSep Laboratories in Perth, Australia.

13.3.9.1 ConSep testwork

The methodology used during the ConSep testwork is very accurate in determining the total gravity recoverable gold (GRG). Each of the three sulphide composites was tested with results as per Table 13-23.

GRG is assessed from 850 µm through various size fractions down to a sub 38 µm fraction.

Typically, for plant scale-up purposes, the total GRG recovery referred to in Table 13-23 is discounted with a circuit recovery factor that incorporates the inefficiency expected due to GRG bypassing the gravity separators via the mill circuit cyclone overflow stream.

For the purposes of this report, the discount factors have not been applied and the results in Table 13-23 indicate laboratory scale recoveries only.

Table 13-23: GRG gravity test results (ConSep)

Comp ID	Total GRG recovery (%)
LG	68.0
MG V3	71.7
HG	66.1

13.3.9.2 ALS Gravity Testwork

A total of three separate gravity recovery tests were performed on the HG composite at the optimum grind of P80 75 µm with results as indicated in Table 13-24. The total GRG recovery figures refer to laboratory scale recoveries and have not been discounted with the plant scale-up factors

Table 13-24: HG composite gravity test results

Comp ID	Test ID	Grind size (P80)	Gravity recovery (%)	Total extraction (%)
HG	JR1321	75µm	53.66	95.34
	JR1322		60.08	93.69
	JR1323		57.82	94.42

A total of four separate gravity recovery tests were performed on the MG V3 composite at the optimum grind of P80 75 µm with results as indicated in Table 13-25. As above, the figures presented refer to laboratory-scale recoveries and have not been discounted with plant scale-up factors.

Table 13-25: MG V3 composite gravity test results

Comp ID	Test ID	Grind size (P80)	Gravity recovery (%)	Total extraction (%)
MG V3	JR1357	75µm	67.22	91.02
	JR1358		63.66	91.88
	JR1359		64.58	93.66
	JR1373		64.85	95.83

A single gravity recovery test was performed on the LG composite at the optimum grind of P80 75 µm with results as indicated in Table 13-26 (note again that no discount for plant scale-up has been applied).

Table 13-26: LG composite gravity test results

Comp ID	Test ID	Grind size (P80)	Gravity recovery (%)	Total extraction (%)
LG	JR1372	75µm	54.3	92.39

13.3.10 Sulphide Leach Recoveries

Grind optimisation leaches for the HG sulphide composite were conducted at P80 of 106 µm, P80 of 75 µm and P80 of 45 µm, the results of which are shown in Table 13-27.

Table 13-27: HG composite leach test results

Comp ID	Test ID	Grind size (P80 µm)	Leach residue grade (g/t)	% Au extraction	NaCN consumption (g/t)
HG	JR1353	106	0.21	92.74	0.78
	JR1321	75	0.14	95.34	0.45
	JR1322	45	0.13	95.70	0.55

An optimum grind with a P80 of 75 µm was selected. Although the overall Au recovery of 95.34% for this grind is marginally lower than that for the P80 of 45 µm (95.70%), the cyanide consumption is significantly lower at 0.45 kg/t versus 0.55 kg/t for a P80 of 45 µm.

Three tests were conducted on the MG V3 composite at the target grind of P80 of 75 µm. Cyanide consumption was measured by subtracting the unreacted cyanide remaining in solution on completion of the leach from the total addition.

The cyanide removed by samples taken during the course of the testwork was taken into account. Three initial cyanide additions were tested: 0.75 kg/t, 0.50 kg/t and 0.25 kg/t. Cyanide levels were monitored throughout the test and additional cyanide dosed if required.

Results of the cyanide optimisation leach test results are shown in Table 13-28.

Table 13-28: MG V3 composite leach test results

Comp ID	Test ID	Grind size (P80 µm)	Leach residue grade (g/t)	% Au extraction	NaCN consumption (g/t)
MG V3	JR1357	75	0.18	91.02	0.66
	JR1358		0.17	91.88	0.50
	JR1359		0.13	93.66	0.43

The optimised cyanide consumption was calculated as 0.43 kg/t with an acceptable leach residue value of 0.13 g/t Au.

Results of the "preg-robbing" leach tests on the oxide samples are shown in Table 13-29.

Table 13-29: Oxide composite leach test results

Comp ID	Test ID	Grind size (P80 µm)	Leach residue grade (g/t)	% Au extraction	NaCN	Lime
					Consumption (g/t)	
OX	JR1266	75	0.03	96.34	0.75	5.65
	JR1267		0.03	97.04	0.63	5.91
	JR1268		0.03	96.46	0.25	5.94

No preg-robbing was apparent during the course of the testwork. Oxide leach residue Au values were low at 0.03 g/t for all tests yielding recoveries of >96%.

Cyanide consumptions ranged between 0.25 kg/t and 0.75 kg/t. Lime consumptions ranged between 5.6 kg/t and 5.9 kg/t.

13.3.11 Flowsheet Validation Testwork

Once the optimum processing parameters of grind size, cyanide consumption and pre-oxygenation with shear had been identified, a series of tests was conducted to validate the proposed flowsheet.

The tests were conducted on the HG, MG V3 and LG composites as well as two additional variability samples. The purpose of this work was to test the consistency of the results with the proposed flowsheet given a range of samples from across the identified resource.

Results of the gravity-leach test results are shown in Table 13-30.

Table 13-30: Flowsheet validation test results

Comp ID	Test ID	Grind size (P80 µm)	Head grade (g/t Au)	Leach residue grade (g/t)	Total GRG recovery (%)	% Au extraction	Consumption (kg/t)	
							NaCN	Lime
LG	JR1372	75	1.4	0.11	54.3	92.39	0.27	1.05
MG V3	JR1373		1.83	0.08	64.85	95.83	0.4	1.09
HG	JR1374		2.7	0.15	57.82	94.42	0.38	1.07
Var #1	JR1375		1.62	0.13	72.37	92	0.33	1.51
Var #2	JR1376		1.15	0.11	74.48	90.33	0.26	0.73

In Table 13-30, the total GRG recovery figures refer to laboratory scale recovery and have not been discounted with the plant scale-up factors.

Across the samples tested, on a laboratory scale the gravity recoveries are expected to range from 54% to 62%, with the recovery in the variability samples being notably higher than those of the other composites. This is likely to be due to a higher proportion of the "nugget-like" particles in the variability samples. Leach residue values were all within an acceptable range of 0.08–0.15 g/t Au. These returned total extractions ranging from 90.3% to 95.8% with cyanide consumptions between 0.26 kg/t and 0.40 kg/t. Lime consumptions varied from 0.73 kg/t to 1.51 kg/t. Residue grades observed for the variability samples are low, but total extraction for these samples is lower than seen for the LG, MG and HG composites due to the lower variability head grades.

Overall, the recoveries are good with fairly low associated reagent consumptions. On the tests performed thus far, there has been no indication of significant arsenic leaching with less than 10 ppm detected in the head solids. No environmental impact is envisaged.

14 Mineral Resource Estimates

The following section describes the methodology, parameters and key assumptions regarding the preparation of the updated Mineral Resource estimates (MREs) of the New Liberty Gold Deposit (New Liberty) and the Ndablama Gold Deposit (Ndablama), prepared in 2018. This study was based on additional infill and step-out drilling since the previous MRE.

The MRE work has been based on interpretations from assaying, and geological logging. Apart from the initial sample data preparation and intermediate spreadsheet processing, all the Mineral Resource interpretation, modelling, and estimation work was conducted using Leapfrog™, Datamine StudioRM™ and Isatis™ software packages. GeoAccess Professional™ and Snowden Supervisor™ software packages were used for statistical analysis and MRE validations.

The deposits have been evaluated within the UTM grid (Zone 29 North in WGS 84 datum), and all directional references in the MRE portions of this report are per this grid.

14.1 Drilling Database

14.1.1 Data Summary

CSA Global was initially provided with two Microsoft Access databases and a series of Microsoft Excel files containing the New Liberty and Ndablama deposit data from Avesoro. These data files contained collar, downhole survey, assay, geology (lithology and oxidation), geotechnical (DD recovery and RC sample weights) and bulk density (BD) data. This information was exported in comma-separated values (CSV) format. A summary of the available drill data, received as at 27 November 2018 for New Liberty, and 24 November 2018 for Ndablama, are shown in Table 14-1 and Table 14-2. The drill data were imported into SQL and Datamine StudioRM™ software for validation.

Table 14-1: New Liberty database – summary of data entries as at 27 November 2018

Collars	Assays	Surveys	Geology	Recovery (DD)	RC weights	BD
2,595	141,192	15,615	60,334	30,037	5,988	14,112

Table 14-2: Ndablama database – summary of data entries as at 24 November 2018

Collars	Assays	Surveys	Geology	Recovery (DD)	BD
267	29,453	3,893	16,381	17,944	8,148

The New Liberty and Ndablama MRE areas were restricted by boundary strings, and data were selected within these boundaries. Summaries of the drilling data as used for the New Liberty and Ndablama MRE's are shown in Table 14-3 and Table 14-4.

Table 14-3: New Liberty database – summary of drilling as used for estimation as at 27 November 2018

	DD	RC	Total
Number of holes	561	1,069	**1,630**
Metres drilled	98,632	41,417	**140,049**
Number of assays	53,811	41,417	**95,228**
Number of BD measurements	13,884	-	**13,884**

Note: DD – diamond drillhole; RC – reverse circulation hole; BD – bulk density.

The New Liberty database contains 28,567 channel samples for 28,822 m within the MRE area. These were not used in the estimation of the Mineral Resource since there is potential bias in sample data (e.g. the high-grade bias in channel samples relative to RC and DD samples).

Table 14-4: Ndablama database – Summary of drilling as used for estimation as at 24 November 2018

	DD	RC	Total
Number of holes	225	33	**258**
Metres drilled	47,610	4,968	**52,578**
Number of assays	25,687	2,900	**28,587**
Number of BD measurements	8,148	-	**8,148**

Note: DD – diamond drillhole; RC – reverse circulation hole; BD – bulk density

14.1.2 Location of Mineral Resource estimate Data Points

At New Liberty, since 2010, all drillhole collars were surveyed using two Trimble R3 receivers, with reference to three control points. From October 2011, a Leica differential GPS survey system was used to resurvey all collar locations, with reference to the same three control points.

A location plan for New Liberty drillholes used in the MRE, coloured by drillhole type (NHTYPE) is presented in Figure 14-1.

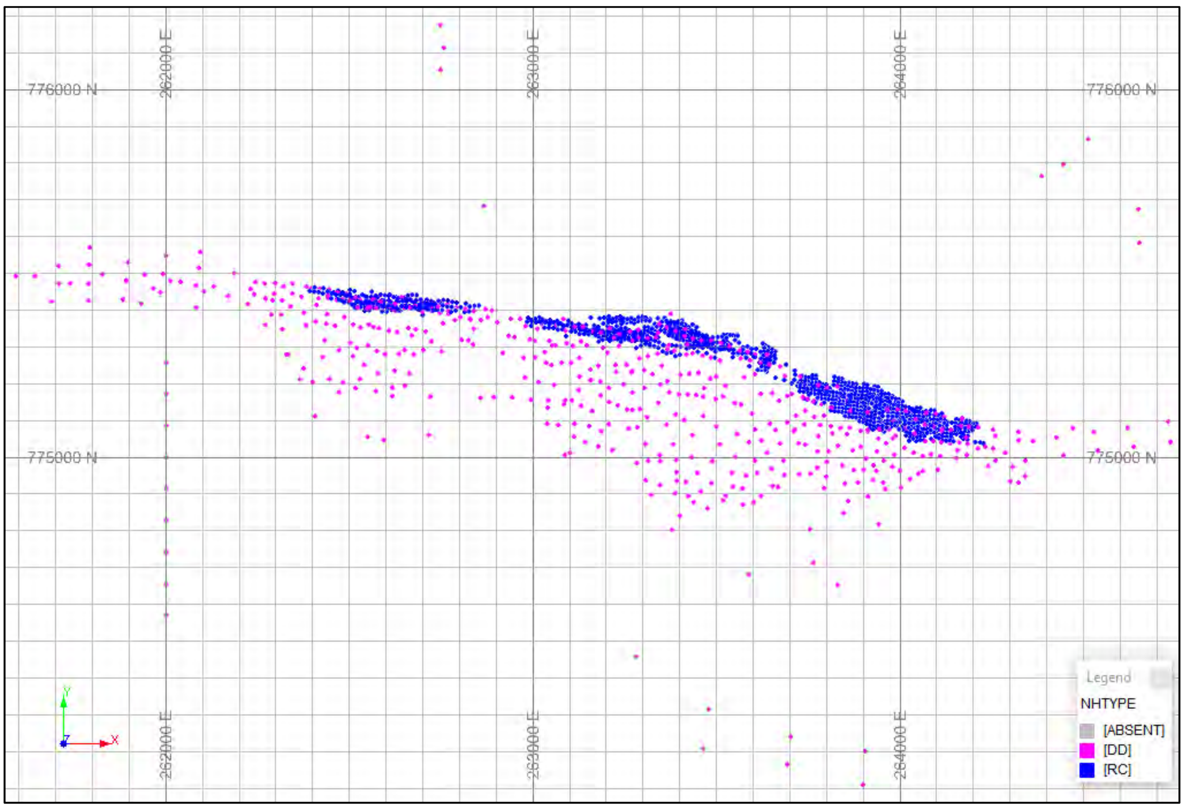


Figure 14-1: Plan view – New Liberty MRE drillhole locations
Source: CSA Global, 2018

Ndablama collar coordinates were originally surveyed with a Garmin handheld GPS, and subsequently picked up by a Sokia Total Station. The points were verified against the contour data and digital terrain model (DTM) obtained from the LIDAR survey carried out in early 2013. To date, all drillholes and collars have been surveyed and are well positioned relative to the LIDAR DTM.

A location plan for Ndablama drillholes used in the MRE, coloured by drillhole type (HTYPEN) is presented in Figure 14-2.

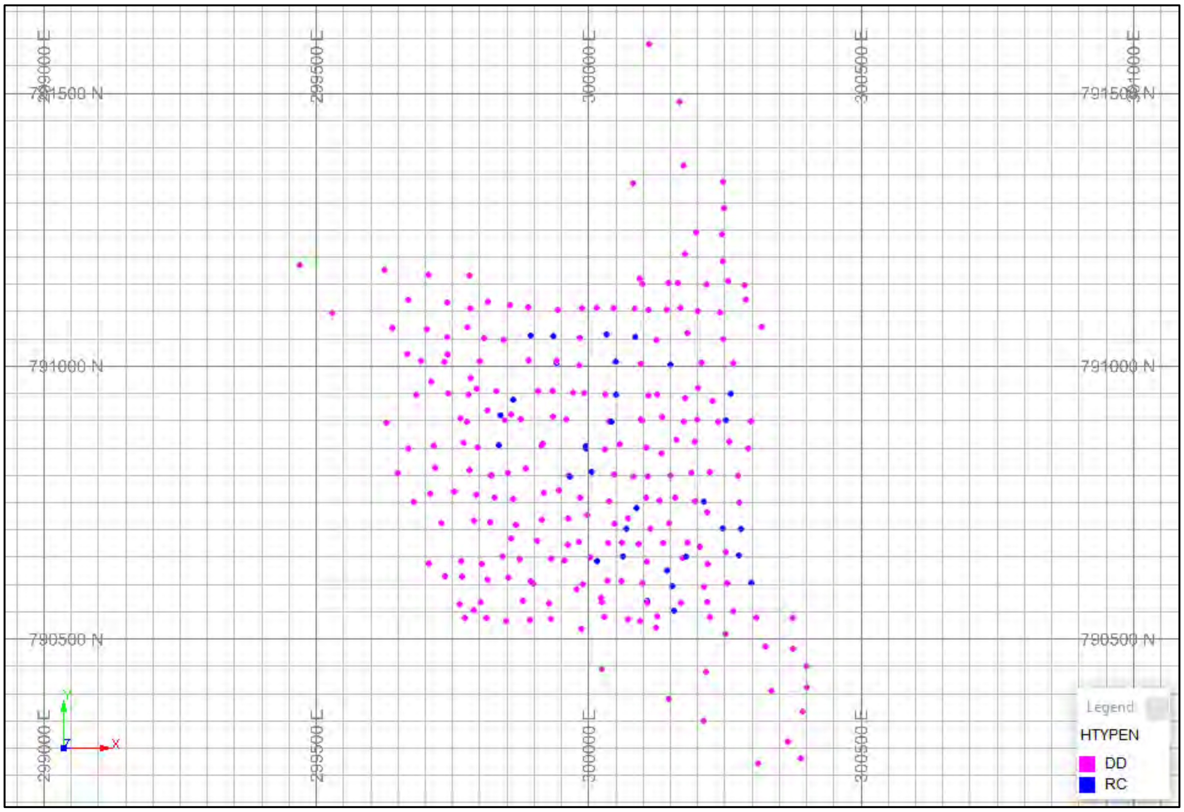


Figure 14-2: Plan view – Ndablama MRE drillhole locations
Source: CSA Global, 2018

14.1.3 Data Spacing and Orientation in Relation of Geological Structure

Diamond drilling within the New Liberty Resource area has been completed on sections which are generally between 25 to 40 m x 40 m apart, whereas RC drilling (for grade control) has generally been drilled on a 10 m x 10 m grid. The drilling was orientated normal to the plane of principal mineralisation ensuring the optimum angle of intersection.

Diamond drilling within the Ndablama Resource area has been completed on sections which are generally between 40–50 m x 50 m apart. The drilling was orientated perpendicular to the north-south strike of Ndablama (east) and at typical angles of inclination of 55–60° ensuring optimum angle of intersection to the shallow dipping mineralisation.

14.1.4 Data Import and Data Excluded

Data were provided in a Microsoft Access database and Microsoft Excel sheets. The drilling database used for the current New Liberty MRE was closed on 27 November 2018, and for the Ndablama MRE on 24 November 2018.

Data were loaded into an SQL database which has constraints and triggers, ensuring that only validated data were included in the database. During the validation process issues were highlighted and corrected where possible. Exports of the clean, verified data were provided to the resource geologists in CSV format for the MRE.

The list below includes the validation and checks completed:

- Collar table: Incorrect coordinates (not within known range), duplicate holes.
- Survey table: Duplicate entries, survey intervals past the specified maximum depth in the collar table, overlapping intervals, abnormal dips and azimuths.

- Geotechnical table: Overlapping intervals, missing collar data, negative widths, geotechnical results past the specified maximum depth in the collar table.
- Geology, sample and assay tables: Duplicate entries, lithological intervals past the specified maximum depth in the collar table, overlapping intervals, negative widths, missing collar data, missing intervals, correct logging codes, duplicated sample IDs, missing samples (assay results received, but no samples in database), missing analyses (incomplete or missing assay results).
- QA/QC material: A QA/QC report is generated in which results of the standards (CRMs), blanks and duplicates are reviewed (includes client QA/QC material and lab checks where applicable).

The absent assay values were left as absent during the data import, as these are lost or missing samples (as communicated by Avesoro). The negative Au values were set to half the detection limit to a value of 0.005 g/t Au for New Liberty. Since different assay analysis methods were used over the Ndablama campaigns, the negative Au values were set to half the detection limit to a value of 0.0025 g/t Au for pre-2018 assays, and 0.025 g/t Au for 2018 assays.

Following de-surveying, missing intervals were identified in the assays. These gaps were discussed with Avesoro, as well as reviewed by CSA Global, and identified as waste zones. As such, these intervals were also set to half the detection limit to a value of 0.005 g/t Au at New Liberty, and at Ndablama to a value of either 0.0025 g/t Au (pre-2018 assays) or 0.025 g/t Au (2018 assays).

The CSA Global data load validations for New Liberty, excluding channel data, showed the following:

- 58 DD collars with no assays
- 38 DD collars with no logged lithology
- 425 DD collars with no BD data (no BD measurements for RC samples)
- 336 DD collars with no recovery data
- 953 RC collars with no sample weights
- Five overlapping BD measurements
- Nine duplicated RC sample weights
- K616 had survey and geology data, but no collar or assay data.

For Ndablama, the CSA Global data import validations, showed the following:

- Two DD collars with no assays (geotechnical holes)
- Two DD collars with no logged lithology (geotechnical holes)
- 140 DD collars with no BD data (no BD measurements for RC samples)
- One overlapping structural measurement.

The appropriateness of data to be used in the New Liberty and Ndablama MREs were reviewed. Summaries of drill data removed prior to estimation are shown in Table 14-5 and Table 14-6 below.

Table 14-5: New Liberty – summary of drill data removed prior to estimation

BHID (excluded)	Reason for exclusion
CD006–CD012, CD020, CD042–CD045, K048, K050, K109–K114, K394, K396–K398, K401, K403, K406, K412, K414–K418, K420–K422, K444–K459, K464–K484, SOP009–SOP013, SOP015, SOP017–SOP019, SOP021, SOP022	Outside MRE area.
GC112, GCK040, GCL006, GCL067, GCL075, GCL078, GCL092, GCL101, GCL135, GCL142, GCM101	Re-drilled, where the re-drilled hole was used in the MRE.
GCM110B	Re-drilled hole, but original hole better honours the overall mineralisation in the area and was used in the MRE.
K546	Re-drilled – original hole has no assays.
HYD003, HYD004, K038, K044, K082, K123, K149, K181, K192, K193, K486, K488, K493, K494, MF001–MF004, SOP001–SOP008, SOP014, SOP016, SOP020, SPT001–SPT012	No assays.
GCM140, GCM619, GCM633, GCM646, K336	Twin holes of GCM433, GCM618, K099, GCM457, and K485, respectively.
K032, K034, K055, K367, K370, K372	Excluded by AMC (2013), however used by SRK (2017). Outside of mineralisation wireframes and exclusion has no impact on the MRE.
K004, K023, K070, K080, K084	Excluded by both AMC (2013) and SRK (2017). Low confidence in spatial positions and poor fit to surrounding mineralised drillholes.

Table 14-6: Ndablama – summary of drill data removed prior to estimation

BHID (excluded)	Reason for exclusion
NBDGT01, NBDGT02	Geotechnical holes with no assays.
NDD038, NDD058, NDD136, NDRC002, NDRC004–NDRC006	Twin holes of NDRC001, NDRC003, NDD060, NDD059, NDD039, NDD006 and NDD040, respectively.

Drillholes have been excluded from the MREs where there is potential bias in sample data, e.g. the grade bias in channel samples relative to RC and DD samples. Drillholes have also been rejected where they do not contain any assays, or proximity to twin holes, or feedback from client with respect to bias of data. The repeat/twin drillhole is generally selected unless it is a poor reflection of the surrounding geology (as observed from other nearby drillholes).

All subsequent data analysis, statistics and estimation for New Liberty and Ndablama are limited to the validated and selected datasets as used in the MREs.

14.1.5 Hole Type Analysis

Statistics were reviewed for the composited flagged drillhole data, by hole type to assess for bias in Au grade between the sample types.

At both New Liberty and Ndablama, there was no grade bias apparent between diamond drilling (DD) and RC within the modelled mineralisation wireframes (Table 14-7, Table 14-8, Figure 14-3 and Figure 14-4).

Table 14-7: New Liberty – grade statistics by hole type

Hole type	No. of samples	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
DD	6,437	0.005	102.00	2.83	5.42	1.91
RC	8,807	0.005	93.40	2.76	4.89	1.78

Table 14-8: Ndablama – grade statistics by hole type

Hole type	No. of samples	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
DD	9,275	0.005	112.00	0.85	3.73	4.40
RC	1,486	0.003	240.00	0.93	6.63	7.17

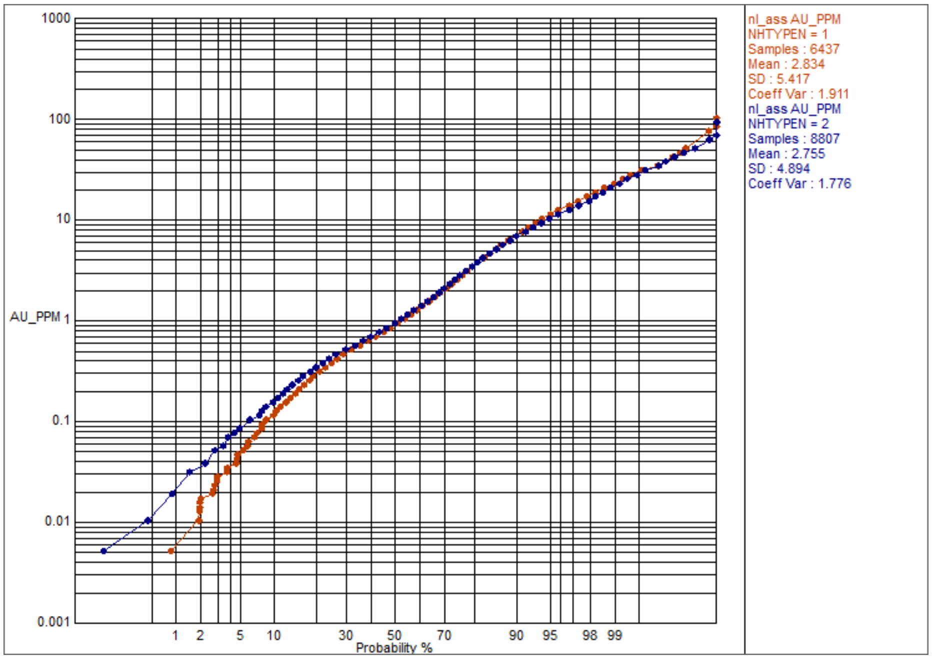


Figure 14-3: New Liberty – log probability plot, Au grouped by hole type (red = DD; blue = RC)
Source: CSA Global, 2018

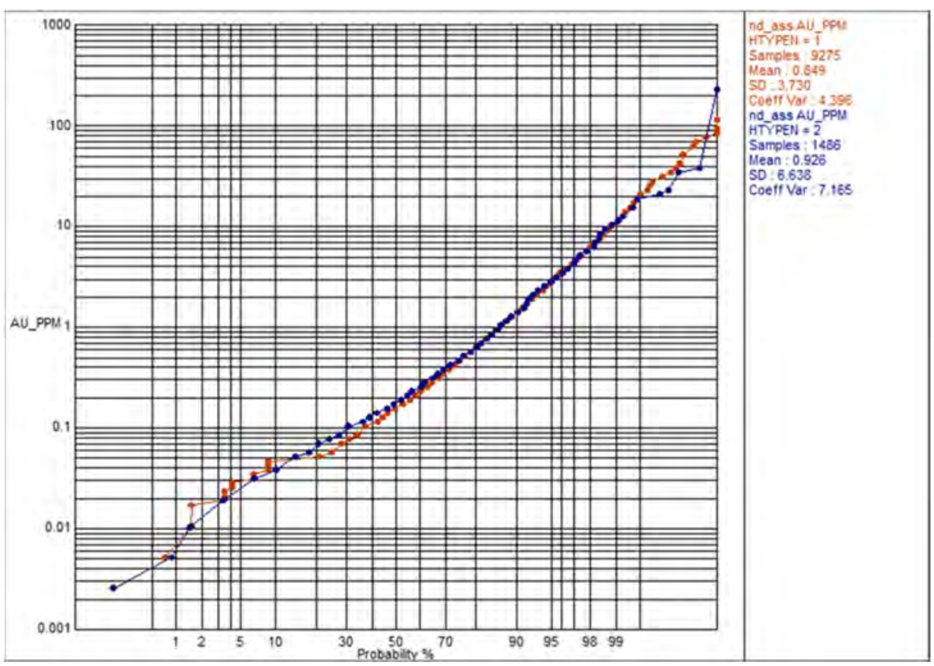


Figure 14-4: Ndablama – log probability plot, Au grouped by hole type (red = DD; blue = RC)
Source: CSA Global, 2018

14.1.6 Recovery

Core recoveries at New Liberty, within the modelled mineralisation wireframes, are good within fresh material (99%), with typically lower recoveries in the oxide (63%) (Table 14-9 and Figure 14-5).

At Ndablama, core recoveries within the modelled mineralisation wireframes, are reasonable within transitional material (79%) and good within fresh material (99%). Lower recoveries are recorded within the oxide (62%) (Table 14-10 and Figure 14-6).

Oxide material in DD core accounts for 2% of the recovery data within the New Liberty mineralisation wireframes, and for 3% of the recovery data within the Ndablama mineralisation wireframes.

A review of the recovery data at both New Liberty and Ndablama indicates that there is no relationship between grade and recovery in the DD data.

Table 14-9: New Liberty – recovery data grouped by weathering

Weathering	No. of samples	Minimum	Maximum	Mean	Standard deviation.	Coefficient of variation
Oxide	87	0	100.00	62.97	42.00	0.67
Fresh	5,436	0	100.00	98.59	6.28	0.06

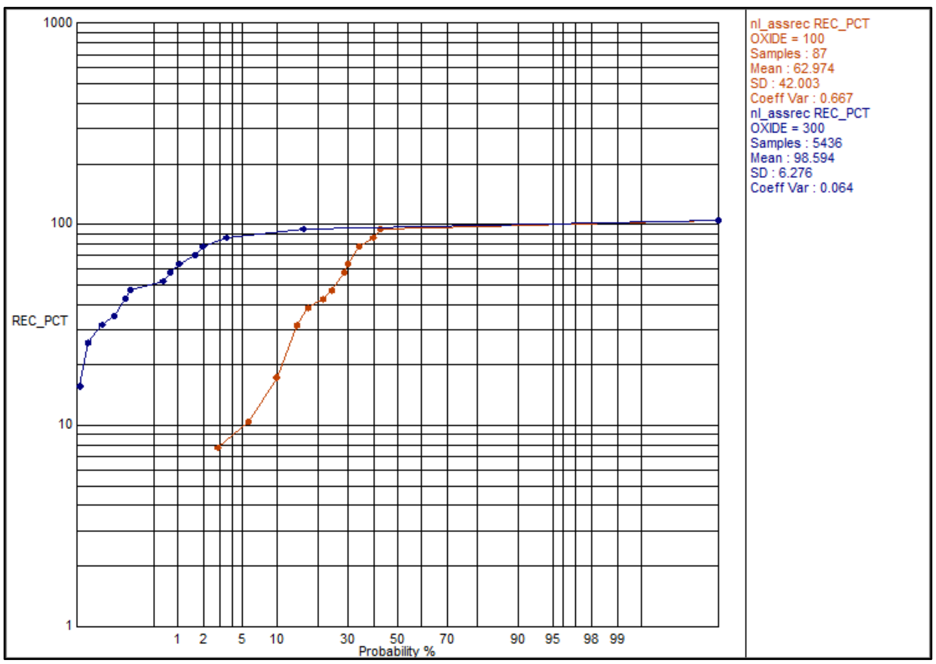


Figure 14-5: New Liberty – log probability plot, recoveries within the mineralisation domain, grouped by weathering (red = oxide; blue = fresh)
Source: CSA Global, 2018

Table 14-10: Ndablama – recovery data grouped by weathering

Weathering	No. of samples	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
Oxide	102	20.00	100	72.03	23.09	0.32
Transitional	80	3.33	100	80.50	25.22	0.31
Fresh	3,316	14.67	100	98.63	6.30	0.06

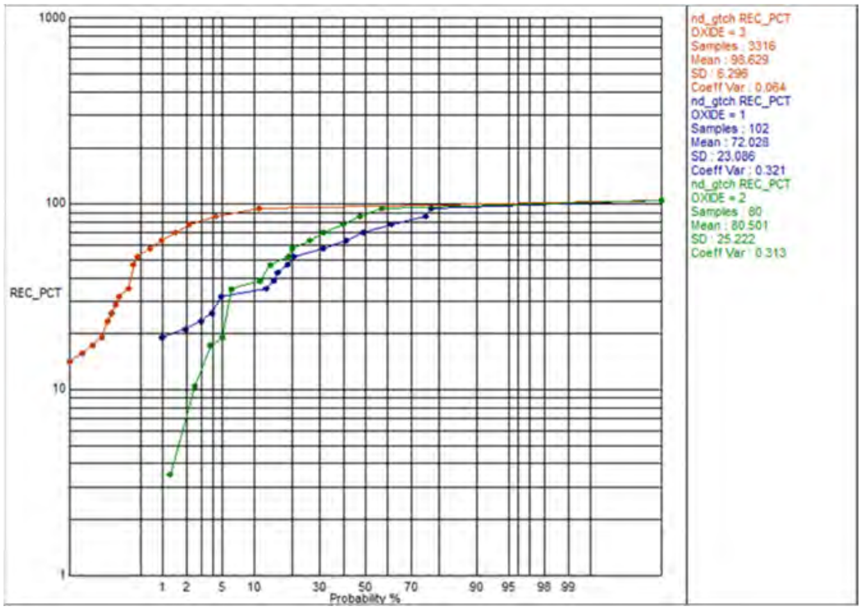


Figure 14-6: Ndablama – log probability plot, recoveries within the mineralisation domain, grouped by weathering (red = oxide; blue = transitional; green = fresh)

Source: CSA Global, 2018

14.2 Bulk Density

In-situ dry bulk density (BD) measurements for the New Liberty and Ndablama deposits were determined applying the "Archimedes" method (water displacement). The BD is calculated with the following formula:

$$\text{Bulk Density } = \frac{\text{Weight in air}}{\text{Weight in air } - \text{ Weight in water}}$$

A total of 14,112 BD measurements for New Liberty were supplied by Avesoro, of which five overlaps were removed during validation. Within the New Liberty MRE area, a total of 13,884 BD measurements were reviewed by CSA Global, coded by mineralisation domain, geology unit and oxidation.

There is no significant difference in BD between the mineralisation and waste domains. However, there is a difference in BD between oxidised and fresh material, and between the Silicified Metamorphic Ultrabasic Suite (SMUS) and the surrounding geology. The SMUS consists of the UMPT (phlogopite-chlorite-tremolite schist), UMTC (tremolite-chlorite–talc schist) and UMMT (magnetite-tremolite-chlorite schist), with a gneissic hanging wall and footwall.

Following statistical analysis, identified outliers were removed, depending on distribution, and the average BD applied per weathering profile and geological unit (Table 14-11, Figure 14-7 and Figure 14-8).

Table 14-11: New Liberty – Mineral Resource estimate in-situ dry bulk densities

Weathering profile	Geological unit	No. of samples	Bottom cut (t/m³)	Top-cut (t/m³)	BD used in MRE (t/m³)
Oxide	SMUS	238	1.0	2.5	1.58
	Other	196	1.0	2.2	1.40
Fresh	SMUS	8,754	2.5	3.3	2.95
	Other	4,541	2.5	3.3	2.83

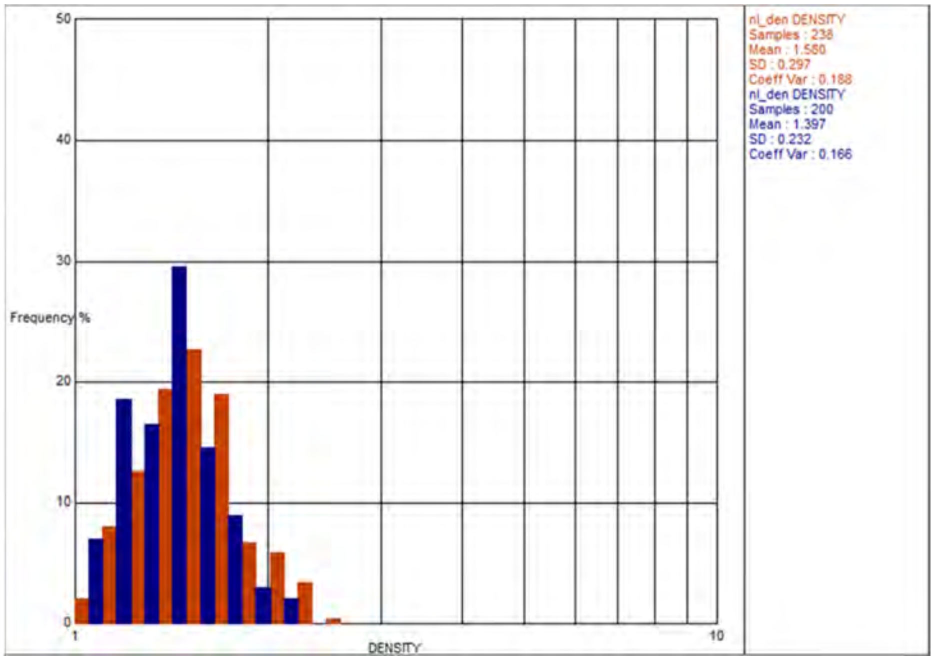


Figure 14-7: New Liberty – oxide material – histogram plot of cut BD per geological unit (red = SMUS; blue = Other)

Source: CSA Global, 2018

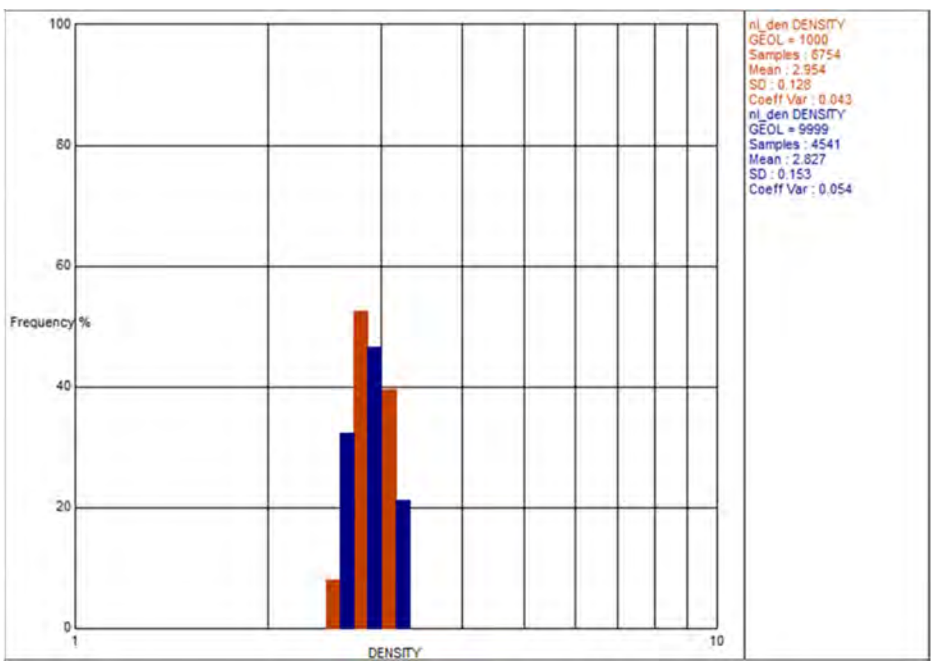


Figure 14-8: New Liberty – fresh material – histogram plot of cut BD per geological unit (red = SMUS; blue = Other)

Source: CSA Global, 2018

Within the Ndablama MRE area, a total of 8,148 BD measurements were supplied by Avesoro and reviewed by CSA Global, coded by mineralisation domain and oxidation.

There is no significant difference in BD between the mineralisation and waste domains. However, there is a difference in BD between oxidised and fresh material (Figure 14-9).

The general geology of Ndablama consist of mafics and ultramafic rocks. The mafic package consists of amphibolite schists and gneisses which envelope a series of ultramafic schists. The ultramafic rocks have been subdivided into magnetite-rich and magnetite-poor zones.

Following statistical analysis, identified outliers were removed, depending on distribution, and the average BD applied per weathering profile (Table 14-12).

Table 14-12: Ndablama – Mineral Resource estimate in-situ dry bulk densities

Domain	Weathering profile	No. of samples	Bottom cut (t/m³)	Top-cut (t/m³)	BD used in MRE (t/m³)
Mineralisation and Waste	Oxide	339	1.0	2.0	1.34
	Transitional	281	1.2	3.0	1.99
	Fresh	7,192	2.5	3.2	2.94

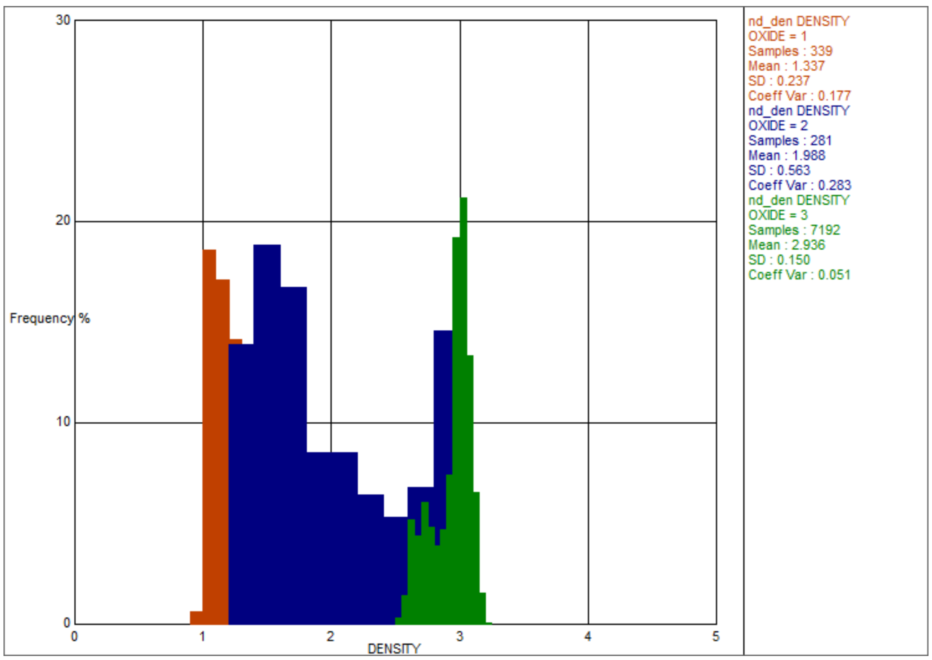


Figure 14-9: Ndablama – histogram plot of cut BD per oxidation states, combined mineralisation and waste domains (red = oxide; blue = transitional; green=fresh)

Source: CSA Global, 2018

14.3 Geological and Mineralisation Modelling

Geotechnical logging has recorded lithology, weathering and oxidation.

14.3.1 New Liberty

CSA Global geologists, in collaboration with Avesoro geologists, created a weathering surface (bottom of complete oxidation), and geology and mineralisation volumes for the New Liberty deposit using Leapfrog™ software. Structural wireframes have not been built due to lack of mapping data.

These interpretations were based on logged weathering/oxidation state, lithology type and chemical Au assays. The oxidation, weathering and lithology codes used for the construction of the weathering surface and the SMUS unit, respectively, are shown in Table 14-13, Table 14-14 and Table 14-15.

Table 14-13: New Liberty – logged oxidation codes

Oxidation code	Description
ox	Oxided
wk	Weakly oxidised
Fr	Fresh

Table 14-14: New Liberty – logged weathering codes

Weathering code	Description
cw	Completely weathered
pw	Partially weathered
sw	Slightly weathered
uw	Unweathered

Table 14-15: New Liberty – logged lithology codes

Lithology code	Description	Geology unit
es	Erosional saprolite	Oxide/Transitional units
esfe	Iron-rich saprolite "Lateritic nodules"	
esrk	Erosional saprock	
emz		
gnqf	Quartz-feldspathic banded leucocratic gneiss	Hanging Wall Basement Complex
gna/amp	Amphibolitic upper gneiss unit	
qul	Quartz rich layer in gnu (probable metasedimentary origin)	
gnb	Quartz-feldspathic-biotite gneiss	
gngp	Garnet phlogopite gneiss (covered under alteration)	
ummt	Magnetite-tremolite-chlorite schist	Silicified Metamorphosed Ultrabasic Suite ("SMUS")
umtc	Tremolite-chlorite–talc schist	
umpt	Phlogopite-chlorite-tremolite schist	
gnqf	Leucocratic lower gneiss unit	Footwall Basement Complex
gna	Amphibolitic lower gneiss unit	
qul	Quartz rich layer in gnl (probable metasedimentary origin)	
gnm	Leucocratic lower gneiss unit with significant microcline content	
gnqp	Quartz-phlogopite gneiss	
gns	Undefined gneiss	
grun	Undifferentiated granite	Syn- to late-tectonic aplites, pegmatites and granitoids
grpb	Phlogopite -biotite granite	
grsv	Granite with intense sulphide veins	
grbr	Quartz-orthoclase granite breccia	
grto	Tourmaline ± beryl granite, tourmaline and albite veins	
grmc	Microcline granite	
grtm	Tourmaline microcline granite	
qzv	Quartz vein	
peg	Pegmatite	
qms		
mig	Migmatite	
dol	Dolerite	
dio	Diorite	

An example cross section of the weathering profile is shown in Figure 14-10.

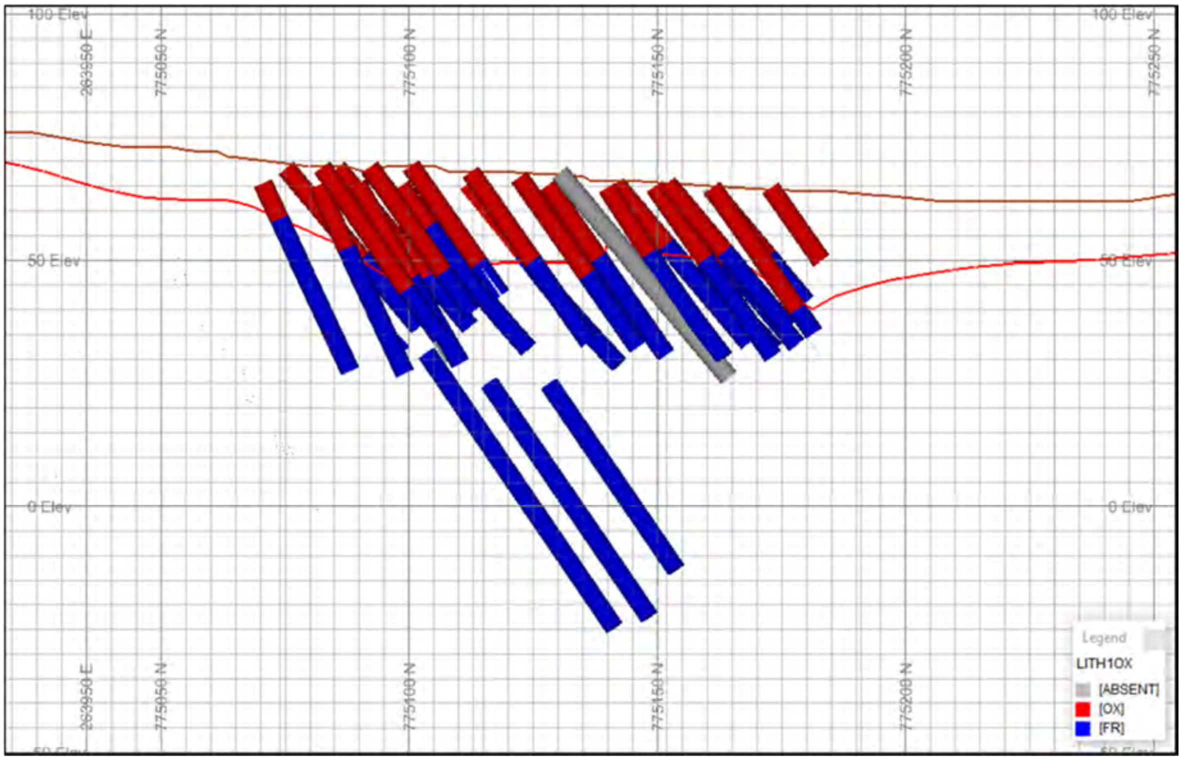


Figure 14-10: New Liberty – cross-section view of the weathering profile and drillholes
Section lines: Topography (brown); Bottom of Complete Oxidation (red),
Source: CSA Global, 2018

The mineralisation at the New Liberty deposit is predominantly hosted within the SMUS (Figure 14-11), which generally contains quartz, chlorite, amphibole, talc and mafic minerals and is strongly sheared. The gold mineralisation is also sometimes associated with sulphides, hosted in the metamorphosed ultrabasic rocks.

CSA Global reviewed the mineralisation continuity at various grade cut-offs by creating mineable intercepts, generated using Datamine Studio RM™'s CompSE grade compositing function. This generates grade composites on the basis of a minimum grade (0.3, 0.5, 0.8 and 1.0 g/t Au) and a minimum true thickness (3 m). This is useful in assessing the reasonableness of blocks above cut-offs. The results show good continuity of the mineralisation at a cut-off of 0.5 g/t Au with a minimum true thickness of 3 m.

All available drillhole and sampling data were used to inform the grade modelling (DD, RC, CH), with close-spaced CH (channel) data used for trend visualisation only.

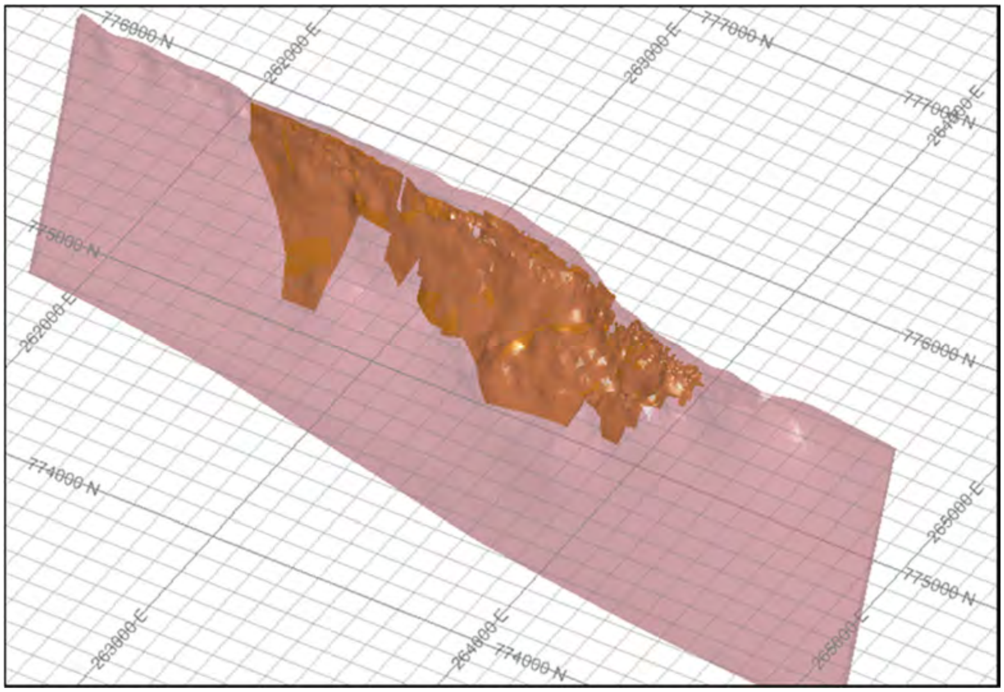


Figure 14-11: New Liberty – 3D view looking northwest, showing the mineralisation (orange) predominantly hosted within the SMUS (pink)
Source: CSA Global, 2018

The New Liberty deposit was subdivided into three areas along strike, namely Marvoe in the east, to Kinjor in the centre, and Larjor in the west (Figure 14-12). Within these three areas, 28 separate mineralisation wireframes were created – 17 within Marvoe, eight within Kinjor and three within Larjor.

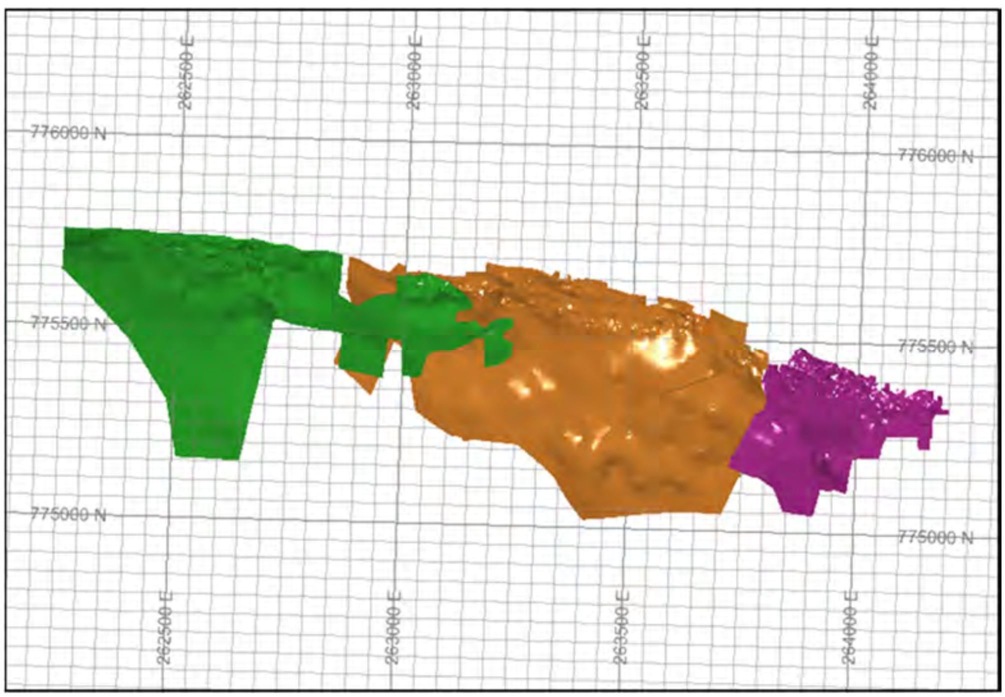


Figure 14-12: New Liberty – plan view of the mineralisation, subdivided into Marvoe (purple), Kinjor (orange) and Larjor (green)
Source: CSA Global, 2018

Wireframes were constructed where continuous mineralisation was defined in two or more drillholes. Mineralisation within single drillholes was not modelled. Mineralised wireframes were extended halfway between drilling, along strike and down dip, at the termination of mineralisation, or 100 m past the last mineralised drillhole at wider spacings.

Figure 14-13 to Figure 14-15 show examples of cross sections with interpreted mineralisation within these areas. The mined surfaces as at 31 December 2018 are also shown.

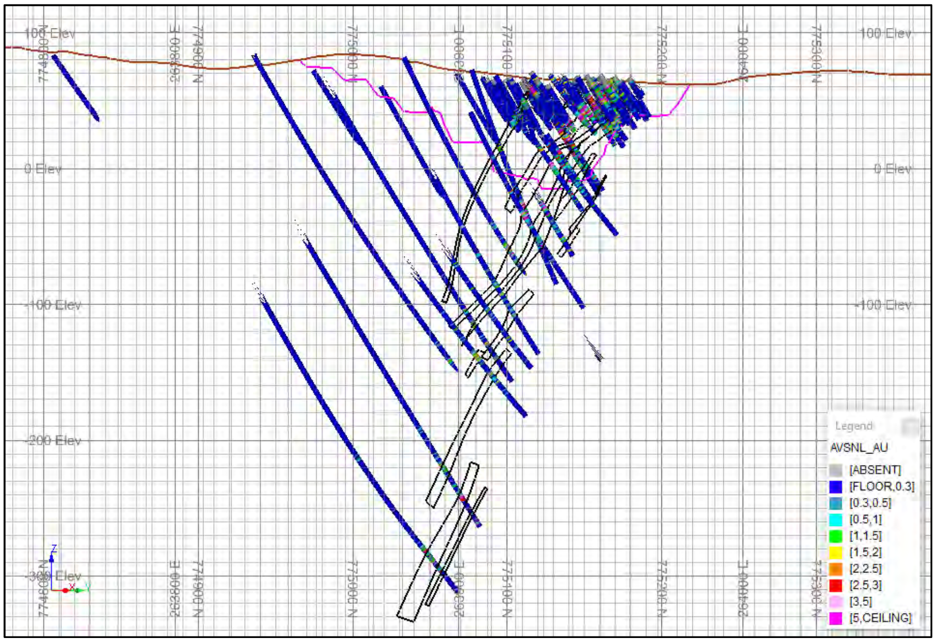


Figure 14-13: New Liberty – cross-section view of the Marvoe area mineralisation and drillholes

Section lines: Topography (brown); Mineralisation (black); Mined surface 31 December 2018 (pink).
Source: CSA Global, 2018

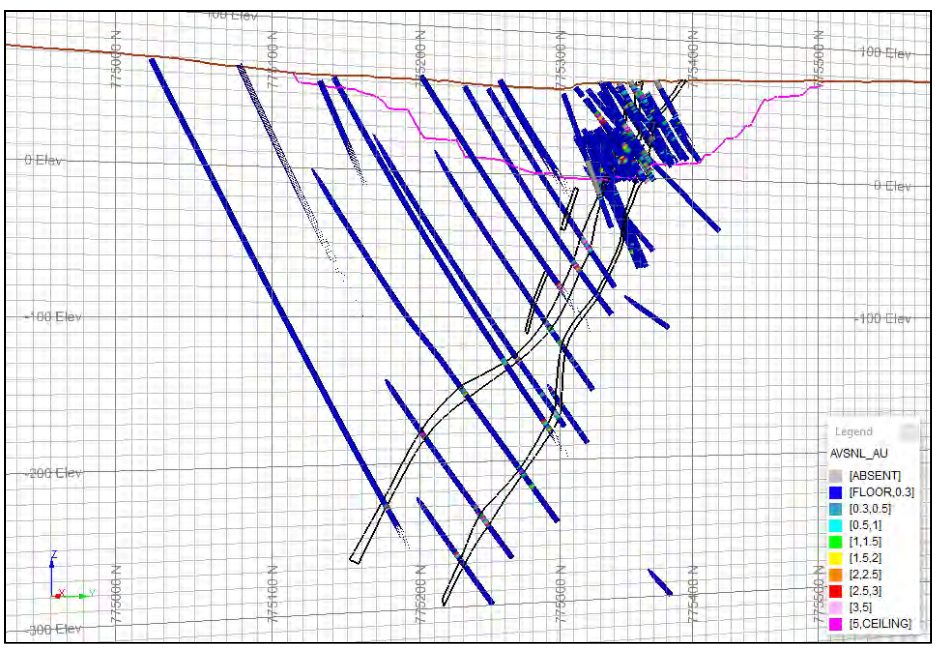


Figure 14-14: New Liberty – cross-section view of the Kinjor area mineralisation and drillholes

Section lines: Topography (brown); Mineralisation (black); Mined surface 31 December 2018 (pink).
Source: CSA Global, 2018

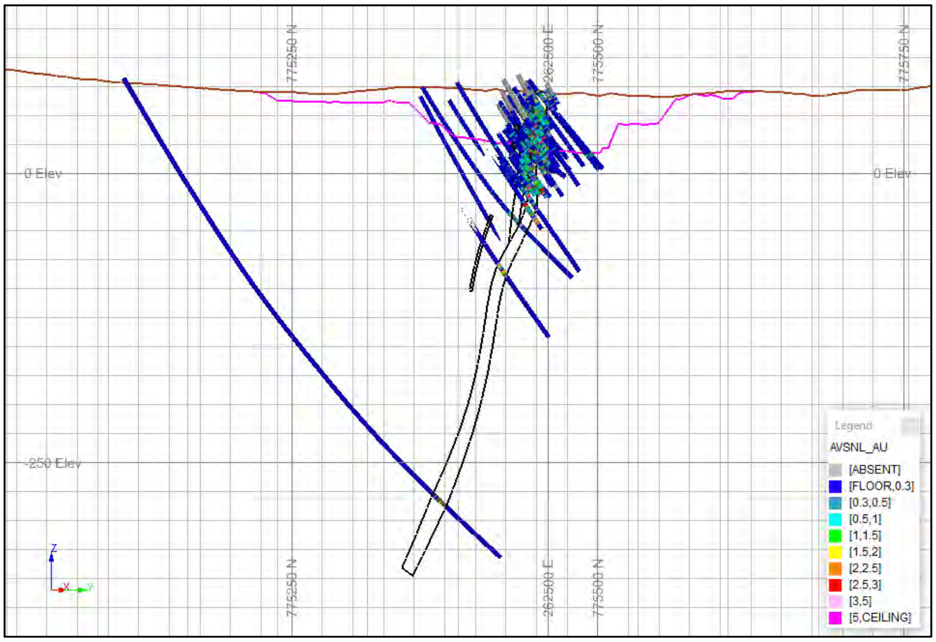


Figure 14-15: New Liberty – cross-section view of the Larjor area mineralisation and drillholes

Section lines: Topography (brown); Mineralisation (black); Mined surface 31 December 2018 (pink).
Source: CSA Global, 2018

14.3.2 Ndablama

CSA Global geologists, in collaboration with Avesoro geologists, created weathering surfaces (bottom of complete oxidation and top of fresh rock), and mineralisation volumes for the Ndablama deposit using Datamine StudioRM™ software. No geology or structural wireframes have been modelled.

These interpretations were based on logged weathering/oxidation state and chemical Au assays. The oxidation and weathering codes used for the construction of the weathering surfaces are shown in Table 14-16 and Table 14-17.

Table 14-16: Ndablama – logged oxidation codes

Oxidation Code	Description
ox	Oxidised
wk	Weakly oxidised
Fr	Fresh

Table 14-17: Ndablama – logged weathering codes

Weathering Code	Description
cw	Completely weathered
pw	Partially weathered
sw	Slightly weathered
Uw	Unweathered

An example cross-section of the weathering profile is shown in Figure 14-16.

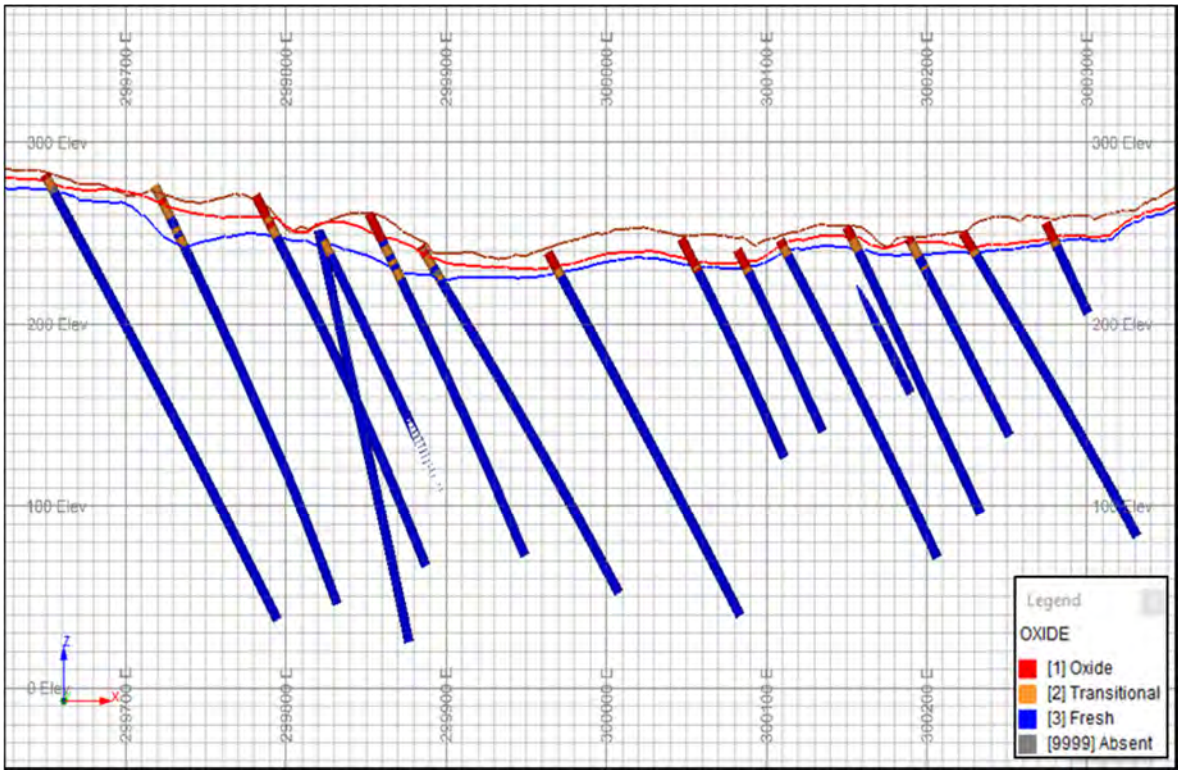


Figure 14-16: Ndablama – cross-section view of the weathering profile and drillholes

Section lines: Topography (brown); Bottom of Complete Oxidation (red); Top of Fresh (blue).
Source: CSA Global, 2018

The mineralisation at Ndablama is structurally controlled with multiple shears located either along ultramafic units or in close proximity to them. The main shear zone, previously interpreted by Aureus Mining Inc. (Aureus) from a combination of correlated drill intersections and inferred shear locations derived from mapping and other geological indicators (AMC, 2014) was modified by AMC and used as the basis for preparing mineralisation zone wireframes.

Since the previous MRE (AMC, 2014) additional infill and step-out drilling was completed at Ndablama. Mineralisation wireframes were updated, incorporating the new data and using CompSE composites of 0.1 g/t Au, with a minimum true thickness of 3 m, a vein dip of 30° and some internal dilution included.

The process of CompSE in Datamine StudioRM™ composites drillhole sample data to honour a defined minimum interval length at a defined minimum grade. The true thickness is calculated from the dip of the vein and the dip of the hole intersecting it. The minimum mining width is based on the practicality to mine with conventional open pit methods since the mineralisation outcrops on surface and the intent is to mine via open pit methods. The modelling of a lower cut-off grade is further based on the determined natural cut-off grade of Au, following review of log probability plots and histograms.

The orientation and strike of the previous wireframes, which honoured the geometry of the main shear zone (Aureus) were found to be robust based on the available data at the time of construction and were used as a guide. All available drillhole and sampling data were used to inform the grade modelling (DD, RC).

Wireframes were constructed where continuous mineralisation was defined in two or more drillholes. These wireframes were extended to halfway between drilling (to a maximum distance of 25 m), along strike and down dip, at the termination of mineralisation, or 50 m past the last mineralised drillhole at wider spacings.

Previously, two separate mineralisation domains were modelled (AMC, 2014). During the mineralisation update, with the inclusion of additional drill data, it was possible to identify and remove an internal waste interval that was previously included in the main mineralisation wireframe. As such, three separate mineralisation wireframes were created (Figure 14-17), with approximately 85% of the data captured in the main domain (MINZON = 10). Figure 14-18 shows an example cross sections with the interpreted mineralisation.

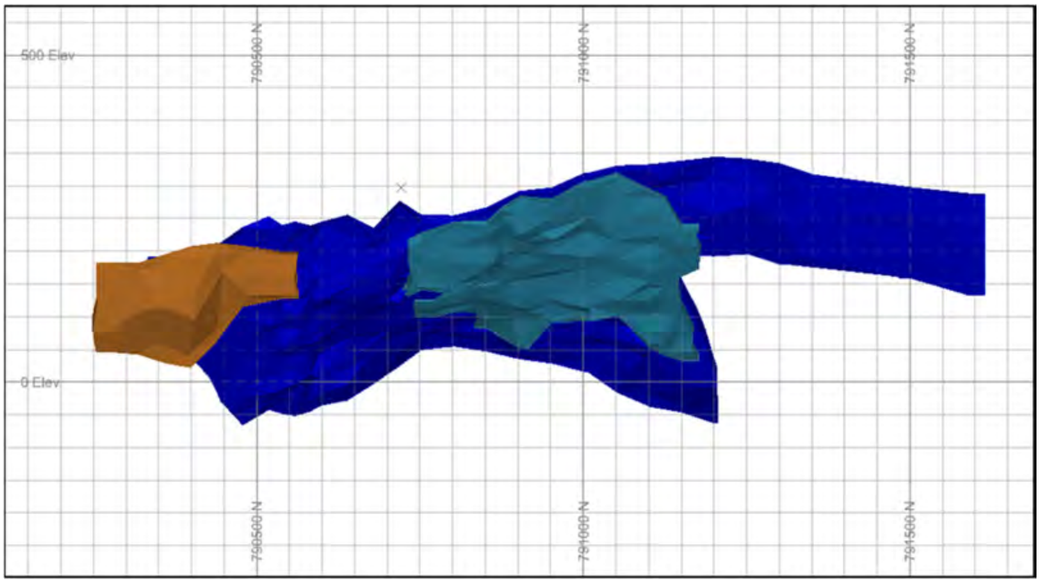


Figure 14-17: Ndablama – 3D view looking west – mineralisation domains (orange = MINZON 30, blue = MINZON 10, light blue = MINZON 20)
Source: CSA Global, 2018

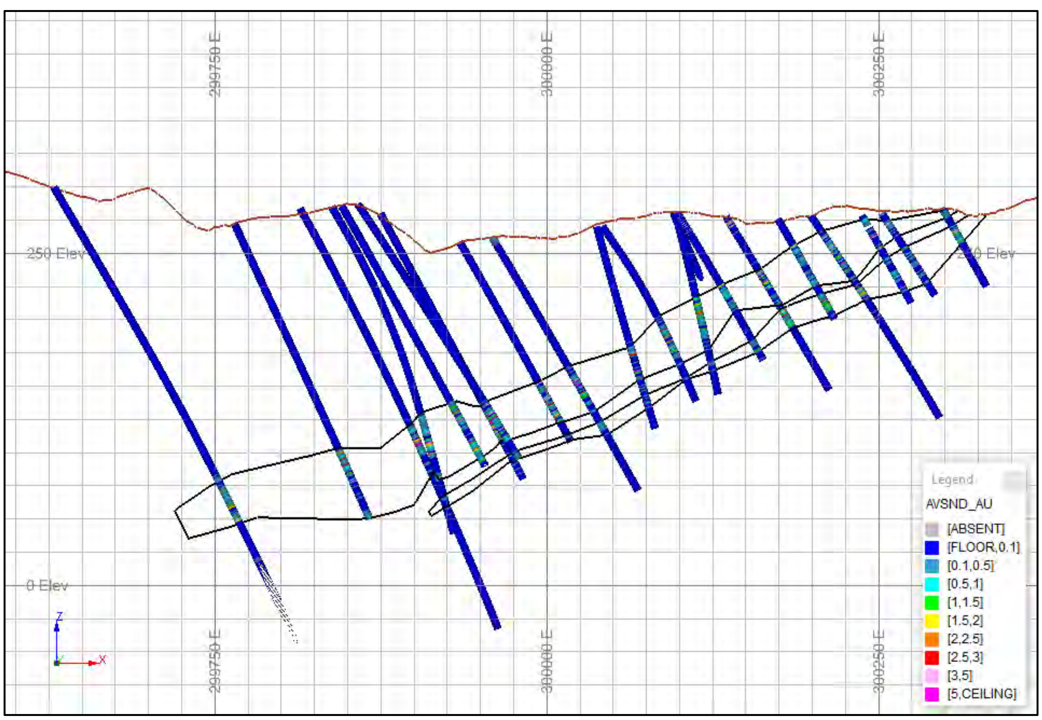


Figure 14-18: Ndablama - Cross section view of mineralisation wireframes and drillholes
Section lines: Topography (brown); Mineralisation (black).
Source: CSA Global, 2018

14.4 Statistical Analysis

Before undertaking the estimates, the data were first analysed to understand how best to conduct the estimates.

The statistical analysis was carried out by CSA Global using Datamine StudioRM™, Snowden Supervisor™ and GeoAccess Professional™ software packages.

14.4.1 Boundary Analysis

Boundaries are either classified as "hard" or "soft". Where hard boundaries are abrupt, they generally represent a sharp geological contact such as the edge of a quartz vein in its host rocks and where the boundary marks the margin of metal grade. A soft boundary is a gradational one and represents a gradual reduction in grade e.g. as one would find in the alteration zone of a copper porphyry system.

It is important to understand the nature of the boundaries between domains. If domain boundaries are gradational, then data from the adjacent domains should be used during estimation (soft boundary). If there are distinct grade boundaries, then estimation should be restricted to only use the data within that domain (hard boundary).

Contact analysis for Au g/t between the modelled mineralisation and waste were carried out to assess the nature of the domain boundaries by graphing the average grade with increasing distance from the domain boundary. The average grades can be calculated by incrementally expanding the wireframes or manually by coding the samples based on distance from the domain contact, as was done in this instance.

The contact analysis result for the New Liberty deposit are shown in Figure 14-19 and Figure 14-20. Based on the results of the boundary analysis between mineralisation and waste, the boundary was interpreted to be hard. The contact analysis between the weathering profiles (oxide vs. fresh) within the mineralised volumes showed soft boundaries.

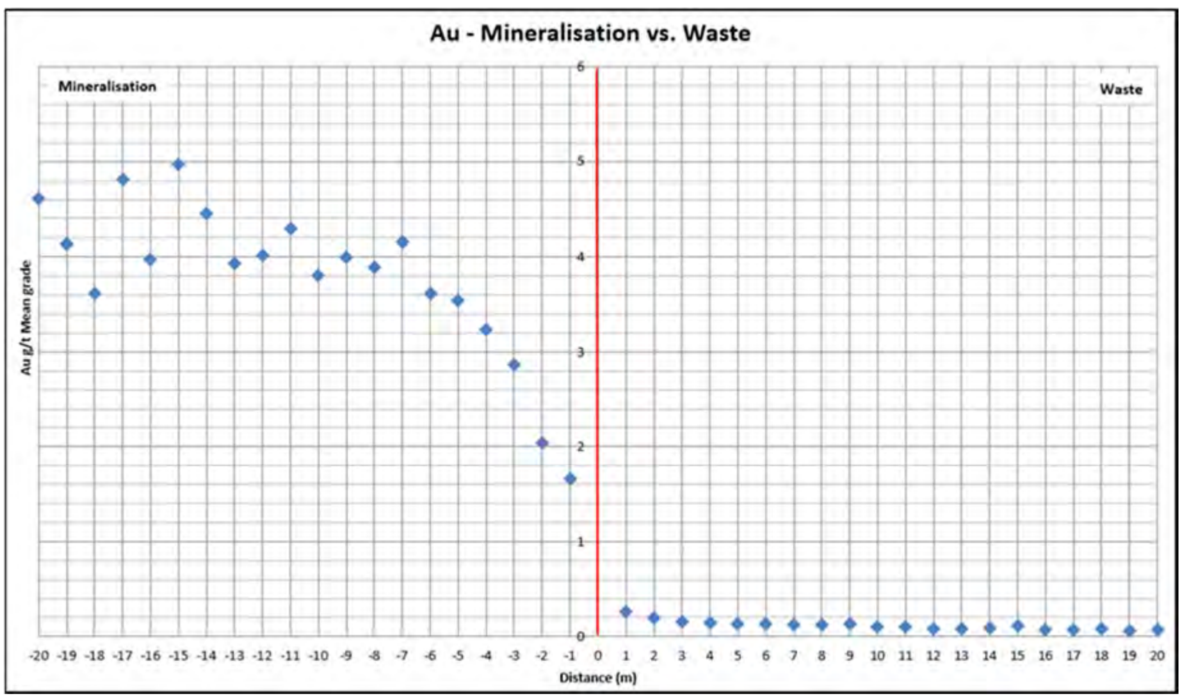


Figure 14-19: New Liberty – mineralised boundary test graph – Au g/t mineralisation vs waste
Source: CSA Global, 2018

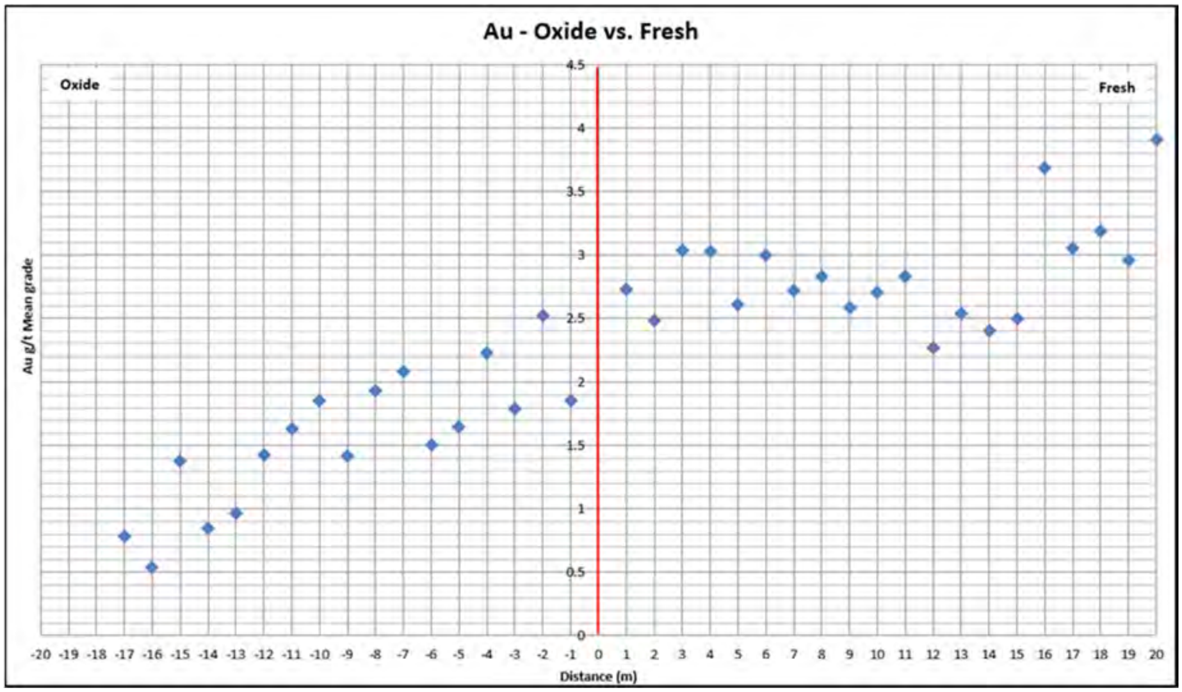


Figure 14-20: New Liberty – oxidation boundary test graph – Au g/t oxide vs fresh
Source: CSA Global, 2018

The contact analysis result for the Ndablama deposit is shown in Figure 14-21 to Figure 14-23. Based on the results of the boundary analysis between mineralisation and waste, the boundary was interpreted to be hard. The contact analysis between the weathering profiles (oxide vs transitional, and transitional vs fresh) within the mineralised volumes showed soft boundaries.

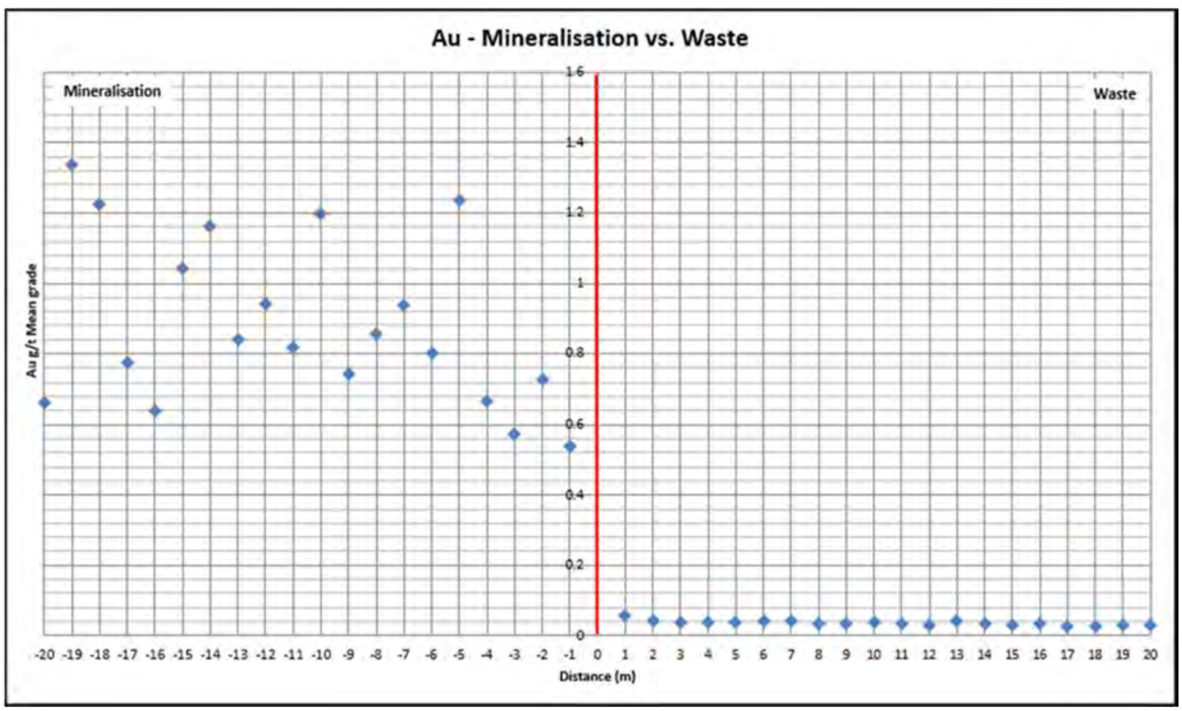


Figure 14-21: Ndablama – mineralised boundary test graph – Au g/t mineralisation vs waste
Source: CSA Global, 2018

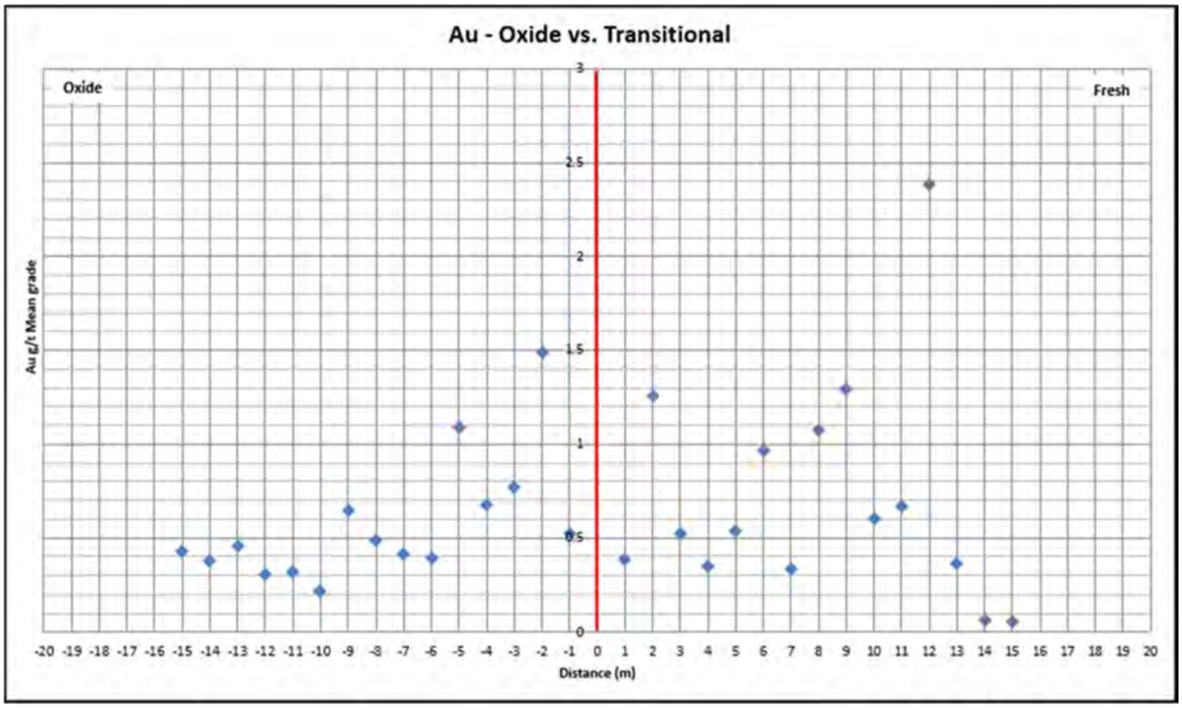


Figure 14-22: Ndablama – oxidation boundary test – Au g/t oxide vs transitional
Source: CSA Global, 2018

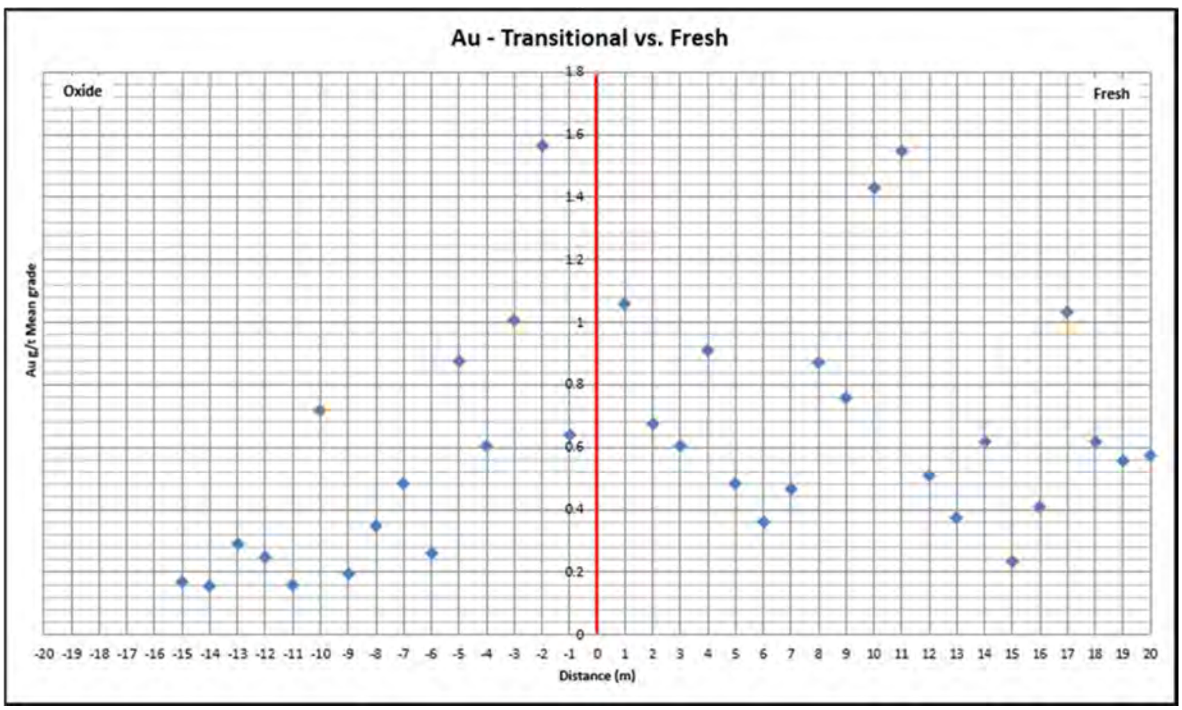


Figure 14-23: Ndablama – oxidation boundary test – Au g/t transitional vs fresh
Source: CSA Global, 2018

14.4.2 Naïve Statistics

Drillhole coding is a standard procedure which ensures that the correct samples are used in statistical and geostatistical analyses, and grade interpolation. The samples were coded by geological and mineralisation domains, and oxidation state.

Summaries of the domain codes, used to distinguish the data during geostatistical analysis and estimation, are shown in Table 14-18 and Table 14-19.

Table 14-18: New Liberty – data field flagging and description

Field	Code	Description
OXIDE	100 300	Oxide Fresh/Sulphide
MINZON	1 to 16 and 27 17 to 23 and 28 24 to 26 9999	Mineralisation in Marvoe area Mineralisation in Kinjor area Mineralisation in Larjor area Waste
DOMAIN	1 9999	Mineralisation Waste
GEOL	1000 9999	SMUS Other

Table 14-19: Ndablama – data field flagging and description

Field	Code	Description
OXIDE	1 2 3	Oxide Transitional Fresh
MINZON	10, 20, 30 9999	Mineralisation in Ndablama Waste
DOMAIN	1 9999	Mineralisation Waste

The mineralised domains for the New Liberty deposit were combined into a single domain and compared to the waste domain, as shown in Figure 14-24. The results for the Ndablama deposit combined mineralised domains compared to the waste domain, are shown in Figure 14-25.

There are some isolated high values within the waste domain; however, the waste sample population is clearly distinct from that of the mineralised domain.

There are some isolated high values within the respective waste domains; however, the waste sample populations are clearly distinct from that of the mineralised domains.

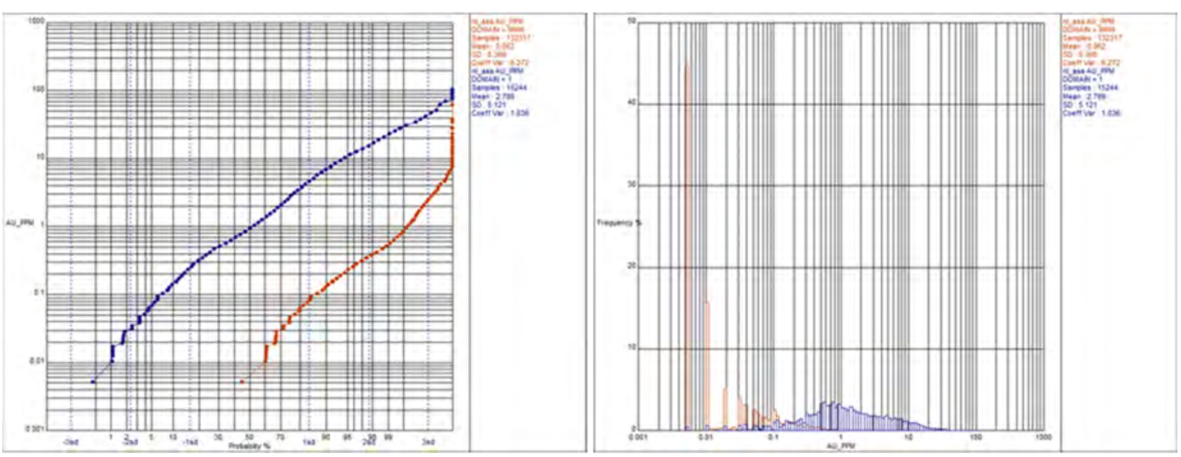


Figure 14-24: New Liberty – log probability (left) and log histogram (right) overlays of mineralisation (blue) vs waste (red)

Source: CSA Global, 2018

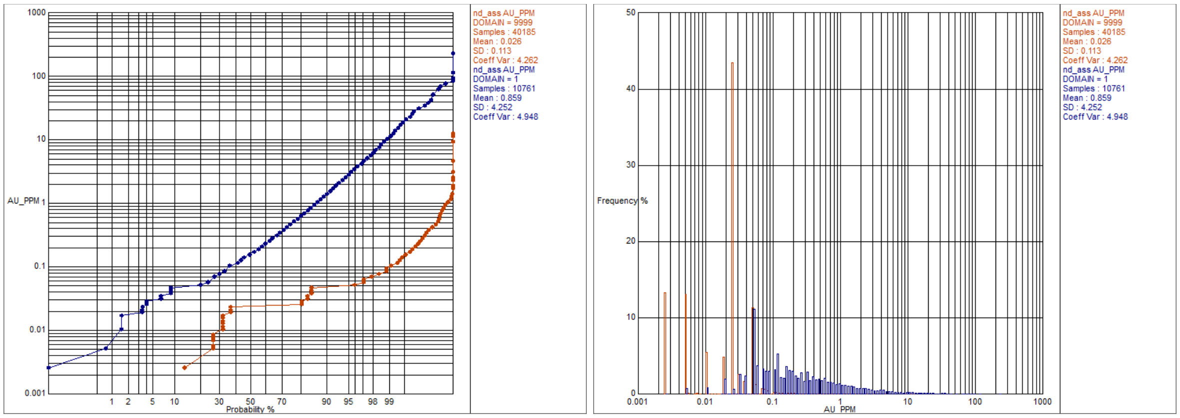


Figure 14-25: Ndablama – log probability (left) and log histogram (right) overlays of mineralisation (blue) vs waste (red)

Source: CSA Global, 2018

The naïve statistics, per MINZON, are given in Table 14-20. Based on visual review and geostatistical analysis, each individual MINZON per deposit show different grade populations and were estimated with hard boundaries.

Table 14-20: New Liberty and Ndablama – naïve statistics per MINZON

Deposit	MINZON	No. of samples	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
New Liberty	1	846	0.010	52.00	3.30	5.51	1.67
	2	509	0.020	34.82	1.81	2.93	1.62
	3	524	0.005	48.00	1.26	2.76	2.19
	4	198	0.060	25.92	1.55	2.89	1.87
	5	621	0.005	36.00	3.17	4.41	1.39
	6	69	0.040	11.00	1.27	1.82	1.43
	7	144	0.100	36.16	2.62	4.50	1.71
	8	40	0.060	17.44	1.68	3.02	1.80
	9	76	0.005	36.64	2.28	4.62	2.03
	10	216	0.040	20.48	2.04	2.79	1.37
	11	205	0.030	7.06	1.42	1.38	0.97
	12	118	0.013	31.20	1.51	3.35	2.22
	13	107	0.169	12.90	2.22	2.77	1.25
	14	152	0.020	12.71	0.92	1.39	1.51
	15	11	0.110	1.61	0.64	0.46	0.72
	16	362	0.020	86.40	2.51	6.91	2.75
	17	600	0.010	49.30	2.84	5.21	1.83
	18	169	0.030	9.91	0.75	1.18	1.57
	19	2,009	0.005	93.40	2.26	5.13	2.27
	20	124	0.005	8.12	0.89	1.61	1.81
	21	1,059	0.010	64.21	4.27	7.20	1.69
	22	98	0.005	8.82	0.96	1.70	1.76
	23	19	0.010	2.54	0.38	0.60	1.57
	24	3,188	0.005	102.00	3.45	5.44	1.58
	25	529	0.005	27.36	0.76	2.10	2.76
	26	443	0.030	8.36	0.89	0.95	1.07
	27	37	0.026	8.35	1.60	1.83	1.14
	28	2,771	0.005	81.31	3.61	5.64	1.56

Deposit	MINZON	No. of samples	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
Ndablama	10	9,246	0.005	240.00	0.93	4.55	4.91
	20	1,107	0.003	22.20	0.41	1.34	3.30
	30	408	0.005	15.60	0.56	1.49	2.65

14.4.3 Compositing

Sampling was undertaken at varying lengths within the New Liberty and Ndablama deposits. CSA Global reviewed all sample lengths within the modelled mineralisation envelopes of both deposits, respectively.

The dominant as well as the mean sample length within the mineralisation envelopes for New Liberty (Figure 14-26) and Ndablama (Figure 14-27) is 1 m, which was selected for compositing.

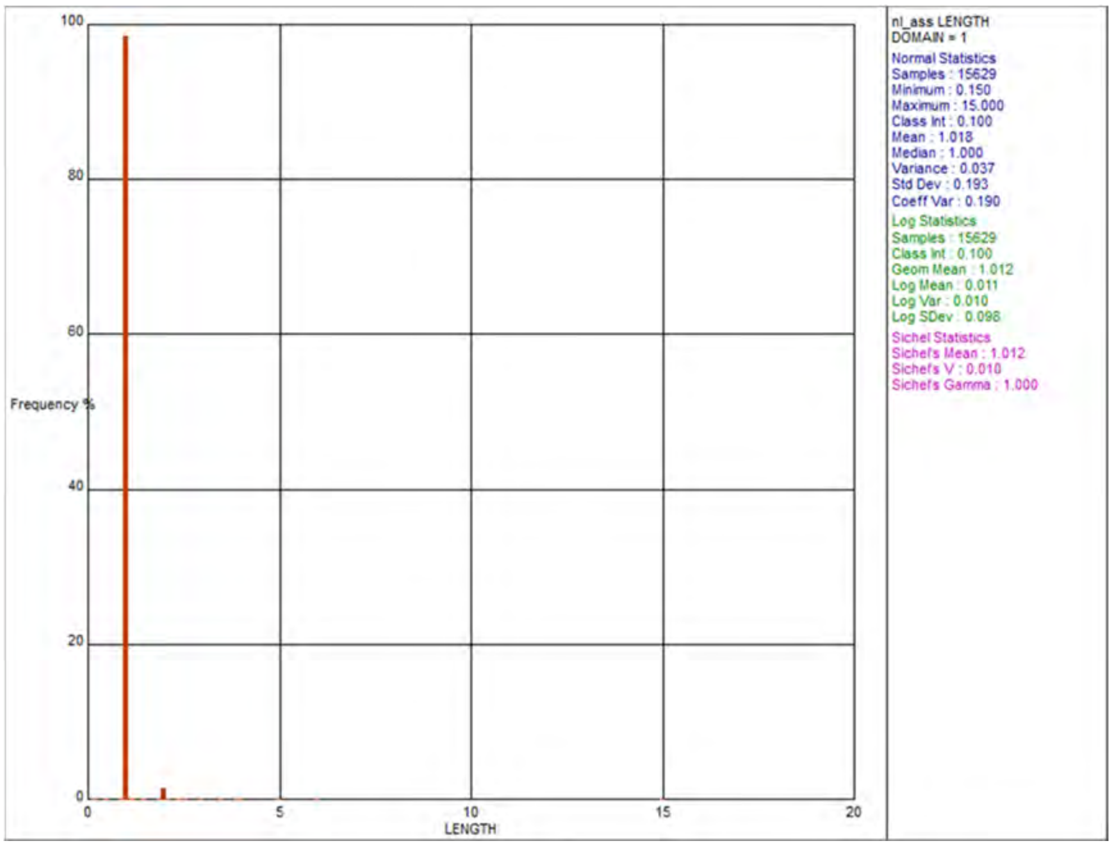


Figure 14-26: New Liberty – histogram sample lengths for mineralised domains
Source: CSA Global, 2018

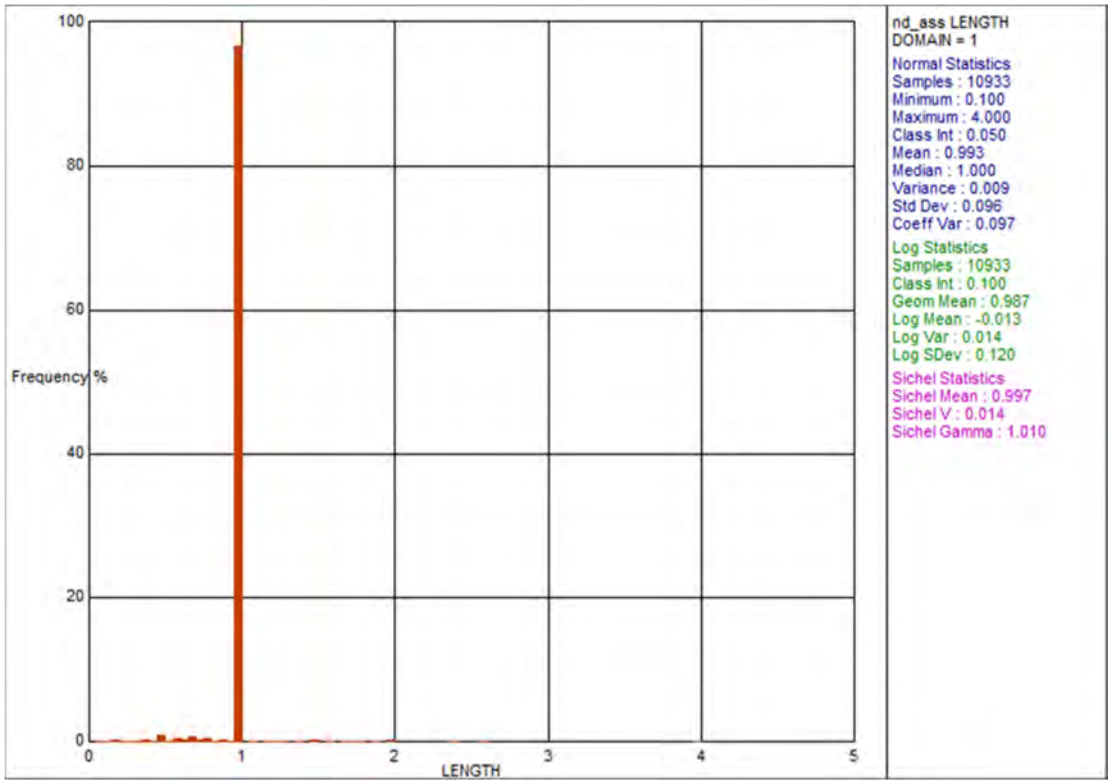


Figure 14-27: Ndablama – histogram sample lengths for mineralised domains
Source: CSA Global, 2018

During the compositing process in Datamine StudioRM™, the MODE parameter was set to 0. Setting MODE = 0 forces the composite length to equal the selected interval and part of samples may be excluded. The maximum composite length was defined by the INTERVAL parameter (1 m) and the minimum composite length by the MINCOMP parameter (0.5 m).

Assays that fall within the modelled mineralisation envelopes were downhole composited to 1 m prior to statistical review, top-cutting, variography and grade estimation.

Following compositing, two residuals (composites <0.5 m) were removed from the New Liberty data, from an original total of 15,922. Within the Ndablama data, seven residuals (composites <0.5 m) were removed, from an original total of 10,861. These residuals were thus excluded from the geostatistical analysis and the estimates. This will limit any potential bias in the sample support during kriging.

The descriptive analysis for the estimation domains (MINZON) is shown in Table 14-21.

Table 14-21: New Liberty and Ndablama – composite statistics per MINZON

Deposit	MINZON	No. of samples	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
New Liberty	1	846	0.010	52.00	3.30	5.51	1.67
	2	514	0.020	34.82	1.81	2.92	1.61
	3	530	0.005	48.00	1.26	2.75	2.19
	4	209	0.060	25.92	1.53	2.83	1.85
	5	663	0.005	36.00	3.19	4.37	1.37
	6	76	0.040	11.00	1.67	2.51	1.50
	7	150	0.100	36.16	2.67	4.58	1.71
	8	40	0.060	17.44	1.68	3.02	1.80
	9	76	0.005	36.64	2.28	4.62	2.03
	10	216	0.040	20.48	2.04	2.79	1.37

Deposit	MINZON	No. of samples	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
	11	205	0.030	7.06	1.42	1.38	0.97
	12	118	0.013	31.20	1.51	3.35	2.22
	13	107	0.169	12.90	2.22	2.77	1.25
	14	155	0.020	12.71	0.93	1.38	1.49
	15	11	0.110	1.61	0.64	0.46	0.72
	16	362	0.020	86.40	2.51	6.91	2.75
	17	604	0.010	49.30	2.83	5.20	1.84
	18	172	0.030	9.91	0.75	1.17	1.57
	19	2,053	0.005	93.40	2.22	5.08	2.29
	20	128	0.005	8.12	0.87	1.60	1.84
	21	1,060	0.010	64.21	4.27	7.20	1.69
	22	98	0.005	8.82	0.96	1.70	1.76
	23	19	0.010	2.54	0.38	0.60	1.57
	24	3,262	0.005	102.00	3.46	5.43	1.57
	25	544	0.005	27.36	0.78	2.14	2.75
	26	455	0.030	8.36	0.90	0.97	1.08
	27	37	0.026	8.35	1.60	1.83	1.14
	28	2,806	0.005	81.31	3.62	5.64	1.56
Ndablama	10	9,201	0.005	240.00	0.93	4.55	4.91
	20	1,105	0.003	22.20	0.41	1.34	3.29
	30	407	0.005	15.60	0.56	1.46	2.63

14.4.4 Top-Cut Analysis

Grade-cutting (top-cutting) is generally applied to data used for grade estimation in order to reduce the local high grading effect of anomalous high-grade samples in the grade estimate. In cases where individual samples would unduly influence the values of surrounding model cells, without the support of other high-grade samples, top-cuts are applied. These top-cuts are quantified according to the statistical distribution of the sample population.

Cutting strategy was applied based on the following:

- Skewness of the data
- Probability plots
- Spatial position of extreme grades

Histograms and probability plots were reviewed for Au g/t within each individual estimation domain to determine the top-cut.

14.4.4.1 New Liberty

Log histogram plots for the New Liberty uncut and top-cut Au g/t within the combined mineralisation domains are shown in Figure 14-28. The associated uncut and top-cut statistics per estimation domain for New Liberty are shown in Table 14-22. Composites greater than the top-cut values were reset to the respective top-cut values.

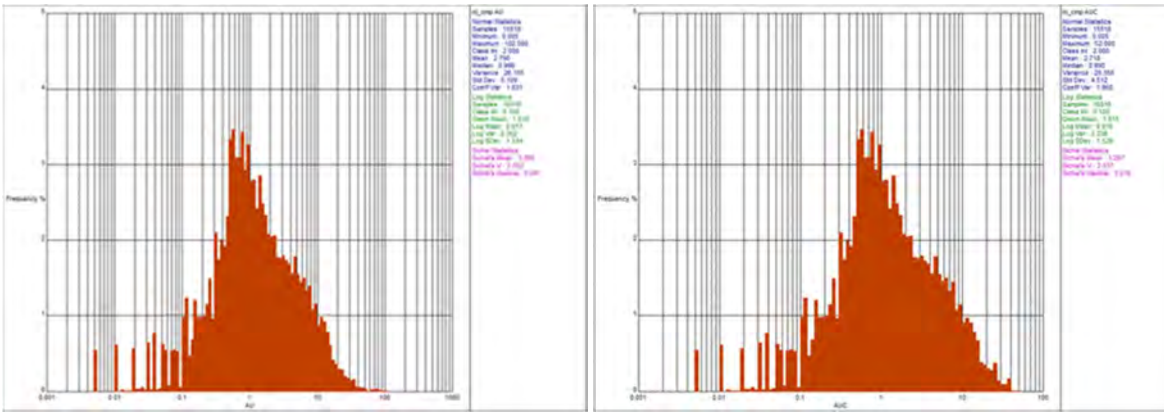


Figure 14-28: New Liberty – 1 m Au composite grades in combined mineralised domains; log histogram uncut (left) and top-cut (right)
Source: CSA Global, 2018

Table 14-22: New Liberty – top-cut statistics per MINZON

MINZON	Top-cut	No. of samples	No. of samples cut	Uncut mean	Cut mean	% metal cut	Uncut standard deviation	Cut standard deviation	Uncut coefficient of variation	Cut coefficient of variation
1	None	846	-	3.30	3.30	0%	5.51	5.51	1.67	1.67
2	20	514	1	1.81	1.78	-2%	2.92	2.66	1.61	1.49
3	10	530	3	1.26	1.14	-9%	2.75	1.42	2.19	1.25
4	20	209	1	1.53	1.50	-2%	2.83	2.61	1.85	1.73
5	25	663	4	3.19	3.15	-1%	4.37	4.09	1.37	1.30
6	None	76	-	1.67	1.67	0%	2.51	2.51	1.50	1.50
7	15	150	5	2.67	2.43	-9%	4.58	3.37	1.71	1.39
8	10	40	1	1.68	1.49	-11%	3.02	2.11	1.80	1.42
9	15	76	1	2.28	2.00	-12%	4.62	2.77	2.03	1.39
10	15	216	2	2.04	1.99	-2%	2.79	2.53	1.37	1.27
11	None	205	-	1.42	1.42	0%	1.38	1.38	0.97	0.97
12	15	118	2	1.51	1.36	-10%	3.35	2.18	2.22	1.61
13	None	107	-	2.22	2.22	0%	2.77	2.77	1.25	1.25
14	None	155	-	0.93	0.93	0%	1.38	1.38	1.49	1.49
15	None	11	-	0.64	0.64	0%	0.46	0.46	0.72	0.72
16	25	362	4	2.51	2.14	-15%	6.91	3.62	2.75	1.69
17	25	604	7	2.83	2.71	-4%	5.20	4.42	1.84	1.63
18	None	172	-	0.75	0.75	0%	1.17	1.17	1.57	1.57
19	25	2,053	16	2.22	2.09	-6%	5.08	3.89	2.29	1.86
20	None	128	-	0.87	0.87	0%	1.60	1.60	1.84	1.84
21	40	1,060	4	4.27	4.22	-1%	7.20	6.87	1.69	1.63
22	None	98	-	0.96	0.96	0%	1.70	1.70	1.76	1.76
23	None	19	-	0.38	0.38	0%	0.60	0.60	1.57	1.57
24	40	3,262	8	3.46	3.41	-2%	5.43	4.84	1.57	1.42
25	8	544	7	0.78	0.67	-14%	2.14	1.23	2.75	1.84
26	None	455	-	0.90	0.90	0%	0.97	0.97	1.08	1.08
27	6	37	2	1.60	1.51	-6%	1.83	1.51	1.14	1.00
28	40	2,806	6	3.62	3.57	-1%	5.64	5.15	1.56	1.44

14.4.4.2 Ndablama

Within the Ndablama dataset, the Au grade distribution of the 1 m composites is typical of highly skewed precious metals distributions, with a coefficient of variation (CV) equal to 4.91 for MINZON = 10, 3.29 for MINZON = 20, and 2.63 for MINZON = 30. The CV characterises the intrinsic level of variability of the distribution.

The shape of the histogram (Figure 14-29) of the data within MINZON = 10 is characterised by a narrow unimodal core of values (50% of values are lower than 0.2 g/t and 80% lower than 0.7 g/t) and a very long tail of high values: 10% of the values are greater than 1.5 g/t (and contain 70% of the metal). The maximum value of 240 g/t is 250 times the mean value of the distribution. This causes a problem for estimation with a clear risk of the tail of high values smearing out into under-sampled areas or being swamped by the background values in well-sampled areas.

MINZONs 20 and 30 also show a tail of high values (Figure 14-30); however, they are not as pronounced as in MINZON = 10.

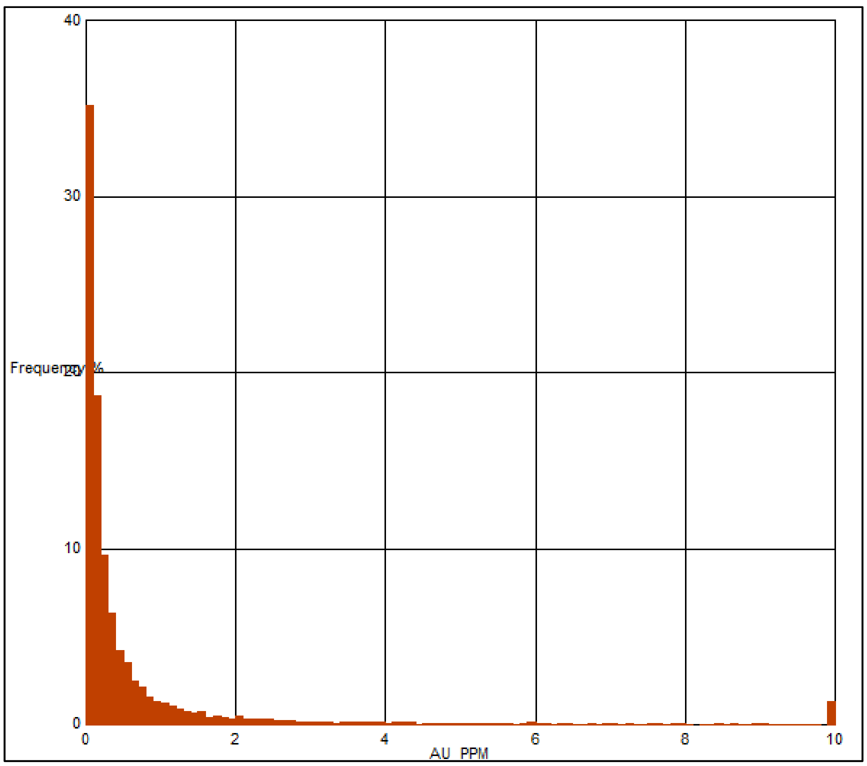


Figure 14-29: Ndablama – histogram of 1 m Au composite grades in MINZON = 10 (data top-cut to 10 g/t Au for display purposes)

Source: CSA Global, 2018

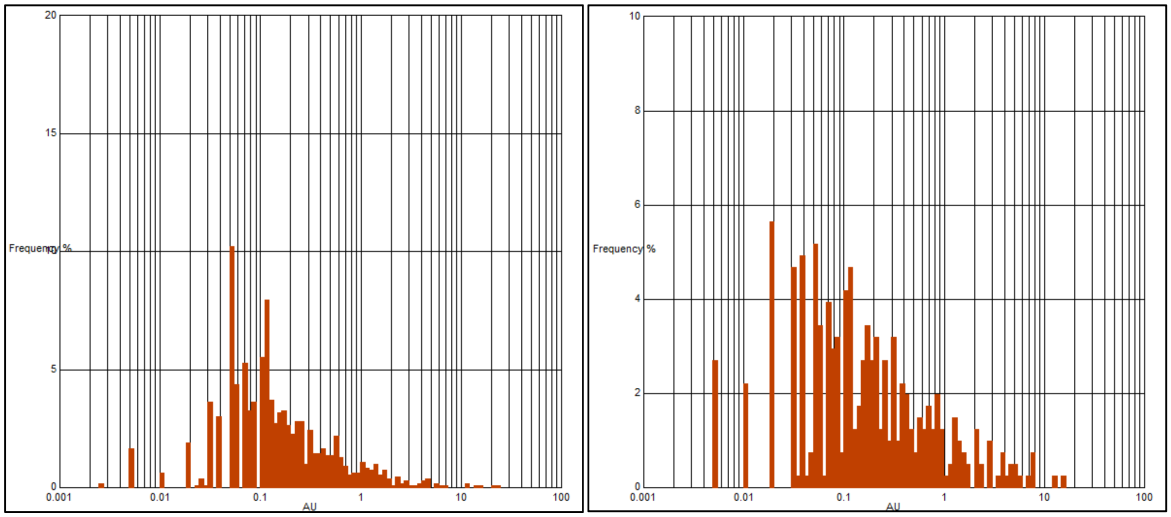


Figure 14-30: Ndablama – histogram of 1 m Au composite grades in MINZON 20 (left) and MINZON 30 (right)
Source: CSA Global, 2018

Top-cutting is not considered the best approach in this instance, since too large a percentage of the metal will be cut and is not representative of the grade distribution. Mitigation strategies on how to conduct an MRE which will best honour the input data grade distribution were considered, namely:

- Compositing
- Wireframing internal high-grade (HG) material
- Considering a method that captures the binary (one mode and one tail) nature of the distribution.

These are reviewed and discussed in more detail in Section 14.5.4.

14.4.5 Variography

Variography (spatial analysis) is carried out to understand how sample values relate to each other in space, and thus reflects the average spatial continuity for a local variable. The variogram is used to determine the weight to apply to each sample during kriging estimation and takes into consideration the average spatial characteristics of the underlying grade distribution. It can help to infer possible similarities between known samples and points that have not been sampled.

14.4.5.1 New Liberty

The variograms for Au g/t were modelled on top-cut 1.0 m composites within subsets of the estimation domains, as follows, MINZON = 1 (Marvoe – used in estimation of domains 1–6; 8–15; and 27), MINZON = 7 (Marvoe), MINZON = 16 (Marvoe), MINZON = 17 (Kinjor), MINZON = 19 (Kinjor – used in estimation of domains 18–23), MINZON = 24 (Larjor – used in estimation of domains 24–26), and MINZON = 28 (Kinjor).

Nuggets were obtained from the downhole variograms, where the lag was set equal to the composite length of 1.0 m. Normal scores transform was used for modelling the variograms. The semi-variograms were well structured, with moderate to high nuggets and moderate to long ranges. The variograms were back-transformed prior to estimation and examples are presented in Figure 14-31 to Figure 14-33. The variogram parameters are detailed in Table 14-23.

Dynamic anisotropy was used during estimation to allow the rotation angles for variograms to be defined individually for each cell in the models, so that the variogram orientation is aligned with the axes of mineralisation.

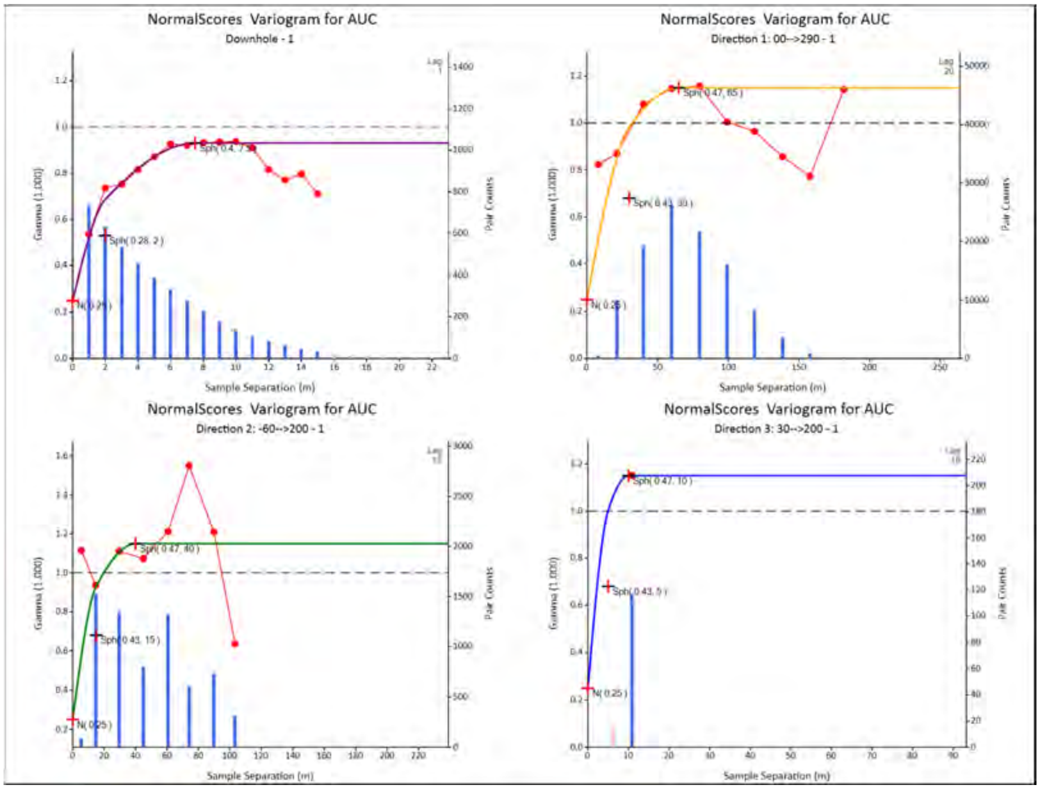


Figure 14-31: New Liberty – Marvoe area variogram (VREFNUM = 1) modelled on MINZON = 1

Note: Used for Au g/t estimation within MINZONs 1–6, 8–15 and 27.
Source: CSA Global, 2018

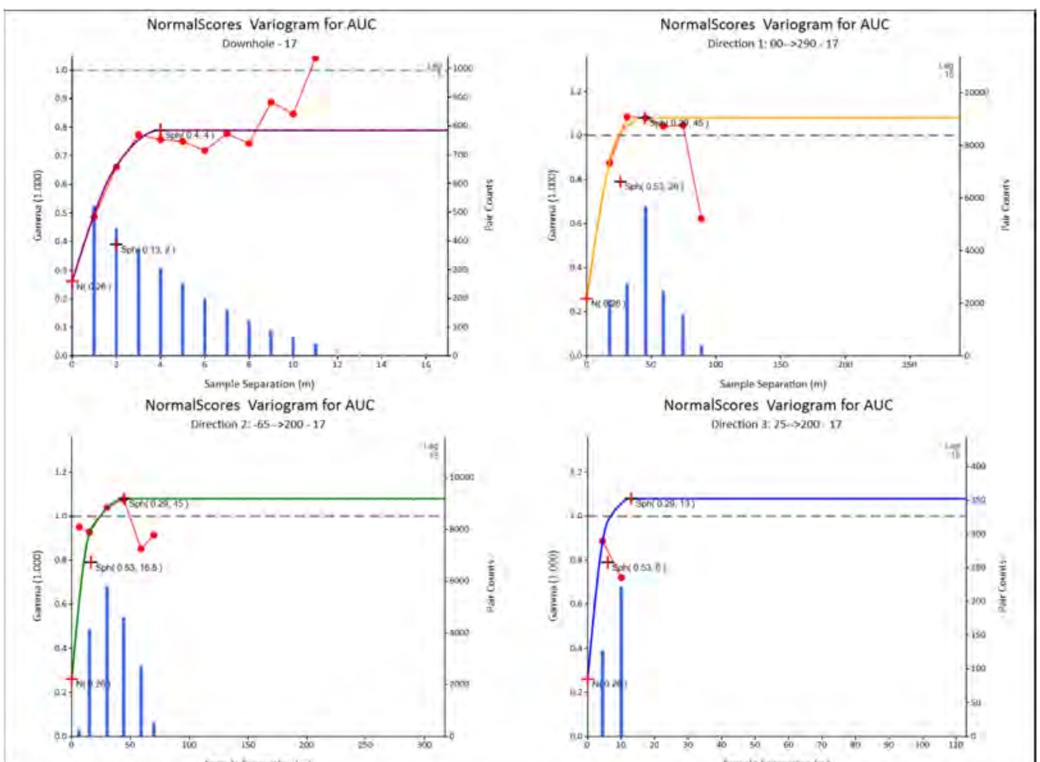


Figure 14-32: New Liberty – Kinjor area variogram (VREFNUM = 4) modelled on MINZON = 17

Note: Used for Au g/t estimation within MINZON 17.
Source: CSA Global, 2018

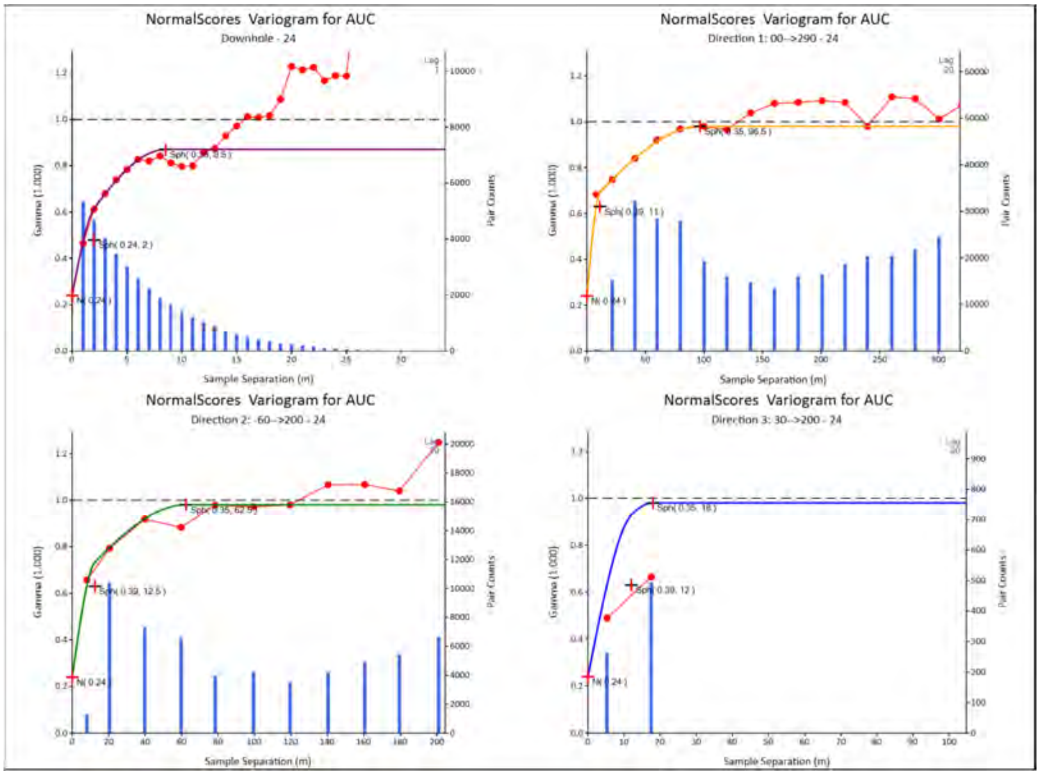


Figure 14-33: New Liberty – Larjor area variogram (VREFNUM = 6) modelled on MINZON = 24

Note: Used for Au g/t estimation within MINZONs 24–26.
Source: CSA Global, 2018

Table 14-23: New Liberty – variogram parameters

Area	VREFNUM	MINZON	Datamine rotation	Datamine axis (ZXZ)	Nugget	Structure 1		Structure 2	
						Partial sill	Range	Partial sill	Range
Marvoe	1	1–6, 8–15 and 27	-160	3	0.35	0.36	30	0.29	65
			60	1			15		40
			0	3			5		10
	2	7	-160	3	0.35	0.34	13.5	0.3	53.5
			50	1			15		35
			0	3			6		15
	3	16	-160	3	0.37	0.5	15.5	0.13	52
			65	1			15		27
			0	3			6		13
Kinjor	4	17	-160	3	0.35	0.47	26	0.18	45
			65	1			16.5		45
			0	3			6		13
	5	18–23	-160	3	0.33	0.43	12	0.24	51.5
			60	1			20.5		38.5
			0	3			5		12
Larjor	6	24–26	-160	3	0.31	0.43	11	0.26	96.5
			60	1			12.5		62.5
			0	3			12		18
Kinjor	7	28	-160	3	0.34	0.38	22	0.27	90.5
			60	1			16.5		58
			0	3			12		18

14.4.5.2 Ndablama

The estimation methodology used for Ndablama was the top-cut Model with indicator residual (see Section 14.5.4), where the estimated grade of each block is derived from a combination of two estimates, namely MIN(AU,2.5) and IND(AU,2.5).

- MIN(AU,2.5) captures the background part of the distribution and is equal to Au if Au is less than 2.5 g/t, and to 2.5 if Au is greater than 2.5 g/t
- IND(AU,2.5), the indicator function at 2.5, captures the geometry of the tail of the distribution, and is equal to 1 if Au is greater than 2.5 g/t, 0 otherwise.

The raw variograms for MIN(AU,2.5) and IND(AU,2.5) used in the estimation process were modelled on 1 m composites within MINZONs 10, 20 and 30. Nuggets were obtained from the downhole variograms, where the lag was set equal to the composite length of 1.0 m. The cross-variograms for the three MINZONs are presented in Figure 14-34 to Figure 14-36, and the parameters are detailed in Table 14-24.

Dynamic anisotropy was used during estimation to allow the rotation angles for variograms to be defined individually for each cell in the models, so that the variogram orientation is aligned with the axes of mineralisation.

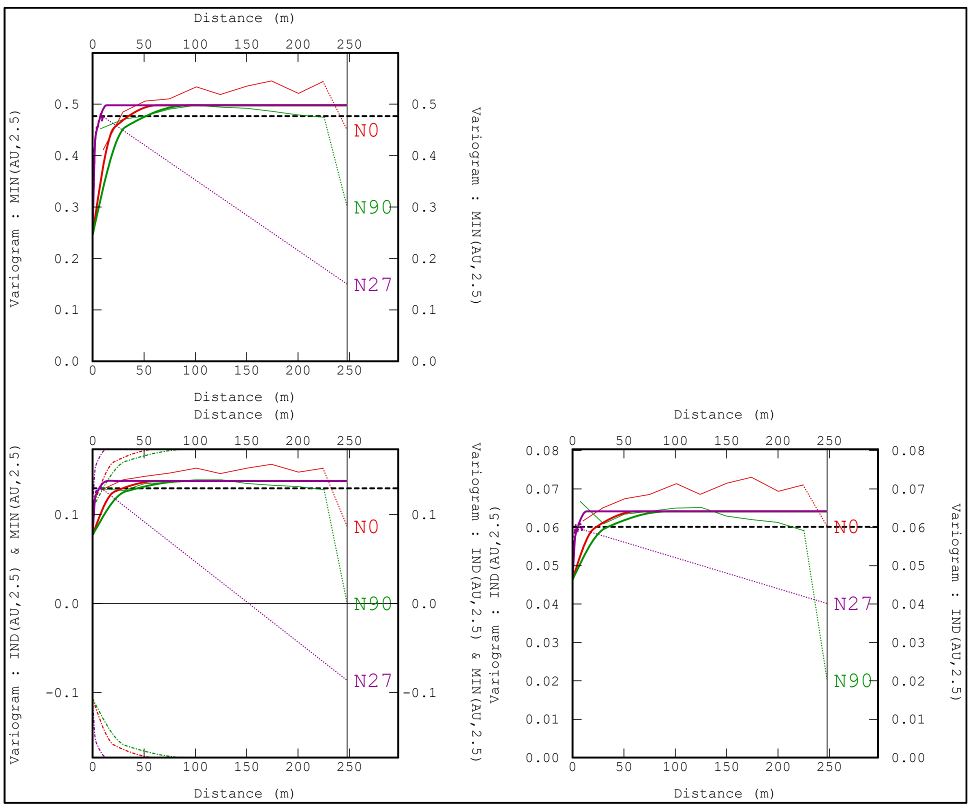


Figure 14-34: Ndablama – cross-variograms – MIN(AU,2.5) and IND(AU,2.5) (MINZON = 10)

Source: CSA Global, 2018

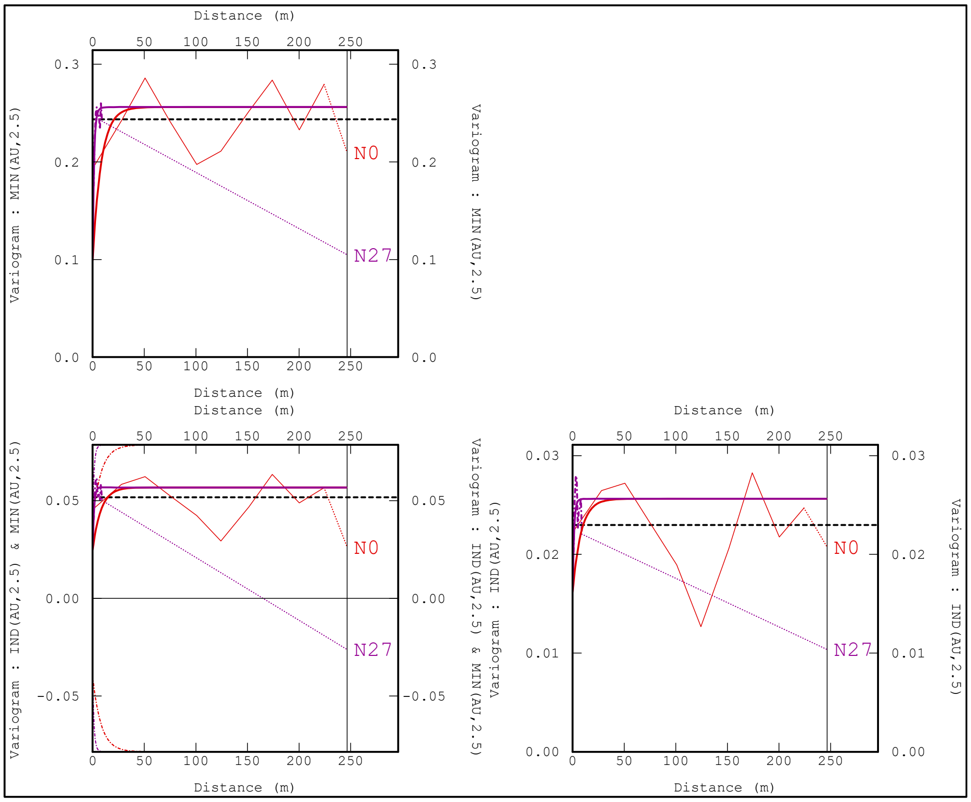


Figure 14-35: Ndablama – cross-variograms – MIN(AU,2.5) and IND(AU,2.5) (MINZON = 20)

Source: CSA Global, 2018

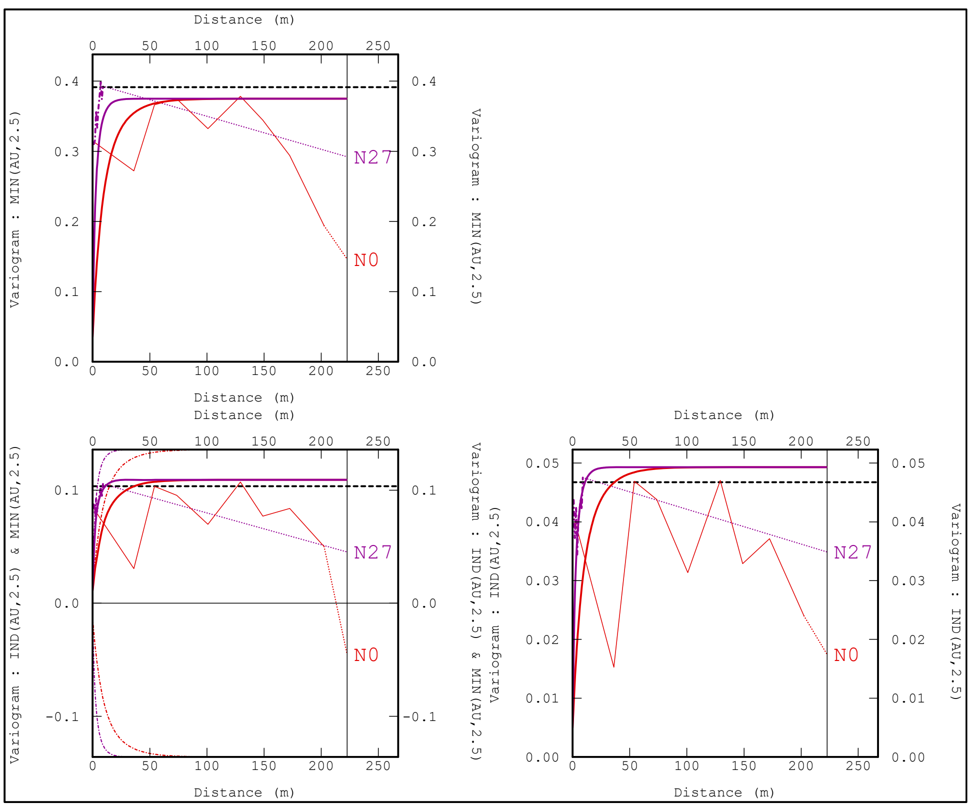


Figure 14-36: Ndablama – cross-variograms – MIN(AU,2.5) and IND(AU,2.5) (MINZON = 30)

Source: CSA Global, 2018

Table 14-24: Ndablama – variogram parameters

MINZON	Variable	Orientation (azimuth, dip, pitch)	Nugget	Structure 1		Structure 2	
				Partial sill	Range (m)	Partial sill	Range (m)
10	MIN(AU,2.5)	180˚	0.246	0.169	21	0.083	63
		30˚			32		94
		-180˚			3		14
	IND(AU,2.5)	180˚	0.046	0.009	21	0.009	63
		30˚			32		94
		-180˚			3		14
	MIN(AU,2.5)-IND(AU,2.5)	180˚	0.077	0.037	21	0.023	63
		30˚			32		94
		-180˚			3		14
20	MIN(AU,2.5)	180˚	0.099	0.153	24	0.004	50
		30˚			24		50
		-180˚			4		15
	IND(AU,2.5)	180˚	0.016	0.009	24	0	50
		30˚			24		50
		-180˚			4		15
	MIN(AU,2.5)-IND(AU,2.5)	180˚	0.025	0.033	24	0	50
		30˚			24		50
		-180˚			4		15
30	MIN(AU,2.5)	180˚	0.035	0.170	20	0.170	50
		30˚			20		50
		-180˚			5		15
	IND(AU,2.5)	180˚	0.005	0.022	20	0.022	50
		30˚			20		50
		-180˚			5		15
	MIN(AU,2.5)-IND(AU,2.5)	180˚	0.011	0.049	20	0.049	50
		30˚			20		50
		-180˚			5		15

14.5 Block Model and Grade Estimation

14.5.1 Summary

Estimation of Au grade for New Liberty was carried out using ordinary kriging (OK) into parent cell panels. Grade was estimated into all mineralisation blocks, using available data within the mineralisation domains. The New Liberty MRE was completed by CSA Global using the Datamine StudioRM™ software package.

At Ndablama, a campaign of infill and step-out drilling during 2018 demonstrated that even though the predicted volume and mineralisation continuity, as modelled at a 0.1 g/t Au cut-off and guided by the main shear zone, remains reasonable, there is a very high variability in grade within the main mineralised domain, which adds risk to the eventual metal predicted by the estimate.

The lower grade variability at New Liberty is amenable to OK, whereas the high-grade variability at Ndablama would cause overestimation and smoothing of higher grades and a different estimation approach needed to be considered.

At Ndablama, the top-cut model with indicator residual (TC estimate) was used for Au grade estimation into all mineralisation blocks. The estimated grade of each block was derived from a combination of two estimates; namely MIN(AU,2.5) and IND(AU,2.5). The two parts of the distribution, the background grade – MIN(AU,2.5) – and the tail geometry – IND(AU,2.5) are intrinsically connected as they are co-estimated in a co-kriging procedure.

Following the generation of the Ndablama TC estimate, recoverable resources were estimated based on a selective mining unit (SMU) of 5 m x 5 m x 5 m, completed using Uniform Conditioning (UC). The UC estimate was further post-processed to produce single cell grades for each SMU, based on Localised Uniform Conditioning (LUC) where the grade tonnage of the panel is reconstituted in SMU sized blocks. The location of the high and low grades in each panel is an estimate based on the spatial distribution of high- and low-grade samples within the panel, but exact locations of the SMUs remain unknown.

The Ndablama MRE was completed by CSA Global using Isatis™ and Datamine StudioRM™ software packages.

14.5.2 Block Modelling

The models were cut to below the topographic surface. A model prototype with parent cells and sub-celling was created. The model prototypes parameters, including cell dimensions and model extents, are shown in Table 14-25.

Panel sizes for grade estimation were based on the following:

- Results of kriging neighbourhood analysis (KNA)
- The density of the drilling grids
- The geometry of the mineralisation
- The mining parameters.

Table 14-25: Block model dimensions

Deposit	Axis	Origin	Model extent (m)	No. of blocks	Parent block dimension (m)	Sub-cell dimension (m)
New Liberty	Easting (X)	261,520	3,450	345	10	2.5
	Northing (Y)	773,970	2,260	226	10	2.5
	Elevation (Z)	-750	850	170	5	2.5
Ndablama	Easting (X)	298,500	3,000	120	25	5
	Northing (Y)	789,500	2,800	112	25	5
	Elevation (Z)	-500	900	180	5	5

Mineralisation wireframes were filled with model cells and the block model volumes were compared to the mineralisation volumes, per MINZON (Table 14-26). The volumes compare to within 2% for New Liberty and within 0.1% for Ndablama, showing very good resolution on mineralisation boundaries.

Table 14-26: Mineralisation volumes – wireframes vs block models

Deposit	MINZON	Wireframe volume (m^3)	Block model volume (m^3)	% difference
New Liberty	1	101,259	101,656	0%
	2	154,069	154,234	0%
	3	251,631	251,391	0%
	4	137,213	137,438	0%
	5	81,097	80,938	0%
	6	17,701	17,984	2%
	7	43,904	43,500	-1%
	8	3,373	3,375	0%
	9	68,406	68,906	1%
	10	221,377	221,234	0%

Deposit	MINZON	Wireframe volume (m³)	Block model volume (m³)	% difference
	11	282,721	282,297	0%
	12	155,824	155,656	0%
	13	271,140	271,094	0%
	14	15,130	15,156	0%
	15	855	859	0%
	16	88,470	88,469	0%
	17	57,969	57,406	-1%
	18	23,975	24,281	1%
	19	1,213,332	1,211,766	0%
	20	20,701	20,422	-1%
	21	1,044,216	1,044,328	0%
	22	17,476	17,219	-1%
	23	45,605	45,797	0%
	24	1,536,090	1,537,672	0%
	25	361,279	361,047	0%
	26	77,472	76,422	-1%
	27	97,010	96,781	0%
	28	2,485,383	2,483,469	0%
Ndablama	10	17,206,474	17,210,500	0.0%
	20	1,799,301	1,800,500	0.1%
	30	1,530,481	1,528,500	-0.1%

14.5.3 Kriging Neighbourhood Analysis

KNA on the top-cut 1 m composites was used to optimise the parent cell sizes and to determine the optimal theoretical estimation and search parameters during kriging and TC estimation.

The following was reviewed for each of the variables per selected domain:

- Slope and Kriging Efficiency (KE) statistics for a well-informed block for different block sizes.
- On choosing a block size, optimum minimum and maximum samples were chosen. The maximum was set at the lowest number of samples from which consistently good slopes and KE could be derived. The minimum was defined as the lowest minimum from which moderate to good statistics could be derived.
- On choosing the minimum/maximum samples, search ellipse ranges were defined. The quality of the statistics was least sensitive to this parameter. The chosen ranges approximated the ranges of the second structure of the variogram.
- Negative weights were reviewed at each stage to ensure the parameters chosen were not leading to excessive negative weights.
- Discretisation (X x Y x Z) was defined at 3 x 3 x 3 for New Liberty, and 4 x 4 x 5 for Ndablama.
- Maximum number of composites allowed per each individual drillhole, per estimate, was set between two and six, depending on the estimation domain at New Liberty.

The KNA results show that the search parameters and block size selected are suitable for use in the MREs and adequately take drill spacing, geology and practicality into account. An example plot of selected estimation parameters is shown in Figure 14-37.

The number of composites used for the Au grade estimations per MINZON are presented in Table 14-27 and Table 14-28. The modelled variogram parameters together with the selected estimation panel size and number of samples was used to determine the appropriate search ellipse for the primary search pass. These are also presented in Table 14-27 and Table 14-28.

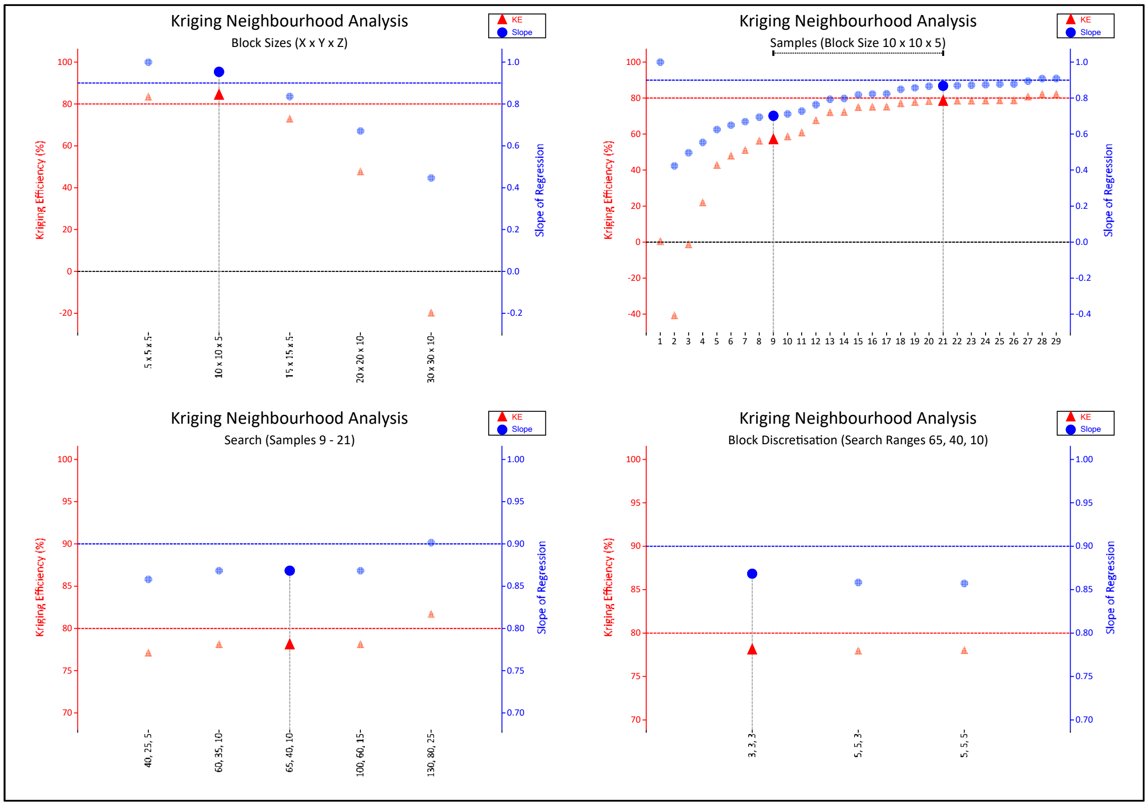


Figure 14-37: New Liberty – Marvoe, KNA parameters modelled on MINZON = 1

From top-left, clockwise: Block size, samples, discretisation and search results. Used as reference for Au g/t estimation within MINZONs 1–16 and 27.

Source: CSA Global, 2018

Table 14-27: New Liberty – kriging neighbourhood for Au by MINZON

SREFNUM	MINZON	Search volume 1 SVOL1)			Search volume 2 (SVOL2)			Search volume 3 (SVOL3)		
		Ranges	Composites		Range	Composites		Range	Composites	
			Min.	Max.		Min.	Max.		Min.	Max.
1	1-4; 6	65 x 40 x 10	10	20		10	20		6	12
2	5	65 x 40 x 10	10	18		10	18		6	12
3	7	55 x 35 x 15	10	20		10	20		6	12
4	8	65 x 40 x 10	10	20		10	20		6	12
5	9	65 x 40 x 10	8	22		8	22		6	12
6	10	65 x 40 x 10	10	18		10	18		6	12
7	12	65 x 45 x 10	8	22		8	22		6	12
8	13	65 x 40 x 10	10	20	SVOL1 x 1.5	8	18	SVOL1 x 3	4	8
9	14-15	65 x 40 x 10	9	21		9	21		6	12
10	16	55 x 30 x 15	8	18		8	18		6	10
11	17	45 x 45 x 15	10	18		10	18		6	12
12	18	55 x 45 x 15	10	20		10	20		6	12
13	19	40 x 35 x 10	12	18		12	18		6	12
14	20	55 x 45 x 15	8	24		8	24		6	12
15	21	55 x 45 x 15	9	21		9	21		6	12

SREFNUM	MINZON	Search volume 1 SVOL1)			Search volume 2 (SVOL2)			Search volume 3 (SVOL3)		
		Ranges	Composites		Range	Composites		Range	Composites	
			Min.	Max.		Min.	Max.		Min.	Max.
16	22	55 x 45 x 15	10	18		10	18		6	12
17	23	55 x 45 x 15	9	21		9	21		6	12
18	25	55 x 45 x 15	9	21		9	21		6	12
19	26	55 x 45 x 15	10	18		10	18		6	10
20	27	65 x 40 x 10	9	21		9	21		6	12
21	11	65 x 40 x 10	8	20		8	18		4	10
22	24	55 x 45 x 15	9	21		9	21		6	12
23	28	55 x 45 x 15	10	22		10	18		6	12

Table 14-28: Ndablama – kriging neighbourhood for MIN(AU,2.5) and IND(AU,2.5) by MINZON

MINZON	Search volume 1 (SVOL1)			Search volume 2 (SVOL2)			Search volume 3 (SVOL3)			Angular sectors
	Ranges	Composites		Range	Composites		Range	Composites		
		Min.	Max.		Min.	Max.		Min.	Max.	
10	125 x 125 x 15	15	25	200 x 200 x 25	15	50	400 x 400 x 50	3	25	4
20	65 x 65 x 10	10	25	130 x 130 x 15	4	25	195 x 195 x 20	4	25	4
30	55 x 55 x 10	10	25	110 x 110 x 15	4	25	165 x 165 x 20	4	25	4

14.5.4 Grade Estimation

14.5.4.1 New Liberty

Estimation of Au g/t was carried out using OK into parent cell panels. Zonal control with a hard boundary between mineralisation domains was used during the grade estimation. MINZON was used as the estimation domain.

A three-phased search pass was applied, and the orientation of the search ellipsoid was aligned to the modelled variography. This process involves the estimation being performed three times, where two expansion factors are used. During each individual estimation run this factor increases the size of the search ellipse used to select samples. This method ensures that blocks which are not estimated and populated with a grade value in the first run, are populated during one of the subsequent runs.

The mineralised areas were estimated using dynamic anisotropy. This process allows the rotation angles for the search ellipsoid to be defined individually for each cell in the models, so that the search ellipsoid is aligned with the axes of mineralisation. This therefore requires the rotation angles to be interpolated into the model cells, which in turn requires a set of angles as the input data file for interpolation. The dip and dip direction of the major axis of anisotropy were defined by importing the hanging wall surfaces generated in Leapfrog™ during the mineralisation wireframing process. These surfaces were converted to points that contained the true dip and dip direction of the mineralisation and stratigraphy (fields SANGLE1_F and SANGLE2_F in the search parameter files).

The rotations of the modelled variograms aligned with the dominant orientation of the mineralisation. Therefore, the variogram also used dynamic anisotropy.

14.5.4.2 Ndablama

The Au grade distribution of the 1 m composites within the mineralisation zones is typical of highly skewed precious metals distributions, with a CV equal to 4.91 for MINZON = 10, 3.29 for MINZON = 20, and 2.63 for MINZON = 30. The CV characterises the intrinsic level of variability of the distribution.

The histogram shape of the data within MINZON = 10 is characterised by a narrow unimodal core of values (50% of values are lower than 0.2 g/t and 80% lower than 0.7 g/t) and a very long tail of high values: 10% of the values are greater than 1.5 g/t (and contain 70% of the metal). The maximum value of 240 g/t is 250 times the mean value of the distribution. This causes a problem for estimation with a clear risk of the tail of high values smearing out into under-sampled areas or being swamped by the background values in well-sampled areas. MINZONs 20 and 30 also show a tail of high values; however, they are not as pronounced as in MINZON = 10.

Mitigation strategies on how to conduct an MRE which will best honour the input data grade distribution were considered, namely:

1. **Compositing.**

- The envisaged bench height is 5 m. As such, compositing to 5 m should be considered for estimation purposes. The 5 m composites yield a CV of 2.6, and the maximum value drops down to 49 g/t. Whilst this is an improvement on the original distribution, it does not solve all issues related to the skewness of the distribution.

2. **Wireframing internal high-grade (HG) material.**

- Within the wireframe modelled at 0.1 g/t Au for the main domain (MINZON = 10), there are intervals of higher grade (HG) (>0.5 g/t Au and even >1.0 g/t Au, both composited with a true minimum thickness of 3 m) that appear to be continuous.
- Without the further development of a geological and structural model, it is unclear if these high grades are petrogenetically distinct from the rest of the population. There is no apparent geological evidence that the extreme grades are not part of a unimodal, heavily skewed continuous population.
- Even if it was possible to wireframe these internal HG zones as a separate domain, and therefore restrict the influence of the tail of high values, it would not be appropriate do to so without further geological support. To do so would form a generally unimodal population yielding a heavily bimodal estimate that has no bearing on reality.

3. **Considering a method that captures the binary (one mode and one tail) nature of the distribution.**

- The top-cut model with indicator residual adapted to deposits with very skewed grade distributions (Rivoirard *et al.,* 2010). This methodology is a geostatistical approach where extreme values are handled based on the assumption that for high grade zones, the only concrete information pertaining to these zones are their geometry.
- The underlying idea is to recognise the binary nature of the distribution which is made up of two components,
  - a diffusive background of low grades, where the transition from very low-grade (LG) material to medium grades is always gradual via intermediate grades, and
  - a mosaic (erratic) tail of HG values where the transition from medium to high or very high grades is sharp and without edge effect.
- The two parts of the distribution are intrinsically connected: the background part (LG) which is well behaved and amenable to proper linear estimation, and the tail of HG values which will be characterised by its probability of occurrence (or proportion, via an indicator function) and by a constant value (to make up for the excess metal lost when considering only the background distribution).
- The key to the method is to identify a grade threshold at which spatially gradational changes in grade cease to be evident (a diffusive model) and instead, marked and substantial changes in grade over very short distances become the characteristic spatial feature of the data (a mosaic model).
- A diffusive model shows a consistent trend from low grade to medium grade then to high grades through the domain (Figure 14-38). This type of behaviour is common within broadly mineralised

domains where a concentric zoning or layering of the grade distribution is related to the mechanism of mineralisation. In a diffusion model, there is a tendency for grade to increase or decrease in a regular manner across grade boundaries (Snowden, 2012).

- In contrast, the grade distribution in a mosaic model has no consistent grade trend across threshold boundaries with instances of high grade abutting both low and medium grades (Figure 14-38). The grade distribution can change abruptly across thresholds, perhaps due to internally geological controls that cannot be resolved at the scale of the information (Snowden, 2012).
- The character of a given data set, diffusion or mosaic, can be tested and identified using a series of grade indicators (and specific indicator variography).

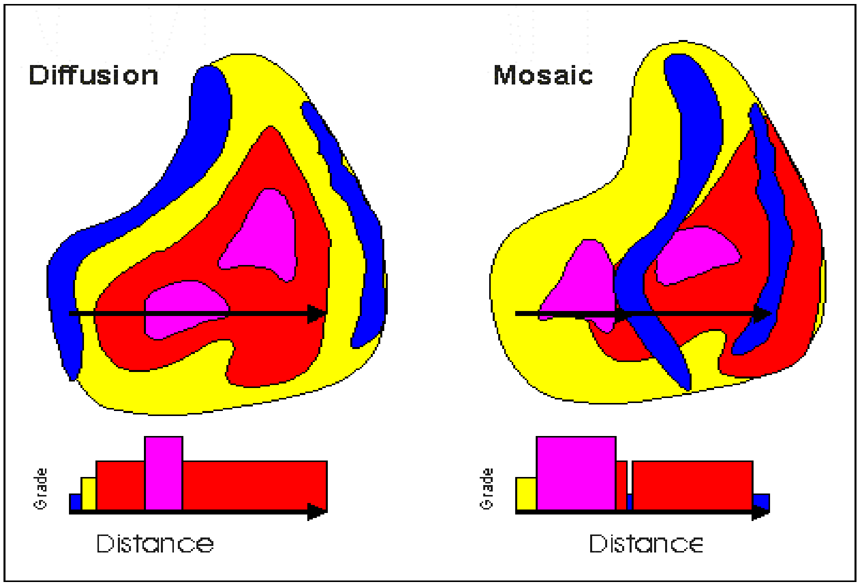


Figure 14-38: Grade contours with conceptual estimation domains
Source: Snowden, 2012

Building a Robust Estimation Platform

A series of grade indicators (and specific indicator variography) were run for the Ndablama deposit and indicate that any value between 2 g/t Au and 3 g/t Au marks the start of the mosaic model, whilst still showing structure for its indicator, thus allowing the model to properly capture the geometry of that part of the distribution.

CSA Global considers the top-cut model with indicator residual (TC estimate) as the most appropriate method for building an estimate and subsequent robust estimation platform, since this method best captures the binary nature of the Au grades in the deposit.

The estimated grade of each block is derived from a combination of two estimates; the first being an OK estimate derived using the top-cut, low grade portion of the input data (with the estimate capped at 2.5 g/t Au). The second estimate is derived from the multiplication of an OK estimate of the indicator function of the 2.5 g/t top-cut, by the residual of the average grade of the "high-grade" portion of the input data having subtracted the top-cut value. This second estimate effectively offers a representation of the proportion of a block estimate which is likely to exceed the top-cut value.

The formulae used in the calculation of the estimate is as follows:

$$AU=MIN(AU,2.5) + IND(AU,2.5) * (AU_{>2.5}-2.5)$$

- MIN(AU,2.5) captures the background part of the distribution and is equal to Au if Au is less than 2.5 g/t, and to 2.5 if Au is greater than 2.5 g/t.

- IND(AU,2.5), the indicator function at 2.5, captures the geometry of the tail of the distribution, and is equal to 1 if Au is greater than 2.5 g/t, 0 otherwise.

Thus, using the formula above:

- If Au <2.5 g/t, then AU = AU + 0 * (0-2.5)
- If Au >2.5 g/t, then AU = 2.5 + 1 * (AU-2.5).

The resulting estimate is obtained as:

$$AU^{est} = MIN^{est}(AU,2.5) + IND^{est}(AU,2.5) * (\text{Average Value of } AU_{>2.5}\text{-}2.5)$$

The two parts of the distribution, the background grade – MIN(AU,2.5) – and the tail geometry - IND(AU,2.5) are intrinsically connected as they are co-estimated in a co-kriging procedure.

A three-phased search pass was applied, and the orientation of the search ellipsoid was aligned to the modelled variography. This process involves the estimation being performed three times, where each successive estimation run increases the size of the search ellipse used to select samples. This method ensures that blocks which are not estimated and populated with a grade value in the first run, are populated during one of the subsequent runs.

Dynamic anisotropy was used during estimation to allow the rotation angles for neighbourhoods to be defined individually for each cell in the models, so that the neighbourhood orientation is aligned with the axes of mineralisation. This therefore requires the rotation angles to be interpolated into the model cells, which in turn requires a set of angles as the input data file for interpolation. The dip and dip direction of the major axis of anisotropy were defined by sectional strings generated in Datamine StudioRM™ during the mineralisation wireframing process. These strings were converted to points that contained the true dip and dip direction of the mineralisation.

Following the generation of the Ndablama TC estimate, recoverable resources were estimated based on a selective mining unit (SMU) of 5 m x 5 m x 5 m, completed using Uniform Conditioning (UC). The key choice was the input distribution, which was cut to obtain a point distribution amenable to change of support and subsequent UC, which would yield results comparable to the TC estimate obtained. A series of top-cuts were tested in MINZON = 10 (60, 20, 10 g/t, etc.) and eventually 5 g/t was selected to model the distribution to be used as an input to the UC process. The selection of 5 g/t was also based on the benchmarking performed with the Conditional Simulation (CS) realisations/simulations (SIMS) (Figure 14-39; further discussed in Section 14.6.2). UC based on the TC estimate, was also completed for MINZONs 20 and 30 where the uncut distributions were used, since these domains are less affected by outliers.

The UC estimate was further post-processed to produce single cell grades for each SMU, based on Localised Uniform Conditioning (LUC) where the grade tonnage of the panel is reconstituted in SMU sized blocks.

Figure 14-40 below shows the satisfactory match between the resulting LUC and the localised recoverable Resource estimate based on the CS. The location of the high and low grades in each panel is an estimate based on the spatial distribution of high- and low-grade samples within the panel, but exact locations of the SMUs remain unknown.

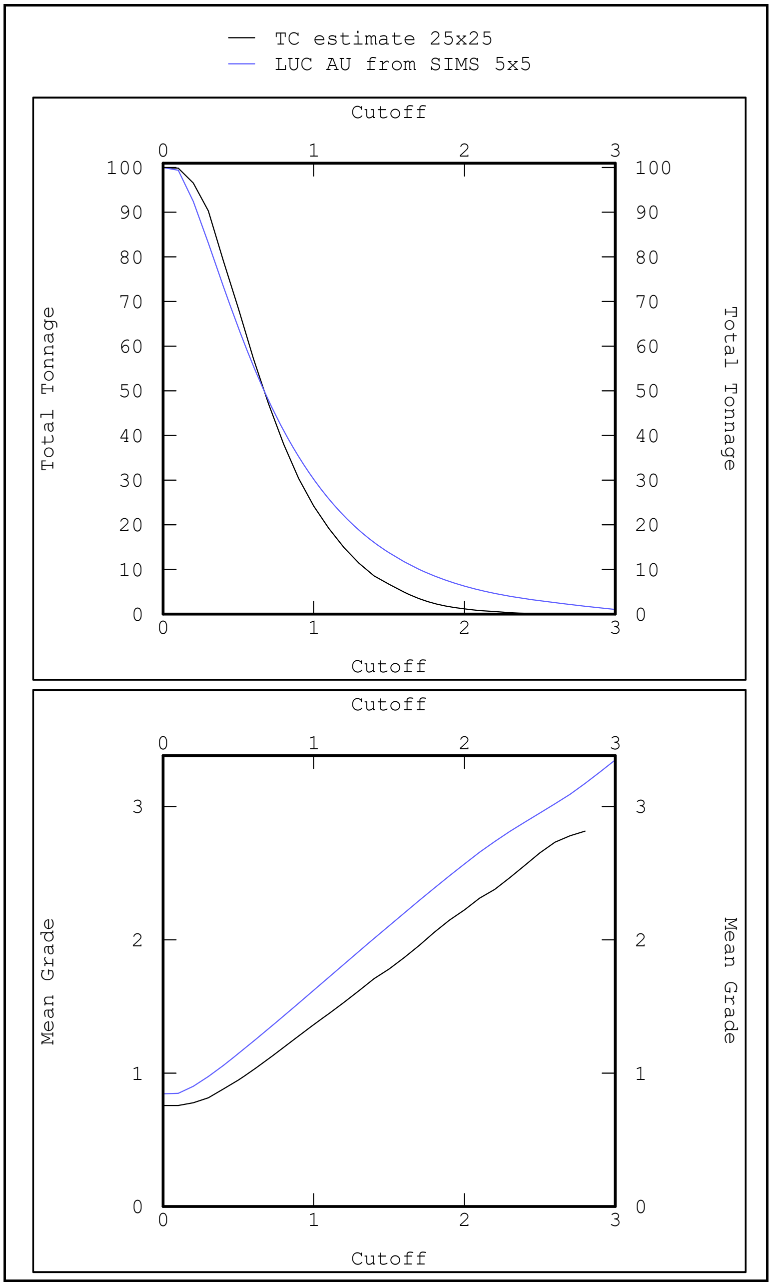


Figure 14-39: Ndablama – grade-tonnage curves for the TC estimate and the UC estimate

Note: Based on 5 m x 5 m x 5 m SIMS at 25 m x 25 m x 5 m panel level in MINZON = 10

Source: CSA Global, 2018

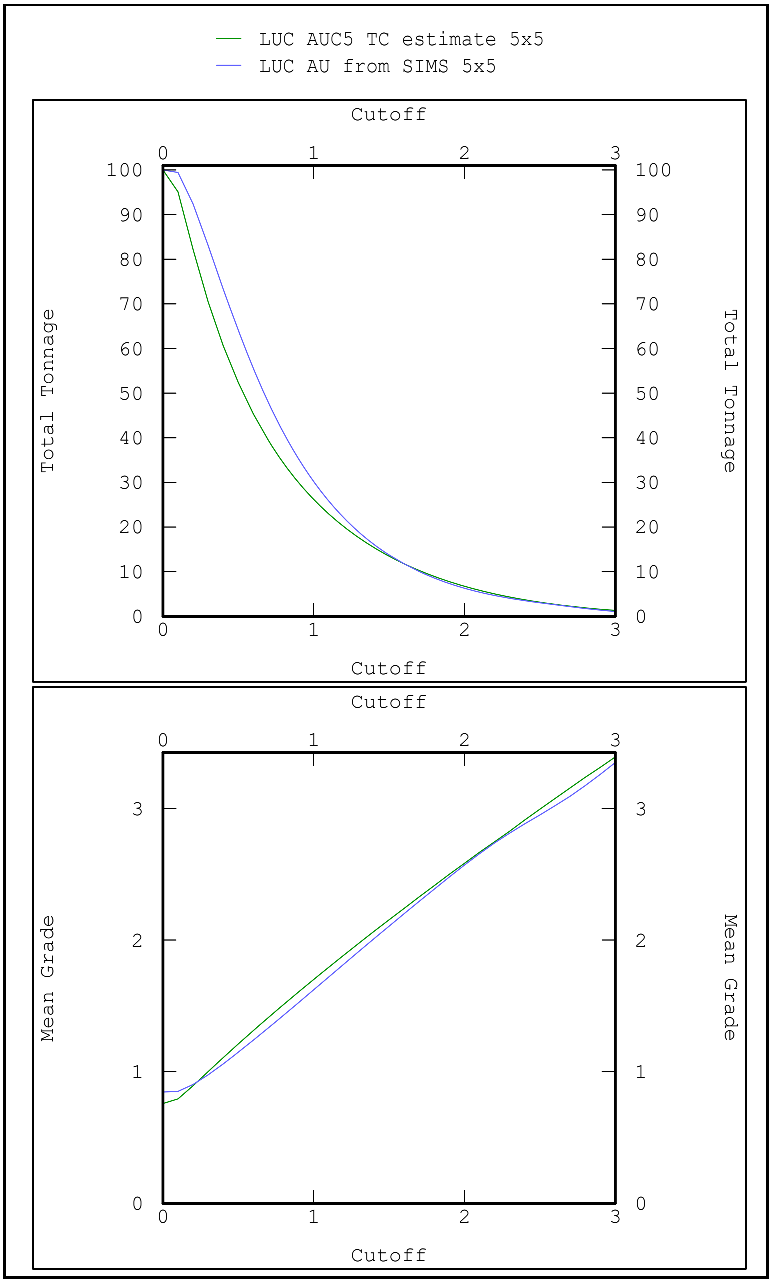


Figure 14-40: Ndablama – grade-tonnage curves for the LUC estimate

Note: Based on the TC estimate, and the LUC estimate based on 5 m x 5 m x 5 m SIMS at 25 m x 25 m x 5 m panel level in MINZON=10.
Source: CSA Global, 2018

14.5.5 Validations

Validation of the block models were completed by comparing input and output means. Several techniques were used for the validation. These included visual validation of block grades, global grade comparisons and swath plots.

14.5.5.1 Visual Validation

The block models were visually reviewed section by section and in 3D to ensure that the grade tenor of the input data were represented in the block models. Generally, the estimates compare well with the input data.

Examples for New Liberty are shown in Figure 14-41 to Figure 14-43, and for Ndablama in Figure 14-44. The grades in the composites align with the corresponding grades in the block models. For Ndablama, the TC estimate successfully restricted the spreading of high-grade samples beyond unreasonable limits.

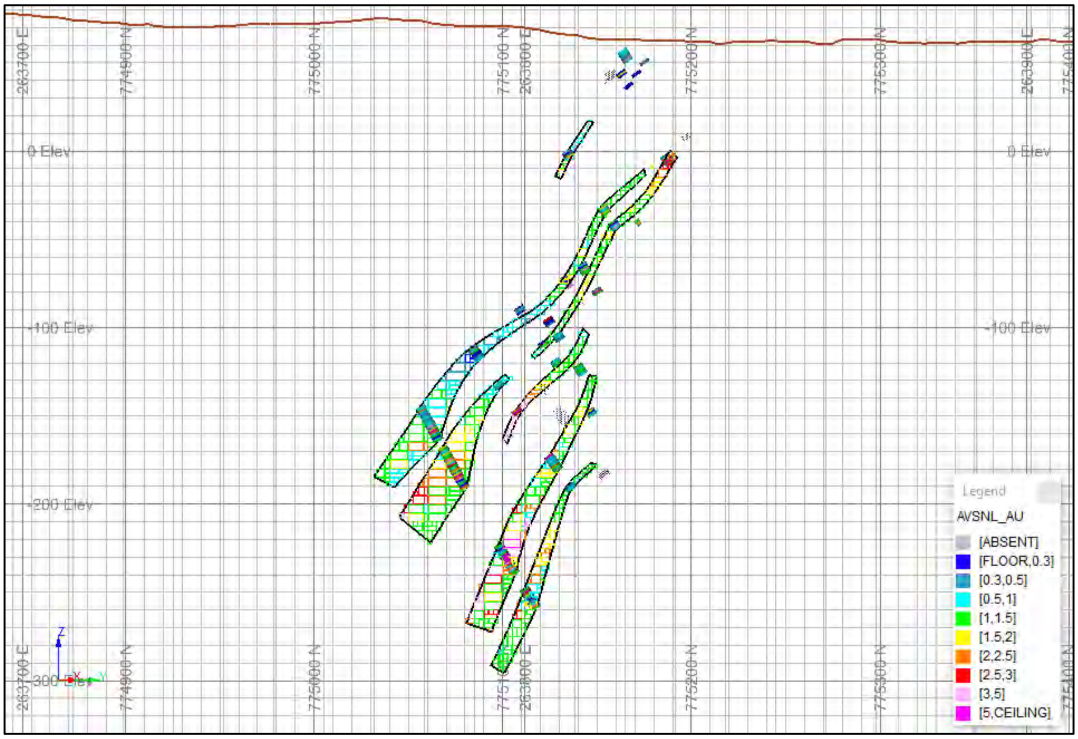


Figure 14-41: New Liberty – cross-section view – Marvoe area grade model and composites
Source: CSA Global, 2018

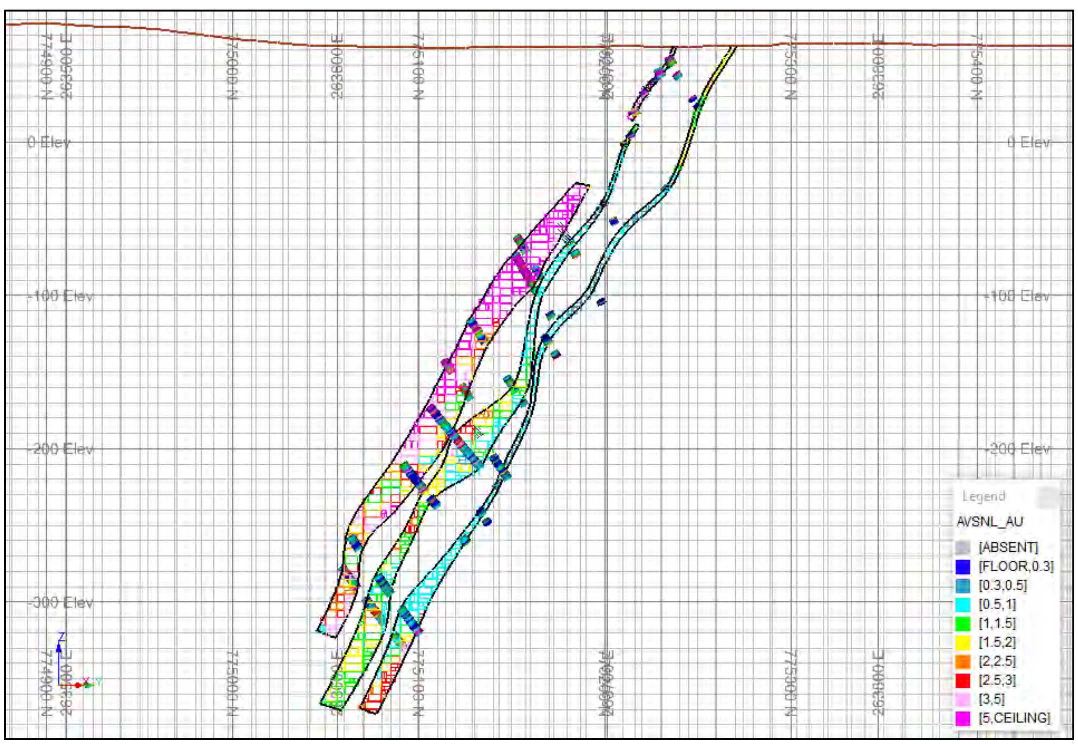


Figure 14-42: New Liberty – cross-section view – Kinjor area grade model and composites
Source: CSA Global, 2018

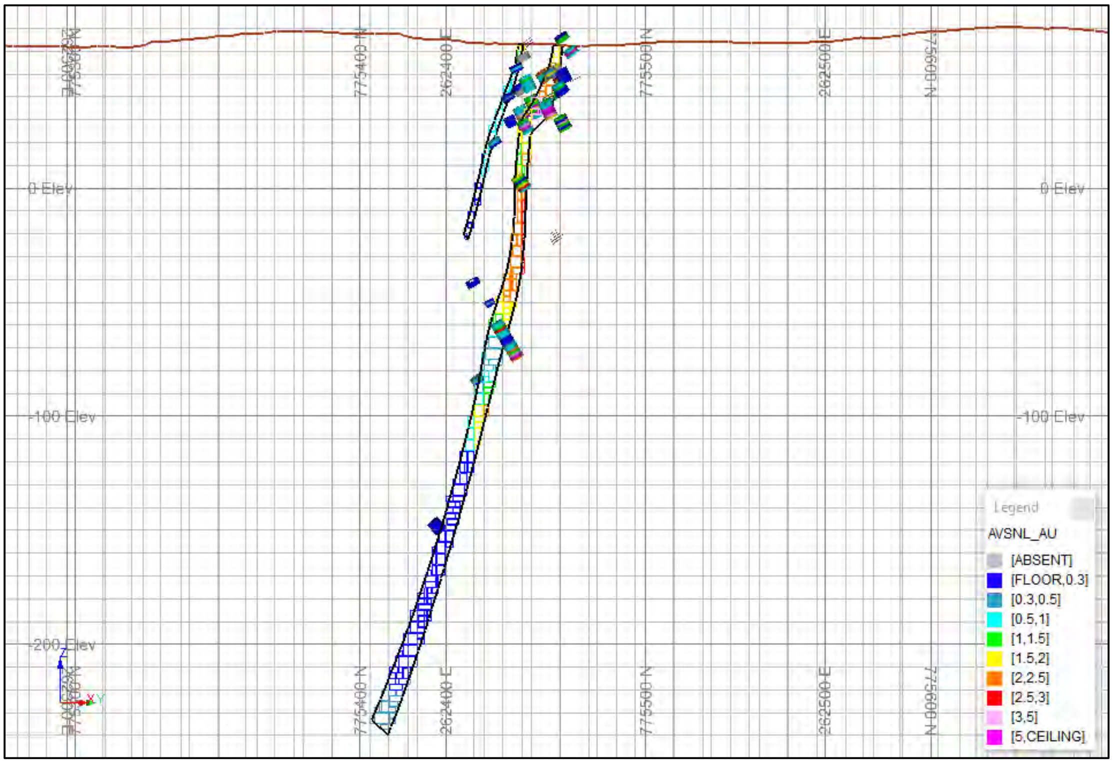


Figure 14-43: New Liberty – cross-section view – Larjor area grade model and composites
Source: CSA Global, 2018

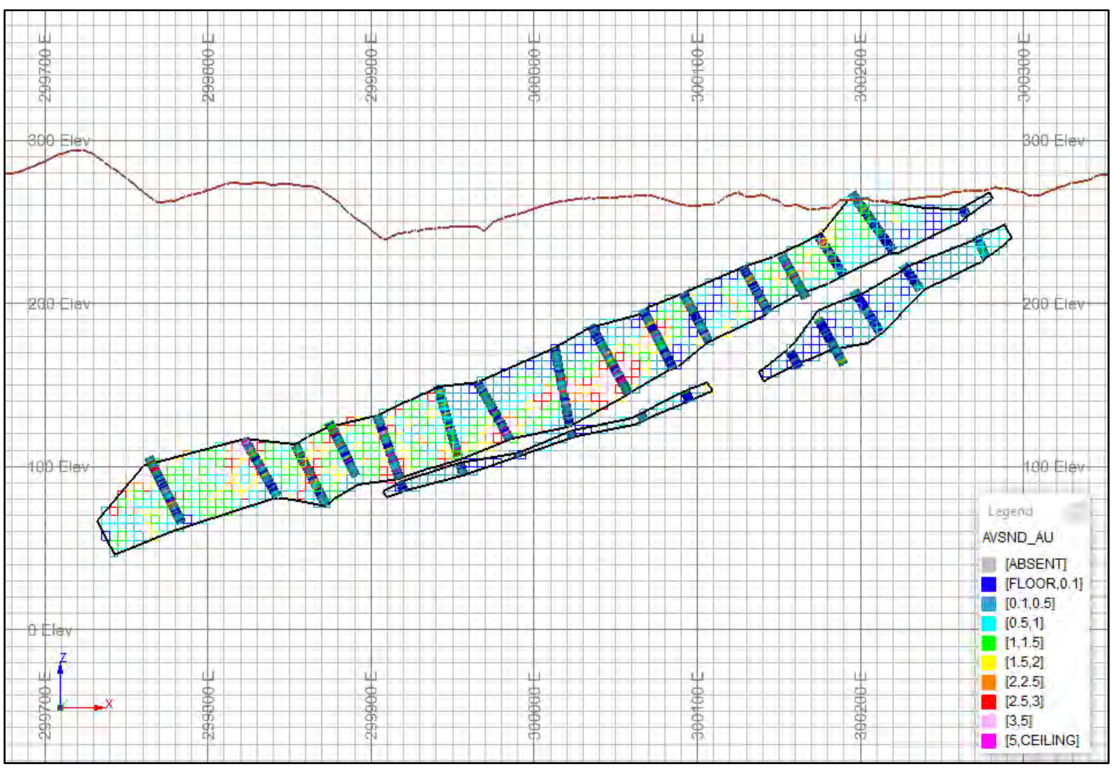


Figure 14-44: Ndablama – cross-section view – Grade model and composites
Source: CSA Global, 2018

14.5.5.2 Statistical Validation

Declustering

Irregular sampling of a deposit, most commonly through infill drilling or drilling in multiple orientations, causes clustering. Clustering results in a disproportionate distribution grades (usually high grades from the infill drilling) in the dataset used for statistical analysis. Mixed populations in the histogram can create a bias when comparing the drillhole sample distribution with the block model distribution (which is declustered) and distort the calculated mean grades and variance.

Different ways of declustering data each give different results. These include interactive filtering, polygonal declustering, nearest neighbour declustering and cell-weighted declustering.

The method used for geostatistical analysis and validation is cell-weighted declustering, since all samples are considered when determining the average. This method involves placing a grid of cells over the data. Each cell that contains at least one sample is assigned a weight of one. That weight of one is distributed evenly between the samples within each cell.

The OK grade estimation process is a very efficient way of data declustering, therefore declustering before grade estimation is not necessary. Declustering of the input data does give a good indication of the global mean. It is used in the validation of the estimate (comparison of the means). Declustering was applied to remove any bias due to drill spacing prior to validation. The declustering parameters as used for New Liberty and Ndablama are presented in Table 14-29.

Table 14-29: Declustering parameters

Deposit	Cell size (m)			Anchor point		
	X	Y	Z	X	Y	Z
New Liberty	10	10	5	261,520	773,970	-750
Ndablama	25	25	5	298,500	789,500	-500

Results

The statistical difference between the naïve and declustered composites against the block grades were assessed on individual domains as well as globally. The global statistics of Au g/t are reported below in Table 14-30 and Table 14-31.

All estimated block grades are included. The mean grades in the estimated model block parent cells were compared to the raw, as well as the declustered composite data.

Generally, the models validate well, showing 6% difference between the declustered composites and the block estimate for New Liberty, and 7% difference for Ndablama. This is well within expected parameters.

Table 14-30: New Liberty – declustered mean grade comparison for Au g/t

	Variable	Count	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
Composites naïve	AUC	15,516	0.01	52.00	2.72	4.51	1.66
Composites declustered	AUC	15,516	0.01	52.00	2.37	4.14	1.75
Model	AU	147,981	0.01	17.96	2.50	1.91	0.77
Difference [(Composite Declustered Grade – Model Grade)/Model Grade]					**+6%**		

AUC: Top-cut Au g/t

Table 14-31: Ndablama – declustered mean grade comparison for Au g/t

	Variable	Count	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
Composites naïve	AU	10,713	0.00	240.00	0.86	4.25	4.95
Composites declustered	AU	10,713	0.00	240.00	0.83	4.04	4.89
Model	AU	164,316	0.03	4.73	0.77	0.80	1.04
Difference [(Composite Declustered Grade – Model Grade)/Model Grade]					**-7%**		

14.5.5.3 Swath Plots

Swath plots were created as part of the validation process, by comparing the model parent block grades and input composites (naïve and declustered) in spatial increments. These plots display northing, easting and elevation slices throughout the deposits in Figure 14-45 and Figure 14-46.

The plots show that the distribution of block grades honour the distribution of input composite grades. There is a minor degree of smoothing evident, which is to be expected from the estimation methods used, with block grades showing lower overall variance. The general trend of the composite grades is reflected in the block models.

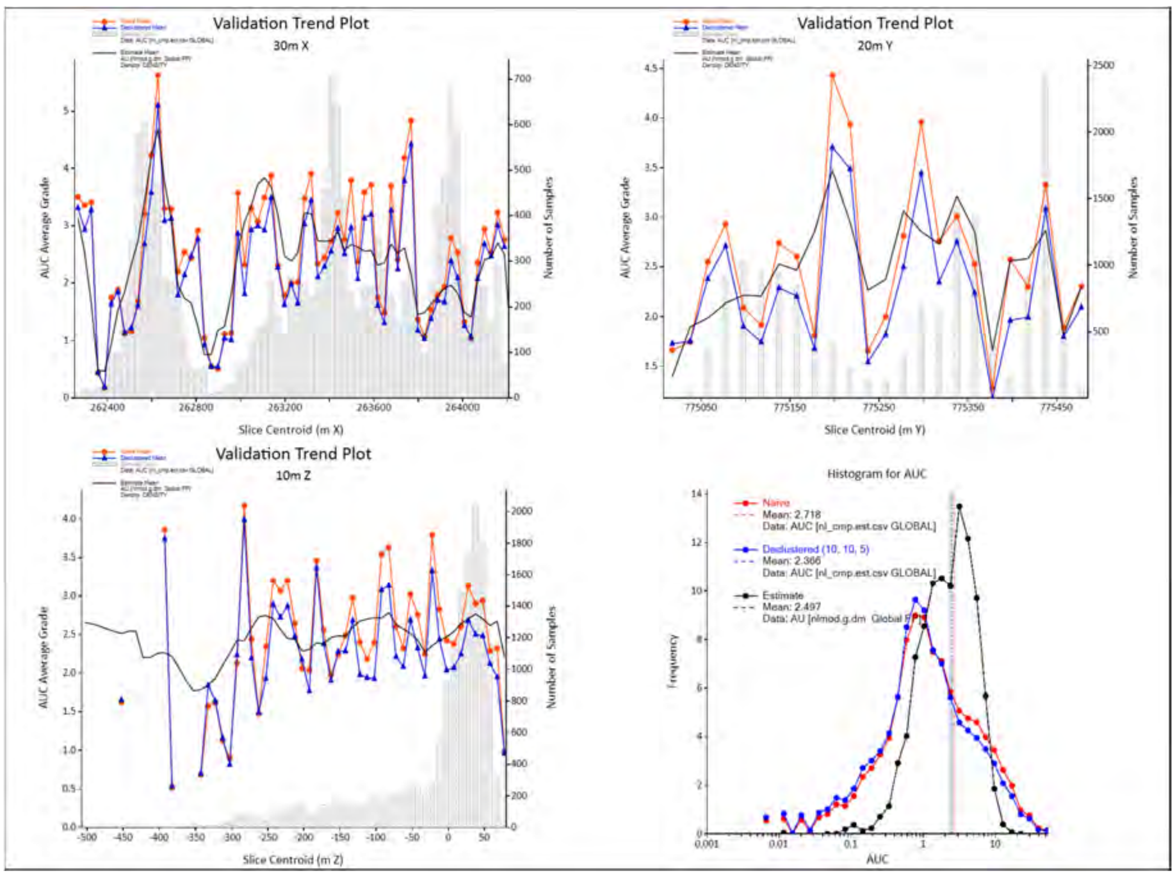


Figure 14-45: New Liberty – swath plots and histogram

Note: Block model (black); Naïve composite (red); Declustered composites (blue).
Source: CSA Global, 2018

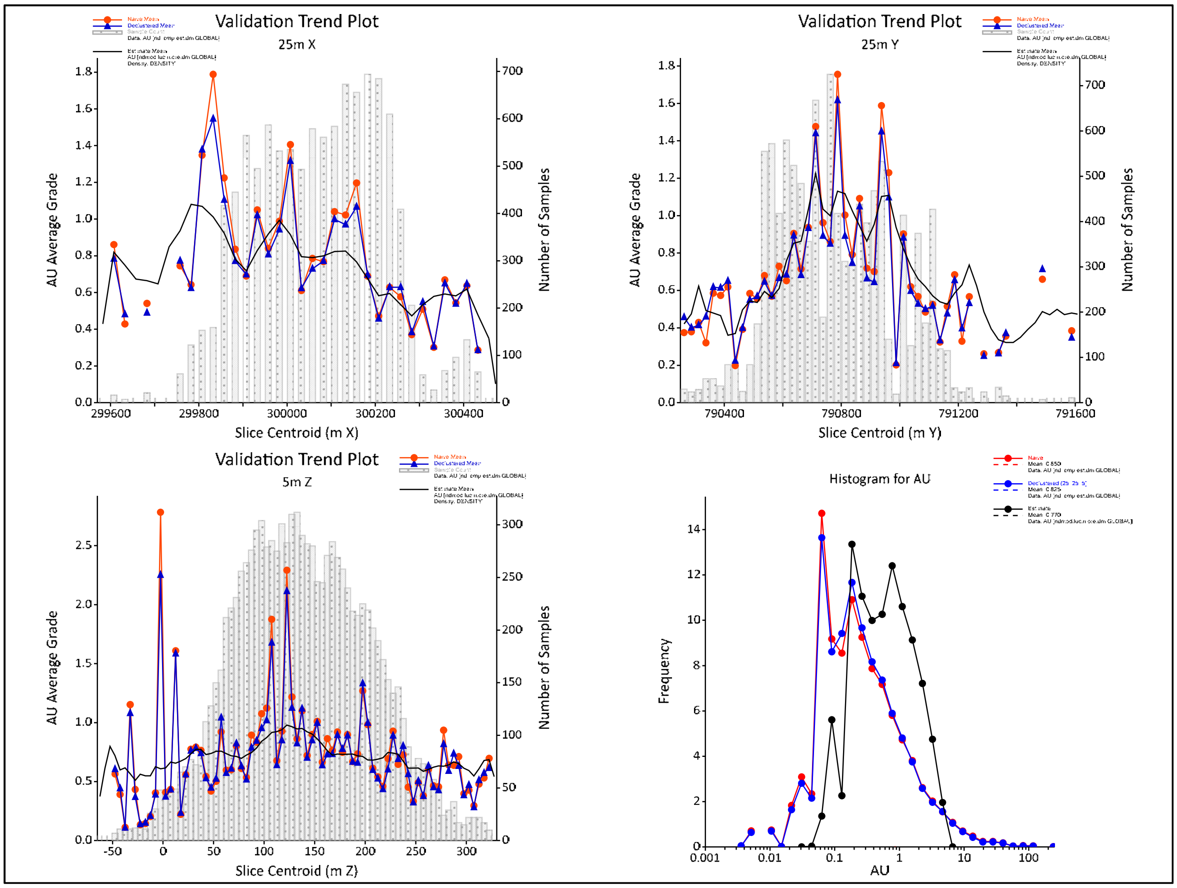


Figure 14-46: Ndablama – swath plots and histogram

Note: Block model (black); Naïve composite (red); Declustered composites (blue).
Source: CSA Global, 2018

14.6 Classification

14.6.1 Mineral Resource Classification

The Mineral Resource has been classified as Measured Mineral Resources, Indicated Mineral Resources and Inferred Mineral Resources under the guidelines of the CIM Standards on Mineral Resources and Reserves, Definitions and Guidelines prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council (2014), and procedures for classifying the reported Mineral Resources were undertaken within the context of the Canadian Securities Administrators NI 43-101.

The classification category is based upon an assessment of geological understanding of the deposit, geological and mineralisation continuity, drillhole spacing, quality control results, search and interpolation parameters, and an analysis of available density information.

The criteria reviewed for classification was as follows:

- Review of geological continuity
- Review of data quality
- Review of QA/QC
- Review of drill spacing and estimation quality statistics such as search pass, number of samples used to estimate, slope of regression.

For New Liberty, a Reserve shell and Underground Mining Stopes, and for Ndablama a Resources shell, were run in NPV Scheduler (NPVS) using input parameters outlined in Table 14-32 to Table 14-34 below.

These surfaces and volumes were used to constrain and classify Mineral Resources. This was completed to provide support that each Mineral Resource has the potential for eventual economic extraction, a key criterion for the definition of Mineral Resources under CIM guidelines. Any material outside the New Liberty Reserve shell and stopes, and Ndablama Resource shell, does not contribute to the Mineral Resource inventory.

Table 14-32: New Liberty – input parameters for Reserve shell (NPVS)

Parameter	Units	Value
Price	US$/oz	1,300
Royalty	%	3
Total selling cost	**US$/oz**	**48.50**
Mining cost	US$/t mined	1.71
Process cost	US$/t ore	20.38
G&A	US$/t ore	7.23
Refining/transport/marketing/other	US$/oz	3.50
Pit slope angle		
Larjor North	°	40
Larjor South	°	45
Latiff North	°	48
Latiff South	°	48
Kinjor North	°	45
Kinjor South	°	45
Marvoe North	°	40
Marvoe South	°	43
Weathered All	°	38
Mining recovery	%	95
Mining dilution	%	10
Process recovery		
Oxide	%	90.3
Fresh	%	92.3

Table 14-33: New Liberty – input parameters for Underground Mining Stopes

Parameter	Units	Value
Price	US$/oz	1,500
Royalty	%	3
Total selling cost	**US$/oz**	**47.00**
Mining cost	US$/t mined	45.00
Process cost	US$/t ore	20.00
G&A	US$/t ore	7.00
Total operating cost	**US$/t milled**	**73.00**
Refining/transport/marketing/other	US$/oz	3.50
Gold loss	%	0
Mining dilution	%	10
Process recovery	%	92

Table 14-34: Ndablama – input parameters for Resource shell (NPVS)

Parameter	Units	Value
Price	US$/oz	1,500
Royalty	%	3
Total selling cost	**US$/oz**	**48.50**
Mining cost	US$/t mined	1.70
Process cost	US$/t ore	20.38
G&A	US$/t ore	7.23
Transport cost	US$/t ore	7.40
Refining/marketing/other	US$/oz	3.50
Pit slope angle		
Fresh	°	43
Weathered All	°	38
Mining recovery	%	95
Mining dilution	%	5
Process recovery – Fresh	%	92.3

Ndablama is located approximately 40 km from the New Liberty Plant, around which the assumptions for transport costs are based, to support the criteria that a Mineral Resource must have reasonable prospects for eventual economic extraction.

For both New Liberty and Ndablama, the drill spacing is sufficient to allow the mineralisation zones to be modelled into coherent wireframes for each domain. Reasonable consistency is evident in the orientations, thickness and grades of the mineralised zones. At New Liberty, the main geological zone (SMUS) was modelled as well, providing a more robust model.

Validation of the historical drillholes, particularly in relation to the exact collar locations and assay results, and the availability of QA/QC information, has allowed for the classification of Measured and Indicated Mineral Resources at New Liberty, and Indicated Mineral Resources at Ndablama. A summary of the classification codes applied in the models is shown in Table 14-35.

Table 14-35: Class field and description

Class	Description
1	Measured Mineral Resource
2	Indicated Mineral Resource
3	Inferred Mineral Resource
9	Unclassified – All waste material not estimated as well as: • <u>New Liberty</u> – Estimated material outside a US$1,300/oz gold price and assumptions regarding operating costs and recoveries optimised pit shell, and below this optimised pit shell; and outside US$1,500/oz gold price and assumptions regarding operating costs and recoveries Underground Mining Stopes (optimised at 1.90 g/t Au cut-off). • <u>Ndablama</u> – Estimated material outside a US$1,500/oz gold price and assumptions regarding operating costs and recoveries optimised pit shell.

For Measured and Indicated Mineral Resources, the specific criteria for each deposit is summarised in Table 14-36. No part of the Mineral Resource estimate for Ndablama has been assigned as Measured Mineral Resources. MINZON = 30 had insufficient drill density to be classified as Indicated Mineral Resources and was therefore classified as Inferred Mineral Resources.

In the case of Ndablama, risk indices (Risk Index) built on CS realisations (further described in Section 14.6.2), was used to assist in classification decisions.

Table 14-36: Additional specific criteria for the classification of Measured and Indicated Mineral Resources

Deposit	Criteria				MINZON	Comment
	Search pass	No. of samples	Slope of regression	Drill spacing		
New Liberty	1	8	>0.75	20 m x 20 m	1–8, 14, 16–22, 24–26	Measured Mineral Resources defined using a wireframe created around blocks where SLOPE>0.75, KV<0.25 and blocks estimated in first search pass.
	1	8	>0.50	40 m x 40 m	1–7, 9–13, 16–22, 24–26, 28	Indicated Mineral Resources defined using a wireframe created around blocks where SLOPE>0.5, KV<0.5 and blocks estimated in first search pass. Remainder Inferred Mineral Resources within Reserve shell and Underground Mining Stopes.
Ndablama	1	4	>0.50	50 m x 30 m	10, 20	Indicated Mineral Resources defined using a wireframe created around blocks where SLOPE>0.5, Risk Index<75 and blocks estimated in first search pass. Remainder Inferred Mineral Resources within Resource shell.

Figure 14-47 shows the classified New Liberty block model in 3D view, alongside the constraining Reserve shell and Underground Mining stopes. The classified Ndablama block model is shown in 3D view in Figure 14-48, alongside the constraining Resource shell.

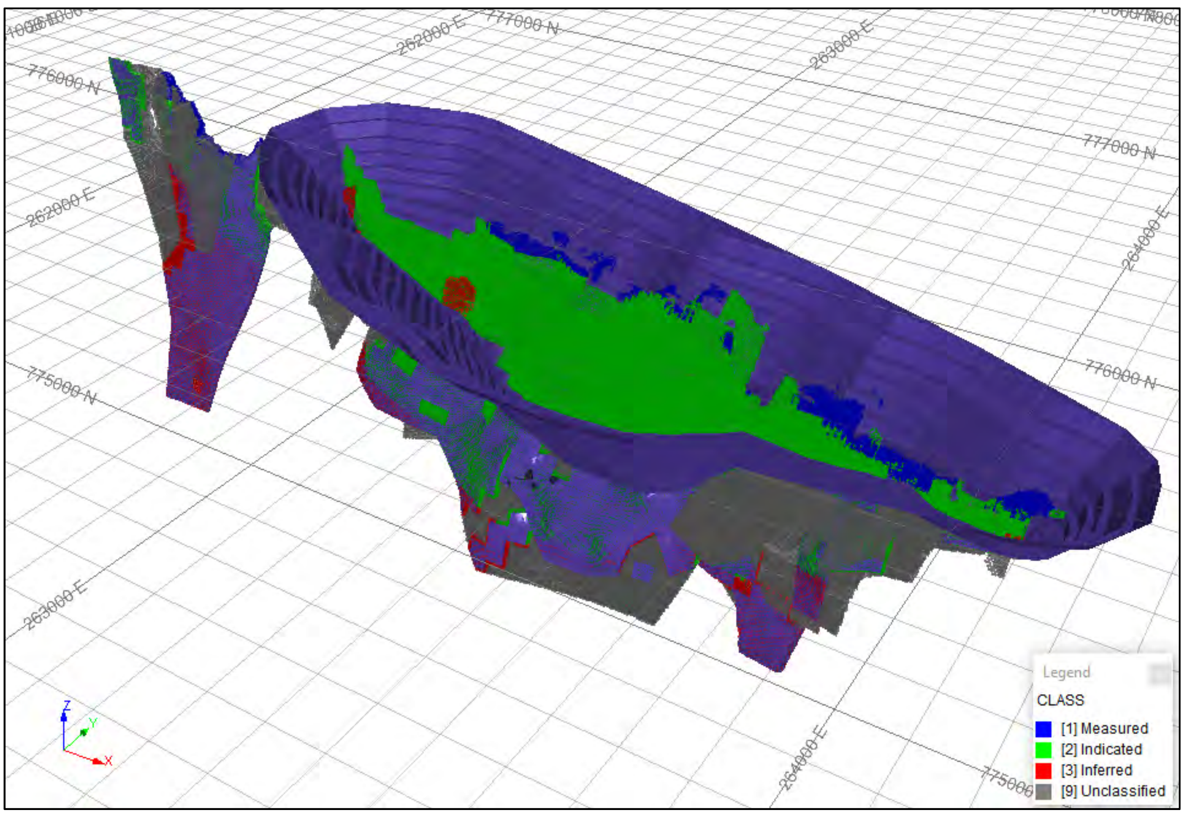


Figure 14-47: New Liberty – 3D view of the classified Mineral Resource and constraining US$1,300 optimised pit shell, and US$1,500 Underground Mining Stopes (optimised at 1.90 g/t Au cut-off)

Note: Unclassified material in grey (falls outside optimised pit shell and Underground Mining Stopes). Depleted to 31 December 2018. View towards northwest.

Source: CSA Global, 2018

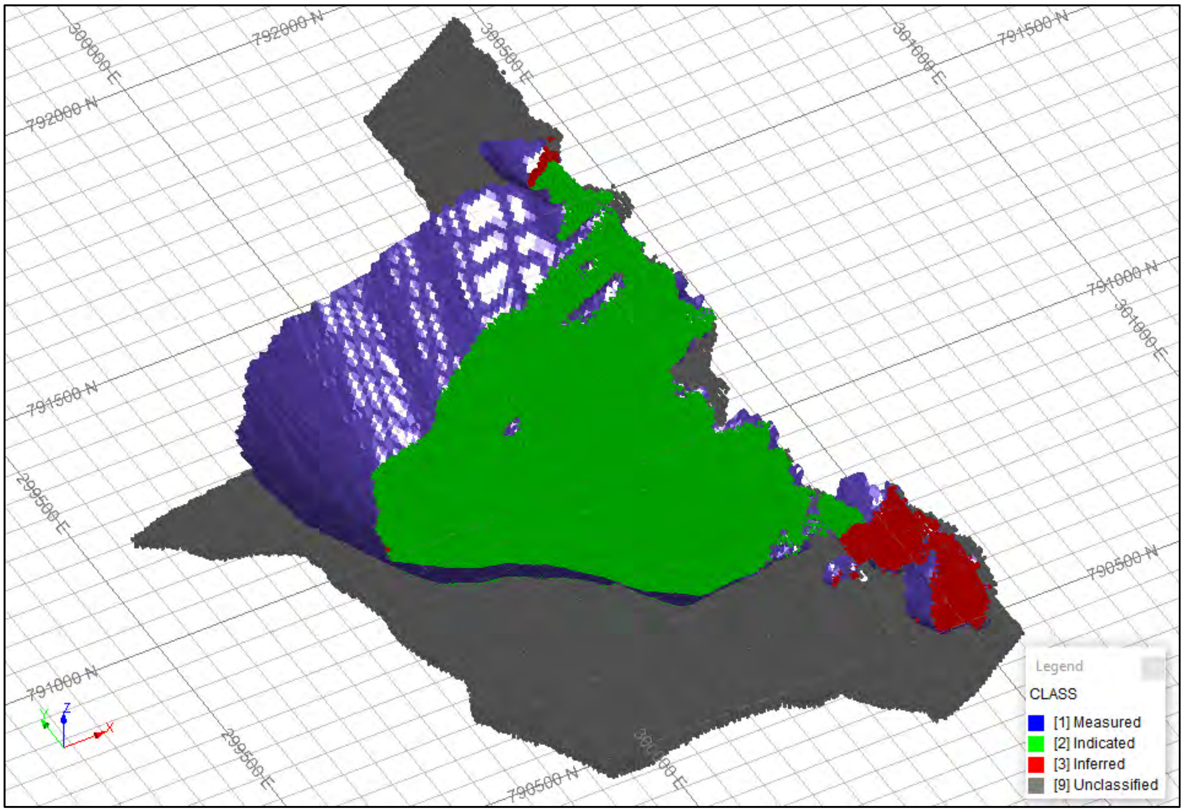


Figure 14-48: Ndablama – 3D view of the classified Mineral Resource and constraining US$1,500 optimised pit shell

Note: Unclassified material in grey (falls outside optimised pit shell). No depletion. View towards northeast. Source: CSA Global, 2018

14.6.2 Risk Analysis for Ndablama

Following the previous Ndablama MRE (AMC, 2014), a campaign of infill and step-out drilling during 2018 demonstrated that even though the predicted volume and mineralisation continuity, as modelled at a 0.1 g/t Au cut-off and guided by the main shear zone, remains reasonable, grade is highly variable within the main mineralised domain, which adds risk to the estimated metal content. Visual correlations can be seen between some higher-grade intersections, particularly >0.5 g/t Au, that broadly align with the main shear zone. However, in some cases these very high-grade intersections can occur in close association with low-grade intersections, as was also noted by AMC (2014).

The goal of estimation is to provide the "best" estimate for a block or panel. This is achieved in any kriging procedure by reducing the estimation variance to a minimum thus making kriging-based estimators the most adapted to estimating in-situ resources.

However, the price we pay for accessing the best estimator is via a smoothing of the underlying grade profile which makes any kriged estimator (the TC estimate is just a particular type of kriging) ill-adapted to handle issues related to grade uncertainty. To perform risk analysis, Conditional Simulation (CS) is better suited, as a family of realisations is produced, representing a range of equally probable possibilities of the underlying unknown reality. CS (conditional: data values are honoured at data locations) reproduce the input histograms and variograms of the target distributions.

CSA Global notes that the CS work for Ndablama was focussed on the risk attached to grade variability within the main domain, based on the geology and mineralisation as it is currently understood. The reason for the occurrence of the extreme outliers is unknown. The first and foremost recommendation for risk mitigation is the advancement of the geological and structural model for the deposit, in order to place the mineralisation into a geological context which might justify the selection of an appropriate estimation/simulation method.

Due to the high-grade variability within the main mineralisation domain at Ndablama, CS is considered to be the best approach in assessing grade uncertainty and risk attached to the in-situ resource.

Individually, while a singular realisation from a CS study may faithfully reproduce the global non-spatial distribution of grades within a study area, it lacks the spatial resolution on grade distribution that is typically desirable for mine planning purposes. The result of CS is that the grade of a block for an individual realisation has a high degree of local error. However, simulation also reproduces the continuity (variogram) of the input data and recognises that there are multiple equally likely models of reality that exist.

Several test runs have been run for MINZON = 10, both at panel level (25 m x 25 m x 5 m) and SMU level (5 m x 5 m x 5 m). Platforms of 50 CS realisations were produced (either by averaging of target point simulation or by direct block simulation) at both levels to allow this rapid sensitivity testwork to be performed. The simulation realisations are obtained by first co-simulating the background grade and the indicator variable and by then using these to reconstruct each grade realisation (the TC model method is described in Section 14.5.4).

CSA Global found that the TC model methodology, as developed by Rivoirard *et al*. (2010), is the only model in this situation (highly skewed distributions) that yields realisations that are model-consistent (models that are internally consistent) which means in particular that the various realisations hover around the benchmark provided by the TC estimate, making them an adapted platform for risk analysis.

Figure 14-49 shows vertical swath plots, comparing input Au composites and the resulting TC estimate, as well as five randomly selected simulations (SIMS), and the simulation mean in MINZON = 10. The plot shows that areas with greater data support results in a more reliable estimate, with less variance in grade, as demonstrated by the close correlation of the example simulations to the estimate grade and the input composites.

The estimation and simulation results shown in Figure 14-50 further illustrates the high degree of grade variability.

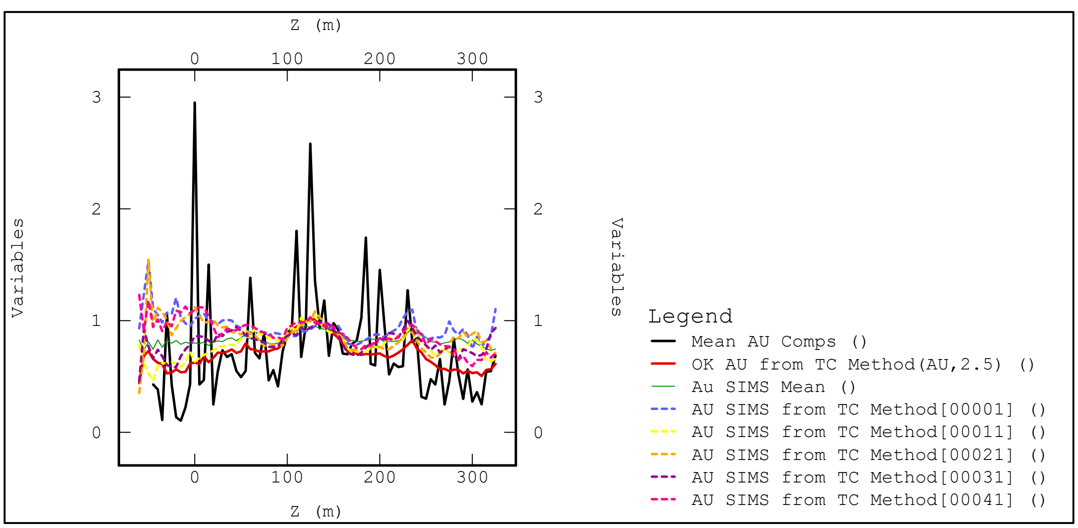


Figure 14-49: Ndablama – vertical swath plots of input Au composites and resulting TC estimate plus five randomly selected realisations (SIMS), and simulation mean in MINZON = 10 (5 m slices)
Source: CSA Global, 2018

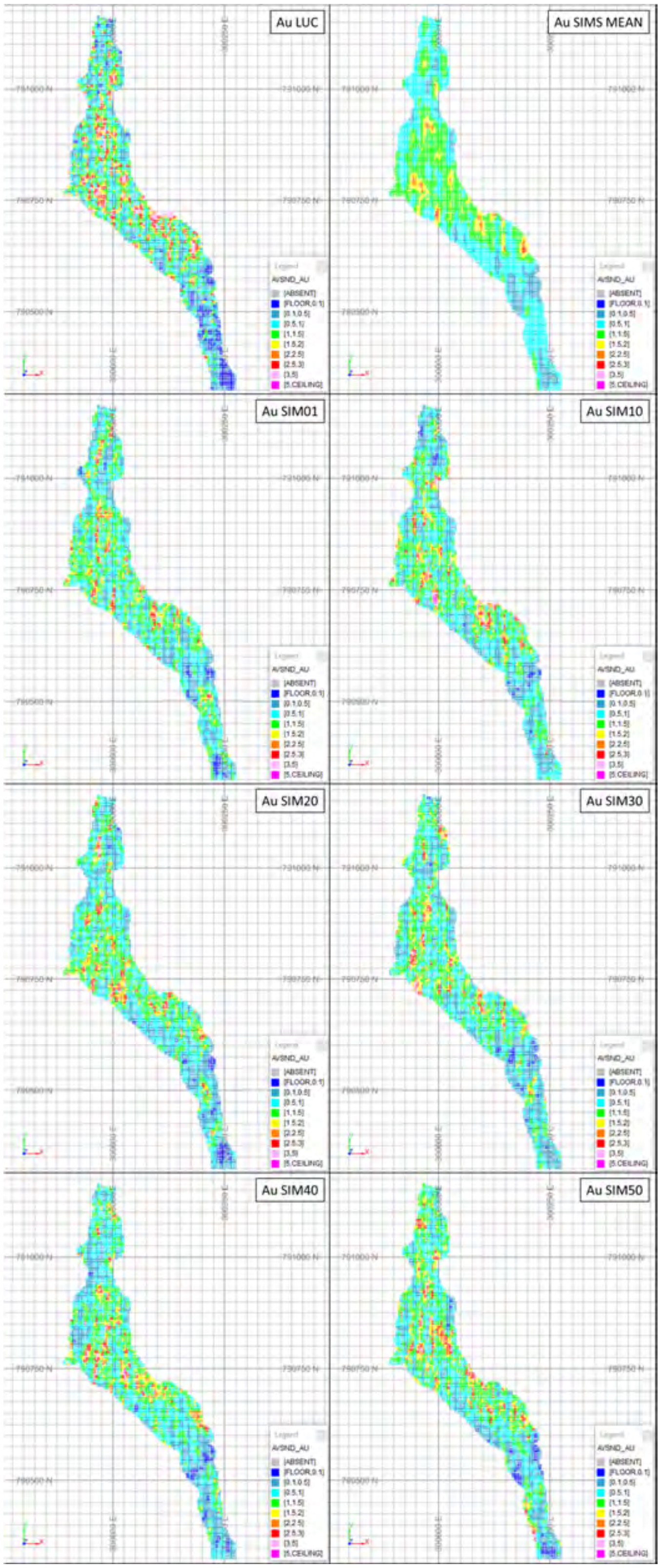


Figure 14-50: Ndablama – example of bench plotting (130 m elevation) of the Au grade characterising the grade variability

Note: The results shown are of the TC estimate (Au LUC), simulation mean (AU SIMS MEAN), and six randomly selected realisations (Au SIM01, Au SIM10, Au SIM20, Au SIM30, Au SIM40, Au SIM50) in MINZON = 10.

Source: CSA Global, 2018

In particular, the CS realisations can be used to build risk indices. For example, confidence intervals can be built to characterise the level of local confidence that can be attached to the local estimates. In this case, the spread of the distribution of CS realisation values for each panel was characterised in order to calculate their standard deviation (example shown in Figure 14-51). The result captures the spread of possibilities, which is large in less informed areas and much narrower in well-informed parts of the deposit (also apparent in Figure 14-49).

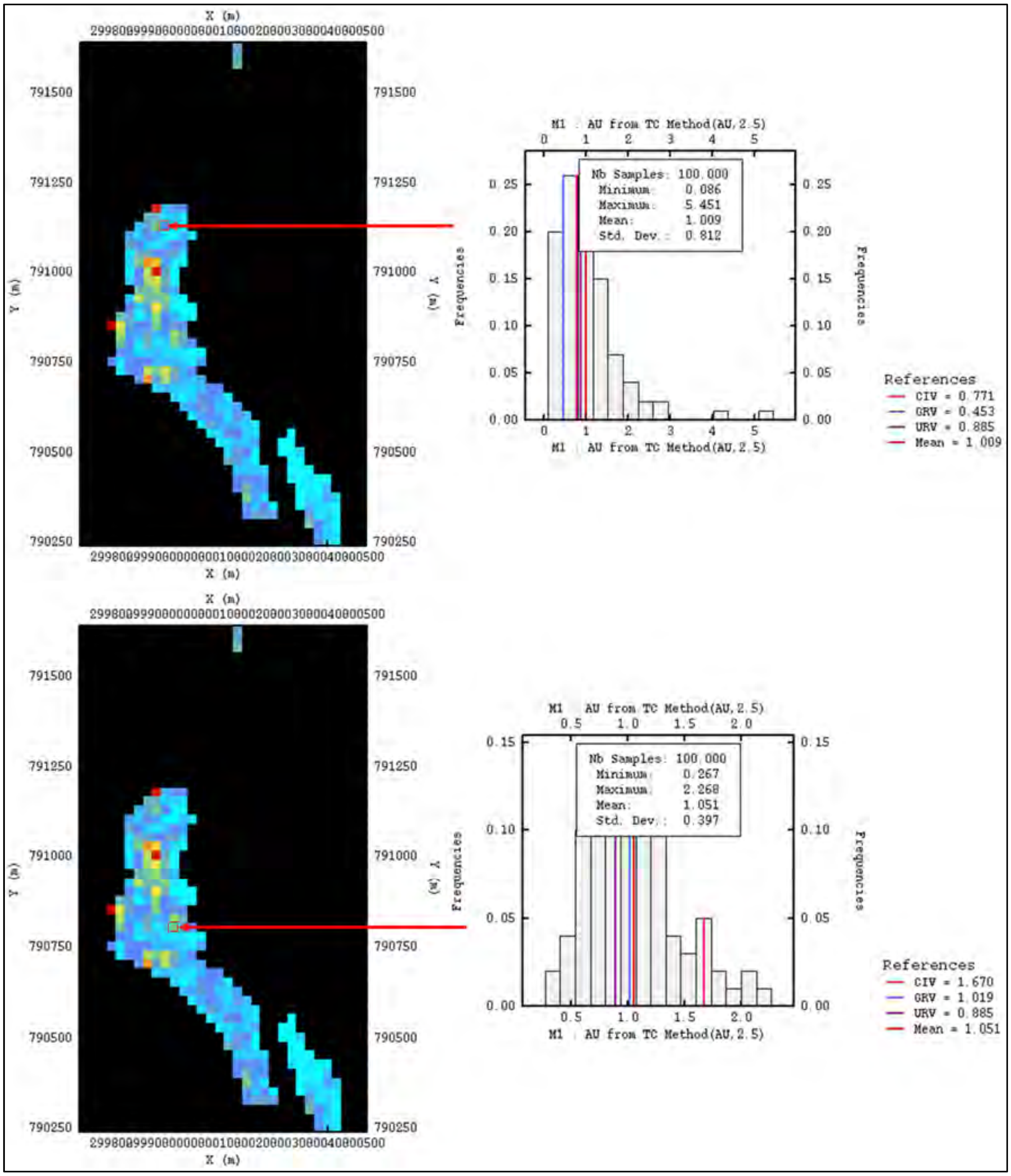


Figure 14-51: Ndablama – example of the local distribution of panel grade values used during risk analysis

Note: The spread of the distribution of CS realisation values for the two panels highlighted was characterised in order to calculate their standard deviation (Std. Dev.), where the spread of possibilities is larger in less informed areas (towards the edge of modelled mineralisation) and much narrower in well-informed parts of the deposit (towards the middle of modelled mineralisation).

Source: CSA Global, 2018

A risk index (local variability index) can be defined as follows:

$$\text{Risk Index} = 2 * 100 * \text{Stdev Au SIMS} / \text{Mean Au SIMS}$$

The result is expressed in percent and fully characterises the local precision of the local estimate, where a value of 50% indicates an estimate with a precision level of ±25%, and a value of 100% equates to a precision level of ±50%.

Figure 14-52 shows an example plot of the Risk Index (variability index) for a random bench and demonstrates the influence of drilling and conditioning on the precision of the local estimates.

A further analysis of the distribution of that risk index shows that the grade estimates are, as expected, still marked with a substantial relative uncertainty and that locally the fluctuations between estimated and realised grades can still be (very) important. The index suggests that around one-third of the panels are estimated with a ±33% local precision, but that two-thirds of the panels (the majority) are estimated with an average local precision of approximately ±60%.

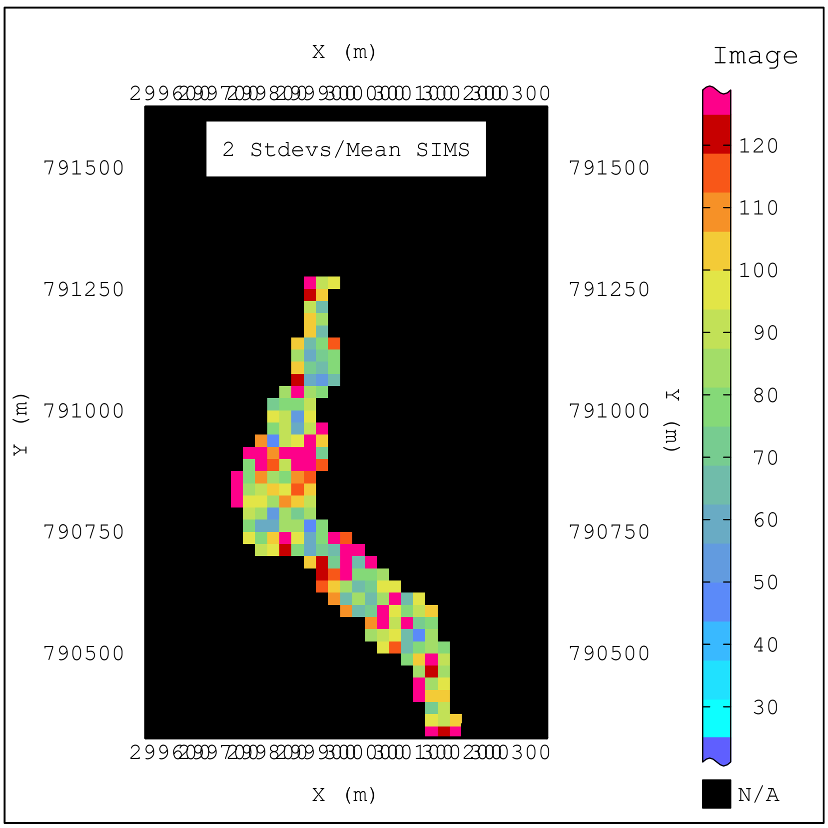


Figure 14-52: Ndablama – example of bench plotting of the Risk Index (expressed in %) characterising the spread of 25 m x 25 m x 5 m Au simulations in MINZON=10
Source: CSA Global, 2018

Various types of probability maps can also be built using the CS realisations. By creating multiple realisations, the probability of a block being above cut-off can be calculated and hence a likelihood or risk of a desired outcome can be determined. For example, mapping the probability of exceeding a key cut-off grade (e.g. 0.5 g/t Au) at panel or SMU level can be determined by calculating the number of realisations exceeding that threshold and dividing it by the total number of simulations produced. The map below (Figure 14-53) shows the probability of exceeding the 0.5 g/t Au at SMU level for two benches picked at random in the deposit. These probabilities can be calculated at different cut-offs and can prove invaluable inputs to the risk analysis around the selectivity of the deposit.

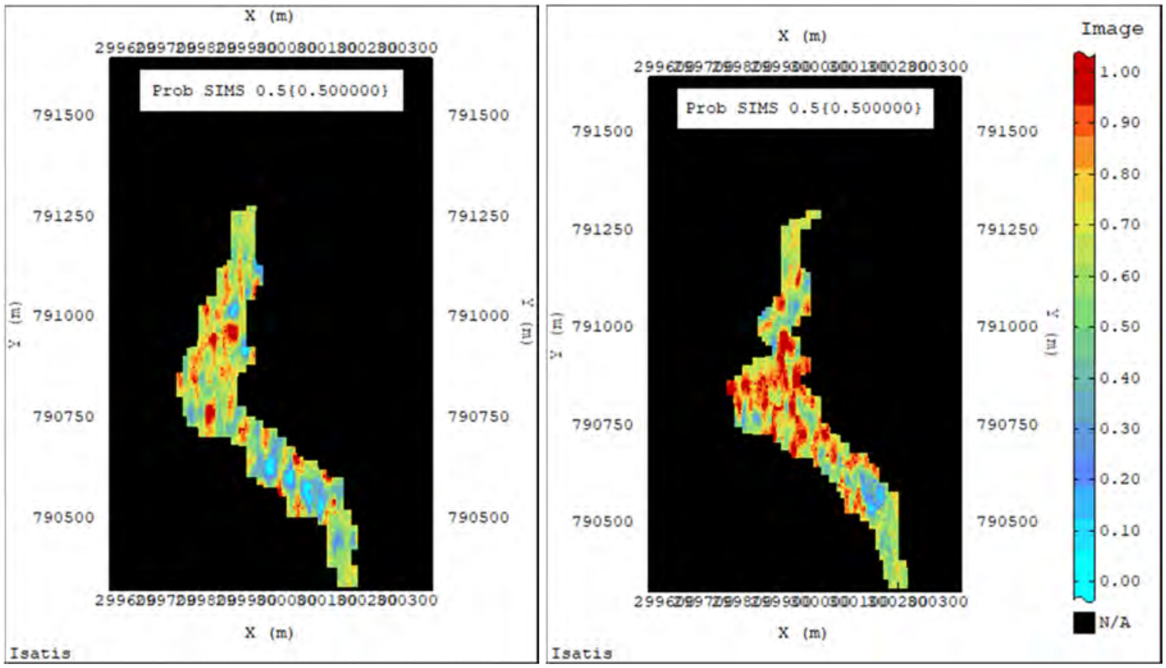


Figure 14-53: Ndablama – probability of exceeding the 0.5 g/t Au at SMU level for two benches picked at random in the deposit (the probability scale is shown on the right)

Source: CSA Global, 2018

CSA Global notes that the Risk Index is not an absolute measure, but a relative measure of the risk of recovery of the expected value. The Risk Index, in combination with estimation statistics (slope of regression, kriging variance, number of samples used to estimate, search volume), drillhole spacing, data quality and QA/QC, volume and mineralisation continuity (as modelled at a 0.1 g/t Au cut-off and guided by the main shear zone), was used to inform classification decisions made.

The Indicated Mineral Resources for Ndablama were classified taking all of the above into account; however, CSA Global stresses that the outcome of the Risk Analysis highlights the variable nature of the high grade areas of the deposit and that selective mining at 5 m x 5 m x 5 m, at a selected cut-off, does carry a high degree of risk.

14.7 Mineral Resource Statement

The MRE is shown in Table 14-37 as at 31 December 2018. The MRE compiled by CSA Global has been classified and is reported as Measured Mineral Resources, Indicated Mineral Resources and Inferred Mineral Resources under the guidelines of the CIM Standards on Mineral Resources and Reserves, Definitions and Guidelines prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council (2014), and procedures for classifying the reported Mineral Resources were undertaken within the context of the Canadian Securities Administrators NI 43-101.

Table 14-37: New Liberty and Ndablama Mineral Resource statement as at 31 December 2018

Mineral Resource estimate for the New Liberty and Ndablama Gold Projects, Liberia, as at 31 December 2018												
Deposit	**Measured**			**Indicated**			**Measured and Indicated**			**Inferred**		
	Tonnes (Mt)	**Au grade (g/t)**	**Au metal (koz)**	**tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**
New Liberty OP	0.19	1.82	10.9	4.48	3.49	503.0	4.67	3.42	513.9	0.0	1.7	2
New Liberty UG	0.18	2.85	16.4	5.90	3.32	630.0	6.08	3.30	646.3	2.7	3.0	253
Ndablama OP				9.72	1.88	588.0	9.72	1.88	588.0	0.3	1.6	16
Total	**0.37**	**2.32**	**27.3**	**20.10**	**2.66**	**1,720.9**	**20.47**	**2.66**	**1,748.2**	**3.0**	**2.8**	**271**

Notes:

- *Reporting cut-off for New Liberty is 0.80 g/t Au for Open Pit (OP), reported above a surface based on the shell from a US$1,300 gold price pit optimisation run to support reasonable prospects for eventual economic extraction. The New Liberty Underground Mining (UG) is reported below the US$1,300 shell, within stope volumes based on a US$1,500 gold price optimisation at 1.90 g/t cut-off (reported at no cut-off), run to support assumptions relating to reasonable prospects of eventual economic extraction.*
- *Reporting cut-off for Ndablama Open Pit (OP) is 0.85 g/t Au, reported above a surface based on the NPVS shell from a US$1,500 gold price pit optimisation run to support assumptions relating to reasonable prospects of eventual economic extraction.*
- *The New Liberty MRE has been depleted for mining up to 31 December 2018. The effective date of the New Liberty Mineral Resource is 31 December 2018.*
- *The Ndablama MRE has not been depleted, since there has been no previous mining. The effective date of the Ndablama Mineral Resource is 24 November 2018.*
- *Figures have been rounded to the appropriate level of precision for the reporting of Mineral Resources.*
- *Due to rounding, some columns or rows may not compute exactly as shown.*
- *The Mineral Resources are stated as in situ dry tonnes. All figures are in metric tonnes.*
- *The Mineral Resource has been classified under the guidelines of the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Standards on Mineral Resources and Reserves, Definitions and Guidelines prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council, and procedures for classifying the reported Mineral Resources were undertaken within the context of the Canadian Securities Administrators National Instrument 43-101 (NI 43-101).*
- *Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability. The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, title, taxation, socio-political, marketing, or other relevant issue.*
- *Mineral Resources have been reported inclusive of Mineral Reserves, where applicable.*

The grade versus tonnage curves for the Measured Mineral Resources and Indicated Mineral Resources categories for the New Liberty open pit and underground mining are shown in Figure 14-54 and Figure 14-55.

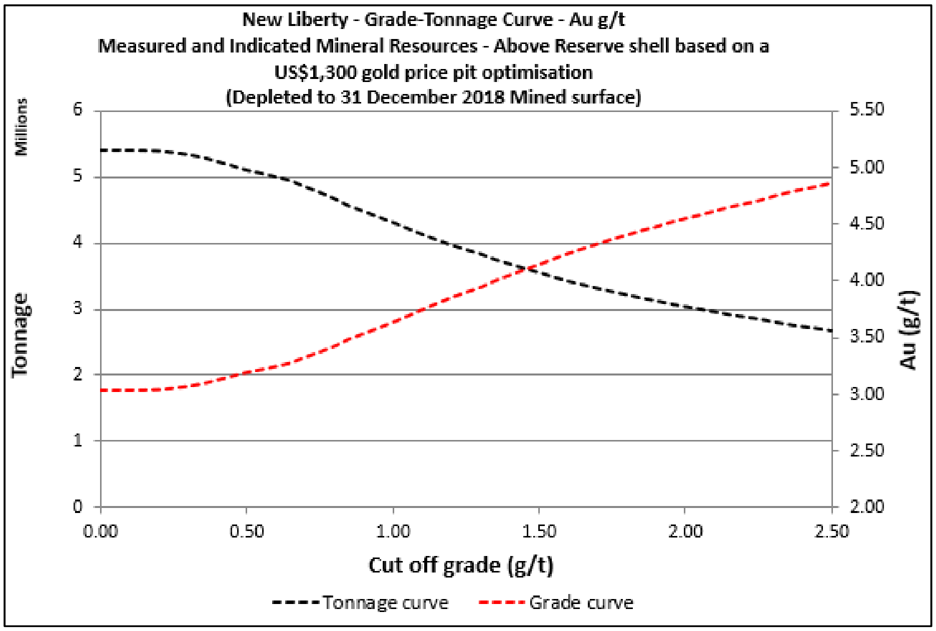


Figure 14-54: New Liberty grade-tonnage curve – Open Pit (Measured and Indicated Mineral Resources)

Source: CSA Global, 2018

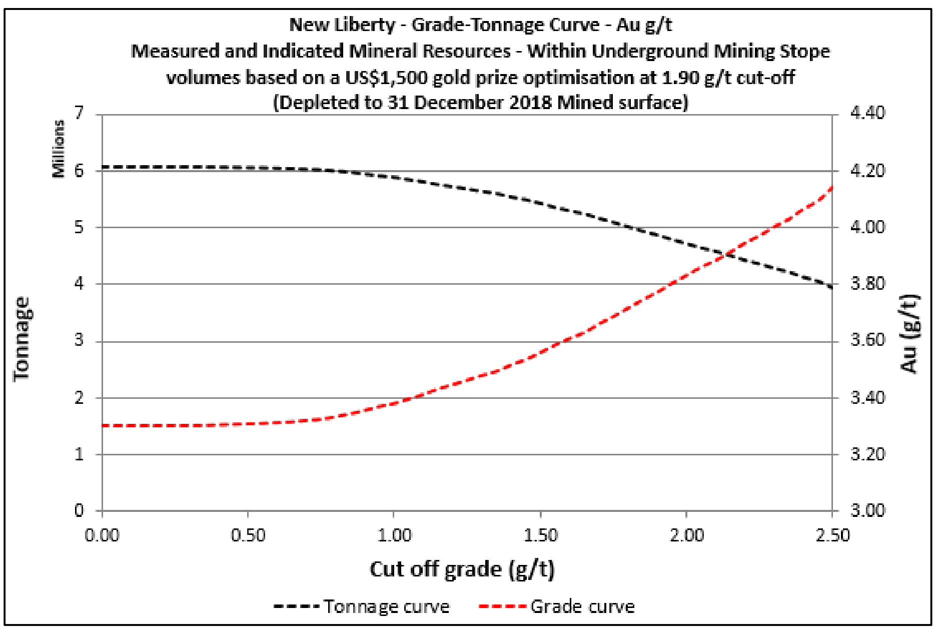


Figure 14-55: New Liberty grade-tonnage curve – Underground (Measured and Indicated Mineral Resources)

Source: CSA Global, 2018

The grade versus tonnage curves for the Indicated Mineral Resources category for Ndablama is shown in Figure 14-56.

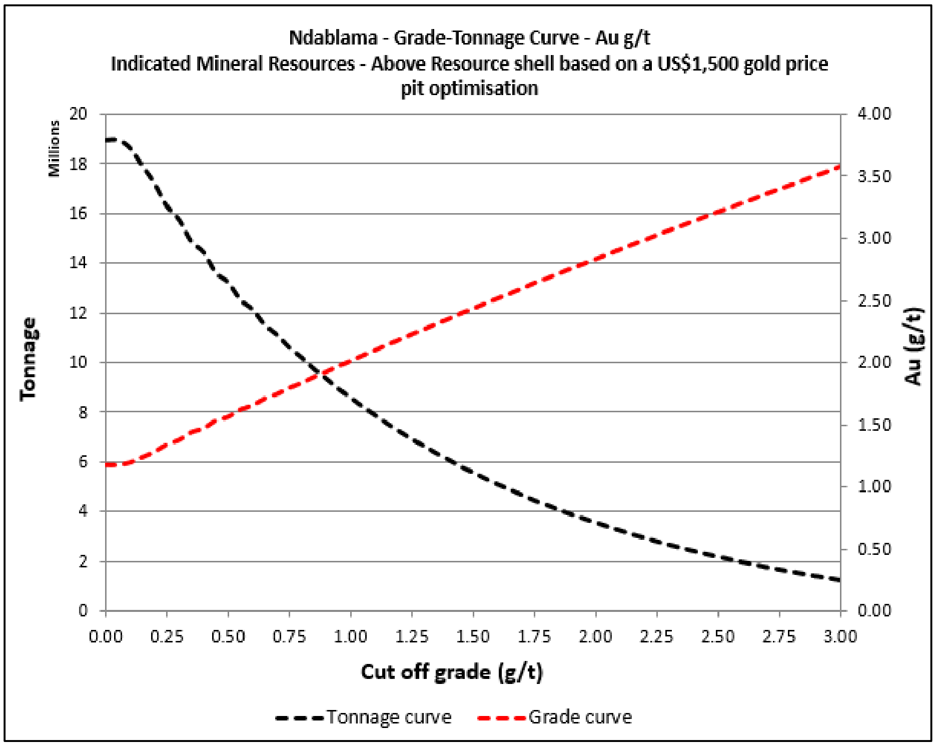


Figure 14-56: Ndablama grade-tonnage curve – Indicated Mineral Resources
Source: CSA Global, 2018

14.8 Comparison with Previous Estimates

The previous New Liberty MRE was reported by SRK as at 31 July 2017 and is detailed in the 2017 Technical Report (SRK, 2017). The Mineral Resource statement from 2017, 2018 and percentage differences between the two is presented in Table 14-38. The reasons for changes, subject to the limitations and assumptions, are outlined below:

- The reporting cut-off for Open Pit is the same at 0.80 g/t Au. However, the reporting of Underground Mining has changed from reporting all contiguous material below the optimised pit shell at a cut-off of 2.00 g/t Au, to reporting all material within optimised stopes at no cut-off.
- The resource shells are different. The shell used to constrain the 2017 model used a gold price of US$1,500/oz, whereas the 2018 model uses a constraining shell based on a gold price of US$1,300/oz.
- MRE 2017 reported Underground Mining as material below a US$1,500/oz gold shell, with lower-grade material within thinner (and less contiguous) zones of mineralisation removed using Deswik's Mining Stope Optimizer (SO) as a spatial guide.
- MRE 2018 reported Underground Mining as material below a US$1,300/oz gold shell, within stope volumes based on a US$1,500 gold price optimisation at 1.90 g/t cut-off (reported at no cut-off).
- MRE 2017 depleted with mining up to 31 July 2017. MRE 2018 depleted with mining up to 31 December 2018.
- Additional infill drilling resulted in an increase in confidence and upgrading of Inferred Mineral Resources to Indicated Mineral Resources.
- Changes to the mineralisation and weathering models are as a result of the additional drilling, leading to re-interpretation below the current mined (31 December 2018) pit surface. Previously, grade shells were produced at a 0.3 g/t cut-off for Kinjor and Larjor, and 0.5 g/t cut-off for Marvoe (SRK, 2017). The current grade shells for Marvoe, Kinjor and Larjor were modelled on mineable intercepts at a cut-off of 0.5 g/t Au with a minimum true thickness of 3 m.

The reported New Liberty Mineral Resource has changed as follows:

- The Open Pit Measured and Indicated Mineral Resources (M&I) have decreased by 3.93 Mt (46%) for a decrease in metal of 391.1 koz (43%).
- Open Pit Inferred Mineral Resources have decreased by 3.6 Mt (99%) for a decrease in metal of 323 koz (99%).
- The Underground M&I Mineral Resources have increased by 5.48 Mt (914%) for an increase in metal of 581.3 koz (894%).
- Underground Inferred Mineral Resources have decreased by 0.1 Mt (5%) for a decrease in metal of 42 koz (14%).

The previous Ndablama MRE was reported by AMC as at 1 December 2014 and is detailed in the 2014 Technical Report (AMC, 2014). The Mineral Resource Statement from 2014, 2018 and percentage differences between the two is presented in Table 14-39. The reasons for changes, subject to the limitations and assumptions, are outlined below:

- The reporting cut-off has increased from 0.50 g/t to 0.85 g/t Au.
- The resource shells are different. The shell used to constrain the 2014 model used a gold price of US$1,700/oz, whereas the 2018 model uses a constraining shell based on a gold price of US$1,500/oz.
- Additional infill drilling resulted in an increase in confidence and upgrading of Inferred Mineral Resources to Indicated Mineral Resources.
- Changes to the mineralisation and weathering models are as a result of the additional drilling, leading to reinterpretation.
- No mining to date.

The reported Ndablama Mineral Resource has changed as follows:

- The Indicated Mineral Resources have increased by 2.13 Mt (28%) for an increase in metal of 202.5 koz (53%).
- Inferred Mineral Resources have decreased by 9.3 Mt (97%) for a decrease in metal of 499 koz (97%).

Table 14-38: New Liberty MRE comparison – 31 July 2017 vs 31 December 2018

Model	Measured			Indicated			M&I			Inferred		
	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)
MRE 2017 OP	0.10	3.60	15.00	8.50	3.30	890.0	8.60	3.30	905.0	3.6	2.8	325
MRE 2018 OP	0.19	1.82	10.9	4.48	3.49	503.0	4.67	3.42	513.9	0.0	1.7	2
% Difference OP	**87%**	**-50%**	**-27%**	**-47%**	**6%**	**-43%**	**-46%**	**4%**	**-43%**	**-99%**	**-40%**	**-99%**
MRE 2017 UG				0.60	3.30	65.0	0.60	3.30	65.0	2.8	3.3	295
MRE 2018 UG	0.18	2.85	16.4	5.90	3.32	630.0	6.08	3.30	646.3	2.7	3.0	253
% Difference UG				**884%**	**1%**	**869%**	**914%**	**0%**	**894%**	**-5%**	**-11%**	**-14%**

Notes:

- *MRE 2017 reported at 0.80 g/t Au Open Pit (US$1,500/oz gold), and 2.00 g/t Au Underground Mining (below US$1,500/oz gold shell, with lower-grade material within thinner (and less contiguous) zones of mineralisation removed using Deswik's Mining Stope Optimizer (SO) as a spatial guide).*
- *MRE 2018 reported at 0.80 g/t Au Open Pit (US$1,300/oz gold), and 1.90 g/t Au Underground Mining (below US$1,300/oz gold shell, within stope volumes based on a US$1,500 gold price optimisation at 1.90 g/t cut-off, reported at no cut-off).*
- *MRE 2017 depleted with mining up to 31 July 2017. MRE 2018 depleted with mining up to 31 December 2018.*
- *Due to rounding, some columns or rows may not compute exactly as shown.*

Table 14-39: Ndablama MRE comparison – 1 December 2014 vs 24 November 2018

Model	Indicated			Inferred		
	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)	Tonnes (Mt)	Au grade (g/t)	Au metal (koz)
MRE 2014	7.59	1.58	385.5	9.6	1.7	515
MRE 2018	9.72	1.88	588.0	0.3	1.6	16
% Difference	**28%**	**19%**	**53%**	**-97%**	**-6%**	**-97%**

Notes:

- *MRE 2014 reported at a 0.50 g/t Au cut-off, MRE 2018 reported at 0.85 g/t Au cut-off.*
- *MRE 2104 constrained within a US$1,700/oz gold conceptual pit shell, MRE 2018 constrained within a US$1,500/oz gold conceptual pit shell.*
- *No depletion, no previous mining.*
- *Due to rounding, some columns or rows may not compute exactly as shown.*

15 Mineral Reserve Estimates

The Mineral Reserves for the New Liberty and Ndablama deposit have been reported using the CIM Code. The Mineral Reserves are part of the Mineral Resources as stated in Section 14. The CIM Code defines a Mineral Reserve as:

"the economically mineable part of a Measured or Indicated Mineral Resource demonstrated by at least a Preliminary Feasibility Study. This Study must include adequate information on mining, processing, metallurgical, economic and other relevant factors that demonstrate, at the time of reporting, that economic extraction can be justified. A Mineral Reserve includes diluting materials and allowances for losses that may occur when the material is mined."

An optimisation process was used to define the optimal pit limits, based on the parameters described in Section 16.1.1 and 16.3.1. The optimised pit limit was then used as a guide to produce an engineered pit design that incorporates ramps and other practical mining constraints.

The pit design was then evaluated against the block model and the appropriate modifying factors applied to determine the Mineral Reserve.

The key assumptions used in determining the Mineral Reserve are listed in Section 16.2.

15.1 Key Assumptions

15.1.1 Open Pit Environs

The pit slopes at New Liberty are based on the recommendations presented in AMC's geotechnical review dated 13 December 2016 and on operational experience gained over the first few years. The recommended overall pit slopes for weathered material are 38° and 42–48° for fresh material. The pit slopes for Ndablama are based on the recommendations listed in Section 1 7.3 of this report. The overall pit slope angle varies from 43° to 55°, depending on the direction of the pit wall.

A long-term metal price of US$1,300/oz has been adopted for the PFS (see Section 19 for detail).

The operating costs of US$1.71/t mined for New Liberty are based on a combination of actual data and an assumed contract mining cost as the transition to mining contractor has not been finalised at the time of writing this report. The negotiations are however at an advanced stage and there is sufficient evidence to justify the assumed costs.

Ndablama will be operated by the same mining contractor once the open pit operations at New Liberty have been completed. Similar equipment and mining methods will be used at both operations and it is reasonable to use a similar mining cost for Ndablama of US$1.7/t mined. Ore from Ndablama will be transported 46 km to the main plant at New Liberty for processing. The operating cost for transport of ROM material has been estimated to be US$5.95/t hauled. This includes provision for road maintenance.

Processing costs of US$21/t have been assessed based on current performance of the mill. Additionally, a G&A cost applied to all ore processed at New Liberty of US$7.23/t has been applied.

15.1.1.1 Pit Optimisation and Phase Design

The pit optimisation was run in NPV Scheduler, which uses the standard Lerch Grossman (LG) algorithm. The output is in the form of pit shells that are based on a Price Factor that ranges from 2% to 120%. The selected pit shell accounts for the decreasing incremental value with Price Factor and the impacts of discounted cashflow at an assumed mining rate of 1.6 Mt/a of ore and a 5% discount rate.

The pit design was carried out in Datamine Studio.

The factors for Ndablama are based on a two-stage approach. Firstly, the Resource model was regularised to a block size of 10 m x 10 m x 5 m and then further modifying factors of 95% and 5% respectively were applied to the bench reserves to account for mining recovery and dilution. The waste dilution is applied at zero grade.

The methodology used at Ndablama was considered necessary as this is a greenfield site with no production data to base the assumptions on. The modelling method used to determine the Resource model is also more complicated (Localised Uniform Conditioning) and suggests that the mineralisation will be more dispersed (nugetty) than New Liberty, which justifies the higher combined factors of 90% mining recovery and 18% waste dilution.

15.1.2 Underground Environ

A long-term metal price of US$1,300/oz has been adopted for the PFS (see Section 19 for detail).

The operating cost estimated for underground mining at New Liberty is $47/t (RoM tonne). This cost was base estimated by applying the rates obtained from a mining contractor to the mining schedule physical quantities presented in Section 16.2.9.

Processing costs of US$21/t have been assessed based on current performance of the mill. Additionally, a G&A cost applied to all ore processed at New Liberty of US$7.23/t has been applied.

15.1.2.1 Mining Recovery and Dilution

For the New Liberty underground mine the following modifying factors were applied:

Cut-off grade

A cut-off grade calculation was performed and is shown in Table 16.14 in Section 16.2. The breakeven grade is 2.0 g/t. The breakeven grade of 2.0 g/t was applied as the cut-off grade to determine which stopes should be mined. All stopes with an in-situ grade of 2.0 g/t or higher were considered for the mine plan, while stopes with grade below 2.0 g/t were not included in the plan. In addition, only stopes which included indicated or measured resources were included in the plan. No inferred resources were included in the mine plan, irrespective of the grade of the inferred resource.

Pillar loss

Pillar losses were calculated based on the pillar dimensions and spans detailed in the geotechnical report. An allowance was made for an 8 m pillar every 22 m (skin to skin) along strike. Although an 8 metre pillar every 22 m amounts to a pillar loss of 27%, this is not the average many stopes do not require a pillar, such as stopes at the end of the strike extent of a block, or single stope blocks surrounded by unpay material. The average pillar loss amounted to 17%.

Dilution

There are two types of dilution included in stopes. The first is planned dilution. In selecting a stope shape that is:

a) large enough to warrant mining, i.e. larger than the smallest mining unit,

b) is a shape that can be practically mined,

Some material that is below the cut-off grade is unavoidably included in the stope. This is referred to as planned dilution.

The second category of dilution is a practical result of inaccuracy in mining. This could be due to drilling inaccuracy, suboptimal blasting practices, ground conditions or even backfill loaded with the ore. Typically, in an open stoping environment such as this this is accepted to be around 10 percent. We have not accounted for any grade in this dilution. It is possible that the dilution tonnage does contain some gold content but since we cannot say for certain what the source of the dilution will be we have not assumed it to be at zero grade.

Planned dilution which is unpay material included in the stope shapes amounted to 11% of stope tonnes. Unplanned dilution of 10 % at zero grade was applied to the stope tonnage.

Ore Extraction

Ore extraction in the stopes is assumed to be 100 %. Ore loading will be done by remote loader so no ore should be left in the stopes. However, the stopes directly below the open pit will be mined last in the mining schedule. It can be expected that there will be significant ground control problems with these stopes as the rock around the pit will be fractured weathered. An extraction of 50% has been allowed for in these stopes in the mining schedule. This drops the overall extraction from the stopes to a weighted average of 96%.

15.1.3 Metallurgical Recovery

The process recovery factor for New Liberty and Ndablama is based on historical data. A recovery factor of 92 % has been used in this study.

15.1.4 Other Costs

Allowances have been made for a royalty of 3% and a selling cost of US$3.5/oz.

15.1.5 Conversion Factors from Mineral Resources to Mineral Reserves

Measured and Indicated Resources have been directly converted to Proven and Probable Mineral Reserves respectively, as shown in Table 15-1.

15.2 Mineral Reserve Statement

The Mineral Reserve statement for the NLGM project is presented in Table 15-1. The independent Qualified Person, as defined by Canadian Securities Administrators National Instrument 43-101 for Mineral Reserve estimates, is Dr Matthew Randall (BSc, PhD, MIMMM, C.Eng) of Axe Valley Mining Consulting Limited, and Mr Clive Brown (Pr.Eng, MSAIMM) of Bara Consulting.

The Project base case economic analysis presented in Section 22 shows that the New Liberty Gold Mine project LOM plan founded on the Mineral Reserve estimate in Table 15-1 provides a positive present value of the net cash flow and a positive rate of return, confirming that the Mineral Reserves are economically viable, and that economic extraction can be justified.

Table 15-1: Mineral Reserve statement – New Liberty Gold Mine and Ndablama Deposit, Liberia

Mineral Reserves estimated for the New Liberty "Combined" Project, Liberia, as at 31 December 2018										
Deposit	**Cut-off grade (g/t)**	**Proven**			**Probable**			**Total Reserve**		
		Tonnes (Mt)	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**
New Liberty Open Pit	0.80	0.216	1.65	11	4.701	3.19	482	4.917	3.12	494
New Liberty Underground	2.00	0.084	3.36	9	4.575	3.07	452	4.659	3.08	461
Ndablama Open Pit	1.00	0.00	0.00	0.0	7.282	1.71	400	7.282	1.71	400
Total (excl. Stocks)		**0.300**	**2.13**	**21**	**16.559**	**2.51**	**1,334**	**16.859**	**2.50**	**1,355**
NL ROM Stockpiles (LG, MG, HG)					0.210	1.47	10	0.210	1.47	10
Total (incl. Stocks)		**0.300**	**2.13**	**21**	**16.769**	**2.49**	**1,344**	**17.069**	**2.49**	**1,365**

Notes:

1. *The Mineral Reserves have been depleted for mining up to 31 December 2018 and stated as of the same date.*
2. *Figures have been rounded to the appropriate level of precision for reporting.*
3. *Due to rounding, some columns or rows may not compute exactly as shown.*
4. *The Mineral Reserves are stated as in-situ dry metric tonnes.*
5. *The Mineral Reserves were prepared under the guidelines of the CIM, for reporting under NI 43-101.*
6. *The Reserve is reported at a US$ 1,300/oz gold price.*
7. *Modifying factors applied:*
   - *New Liberty Open Pit: mining recovery of 95% and waste dilution of 10% at 0g/t Au.*
   - *New Liberty Underground: pillar loss 17%, ore loss 4%, waste dilution 9 %*
   - *Ndablama Open Pit: mining recovery of 95% and waste dilution of 5% at 0g/t Au.*
8. *Proven Mineral Reserves were derived from Measured Mineral Resources and Probable Mineral Reserves from Indicated Mineral Resources.*
9. *There are no known legal, political, environmental, or other risks that could materially affect the potential Mineral Reserves.*

16 Mining Methods

Mining activity for the combined project will include

- open pit mining of the New Liberty deposit until the breakeven cut-off for underground mining is reached, which corresponds to pitshell 33.
- a transition to underground mining by long-hole open stoping methods (LHOS) and mining of reserves by underground methods
- open pit mining of the reserves at the Ndablama deposit and direct shipping of Ndblama ore to the New Liberty mill later in the life of the project. This section describes mining methods at both deposits.

16.1 New Liberty Open Pit

16.1.1 Pit Optimisation

There is an existing open pit mine already in operation at New Liberty. Mining methods are by conventional truck-shovel fleet operated by a mining contractor. Mining has already ceased at the Larjor pit; however, current mining plans include operation of the Kinjor and Marvoe pits until 2027 ("Pit 46"). The Project under consideration involves the re-optimization of the existing pit operation from 2019 onwards in the context of proposed underground operations and the curtailment of open pit operations at the break-even between open pit and underground mining.

A new pit optimisation for New Liberty Gold Mine was run using Datamine's NPV Scheduler (NPVS) software. This uses the standard Lerch Grossman (LG) algorithm and the results have been shown in the past to be very similar to that of Whittle. The starting surface for pit optimisation was taken from the pit survey for 31 December 2018 and the block model was depleted to this date. A constraint was added to NPVS to prevent further mining of the Larjor pit as a decision was made to mine the remaining resources under the existing Larjor pit by underground mining methods.

The parameters used in the study are shown in Table 16-1 and the geotechnical parameters are summarised in Table 16-2. The geotechnical parameters are based on the study undertaken by SRK (November 2017) and the overall slope angles have been adjusted to account for the proposed locations of the ramps. The block model used in this study was updated by CSA Global in November 2018 and has been depleted to 31 January 2018. The model does not include any allowance for mining recovery or dilution and these factors are applied in NPVS to obtain the mined quantities and the recovered metal.

Table 16-1: Pit optimisation parameters for New Liberty

Parameter	Units	Value	Comments
Mining Cost	US$/t mined	1.90	Averaged over LOM
Ore Cost Adjustment Factor	factor	1.03	Allows for grade control costs
Mining Recovery	%	95.0	From reconciliation studies
Waste Dilution	%	10.0	From reconciliation studies
Processing Cost	US$/t ore	20.12	
Process Recovery	%	92.3	
G&A	US$/t ore	7.0	Assumed for 36 Mt/a mining rate
Metal Price	US$/Troy oz	1,300	
Selling Cost	US$/Troy oz	3.5	
Royalty	%	3.0	
Discount Rate	%	5.0	
Plant Production rate (max)	Mt/a	1.8	

Table 16-2: Geotechnical parameters for New Liberty Open Pit

Pit/Area	Rock type	North wall (°)	South wall (°)
Kinjor/Marvoe	Weathered	38	38
Kinjor	Fresh	48	47
Marvoe	Fresh	48	48

16.1.1.1 Optimisation Results

The pit optimisation for New Liberty Gold Mine was run in NPVS with the Price Factor ranging from 2% to 100%. This generates a series of incremental pit shells that simulate a pseudo optimum mining sequence that will generate a mining sequence with the maximum cash flow. A total of 47 pit shells were generated using a base price of US$1,300/oz. The results are shown in Figure 16-1.

The Larjor pit was excluded from the pit optimisation, due to the curtailment of operations in the pit on account of its relatively high stripping ratio and lower grades. The remaining reserve at Larjor will therefore be mined by underground methods ahead of cessation of operations at Kinjor and Marvoe pits. A pit limit boundary string was therefore imported into NPVS to limit the extent of the maximum pit size and exclude Larjor.

By inspection of the graphs of cumulative NPV, rock and ore tonnage (Figure 16-1), it can be seen there is a rapid increase in both ore and waste tonnage after Pit Shell 39. It can also be seen that the NPV starts to level off after Pit Shell 30 and 90% of the maximum NPV is attain by moving 42% of the maximum rock tonnage.

The maximum pit size is defined by Pit Shell 46 with a price factor of 100% (US$1,300/oz). Even with increasing price, the NPV starts to decline after this point, due primarily to the increase in stripping ratio.

16.1.1.2 Transition from Open Pit to Underground Mining

Considering the diminishing incremental value beyond Pit 30, it is proposed that at some point it will become more economic to transition to underground mining than continue to expand the open pit. This was studied by looking at the pit increments between Pit 33 and Pit 46 (see Figure 16-1).

For example, if the Price Factor is increased to 100% (US$1,300/oz), the NPV5 increases from US$78 million to US$189 million, whilst the waste tonnage also increases from 74 Mt to 180 Mt. Meanwhile, the ore increases from 4.5 Mt to 8.3 Mt and the increment in ore (3.8 Mt) is at a stripping ratio of 28:1.

With an assumed mining cost of US$1.9/t, and an underground mining cost of US$45/t, it can be shown that it is more economic to transition to underground mining after Pit 33 than expand the open pit to its limit at Pit 46. This strategy has been adopted in the PFS.

This analysis is somewhat simplistic (qualitative) as it does not consider:

- Capital expenditure to develop the underground vs increasing fleet capacity.
- Production capacity (1.2–1.6 Mt/a for open pit vs 0.6–0.8 Mt/a for underground)
- Plant feed grade (dependent on cut-off grade)

However, the overriding factor is the practicality of increasing the mining rate for open pit mining, which is highly restricted by the size of the pit (long, narrow and deep) and the acceptable limits on vertical sinking rate.

Even with the smaller pit (Pit 33), design it was found that the sinking rate exceeded nine benches (90 m) per year at times and it would be very difficult to find sufficient faces for the given fleet size. For this reason alone, the maximum extent of the open pit should be limited to Pit 33.

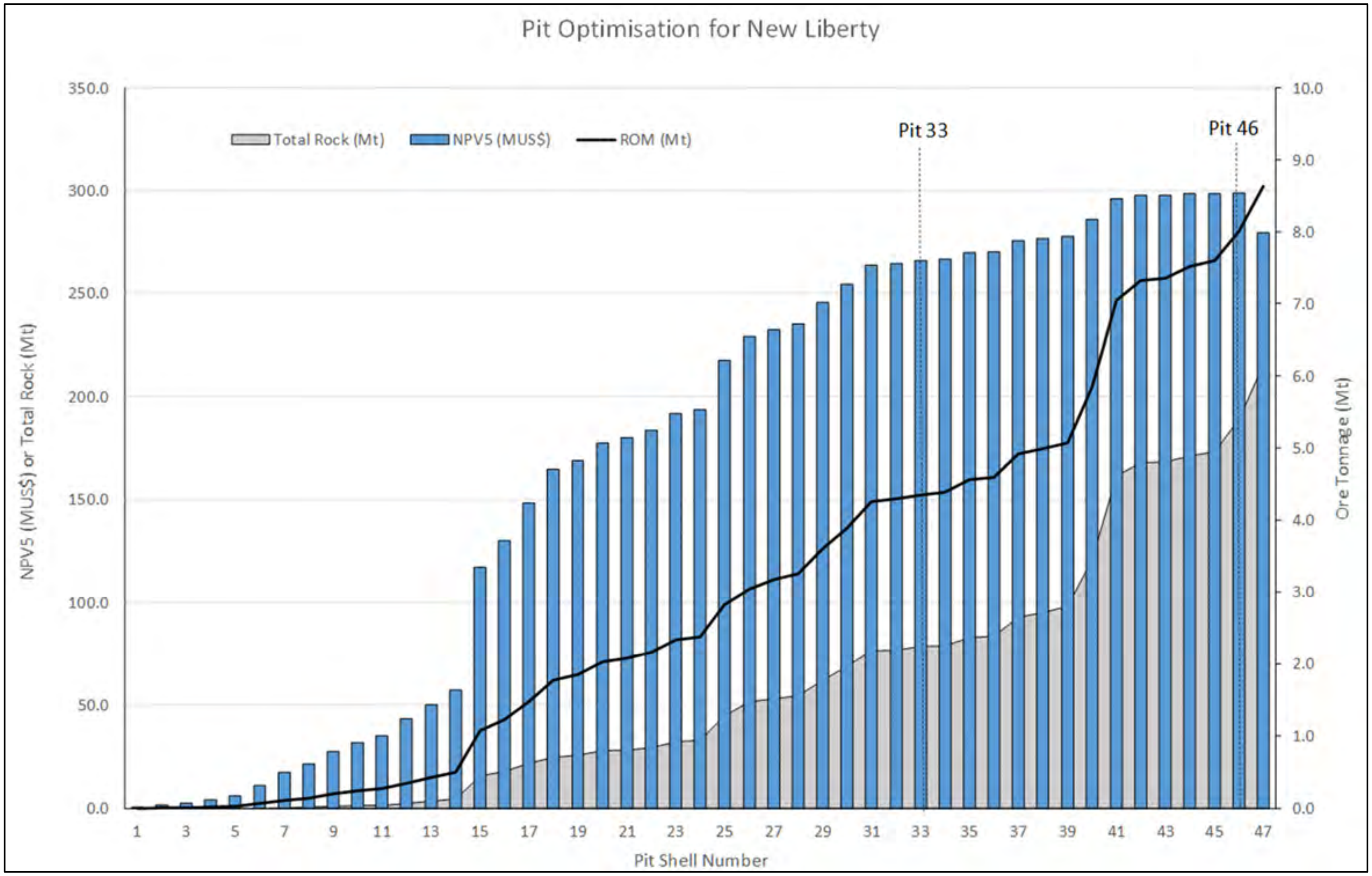


Figure 16-1: Pit optimisation results for New Liberty (US$1,300/oz)

16.1.1.3 Sensitivity Studies

A series of pit optimisations were run using Pit Shell 33 as the limiting surface in order to investigate the sensitivity of the open pit to:

- Mining cost (±10% relative to Base Case)
- Processing cost (±10% relative to Base Case)
- Waste dilution (±50% relative to Base Case).

The sensitivity cases were run with the results are summarised in Table 16-3.

Table 16-3: Sensitivity study for New Liberty Open Pit

Sensitivity	Case	NPV (US$M)	Rock (Mt)	Waste (Mt)	Ore		
					Mt	Au g/t	Au koz
Process cost	-10%	219.0	77.44	73.42	4.02	3.17	410
	Base Case	211.7	77.44	73.51	3.93	3.23	408
	10%	204.6	77.44	73.62	3.83	2.89	356
Mining cost	-10%	225.4	77.44	73.51	3.93	3.23	408
	Base Case	211.7	77.44	73.51	3.93	3.23	408
	10%	198.0	77.44	73.51	3.93	3.23	408
Dilution	+5%	207.0	77.44	73.75	3.69	3.43	406
	Base Case	211.7	77.44	73.51	3.93	3.23	408
	-5%	216.6	77.44	73.28	4.15	3.06	409

Within the sensitivity ranges used it is concluded that:

- Project NPV is more sensitive to Mining Cost than Process Cost or Dilution
- Ore tonnage is more sensitive to Dilution than Process or Mining Cost
- Recovered Au is more sensitive to Process Cost than Mining Cost or Dilution.

The pit size is constrained by selecting a given pit shell and hence the total rock tonnage is the same for all scenarios. It can also be seen that the waste to ore tripping ratio is relatively unchanged between scenarios.

It also worth noting that with the selected pit set at Pit Shell 33 that the NPV is relatively insensitive to changes in price, where Pit Shell 33 is at Price Factor of 74% (US$962/oz) and Pit 39 is at a Factor of 86% (US$1,118/oz).

16.1.1.4 Mine Design

The detailed mine design for New Liberty was based on the selected pit limit (Pit 33) from the optimisation work and utilised the existing interim pit stages (Stages 1, 2 and 3) that are currently being mined. An additional pit stage (Stage 4) was added to smooth out the waste stripping over the remaining life of the open pit.

The following design parameters are based on the Geotechnical report published by SRK (Table 16-4).

Table 16-4: Geotechnical parameters

Parameter	Units	Oxide		Fresh	
		South	North	South	North
Batter angle	°	45	45	75	70
Berm width	m	5	5	8.5	8.5
Face height	m	10	10	20	20
Road width (dual)	m	25	25	25	25
Road width (single)	m	16	16	16	16
Ramp gradient	%	10	10	10	10

The individual stages are shown in Figure 16-2, Figure 16-3, Figure 16-4 and Figure 16-5 and the Reserves are summarised in Table 16-5.

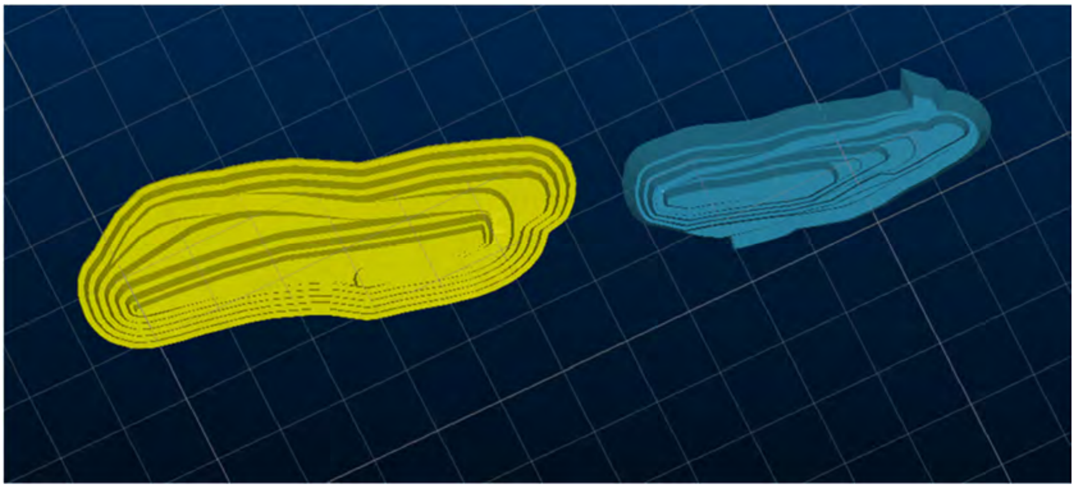


Figure 16-2: Initial stages for Kinjor and Marvoe (Stages 1 &2)

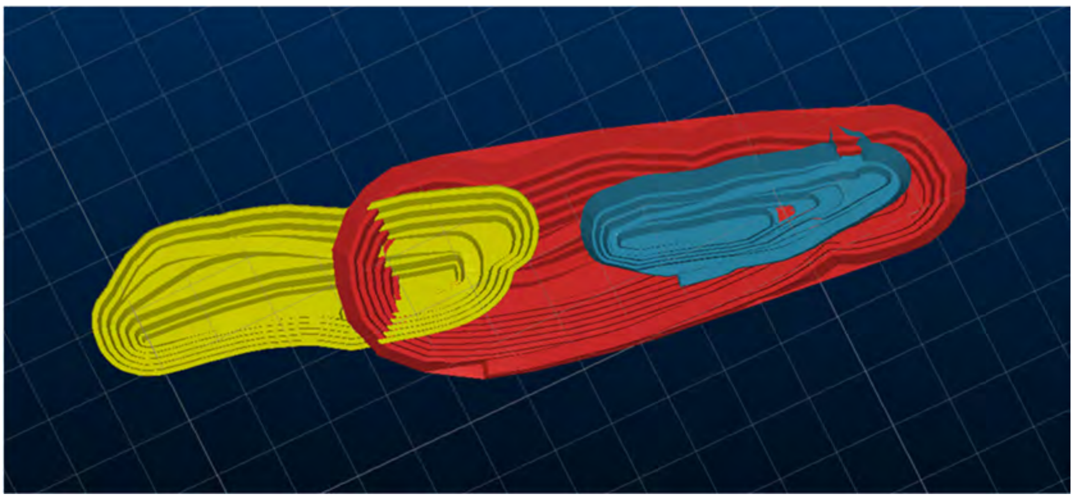


Figure 16-3: Pit limit (Stage 3)

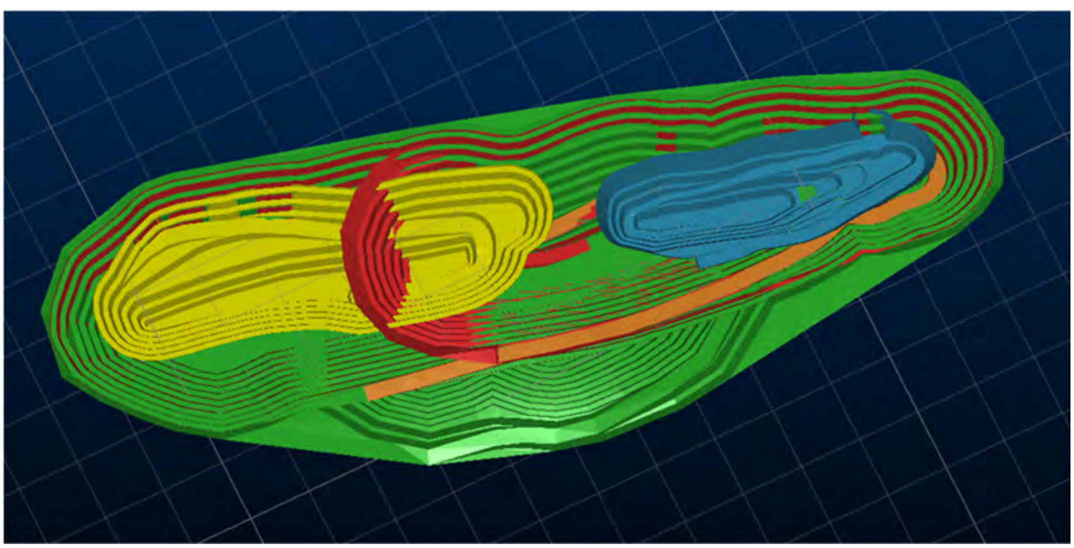


Figure 16-4: Expansion Stage 4

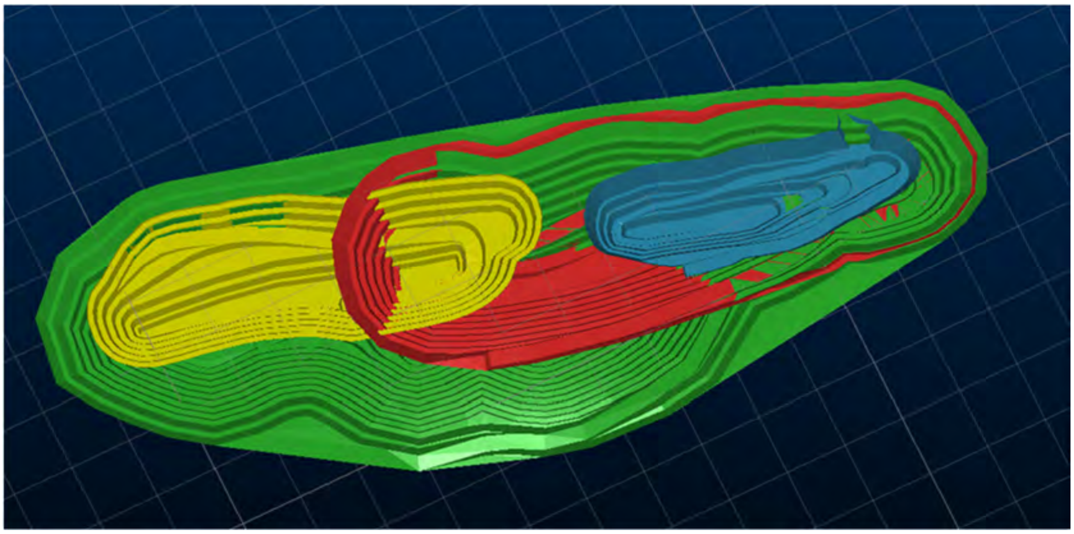


Figure 16-5: Additional stage (Stage 5)

Table 16-5: New Liberty – Reserves by stage design

Pit name	Cut-off (g/t Au)	Rock (tonnes)	Waste (tonnes)	Ore Reserve			Marginal Stockpile		
				Tonnes	Ounces	g/t Au	Tonnes	Ounces	g/t Au
New Liberty OP									
Stage 1	0.80	4,925,205	4,463,763	430,335	46,068	3.33	31,107	0.62	0.58
Stage 2	0.80	2,741,529	2,321,476	369,273	26,309	2.22	50,780	1,013	0.62
Stage 3	0.80	26,921,455	25,286,091	1,469,529	130,526	2.76	165,866	3,250	0.61
Stage 4	0.80	21,611,941	20,666,091	849,056	80,304	2.94	96,794	1,894	0.61
Stage 5	0.80	38,763,528	36,854,673	1,799,296	210,636	3.64	109,559	2,143	0.61
Total		**94,963,658**	**89,592,062**	**4,917,490**	**493,844**	**3.12**	**454,106**	**8,300**	**0.61**

Notes:

- *All tonnages expressed in dry metric tonnes.*
- *Includes waste dilution of 10% at zero grade.*
- *Includes a mining recovery of 95%.*
- *Cut-off grade for Marginal material is 0.5 g/t Au.*

16.1.1.5 Waste Dump Design

The waste dump design is based on the existing dumps and allows for a capacity in excess of 90 Mt. There is no provision for backfilling the pit as access will be required on the main ramps to the portals for the underground workings.

The dumps have been designed to limit their height in order to reduce the haul cycle times. This provides some flexibility in deciding the percentage of the waste that goes to the North, South and West dumps. Whilst the final ramps are predominately on the south side of the pit there will be opportunities to direct waste to the North dump as part of the stripping of Phase 3 and 4 and the final expansion (Stage 5).

A further consideration in the waste dumps is the location of the water diversion channel that currently runs around the eastern and south eastern edge of Marvoe. At some stage, this will have to be relocated to the east of the dump. A similar issue arises with the South dump.

The general layout of the waste dumps is shown in Figure 16-6 with the existing survey pickup for Larjor, Kinjor and Marvoe as well as the proposed open pit limit and the water diversion channels. A suitable offset distance of 100 m has been left between the toe of the dumps and the pit rim.

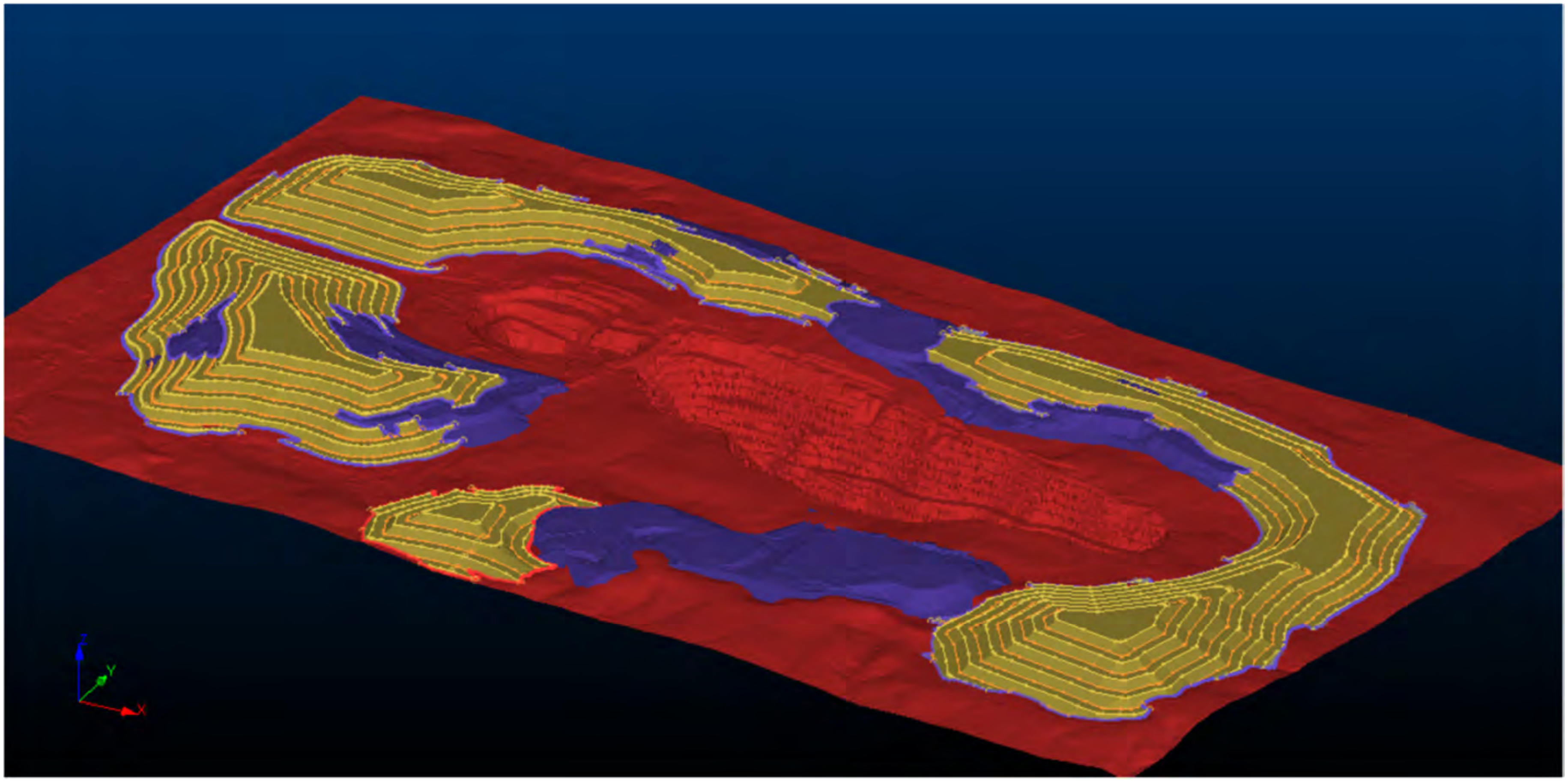


Figure 16-6: Proposed layout of waste dumps at New Liberty

16.1.1.6 Grade Control

The grade control procedure at is based on channel sampling of the exposed benches with a jack hammer. The samples lines are placed perpendicular to the strike of the orebody and are spaced every 10 m along strike.

The samples are bagged and taken to the assay lab on site for analysis.

16.1.1.7 Combined Schedule

Using the Reserves from New Liberty open pit (NLGM-OP) and Ndablama open pit (ND-OP), plus the New Liberty underground (NLGM-UG), a combined LOM schedule was created that is constrained by:

- Maximum open pit fleet capacity of 36 Mt/a
- Maximum plant throughput of 1.8 Mt/a
- Early start-up of NLGM-UG by Q2 2020
- ND-OP to start after NLGM-OP closed.

It is assumed that the initial development of NLGM-UG will be from the portal in the old Larjor pit so that there is time to deplete the open pit reserves in Kinjor Stage 5 prior to mining the underground reserves from Kinjor.

It is also assumed that the mining fleet from NLGM-OP will be moved to ND-OP so as to limit the required fleet and minimise additional capital. It will however be possible to start the pre-stripping of ND-OP before completing NLGM-OP.

The scheduling logic assumes that the mined material will be split into the following material streams according to their cut-off grades (Table 16-6).

Table 16-6: Classification of material streams by cut-off grades

Material	Code		New Liberty		Ndablama	
			Au ≥	Au <		
Waste	Wst	g/t	0.0	0.5	0.0	0.5
Marginal	Marg	g/t	0.5	0.8	0.5	1.0
Low Grade	LG	g/t	0.8	1.5	1.0	1.5
Medium Grade	MG	g/t	1.5	3.5	1.5	3.5
High Grade	HG	g/t	3.5		3.5	

The ROM stockpiles (LG, MG and HG) are normally reclaimed in order of highest grade first. However, it is also possible to delay the reclaiming of selected stockpiles in order to smooth out the feed grade to the plant and also to maintain sufficient stockpile levels where there are peaks and troughs in supply of ore from the pit. The Marginal material is stockpiled as a potential source of ore for the future.

16.1.2 In-Pit Pumping

There are often flooding risks associated with underground mines when the primary access is from an open pit. Intense rainfall and runoff could flood the pit and hence the underground workings if not managed correctly. New Liberty is no exception to this risk, the planned Larjor and Kinjor final pit dimensions are significant catchment areas and, combined with intense rainfall in the area, an evaluation of a severe storm event was therefore undertaken.

A surface water quantity assessment was undertaken by Peens and Associates with a recommended 24-hour design rainfall quantity as presented in Table 16-7. The table shows that for a 1:100-year storm event, a rainfall of 376 mm may be expected.

Table 16-7: Recommended 24-hour design rainfall

Location	Recurrence interval						
	1:2	1:5	1:10	1:20	1:50	1:100	1:200
New Liberty Mine	145	190	228	267	326	376	432

Assuming no ex-pit inflows or in-pit losses, this expected 1:100-year design rainfall equates to total of 922 l/s and 2,798 l/s inflow for the Larjor and Kinjor pits respectively. With the pit depths of approximately 100 m and 260 m below surface elevation, the power requirement to address this quantity of water through pumping is excessive.

In order to mitigate the risk of significant water inflows or even flooding the underground workings, it is proposed that a both pits include a large in-pit sump to arrest rainfall inflows and runoff and transfer the water from the sump at appropriate flow rate in order to reduce the pumping power requirements.

Provisional dam capacity calculations have been undertaken for both sumps. The recommended 24-hour design rainfall distribution was incorporated into a time-based simulation and the inflows and outflows from the sumps determined. Although a risk assessment be undertaken, including further statistical analysis, it is proposed at this stage that a 1:100-year event be pumped from the sumps over a period of a week. This would equate to a pumping rate of 100 l/s and 400 l/s for Larjor and Kinjor respectively. Simulated sump capacities with these assumptions are presented in Figure 16-7 and Figure 16-8.

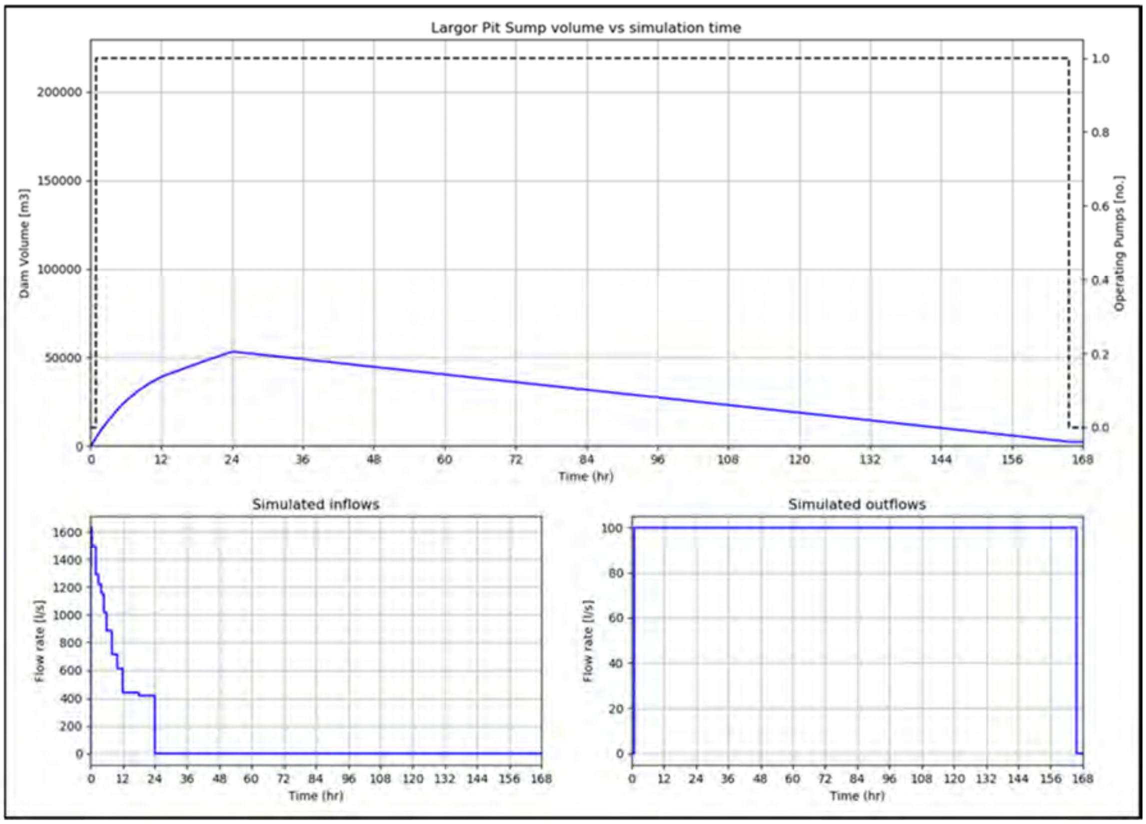


Figure 16-7: Larjor sump capacity (1:100-year storm event)

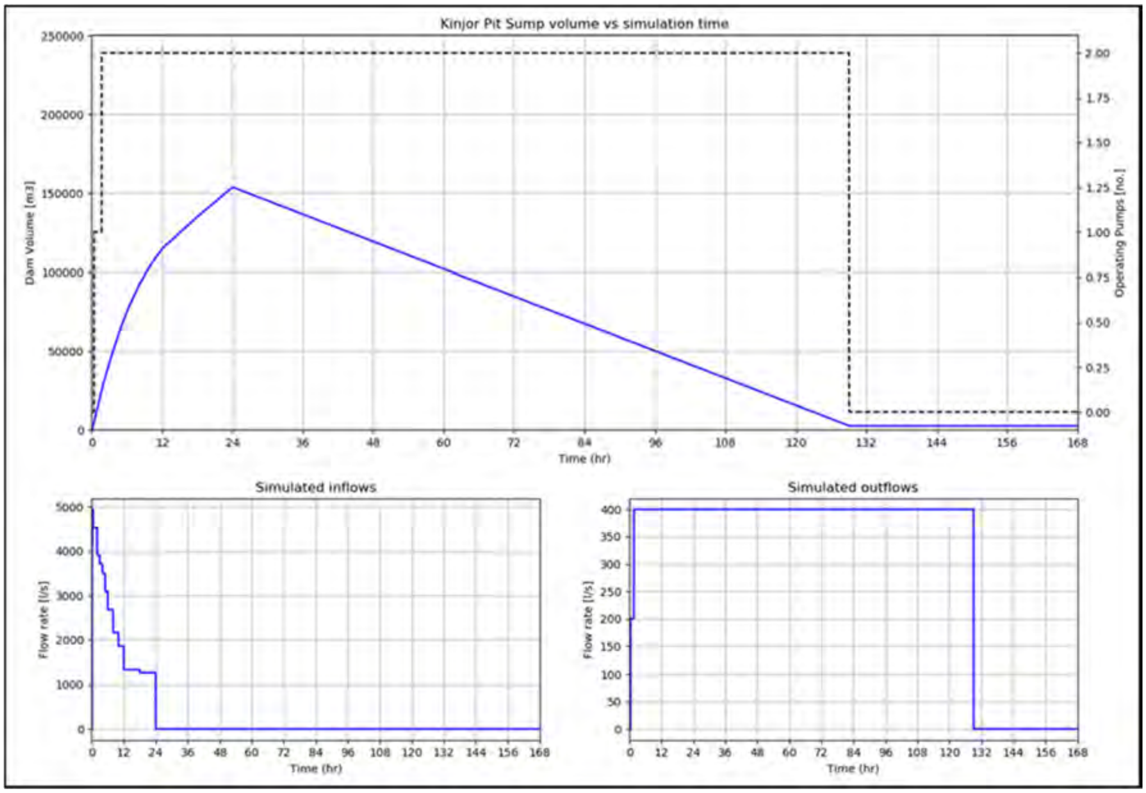


Figure 16-8: Kinjor sump capacity (1:100-year storm event)

The simulations show that a sump capacity of approximately 50,000 m^3 and 150,000 m^3 is required for Larjor and Kinjor pits respectively, assuming a single event at the outflow rates previously stated. For the purposes of this study, sump volumes of approximately 230,000 m^3 have been included for each pit. In order to achieve the storage volumes required by the sumps, the pits have been backfilled and the portal position raised as to provide sufficient in-pit area for the sumps.

Water will be transferred from the sumps by dirty water centrifugal pump sets. The Larjor sump pump station will be equipped with two 75 kW pumps in series in order to transfer 100 l/s over a 70 m total head. Water will be transferred through 200 mm nominal diameter piping which will be anchored to the pit sidewalls and supported with concrete trust anchors where appropriate. The Kinjor sump pump station will be equipped with four 220 kW pumps in series in order to transfer 200 l/s over a 247 m total head. Water will be transferred through 300 mm nominal diameter piping which will also be anchored to the pit sidewalls and supported with concrete trust anchors where appropriate. An additional pump set and pipeline will be included for Kinjor to account for the 400 l/s emergency pumping requirement. Pressure analysis on both Larjor and Kinjor pipelines was undertaken to ANSI B31.3.

16.2 New Liberty Underground

16.2.1 Open Pit to Underground Transition

As discussed in the previous section, transition to underground mining at New Liberty was determined by assessing the breakeven cut-off between current open pit mining approaches and underground methods. For that assessment, the pit increments between current Pit 33 and Pit 46 shells were studied and traded off vs. the cost and outputs of the underground approach. While an economic trade-off was performed, using open pit mining costs of US$1.9/t, and underground mining cost of US$45/t, other factors were identified in the trade-off that drive the decision to go underground. The overriding factor was the practicality of increasing the mining rate for open pit mining, which becomes increasingly restricted, as well as practical limits on vertical sinking rate driven by the geometry and orientation of the New Liberty orebody. Even with the smaller pit (Pit 33) design, it was found that the sinking rate exceeded nine benches (90 m) per year at times, and it would therefore be very difficult to find sufficient faces for the required production rate. For this reason, the maximum extent of the open pit was limited to Pit 33. This strategy was therefore adopted in the PFS.

16.2.2 Mining Method

The New Liberty deposit is hosted in sheared and altered ultramafic rocks. The gold mineralisation is associated with disseminated sulphides. The disseminated sulphide host bodies are more continuous than a typical quartz hosted vein. The orebody is in a highly sheared and mylonitised schist belt which trends east-southeast.

The average dip of the orebody is approximately 60°, with local variations in dip ranging from near vertical to around 40°. The orebody consists of a number of veins, generally parallel to each other. Mineralisation can occur in more than one of the veins, creating the potential for multiple parallel stopes in some parts of the deposit.

The widths of the mineralised zones range from 2 m to 30 m, with an average width of 10 m.

As discussed in the geotechnical section later in this report, the rock conditions are described as generally good. A range of mining methods were therefore initially considered.

During Scoping Study work on the underground mining of New Liberty ("Liberia Operation Underground Scoping Study" MMNamibia, 2015), mining methods for underground were discussed and compared. The mining method selection process short listed two mining methods for consideration, namely:

- Long hole open stoping.
- Sublevel caving.

The Scoping Study was based on open stoping with pillar support. The work done during the scoping study in short listing the appropriate mining methods for this orebody was reviewed and considered to be valid. The process was not repeated and the short list of two main mining methods was considered appropriate.

Consideration was given to sublevel caving as well as various options of open stoping, including:

- Open stoping with pillar support (no backfill)
- Open stoping with waste rock fill
- Open stoping with cemented hydraulic (or paste) fill.

While sublevel caving is a cost-effective mining method which could possibly be applied in this orebody there are a number of technical reasons which count against the selection of sublevel caving for New Liberty. These include:

- Location of infrastructure – There is significant infrastructure located immediately to the South of the mining areas including waste dumps, pit access roads and offices. This infrastructure lies in the hangingwall of the orebody, which would be within the zone of influence of the cave if a caving mining method is applied. Although this infrastructure could be moved it would add significant complications to the operation of the mine. The presence of the waste dumps would have geotechnical implications as well.
- Water ingress – The New Liberty site receives an average rainfall of over 3.5 m per year, much of it in a short period of time during the very wet months. In addition, the open pits above the underground workings will act as sumps, collecting rainwater and groundwater inflows during times of high rainfall. If a caving mining method is selected and there is no solid water barrier between the open pits and the underground workings, the risk of flooding will be extreme. Experience in the operation of the open pits has shown that in times of extreme rainfall the pit dewatering arrangements are unable to cope with the water quantities and pit floor becomes flooded.

- Low angle dips – There are numerous areas in the orebody where the dips are in the range of seventy to fifty degrees. Although at these dips the rock will still flow under gravity, there lower dips are likely to result in excessive dilution when in a sublevel cave operation.
- Caveability of rock mass (country rock) – For sublevel caving to be successful, the rock mass (particularly the country rock) needs to be suitably incompetent to allow natural caving to take place as the mining front advances. Timely initiation of caving cannot be assumed. Walls in UMMT and UMTC may not collapse until spans exceed 60 m x 60 m. The rock properties that suggest sidewall hydraulic radii could exceed 15 m. There is potential for an air blast which could be generated by collapse of such a span, which poses an unacceptable safety risk.
- Primary access location – If a caving mining method such as sublevel caving was selected, the primary access infrastructure would need to be placed in the footwall, away from the zone of influence of the cave. There are a number of reasons why this is not desirable at New Liberty, including:
  - The portals could not be placed in the pit and would have to be placed in the footwall to the north of the pits. This will increase development distances and consequently the time to production. The underground access would be far from the current plant site increasing haul distances.
  - There is limited space for infrastructure to the north of the open pits due to the location of the river diversion and water storage dam

Since sublevel caving has a number of issues which preclude it from being the preferred mining method at New Liberty, some form of open stoping should be used.

In order to decide on the type of support (i.e. pillars only, waste rock fill or cemented pastefill) should be used in the open stoping environment, a comparison was done on the extraction rate with the different fill methods. In order to calculate the extraction rates (inverse of pillar loss) the spans and pillar dimensions described in the geotechnical section below were used, namely:

- Maximum unsupported stope span on dip – 20 m
- Maximum unsupported stope span on strike – 22 m
- Rib pillar thickness – 8 m (based on 10 m wide orebody)
- Sill pillar thickness – 10 m (based on 10m wide orebody).

The resulting pillar losses are presented in Table 16-8 .

Table 16-8: New extraction ratio vs support type in open stoping

	Pillars	Waste rock fill	Cemented pastefill
Stope dip span (m)	20	20	20
Stope strike span (m)	22	22	22
Rib pillar width (m)	8	8	0
Sublevels between sill pillars	1	2	5
Span between sill pillars (m)	20	40	100
Sill pillar width (m)	10	10	10
Stope area (including pillars)	900	1500	2420
Pillar area (m^2)	460	620	220
Pillar loss (%)	51%	41%	9%
Extraction (%)	49%	59%	91%

Clearly, a cemented hydraulic or pastefill will result in the highest extraction ratio. On discussion of the options with Avesoro management, they expressed concern with the application of pastefill on the New Liberty site based on:

- High capital cost of a pastefill plant for a relatively short mine life
- Technical complexity of operating a cemented fill plant and reticulation system.

In order to reduce the pillar loss when using waste rock fill, consideration was given to the installation of a cemented waste rock layer on the floor of the stope to create an engineered sill pillar and thereby negate the need for sill pillars. This is discussed in more detail in the geotechnical and mining method sections of this report. The inclusion of this engineered, cemented, waste rock pillar reduces the pillar loss in the waste rock fill option to from 41% to 27%. This option was selected as the primary mining method for the Pre-feasibility study.

16.2.3 Geotechnical Investigations

Ground conditions influencing opening stability in proposed underground development and production areas at the New Liberty deposit at the Avesoro New Liberty Project have been investigated using:

- Current geological interpretations
- Review of the New Liberty site
- Inspection of selected resource definition cores and core photographs
- Structural geological data obtained from resource definition cores
- General geotechnical data obtained from selected resource definition cores
- Experience in geotechnical assessment and review in similar geological and geotechnical settings.

The work has been completed to pre-feasibility standard.

16.2.3.1 Ground Conditions

Ground conditions for development in fresh country rock at New Liberty are expected to be generally good.

Ground conditions for stoping will vary with location and orebody dip; however, at present there are too few data to identify any pattern to the variation. It is considered that it will not be possible to predictively identify patterns to variations with any degree of certainty prior to mining.

Stability of openings in future underground mining at New Liberty will be governed largely by structural geological conditions, the influences of which will, in turn be controlled by the relative geometries of geological structures and fabric and opening surface orientations.

Given the limited depth and extent of mining, mining-induced stress re-distributions are not expected to have a major influence on currently proposed stoping.

16.2.3.2 Development Minimum Support Schemes

Portal and initial decline to ≥20 m advance:

- Development profile: 5.5 m wide x 5.0 m high (semi-arched back recommended)
- 75 mm fibrecrete applied shoulder to shoulder to within ≤3.5 m of floor level
- 2.4 m long, 46 mm diameter galvanised friction bolts installed on a 1.2 m x 1.4 m pattern
- 6m long twin bulbed strand cable bolts installed on a 2 m x 2.8 m pattern (three cables per ring)
- As ground competence increases with advance, surface support may revert to galvanised weldmesh (5.6 mm diameter wire, 100 mm × 100 mm grid) installed shoulder to shoulder to within ≤3.5 m of floor level.

Standard decline and crosscuts:

- Development profile: 5.5 m wide x 5.0 m high (semi-arched back recommended)
- 2.4 m long, 46 mm diameter galvanised friction bolts installed on a 1.2 m x 1.4 m pattern
- Galvanised weldmesh (5.6 mm diameter wire, 100 mm x 100 mm grid) installed shoulder to shoulder to within ≤3.5 m of floor level.

Re-muck piles:

- Development profile: 5.0 m wide x 5.0 m high x 15 m long
- 2.4 m long, 46 mm diameter galvanised friction bolts installed on a 1.2 m x 1.4 m pattern
- Galvanised weldmesh (5.6 mm diameter wire, 100 mm x 100 mm grid) installed shoulder to shoulder to within ≤2.5 m of floor level.

Ore drives:

- Development profile: 4.0 m wide x 4.5 m wide (semi-arched back recommended).
- 2.4 m long, 46 mm diameter black friction bolts installed on a 1.2 m x 1.4 m pattern.
- Number of back bolts will be slightly reduced (compared with capital development).
- Black weldmesh (5.6 mm diameter wire, 100 mm x 100 mm grid) installed shoulder to shoulder to within ≤3.5 m of floor level.
- Use of non-galvanised reinforcing and support elements assumes 'just in time' ore drive development. Where longer lead times are required galvanised elements should be used.

Wide spans/intersections:

- Wide spans and intersections require additional reinforcement:
    - 2.4 m long, 46 mm diameter galvanised friction bolts installed on a 1.2 m x 1.4 m pattern
    - Galvanised weldmesh (5.6 mm dimeter wire, 100 mm x 100 mm grid) installed shoulder to shoulder to within ≤3.5 m of floor level
    - 6 m long twin bulbed strand cable bolts installed on a 2 m x 2.5 m pattern.

16.2.3.3 Stoping Parameters

Stoping conditions in this assessment have been based on Q' values for the zone 30 m above and below ore zones. Q' are assumed = Q values for this phase, hence there is some scope for upside; however, further review is required to make judgment on the viability of that move.

It is recommended that stope backs be uniformly supported and have hydraulic radii (HR) ≤6 m. Minimum support scheme based on standard plus cables as defined by interpreted structural needs (assume for ≥25% of top sills backs):

- 2.4 m long, 46 mm diameter galvanised friction bolts installed on a 1.2 m x 1.4 m pattern
- Galvanised weldmesh (5.6 mm dimeter wire, 100 mm x 100 mm grid) installed shoulder to shoulder to within ≤3.5 m of floor level
- 6 m long twin bulbed strand cable bolts installed on a 2 m x 2.5 m pattern
- Unsupported stope walls should be mined with HR ≤7 m
- It is inferred that the locations, orientations and profiles of access development would not allow for uniform reinforcement of stope walls.

Unsupported Sidewall Spans

Sustainable unsupported sidewall spans are expected to govern achievable stable stope sizes, as access to enable uniform wall reinforcement is not expected to be available.

Calculations are based on 20m floor to floor vertical sub-level interval.

Rock mass conditions to 30m (true width) above the stope hangingwall and below the footwall (of the lowest ore intercept) have been considered.

For preliminary planning purposes, it is recommended that stoping parameters be based on dimensions defined by median Q' values for magnetite-rich ultramafic rocks (UMMT), which is expected to be the dominant stope sidewall rock type exposed at New Liberty. These parameters are those in the shaded portion of Table 16-9.

Table 16-9: Recommended unsupported stop sidewall spans by lithology and orebody dip

Lithology	Ore/ Stope dip	1st Quartile Q' value calculations			Median Q' values calculations			Comments
		Hydraulic radius	Wall dip span	Allowable unsupported strike span	Hydraulic radius	Wall dip span	Allowable unsupported strike span	
UMMT	75°	5 m	26 m	16 m	6 m	26 m	22 m	Calculations assume potential for instability is derived from foliation fabric oriented sub-parallel to stope sidewalls. All calculations assume absence of major geologic structures.
	65°	5 m	27.5 m	16 m	6 m	27.5 m	21 m	
	55°	5 m	30 m	15 m	6 m	30 m	20 m	
UMTC	75°	4.5 m	26 m	14 m	5 m	26 m	17 m	
	65°	4.5 m	27.5 m	13 m	5 m	27.5 m	16 m	
	55°	4.5 m	30 m	13 m	5 m	30 m	15 m	
UMPT	75°	3.5 m	26 m	9.6 m	4 m	26 m	11.6 m	
	65°	3.5 m	27.5 m	9.4 m	4 m	27.5 m	11.3 m	
	55°	3.5 m	30 m	9.1 m	4 m	30 m	10.9 m	
GNQF	75°	9 m	26 m	58 m	9.5 m	26 m	70 m	
	65°	9 m	27.5 m	52 m	9.5 m	27.5 m	91 m	
	55°	9 m	30 m	45 m	9.5 m	30 m	52 m	

Reinforced/Supported Stope Backs

Sustainable sub-horizontal stope back parameters are listed in Table 16-10. It is assumed that these backs will be able to be adequately reinforced and supported from top sill ore drive development.

Table 16-10: Recommended unsupported stope endwall heights spans by orebody width

Lithology	1st Quartile Q′ value calculations			Median Q′ value calculations			Comments
	Stope width	Hydraulic radius	Allowable supported strike span	Stope width	Hydraulic radius	Allowable supported strike span	
UMMT	5 m	5 m	Any	5 m	6 m	Any	Spans assume uniform installation of adequate capacity reinforcement is possible. All back strike spans exceed those allowable for stope sidewalls. GNQF not expected to be relevant
	10 m	5 m	Any	10 m	6 m	Any	
	15 m	5 m	30 m	15 m	6 m	60 m	
UMTC	5 m	5 m	Any	5 m	6 m	Any	
	10 m	5 m	Any	10 m	6 m	Any	
	15 m	5 m	30 m	15 m	6 m	60 m	
UMPT	5 m	4 m	Any	5 m	5 m	Any	
	10 m	4 m	40 m	10 m	5 m	Any	
	15 m	4 m	17 m	15 m	5 m	30 m	
GNQF	5 m	7 m	Any	5 m	8 m	Any	
	10 m	7 m	Any	10 m	8 m	Any	
	15 m	7 m	Any	15 m	8 m	Any	

Unsupported Stope Endwalls

Based on development of vertical endwalls and assumed absence of major crosscutting geological structures, unsupported stope endwalls were recommended (Table 16-11).

Table 16-11: Recommended uniformly supported stope back spans by lithology and ore width

Lithology	1st Quartile Q′ value calculations		
	Stope width	**Hydraulic radius**	**Allowable unsupported stope height**
UMMT	5 m	8 m	Any
	10 m	8 m	Any
	15 m	8 m	Any
UMTC	5 m	7.5 m	Any
	10 m	7.5 m	Any
	15 m	7.5 m	Any
UMPT	5 m	5.75 m	Any
	10 m	5.75 m	Any
	15 m	5.75 m	49 m
GNQF	Not expected to be applicable		

Backfill

It is expected that backfill will be needed in wider ore zones and to enable orebody extraction to be maximised.

To facilitate secondary stoping operations, some primary stope backfill will need to be self-supporting, hence there will be a need for engineered backfill.

Assessment of specific requirements will need to be based on actual stoping blocks/panels, individual stopes and the proposed stoping sequence (and/or alternative stoping sequences).

Artificial Sill Pillars

Development of artificial sill pillars may be used to assist in maximisation of ore extraction. In this regard Avesoro has indicated that economics would dictate use of cemented rock fill (CRF) sill pillars.

For preliminary assessment it is recommended that ~ 10 m wide sill pillars (approximate mean orebody width indicated by Avesoro) comprised of ROM waste rock (three parts), plus minor addition of aggregate (one part) and fines (one part) with a cement binder added as a slurry, would need to be ≥10 m high and comprise ≥8% cement binder (≥0.45 parts by mass of solids). The minimum target uniaxial compressive strength of the CRF would be ≥ 4 MPa (28 days strength).

These specifications are based on experience and must be confirmed by expert investigation and assessment.

Several issues need also to be considered in assessment of performance of under-cut CRF sills, including: material types and availability; particle size distributions; mix method and control of cement and water addition; stope geometry; placement method(s) and available placement (tip-head) positions; and general quality control, noting that this list is not exhaustive.

Dilution

Dilution will be governed variously by inherent structural conditions, particularly degree of development of foliation fabric within wall rocks and type and intensity of alteration of wall rocks; orebody geometry, particularly dip, hence dip of stope hanging and footwalls; and mining practices.

A preliminary empirically based estimate of stope overbreak using the Equivalent Linear Overbreak Slough (ELOS) method suggests that with a Stability Number $N \approx 4$ (sidewall at 250 mbs) and $HR = 6$ m ELOS would be ~ 1.0 m (= slough volume ÷ stope wall surface).

16.2.3.4 Future Geotechnical Requirements

Work required to take investigations to feasibility level includes:

- Drilling investigation:
  - Assessment of further geotechnical data obtained from resource definition/geotechnical drillholes to improve spatial coverage of the deposit.
  - Continued review of cores and/or core photographs and logs from ongoing resource definition drilling.
- Laboratory testwork:
  - UCS testing of representative core samples with i) core axis perpendicular to foliation and ii) core axis sub-parallel to the foliation fabric.
- Portal assessment:
  - Generic recommendations for portal development have been provided; however, actual conditions must be assessed to define specific requirement. It is possible/likely that the generic recommendations will need to be amended.
  - Detailed face mapping must be carried in portal areas and geotechnical drilling should be allowed for to obtain data to confirm/refine reinforcement and support requirements for the pit walls and, more importantly, initial decline development.
- Ventilation shaft investigation:
  - A preliminary assessment of ground conditions within the general vicinity of the proposed ventilation and escapeway shafts will be required to assess the most appropriate construction method/s for costing purposes.
  - Dedicated geotechnical drilling investigations will be required for major shafts, regardless of the proposed means of development.
- Open pit slope monitoring:
  - Slope stability monitoring will need to be established around the pit ramp accesses to portals in the Larjor and Kinjor open pits and must be maintained while access to the pit is required during underground mining.
- Lode geometry assessment:
  - Adjustment of stoping dimensions is expected to be necessary in zones where orebody dips are appreciably shallower than average. Available data suggest that some of the poorer quality rock conditions coincide with these shallower lode dips.
  - Planned stoping of multiple adjacent lodes needs also to be considered in assessing mine stability and dilution.
- Open pit slope monitoring
  - Slope stability monitoring needs to be continued while the pit is accessed for underground operations.
- Ground Control Management Plan (GCMP):
  - Prior to commencement of underground mining operations, a GCMP will need to be developed to meet current industry practice.
- Numerical modelling:
  - Given that a relatively high extraction ratio will be beneficial at New Liberty, it is considered that stope sequencing options should be modelled to assess likely mining-induced stress redistribution patterns and the implications of such on the safety and viability of planned mining.

- In-situ rock stress measurement:
  - The veracity of all numerical modelling results depends on the accuracy of the initially applied stress field (magnitudes and directions of principal stresses). Accordingly, when/if numerical modelling of stoping sequences is to be employed consideration should be given to measuring the in-situ rock stress at New Liberty.

16.2.4 Mine Design Parameters

16.2.4.1 Design Criteria

A set of mine design criteria was developed for the New Liberty Underground Mine and are presented in Table 16-12. More detail on the underground design is given in sections that follow.

Table 16-12: New Liberty Underground Mine design criteria

Main Access and Transport	Trackless decline, trucking, rubber tyred ADTs
Level Access and Transport	Strike drives in ore, trackless.
Stoping Method	Long hole open stoping
Modifying factors	
Stope width	2 m to 30 m
Sublevel spacing	20 m
Main level spacing (no of sublevels)	2
Stability pillar loss	27% (rib pillar of 8 m spaced 22 m skin to skin), sill pillars replaced by cemented waste rock fill
In-stope dilution	10% estimated
Explosives	Bulk emulsion
Development maximum advance rate (m/month)	
Waste development	80
Ore development	60
Advance rate per crew	3.7 m per shift, 240 m per month.
Stope Productivity and Design	
Shift system	7-day week, 2 shifts per day, 2 blasts per day
Ring burden	150 cm
Hole spacing	150 cm
Stope drilling	Electrohydraulic Production rig
Mining drive dimensions	4.0 m (w) x 4.5 m (h), slyped to orebody width.
Face cleaning	LHD onto dump truck
Support	Waste rock backfill
Pillar size (sill)	10 m thick cemented waste rock pillar, every 40m.
Pillar size (rib)	8 m or 0.8 * stope width.
Engineering Infrastructure	
Water consumption	0.5 tonne water per tonne rock
Fissure water	To be confirmed
In-situ ore density kg/m³	2.95
Broken ore density kg/m³	1.84
In-situ waste density kg/m³	2.83
Broken waste density kg/m³	1.77
Underground reticulation	11kV to be confirmed
Cabling	Blue stripe fire retardant
Design life	10 years
Decline lighting	Yes

Main Access and Transport	
Excavation dimensions	
Main decline (broken)	5.0 m (w) x 5.3 m (h)
Roadway depth	0.3m
Muck bay frequency	75m
Decline angle	-8° (1 in 7)
Orebody Access and Transport	
Access crosscut	5.0 m (w) x 5.0 m (h)
Strike footwall drive	5.0 m (w) x 5.0m (h)
Strike ore drive	4.0 m (w) x 4.5m (h)
Equipment Specification	
Trackless	
LHD (development)	Sandvik LH417 (17T), or equivalent
LHD (stoping)	Sandvik LH417 (17T), or equivalent, LH204 (for narrow areas)
Drilling (development)	Sandvik DD421 (twin boom development jumbo), or equivalent
Drill rig stope	Sandvik DL431 (Solo stope drill rig), or equivalent
Dump truck	Sandvik TH551 (50 T ADT), or equivalent
Personnel carriers	Lancruiser pick-ups
Service vehicles/explosives vehicle	Normet, or equivalent
Production Equipment	
Diaphragm pumps	Air operated
Vertical spindle pumps	Yes
Skid dam pumps	Yes
Communications	Telephone, Leaky feeder
Centralised blasting	Yes
Fire detection	Yes, on TMM

16.2.4.2 Primary Access

Access to the orebody below the current pen pits will be from within the pits. Separate portals will be developed in the Larjor and Kinjor pits providing access to the orebodies. Trucking ramps or declines will be developed from the portals, which will be established on the footwall side of the open pits, into the footwall of the orebody. The ramps will spiral down providing access to all main and sublevels in the mine. In order to access the ore blocks that remain outside strike of the final pit shells, but above the elevation of the portals, ramps will be developed up to the levels above.

Consideration was given to the establishment of a single portal and mine access, which would have resulted in a lower capital cost, but there are a number of factors which counted against this as the preferred option. The first is the additional waste development. To access the Kinjor orebody from Larjor, or vice versa, would require additional lateral waste development of approximately 1,000 m. If the portal were established in Kinjor Pit, which is more central to the underground orebody, access to the portal could only be established once open pit mining in Kinjor is completed. Since Larjor pit is currently not working and further cut backs of the Larjor pit result in unacceptably high strip ratios, access via Larjor is possible much earlier. However, Larjor is relatively far from the centre of the orebody and if the main access were located there the underground haul distances would be significantly increased.

It was therefore decided to provide for two entrances for the mine. The first entrance to be established will be in Larjor Pit. This portal will service the mining of the Larjor orebody. A second entrance, in the Kinjor Pit, will be established as soon as open pit mining is completed in Kinjor. This will be the main entrance for the latter part of the mine life and will service the mining of the Kinjor orebody, which accounts for 81%, by tonnes, of the orebody.

The pits will both be backfilled with waste rock to a selected elevation, on which the portals into the underground mine will be established. The portals will be located as low as possible in the open pits, while providing sufficient pit room to allow for:

- Safe access and turning space for surface and underground vehicles.
- Ore and waste rehandling areas.
- Electrical infrastructure.
- Pumping and dewatering infrastructure. Large dams are required to provide a surge capacity for the permanent dewatering of the pit, to prevent flooding of the underground mine. This is discussed in detail in the infrastructure section of this report.
- Compressors.

The Larjor portal will be located on the Z elevation of 10 m, which is 55 m above the pit bottom. It is necessary to place the portal at this elevation in order to have sufficient pit room for the required access and infrastructure around the portal area. Figure 16-9 below shows a plan view of the Larjor portal area with proposed infrastructure. The Larjor pit will be backfilled with waste from the open mining operations at Kinjor. It has been assumed in the cost estimates that the cost of this backfilling will be covered by the mining operating cost at Kinjor open pit.

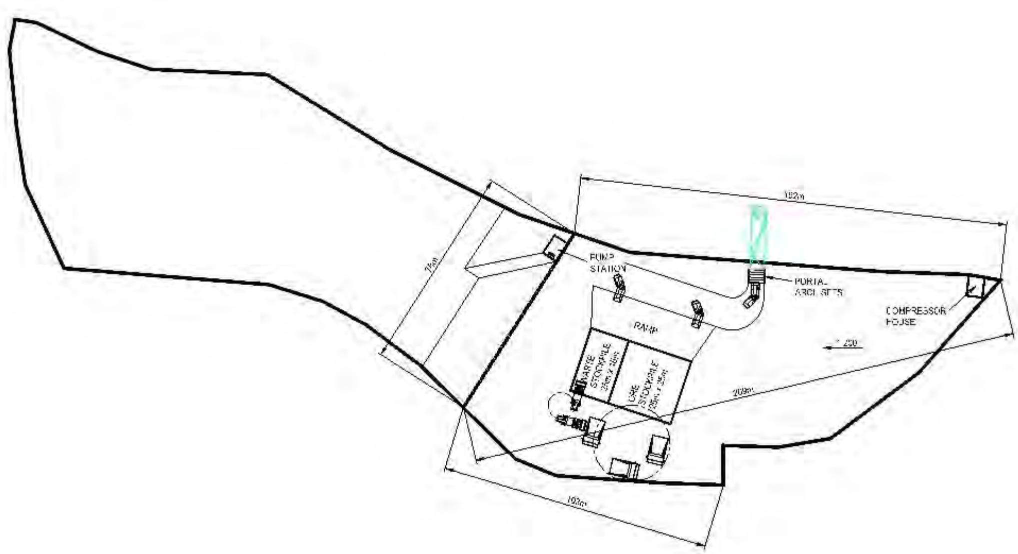


Figure 16-9: Larjor portal area

Figure 16-10 shows a similar plan for the Kinjor portal which is located on the z elevation of -145 m, 25 m above the pit bottom. A cost has been allowed for the haul and placing of waste rock backfill in the Kinjor pit as open pit mining will be complete when this activity is required.

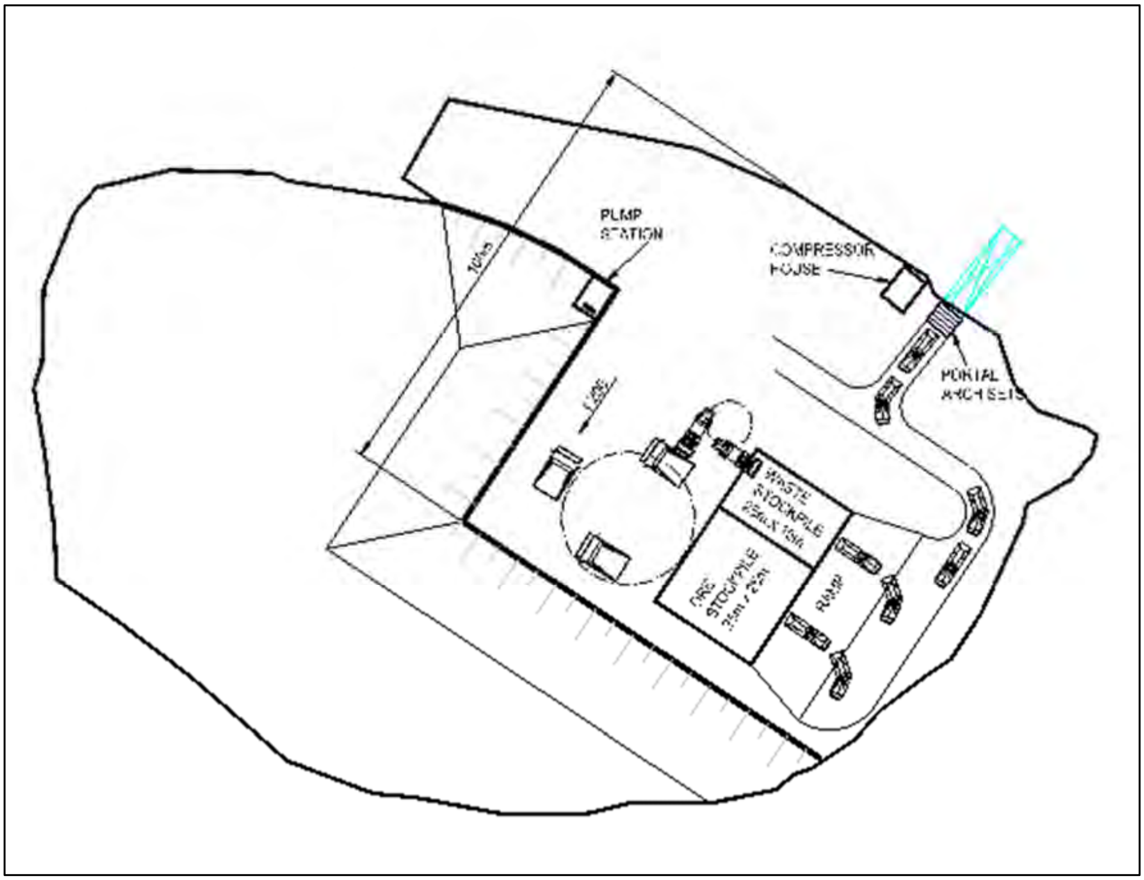


Figure 16-10: Kinjor portal area

All transport of men, material and rock will be via rubber tyred vehicles. Men and material will be transported by utility vehicles (light and heavy) and rock will be trucked using diesel driven articulated dump trucks.

The design and support of the portals and highwalls above the portals are discussed in the geotechnical section of this report (Section 16.2.3).

The main trucking ramps will be developed at a size of 5.0 m wide x 5.3 m high at a nominal inclination of 8° or 14% (1:7.1). This allows for a roadbed of 0.3 m and a finished excavation size of 5.0 m x 5.0 m.

16.2.4.3 Development

The trucking ramp will be located in the footwall of the orebody, at a minimum of 30 m from the footwall contact, as per the recommendation in the geotechnical report.

Access to the orebody will be established every 20 m vertically, by means of a level crosscut. The dimensions of the level crosscut will be 5.0 m x 5.0 m. Between the decline and the orebody intersection two stub drives of 15 m length will be established, one left and one right. These will initially be used as muckbays. These will later be used to house infrastructure such as pump stations, dams and electrical switchgear.

A set of return ventilation raises will be established between levels, which link up to an upcast vent raise, holing to surface and which will be equipped with the main fans. The level-to-level ventilation raises, which will be developed by drop raising techniques, will be located in one of the stub drives. Where required this drive will be extended to provide access to the required location of the ventilation raise.

These ventilation raises will also serve as service raises and will contain all service reticulation including:

- Pump columns
- Service water columns
- Electrical cables
- Compressed air columns.

The raises will also be equipped with a ladderway which will allow for installation and servicing of the services but will also allow the raises to be used as emergency escapeways from the underground workings, should the trucking ramp become compromised.

The level access cross cut will be developed perpendicular to the dip direction intersecting the footwall contact of the orebody first but then advancing through the orebody to the hangingwall contact. Where multiple ore zones are present the crosscut will advance to the hangingwall contact of the southern-most (uppermost) ore zone.

Ore drives will be established in the strike direction from the level access cross cut advancing to the limit of the orebody. Where multiple zones are present, which separated by a suitably sized pillar, minimum pillar width of 8 m, multiple drives will be established. Similarly, where one or more of the ore zone is sufficiently wide multiple ore drives will be developed in parallel. The minimum spacing between drives is required to be at least the width of the drive (4.0 m), so where the orebody is wider than 12 m a second ore drive will be developed.

Figure 16-11 shows a 3D view of the development layout, while Figure 16-12 shows a plan view of a typical production level.

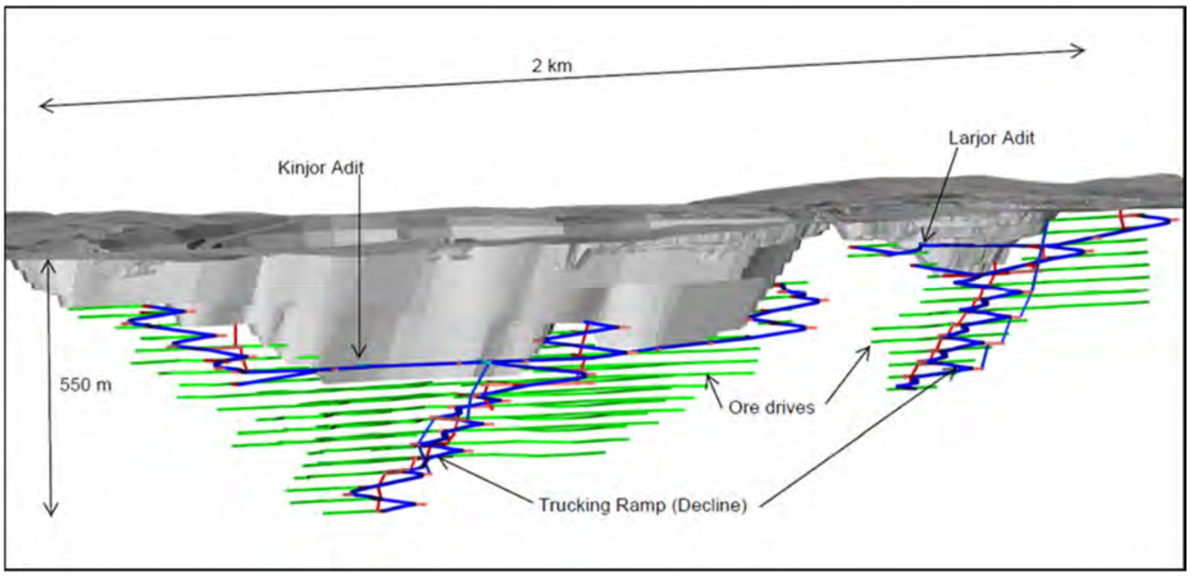


Figure 16-11: 3D view of development layout

All development will be completed using mechanised drill, blast, support, load and haul methods. Ore and waste will be hauled to surface (in-pit portal area) by underground ADT, where it will be tipped on the appropriate re-handling pad. The ore and waste will be re-handled from this position to the plant RoM pad or waste dump by a separate surface transport contractor who will operate a suite of surface tipper trucks and a front-end loader.

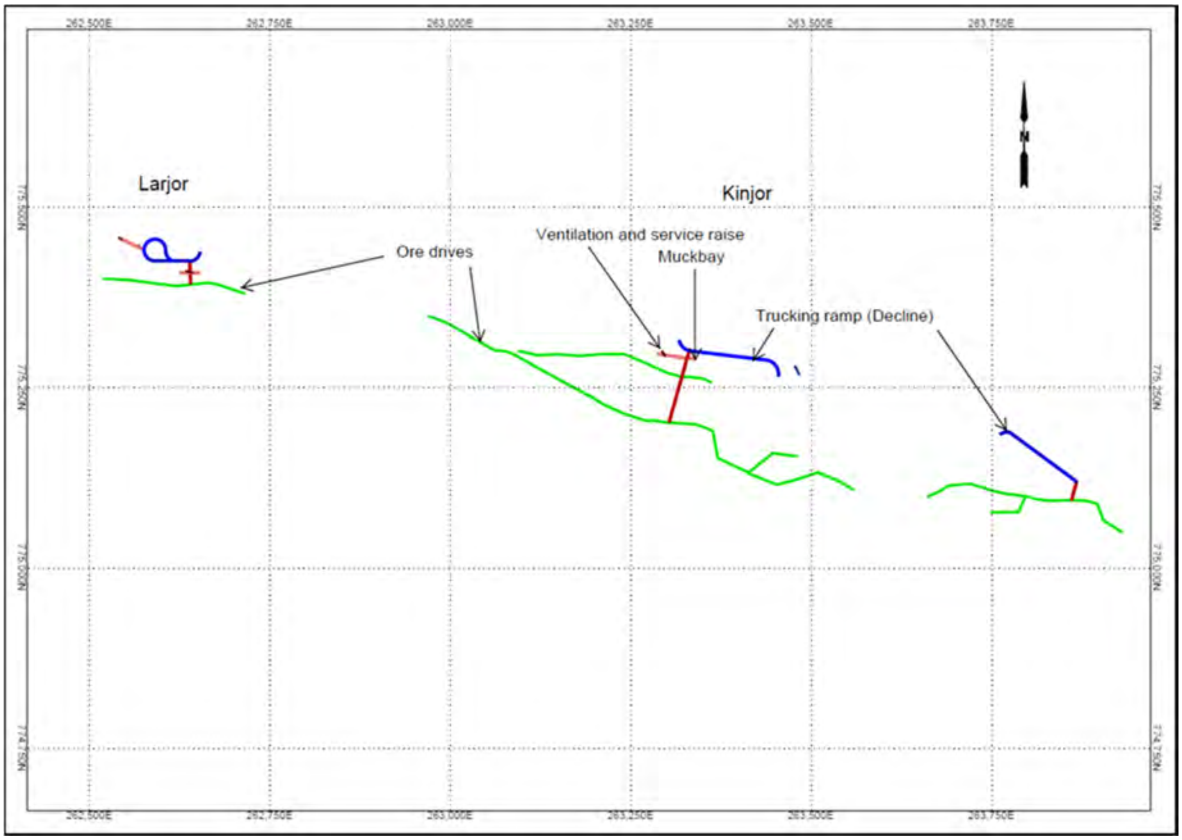


Figure 16-12: Plan view of typical level

The dimensions of the various excavations included in the development design are shown in Table 16-13 below.

Table 16-13: Development excavation dimensions

Development type	Width (m)	Height (m) (1)	Tonnes/m (2)
Decline	5.0	5.3	78
Muckbay	5.0	5.0	74
Level access crosscut	5.0	5.0	74
Ore drive	4.0	4.5	53
Drill cuddy	4.0	4.5	53
Slot raise	2.0	2.0	12
Return air raise	3.5	3.5	36
Fresh air raise	3.5	3.5	36

(1) Permanent excavations requiring a road surface are excavated to 0.3 m higher than the required finished height to allow for construction of road surface.

(2) Based on average density of 2.95 t/m^3.

The horizontal waste development which is made up of the ramps, level access crosscuts and muckbays are all 5.0 m x 5.0 m finished, although the ramp is excavated 0.3 m higher to allow for a permanent road base to be established. Lateral ore development is all 4.0 m x 4.5 m excavated and finished.

Figure 16-13 and Figure 16-14 show cross sections of the decline (5.0 m x 5.0 m) and lateral ore drives (4.0 m x 4.5 m finished) with the largest equipment expected to operate in these ends.

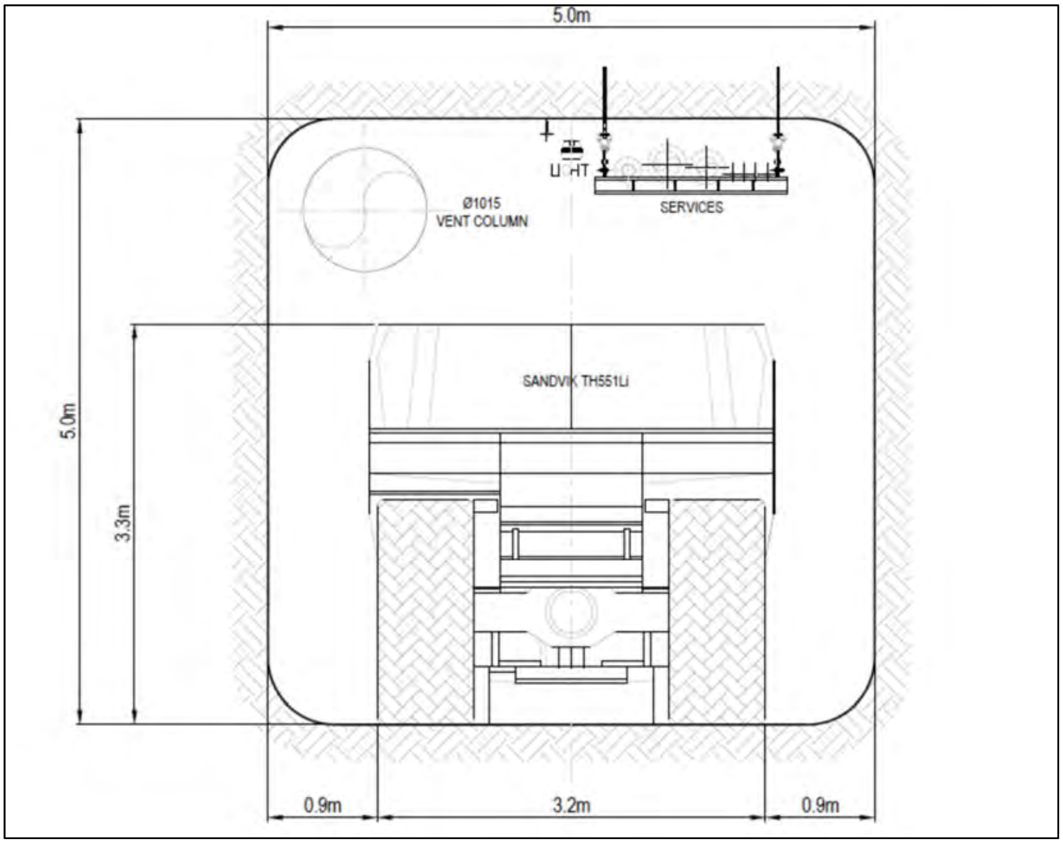


Figure 16-13: Decline cross-section showing haul truck

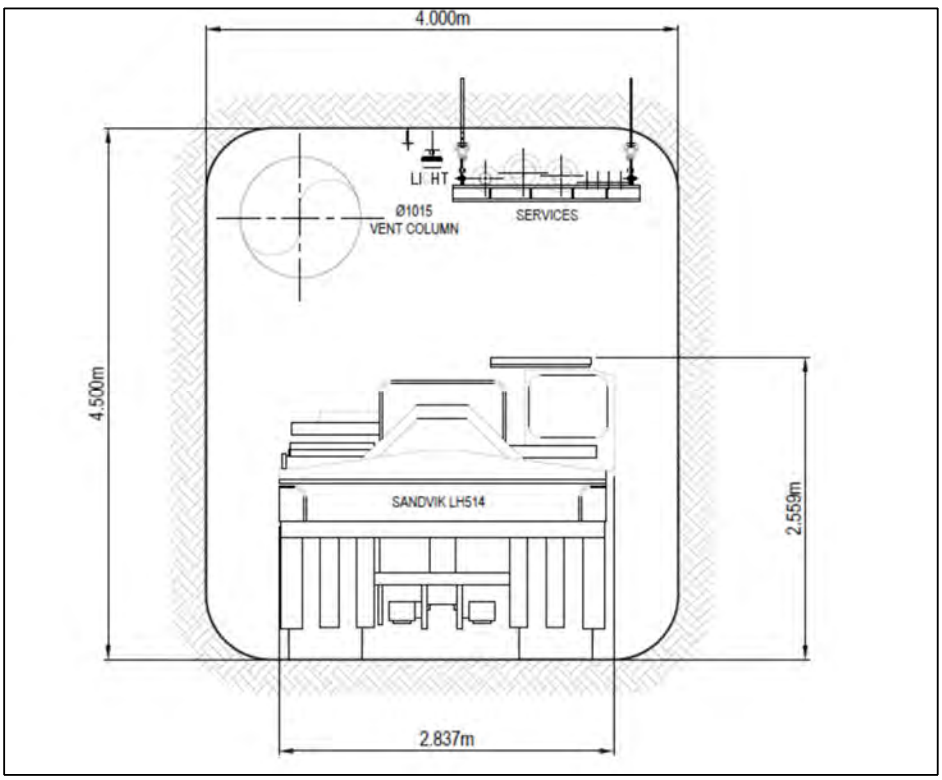


Figure 16-14: Ore drive cross-section showing LHD

All development drilling will be done by a twin boom electrohydraulic drill rig (Sandvik DD421 or equivalent). The blast-hole length will be 3.7 m, resulting in an expected advance per blast of 3.2 m. Holes will be charged with bulk emulsion. The initiation system will be shocktube long period detonators (LPDs).

Ground support of the various development end types is discussed in Section 16.2.3, the geotechnical section.

16.2.4.4 Stoping

Once the lateral development on a level is completed and the service raise linking to the level above has been developed and equipped, the level is ready for stoping to commence. Stope preparation starts with the development of a slot raise at the strike extent of the block of ground to be mined.

The slot raise will be mined at 2.0 m x 2.0 m and will hole between sublevels. Slot raises will be mined using drop raising techniques. The drilling of the holes will be completed with the long-hole production rig.

Once the slot raise is completed the raise will be opened up to the full width of the orebody, to form a complete slot, using a pattern of fanned blast holes. Once this slot is complete the stope is ready for production stoping to commence.

During development of the sublevel information regarding the orebody geometry and grade is collected by two main methods:

- Development sampling. Ore development will be sampled with chip sampling at regular intervals, most likely every round (3.2 m) of advance.
- Infill diamond drilling. Short diamond drillholes will be drilled to intersect the stope below, from the access ramp, muckbays or drill cuddies on the level above.

Prior to the commencement of stoping on a level a 3D model of the stope will be developed by the technical services department using all data available including surface diamond drilling, underground diamond drilling and development sampling. This model forms the basis for stope grade estimation, stope design and blast-hole ring design.

The preferred method of operation of the stope is for a number of rings to be pre-drilled and then blasted, one ring at a time. However, if ground conditions do not allow for pre-drilling of holes (i.e. holes closure is excessive between the time of drilling and charging of the holes), then rings will be drilled one at a time, just prior to blasting.

A stope panel will consist of two sublevels of 20 m, with main levels situate 40 m apart vertically. The geotechnical guidelines have set the maximum stope length at 22 m, based on the average orebody width of 10 m and a sublevel spacing of 20 m. In order to reduce the vertical span of unsupported stopes to 20 m, as specified in the geotechnical report, the bottom stope of each stope panel will be filled with waste rock fill. Since there are no waste drives on the level, the sequence of mining is to retreat from the ore block extent, back towards the level access crosscut. After the stope has advanced 22 m from the initial slot raise, a pillar must be left before re-slotting and recommencing the stoping operation. Once the first stope has been mined out it can be filled with waste. The waste rock fill will be tipped into the stope from the ore drive on the level above.

The sequence of mining is bottom up from a main level, for two sublevels. Conventionally a sill (horizontal) pillar would be left below the main level in this type of mining, to protect the ore drive on the main level. In order to reduce the loss of ore in pillars, an artificial horizontal pillar will be created by the use of cemented waste rock fill in the bottom 10 m of the stope, which will replace the horizontal pillar. Detail on the specifications of the artificial pillar are covered in Section 16.2.3. Figure 16-15 shows a schematic vertical projection illustrating the mining and filling sequence.

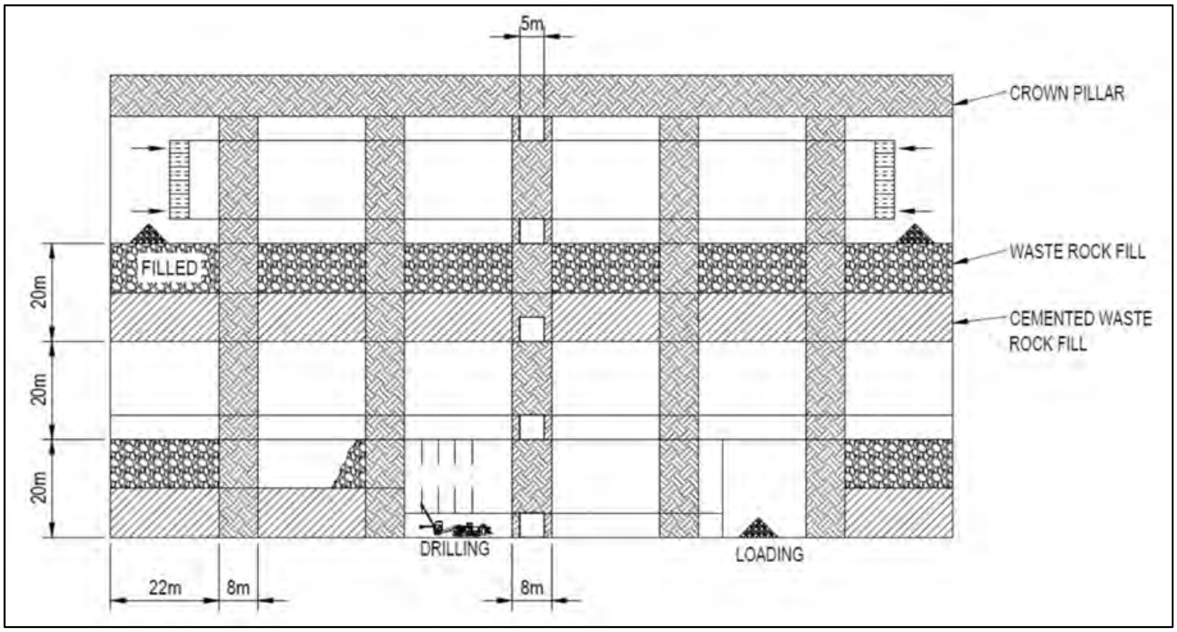


Figure 16-15: Schematic vertical projection illustrating the mining and filling sequence

16.2.4.5 Mining Modifying Factors

Cut-Off Grade

In order to convert the in-situ resources to a mining inventory appropriate modifying factors need to be applied. The following modifying factors were applied in the mine planning for the New Liberty Underground Mine (Table 16-14).

Table 16-14: Cut-off grade calculation

	Breakeven	Marginal cut-off (no mining cost)
Gold price (US$/oz)	1300	1300
Gold price (US$/g)	41.80	41.80
Refining, transport and marketing (US$/oz)	3.50	3.50
Royalty (% of revenue)	3%	3%
Received gold price	40.43	40.43
Mining cost (US$/t)	40.00	-
Processing cost (US$/t)	20.38	20.38
G&A cost (US$/t)	7.23	7.23
Total operating cost (US$/t milled)	68	28
Breakeven recovered grade (g/t)	1.7	0.68
Gold loss (%)	0%	0%
Metallurgical recovery (%)	92%	92%
Breakeven ROM grade (g/t)	1.8	0.7
Mining dilution (%)	10%	10%
Breakeven in-situ grade (g/t)	2.0	0.8

The breakeven grade of 2.0 g/t was selected as the cut-off grade to determine which stopes should be mined. All stopes with an in-situ grade of 2.0 g/t or higher were considered for the Mine Plan, while stopes with grade below 2.0 g/t were not included in the plan. In addition, only stopes which included indicated or Measured Resources were included in the plan. No Inferred Resources were included in the Mine Plan, irrespective of the grade of the Inferred Resource.

A marginal cut-off was applied to potential ore from development. Since the ore has already been mined, it only has to cover the processing and G&A costs to make a contribution to the project value. Although the marginal cut-off was calculated to be 0.8 g/t, a cut-off of 1.0 g/t was applied to development ore, in order to preserve ensure some profit margin on the material. Mineralise material from development with a grade of less than 1.0 g/t has been treated as waste in the study, but the potential does exist to stockpile this material and treat it at a later date should the gold price warrant it.

Pillar Loss

Pillar losses were calculated based on the pillar dimensions and spans detailed in the geotechnical report. An allowance was made for an 8 m pillar every 22 m (skin-to-skin) along strike. Although an 8 m pillar every 22 m amounts to a pillar loss of 27%, this is not the average many stopes do not require a pillar, such as stopes at the end of the strike extent of a block, or single stope blocks surrounded by unpay material. The average pillar loss amounted to 17%.

Dilution

There are two types of dilution included in stopes. The first is planned dilution. In selecting a stope shape that is:

- Large enough to warrant mining, i.e. larger than the smallest mining unit and;
- Is a shape that can be practically mined?

some material that is below the cut-off grade is unavoidably included in the stope. This is referred to as planned dilution.

The second category of dilution is a practical result of inaccuracy in mining. This could be due to drilling inaccuracy, suboptimal blasting practices, ground conditions or even backfill loaded with the ore. Typically, in an open stoping environment such as this, this is accepted to be around 10%. CSA Global has not accounted for any grade in this dilution. It is possible that the dilution tonnage does contain some gold content but since CSA Global cannot say for certain what the source of the dilution will be, it has not assumed it to be at zero grade.

Unplanned dilution of 10% at zero grade was applied to the stope tonnage. When the ore development, which has no dilution added to it is taken into account, the average dilution is 9%.

Ore Extraction

Ore extraction in the stopes is assumed to be 100%. Ore loading will be done by remote loader, so no ore should be left in the stopes. However, the stopes directly below the open pit will be mined last in the mining schedule. It can be expected that there will be significant ground control problems with these stopes, as the rock around the pit will be fractured weathered. An extraction of 50% has been allowed for in these stopes in the mining schedule. This drops the overall extraction from the stopes to a weighted average of 96%.

16.2.5 Mine Layout

A mine layout was developed for the New Liberty Underground Project using Deswik® mine design software. Deswik consists of a CAD module in which the underground layouts were drawn up, as well as a scheduling module, which was used to produce the mining schedule. The mine layout, showing both development and stoping is illustrated in Figure 16-16 below. The mining extends to a maximum depth of 550 m below surface. The depth limit of mining is due to the resource category only and it is expected that with future drilling from either underground or surface the inferred resources will be upgrade and mining will continue at depth. The mining layout allows for further extension in depth.

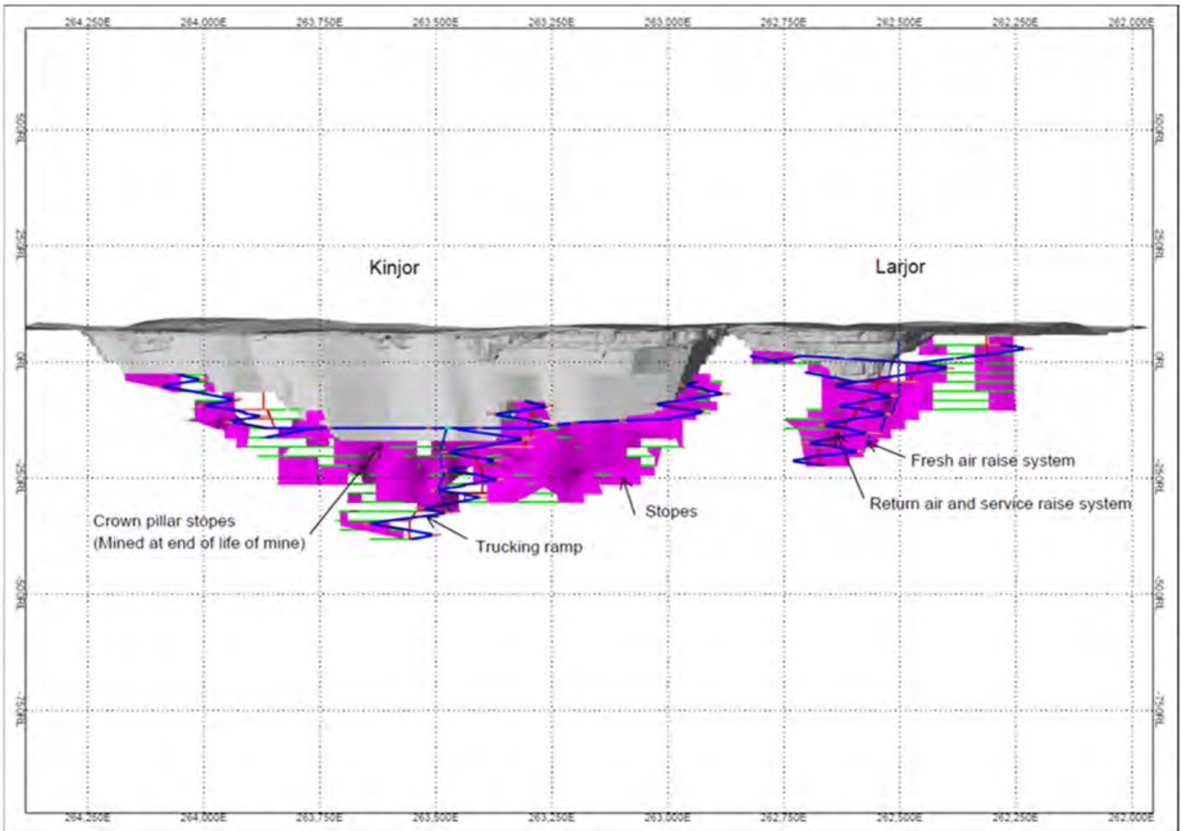


Figure 16-16: Underground mine layout

16.2.6 Mining Sequence

Underground mining will commence with the establishment of the Larjor adit and trucking ramp. Mining will take place only at Larjor while open pit mining continues in the Kinjor pit. The basic mining sequence is to develop the trucking ramp down and establish a main level every 40 m vertically. Stoping commences on the main level. The main level stopes are mined out and filled with waste rock allowing access to the sublevel above. In the meantime the trucking ramp and all other development continues down in order to open up additional mining faces.

The stopes above the portal elevation are mined in a bottom up configuration, with the bottom stope being filled with waste rock and the next stope being mined from the top of the waste rock fill.

After Kinjor Pit is exhausted in 2021 and access to the proposed portal location on Kinjor pit is established, mining will commence at Kinjor. Again, the mining sequence is similar to that described for Larjor, with the stopes below the portal elevation, which make up the majority of the orebody, being mined in a bottom up sequence from main levels established every 40 m vertically. The stopes above the portal elevation will be mined in a bottom up sequence.

Mining at Larjor continues until 2023, after which Larjor is exhausted and all the production comes from Kinjor.

The upper most level of stopes, directly below the open pit, form a crown pillar during normal operation of the mine. Prior to backfilling of the bottom of the open pits at Larjor and Kinjor, to establish access to the portal elevations, a cemented waste rock layer will be placed in the bottom of the pits. The detail of this 10 m thick artificial pillar is discussed in the geotechnical report. The cost of the cemented rockfill pillars has been included in the capital cost of the preparation of the portal locations in the respective pits. This cemented rock pillar will act as a crown pillar when mining takes place directly below the open pits. This will allow the stopes directly below the pit, which would normally be left as a permanent crown pillar, to be extracted. These stopes are the last stopes to be mined at the end of the mine life. This sequencing is to mitigate the risk of flooding if there is an ingression of water into the underground workings should one of the artificial pillars fail during mining of the crown pillar stopes. In the event of ingression of a significant quantity of water into the workings, the voids below will act as a large sump and allow time for the safe extraction of men and equipment.

16.2.7 Mining Equipment and Productivities

The mining equipment fleet at New Liberty has been selected with the orebody dimensions and geometry in mind in order to minimise dilution, while maximising productivity. Although the mining at New Liberty will be conducted by a contractor and CSA Global has not had sight of the contractor's proposed mining fleet, CSA Global has proposed a fleet of mining equipment suitable to this operation (Table 16-15).

Table 16-15: Summary of selected mining equipment

Equipment type	Model	Capacity	Quantity
Development jumbo twin boom	Sandvik DD421 or equivalent	240 m/month (multiple ends) 80 m/month (single end)	3
Production drill	Sandvik DL421 or equivalent	13 m/hour	2
Loader	Sandvik LH514 or equivalent	90 t/hour	3
Loader	Sandvik LH204 or equivalent	34 t/hour	3
Truck	Sandvik TH551 or equivalent	110 t.km/hour	3
Grader	Elphinstone K Series or equivalent		1
Telehandler	Manitou or equivalent		2
Utility vehicle (Cassette carrier)	Aard UV80 or equivalent		2
Shotcrete vehicle	Normet Spraymec MF050 D or equivalent		1
Agicar (shotcrete and concrete fill)	Normet Ultimec MF500 or equivalent		1
Light utility vehicles (pick-ups)	Toyota Landcruiser or equivalent		4

At least two of the loaders will be equipped with remote operating equipment. This allows the LHD to be operated remotely when loading in dangerous conditions such as under a damaged brow or in the open stope. These remote equipped loaders will also be used for placing of the cemented waste rock fill in the stopes, where required.

The smaller 4.5-t LHD will be used to load in narrow stopes and for general clean-up on the mine.

The productivity of the selected equipment fleet at New Liberty was calculated based on the following parameters:

- A shift cycle of two 12-hour shifts per day, seven days per week. This amounts to an average of 30 working days or 60 shifts per month.
- A total of two hours per shift was allowed for as unproductive time. This accounts for:
  - travelling time in and out of the mine
  - pre-shift meeting
  - pre-shift equipment checklist
  - post-production handover.

Equipment availability and utilisation were applied to the remaining 10 hours per shift to estimate the total working hours per month for each unit of mining equipment (loaders, jumbos and trucks).

Based on the operating conditions, which include haul distances and estimated travelling speeds, the productivity of the loaders and trucks was estimated (Table 16-16 and Table 16-17)

Table 16-16: Productivity estimated for 14-t LHD

Days per month = 30; Shifts per day = 2; Hours per shift = 12		
	Units	**LH514**
Loaded bucket capacity	t	12.00
Speed empty	m/min	67
Speed loaded	m/min	50
Distances		
Face to tip (minimum)	m	50
Face to tip (maximum)	m	250
Face to tip (average)	m	150
Task times		
Load bucket	min	1.5
Manoeuvre out of face	min	0.3
Manoeuvre into tip area	min	0.3
Tip	min	0.3
Manoeuvre out of tip area	min	0.3
Manoeuvre into face	min	0.3
Tram to tip	min	3.0
Tram back to face	min	2.2
Total cycle time	min	8.0
Trips per hour	No	7.5
Tonnes per hour	t/h	90
Working time		
Days per month	days	30
Shifts per day	shifts	2
Shifts per month	shifts	60
Shift length	hours	12
Travelling time in	mins	45
Pre-shift meeting	mins	10
Pre-shift checklist	mins	10
Post-production	mins	10
Travelling time out	mins	45
Total traveling and auxiliary time	hours	2
Face time per shift	hours	10.0
Face hours per month	hours	600
LHD capacity		
Availability		80%
Available hours	hours	480
Utilisation		70%
Utilised hours	hours	336
Tonnes per hour	**t/hr**	**90**
Tonnes per month	**t**	**30,282**

Table 16-17: Productivity estimated for 50-t ADT

Days per month = 30; Shifts per day = 2; Hours per shift = 12		
	Units	**TH551**
Payload	t	50.00
Dump box volume	m^3	30.00
Fill factor		87.00%
Loaded box size	m^3	26
Loaded bucket capacity	t	48
Speed empty	m/min	150
Speed loaded	m/min	100
SG	t/m^3	2.93
Bulking factor		1.60
Bulk SG	t/m^3	1.83
Distances		
Loading bay to tip (min)	m	1000
Loading bay to tip (max)	m	3500
Loading bay to tip (average)	m	2250
Task Times		
Load	min	4.5
Manoeuvre out of loading bay	min	0.5
Travel to tip	min	22.50
Load on surface	min	
Manoeuvre into tip area	min	0.5
Tip	min	0.5
Manoeuvre out of tip area	min	0.5
Manoeuvre into loading bay	min	0.5
Travel from tip	min	15.00
Tip waste (backfill)	min	1.00
Time for round trip	min	46
Working time		
Days per month	days	30
Shifts per day	shifts	2
Shifts per month	shifts	60
Shift length	hours	12
Re-entry period and planned maintenance	hours	2.0
Face time per shift	hours	10.0
Face hours per month	hours	600
Truck capacity		
Availability		85%
Available hours	hours	510
Utilisation		80%
Utilised hours	hours	408
Loading cycle	min	46
Cycles per month		538
Tonnes per cycle	t	48.0
Tonnes per month	t	25,838
Tonne.km per month	**t.km/month**	**58,135**
Tonne.km per hour	**t.km/hour**	**142**

It is assumed that, due to space constraints, only one loader will work in a particular stope. This means that while the stope is being loaded, the production rate from the stope is set by the productivity of the loader. It is assumed that sufficient trucking capacity will be provided to keep up with the loader.

The time to drill, charge and load a stope face were calculated, based on the average stope width of 8 m. Table 16-18 shows the calculation which results in an overall production rate of 11,700 tonnes per stope per month. Three operating stopes will be required to maintain the production rate of 30,000 tonnes per month.

Table 16-18: Stoping productivity estimate

Stoping width (m)	8
Sublevel spacing (m)	20
Stope length (m)	22
Mining drive height (m)	4.5
Stope height (m)	15.5
SG of ore (t/m^3)	2.9
Dilution (%)	10
Tonnes per m stope advance	396
Tonnes per stope	8702
Stope drill and bBlast	
Metres per stope drill/month	5000
Spacing	1.2
Burden	1.8
Holes per ring	8
Tonnes per hole	97
Tonnes per ring	712
Tonnes per m drilled	6.3
Tonnes per stope drill per month	31,320
Metres per ring	124
Metres per stope	1,516
Drilling rate (m/hr)	10
Days to drill stope	9
Days to charge rings	2
Days to muck stope	9
Filling	
Volume to be filled	3,520
Volume of fill	5,632
Fill rate (t/hr)	90
Days to fill stope	4
Total days	24
Tonnes per day	**356**
Tonnes per month per stope (Main level)	**10,678**
Tonnes per month for stope (Sublevel)	**12,712**
Tonnes per month for stope (average)	**11,695**

In order to estimate the development advance rates to be used during mine scheduling the advance per development end and per development jumbo were calculated. The blast-hole length that will be drilled by the singe boom drilling jumbo is 3.7 m. It is assumed that an effective advance of 3.2 m per blast will be achieved. Table 16-19 shows the estimate of advance rates per end type.

Table 16-19: Scheduling advance per month per end type

	Unit	Ramp/Access crosscut	Ore drive
Shifts per day	unit	2	2
Days per month	unit	30	30
Blast hole length	m	3.7	3.7
Effective advance	m	3.2	3.2
Time to drill and blast (shifts)	unit	1	1
Time to muck and support (shifts)		1	1
Grade control (shifts)	unit	0	0.5
Blasts per day	unit	1.0	0.80
Advance per day	m	3.2	2.6
Blast efficiency	%	85%	80%
Advance per month	m	82	61

The time to drill a face will vary between four and five hours, depending on the end type. Considering travel time between ends, it is reasonable to assume that the jumbo will complete a minimum of 1.5 rounds per shift. The expected advance rate per jumbo is then 230 m. This includes an allowance of 80% efficiency. The calculation of advance per jumbo is shown in Table 16-20.

Table 16-20: Development jumbo prospectivity

Time to drill face (hours)	5
Faces completed per day	3
Meter advance per shift	4.80
Shifts per day	2
Days per month	30
Efficiency	80%
Advance per month (metres)	**230**

16.2.8 Operational Considerations

16.2.8.1 Contract Mining

Underground mining at New Liberty will be undertaken by a mining contractor. Avesoro have already commenced negotiations with a preferred contractor, who provided the underground mining rates used in the operating cost estimates for this PFS. The contractor will undertake all drilling, blasting, load and hauling to surface of waste and ore from both development and stoping underground.

The contractor will provide the mining equipment, labour and required consumables to complete the work, as per the responsibility matrix included in its proposal to Avesoro.

16.2.8.2 Owners Team Responsibilities

Although the underground mining will be undertaken by a contractor, the mine owner (Avesoro) will have responsibility for managing and supporting the contractor. A schedule of responsibilities was provided by the contractor. There are a number of functions during ongoing production which the mine owner remains responsible for. These include:

- All engineering designs and drawings.
- All mine planning and scheduling (long and short term).
- Survey for payment purposes.
- Completion of survey plans and “as built” drawings.
- Contract management including provision of underground supervisors and mine manager.

- Technical services functions including geology, mining engineering. This will include ventilation and geotechnical monitoring.
- Safety management in the form of a safety and training superintendent.
- Site security.
- Supply of process water and associated infrastructure.
- Supply and management of the explosives magazines.
- Ambulance and first aid services.

These functions have been considered in the make-up of the owner's team manpower schedule and included in the mining related owners team cost as part of the operating cost estimate.

16.2.9 Production Schedule

A mining schedule was developed based on the mine layout presented above, using DeswikSched® mine scheduling software. The metres of development, waste and ore tonnes from development and stope ore tonnes were scheduled by month for the LOM. The monthly periods were consolidated in quarters for inclusion of the underground mining schedule into the overall project schedule for New Liberty and Ndablama.

16.2.9.1 Production

Development from the Larjor portal commences in Month 1 of the project, or January 2020. Limited ore is mined from some initial stopes in close proximity to the portal as well as from ore development in the first six quarters with stope production ramping up to 75,000 tonnes in Quarter 7. Ore production from Larjor peaks at 108,000 tonnes per quarter in Quarters 11 and 12, after which production from Larjor tails off.

In January 2022, development of the Kinjor Decline commences. First ore is produced within the first quarter from ore development. The first stope ore is mined from Kinjor in the second quarter of Kinjor operation. The ramp up of production in Kinjor corresponds to the tailing off of Larjor production. The nameplate production rate of 150,000 tonnes per quarter is first achieved in Quarter 18 of the project, when Kinjor reaches full production capacity. Steady state production of around 600,000 t/a continues for five years after which production tails off for two years, resulting in a 10-year LOM.

Figure 16-17 shows view of the mine plan coloured by year, while Figure 16-18 illustrates the production profile graphically. The production schedule, by year, is shown in Table 16-21.

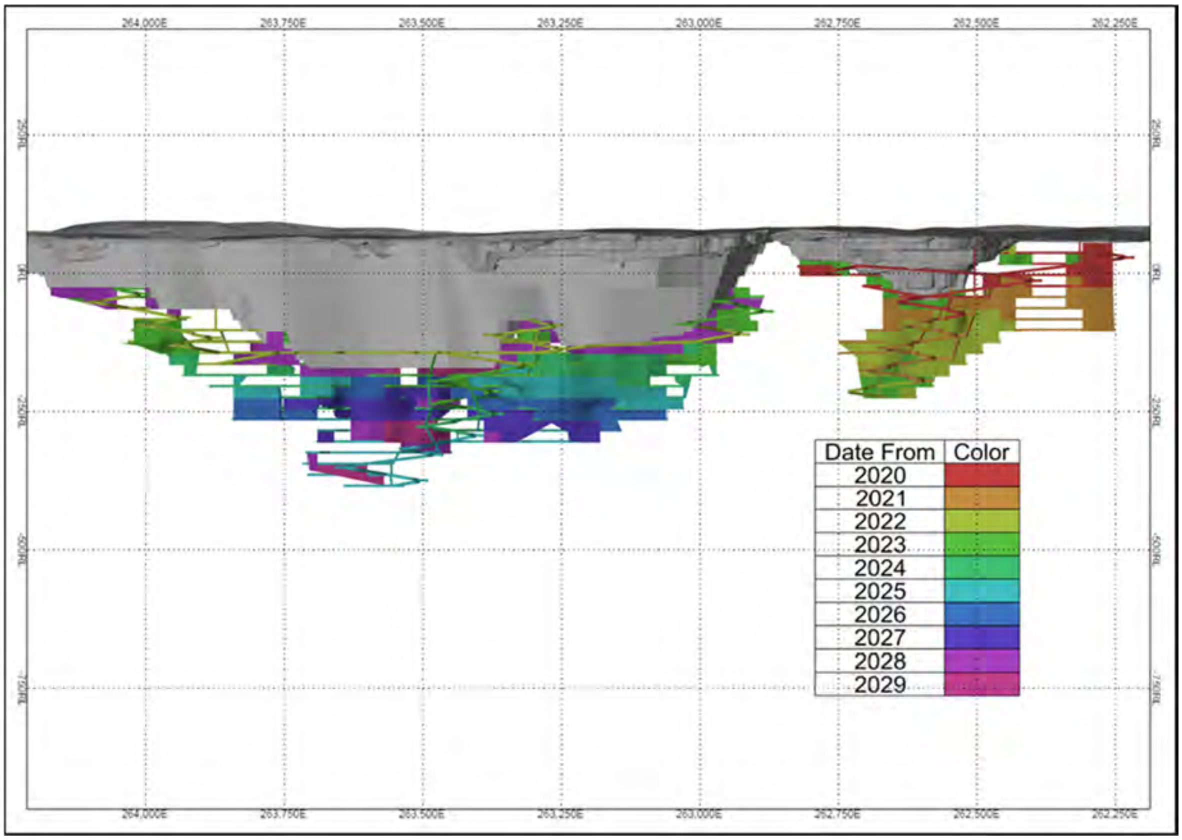


Figure 16-17: Mine Plan coloured by year

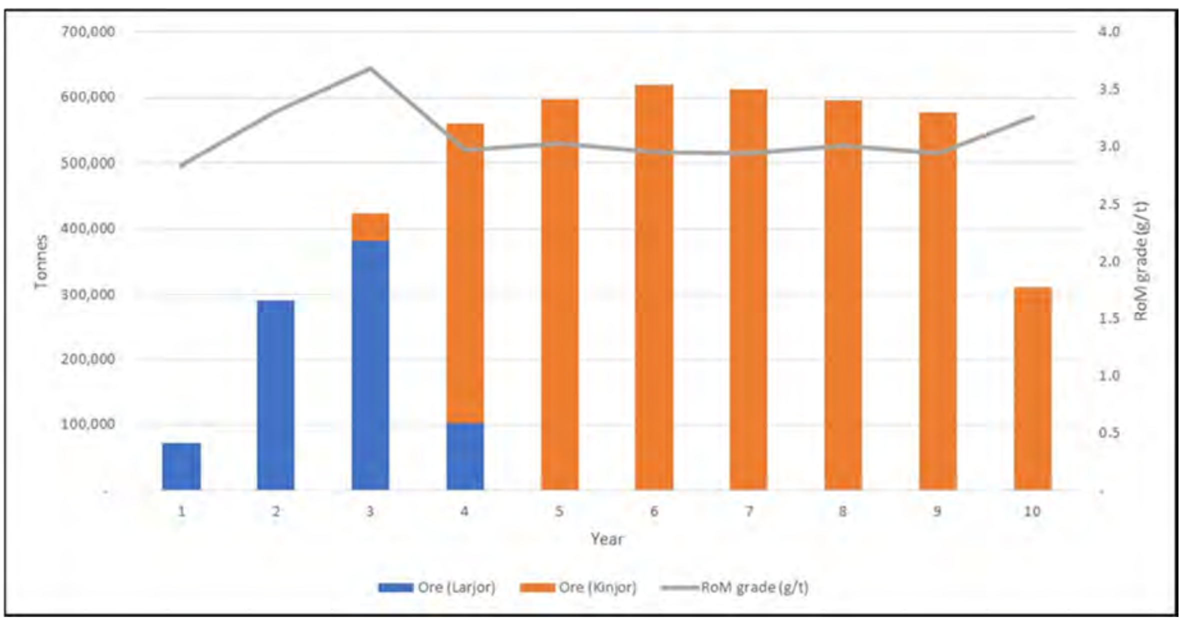


Figure 16-18: Underground Mine production profile

Table 16-21: New Liberty Underground Mine production schedule

New Liberty Underground Mine	Unit	Year										Total
		1	2	3	4	5	6	7	8	9	10	
Waste development flat	m	661	492	1,369	906	527	398	-	-	-	-	**4,353**
Ramp development metres	m	1,413	841	2,746	1,040	333	643	-	-	-	-	**7,016**
Ore development flat	m	1,315	2,613	2,309	4,808	6,071	2,724	-	-	-	-	**19,841**
Invlined metres waste	m	145	322	241	148	168	198	-	-	-	-	**1,221**
Inclined metres ore	m	-	-	-	-	-	-	-	-	-	-	**-**
Stope tonnes LHOS	ROM t	28,182	191,077	372,172	392,912	362,344	542,783	611,931	596,081	577,183	311,690	**3,986,356**
Stope grade	ROM g/t	2.7	3.1	3.8	2.8	2.9	3.0	2.9	3.0	2.9	3.3	**3.0**
Stope Au	g	2,482	18,802	45,219	35,087	33,946	52,503	57,828	57,667	54,648	32,634	**390,816**
Ore development	ROM t	43,691	99,030	51,690	166,752	234,324	77,078	-	-	-	-	**672,564**
Development ore grade	ROM g/t	2.9	3.8	2.9	3.4	3.2	2.6	-	-	-	-	**-**
Development ore Au	g	4,079	12,028	4,900	18,396	24,061	6,330	-	-	-	-	**-**
Total ore tonnes	**ROM t**	**71,873**	**290,107**	**423,863**	**559,663**	**596,667**	**619,861**	**611,931**	**596,081**	**577,183**	**311,690**	**4,658,920**
ROM g/t	ROM g/t	2.8	3.3	3.7	3.0	3.0	3.0	2.9	3.0	2.9	3.3	**3.1**
ROM Au oz	ROM Au oz	6,561	30,830	50,119	53,483	58,006	58,833				32,634	**460,609**
Waste tonnes	t	162,286	112,130	323,396	152,430	70,973	86,801	-	-	-	-	**908,016**
Unpay development tonnes	t	26,046	39,710	70,902	87,939	87,417	67,262	-	-	-	-	**379,276**
Hauled tonnes	hauled t	260,205	441,947	818,161	800,032	755,058	773,924	611,931	596,081	577,183	311,690	**5,946,212**
Tonne.km	t.km	100,007	242,806	579,886	759,869	1,103,271	1,279,904	1,155,375	1,224,406	936,261	724,730	**8,106,515**

16.2.9.2 Equipment Requirements

The equipment requirements over the LOM were estimated by Bara based on the productivities detailed above. The required working hours per month per primary equipment type was divided by the maximum utilised hours per unit calculated in the productivity calculations to determine the number of units required.

For the ancillary equipment an estimate was made on the number of units required based on experience from similar operations. Table 16-22 below shows the schedule of mining equipment by year. Note that this estimate was completed by Bara and the mining contractor may choose to deploy a different mining fleet.

Table 16-22: Schedule of mining equipment requirements

Equipment type	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Development jumbo twin boom	2	2	3	3	3	3	-	-		
Production drill	1	1	1	2	2	2	2	2	2	2
Loader (14-t)	2	2	3	3	3	3	3	3	3	3
Loader (4.5-t)	1	1	1	1	1	1	1	1	1	1
Truck	1	1	2	2	2	3	3	3	3	2
Grader	1	1	1	1	1	1	1	1	1	1
Telehandler	2	2	2	2	2	2	2	2	2	2
Utility vehicle (Cassette carrier)	2	2	2	2	2	2	2	2	2	2
Shotcrete vehicle	1	1	1	1	1	1	1	1	1	1
Agicar (shotcrete and concrete fill)	1	1	1	1	1	1	1	1	1	1
Light utility vehicles (pick-ups)	4	4	4	4	4	4	4	4	4	4

16.2.9.3 Labour

Majority of the underground work force at New Liberty will be employed by the mining contractor. The submission by the mining contractor does not include a manpower schedule. In order to estimate the manpower required to operate the mine and support infrastructure, Bara have prepared a manpower complement. The contractor may choose to use a different manpower arrangement, but the schedule presented would be adequate to operate the mine.

Table 16-23 below shows a summary of the total manpower complement for the underground mine. Of these, 21 will be employed by the mine owner and 205 by the contractor.

It is expected that at least 88 will be expatriate employees with the remainder being Liberian nationals.

Table 16-23: Manpower complement for New Liberty Underground

Breakdown by area	Contractor	Mine	Total
Mining supervision	10	4	14
Development	42	0	42
Stoping	27	0	27
Loads and haul	25	0	25
Technical services	22	12	34
Surface engineering	38	5	43
Underground engineering	41	0	41
Total Mining Labour	**205**	**21**	**226**

The mine owner's team will consist of the following:

- Underground mining contract manager (Mine Manager)
- Mining supervisors, as called for in the contractor's responsibility matrix
- Technical services team, which will perform the geological and grade control function as well as mine planning
- Surface engineering, which will ensure provision and maintenance of bulk services to the contractor.

Senior mine management and other shared services such as human resources, accounting and finances, security and stores are covered under the G&A costs for the overall project.

16.2.10 Ventilation

This ventilation design for New Liberty Mine gives the intended ventilation method, layout, air quantities and the dimensions of the primary and secondary excavations to cater for the air quantities. The ventilation plan has been modelled using Ventsim Design 5, a state-of-the-art ventilation and underground environmental conditions modelling program.

Ventilation is the primary means of diluting and removing pollutants such as dust, gases, diesel exhaust emissions and heat.

Table 16-24 lists the principal criteria used in this study.

Table 16-24: Ventilation design criteria

Design intake air temperature (wet bulb/dry bulb)	25.0/30.0°C
Design relative humidity	67%
Design reject air temperature (wet bulb/dry bulb)	30.0/35.0°C
"Withdraw from working place" wet bulb temperature	32.0°C
Air to engine rated diesel power ratio at point of use	0.06 $m^3/s/kW$
Overall air leakage factor for the mine	12 %
Declines and intake air tunnels – air velocity	maximum 8 m/s
Return airways – air velocity	maximum 14 m/s
Unequipped air raises and raise bored holes – air velocity	maximum 22 m/s
Return air raises with emergency ladders, pipes and cables – air velocity	maximum 15 m/s
Friction factor – Declines and haulages and crosscuts (average blast)	0.012 Ns^2/m^4
Friction factor – unequipped raises (rough blast)	0.02 Ns^2/m^4
Friction factor – Ladder way, pipes and cables equipped raises	0.03 Ns^2/m^4

New Liberty Mine experiences a tropical climate. Climatic data has been obtained for the town of Tubmanburg, some 35 km east of the mine site and at a similar altitude is given in Table 16-25.

Table 16-25: Climate data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average temperature (°C)	26	26.7	26.8	26.7	26.6	25.6	24.4	24.4	25.3	26.1	25.6	25.5
Minimum temperature (°C)	20.8	21.4	21.4	21.2	21.3	21	20.2	20.5	21.1	21.5	20.8	20.6
Maximum temperature (°C)	31.3	32.1	32.3	32.2	31.9	30.3	28.7	28.4	29.5	30.8	30.4	30.5
Average temperature (°F)	78.8	80.1	80.2	80.1	79.9	78.1	75.9	75.9	77.5	79.0	78.1	77.9
Minimum temperature (°F)	69.4	70.5	70.5	70.2	70.3	69.8	68.4	68.9	70.0	70.7	69.4	69.1
Maximum temperature (°F)	88.3	89.8	90.1	90.0	89.4	86.5	83.7	83.1	85.1	87.4	86.7	86.9
Precipitation/Rainfall (mm)	27	54	107	159	300	591	604	420	560	382	162	72

16.2.10.1 Determination of Air Requirements

The air requirements are based upon the active mining fleet in Larjor and Kinjor underground sections and other standard mine ventilation criteria:

- Sufficient air to dilute and remove diesel exhaust gases from the active fleet
- Sufficient air to dilute and remove heat to provide a safe and healthy working environment without requiring refrigeration
- Sufficient air to ventilate all places where persons work or travel
- Sufficient air to provide a robust ventilation system to cater for any possible flammable gas occurrences
- Allowance for the inevitable leakages that occur in mines.

An air to diesel power ratio of 0.06 $m^3/s/kW$ of rated power is applied. This ratio is internationally accepted and assumes modern machinery, a good maintenance regime, pollution control measures such as catalytic converters and diesel filters are used combined with low sulphur diesel fuel. The air requirements reflecting sizes of the mining fleet the for both Larjor and Kinjor are given in Table 16-26 and Table 16-27.

Table 16-26: Active diesel fleet air requirements – Larjor

Item	kW	No.	kW
Truck 50-t	551	2	1,102
LHD 14-t	256	2	512
LHD 4½-t	93	1	93
Telehandler	80	1	80
Pick-up trucks	80	1	80
Grader	125	1	125
Long hole rigs	110	1	110
Development rigs	110	2	220
Utility vehicles	80	1	80
Explosives chargers	80	1	80
Total kW diesel power in use			**2,482**
Air requirements			
Diesel power in use x dilution rate in $m^3/s/kW$			
2482	x	0.06	149
Leakage allowance	15	%	22
Allowance for ventilation of workshops etc.			25
Total airflow required m^3/s			**196**

Table 16-27: Active diesel fleet air requirements – Kinjor

Item	kW	No.	kW
Truck 50-t	551	3	1,653
LHD 14-t	256	3	768
LHD 4½-t	93	1	93
Telehandler	80	1	80
Pick-up trucks	80	2	160
Grader	125	1	125
Long hole rigs	110	2	220
Development rigs	110	3	330
Utility vehicles	80	2	160
Explosives chargers	80	2	160
Total kW diesel power in use			**3,749**
Air requirements			
Diesel power in use x dilution rate in m³/s/kW			
3749	x	0.06	225
Leakage allowance	15	%	34
Allowance for ventilation of workshops etc.			25
Total airflow required m³/s			**284**

The air flow requirement for individual vehicles at point of use is given in Table 16-28.

Table 16-28: Individual vehicle air requirements

Vehicle	kW	m³/s
Truck 50-t	551	33.1
LHD 14-t	256	15.4
LHD 4½-t	93	5.6
Drill rigs	110	6.6
Grader	123	7.4
Telehandler	80	4.8
Material transporter	80	4.8
Explosives truck	80	4.8
Pick-ups	100	6.0

16.2.10.2 Ventsim Simulations

The mine ventilation circuit was modelled program to simulate airflow and temperatures in the mine.

Larjor and Kinjor sections are entirely independent from a ventilation aspect. They were modelled for a "worst case" scenario, daytime mid-summer and mining at the deeper levels. The model also reflected the typical use of diesel-powered equipment. Allowances were made for the wetness of the rock surfaces exposed to air. It was assumed that there was no significant inflow of warm ground water. In the absence of any geothermal data for the mine, default rock settings were used.

The relatively shallow depth of less than 400 m auto compression of the air does not make a significant contribution to the mine heat load.

Simulation Conclusions

Larjor requirements:

- Intake: The 5.0 m x 5.0 m portal and decline and a second intake holing (9 m²) in addition to the portal for fresh air will be required. This will also serve as a second emergency escapeway.

 - In addition, 4 x 6.0 m² intake drop raises covering five levels in parallel with the decline to reduce the air velocity in the decline to an acceptable level, particularly where there are 50-t trucks operating.
- Exhaust: The exhaust shaft through the crown pillar to surface, consisting of 4.2 m diameter raise bore hole (or equivalent ventilation rise) with one fan station with two axial fans.

Kinjor (Main section) requirements:

- Intake: The 5.0 m x 5.0 m portal and decline and a second intake holing of 3.6 m in diameter from the pit to the second level for fresh air will be required. This will also serve as a second emergency escapeway.
    - In addition, 4 x 6.0 m² intake drop raises covering three levels in parallel with the decline to reduce the air velocity in the decline to an acceptable level, particularly where there are 50-t trucks operating would be recommended.
- Exhaust: The exhaust shaft, should be 4.2 m in diameter with one fan station with two axial fans.

Kinjor (Western section) requirements:

- Intake: Air will be supplied by from the Main section
- Exhaust: An exhaust shaft 2.4 m diameter into the pit with one fan station with one axial fan.

The importance of having good seals for the worked-out levels, and ventilation doors and ensuring that the correct volume of air is delivered at point of use in the development ends is apparent, otherwise temperatures from the use of diesel equipment become excessive. The mining scenarios were modelled with three levels of active stopes in each section. The simulation showed that provided the ventilation circuit and air leakage was properly controlled, the air quantities were sufficient to provide safe working conditions.

16.2.10.3 Air Distribution

The mine will consist of two independent ventilation districts or sections (i.e. Larjor and Kinjor). The primary air distribution for the Larjor section is shown schematically in Figure 16-19.

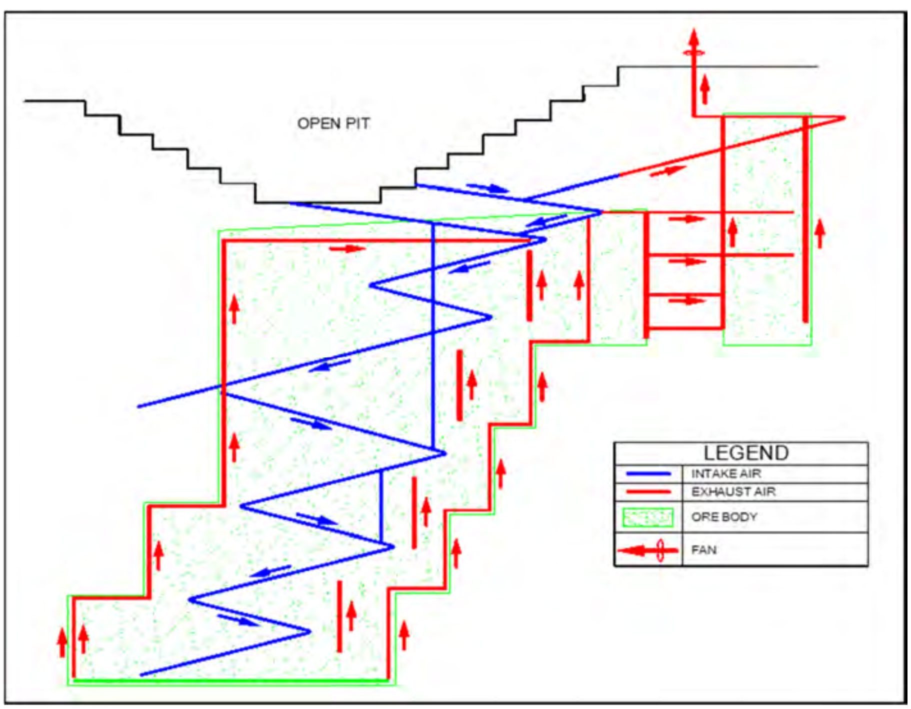


Figure 16-19: Schematic ventilation diagram – Larjor section

The intake ventilation system at Larjor will consist of a single 5.0 m x 5.0 m (finished size) decline from the portal supplemented by a 9 m^2 intake daylighting into the pit. This will also serve as a second escapeway.

Drop raises 6 m^2 from level-to-level in parallel with the decline for the three levels below the portal will be required to prevent excessive air speed in the decline, particularly with 50-t trucks running in the decline.

The Return Airway (RAW) system will consist of a series of 3.5 m x 3.5 m drop raises going from level to level. These drop raises will be equipped with an emergency escape ladder as well as cables and pipes as required. Used air will also exhaust through the mined-out area to the exhaust fan station in the pit.

Only half of the mined-out area will be filled with waste and where necessary ventilation raises can be left in the stoped out area.

The primary air distribution for the Kinjor section is shown schematically in Figure 16-20.

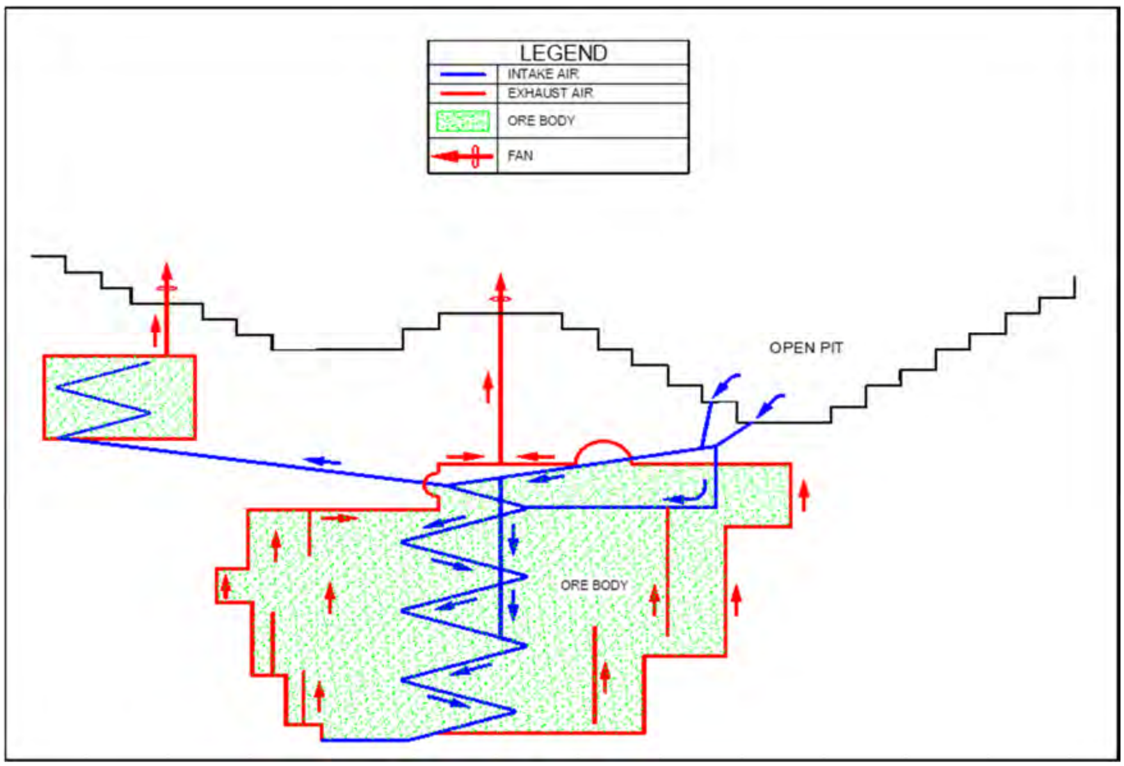


Figure 16-20: Schematic ventilation diagram – Kinjor section

The intake ventilation system at Kinjor will consist of a single 5.0 m x 5.0 m (finished size) decline from the portal supplemented by a 12 m^2 intake daylighting into the pit. This will also serve as a second escapeway.

Drop raises 6.3 m^2 from level-to-level in parallel with the decline for the three levels below the top intake airway elevation will be required to prevent excessive air speed in the decline, particularly with 50-t trucks running in the decline.

The RAW system will consist of a series of 3.5 m x 3.5 m drop raises going from level-to-level. These drop raises will be equipped with an emergency escape ladder as well as cables and pipes as required. Used air will also exhaust through the mined-out area to the exhaust fan station in the pit.

Only half of the mined-out area will be filled with waste and where necessary ventilation raises can be left in the stoped out area.

16.2.10.4 Development Ventilation

Decline and adjacent ventilation

To cater for decline development, a fleet consisting of 1 x 50-t truck, 1 x 14-t LHD and a diesel drill rig/bolter was used to estimate the required airflow. Employing the convention for vehicles operating in a single major excavation area, the formula used is:

$$(\text{Largest vehicle x } 1) + (\text{2nd largest x } 0.75) + (\text{other vehicles x } 0.5).$$

The results of this calculation are shown in Table 16-29.

Table 16-29: Minimum air required when haul truck is present

Item	Rated kW	Factor	kW
50 t truck	551 kW	1	551
14 t LHD	256 kW	0.75	192
Drill rig	110 kW	0.5	55
	Total kW	Ratio	789
798 kW x 0.06 m³/s/kW = Minimum air required m³/s			**48.0**

Thus, at least 48 m³/s of air has to be supplied to the last point where the truck operates. This air will be delivered to the working face by 2 x 1.4 m diameter flexible ventilation columns equipped with 110 kW silenced auxiliary fans. Beyond this, rock will be taken by LHD to the remuck bay.

Table 16-30 shows the minimum amount of air required in development ends and ore drives (stopes) where only LHDs and drill rigs are used.

Table 16-30: Air required in development ends and ore drives

Item	Rated kW	Factor	kW
14 t LHD	256 kW	1	256
Drill rig	110 kW	0.75	83
	Total kW	Ratio	339
339 kW x 0.06 m³/s/kW = Minimum air required m³/s			**20.4 m³/s**

Development to the Orebody

Once the decline has reached the particular level's sump position, development will normally stop or be done at a reduced rate. Development towards the orebody can commence and once the appropriate cubby has been mined, work on the drop raise form the level above can commence.

Development from the decline towards the ore body and thereafter the development of the strike drives will consist of 1 x 1.2 m diameter flexible force columns each equipped with a 75 kW force fan in each end. As only the LHD and drill rig will operate in the strike drive one column will suffice to ventilate each strike drive. The 50-t truck will load at the remuck bay.

The general layout for development is shown in Figure 16-21. As there is only one fleet operating in the decline and the initial development towards the ore drives, air can be reused as shown in the lower section of Figure 16-21 below.

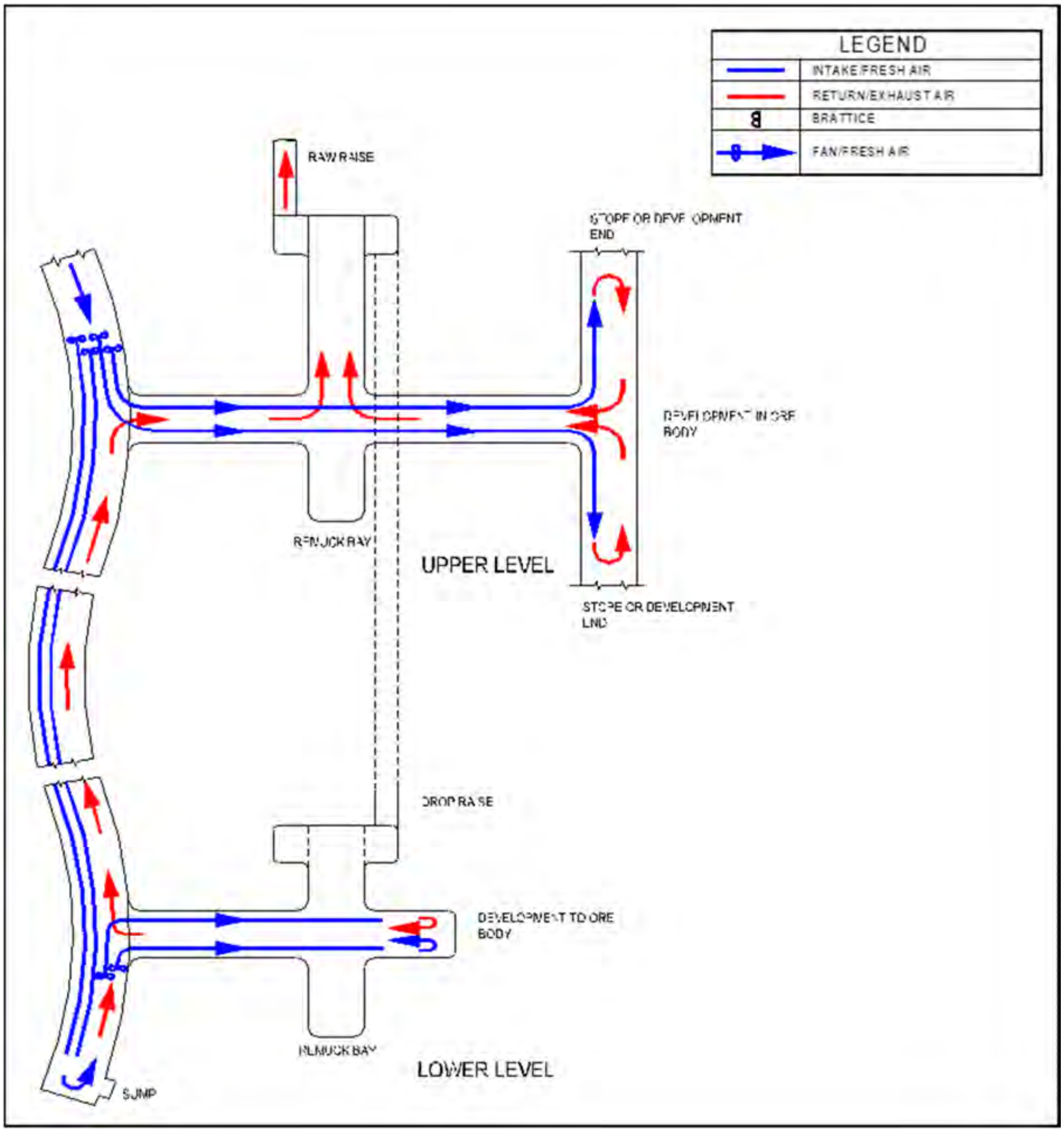


Figure 16-21: Ventilation layout for the development to and in the orebody

16.2.10.5 Stoping Ventilation

The stopes will be ventilated by retaining the development and columns with the return air being extracted up the ventilation exhaust drop raises in the RAW system and out via the main fans. Some air will pass through the worked-out stopes above. The amount will vary depending upon the amount and location of waste fill and the state of the muck pile being extracted. As the mining is carried out on a retreat basis, the column will be gradually shortened until stoping is complete on the particular strike drive. This is shown in Figure 16-22.

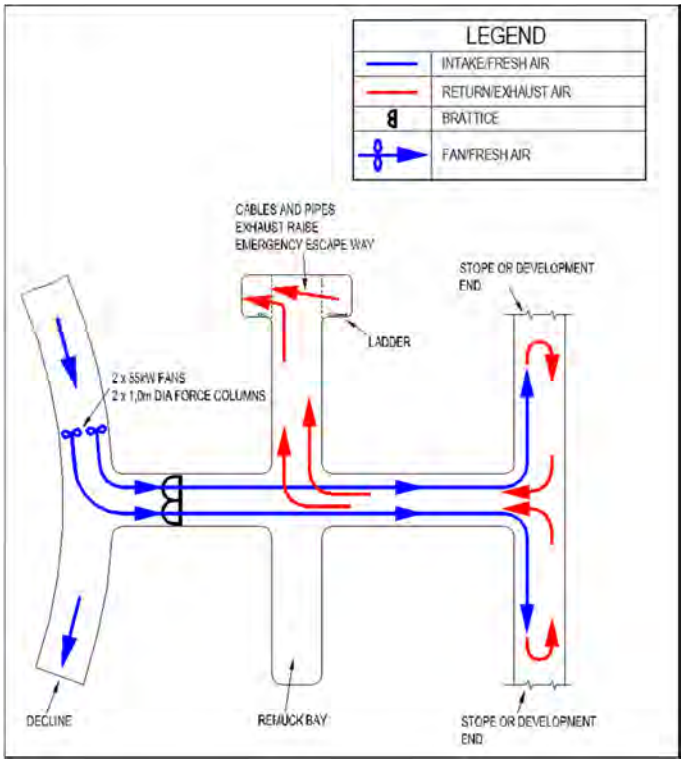


Figure 16-22: Ventilation layout for stopes

Figure 16-23 shows ventilation of stoping with fill.

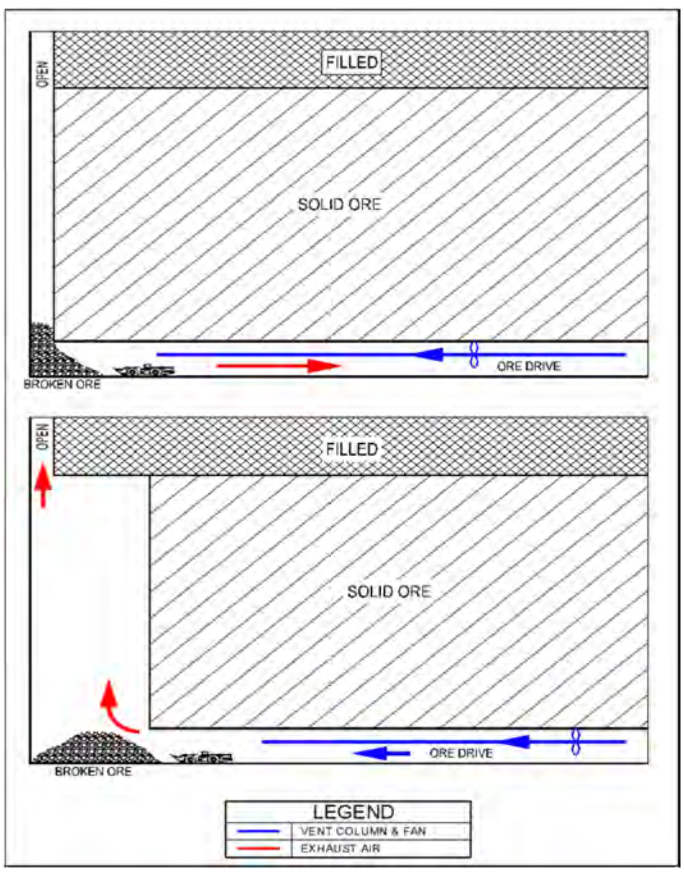


Figure 16-23: Stoping ventilation

16.2.10.6 Ventilation Controls

The primary ventilation control consists of a series of seals installed in the access crosscut immediately the level concerned has been mined out. It is essential that these seals are properly constructed to ensure that any leakage is kept to a minimum (±1.0 m³/s). This requires that any ballast be removed down to solid rock and a robust seal of concrete bricks be built with a 1 m x 1 m steel door (with gasket) and a latch capable of being opened from both sides for emergency exit purposes. The seal area should be shotcreted to prevent leakage through the rock fracture zone surrounding the excavation. The detail is shown in Figure 16-24 and the general position of the seal is shown in Figure 16-25.

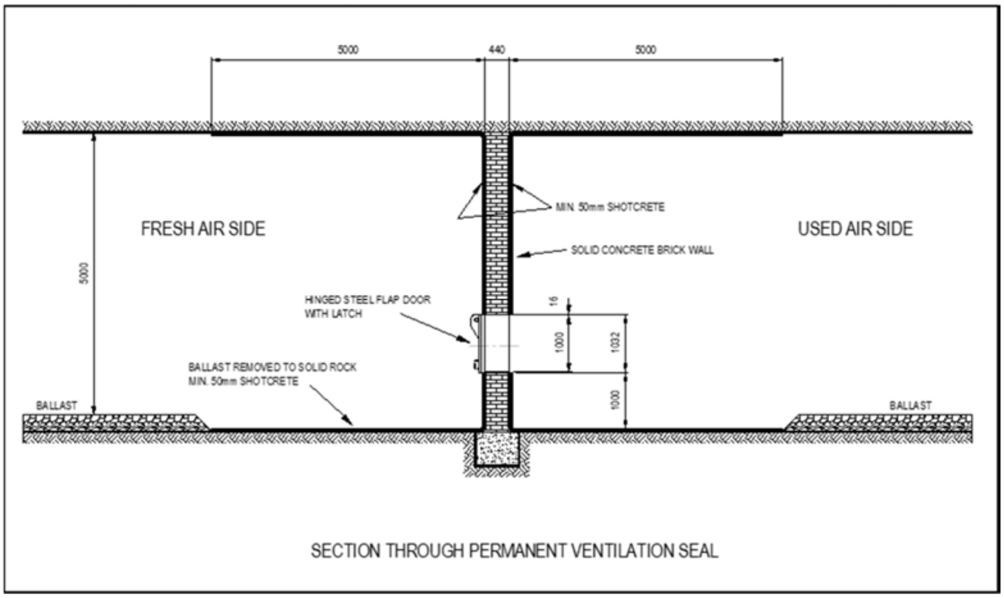


Figure 16-24: Detail of permanent ventilation seal

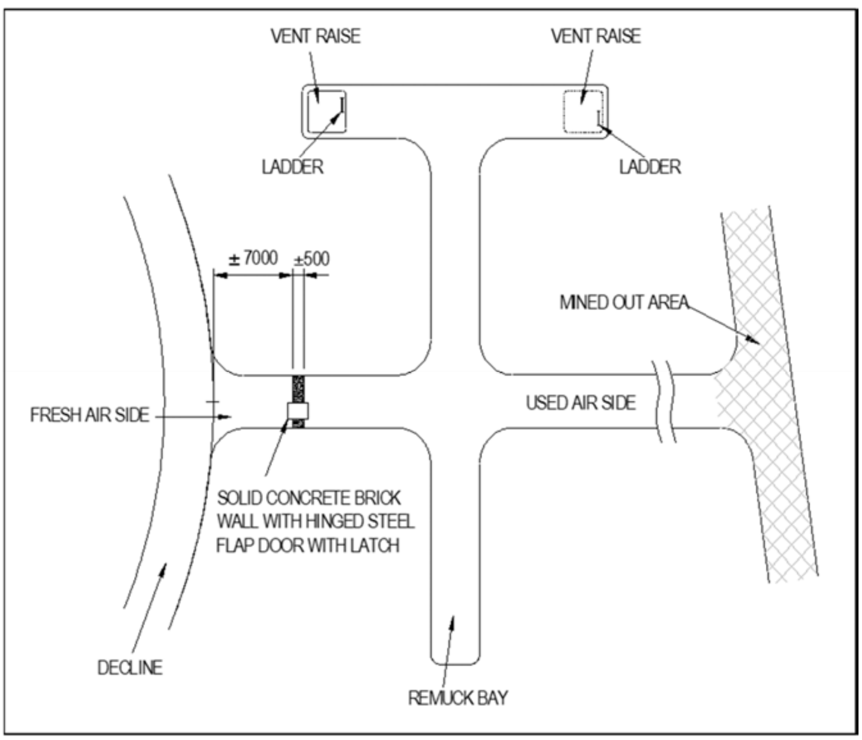


Figure 16-25: General position of ventilation seal

16.2.10.7 Fans

Main Fans

The main fans will each have a peak design operating point of 125 m^3/s at 1.3 kPa. Due to the fact mining progresses over essentially three separate orebodies, there will be three exhaust shafts with three fan stations over the life of the mine.

The Larjor and Kinjor Main section fan stations will be equipped with a 90° bend, a bifurcation and axial fans with self-closing doors. The Kinjor eastern orebody will only require a single fan. Depending upon operations in the pit and environmental considerations silencers may be installed. Due to the fact varying amounts of air will be required for the three orebodies as the orebodies build up, achieve steady state production and wind down, it is recommended that variable speed drives by installed as they will optimise air requirements and provide considerable power savings over fixed power fans.

Figure 16-26 shows a typical twin axial fan surface installation.

Figure 16-26: Typical surface fan installation

Larjor section:

- One fan station having two fans
- As this phase winds down one fan will be removed.

Kinjor section (Central orebody and Eastern orebody):

- One fan station at the central exhaust shaft with two fans operating
- One fan on the eastern exhaust shaft.

Underground Auxiliary Fans

In addition, the following fans will be required for underground operations:

- Decline and main tunnel development: 110 kW fans
- Other development and stoping: 75 kW fans
- Other fans as required for minor development: 45 kW and 15 kW units.

All underground fans should be equipped with silencers.

Figure 16-27 and Figure 16-28 show the typical fan curves for single and twin 110 kW auxiliary fans. Figure 16-29 shows the typical 75 kW fan curve.

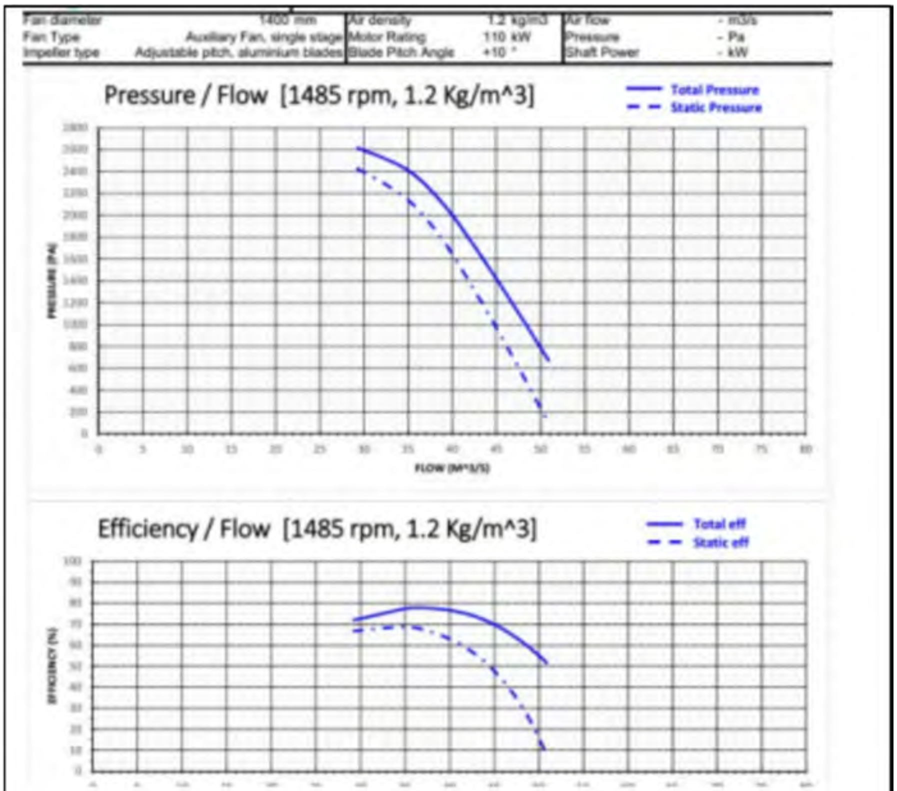


FIG 1 – Single 110 kW fan curve (source: Zitron).

Figure 16-27: Typical single 110kW fan curve

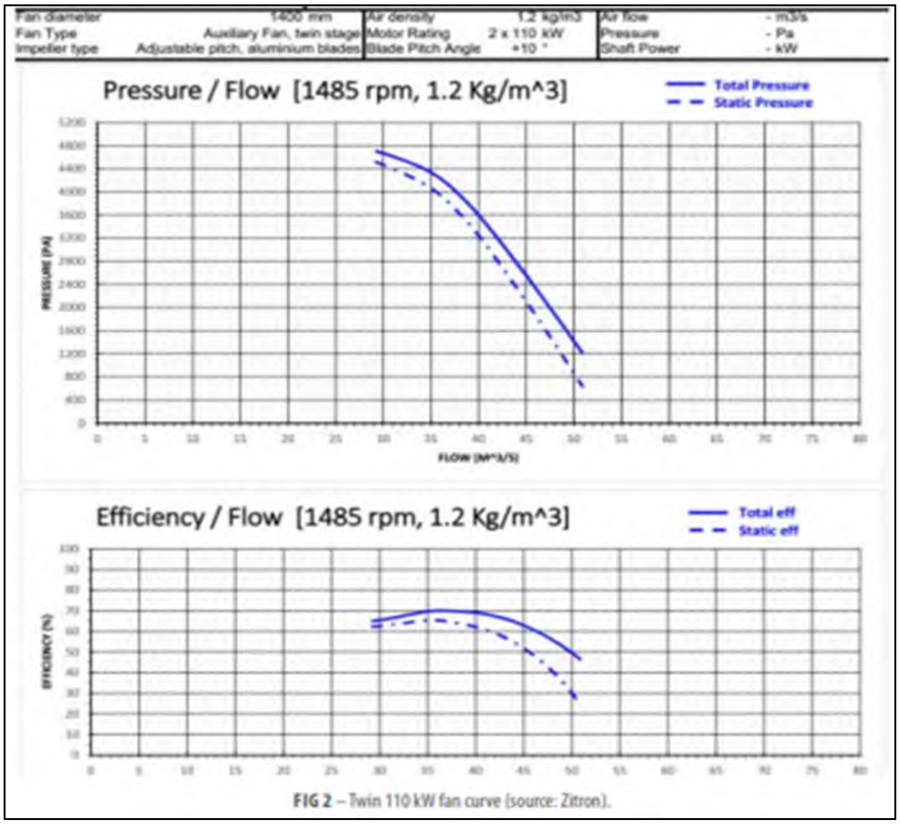


Figure 16-28: Typical twin 110 kW fan curve

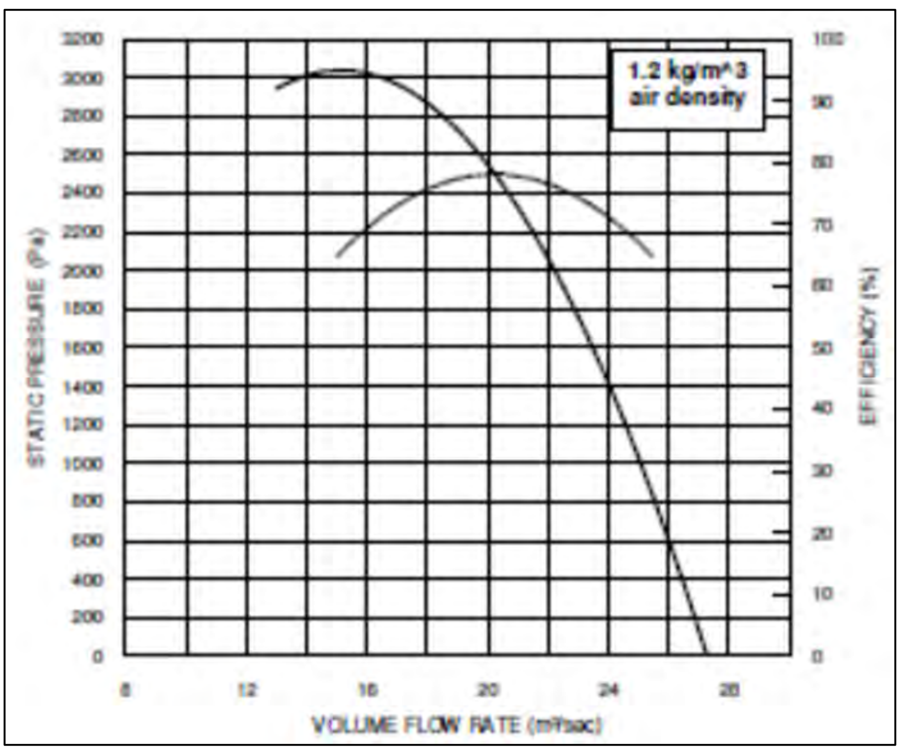


Figure 16-29: 75 kW development fan curve

16.2.10.8 Health and Safety

There are also a number of ventilation related health and safety issues that should be addressed.

Fires

Fires involving rubber tyred vehicles present a considerable risk to any underground mine.

If the fire is not quickly suppressed and spreads to the tyres, then it can only be extinguished with water. Dry powder is unable extinguish a rubber tyre fire as it does not remove sufficient heat to prevent re-ignition of the gases emanating from the hot rubber. If the fire is not quickly extinguished with water, then it is almost inevitable that the vehicle will be completely destroyed.

Dense black smoke with high levels of Carbon Monoxide from burning rubber tyres will quickly circulate through the mine and for this reason body worn Self Contained Self Rescuers (SCSR) and availability of Refuge Bays should be mandatory.

All rubber tyred vehicles should be equipped with on-board fire suppression and a fire extinguisher to control any fire quickly. Vehicle maintenance plays a part in ensuring no leaks of diesel fuel and no accumulations of oil or grease are present.

All diesel refuelling should be carried out in accordance with a mine standard and trucks should only be refuelled on surface unless this is unavoidable.

Flammable Gas

As a general rule, all underground mines should assume that the occurrence of flammable gas (methane) is a possibility, unless conclusively proved otherwise. A robust ventilation system coupled with flammable gas testing to a defined standard and a clear procedure for dealing with any gas intersection is the solution to preventing flammable gas explosions.

Appropriate instruments are available to give warning and/or take measurements should be obtained.

Heat

The mine operates in a tropical climate with heat generating diesel-powered vehicles. Thus, the possibility exists of heat stroke conditions (wet bulb temperature in excess of 32.5°C) occurring if the ventilation is not up to standard or some other abnormal circumstance occurs. Instruments to measure wet and dry bulb temperature, air velocity and air humidity are available. It is also recommended that truck and LHD cabs are equipped with air conditioning. As part of the Mine Standards, any place where the wet bulb temperature is ≥32.5°C, persons should be withdrawn.

Gases

There are two principal situations in an underground mine where immediate danger to persons can be caused:

- Deficiency of oxygen in the general atmosphere (normal level 21%). The usual causes are displacement by other gases or due to a fire.
- Presence of high levels of carbon monoxide (CO). The usual causes are fire or inadequate air to dilute the diesel exhaust gases.

Other harmful gases can occur in mines, generally if there is insufficient air to dilute and remove them, examples are:

- Oxides of nitrogen from diesel engines
- Blasting fumes
- Welding fumes (welding/cutting of cadmium plated metal is particularly dangerous)
- Fumes from chemicals used on the mine (check product data sheets).

Escape and Rescue

Persons proceeding underground should be equipped with a SCSR. In addition, refuge bays with a source of breathable air should be made available and positioned so that any person underground can reach one within the duration of their SCSR. The position of all refuge bays should be determined on a risk assessment basis.

The mine must also have a second means of exit from the workings and eventually to surface should a portion of the main decline suffer a collapse preventing persons exiting. This is catered for underground by equipping the ventilation exhaust drop raises going from level to level with a ladder way.

Escapeways to surface have been provided for in the mine design and include:

- Larjor – Return air/service raise system
- Kinjor (Main section) – Return air/service raise system
- Kinjor (Eastern section)– Return air/service raise system.

The possibility furthermore exists to equip the in-take ventilation raises at Larjor and Kinjor with ladderways, to allow them to be used as escapeways.

16.3 Ndablama Open Pit

16.3.1 Mining Method

16.3.1.1 Pit Optimisation

A new approximately 1,200,000 tpa ROM open pit is to be developed at Ndablama. Mining methods are by conventional truck-shovel fleet operated by a mining contractor. The Project under consideration involves a very minimal pre-strip of the pit in 2020 followed by open pit mining in 4 stages from 2021 to 2027.

The pit optimisation for Ndablama (ND) was run using Datamine's NPV Scheduler (NPVS) software. This uses the standard Lerch Grossman (LG) algorithm and the results have been shown in the past to be very similar to that of Whittle.

The starting surface for pit optimisation was the original surface topography as no mining has taken place in the pit area as yet. The only mining active at this time is the artisanal alluvial workings to the south of the deposit and they do not impact the study.

The parameters used in the study are shown in Table 16-31 and the geotechnical parameters are summarised in Table 16-32. The slope parameters have been assessed for each of the pit walls as shown in Figure 16-30. The geotechnical parameters are based on the study undertaken by CSA Global.

The regularised block model used in this study was created by CSA Global in December 2018 and is based on the original Resource model. For this exercise, the blocks were regularised into 10 m x 10 m x 5 m blocks to model the expected selectivity and to eliminate isolated blocks of 5 m x 5 m x 5 m in the original model that would not be economic due to high levels of dilution.

The regularised model therefore includes some allowance for mining recovery or dilution and these factors are applied in NPVS to obtain the mined quantities and the recovered metal.

Table 16-31: Optimisation parameters for New Liberty

Parameter	Units	Value	Comments
Mining cost	US$/t mined	1.70	Averaged over LOM
Ore cost adjustment factor	factor	1.03	Allows for grade control costs
Mining recovery	%	95.0	Applied to regularised model
Waste dilution	%	5.0	Applied to regularised model
Processing cost	US$/t ore	20.38	2019 Budget
Process recovery	%	92.0	
G&A	US$/t ore	7.23	2019 Budget
Metal price	US$/Troy oz	1,300	
Selling cost	US$/Troy oz	3.5	
Royalty	%	3.0	
Discount rate	%	5.0	
Plant production rate (maximum)	Mt/a	1.8	

Table 16-32: Geotechnical parameters for Ndablama

<table>
<tr><th>Design sector material</th><th>Bench height (m)</th><th>Berm width (m)</th><th>No. of benches</th><th>Bench face angle (°)</th><th>Stack angle (°)</th><th>Overall slope angle (°)</th><th>Safety factor</th></tr>
<tr><td colspan="8">Ndablama Pit – DS 1, 5, 6, 7 and 8</td></tr>
<tr><td rowspan="2">Weathered</td><td>5.00</td><td>6.00</td><td>1.00</td><td>40</td><td rowspan="2">29</td><td rowspan="4">55</td><td rowspan="4">2.58</td></tr>
<tr><td>10.00</td><td>12.00</td><td>1.00</td><td>40</td></tr>
<tr><td>Transitional</td><td>10.00</td><td>6.00</td><td>1.00</td><td>80</td><td>80</td></tr>
<tr><td>Fresh</td><td>10.00</td><td>5.60</td><td>14.00</td><td>80</td><td>54</td></tr>
<tr><td colspan="8">Ndablama Pit – DS 2, 3 and 4</td></tr>
<tr><td rowspan="2">Weathered</td><td>5.00</td><td>6.00</td><td>1.00</td><td>40</td><td rowspan="2">29</td><td rowspan="4">43</td><td rowspan="4">3.27</td></tr>
<tr><td>10.00</td><td>12.00</td><td>1.00</td><td>40</td></tr>
<tr><td>Transitional</td><td>10.00</td><td>6.00</td><td>1.00</td><td>60</td><td>60</td></tr>
<tr><td>Fresh</td><td>10.00</td><td>5.60</td><td>14.00</td><td>60</td><td>54</td></tr>
</table>

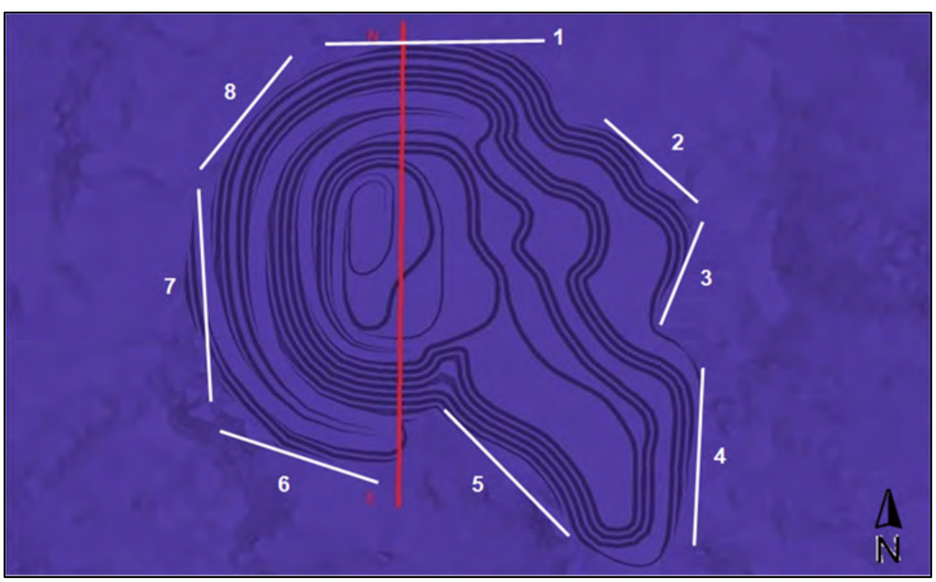


Figure 16-30: Pit wall nomenclature at Ndablama

16.3.1.2 Optimisation Results

The pit optimisation for ND was run in NPVS with the Price Factor ranging from 2% to 120%. This generates a series of incremental pit shells that simulate a pseudo optimum mining sequence that will generates pit shells in order of maximum cash flow. A total of 60 pit shells were generated using a base price of US$1,300/oz. The results are shown in Figure 16-31.

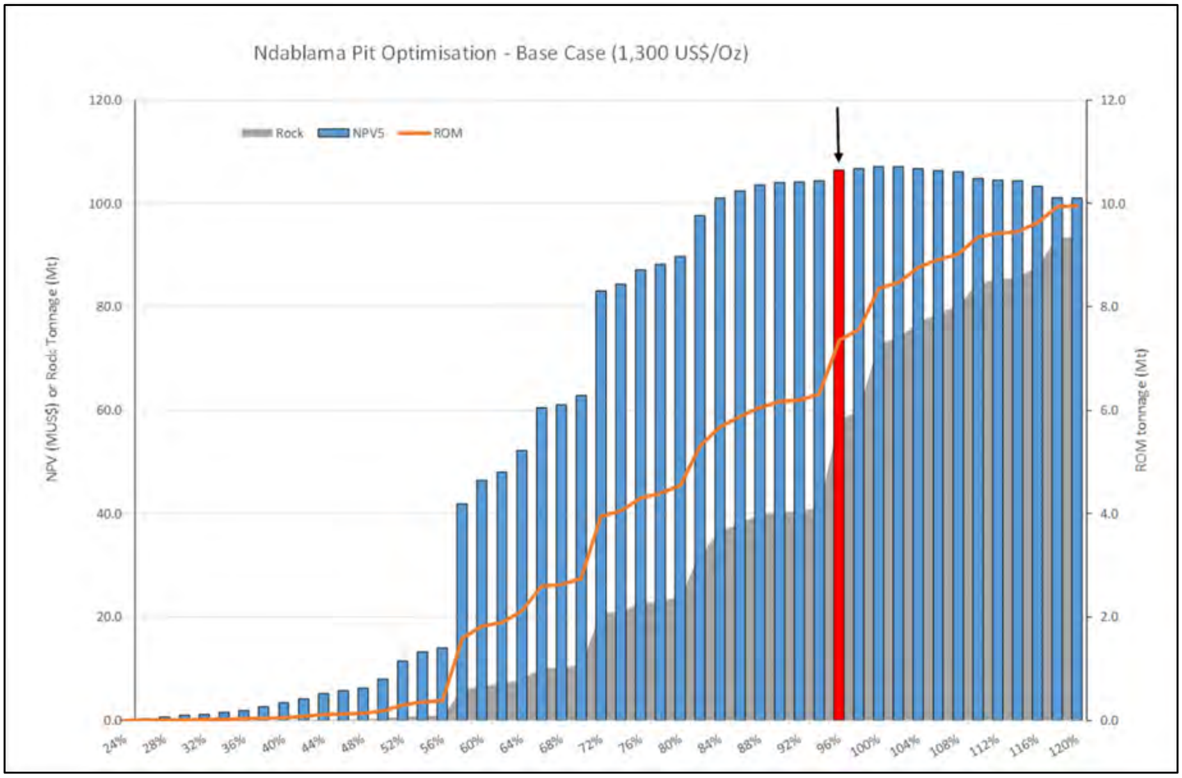


Figure 16-31: Pit optimisation results for Ndablama – Base Case (US$1,300/oz)

By inspection of the graphs of cumulative NPV, Rock and Ore it can be seen there is a rapid increase in stripping ratio at a Price Factor of 94% and that as expected the incremental cash flow beyond a Price Factor of 100% (US$1,300/oz) is negative. However, the sharp increase in ore tonnage between 94% and 106% (almost 2.6 Mt of ore) highlights the sensitivity of pit size to price.

The NPV starts to level off at a Price Factor of 84%, with 94% of the maximum NPV attain by moving 50% of the maximum rock tonnage at a Price Factor of 100%. Another way of looking at this is that at 84% Price Factor the total Ore tonnage is 6.3 Mt, compared to a total Ore tonnage of 8.3 Mt at 100% Price Factor. This highlights the diminishing returns of expanding the pit beyond a Price Factor of 84%.

A series of pit optimisations were run in order to investigate the sensitivity of the 100% Price Factor pit to:

- Price
- Mining cost
- Processing cost
- Process recovery
- Slope angle.

The results are summarised in Table 16-33.

Table 16-33: Sensitivity study for Ndablama

Variable	Case	NPV5 (US$M)	Total rock (Mt)	Ore (Mt)	Contained metal (koz)
Price	+ 10%	104.0	40.4	6.15	341
	Base	107.0	72.8	8.33	459
	- 10%	104.8	84.4	9.32	503
Process cost	+ 10%	83.3	41.1	5.70	329
	- 10%	108.4	73.4	8.40	462
Mining cost	+ 10%	97.9	41.8	6.43	353
	- 10%	104.8	72.9	7.90	469
Slope angle	- 2°	102.9	74.1	5.70	454
	+ 2°	111.6	69.8	5.52	458

It can be seen that pit size is sensitive to price, process cost and mining cost but less so to pit slope angle. In all cases, the pit size nearly doubles over the range -10% to + 10%. Ore tonnage and contained metal are less sensitive, particularly with respective to slope angle, but it is evident that a small change in either cut-off grade or costs have a significant impact on the potential reserves.

It follows that the pit size will also be sensitive to the time lag between costs and revenue for the final pit stage. This is typical for a relatively low-grade project with a stripping ratio that is rapidly increasing with pit depth and care must be taken in the design and evaluation of the stages to avoid including pit increments that are not economic.

16.3.1.3 Pit Design

The pit design for Ndablama assumes that the mining equipment and mining method will be the same as New Liberty. Therefore, the same design criteria for the roads have been adopted with a standard running width of 25 m and maximum gradient of 10%. Single-lane ramps (12 m wide) have been adopted for the lowest benches.

A standard bench height of 10 m is used with the ore mined on two flitches of 5 m. Where possible, the blasting will be on 10 m benches, but a 5 m bench height may be adopted to improve selectivity. The pit slope parameters are given in Table 16.59.

A total of four pit stages were designed based on the optimised pit shells generated by NPV Scheduler. Each pit stage was designed to have at least 1 Mt of ore and the initial stages target the blocks with the highest value.

It can be seen the mining sequence is primarily driven by the stripping ratio rather than grade and mining progresses down dip in a southeast to northwest direction.

An expansion (Stage 5) was considered that would take the pit design to the pit final limit (Price Factor of 100%). However, this resulted in a stripping ratio for the increment of 15:1. With an average grade of 1.7 g/t, this expansion would be marginally economic when the time lag between the cost of the waste stripping and the revenue from the ore is taken into account.

A decision was therefore made to limit the pit designs to the smaller pit and consider this upside expansion potential once in production and there is a better understanding of the costs and the modifying factors for ore loss and waste dilution.

Table 16-34: Reserves for Ndablama stages

Pit name	Cut-off (g/t Au)	Rock (t)	Waste (t)	Ore Reserve			Marginal Stockpile		
				t	oz	g/t Au	t	oz	g/t Au
Stage 1	1.00	4,718,723	2,962,565	1,011,287	51,368	1.58	744,872	16,675	0.70
Stage 2	1.00	18,178,061	14,896,408	1,947,264	105,248	1.68	1,334,389	30,215	0.70
Stage 3	1.00	17,966,375	14,787,517	2,074,477	116,148	1.74	1,104,382	24,855	0.70
Stage 4	1.00	21,433,507	18,106,947	2,249,298	127,370	1.76	1,077,262	24,496	0.71
Total		**62,296,667**	**50,753,437**	**7,282,325**	**400,135**	**1.71**	**4,260,905**	**96,241**	**0.69**

Dump Design

The pit exit has been placed at the lowest elevation in order to minimise the ramp haul distance and cycle times. This means that both the crusher and the waste dumps are placed to the south of the pit in a valley that runs northwest to southeast.

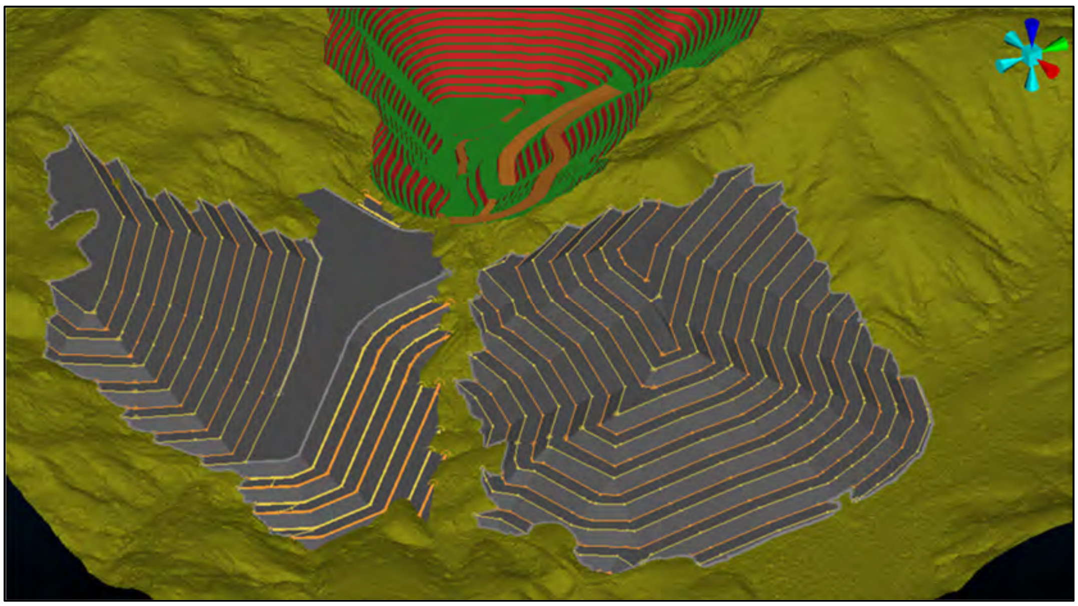


Figure 16-32: Ndablama long section showing Stage 4 and expansion potential (Stage 4)

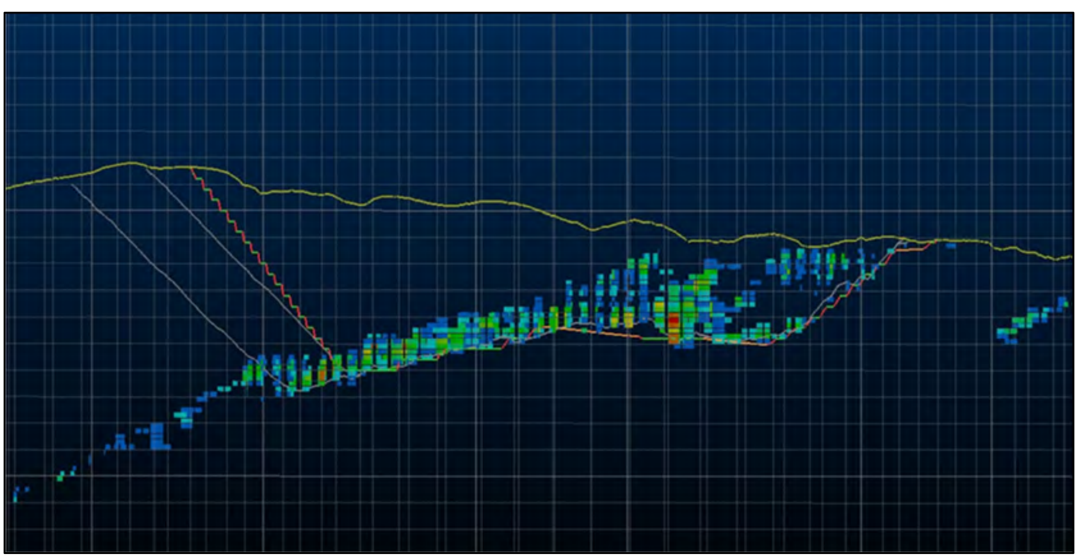


Figure 16-33: Ndablama isometric view of north and south dumps

16.3.1.4 Stockpiling Strategy

The ROM ore from Ndablama will be transported by a haulage contractor in 50-t trucks on a 46 km private road constructed between Ndablama and New Liberty. The ROM ore will be loaded by front-end loader from the ROM stockpiles at Ndablama and dumped at the appropriate ROM stockpile (LG, MG or HG) at New Liberty. The ore is then fed from the NLGM stockpiles to the centralised processing plant.

16.3.2 Fleet Assumptions

A key assumption for the mining of Ndablama is the re-mobilisation of fleet from New Liberty open pit as it curtails to the Ndblama pit as it starts up. Based on assessment of the mining rate at Ndablama, and stripping ratio at Ndablama according to the design, and comparing to the mining rate and stripping ratio at New Liberty, an excess of equipment exists at New Liberty for this, therefore the final complement of fleet at Ndablama will be far smaller than that currently deployed at New Liberty. A summary assessment of the fleet required to be transferred from New Liberty is shown in Table 16-35.

Table 16-35: Fleet assumptions for Ndablama Pit

	Asset ID	Make	Model	No. of
Drill rigs				
	DR0007	Sandvik	DP 1500i T3 Top Hammer	6
Excavators				
6	EX0044	Komatsu	PC1250SP-8R	9
Articulated dumping trucks				
3	AT0032	Caterpillar	740B	3
Haul trucks				
1	DT0001	Komatsu	785-7	28
Dozers				
1	DZ0006	Caterpillar	D9R	3
3	DZ0013	Caterpillar	D6K XL	1
8	DZ0028	Komatsu	D275A-5R	2
10	DZ0030	Komatsu	D155A-6	1
11	PD-P-001	Caterpillar	824C	1
Loaders				
3	WL-P-002			
Motor graders				
3	MG0006			
Water tanks				
1	WT0004			
Backhoe loader				
1	ABH001			

In addition to the mining fleet, haulage of ROM ore from Ndablama to New Liberty will be by means of haulage contractor. A total haulage cost of $5.95/t has been allowed, providing for loading of trucks by FEL, fuel, tyres, operators, spares, amortization of the fleet and profit.

16.3.3 Geotechnical Investigations

The following sub sections describe the geotechnical investigative studies undertaken to obtain a PFS level of accuracy for the Avesoro Ndablama open pit slope design.

16.3.3.1 Collation and Synthesis of Input Parameters

Avesoro provided the geotechnical data which was collated and repackaged for design of the Ndablama open pit. Middindi did not geotechnically log core or gather data directly from site but conducted a QA/QC exercise. The geotechnical information provided by Avesoro included:

- Geotechnical drill core data from 21 historical drillholes, contained in spreadsheet format.
- Three validation geotechnical drillholes were drilled and logged, and the data was used to validate the data from the historical drillholes
- Laboratory results from a rock testing program
- Defect orientation data, which was included in the geotechnical drillhole logs.

16.3.3.2 Slope Engineering Design

The following investigations were executed for the purposes of the open pit design:

- Analyses of all geotechnical data retrieved from various sources.
- A desktop study of available information including geotechnical and geological reports, and feasibility studies
- Determination of geotechnical design parameters relevant for basic mine design, including intact rock strengths, rock mass strength, Hoek-Brown parameters (mi, mb, s and a), and Mohr-Coulomb parameters (c and Φ), for the various geotechnical domains
- Statistical analysis of input and output parameters to facilitate sensitivity studies on bench scale, overall and inter-ramp slope stability for each design sector
- Slope stability analyses using the *Slide*, *RocData*, *RocPlane*, *Dips* and *Swedge* algorithms to determine stable inter-ramp slope angles for basic mine design
- Kinematic assessments of slope configurations
- Berm configurations from failure volume analysis.

16.3.3.3 Assumptions

The following design assumptions were made for evaluating the stability of pit walls:

- The domain depth in the geotechnical validation and historical drillholes referred to the base of that domain
- The lowest values for RMR and GSI for saprolite recorded in drillhole NBDGT03 was applied for the saprolite in drillholes NBDGT01 and NBDGT02
- The code "GRBR" in the logging sheets were assumed to be brecciated granite
- The pit will extend to a depth of 235 m.

16.3.3.4 Geotechnical Geology

The geology derived from logging is presented in

Table 16-36. This was further simplified based on major rock types intersected in the logging data, which were used for the slope design, and is presented in Table 16-37.

Table 16-36: Ndablama – logging codes and rock types

Code	Rock type
UMMT	Magnetite tremolite chlorite schist
GRBR	Assumed brecciated granite
GNA	Hornblende plagioclase gneiss in lit par lit repetition with GNqf
AMP	Amphibolite schist
UMPT	Phlogopite-chlorite talc schist
UMTC	Tremolite chlorite talc schist
GRPT	Not available
GRUN	Undifferentiated biotite bearing granite
GRBP	Not available
GNQF	Quartz-feldspathic banded leucocratic gneiss
GRSV	Not available

Table 16-37: Ndablama open pit – simplified geology

Code	Rock type
GNA	Hornblende plagioclase gneiss in lit par lit repetition with GNqf
UMMT	Magnetite tremolite-chlorite schist
AMP	Amphibolite schist
GRBR	Brecciated granite*

**Assumed*

16.3.3.5 Ndablama Drillholes

Three new drillholes were drilled in 2018 for geotechnical/validation purposes. The data gathered from the new geotechnical drillholes were compared to data from 21 historically drilled drillholes, in order to determine if the historical data was applicable and valid to be used as part of the open pit design.

The three geotechnical drillholes, their coordinates and depths are shown in Table 16-38. The 21 historical drillholes, their coordinates and depths are shown in Table 16-39.

Table 16-38: Ndablama open pit – geotechnical/validation drillholes

New Geotechnical Holes				
BHID	**X-Collar**	**Y-Collar**	**Z-Collar**	**Hole depth (m)**
NBDGT01	299625.000	791000.000	290.000	285.000
NBDGT02	299700.000	790900.000	290.000	175.000
NBDGT03	299625.000	790800.000	290.000	285.000

Table 16-39: Ndablama open pit – historical drillholes

Historical Resource Holes				
BHID	**X-Collar**	**Y-Collar**	**Z-Collar**	**Hole depth (m)**
NDD037	300188.740	790804.750	247.610	125.900
NDD038	300153.560	790600.840	217.493	80.000
NDD039	300037.810	790752.440	233.476	157.800
NDD040	300056.810	790856.620	266.717	148.700
NDD041	300172.360	790648.340	225.581	104.500
NDD042	300106.500	790641.430	218.890	149.200
NDD043	300194.540	790861.580	267.710	103.700
NDD044	300046.790	790801.290	247.210	136.600
NDD045	300095.470	790902.290	280.124	128.300
NDD046	300098.510	790900.490	280.104	128.100

NDD047	300113.280	790701.910	230.505	134.300
NDD048	300125.770	790947.870	289.824	148.900
NDD049	300168.880	790566.210	215.432	104.400
NDD050	300098.770	790602.060	212.741	155.800
NDD051	300308.000	790539.030	223.397	125.400
NDD052	300324.140	790486.470	213.773	122.200
NDD053	300335.600	790404.950	178.552	137.400
NDD054	300072.050	790720.970	231.531	140.600
NDD055	299914.373	790718.144	222.409	400.200
NDD056	299963.523	790799.507	239.594	233.200
NDD057	299913.175	790854.782	241.781	230.000

16.3.3.6 The Rock Mass Rating System

Rock Mass Ratings were calculated on the logging sheets that were provided by Avesoro for each drillhole. The Rock Mass Rating (RMR) system developed by Bieniawski (1973, 1979) was calculated for the 1976 and 1989 versions. The 1989 version of the RMR system was used for the data validation exercise. The following six parameters are used to classify a rock mass using the RMR system:

- Uniaxial compressive strength of rock material.
- Rock quality designation (RQD)
- Spacing of discontinuities
- Condition of discontinuities
- Groundwater conditions
- Orientation of discontinuities.

16.3.3.7 The Geological Strength Index

The Geological Strength Index (GSI) is a system that can be used for estimating the reduction in rock mass strength for different geological conditions. The GSI is determined by taking into account the surface conditions of the rock mass and the geological structure (Hoek, 2007). This system was introduced by Hoek (1994) and Hoek, Kaiser and Bawden (1995). The information derived from logging contained GSI values calculated with the Russo, Cai et al, and Hoek methods. The overall average GSI was also provided, which was the selected GSI used in the data validation process.

16.3.3.8 Data Validation

In order to assess the validity of the data from the historical drillholes, it was compared to the data gathered from the new geotechnical drillholes. The data analysis from the historical holes were considered to be valid and was therefore included in the pit slope design.

The RMR and GSI values were compared for each rock type from the new geotechnical drillholes, to the corresponding RMR and GSI values for each rock type from the historical drillholes.

The average values of RMR_{89} and GSI for the new holes and for the historical holes, for each rock type were plotted in Figure 16-34 and Figure 16-35. The RMR and GSI graphs indicated that for most of the cases, the values were similar for the new holes and for the historical holes. The values of the RMR_{89} graph may have differed slightly, but the rock quality class remained the same. The GSI values, UMMT, GRBR, UMPT and UMTC were all lower than the historical drillhole data.

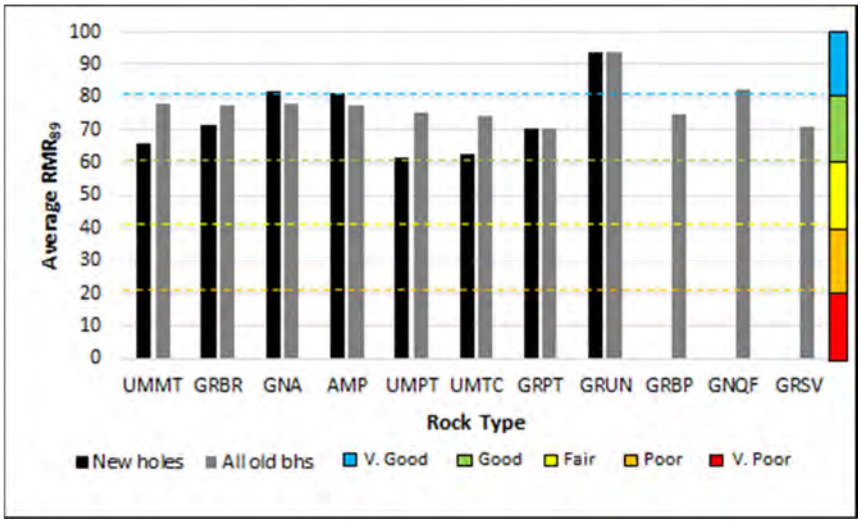


Figure 16-34: Average RMR_{89} values for new and historical drillholes
Source: CSA Global, 2018

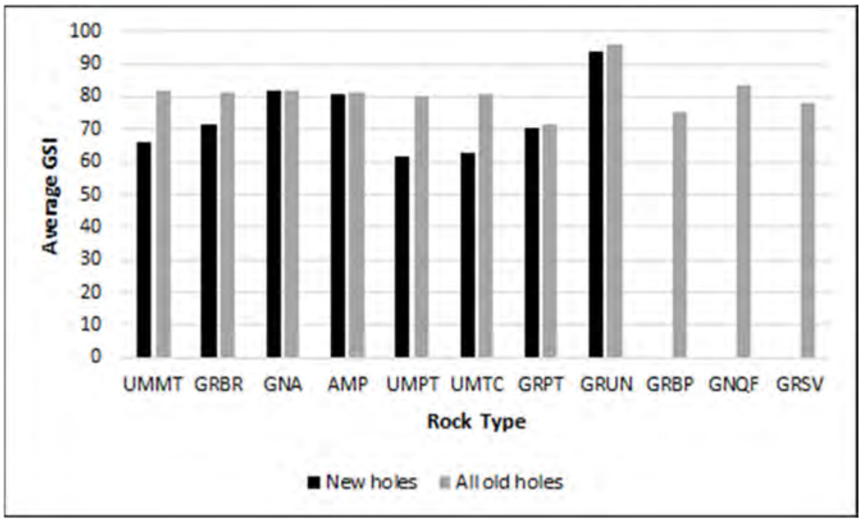


Figure 16-35: Average GSI values for new and historical drillholes
Source: CSA Global, 2018

The RMR values for each rock type for all drillholes are shown in Figure 16-36, and the GSI values for each rock type for each rock type from all drillholes are shown in Figure 16-37. The RMR_{89} values for all rock types range from 67.00 to 83.00, except for GRUN, which has a value of 93.80. Majority of the rock types are classified as good rock, while GRUN is classed as very good rock. The GSI value for all rock types except GRUN range from 70.00 to 84.00. GRUN has a GSI value of 95.90. These values were applied to the open pit design.

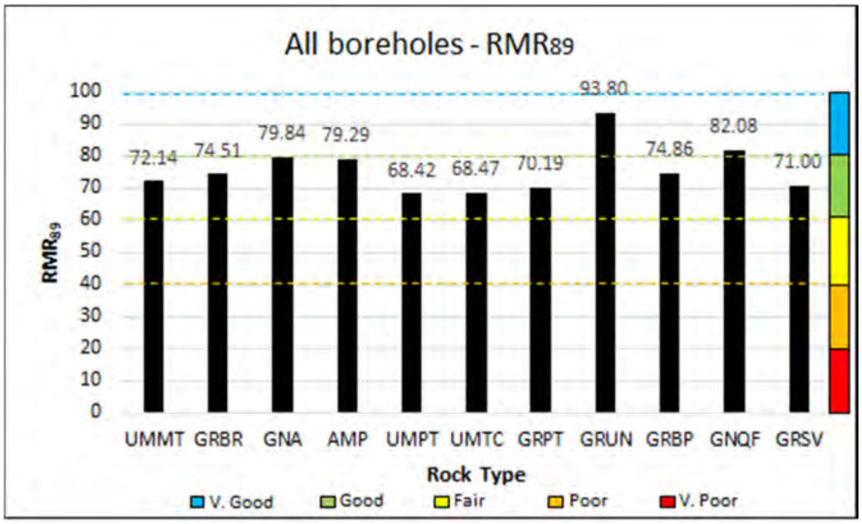


Figure 16-36: RMR values for all drillholes and rock types
Source: CSA Global, 2018

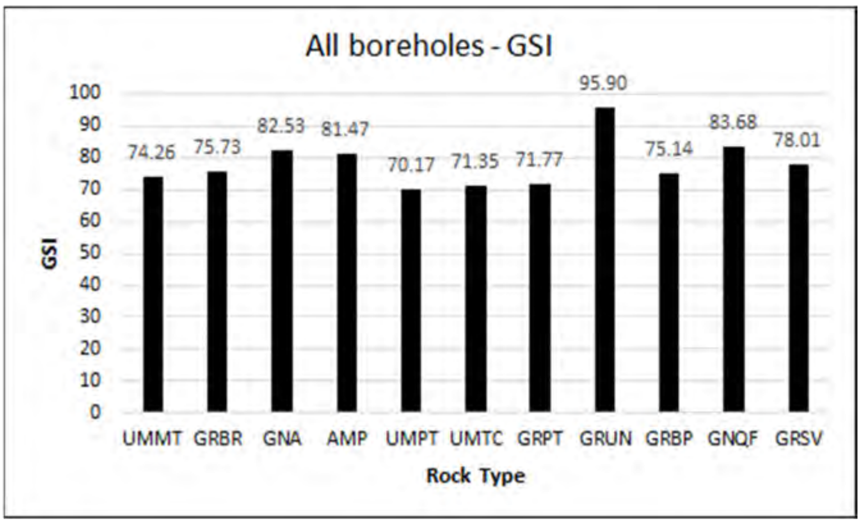


Figure 16-37: GSI values for all drillholes and rock types
Source: CSA Global, 2018

16.3.3.9 Weathering Profile

The type of material in the Ndablama pit, besides rock type, was classified according to the level of weathering that was recorded in the logging data. The materials were divided into weathered material, transitional material and fresh rock. The depth to the weathered and transitional zones were recorded from the new and historical holes, and the average depths were derived. The average depths were rounded up and used for the slope design and is shown in Table 16-40.

Table 16-40: Weathering and transitional depths, all drillholes

Weathering depth (m)		
BHID	**Saprolite**	**Transitional**
NBDGT01	12.70	40.90
NBDGT02	3.45	23.00
NBDGT03	12.00	38.00
NDD037	12.50	20.00
NDD038	7.90	na
NDD039	16.50	na
NDD040	21.00	na
NDD041	16.90	na
NDD042	19.90	na
NDD043	22.50	na
NDD044	19.50	na
NDD045	13.90	na
NDD046	18.40	na
NDD047	18.40	na
NDD048	21.30	na
NDD049	12.40	na
NDD050	na	11.80
NDD051	9.40	18.40
NDD052	19.80	na
NDD053	4.90	na
NDD054	16.50	na
NDD055	15.40	na
NDD056	11.00	na
NDD057	4.80	11.40
Average	**14.39**	**23.36**
Applied to design	**15**	**25**

16.3.3.10 Laboratory Test Results

Density

The densities for the major rock types were derived from laboratory tests and are listed in Table 16-41.

Table 16-41: Ndablama – densities of major rock types

Rock type	Average density (g/cm³)	Unit weight (kN/m³)
GNA	na	na
UMMT	2.95	28.91
AMP	2.98	30.38
GRBR	2.62	25.71

**na = not available*

UCS

The UCS (Uniaxial Compressive Strength) test allows rock samples to be assessed and categorized by their unconfined strengths and is the most commonly used strength test. The Modulus of Elasticity and Poisson's Ratio was also determined. A total of 10 UCS tests were carried out on samples of core. The UCS laboratory test results of the major rock types, which is displayed in Table 16-42.

Table 16-42: Ndablama – UCS results for major rock types

Rock type	Average UCS (MPa)	Modulus of Elasticity (GPa)	Poisson's Ratio
GNA	89.00	na	na
UMMT	110.66	75.22	0.19
AMP	118.10	95.23	0.16
GRBR	81.10	65.18	0.18

**na = not available*

mi

The mi is a constant in the Hoek-Brown failure criterion, which together with the UCS value, describe the relationship between the principal stresses at failure, for a given rock (Hoek, 2007).

The lab test mi results for UMMT and AMP were invalid, therefore mi values from the RocScience program, *RocLab*, were assigned. The *RocLab* mi value that was selected is shown in Figure 16-38. A value of 12 was used for the amphibolite schist (AMP). The same value of 12 for schists, shown in Figure 16-38 was applied to the magnetite-tremolite schist (UMMT); however, the lower bound of the mi value suggested was applied, which was 12 minus 3, hence the mi value for UMMT was 9.

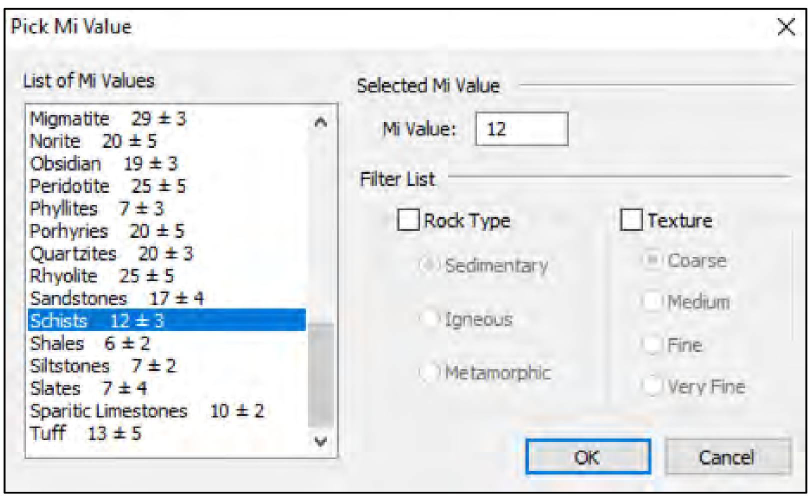


Figure 16-38: RocLab table for mi selection, (RocLab, v5.0)
Source: CSA Global, 2018

The mi values for GNA and GRBR were derived from the Avesoro laboratory tests. The mi values used for the slope design are presented in Table 16-43 below.

Table 16-43: Laboratory and literature mi values

Rock type	Laboratory mi	RocLab mi
GNA	23.49*	23.00
UMMT	Invalid	9.00*
AMP	Invalid	12.00*
GRBR	8.519*	14.00

** = mi value that was used for design*

Direct Shear Tests

The direct shear strength tests were carried out by applying a constant load to a cemented or closed discontinuity in the core sample.

The shear load is gradually increased on the discontinuity to allow for a determination of a peak and residual shear strength of the discontinuity, leading to the derivation of the discontinuity strength properties of cohesion and friction angle. Four shear tests were carried out on samples of GNA and UMMT. The summarized direct shear results are presented in Table 16-44.

Table 16-44: Ndablama – direct shear strength results

Rock type	Discontinuity type	Average friction angle (°)	Average cohesion (kPa)
GNA	Joint	32.60	250.00
UMMT	Joint	36.90	0.00

16.3.3.11 Orientation Data

The RocScience program *Dips* was used to analyse the orientation data. *Dips* is a program used for plotting, analysis and presentation of structural data using spherical projection techniques. It is also used to provide an indication or probability of various failure mechanisms through kinematic assessment.

The alpha and beta angles for each discontinuity from the three geotechnical holes were used for the analysis, as the orientation line and orientation data from the historical holes was not recorded. Only data that was classified as very reliable to reliable was used, which provided 379 discontinuity points.

The orientation data was divided into rock type. The *Dips* plots for the different rock types were similar, therefore the orientation for all rock types, for the three drillholes were combined to provide a general discontinuity signature for the Ndablama pit. The major joint sets for the Ndablama pit are displayed in Figure 16-39, and listed in Table 16-45.

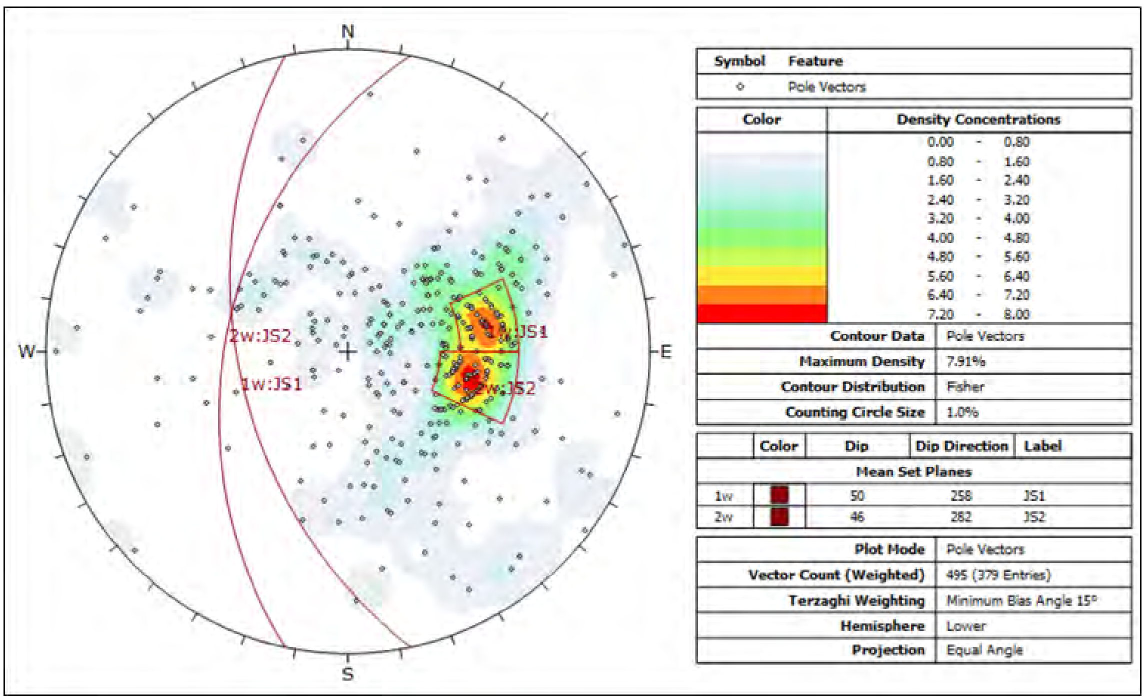


Figure 16-39: Ndablama – major discontinuity dips plot
Source: CSA Global, 2018

Table 16-45: Ndablama – major discontinuity orientations

Major joint sets		
Joint set	Dip (°)	Dip direction (°)
1	50	258
2	46	282

There were two major joint sets, JS1 and JS2, both joint sets are moderately dipping. A symbol plot (shown in Figure 16-40), is a *Dips* plot where the data points are separated according to the type of discontinuity.

The major discontinuities at Ndablama are joints, marked with black crosses. The only other discontinuity type were contacts (which is the boundary where rock types change), which are marked in green.

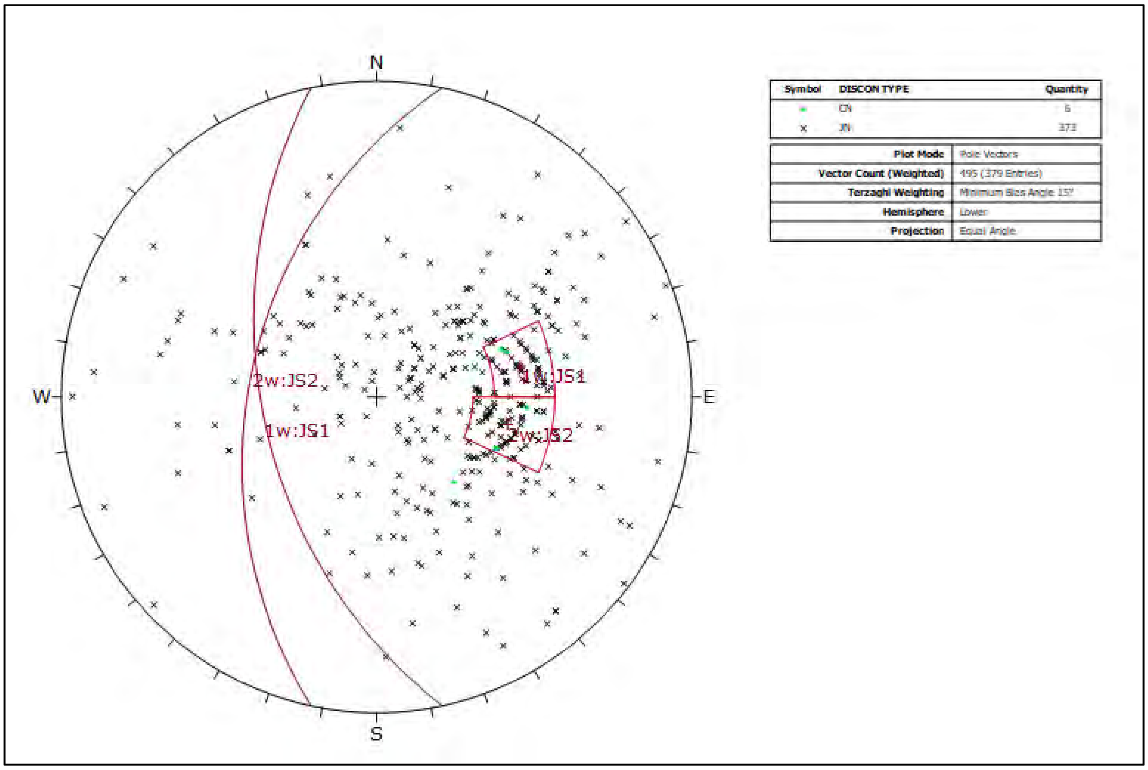


Figure 16-40: Ndablama – symbol dips plot

Source: CSA Global, 2018

16.3.3.12 Rock and Joint Properties

In order to carry out analysis on failure modes and describe the general geotechnical character of rock in the pit, the Hoek-Brown (HB) failure criterion was used. The input and output parameters for the HB criterion are:

- The average UCS of the intact rock
- The value of the GSI for the rock mass
- The value of the Hoek-Brown (HB) constants of mi, mb, s and a for the intact pieces
- Rock density
- Values of Mohr-Coulomb (MC) parameters, cohesion and friction angle
- The disturbance factor, D.

The intact rock mass properties, field properties, HB constants and equivalent MC criteria are presented in Table 16-46 for the different materials at Ndablama.

Table 16-46: Ndablama – rock mass properties for all material

Rock properties	Units	Saprolite	Transitional	GNA	UMMT	AMP	GRBR
RMR_{89}	N/A	N/A	40.40	79.84	72.14	79.29	74.51
GSI	N/A	N/A	35.20	82.53	74.26	81.47	75.73
UCS	MPa	N/A	12.40	89.00	110.66	118.10	81.10
mi	N/A	N/A	8.52	23.49	9.00	12.00	8.52
D	N/A	N/A	0.00	0.70	0.70	0.70	0.70
mb	N/A	N/A	0.836	9.230	2.157	4.225	2.279
s	N/A	N/A	0.0007	0.085	0.023	0.064	0.031
a	N/A	N/A	0.516	0.500	0.501	0.501	0.501
ρ	kg/m^3	1,600.00	2,571.00	3,000.00	2,891.00	3,038.00	2,571.00
c	kPa	30.00	124.00	4,288.00	2,553.00	5,115.00	2,913.00
Φ	°	28.5	41.0	54.7	55.9	49.8	43.8

**N/A = not applicable*

Notes for rock mass properties:

- The UCS values were derived from laboratory tests.
- The UCS value for weathered amphibolite was also applied to the transitional material.
- The GSI and RMR values were determined from logging data.
- Hoek Brown parameters D, mb, s and a determined using *RocData*.
- Densities for fresh rock from lab tests. Density for GNA was estimated.
- Transitional material RMR and GSI values derived from NBDGT03.
- The slopes application was applied in *RocData*.

Cohesion and friction angle properties for discontinuities were derived from Ndablama laboratory test results and are shown in the table below.

Table 16-47: Ndablama – joint properties

Rock type	Discontinuity type	Average cohesion (kPa)	Average friction angle (°)
GNA	Joint	250.00	32.60
UMMT	Joint	0.00	36.90

16.3.3.13 Slope Nomenclature

The slope design reported herein provides recommendations for the vertical bench separation (bench or batter height), bench width or berm, bench face (or "batter") angle, inter-ramp angle, and overall slope angle, for different design sectors of the open pit. The descriptions below provide further information of the mentioned slope configurations, which is illustrated in Figure 16-41:

- **Berm or bench widths** – bench widths are selected to facilitate containment of potential failing material (small wedges and blocks) and to ensure that loose material does not become hazardous to personnel and equipment.
- **Bench height** – mining equipment used to drill and blast the rock determines the bench height. Currently, most large mining operations drill and blast on 12–15 m intervals, with 15 m being the most common.
- The **bench face angle (BFA)** is controlled by the material strength, the orientation of the discontinuities in relation to the face azimuth, and/or blasting and excavation practices.
- **Stack** – when there are multiple benches in a slope design. A stack usually refers to several production benches between catch benches so that the vertical catch bench separation is a multiple (usually two, three, or four) of the production bench height.

- **Bench toe** – the bottom edge of a bench is referred to as the toe.
- **Bench crest** – The top edge of a bench is referred to as the crest.
- The **inter-ramp angle (IRA)** or stack angle is formed by a series of uninterrupted benches and corresponds to the inclination from the horizontal of a line joining the toes of the benches.
- The **overall slope angle (OSA)** is formed by a series of inter-ramp slopes separated by haul roads and corresponds to the angle formed by the line joining the toe of the lowest bench with the slope crest. The incorporation of ramps onto a wall will result in a slope that has a shallower overall slope angle than the inter-ramp angle.

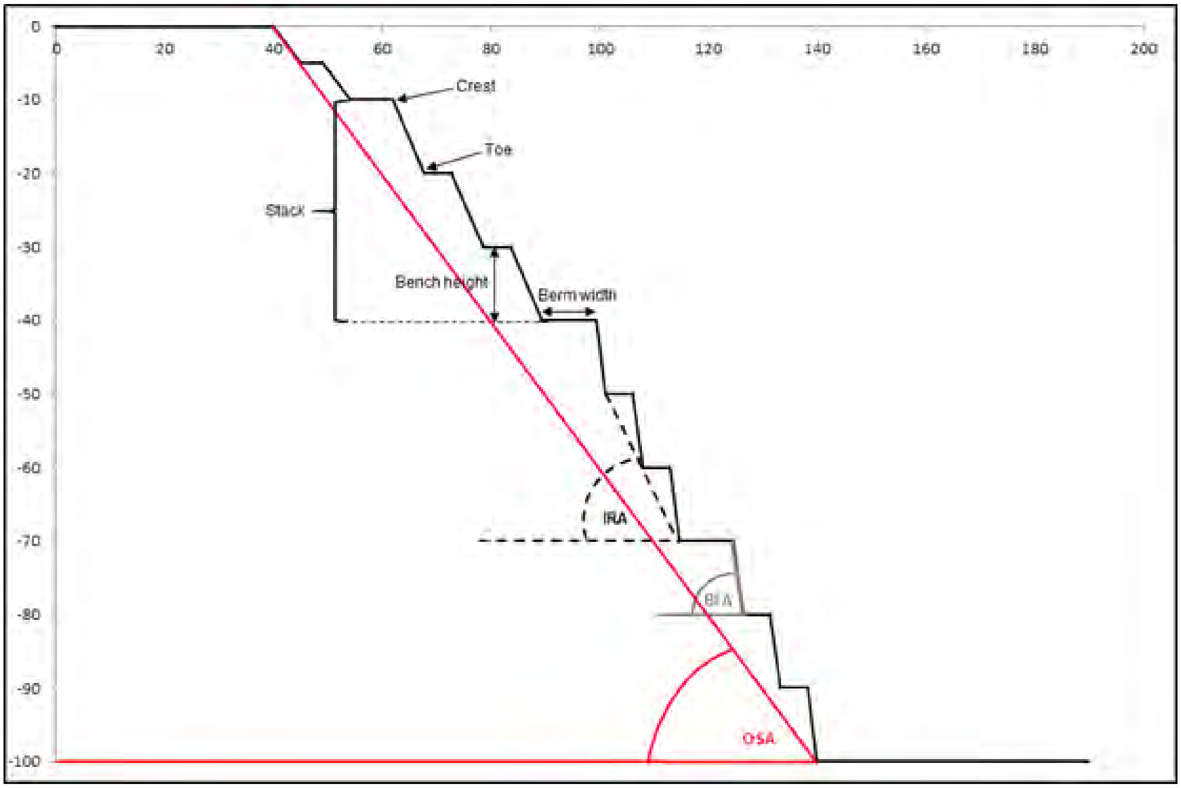


Figure 16-41: Slope nomenclature and geometry
Source: CSA Global, 2018

16.3.3.14 Design Assumptions

The following design assumptions were made for the purpose of evaluating the stability of pit walls:

- Saturated pit walls, due to the heavy rainfall seasons
- A maximum pit floor depth of 235 m below surface
- The presence of pseudo-circular and non-circular type failure modes at inter-ramp and overall scale
- A limiting SF of 1.3 is considered appropriate for overall slope stability.

16.3.3.15 Design Sectors

The pit layout that was considered and assessed for slope stability will reach a maximum depth of 235 m. It was divided into eight design sectors, which were based on the planned pit wall orientations. The design sectors are illustrated in Figure 16-42 with the wall directions that make up each design sector, listed in Table 16-48.

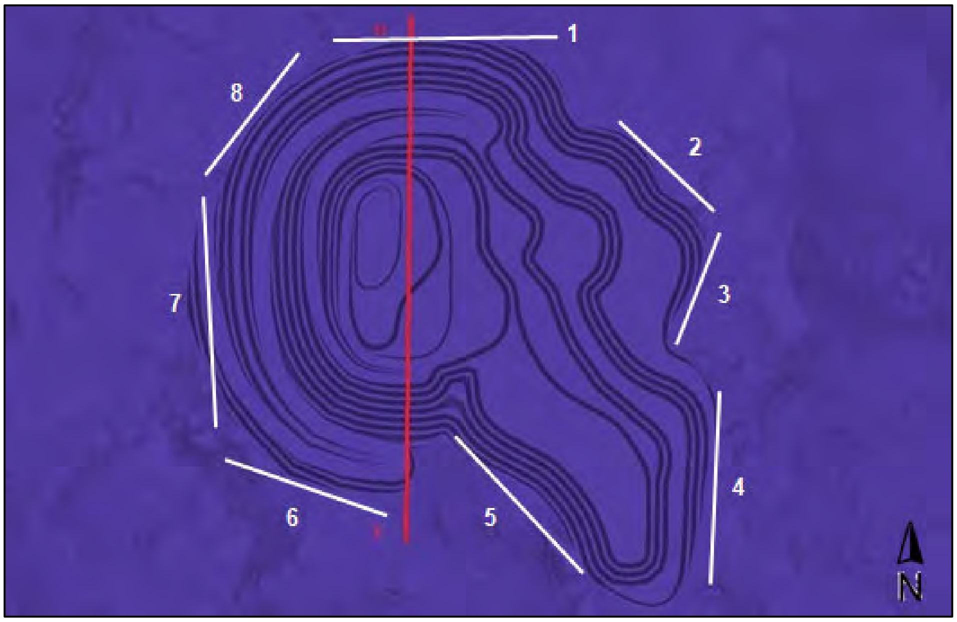


Figure 16-42: Design sectors for the Ndablama open pit
Source: CSA Global, 2018

Table 16-48: Wall directions for corresponding design sectors

Design sector	Wall direction
1	180
2	240
3	280
4	270
5	45
6	25
7	80
8	130

16.3.3.16 Threshold Safety Factors

The limiting overall slope safety factor (SF) of 1.3 was adopted for the Ndablama pit slopes, as suggested by Stacey in Table 16-49.

The limiting overall slope probability of failure (PoF) was 10% for the *Dips* probabilistic assessment.

Table 16-49: Suggested limiting safety factors and probability of failure (Stacey, 2009)

		Acceptance criteria[a]		
Slope scale	Consequences of failure	FoS (min) (static)	FoS (min) (dynamic)	PoF (max) P[FoS ≤ 1]
Bench	Low–high[b]	1.1	NA	25–50%
Inter-ramp	Low	1.15–1.2	1.0	25%
	Moderate	1.2	1.0	20%
	High	1.2–1.3	1.1	10%
Overall	Low	1.2–1.3	1.0	15–20%
	Moderate	1.3	1.05	10%
	High	1.3–1.5	1.1	5%

a: Needs to meet all acceptance criteria
b: Semi-quantitatively evaluated, see Figure 13.9

16.3.3.17 Modes of Failure in Open Pits

Different materials have different modes of failure. The lithologies at Ndablama were divided into weathered, transitional and fresh material. Saprolite was designated as soft/weathered material, semi-weathered rock was designated as transitional material, and fresh/unweathered material consisted of the major rock types in the pit, gneiss, schists and brecciated granite.

Rotational or circular slips occur characteristically in homogeneous soft rocks or soils. Movement takes place along a curved shear surface in such a way that the slipping mass slumps down near the top of the slope, and bulges near the toe.

The hard material slopes were assessed kinematically. The stability of surface excavation in hard rock is frequently controlled by the orientation of discontinuities within the rock mass. Structurally controlled failure in rock usually occurs as a result of slip or failure along (or from) pre-existing geological discontinuities. Three basic failure mechanisms are studied for rock slopes; these being plane failure, wedge failure and toppling failure.

16.3.3.18 Rotational and/or Circular Failure

Analysis was carried out using RocScience *Slide* slope stability software. *Slide* is a 2D slope stability program for evaluating the stability of circular or non-circular failure surfaces in soil or rock slopes. Table 16-50 presents the properties used in *Slide* for the Ndablama materials.

Table 16-50: Properties used for material types in Slide analysis

Property	Units	Saprolite	Transitional	UMMT
UCS	kPa	na	na	110,660.00
GSI	none	na	na	74.26
mi	none	na	na	9.00
D	none	na	na	0.70
Unit weight	kN/m^3	16.00	25.71	28.91
Hu	none	1.00	1.00	1.00

**na = not applicable*

The Hu number is a factor between 0 and 1 and is used to calculate the pore pressure. The Hu number for all the materials was set to 1, to model completely saturated conditions. The Hu number was applied to the material types and water table in *Slide*.

The weathered and transitional material design was carried out in *Slide*. Bench face angles of 30° and 40° were tested to determine the stability of the benches in weathered material. The analysis shown in Figure 16-43 indicated that the weathered material at a 30° BFA had a factor of safety of 1.54, which is much higher than the threshold safety factor, therefore the slope could be steepened.

The analysis displayed in Figure 16-44 indicated that the weathered material has a factor of safety of 1.26 at a BFA of 40° , which is very close to the threshold safety factor of 1.3, therefore a 40° bench face angle was applied to the weathered material in the pit design.

Bench face angles of 60°, 70°, and 80° were tested for transitional material to determine the stability of the bench. The analysis shown in Figure 16-45 indicated that the transitional material at a 60° BFA had a factor of safety of 2.77, which is much higher than the threshold safety factor. Figure 16-46 indicated that the transitional material has a factor of safety of 2.31 at a BFA of 70°, which is still higher than the threshold safety factor of 1.3.

The analysis presented in Figure 16-47 indicated that at an 80° BFA, the transitional bench has a SF of 1.91. The *Slide* analysis for the transitional material indicated a stable bench for all BFA's tested. Therefore an 80° BFA for the transitional material was used for the pit design, unless otherwise stated.

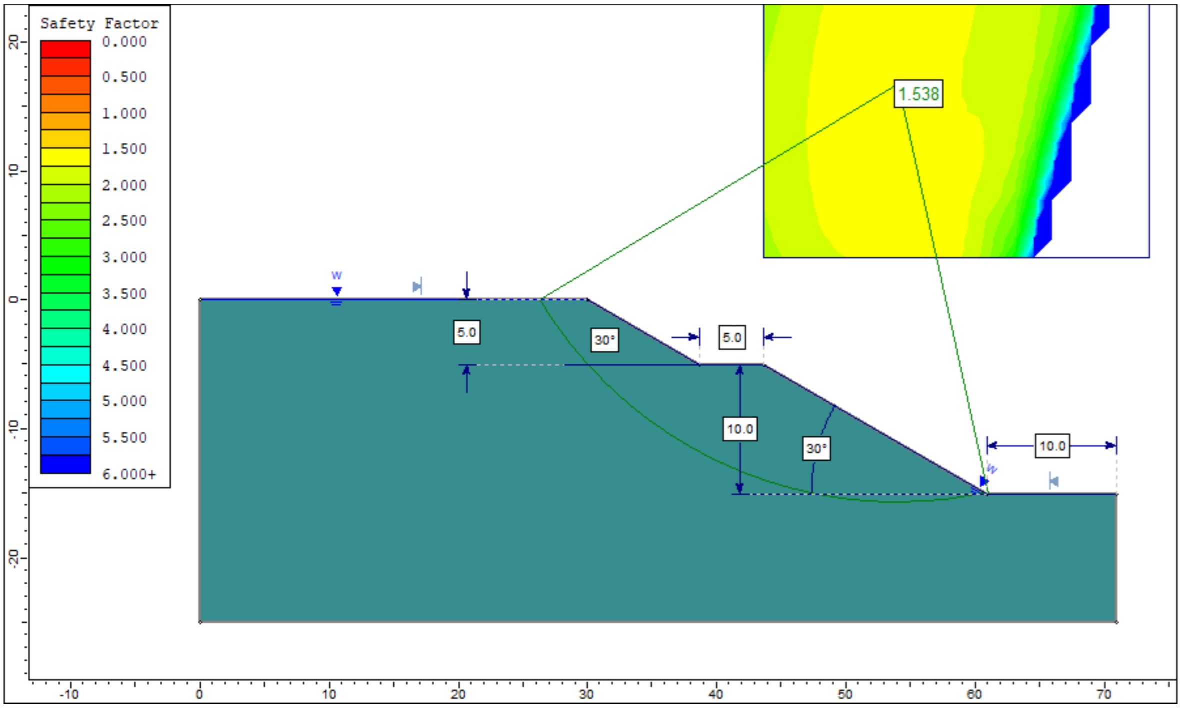


Figure 16-43: Weathered material analysis with a 30° BFA

Source: CSA Global, 2018

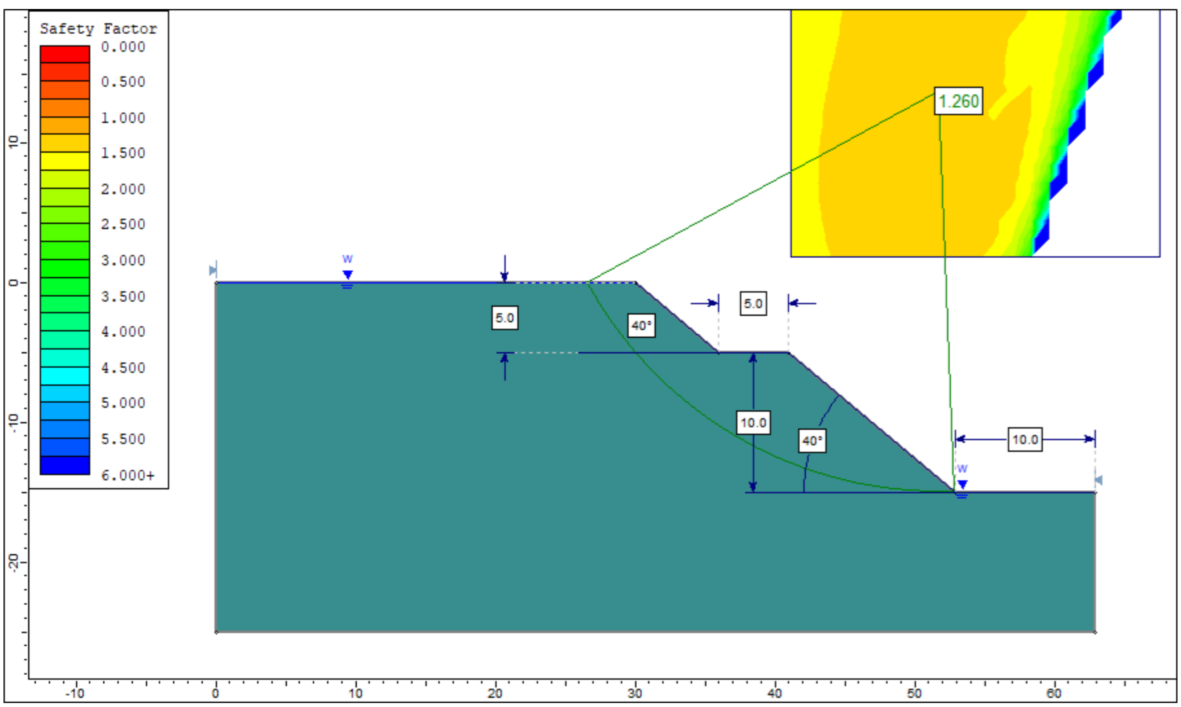


Figure 16-44: Weathered material analysis with a 40° BFA

Source: CSA Global, 2018

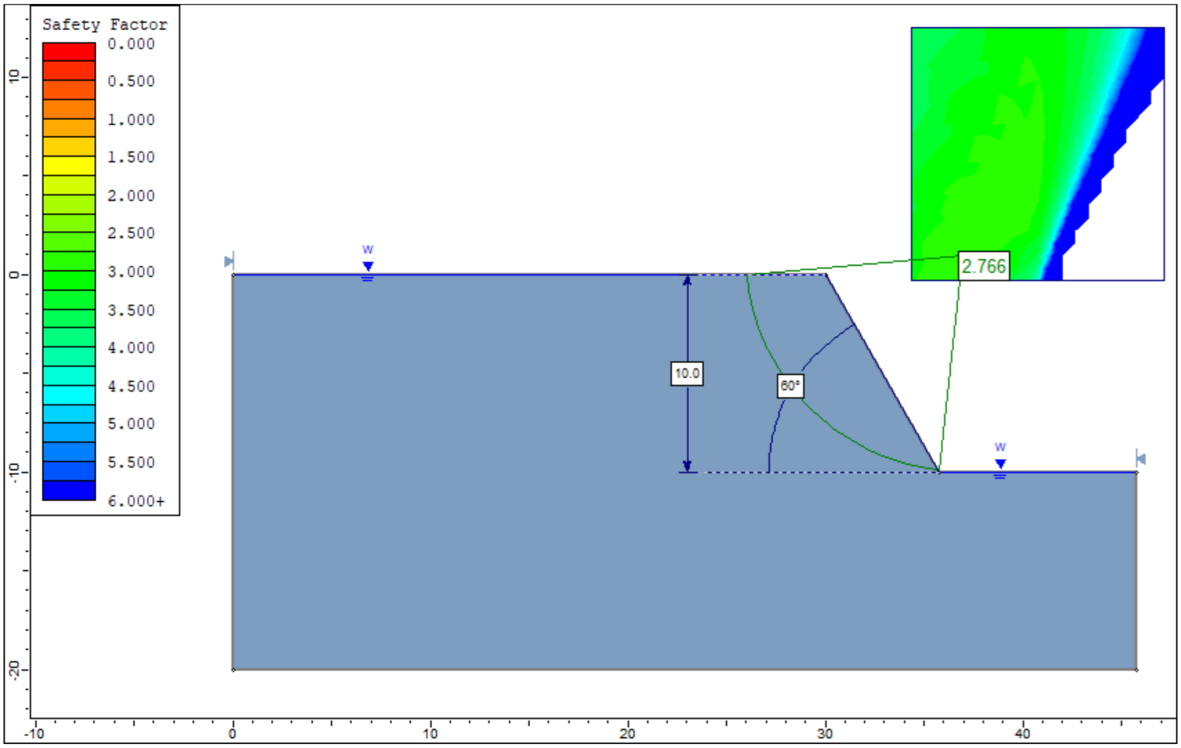


Figure 16-45: Transitional material analysis with a 60° BFA

Source: CSA Global, 2018

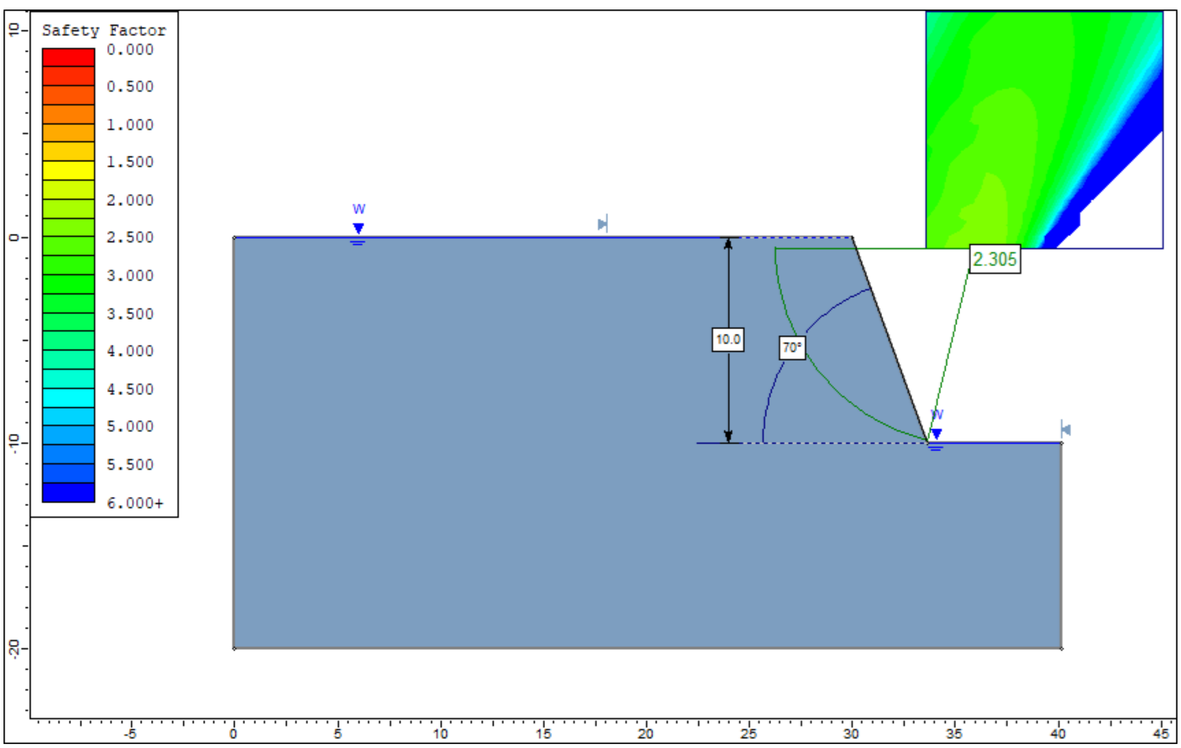


Figure 16-46: Transitional material analysis with a 70° BFA

Source: CSA Global, 2018

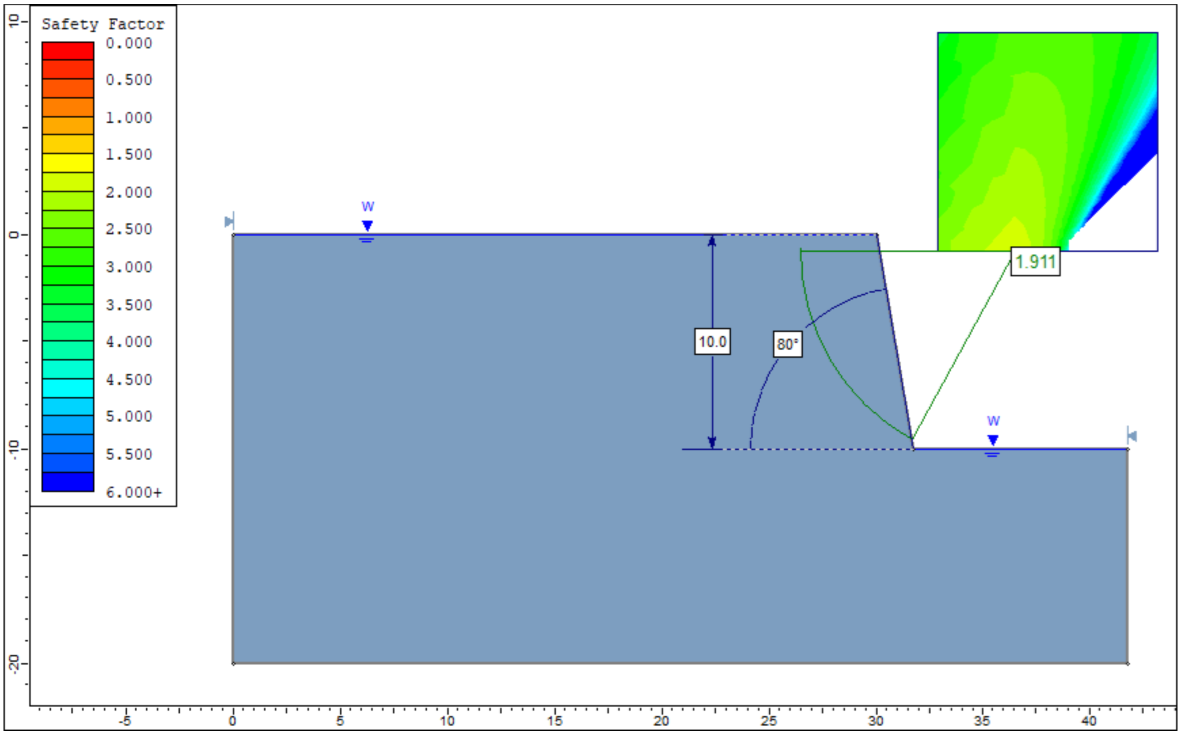


Figure 16-47: Transitional material analysis with an 80° BFA
Source: CSA Global, 2018

16.3.3.19 Wedge Failure

The probability of wedge failure was tested in *Dips*. Different bench face angles of 60°, 70° and 80° were modelled for each pit wall sector.

An example of the *Dips* wedge failure probability analysis is shown in Figure 16-48.

The shaded crescent area represents the zone of possible wedge failure. The red area is the primary critical zone of possible wedge failure, while the orange area is the secondary critical zone of failure. The primary critical zone falls within the plane friction cone, and outside of the slope plane. Any intersection planes that plot within this zone represent wedges that can slide. The intersections that fall within the secondary critical zone, represent wedges which slide on one joint plane.

The results of the wedge failure analysis indicate that in design sector 1, the probability of wedge failure is 12.71%, which indicates a possibility that wedge failure will occur as it exceeds the threshold of 10%.

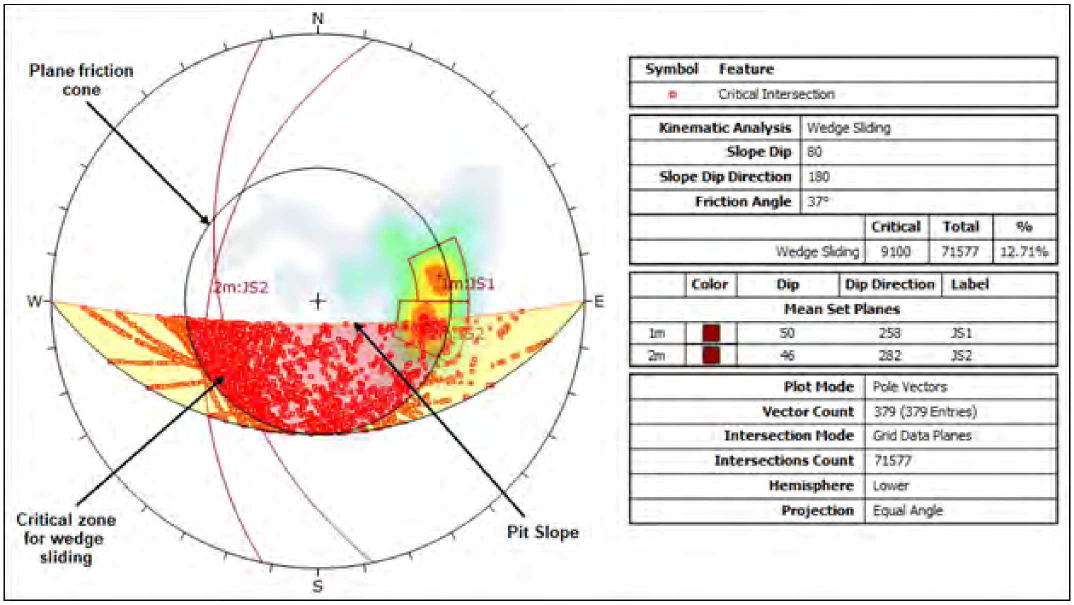


Figure 16-48: An example of the Dips wedge failure, design sector 1 at 80° BFA
Source: CSA Global, 2018

The analysis in *Dips* is a pseudo-probabilistic method to determine the likelihood of failure. The *Dips* plots that indicated a probability of failure greater than the 10% threshold, were further analysed in the RocScience program *Swedge*.

Swedge determines the factor of safety in a bench face with the wedge failure, by two intersecting discontinuity planes, taking into account the discontinuity properties, as well as the inclination of the bench face angle and orientation of the pit wall. An example of the *Swedge* results is shown in Figure 16-49. The analysis indicates that there is potential for wedge failure in the slopes of design sector 4, at a 60° BFA, because the SF is 0.20, which is below 1.00, thereby indicating unstable conditions.

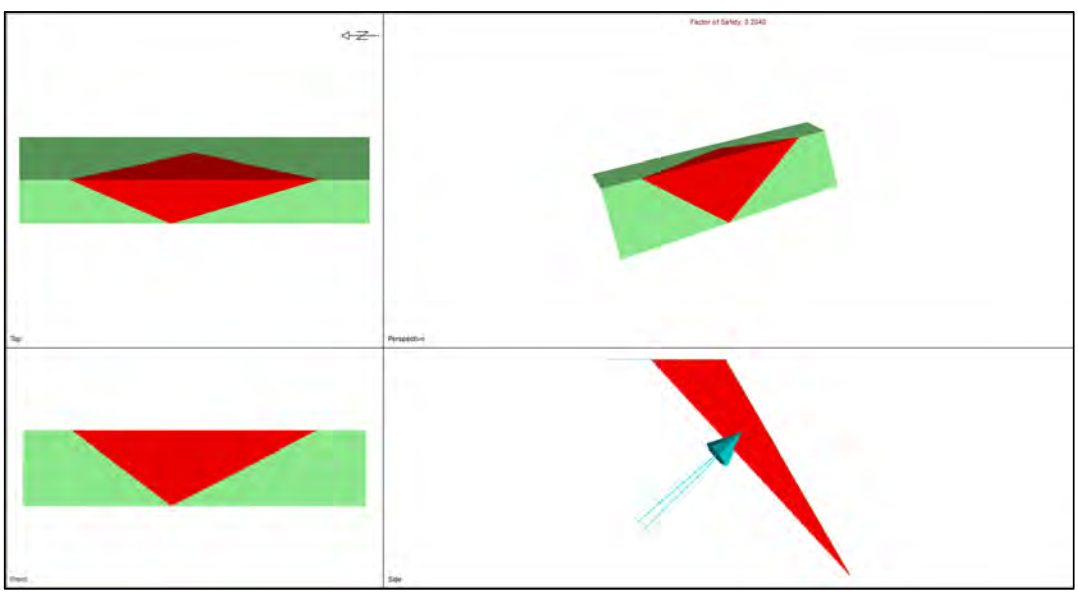


Figure 16-49: An example of Swedge analysis in design sector 4, with joint sets 1 and 2
Source: CSA Global, 2018

16.3.3.20 Plane Failure

The likelihood of planar failure to occur was analysed in RocScience *Dips*. Bench face angles of 60°, 70° and 80° were modelled for each design sector in the pit. An example of the *Dips* analysis for plane failure in design sector 2, with a 60° bench face angle, is displayed in Figure 16-50.

The critical zone in which planar sliding occurs, falls within the daylight envelope of the slope, and outside the friction cone. The daylight envelope of the slope represents the area of 'free space' or area where a slab of rock can fall into, if frictionally unstable. Any pole falling outside of the friction cone, and within the daylight envelope represents a plane that is frictionally and kinematically unstable.

The results from the plane failure analysis in design sector 2, with a 60° bench face angle indicate that plane failure is likely, with a probability of failure of 19.79%.

The *Dips* analysis done on plane failure provided the likelihood of failure of defined joint sets. The areas of possible failure, with a probability of failure greater than 10%, were further analysed in the RocScience program *RocPlane* to determine a safety factor. An example of the *RocPlane* results is shown in Figure 16-51.

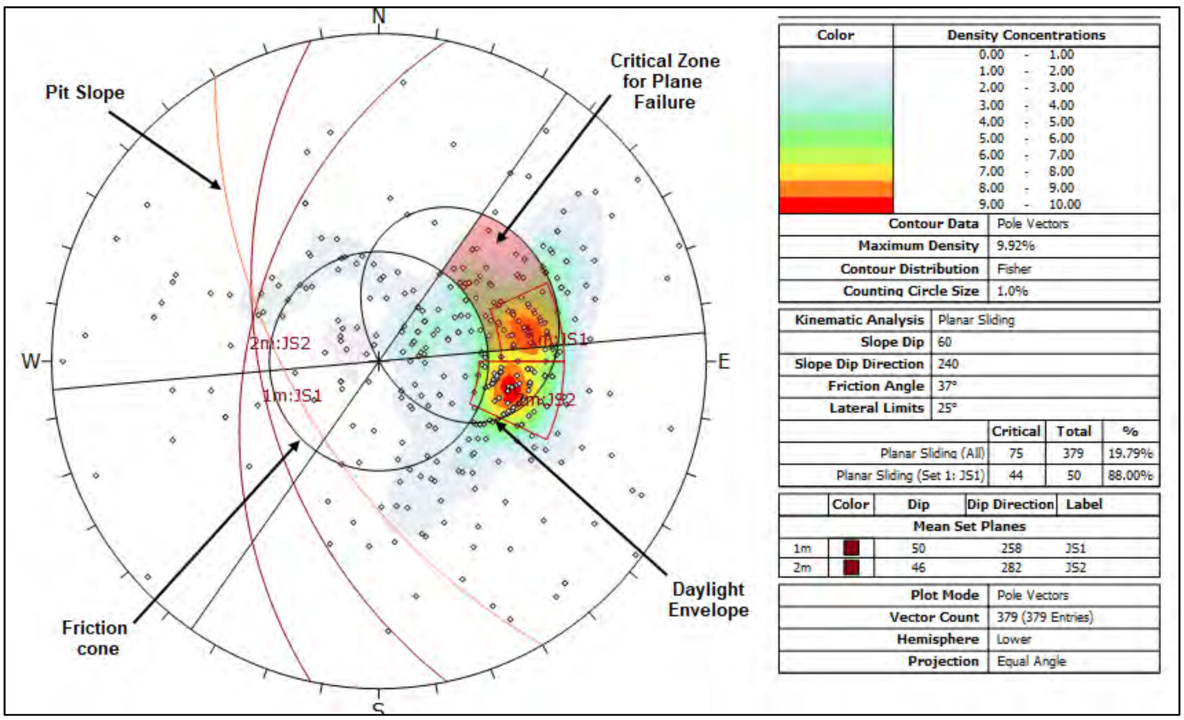


Figure 16-50: An example of plane failure in design sector 2, with a 60° BFA
Source: CSA Global, 2018

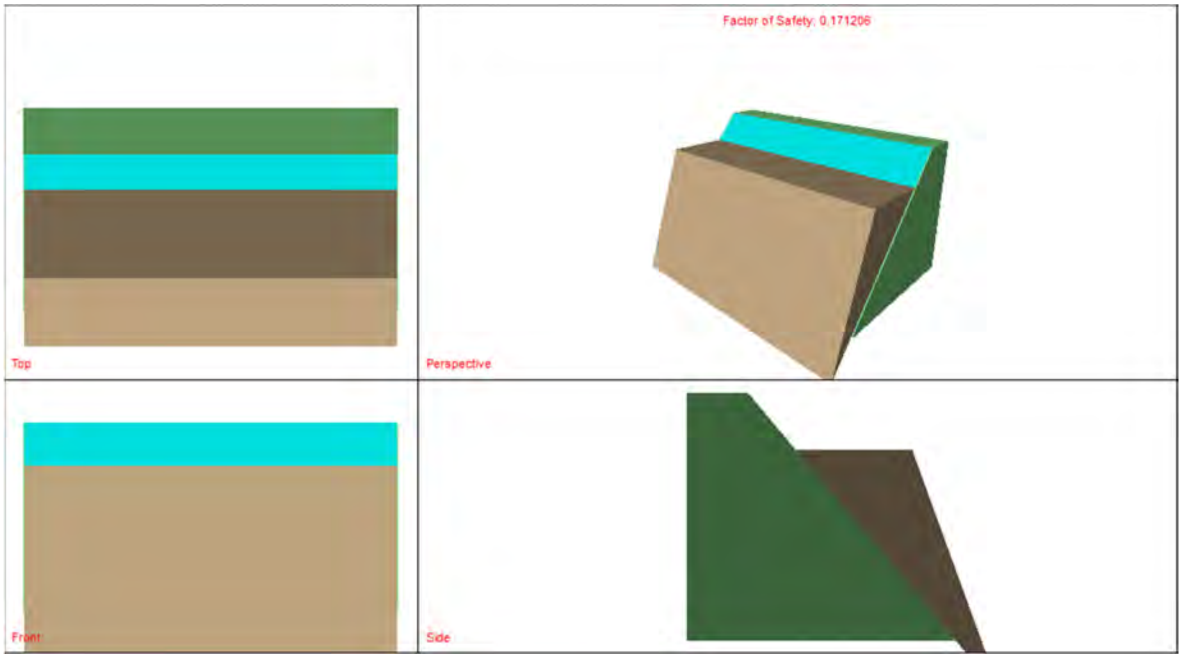


Figure 16-51: RocPlane analysis for JS1 at 70° BFA
Source: CSA Global, 2018

16.3.3.21 Flexural and Direct Toppling Failure

Toppling failure involves rotation of columns or blocks of rock about a fixed base (Hoek and Bray, 1981). There are two types of toppling failure, namely block (direct) toppling and flexural toppling.

Block toppling occurs where closely spaced joints dip steeply between 65° and 85° into the bench to form individual columns, and another, more widely spaced joint set undercut at the toe of the bench (Lorig, L. *et al.,* 2009).

Flexural toppling occurs when inward dipping columns are more continuous and maintain face-to-face contact as they bend over in flexure. Flexural toppling is usually associated with thinly bedded or slightly metamorphosed rocks rather than jointed igneous or sedimentary rocks (Lorig, L. *et al.,* 2009).

Flexural and direct toppling was not assessed, as the Ndablama rock mass did not meet toppling failure criteria.

16.3.3.22 Kinematic Assessment Results

The kinematic assessment carried out in *Dips*, determined the probability or likelihood of plane and wedge instability. The probability of each method of failure was recorded for each design sector at varying bench face angles of 60°, 70° and 80°.

A probability cut-off of 10% was used, where any probability greater than 10%, implied a significant likelihood that failure will be experienced. The results of the assessment are shown in Table 16-51. The probability percentages shaded in red are all above 10%.

The *Dips* kinematic assessment yielded the following results:

- Design sectors 2, 3, and 4 have indicated the possibility of planar and wedge failure at all BFA's.
- Design sectors 1 indicated the possibility of wedge failure an 80° BFA.
- Design sectors 5, 6, 7 and 8 all have potential for plane and wedge failure below 10% for all BFA's.

The plane failure and wedge failure were further assessed in *RocPlane* and *Swedge* respectively.

Table 16-51: Dips kinematic analysis results for all design sectors

Ndablama Open Pit								
Sector 1 (180)			Sector 2 (240)			Sector 3 (280)		
Slope angle	Failure mode		Slope angle	Failure mode		Slope angle	Failure mode	
	Planar (%)	Wedge (%)		Planar (%)	Wedge (%)		Planar (%)	Wedge (%)
60	2.37	6.31	60	19.79	23.21	60	27.97	34.36
70	2.64	9.60	70	24.80	33.59	70	30.87	40.29
80	3.17	12.71	80	26.39	39.26	80	31.40	43.84
Sector 4 (270)			Sector 5 (045)			Sector 6 (025)		
Slope angle	Failure mode		Slope angle	Failure mode		Slope angle	Failure mode	
	Planar (%)	Wedge (%)		Planar (%)	Wedge (%)		Planar (%)	Wedge (%)
60	29.29	33.79	60	1.58	1.65	60	0.79	2.98
70	32.72	40.12	70	1.85	2.63	70	1.32	5.69
80	33.51	43.60	80	1.85	3.80	80	1.32	8.95
Sector 7 (080)			Sector 8 (130)			**A 10% threshold of probability of failure was used.*		
Slope angle	Failure mode		Slope angle	Failure mode				
	Planar (%)	Wedge (%)		Planar (%)	Wedge (%)			
60	1.32	1.58	60	3.96	3.39			
70	1.85	2.66	70	4.49	4.71			
80	2.37	3.67	80	4.75	6.24			

16.3.3.23 Wedge Kinematic Assessment

The results of the *Swedge* analysis for potential areas of wedge failure are presented in Table 16-52. The safety factors shaded in red all indicate SFs less than 1, which represents a failed or unstable slope.

Failed slopes occur in design sectors 2, 3, and 4. The remaining sectors indicated that no wedges were formed.

Table 16-52: Swedge kinematic analysis results for all sectors

Joint set	60°	70°	80°
DS 1, Wall direction 180, Bench height 15 m			
J1 + J2	na	na	na
DS 2, Wall direction 240, Bench height 15 m			
J1 + J2	0.035	0.035	0.35
DS 3, Wall direction 280, Bench height 15 m			
J1 + J2	0.212	0.212	0.212
DS 4, Wall direction 270, Bench height 15 m			
J1 + J2	0.204	0.204	0.204
DS 5, Wall direction 045, Bench height 15 m			
J1 + J2	na	na	na
DS 6, Wall direction 025, Bench height 15 m			
J1 + J2	na	na	na
DS 7, Wall direction 080, Bench height 15 m			
J1 + J2	na	na	na
DS 8, Wall direction 130, Bench height 15 m			
J1 + J2	na	na	na

Note: n/a= not applicable, no wedge formed

16.3.3.24 Plane Kinematic Assessment

The *RocPlane* analysis considers the joint dip only and examines its stability in relation to the slope bench face angle. The results for the plane kinematic assessment are listed in Table 16-53.

Joint set 1 and joint set 2 proved to be problematic, where plane failure will occur for bench face angles of 60°, 70°, and 80°.

Table 16-53: RocPlane kinematic results

10m bench	Bench Face Angles (°)		
Joint set dip (°)	60	70	80
50	0.00	0.17	0.30
46	0.09	0.32	0.41

16.3.3.25 Kinematic Summary

A bench face angle of 60° was chosen to be applied to the fresh rock bench face angles in sectors 2, 3, and 4. The sectors that indicated plane or wedge failure will be further analysed, to ensure that the berm widths of the benches are wide enough to hold any failed material from wedges or planes.

16.3.3.26 Bench Heights

A standardized bench height of 10 m was applied to all fresh rock benches in the Ndablama pit, for all material types, and was based on industry practice. The bench height for the weathered material was also 10 m, unless the total height of weathered material exceeded 10 m, it was split into a 5 m and a 10 m bench height.

16.3.3.27 Berm Widths

Berm widths for the pit were calculated using the failure volume that can be contained on a berm from weathered, transitional and fresh material benches. To account for an accurate failure volume, bulking factors were applied to the material. The bulking factors used for the calculations are presented in Table 16-54.

A factor of 1.30 was deemed appropriate to be applied to the weathered/saprolite material, and transitional material, and a factor of 1.64 was applied to the fresh material.

Table 16-54: Bulking factors used in berm width calculations

Bulking factors				
Material	**Bulk density (Mg/m^3)**	**Bulking factor**	**Shrinkage factor**	**Diggability**
Clay (low PI)	1.65	**1.30**	-	M
Clay (high PI)	2.10	1.40	0.90	M-H
Clay and gravel	1.80	1.35	-	M-H
Sand	2.00	1.05	0.89	E
Sand and gravel	1.95	1.15	-	E
Gravel	2.10	1.05	0.97	E
Chalk	1.85	1.50	0.97	E
Shales	2.35	1.50	1.33	M-H
Limestone	2.60	1.63	1.36	M-H
Sandstone (porous)	2.50	1.60	-	M
Sandstone (cemented)	2.65	1.61	1.34	M-H
Basalt	2.95	**1.64**	1.36	H
Granite	2.41	1.72	1.33	H

Note: E – Easy digging, M – Medium diggability, H – Hard diggability.

The rotational slip surface for a bench of weathered material in *Slide*, was used to determine the weight of each slice of the 25 slices in a rotational slip surface. The total weight of the slices was converted to total mass. The total mass was divided by the unit weight and multiplied by the appropriate bulking factor, which resulted in the failure volume of the material in the bench, presented in Table 16-55. The berm width applied to weathered and transitional material was 6.00 m.

Table 16-55: Berm width calculation for weathered material

Slice	10m ht, 60° BFA
	Saprolite weight (kN)
1	18.52
2	50.53
3	75.00
4	95.30
5	111.45
6	111.03
7	104.99
8	97.59
9	89.04
10	89.52
11	98.85
12	107.40
13	115.22
14	122.37
15	128.92
16	134.89
17	138.16
18	126.09
19	110.71
20	94.86
21	78.55
22	61.82
23	44.65
24	27.08
25	9.09
Sum	2,241.60
Mass	228,338.67
Volume	228.34
Bulking factor	1.3
Berm width	6.11

The wedge and plane failure analysis were used to determine the bench width required for the pit by analysing the failure volume that can be contained within a bench. The weight for failed material was obtained from *RocPlane* and *Swedge*. The failure volume was determined by dividing the failed weight by the density and multiplying by an appropriate bulking factor. The berm width was calculated by obtaining the cube root of the failed volume, which is shown in the equation below.

$$\text{Berm width} = \sqrt[3]{}\,((\text{failure volume (m}^3) * \text{Bulking factor})$$

The critical plane from plane failure analysis on *RocPlane* would have been used to determine the berm width, however in the analysis shown below, the planes that indicated failure, showed no significant failure volumes to limit the berm widths.

Table 16-56: Berm width results from planar failure volume

Plane Failure – All design sectors					
BFA (°)	**Wedge weight**	**Density (g/m)**	**Failure volume (m^3)**	**Bulking factor**	**Berm width (m)**
Joint set 1					
60	376.27	2.88	0.21	1.64	0.60
70	682.99	2.88	0.39	1.64	0.73
80	952.74	2.88	0.54	1.64	0.82
Joint set 2					
60	558.24	2.88	0.32	1.64	0.68
70	864.97	2.88	0.49	1.64	0.79
80	1,134.71	2.88	0.65	1.64	0.87

The critical wedge slip surfaces from *Swedge*, was used to determine the berm width in each design sector. The weight for failed material was obtained from *Swedge.* The cube root of the failure volume resulted in the berm width. The results for this analysis are presented in Table 16-57. The limiting berm width that was derived was 5.61 m. A berm width of 5.60 m was applied to all fresh material benches.

Table 16-57: Berm width calculations from wedge failure volumes

Joint set	BFA (°)	Wedge weight	Density (g/m)	Failure volume (m^3)	Bulking factor	Berm width (m)
DS 2						
J1 + J2	60	153.00	2.88	0.09	1.64	0.44
	70	2,544.00	2.88	1.45	1.64	1.13
	80	7,039.00	2.88	4.02	1.64	1.59
DS 3						
J1 + J2	60	74,209.00	2.88	42.33	1.64	3.49
	70	176,579.00	2.88	100.73	1.64	4.65
	80	310,100.00	2.88	176.89	1.64	5.61
DS 4						
J1 + J2	60	18,133.00	2.88	10.34	1.64	2.18
	70	47,478.00	2.88	27.08	1.64	3.00
	80	84,734.00	2.88	48.34	1.64	3.64

16.3.3.28 Geotechnical Berms

A geotechnical berm or catch berm is usually placed at the base of a stack at double the designed berm width. A stack is generally made up of four to six benches.

A geotechnical of 12 m (6 m x 2) was placed at the base of the weathered benches. Thereafter, geotechnical berms were placed every four to six benches and have widths of 11.5 m (5.6 x 2).

16.3.3.29 Slope Configurations

The overall slope configurations for each sector of the pit are presented in Table 16-58 and Table 16-59. The most aggressive OSA is 55° in design sectors 1, 5, 6, 7 and 8.

The shallowest OSA is 43° in design sectors 2, 3 and 4 due to the orientations of discontinuities in relation to the pit wall orientations, and because the ore is shallow dipping in those sections of the pit. The transitional material bench must be battered back to 60° in these design sectors because of the fresh material benches have BFAs of 60° which were determined from the kinematic analysis.

All highwalls that have been designed are the pit's endwalls. No designs have been undertaken for the pit's interim highwalls, as mining commences. The Ndablama pit highwall configurations are presented in Figure 16-52 and Figure 16-53.

Table 16-58: Slope configuration for design sector 1, 5, 6, 7 and 8

Ndablama Pit – DS 1, 5, 6, 7 and 8							
Design sector material	**Bench height (m)**	**Berm width (m)**	**Number of benches**	**Bench face angle**	**Stack angle**	**Overall slope angle**	**Safety factor**
Weathered	5.00	6.00	1.00	40°	29°	55°	2.58
	10.00	12.00	1.00	40°			
Transitional	10.00	6.00	1.00	80°	80°		
Fresh	10.00	5.60	14.00	80°	54°		

Table 16-59: Slope configuration for design sector 2, 3 and 4

Ndablama Pit – DS 2, 3 and 4							
Design sector material	**Bench height (m)**	**Berm width (m)**	**Number of benches**	**Bench face angle**	**Stack angle**	**Overall slope angle**	**Safety factor**
Weathered	5.00	6.00	1.00	40°	29°	43°	3.27
	10.00	12.00	1.00	40°			
Transitional	10.00	6.00	1.00	60°	60°		
Fresh	10.00	5.60	14.00	60°	54°		

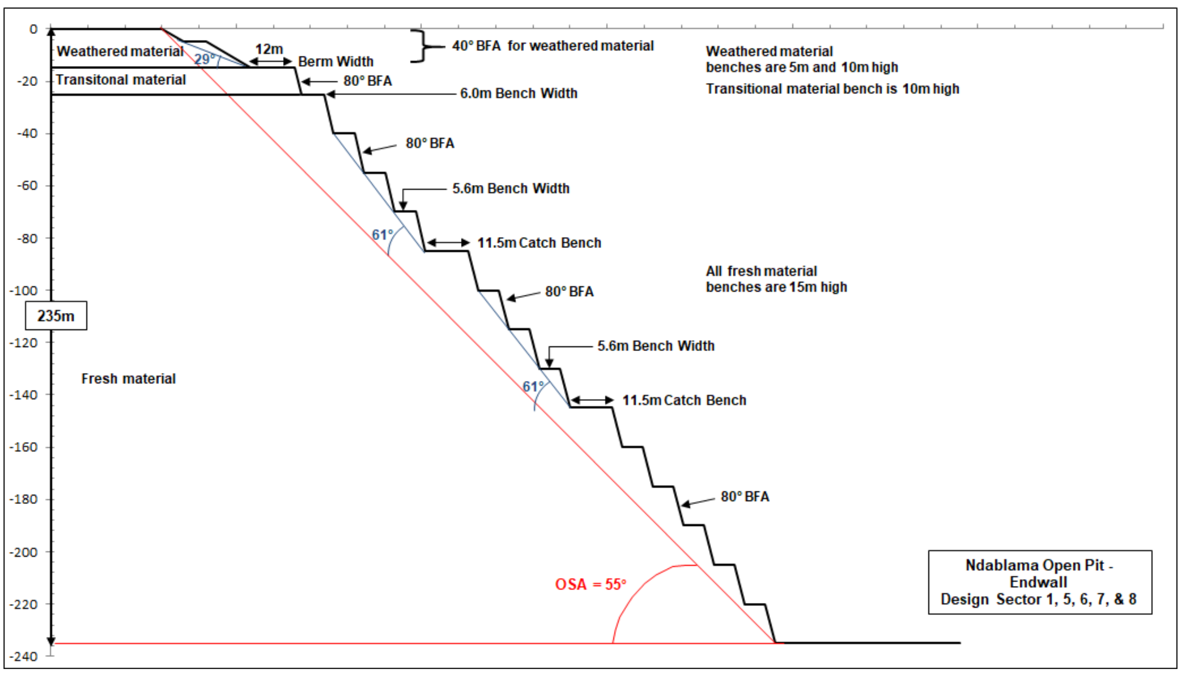


Figure 16-52: Slope geometry for design sectors 1, 5, 6, 7 and 8
Source: CSA Global, 2018

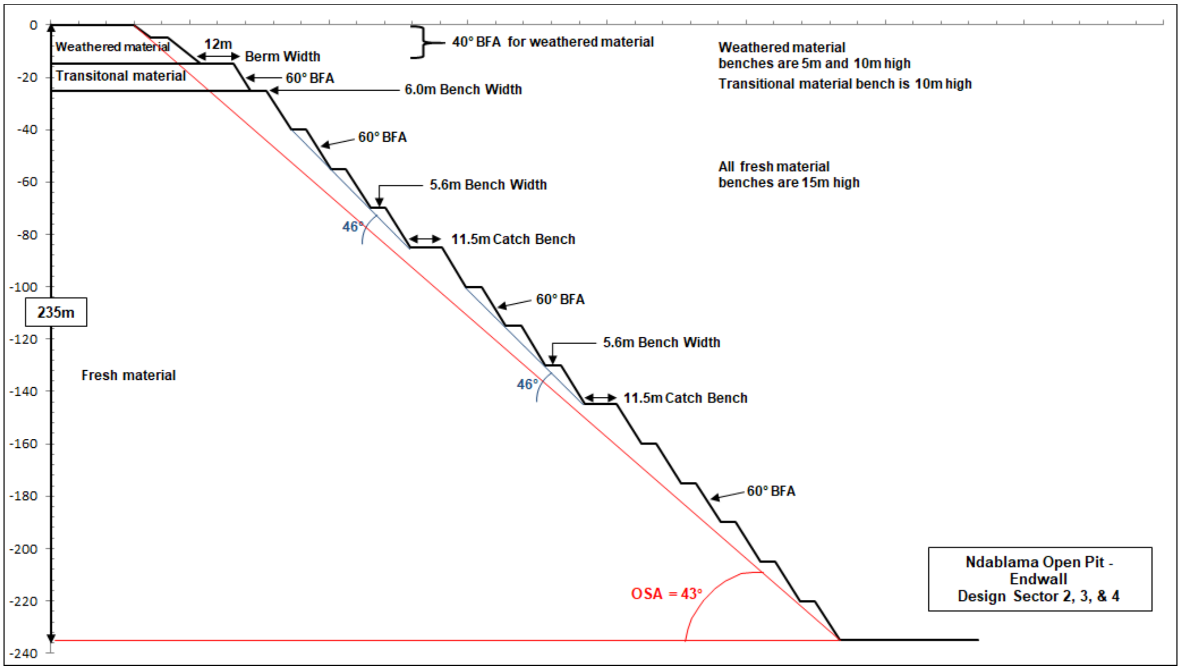


Figure 16-53: Slope geometry for design sectors 2, 3, and 4
Source: CSA Global, 2018

16.3.3.30 Slope Stability

The overall slope stability for each design sector was evaluated in *Slide*. Safety factors for each sector was determined and is presented in Table 16-60. Design sectors 1, 5, 6, 7 and 8 could be grouped together based on the kinematic assessment, and one slope configuration could be applied. The same principal applied to design sectors 2, 3 and 4. The orebody also dips a direction that corresponds to the steep and shallow areas of the pit, as depicted in Figure 16-54.

The *Slide* results from the analysis are illustrated in Figure 16-55 and Figure 16-56.

Table 16-60: Overall slope stability and SFs for each design sector

Design sector	Safety factor
1, 5, 6, 7 and 8	2.58
2, 3, and 4	3.27

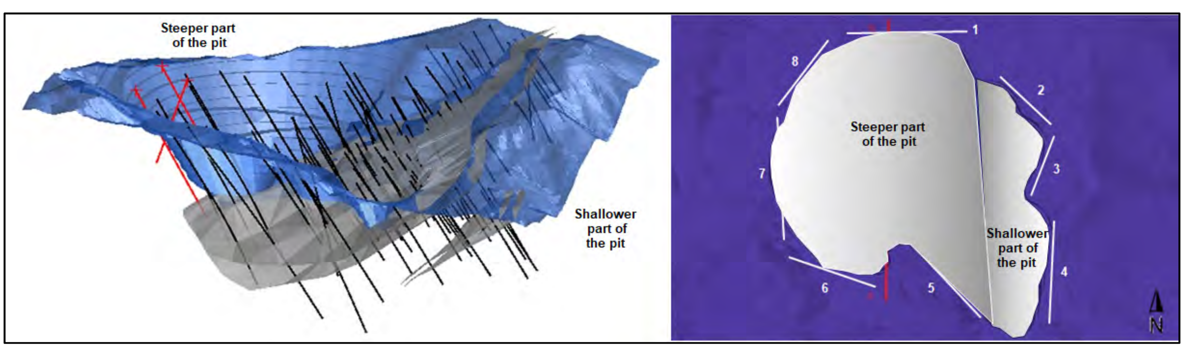


Figure 16-54: The orebody dip and sectors of the Ndablama open pit
Source: CSA Global, 2018

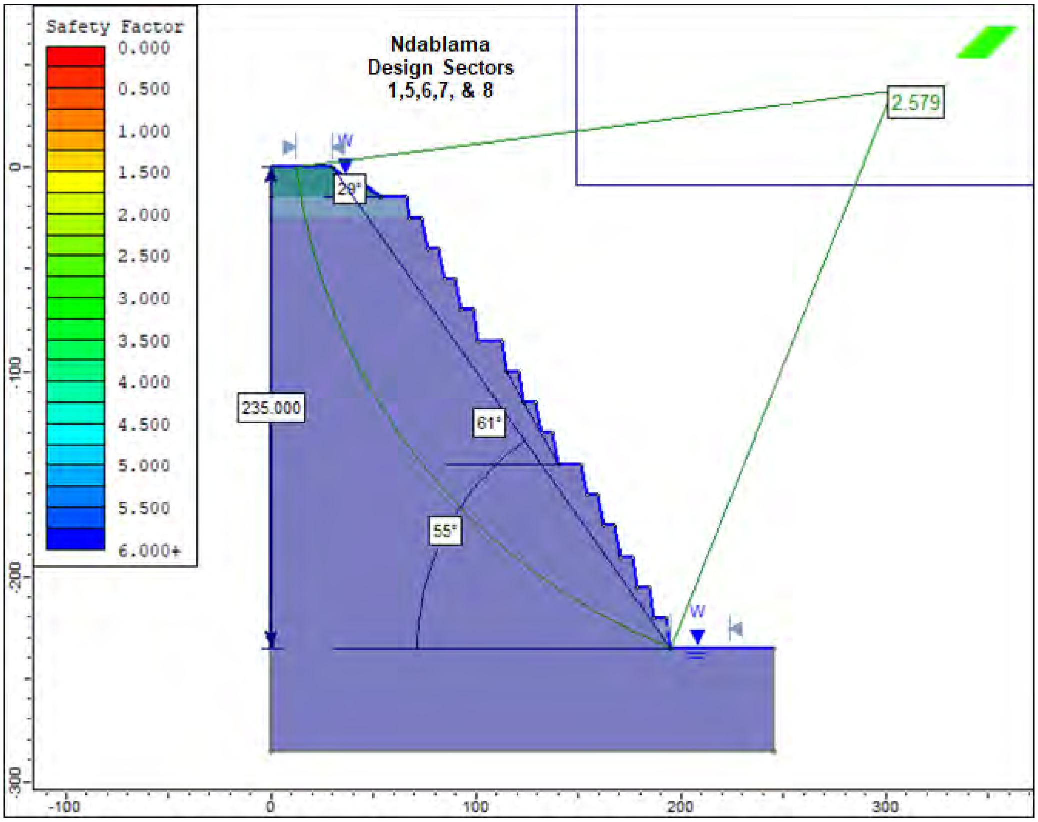


Figure 16-55: Slope stability for design sectors 1, 5, 6, 7 and 8

Source: CSA Global, 2018

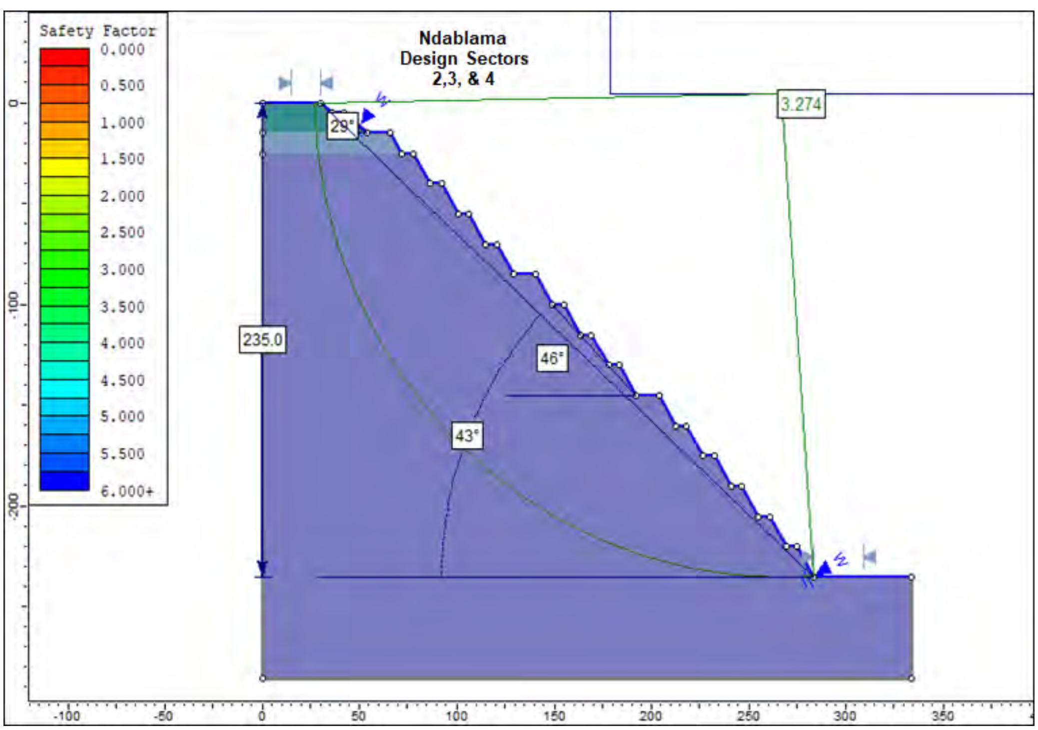


Figure 16-56: Slope stability for design sectors 2, 3 and 4

Source: CSA Global, 2018

16.3.3.31 Conclusion

The geotechnical data made available and transformed into analysis input parameters allowed for a technically robust design to be produced at a pre-feasibility level of accuracy. The following points summarises the geotechnical content of this submission:

- Rock quality indicators (RMR_{89}) were obtained from 24 drillholes drilled within the Ndablama area pit footprint, 21 of the 24 holes were historical drillholes that have been validated with three new geotechnical drillholes.
- In excess of 300 pole counts were used to kinematically assess the impact of defects on pit wall stability.
- Rock strength test results were provided for major host rock domains which was used either directly or indirectly to derive:
  - Hoek-Brown strength parameters
  - Equivalent Mohr-Coulomb parameters
  - Rock quality indicators
  - Defect properties of cohesion and friction angle
  - Design sectors have been devised based on a combination of pit wall directions and kinematic assessments.
- The slope design included various degrees of conservatism, which are:
  - an average depth of 15 m was used to model the weathered material, which may prove to be shallower upon commencement of mining
  - an average thickness of 10 m was used to model the transitional material, which may prove to vary upon commencement of mining
  - the water table depth was placed on surface, which depicted worst case, or saturated conditions.

17 Recovery Methods

17.1 Introduction

There is an existing processing facility already operating, treating oxide resources from the New Liberty mine, as well as well fresh ore sources from other satellite deposits in the area.

The underground ore sources from the Larjor, Kinjor South/North, and Marvoe deposits will be processed at the existing processing plant, along with ore mined from the Ndablama deposit.

17.2 Plant Layout

The plant layout is shown in Figure 17-1.

Source: BMMC, 2017

Figure 17-1: New Liberty existing plant layout

17.3 Process Plant Description

Metallurgical testwork results and industry norms were used to define the process design criteria for the New Liberty Plant. The original process plant was designed, built and commissioned in July 2015 by DRA, an international engineering company, to treat 1.1 Mt/a of ore, corresponding to a mill feed of 146 t/hr.

Since start-up there have been a number of operational issues that have affected plant performance. In late 2016 following the change of project ownership, the operational issues were evaluated and measures identified to improve performance. The planned modifications to the plant, some already implemented, and some planned for late 2017, have been designed to increase the throughput in stages up to 200 t/hr (1.8 Mt/a), while achieving the original design gold recovery of 91–93%.

The process flowsheet is an industry-standard arrangement consisting of crushing, ore stockpiling, grinding and classification, gravity gold recovery, thickening and gold extraction by cyanidation in a CIL circuit. Gold is recovered from the activated carbon by acid washing, elution and electowinning, followed by smelting to produce gold doré. The CIL tailings undergo cyanide detoxification followed by arsenic precipitation from tailings solution prior to disposal in the tailings dam.

An overall process flowsheet for the New Liberty treatment facility is shown in Figure 17-2.

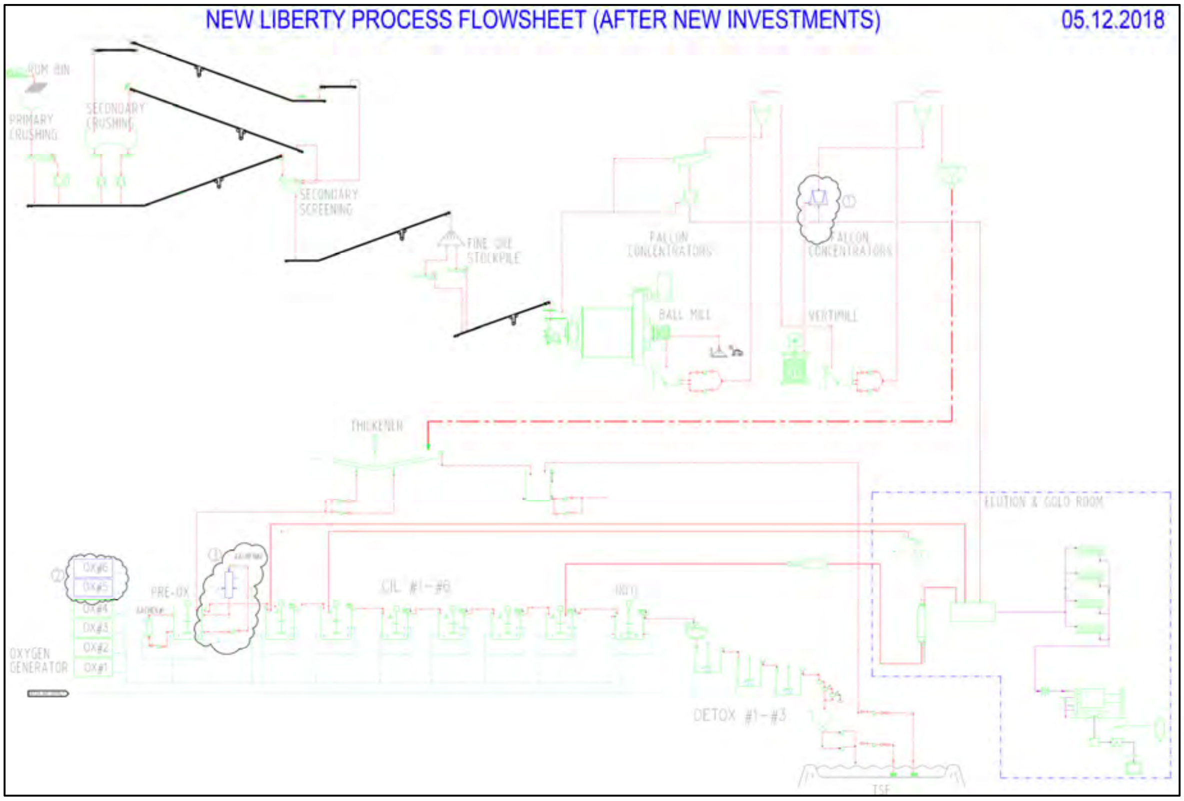


Figure 17-2: New Liberty plant flowsheet

17.3.1 Process Plant Performance

Records of historical process plant performance at New Liberty are shown in Table 17-1.

Table 17-1: New Liberty historical plant performance (2017–2019)

Month	Tonnes milled	Feed grade (g/t)	Recovery (%)	Plant utilisation (%)	Comment
Jan-17	99,280	1.62	85.0%	93.0%	
Feb-17	81,436	2.05	90.0%	89.0%	
Mar-17	99,597	2.24	90.8%	95.0%	
Apr-17	86,636	1.82	90.0%	84.0%	
May17	93,236	1.93	84.0%	87.0%	
Jun-17	114,664	2.19	89.0%	97.0%	
Jul-17	85,686	2.62	90.0%	69.0%	Low tonnes due to insufficient stock on ROM
Aug-17	99,367	2.67	91.0%	80.0%	
Sep-17	68,998	2.43	92.2%	57.0%	Low tonnes due to insufficient stock on ROM and plant breakdowns
Oct-17	78,449	3.48	91.0%	62.0%	Low tonnes due to insufficient stock on ROM and pit flooding and plant breakdowns
Nov-17	111,406	2.88	89.0%	94.0%	
Dec-17	124,612	2.74	89.4%	98.0%	

Month	Tonnes milled	Feed grade (g/t)	Recovery (%)	Plant utilisation (%)	Comment
Jan-18	117,194	3.33	87.7%	93.6%	Low tonnes due to tertiary crusher not commissioned
Feb-18	101,923	2.78	87.4%	100.0%	Low tonnes due to tertiary crusher not commissioned
Mar-18	124,472	2.62	86.0%	91.4%	
Apr-18	113,469	2.73	87.1%	79.8%	Low tonnes due to insufficient stock on ROM
May-18	132,911	2.98	87.7%	90.2%	
Jun-18	105,771	2.68	87.5%	81.5%	Low tonnes due to insufficient stock on ROM
Jul-18	101,513	2.83	90.5%	80.9%	Low tonnes due to insufficient stock on ROM
Aug-18	120,323	2.67	89.9%	83.3%	Low tonnes due to insufficient stock on ROM
Sep-18	131,807	2.94	88.4%	91.1%	
Oct-18	124,986	2.54	89.9%	94.1%	
Nov-18	124,488	2.23	88.4%	95.7%	
Dec-18	112,339	2.55	88.5%	80.2%	Low tonnes due to insufficient stock on ROM
Jan-19	122,600	2.38	87.5%	79.5%	Low tonnes due to insufficient stock on ROM

Overall, the plant has delivered an average throughput of 107,087 tonnes milled per month (1.2 Mt/a) with a maximum in the period of 132,911 tonnes milled per month (1.6 Mt/a). Low throughputs are by and large a consequence of limitations in mine production rate, in combination with low plant availability which was 88% over the period.

17.3.2 Predicted Plant Throughput

The original plant design incorporates a comminution circuit with a ball mill and regrind vertimill circuit to treat crushed ore at a design feedrate of 146 t/hr dry solids producing a final product with a nominal P80 of 45 µm, for a rated throughput of 1.1 Mt/a. Design crushing and concentrator utilisation was 76.5% and 90.0% respectively.

In 2013, the circuit configuration was upgraded to two-stage crush followed by two-stage milling. The primary ball mill consists of a 17.5 ft x 22 ft EGL ball mill, fitted with a 3.5 MW motor. This is operated in series with a VTM-1,500 fitted with a 1 MW motor. The design throughput remained the same however a finer grind size P80 of 45 µm to the CIL circuit was targeted to improve recoveries.

In 2017, a tertiary crusher was commissioned which would have attributed to the in the increase in throughput rate cf. 2017 as a result of a finer F80 to the ball mill for an annualised production rate of 1.6 Mt/a.

Based on the Bond Rod and Ball Mill Work indices reported in Section 13.14, the existing grinding circuit has sufficient installed grinding capacity to process the underground ore sources from the New Liberty mine at an annual production rate of 1.8 Mt/a, targeting a grind size P80 of 75 µm. However, when processing the harder ore from Ndablama alone the annual production rate is predicted to decrease to 1.6 Mt/a; at a grind size P80 of 75 µm.

In order to achieve the study throughput rate of 1.8 Mt/a when treating the UG ore types, NLGM will have to ensure:

- Continuous ore fed from the mine
- Three-stage crushing to achieve a final product size of 100% -10 mm
- Two-stage grinding; primary ball mill, and secondary Vertimill
- Product size P80 of 75 µm reporting to the CIL circuit
- Maintain an overall plant availability of between 95% and 96%.

In order to achieve the desired throughput in processing harder ore from Ndablama, it would be recommended to reduce the grind size to reflect the coarser liberation size for gold noted in this ore.

Additionally, in order to achieve targeted recoveries and throughputs, several other areas of optimisation are recommended:

- Maximise recovery of GRG in the gravity circuit to relieve residence times in the leach section;
- Operate the Acacia leach reactor to increase kinetics in leaching the gravity concentrate; and
- Consider addition of oxygen to the CIL circuit to increase leach kinetics.

17.3.3 Predicted Metallurgical Recoveries

The metallurgical testwork recoveries obtained by gravity-leach tests carried out on samples representing underground ore sources from New Liberty and fresh ore from Ndablama are summarised in Section 13.15.

The current process plant configuration includes all the unit processes to ensure that target gold recovery is achieved including; gravity, intensive cyanidation leach, and conventional CIL/ADR circuits.

Testing showed that the New Liberty ore types have a significant GRG component and therefore it will be essential to maximise gravity recovery using the existing Falcon concentrator. It will also be important to ensure that the gold head grade to the CIL circuit does not spike in the event the Falcon concentrator is off-line for maintenance.

At an annual production rate of 1.8 Mt/a, the current CIL circuit has a calculated leach residence in the range of 19–20 hours. This is on the low side in the event the Falcon concentrator is offline.

To ensure that the target gold recovery of 92% is achieved, it is recommended to investigate the installation of a second Falcon concentrator in the primary grinding circuit to maximise the GRG recovery, and to ensure that the leach tanks are injected with pure dissolved oxygen to increase leach kinetics.

18 Project Infrastructure

18.1 New Liberty Mine

New Liberty is to have a new, approx. 600,000 ROM t/a underground mine, accessed by portals from the old Larjor pit as well as the existing New Liberty pit (Kinjor), with a ramp accessing reserves between the current US$1,300 and US$$1,500 New Liberty pit shell. Each portal will have constructed entry, plus support, and services including sumps/pumping and a main ventilation fan (and vent shaft) in the vicinity. Extensive facilities including sumps and pumps to maintain/control water in the final pit (Pit 33) will be provided around each portal. Additionally, an ore transfer station, with a dump for underground ore trucks, and front-end loader to load haul trucks will be provided at each portal. Water from underground will be pumped to the two in-pit sumps, where this water, plus the pit inflows will be settled, then pumped to the existing water diversion trench to the south of Kinjor pit for discharge.

The underground mine is to be designed with relevant in-mine infrastructure to support conventional diesel mining fleet plus labour/supervision, including fuel stations, lubrication stations, miner's stations, refuge stations, ventilation and pumping infrastructure. Workshops will be on surface. Operations are to be via three shifts of eight hours, plus a spare shift, operating 24/7/365. Main electrical reticulation is at 6,000 V, transformed to 500 V in working sections. Lighting and small power will be provided in stationary working places; in all other locations lighting is to be by cap lamps and lights from mobile equipment. The mine is non-methaniferous, therefore electrics are to be to IP55 and explosion protected standard only (i.e. intrinsically safe not required). Underground communications by radio, with transmission by leaky feeder is assumed. Underground communications will interface via a new digital base station on surface with existing surface radio communications/dispatch and the mine's existing control network.

Power generation by two new 2.25 MVA diesel generators is assumed, with reticulation at 6,000 V to the new pumps, fans and the underground. Additional workshop capacity for planned maintenance of underground fleet will be provided. New/updated roads for mobile fleet to travel from the portal(s) to the plant stockpile and workshops will be laid out.

There is an existing 1.8 Mt/a mill on site at New Liberty therefore no new milling facilities relating to NL underground are contemplated. A new road train side-tip (two 90-t cars) will be required in the ROM area to handle ROM coming from Ndablama pit from Year 5.

The following buildings will be allowed for:

- Mine control room
- Surface workshop
- Generator station/substation
- Ventilation stations (two)
- Additional drawings for the two portals, plus an overall block plan showing updated pit extents, dumps, and new structures where relevant will be required.

18.1.1 Power and Electrical Reticulation

The combined project will utilise local diesel generation plants to supply the operational power requirements. Extension to the existing New Liberty power plant has been allowed to support the underground mining operation. Ndablama is a greenfields site and will include a new diesel power plant in order to supply the electrical requirements. Main distribution reticulation will be at 11 kV with equipment operational voltages being 525 V and 400 V.

18.1.1.1 Peak Demand and Power Consumption

New Liberty

The calculated maximum demand for the New Liberty underground operation is 4.1 MVA which occurs during Year 3 of the underground schedule. Figure 18-1 illustrates the load profile and annual power consumption estimate for the LOM. The Larjor and Kinjor areas are supplied with separate feeders and with the loads of each of the respective areas provided in Figure 18-1 and Table 18-2.

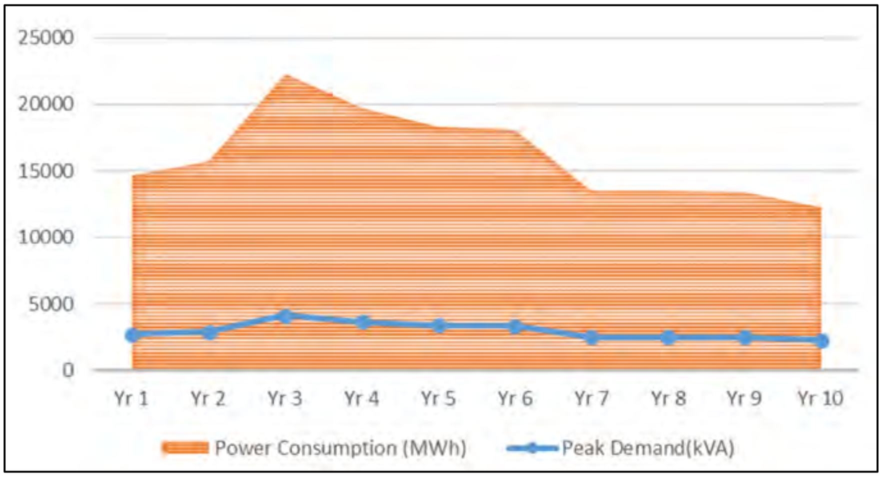


Figure 18-1: New Liberty annual peak demand and power consumption

Table 18-1: New Liberty – Larjor loads

Description	Connected power (kW)	Operating load (kW)	Peak demand (kVA)
Larjor Pit De-watering Pump Station	195	139	174
Larjor Dirty Water Pump Station – Upper Level (1 x off)	151	68	86
Larjor Dirty Water Pump Station – Lower Level (5 x off)	823	371	467
Larjor Level VSPs (13 in total – 6 already accounted for)	40	30	38
Development Suite (x4 operating – 6 installed)	1,416	1,188	1,485
Production Suite (x2 operating – 6 installed)	558	446	557
Larjor Main Vent Fans	445	364	456
Larjor Decline Development Fans	440	396	495
Total	**4,067**	**3,001**	**3,757**
Diversity factor			0.7
Peak demand (kVA)			**2,630**

Table 18-2: New Liberty – Kinjor loads

Description	Connected power (kW)	Operating load (kW)	Peak demand (kVA)
Kinjor Pit De-watering Pump Station	1,805	796	996
Kinjor Dirty Water Pump Station – Upper Level (1 x off)	128	58	73
Kinjor Dirty Water Pump Station – Lower Level (7 x off)	658	297	374
Kinjor Level VSPs (13 in total – 8 already accounted for)	40	30	38
Development Suite (x4 operating – 6 installed)	1,416	1,188	1,485
Production Suite (x2 operating – 6 installed)	558	446	557
Kinjor Central Main Vent Fans	445	364	456
Kinjor Decline Development Fans	440	396	495
Total	**5,490**	**3,574**	**4,472**
Diversity factor			0.7
Peak demand (kVA)			**3,131**

Ndablama

Peak power requirement for the Ndablama operation is calculated at 360 kVA, which will be supplied via two 500 kVA generating units configured in a running/standby arrangement. The loads making up the peak demand are detailed in Table 18-3.

Table 18-3: Ndablama loads

Description	Connected power (kW)	Operating load (kW)	Peak demand (kVA)
Camp including Change house	82	66	82
Surface Offices and First Aid Facility	68	54	68
Surface Workshop Building	46	27	34
Surface Stores Building (including oils)	4	4	4
Sewage Treatment Plant	10	8	10
General Surface Infrastructure	4	3	4
Bulk Water Supply	140	112	140
Diesel Storage and Dispensing	7	6	7
Lighting	10	8	10
Total	**371**	**288**	**360**

18.1.1.2 Electrical Reticulation

New Liberty

The underground operations will be fed from the main substation, which will be expanded to include two additional 2.25 MVA generating units, two 11 kV incomer panels and the two underground operations feeders. One feeder will supply the Larjor mining area and the second feeder will supply the Kinjor mining area. Reticulation to the portal areas will be via overhead lines, Figure 18-2 shows the single line diagram (SLD) of the substation extension and the feeders to the portals.

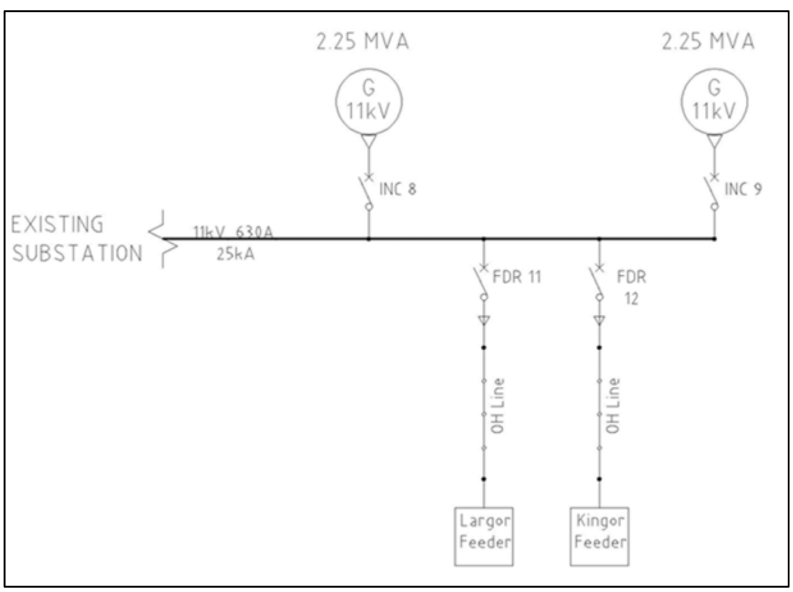


Figure 18-2: New Liberty main substation extension SLD

The overhead line from the main substation will terminate at the portals at ring main units (RMUs), the RMUs will supply power to the area main ventilation fans, the area pit de-watering and the area underground loads. From the portal, power is reticulated underground at 11 kV by means of cabling, which will be installed down the service raises. RMU's will be provided to reticulate the power to the dirty water pumping, mining, ventilation and services requirements. Typically, every second level will be equipped with a five-way RMU, one of the circuit breakers will feed a mini-substation unit (MSU) supplying the dirty water pump station and the station level power requirements. The other two feeder circuit breakers will supply the mining development, production and ventilation loads. Figure 18-3 below shows the reticulation for the Larjor operation, the Kinjor layout will be similar with additional RMUs required to cater for the extra mining levels.

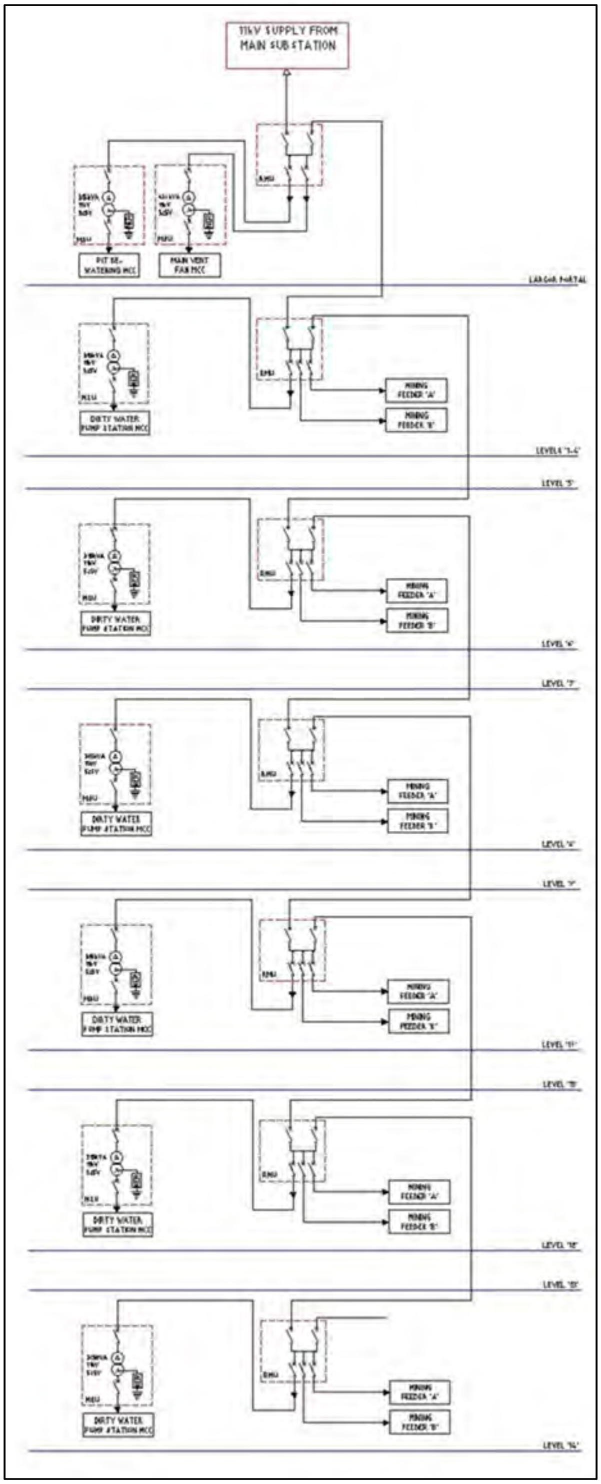


Figure 18-3: Larjor operation underground MV SLD

Larjor Electrical Loads

Dewatering pumps:

- The Larjor pit de-watering consists of two 75 kW pumps connected in series, the pump station will be supplied by a 315kVA MSU with the loading detail provided in Table 18-4.

Table 18-4: Larjor pit dewatering pump station loads

Description	Connected power (kW)	Operating load (kW)	Operating load (kVA)
Larjor Pit De-watering Pump Station	**195**	**171**	**174**
Set 1 Pump 1	75	68	84
Set 1 Pump 2	75	68	84
Lighting and small power	5	4	6
Welding plug	40	32	46

Larjor main ventilation fans:

- Two 200 kW fans operated by means of variable speed drives (VSD) will be installed to support the Larjor mining operation. The vent fan motor control centre (MCC) will be supplied from a 630 kVA MSU. Table 18-5 provides the load detail of the MCC panel.

Table 18-5: Larjor main ventilation fan loads

Description	Connected power (kW)	Operating load (kW)	Operating load (kVA)
Larjor Main Vent Fans	**445**	**396**	**456**
Ventilation fan 1	200	180	225
Ventilation fan 2	200	180	225
Lighting and small power	5	4	6
Welding plug	40	32	46

Larjor dirty water pump stations

- A total of six dirty water pump stations will be provided to relay pump dirty water out of the mining operation. The pump stations will typically consist of two pumps operating in a running/standby configuration and two agitators. The pump stations will be supplied via 315 kVA MSUs feeding the pump station MCC panels. Table 18-6 provides the pump station loads.

Table 18-6: Larjor dirty water pump station loads

Description	Connected power (kW)	Operating load (kW)	Operating load (kVA)
Larjor Dirty Water Pump Station	**165**	**74**	**93**
Pump 1	37	33	42
Pump 2	37	0	0
Ventilation fan	19	17	21
Agitator 1	11	8	10
Agitator 2	11	8	10
Level vertical spindle pump	5	4	5
Lighting and small power	5	4	6
Welding plug	40	32	46

Kinjor Electrical Loads

The Kinjor pit de-watering consists of two sets of four pumps in series, one set is used to cater for the normal operation de-watering and the second set to cater for emergency situation following abnormal rain conditions. During the emergency pumping both pump sets will operate simultaneously. The pump station MCC panel will be supplied by a 2,500 kVA transformer. The pump station loading is provided in Table 18-7 below.

Table 18-7: Kinjor pit dewatering pump station loads

Description	Connected power (kW)	Operating load (kW)	Operating load (kVA)
Kinjor Pit De-watering Pump Station	**1,805**	**796**	**996**
Set 1 Pump 1	220	198	248
Set 1 Pump 2	220	198	248
Set 1 Pump 3	220	198	248
Set 1 Pump 4	220	198	248
Set emergency Pump 1	220	0	0
Set emergency Pump 2	220	0	0
Set emergency Pump 3	220	0	0
Set emergency Pump 4	220	0	0
Lighting and small power	5	4	6
Welding plug	40	32	46

Kinjor main ventilation fans:

- Kinjor operation main ventilation will consist of two 200 kW fans installed for the central area and a single 200 kW fan installed for the eastern area. The fans will be operated by means of variable speed drives (VSD). The central vent fan station motor control centre (MCC) will be supplied from a 630 kVA MSU and the eastern area MCC a 315 kVA MSU.

Kinjor dirty water pump stations:

- A total of eight dirty water pump stations will be provided to relay pump dirty water out of the mining operation. The pump stations will typically consist of two pumps operating in a running/standby configuration and two agitators. The pump stations will be supplied via 315 kVA MSUs feeding the pump station MCC panels. Table 18-8 provides the pump station loads.

Table 18-8: Kinjor dirty water pump stations

Description	Connected power (kW)	Operating load (kW)	Operating load (kVA)
Larjor Dirty Water Pump Station	**165**	**74**	**93**
Pump 1	37	33	42
Pump 2	37	0	0
Ventilation fan	19	17	21
Agitator 1	11	8	10
Agitator 2	11	8	10
Level Vertical spindle pump	5	4	5
Lighting and small power	5	4	6
Welding plug	40	32	46

New Liberty Mining Suite Loads

The stoping and development suites will both service the Larjor and Kinjor operational areas. In total, six development ends will be equipped with a peak of four operating at any one time. Six production suites will be installed, with a peak of two operating concurrently. Table 18-9 provides a single development suite electrical load list and Table 18-10 a standard production suite electrical load list. The development suite will be supplied by a 630 kVA MSU and the stoping suite with a 315 kVA MSU.

Figure 18-4 and Figure 18-5 show the SLD reticulation for the development and stoping suites.

Table 18-9: New Liberty mining development suite loads

Description	Connected power (kW)	Operating load (kW)	Operating load (kVA)
Development Suite	**354**	**297**	**371**
Skid mounted pump	15	11	14
Ventilation fan	75	68	84
Ventilation fan	75	68	84
Vertical spindle pump 1	3	2	3
Vertical spindle pump 2	3	2	3
Vertical spindle pump 3	3	2	3
Drill rig DD421 (maximum 175 hours per month)	180	144	180

Table 18-10: New Liberty mining stoping suite loads

Description	Connected power (kW)	Operating load (kW)	Operating load (kVA)
Production Suite	**279**	**223**	**278**
Ventilation fan	75	60	82
Ventilation fan	75	60	82
Vertical spindle pump 1	3	2	3
Vertical spindle pump 2	3	2	3
Vertical spindle pump 3	3	2	3
Drill rig DD421 (max 123 hours per month)	120	96	132

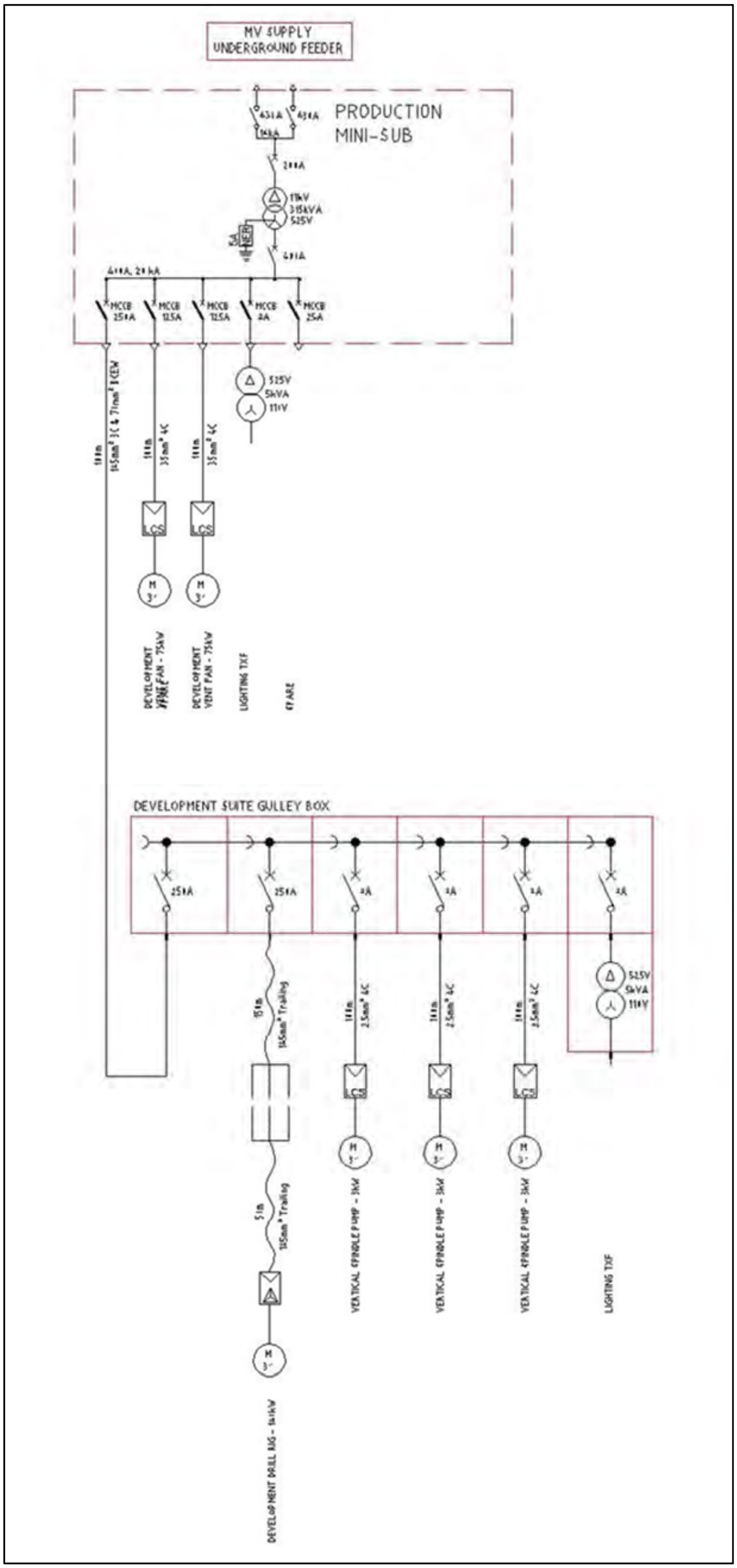


Figure 18-4: New Liberty development suite SLD

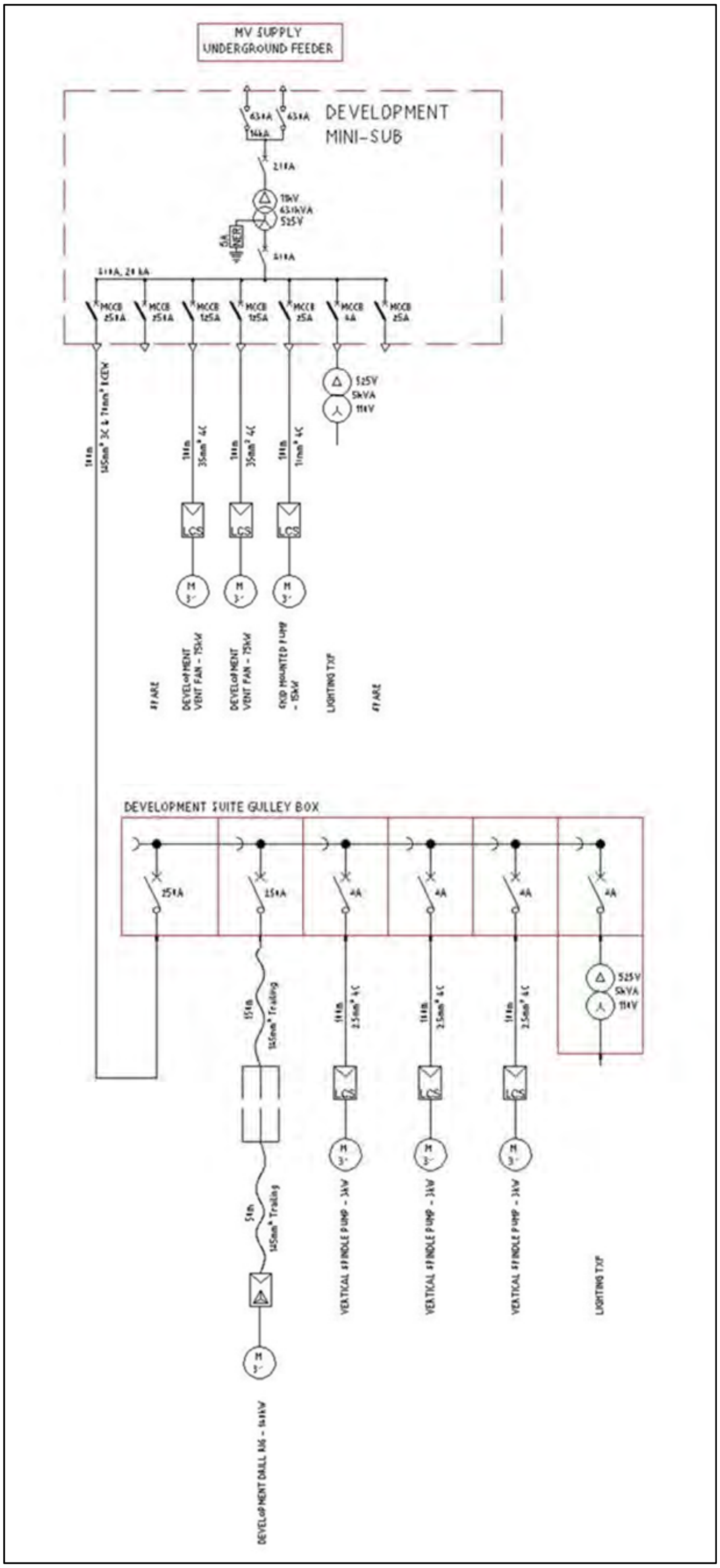


Figure 18-5: New Liberty production suite SLD

18.1.1.3 Communication Systems

Production communication will be via a VHF radio system. The mining, engineering and emergency services will operate off different channels of the radio system. The radio system will include an antenna for surface communications and a leaky feeder system for underground. Handheld radio units will be provided to personnel and fixed units installed in vehicles and control rooms as required.

A fibre ethernet backbone system will be installed underground to provide a data conduit between underground equipment and the surface control room. Non-production communication will be an IP telephone system connecting into the ethernet backbone system.

18.2 Ndablama – On-Site Infrastructure

18.2.1 Introduction

Ndablama is to be an approx. 1,600,000 ROM t/a open pit mine, with conventional truck/shovel fleet and associated labour/supervision, three shifts of eight hours, plus a spare shift, operating 24/7/365. The pit is to be provided with all relevant infrastructure to support conventional diesel mining fleet plus labour/supervision, including a combined workshop, fuel station and lubrication station, stores, offices, changehouse facilities, and pit dewatering infrastructure. Pit dewatering will be by Global type diesel pumps as at New Liberty, discharging into the surface stormwater diversion trenches as required. Workshops will be designed for the estimated complement of mobile fleet; offices and changehouse facilities will be designed for the estimated labour complement plus contingency. Haul trucks from the pit will dump to a ROM pad, where a front-end loader will load off-highway trucks for the transport of ore to the New Liberty ROM pad. Roads to connect the crushing station to the ND-NL haul road must be laid out. A haul road from Ndablama mine to New Liberty mine (±46 km; already laid out by AVS consultant). Power generation by a single new 400 kVA generator for small power (offices, changehouses, stores) only is assumed. Solar generation has been allowed on the changehouse roof to support power requirements. Power reticulation will be at 6,000 V, transformed to 500 V in working sections. Communications/dispatch is to be by radio, with an additional 3G tower for cellular and data communications back to New Liberty.

The following buildings will be allowed for:

- Road train loadout
- Central workshop
- Fuel/lubrication station
- Stores building
- Offices
- Changehouse
- Generator station and substation
- Gate access point/security
- Pumping station(s) and settling pond.

Workshops and other structures are to be simple, low cost structures suitable for 20-year mine life. Structures will be generally steel framed and sheeted, with plinths on a reinforced concrete slab for working areas. Louvres will be included for ventilation requirements. Windows to be translucent polycarbonate with max 15% of floor area as translucent sheet. All steel to be either hot dipped, powder coated to 75 um, or sandblasted to 50 um, primed and painted with epoxy. Workshops and fuel stations to be provided with oily water treatment “Drizit” skimmers or equivalent. Fuel station equipment to be provided by the fuel supplier.

Offices will be pre-fabricated, converted containers or "ATCO" type cabins. Changehouses will be of stock brick construction on concrete slabs, with galvanized sheeting roof on timber joists, steel-framed windows with float-glass, with sanitation/boiler facilities as required. Tiled areas to be provided for toilets and showers. Additionally, solar panels for small power and water heating has been provided for the Ndablama changehouse. Sanitary water treatment to be by "Bio-disc" type packaged mechanical contacting sewage treatment plant specced for personnel load. Stock brick walls to be painted outside with sealing paint to +1.5 m above TOC for water/splash protection. Doors to be single, semi-solid hardwood in steel frames. Internal ceilings to be 6.4 mm thick fibre cement board with fluorescent lighting fixtures to suit. Piping to be hot-dipped galvanised.

18.2.2 Ndablama–New Liberty Haul Road

A new, reliable haul road is required to move direct shipping ore from the Ndablama satellite pit to the New Liberty mill. A study to determine the requirements to move ore material from their other mining areas to the New Liberty processing facility, including a preliminary road design, was commissioned by Avesoro's precedent, Aureus Mining. The study was reviewed, determined to be valid with costs updated for the purposes of this PFS. Additionally, a new study confirming the optimal alignment of the Ndablama–New Liberty haul road was commissioned by Avesoro and undertaken by ABS Consulting of South Africa. The findings of both reports are summarised here for completeness.

18.2.2.1 Preferred Road Alignment

Avesoro requested that Enviro-Insight CC carry out a scoping study in order to ensure environmental compliance for a proposed road between New Liberty Gold Mine (NLGM) and the Ndablama Concession (NC). The road is intended for use as a haul road to transport gold ore from the NC and WC to the processing plant at NLGM. Environmental compliance in the design and implementation of such a haul road requires an adherence to industry best practice standards, the laws and environmental regulations of Liberia, as well as the standards of the Equator Principles, representing the company lender requirements. The conceptually proposed road alignment is shown in Figure 18-6.

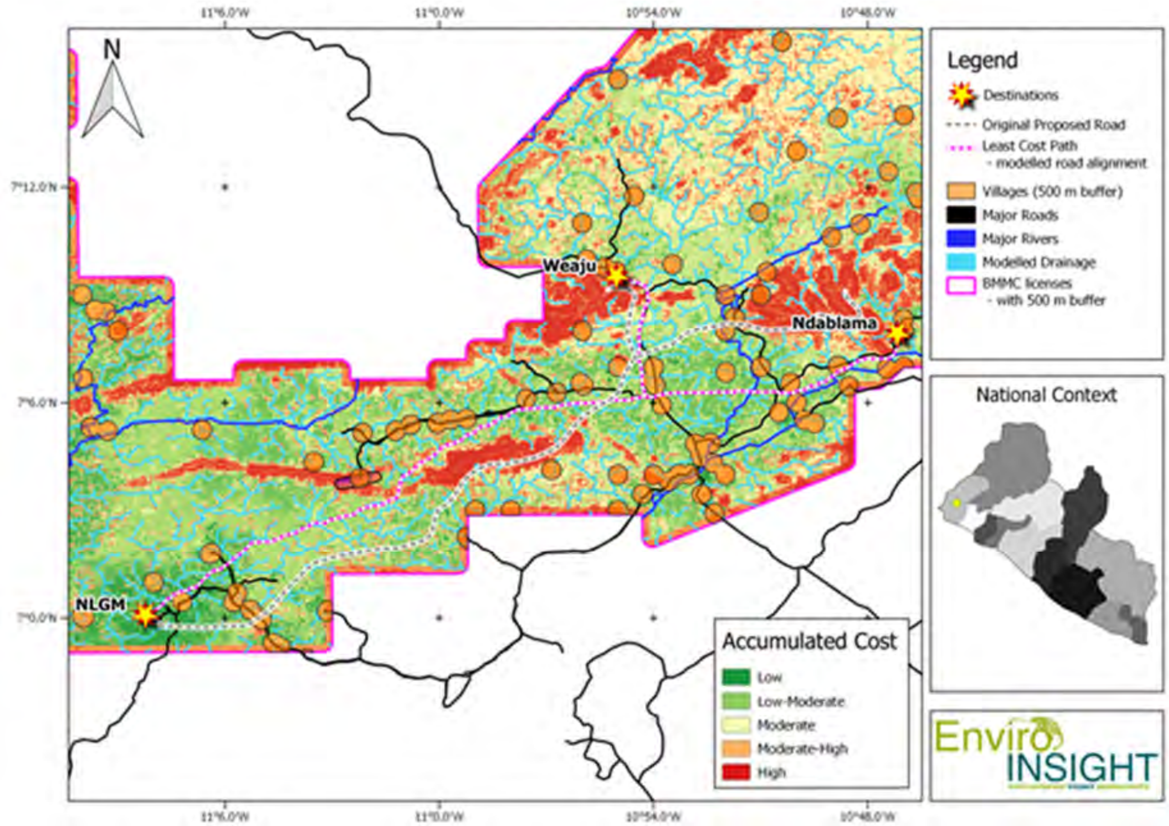


Figure 18-6: Alignment of proposed road from Ndablama to New Liberty (Enviro-Insight, 2017)

The proposed haul road location has been laid out taking all the following factors into consideration:

- Topography
- Existing roads
- Water courses and rainfall
- Vegetation
- Soil and subsurface material properties
- Population centres
- Travel distance.

The distance of the preferred alignment from NLGM to Ndablama is 46 km. Following completion of the alignment study, several recommendations were made:

- Once agreement on the alignment has been achieved, it must be ground-truthed to identify any high cost factors overlooked, as discussed above in the limitations section. Changes to the LCP model alignment may be required during this step; and
- Following final alignment confirmation after ground-truthing, a comprehensive environmental impact assessment (EIA) must be developed. The magnitude of potential environmental impacts will be evaluated according to the extent, duration, severity and probability of occurrence. Mitigation measures and management recommendations will be proposed to reduce the impact magnitude where after the impact assessment will be repeated assuming the implementation of all mitigation and management recommendations. This EIA will comply with Liberian Law and the standards of the Equator Principles.

18.2.2.2 Road Design and Construction

The road design will be the standard two-layer construction and will be unsealed though, due to the use of rock material from the mining operations, it can be considered as an all-weather road.

Based upon observations, the area in general is made up of laterites and residual soil that are classified as stiff/medium dense. In general, laterites are good road building material and can be used as sub-base material. The following main criteria are of relevance:

- In general, laterites are good road building material and can be used as sub-base material.
- Topsoil strip, clear or grub remove at least 300 mm.
- Rip and re-compact 300 mm and compact this layer to 95% Mod AASHTO density at OMC.
- Replace the 300 mm material removed with a G6 quality material. The geotechnical results indicated that the in-situ laterites were of G6 quality.
- Compact these layers to 95% mod. AASHTO density at OMC.
- Place gravel-wearing course/layer of G4 quality material compacted to 98% Mod AASHTO density at OMC. Layer thickness of 200 mm. The G4 will be blended with some of the laterite to increase the PI of the layer so that it binds.
- Final wearing course to be above NGL.
- Drains to be installed to keep water off the road surface.
- Camber of road to be 2.5% to 3% to allow water to drain.

Windrows can be constructed on both road edges and in the centre on the road for traffic delineation. These central windrows can be constructed from the finer crushed road surfacing material and can be used for road maintenance as well a traffic delineation. Windrows are not costed into project costs. Figure 18-7 shows a typical cross-section through the proposed road.

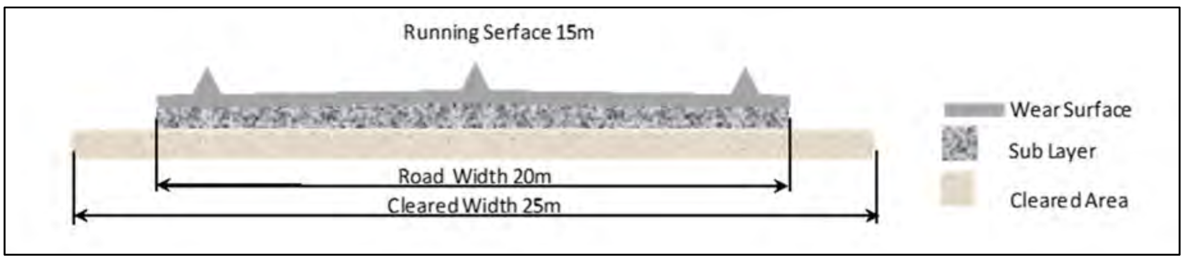


Figure 18-7: Typical road cross-section

18.2.2.3 Construction

This section covers the road construction, including surveying, clearing and grubbing, excavation, surfacing, and drainage.

Setting out

Setting out of the road would be via GPS. During the road construction a surveyor should be present for the entire duration to ensure correct cut to fills, to ensure road cross-falls are correct, and to provide correct measurement of quantities for payment. Should there be any survey issues the Avesoro surveyor could be used as a check.

Clearing and Piling

Clearing can be accomplished in a number of ways, including men with axes or power saws. Merchantable logs may be removed by skidder or tractor and the remainder piled by dozer for burning or decay. Felling rates and skidding rates for logging can be used for determining the cost of the removal of merchantable logs. On gentle terrain, if a wide zone is being cleared to permit sunlight to dry the road surface after frequent rains, the project might be estimated as a land clearing project.

The road route has a triple canopy forest with a canopy of 40 m above Natural Ground Level (NGL).

Due to the number of large trees which will need to cut up into smaller logs so they can be pushed to the sides. An additional cleared area is allowed for to make place for the trees and vegetation that are felled as well as areas for borrow pits. A cleared zone of 35 m is used to take account of these additional requirements.

Five hectares per km of cleared area in hardwoods are being cleared for a road (extra width is being used to help the road dry after rains). Of the 5 ha, 1.2 ha/km will need to have the stumps removed.

The area is very hilly and the tops of hills may need to be flattened in order to maintain decent road grades. Once the LiDAR is completed, the final route and cut/fill volumes will be determined.

There is a high probability that rock outcrops will have cultural significance and the road will need to be diverted around the outcrops based on experience. These will only be identified during the actual bush clearing.

Surfacing

The road will be surface with crushed rock sourced from the New Liberty mine dumps. The volume is assumed to be 20% of the sub-layer volume so 4,000 m^3 solid rock source per kilometre of road. A total of 123,371 m^3 of material will be used.

Drainage

The road will be built unsealed in tropical conditions. Extensive drainage including dips and water bars, culverts, and bridges are provided. Culverts will be required every 300 m.

Bridges

Bridges are based on Armco tunnel sections installed similar to the converts though of far larger diameter. A review of the route shows 15 bridges and one major bridge, with bridges requiring one additional culvert each and the major bridge five additional 2.5 m culverts. Road Costing Summary

Cost

Cost per linear kilometre of road has been estimated at $300,000. The cost estimate will need to be refined once a LiDAR survey is completed. Additionally, the road specification is for an unsealed gravel road and will require continuous maintenance. An amount of $500,000 per annum for ongoing road maintenance has been allowed. Note no geotechnical work for the road alignment has yet been done and the design and cost estimate are subjected to detailed work on the road including line survey, staking and geotechnical assessments for the route.

18.2.3 General Infrastructure

The layout and provision of surface infrastructure takes into consideration the labour complement and the proposed mining method and the size and type of equipment to be used. It is understood that it is a contractor’s camp and that no accommodation is to be provided.

The site area will be fenced off with a 1.8 m high, medium security fence with vehicle access via manned gates. The surface infrastructure is planned to be serviceable and fit for purpose, with most of the standard structures being prefabricated and based on typical structures that are provided by a specialised supplier of this type of building, called “Red Sea”, who operate out of Ghana. The structures are designed to provide facilities that are quickly erected and easy to remove at the end of the life of the mine.

The infrastructure and contractor camp that has been planned for the Ndablama operations will include a combined activity site approximately 6 km away from the pit and outside of a 500 m blast radius line, and a small control tower near the pit entrance. The selected area where the surface infrastructure is to be located, is deemed to be the most suitable although the general area is undulating, and typical cut and fill procedures will be required to create the terraced platform.

The selected area for locating the infrastructure and contractor's camp is shown on a plan view of the Ndablama operations, on a 1 m contour line topographical image, with the blast radius line in blue, in Figure 18-8.

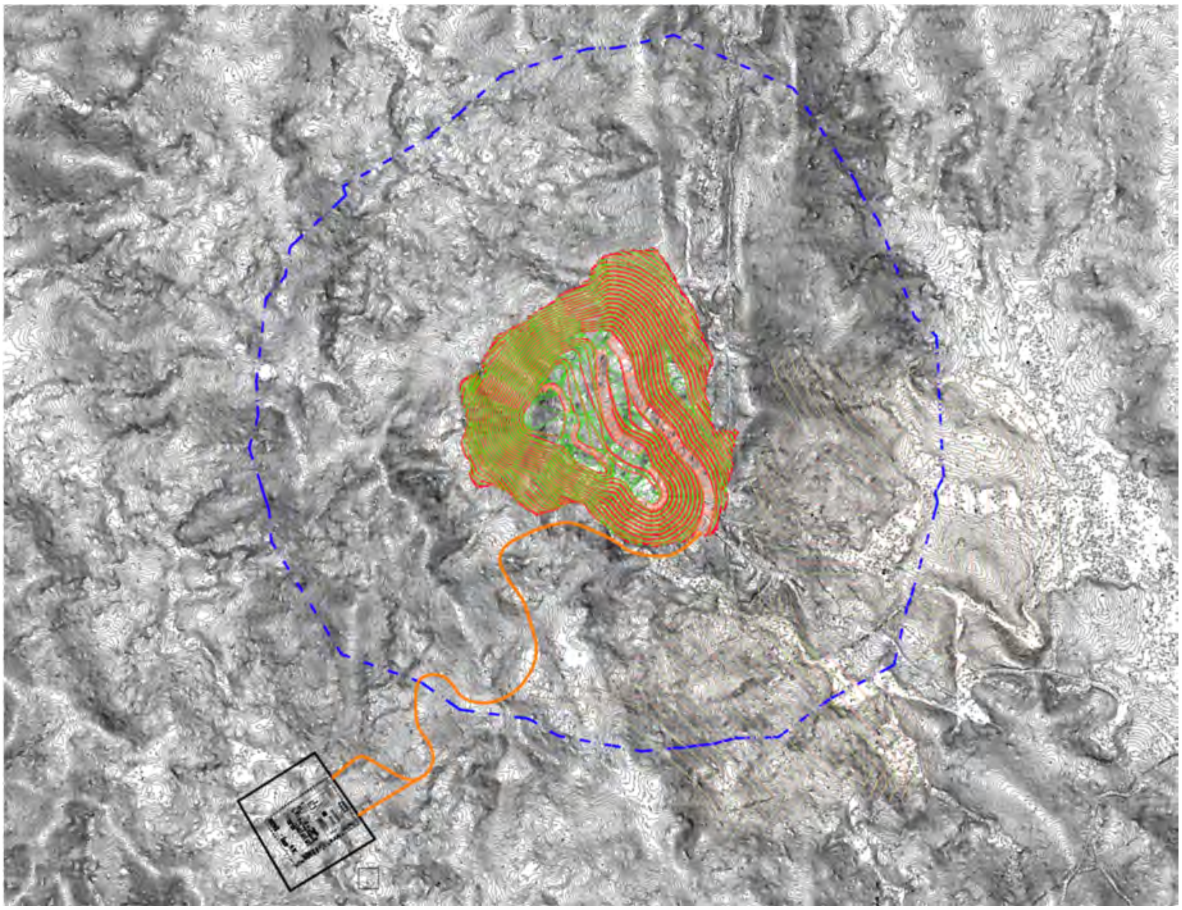


Figure 18-8: Plan view of Ndablama operations and the location of the associated infrastructure

18.2.4 Water

The water supply for the infrastructure and contractor's camp will be provided by borehole drilling in the area. This supply will include a take-off to feed a raw water storage tank which in turn will incorporate a feed to a purification plant where potable quality water will be produced. The potable water will be stored in a tank from where it will be reticulated to all buildings and facilities, including the changehouse, offices, and the workshops.

Storm water in general will be channelled away from the infrastructure site by means of diversion berms and drains, to avoid contamination. Run-off water from the stores and storage areas around the site, that cannot be redirected is classified as dirty water and will drain into a sump for collection. The sump will be connected to an oil separation system to remove the hydrocarbons and the clean water will be available for general site use.

18.2.5 Electricity

The Ndablama operation will be provided with power by a diesel generating plant consisting of two 500 kVA units, configured in a running/ standby arrangement. The generators will generate at 400 V and supply the site main distribution board which reticulates power to the specific load points. Figure 18-9 shows the SLD for the operation. Electrical power requirements for the contractor's camp and facilities will be provided by these facilities. The changehouse facility will be equipped with solar geyser installations to reduce the power requirement.

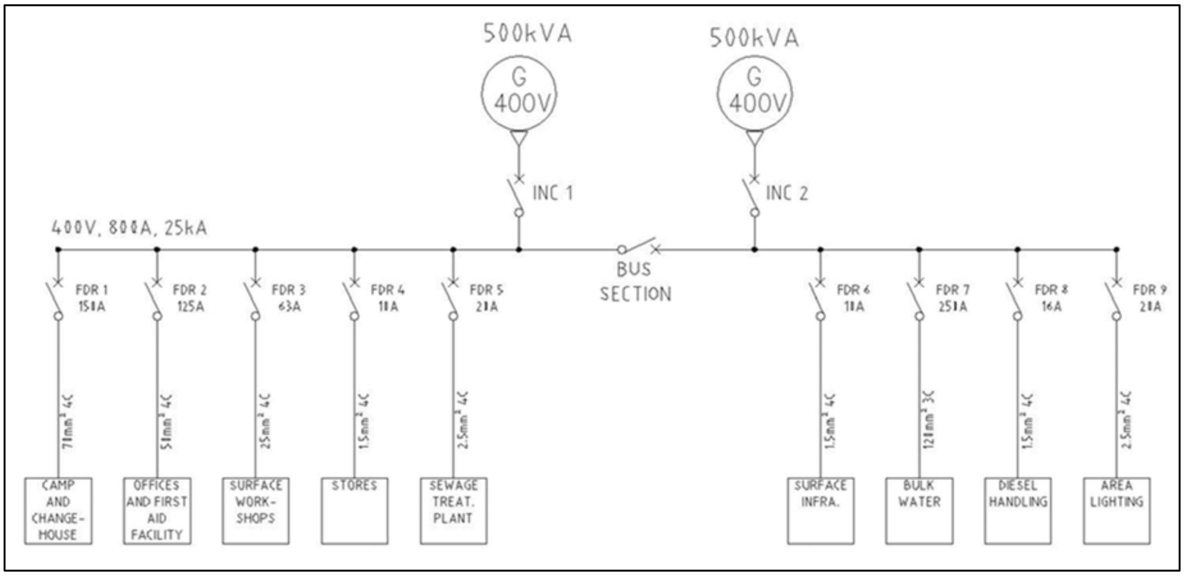


Figure 18-9: Ndablama SLD

18.2.6 Access

The contractor's camp area will be completely fenced off, with motor gates to control the access of personnel and vehicles entering and leaving the facilities. Two gate entry points have been provided along dedicated routes to separate heavy and light vehicle traffic. The haul roads are typically 9 m wide and service roads are planned to be 6 m wide.

18.2.7 Buildings

The buildings and structures that are described hereunder are shown in a general arrangement plan in Figure 18-10.

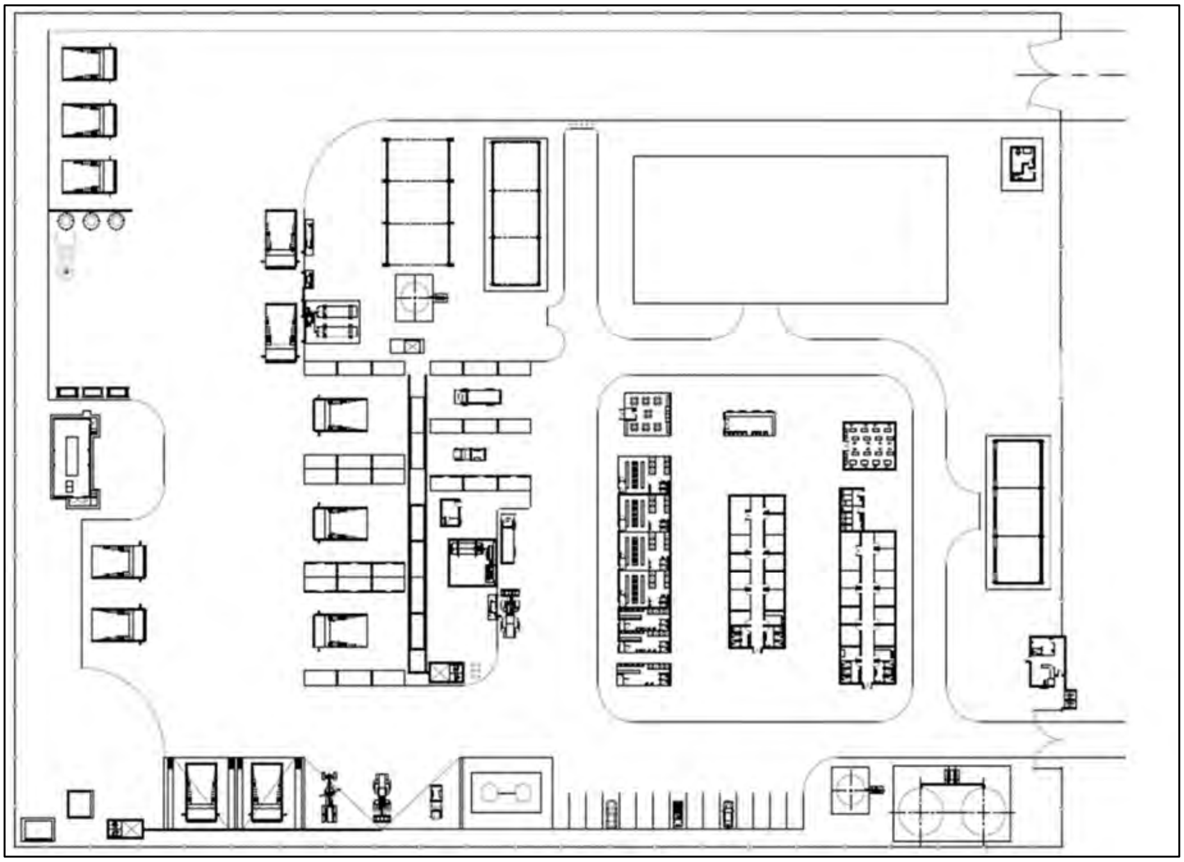


Figure 18-10: Planned infrastructure layout of the contractor's camp showing the various structures

18.2.7.1 Main Office Complex

The main office complex is located within the contractor's camp and includes offices for the following:

- General management and administration
- Computer and server room
- A first aid station
- Safety officers and clerical staff
- Supervisory personnel.

Each of the office units will be fully equipped with office furniture, air-conditioning and IT networking. Toilet facilities are within the changehouse building. Additional office space will be provided for engineering and maintenance personnel at within the workshop facilities and will be similarly equipped.

18.2.7.2 Changehouse and laundry room

A changehouse facility consisting of six units measuring 3 m x 12 m, has been provided for all staff requiring changing and ablution necessities. The units will be equipped with lockers, showers and toilets. Solar powered hot water systems have been allowed for, together with a hot water circulating system.

A set of two laundry units will be located nearby the change house to service the laundry and general cleaning requirements. The laundry will be equipped with benches, washing machines, tumble dryers and an area to store clean laundry. The waste water outflow from the change houses and laundry will report to a sump for collection and re-use as required. The discharge from toilets will be gravity fed to the sewage treatment plant.

18.2.7.3 Workshop and Maintenance Facilities

A workshop facility will be provided for the maintenance and servicing of all the different mining and general-purpose vehicle fleet requirements, including:

- Mechanical repairs and refurbishments
- Boilermaking and fitting
- Electrical repairs and Instrumentation
- Hydraulic component repairs and the manufacture and replacement of hydraulic hose assemblies.

The major fleet will be serviced in facilities designed around the use of 12 m containers, stacked and positioned to form three separate service and maintenance bays. Each bay will also be equipped with a steel truss and roof structure. The containers will serve as office space, specialised storage facilities and electrical workshop space.

A secondary workshop comprising three structures measuring 10 m x 12 m has also been provided for smaller vehicles and equipment, and to provide general engineering repair and maintenance services. The buildings will be steel frame structures with insulated sheeting. The facility is provided with general and specialised tools and maintenance equipment, including welding machinery and a metal working lathe.

The workshop facility is equipped with oils separator units, power, water and lighting. A separate vehicle wash bay has also been allowed for.

18.2.8 Stores Facilities

A central storage facility will be provided near the workshops, for receiving and handling both general mining spares and consumables and critical maintenance items. Two buildings have been allowed for, together with a set of offices for the store's administration requirements, including procurement and stores management. A small fenced off are has also been provided for high theft risk items. Provision has also been made for compressed gas bottle storage.

The following service vehicles have been provided to assist with the storage and mechanical handling of goods and spares in both the store facility and the workshops:

- A 25-t capacity all-terrain crane
- An 8-t capacity telehandler (also equipped for tyre handling)
- A 10-t capacity flat-bed truck with hydraulic crane.

18.2.9 Fuel Storage

Provision has been made for a fuel storage and dispensing facility near the workshop area. The facility comprises six of 23,000 L, containerised type fuel storage tanks and an integrated dispensing system to supply fuel for the primary mining equipment, secondary mine vehicles and all the support vehicles.

The fuel dispensing area will also be equipped with an oil handling and separation system to remove hydrocarbons from the runoff and wash water.

Provision has also been made for bunded areas to accommodate the storage and handling of new and used oil, alongside the fuel dispensing and storage facility. The oil handling and separation system associated with the oil handling requirements will tie into that of the fuel dispensing facility.

The fuel and oil storage areas will be provided with a concrete pad and a roof covering.

A dedicated fire protection system has also been allowed for.

18.2.10 Fire Protection

Provision has been made for a dedicated fire station and pump house for firefighting. Firewater will be drawn from the bulk potable water supply and reticulated using a nominal 80 mm diameter fire main. The fire protection system includes hydrants connected to the mains with hose reels and extinguishers in all surface buildings. A 5,000 L fire water bowser has also been provided for.

18.2.11 Waste and Sewage

The contractor's facilities and change houses will be serviced by two compact 400-man type sewage treatment plants that require little maintenance. Sewage will be treated by a moving bed bio-film reactor plant comprising two self-contained modularised units and a system of septic tanks. Grease traps and oil separators will be installed on the incoming lines to remove hydrocarbons from the sewage before it reaches the facility.

Sewage will be collected and transported via a buried PVC pipeline system, reticulated with manholes, junctions, rodding eyes and gullies, using the natural difference in the ground elevation, as far as possible. The treated discharge water would be used on site for dust allaying, road maintenance and if necessary, for make-up, process water.

Waste matter will be collected and deposited in a nearby excavation and covered to rehabilitate the disturbed ground.

Contaminated wash water will be collected via concrete launder and channelled into hydrocarbon recovery units. Grey water will be collected and used for road maintenance and dust allaying.

18.2.12 Transport

18.2.12.1 Surface Vehicles

No provision has been made for any additional vehicles other than those mentioned under Item 16.3.2 as it is understood that the entire vehicle fleet will be transferred from New Liberty to service the Ndablama activities.

18.3 Tailings

18.3.1 Introduction

In order to store the LOM tailings, the existing Tailings Management Facility (TMF) at the New Liberty Gold Mine will require expansion (note that in previous studies the acronyms TDF and TSF have also been used where D is for Disposal and S is for Storage. These are effectively considered interchangeable, with a preference toward Management being preferred by the author). Further to the recent trade-off study carried out by Golder Associates (Golder, 2018), a vertical expansion option using the centreline method of construction was selected.

The proposed LOM is forecast to produce 18 Mt tailings in 10 years from October 2018 at an average throughput of 1.8 Mt/a. Throughput to the existing facility as of the end of October 2018 was approximately 3.4 Mt, resulting in a total storage capacity requirement of 21.4 Mt within the TMF at closure.

Sections of the pre-feasibility report for the expansion of the TMF, carried out by Golder, are summarised in the text below; these sections should be read in conjunction with the full report and its appendices.

18.3.2 Site Conditions

Topography

The TMF is located in a broad and shallow natural valley that runs east to west. The basin outfalls to an area of relatively flat and heavily vegetated marshy ground that falls towards a tributary of the Marvoe Creek. The basin is flanked by gently sloping ground (at approximately 5%) forming a ridge to the south, with relief of approximately 13 m from the basin floor (c. 62 mRL) to the crest of the ridge at (c. 79 mRL). To the north of the TMF, the gentle slopes of the basin become steeper above 78 mRL (at approximately 7%) reaching a high ridge at approximately 95 mRL. Secondary forest covers most of the undeveloped areas of the site.

At the time of writing this report the Phase 2 construction of the TMF was partially complete to a crest elevation of 82.5 mRL with embankments being constructed around the perimeter of the facility crossing the western valley sides wrapping around the southern ridge and abutting high ground to the west (Figure 18-11). Tailings beaches have inundated the valley up to approximately 78 mRL in the western portion of the site, with the supernatant pond covering most of the middle and eastern portions of the basin area. Phase 2 construction to 82.5 mRL is scheduled to provide at total storage capacity of 9.35 Mt and should be completed by June 2019.

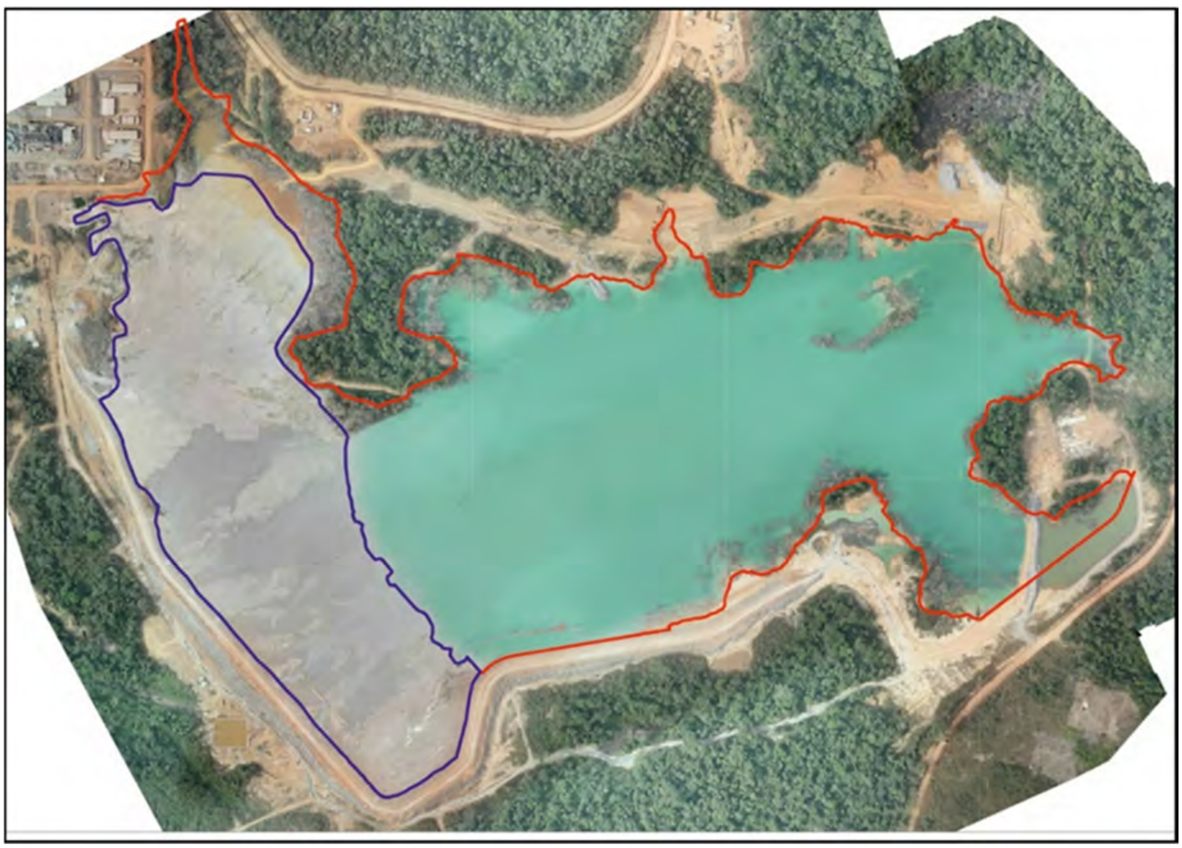


Figure 18-11: Site aerial photo, BMMC dated 18 February 2019

18.3.2.1 Ground Conditions

Local Geology

The geological setting of the area comprising and surrounding the TMF is described in numerous previous studies. The regional and local geology presented in the next two paragraphs respectively was initially summarised in Newfields Phase 2 design report (Newfields, 2017).

“The New Liberty Gold Mine is located in the geological region known as the Man Craton. The geology of the area is typical of other Greenstone belts in West Africa and comprises a mineralized zone in a sheared ultramafic talc schist, with a hanging wall comprised of granite [and] gneiss and a footwall of amphibolite.”

“The country rock at the TDF site is primarily comprised of the Leucocratic Gneiss. This formation is a quartz-biotite mineral assemblage with minor plagioclase and magnetite. The foliation and gneissic banding has an attitude of south 85°. Five narrow amphibolite bands traverse the TDF impoundment striking approximately 100–110°. Three of the bands truncate within the upstream area of the impoundment. One lenticular band of ultramafic rock is present between the gneiss and the northern amphibolite band near the headwaters of the TDF Impoundment. Occasional pegmatite dikes are present within the gneiss, consisting of quartz, plagioclase, muscovite and minor tourmaline. A dolerite dike that runs in a northwest-southeast trend (approximately 310°) extends across the TDF embankment area.”

Gneiss

Providing the basement for the superficial geology of the area, the gneiss is encountered at varying depths and degree of weathering across the TMF site. Mostly, the gneiss is ‘heavily’ to ‘freshly’ weathered with the less-weathered material observed at depth. The extent of weathering of the gneiss across the TMF is recorded to a maximum depth of around 24 m to the southeast. All available intrusive data in the borehole record that intersect the gneiss describe it as heavily fractured but quite competent in terms of strength. Towards the east to northeast of the TMF and lower-lying areas of the valley in the southwest, the weathered gneiss tends to crop closer to the surface at depths between 0.5 mbgl and 4 mbgl, where most of the overlying in-situ material has been eroded.

Residual Soil

Comprising the majority of the near-surface superficial geology of the basin slopes, the residual soil is described as a red-brown, greyish lateritic gravelly silts, sands and clays (with frequent roots), particularly in the north-east corner of the TMF. Towards the southwest of the TMF, the gravel content is higher and is generally well-rounded. Gravels are described as being angular to sub-rounded and heavily weathered (saprolite), deriving from the parent rock, gneiss. Thicker sequences of residual soils are observed at higher elevations, along the basin slopes where high-energy erosional process are minimal.

Laterite

Laterites are typically seen near-surface, either just below or forming part of the residual soil horizon across most of the TMF. Described as red or reddish-brown in colour and comprising varying quantities of clays, silts, sands and gravels, the lateritic sequence across the TMF is fairly heterogenous. Thicker laterite deposits are observed along the basin slopes at higher elevation.

Saprolite

Representing the lower-zone of the tropically weathered soil profiles, the saprolites represent the coarse-fraction of the in-situ weathering process of the parent rock. Saprolite rocks, as with the laterites, are observed across the TMF with varying quantities of red-brown and orangish-yellow clays, silts and sands but almost all contain large fractions of coarse angular to sub-angular, highly weathered/altered gravels and cobbles of varying strengths deriving from the bedrock. Unlike the finer residual soils and some of the in-situ laterites which are easily eroded, the saprolite layers are more prominent at the near-surface in the north and south-western areas of the TMF. Thicker saprolite sequences are observed in the borehole record, particularly in the southwest.

Saprock

Saprock, or transitional zone from saprolite to bedrock, was generally sandy with varying amounts of silt, clay and gravel. The thickness of the saprock varied from 0 to 3 m. The transition of saprolite-saprock was observed in BH16-04 and BH16-07.

Alluvial Deposits

Occupying the lower ephemeral channels of the basin, alluvial deposits are present, described as being very loose to loose and fibrous and consisting of dark to light grey-brown, gravelly, silty, clay with some fine to coarse grained sands. Generally, the alluvial deposits are seen in the trial pit and borehole record at ground elevations between 63 mRL and 64 mRL in the southwest, increasing to 69 mRL in the central and low-lying areas further northeast. Additional alluvial deposits are also recorded in the south. Proven thicknesses of alluvium vary between 0.2 m and 4 m, with thicker layers generally located in the centre of the low-lying channels. Due to the fine grained, unconsolidated nature of the alluvium, the material is described in the trial pit record as weak, with evidence of collapsing sides and cracking at the surface, particularly in the thicker alluvial sequences.

Climate

Newfields (2017) carried out a detailed review of the climatology of the site as part of the TMF Phase 2 design. A summary of the findings pertinent to the design of the TMF are provided below.

Based on a monthly rainfall data set obtained for a 58-year period of record, the average monthly climatic data was established and is presented in Table 18-11.

Table 18-11: Average monthly climatic data

Month	Dry year precipitation (mm)	Average year precipitation (mm)	Wet year precipitation (mm)	Average lake evaporation (mm)
January	0	22	17	100
February	20	40	61	89
March	52	81	144	107
April	146	147	136	97
May	272	246	373	84
June	288	423	597	73
July	361	559	642	66
August	298	621	1,081	65
September	544	603	689	65
October	103	366	610	76
November	153	152	205	82
December	11	47	165	95
Annual	**2,248**	**3,307**	**4,720**	**999**

Seismicity

Newfields carried out a detailed probabilistic seismic hazard assessment (PSHA) for the mine site as part of the TMF Phase 2 design (Newfields, 2017). A summary of the findings pertinent to the design of the TMF are provided below.

The TMF dam hazard classification has been assessed to be 'high' in accordance with the Canadian Dam Association regulations 2013 (CDA 2013). This assessment is based on the height, storage, downstream population at risk, as well as key habitats and species at risk and the potential economic consequences of failure.

Based on this classification the development of operational base earthquake and maximum credible earthquake loadings are computed on the basis of a 1,000-year return period for operational conditions and a 2,475-year return period for post closure conditions.

These return periods correlate to peak horizontal ground accelerations of 0.055 g and 0.11 g respectively.

18.3.3 Site Investigation and Laboratory Testing

Three phases of geotechnical site investigation have taken place at the site of the TMF to date, these are as follows:

- Epoch Phase 1 Detailed Design (Epoch, 2013)
- Newfields Phase 2 Detailed Design (Newfields, 2017)
- Golder Associates, Pre-feasibility Study for TMF Expansion (Golder, 2018).

All the intrusive investigation locations have been plotted on Drawing 18110766-1002-PFS-0005. The intrusive investigation logs and laboratory test results can be found in appendices to the relevant reports referenced.

Epoch, 2013

Geotechnical site investigations were undertaken by Knight Piésold (2013) for the entire mine site development and consisted of works in the area of the TMF, including:

- 22 mechanically excavated trial pits
- Four rotary cored boreholes.

Laboratory testwork on soil samples obtained from the TMF site were limited to:

- 28 Atterberg limits
- Five natural moisture contents
- 28 gradings
- Five bulk density tests
- 11 oedometer consolidation test
- Nine dispersion tests.

In addition to the above, a number of other tests were carried out on near surface lateritic soils obtained from the plant site situated a short distance from the northwest corner of the TMF including: eight proctor compaction tests, and five consolidated undrained triaxial tests.

Newfields, 2017

Geotechnical site investigations were undertaken by Newfields (2017) and consisted of:

- 11 mechanically excavated trial pits
- Seven rotary cored boreholes.

Laboratory testwork on obtained soil samples included:

- 21 Atterberg limits
- 61 natural moisture contents
- 28 gradings.

Golder Associates, 2018

Golder Associates carried out an additional 16 mechanically excavated trial pits across the site for the purpose of ground proofing in areas of the site where little or no investigation had been carried out to date.

No additional laboratory testing was carried out.

18.3.4 Characterisation of Ground Conditions

18.3.4.1 Embankment Foundations

Alluvium

Alluvium was excluded from ground models for Phase 1 and Phase 2 embankment stability analyses and removed as part of the construction the same approach will be taken for the proposed expansion of the TMF.

A seepage cut-off trench has been included in the design of the main starter wall in the Phase 1 design (Epoch, 2013), this combined with the likelihood of long-term consolidation of the alluvium beneath placed tailings (Knight Piesold, 2013) resulting in a significant reduction in the porosity of the alluvium, these materials have also been ignored in seepage modelling assessments.

As such, a detailed assessment of the parameters for alluvium has not been included.

Residual Soils – Laterites and Saprolites

Embankments are predominantly founded on residual lateritic/saprolitic soils. Available test data indicate that the soils are generally clays or silts with vary degrees of sand and gravel. The fine soils are indicated as being of intermediate plasticity (see Figure 18-12).

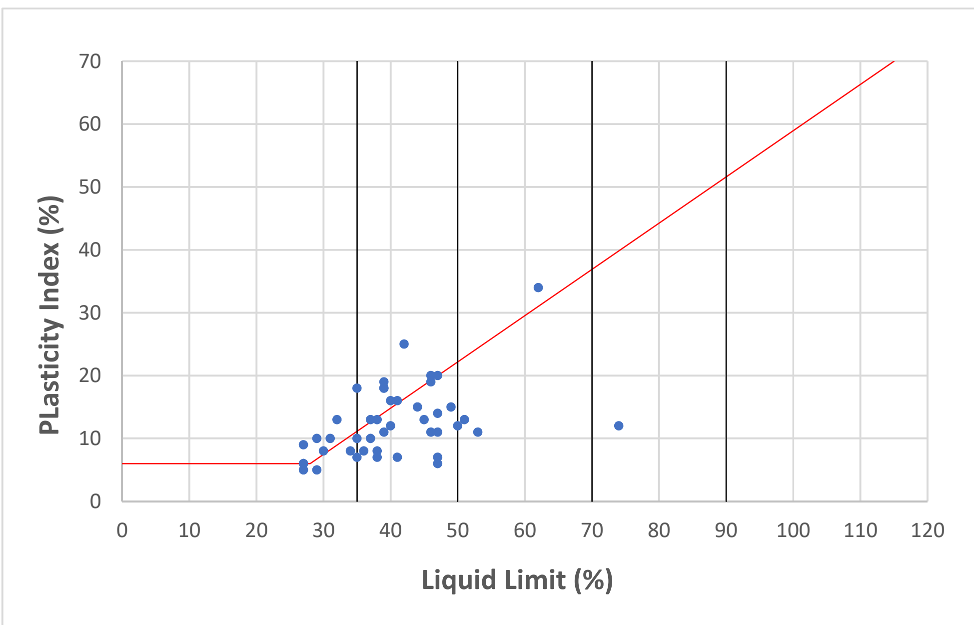


Figure 18-12: Plasticity data for residual soils in TMF area

SPT data from borehole logs show variable degrees and depths of weathering, with SPT N300¬ values ranging from as low as 2 up to 75, with occasional tests recording refusal. The data is presented in Figure 18-13.

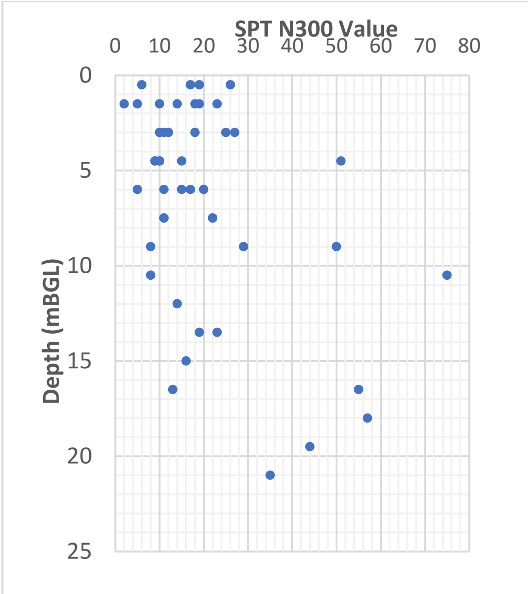


Figure 18-13: SPT data for residual soils in TMF area

Based on the available triaxial tests for lateritic soils taken from the plant site area, the material has been assigned parameters, internal angle of friction of 31º and effective cohesion (c') of 0 kPa.

These values are considered appropriate based on a literature review of engineering parameters for tropical residual soils formed from a parent rock type gneiss, including work reported by Wesley (2010). Due to the lack of available supporting laboratory test data, the selected parameters do not take in to consideration any in-situ structure or associated cohesion, often attributable to well confined undisturbed tropical residual soils.

Moderately Weathered Rock

Weathered bedrock or "Saprock" is described as freshly to heavily weathered Gneiss (Newfield, 2017). Based on engineering descriptions provided in borehole logs (handful of very high SPT values are available) the material has been assigned the following strength parameters, internal angle of friction of 32º and effective cohesion (c') of 0 kPa.

Fresh Rock

The gneiss is considered a high strength material and based on engineering descriptions provided in borehole logs, has been designated an impenetrable layer for the purposes of embankment stability analyses. The depth to bedrock has been modelled ranging between 4 mbgl and 21 mbgl in the main design sections.

18.3.4.2 Earthworks Borrow Materials

Residual Soils

Residual soils shall be won on site for use as low permeability fine fill material in embankments.

Proctor compaction tests carried out on samples of residual soils from the plant site indicate that the soils have a maximum dry density of 1.9 t/m^3 and an optimum moisture content of around 22%.

Given the range of natural moisture contents recorded (9% to 49%) it is likely that some moisture conditioning will be required.

Remoulded drained strength properties are taken from the triaxial test data giving an internal angle of friction of 31º and effective cohesion (c') of 0 kPa.

Undrained shear strengths of 150 kPa shall be assumed based on the lower bound for fully remoulded soils compacted close to the maximum dry density at their optimum moisture content of around 22%. In this condition a low Liquidity Index of less than 0 is generally achieved, this assessment is based on work by Wesley (2010).

Waste Rock

Waste rock from open pit operations will continue to be used in the development of the buttress of the embankments and the transition zone between low permeability fine fill materials. Waste rock will be selected to conform to strict grading requirements and will be hard, durable and inert.

The waste rock buttress will have a relatively large coarse fraction and a maximum particle size of 600 mm, and as such will have a high internal angle of friction to be taken as 40º based on experience of similar material types.

For the transition fill, materials will have a smaller maximum particle size of around 100 mm and shall be closer to a well graded gravel, and as such a slightly lower internal angle of friction of 38º will be assume, based on experience of similar material types.

18.3.4.3 Hydrogeological Site Characterisation

Hydrogeologic Units

The hydrogeology within the planned TMF area has been investigated as part of several geotechnical and hydrogeologic site investigations undertaken across the mine site, summarised in Section 20.6 of this report. These studies included test work on rock or soil of a similar geological nature, obtained from other parts of the site, but noted as being representative of the TMF area.

The results of groundwater studies undertaken to date are summarised in an Environmental and Social Impact Assessment (ESIA) prepared by Digby Wells Environmental (2013). The major conclusions from the studies are summarised as follows:

- The geology underlying the TMF consists of deformed and folded ultramafic rock that has been weathered at surface into thick water bearing units of saprolite and saprock overlying a foliated quartz-biotite gneiss bedrock.
- The geologic structure in the area influences groundwater flow and has affected the weathering pattern of the saprolite and saprock.
- The upper layer of saprolite has a low permeability and may act as a confining layer for the saprock.
- The saprock is considered to form a localised productive aquifer in some areas and varies in thickness and lateral extent across the site.
- The bottom of the saprock layer has the highest permeability at the contact between the saprock and fresh rock.
- The bedrock generally presents with lower permeability with fracture-controlled groundwater flow therefore localised zones of moderate permeability around isolated fracture networks are likely present.
- Based on falling head permeability tests in the TMF area conducted in boreholes in 2011–2012 hydraulic conductivities ranging from 1.9×10^{-7} m/s and 5×10^{-8} m/s were reported.
- Based on the results of permeability testing by Aquaterra in 2013 hydraulic conductivities ranging from 5×10^{-7} m/s to 7×10^{-6} m/s were reported in the TMF area. Hydraulic conductivities of 1×10^{-6} m/s were reported for the fractured aquifer in the ore zone and 5×10^{-6} m/s for the saprock.
- The depth to groundwater ranged between 0 mbgl and 16 mbgl, fluctuating seasonally, rising during the wet season and dropping during the dry season.

- Groundwater flow was reported as generally follow surface topography, contributing to shallow base flow in the natural drainages;
- One groundwater type is found in the area, dominated by bicarbonate (HCO_3) and calcium (Ca^{2+}). This is typical of recently recharged groundwater from rainwater as reported in Lloyd (1985). Groundwater recharge is primarily by rainfall percolation through the surface soils to the underlying bedrock.

Findings of the studies are broadly consistent with those of the geotechnical investigations.

Based on the results of the previous investigations it is considered that the following hydrogeological units may be identified based on their hydrogeological characteristics:

- **Alluvium**, predominantly comprising weathered saprolite with a hydraulic conductivity ranging from 5 x 10^{-8} m/s – 7 x 10^{-5} m/s based on test work across the site
- **Saprolite**, comprising completely weathered bedrock, considered to be low permeability, with a hydraulic conductivity ranging from 1.9 x 10^{-7} m/s – 5 x 10^{-8} m/s based on test work in the TMF area
- **Saprock**, comprising slightly weathered bedrock with a representative hydraulic conductivity of 5 x 10^{-6} m/s measured in the saprock and a range of 5 x 10^{-8} m/s to 7 x 10^{-5} m/s based on test work across the site
- **Gneiss**, comprising intact bedrock with a hydraulic conductivity ranging from 5 x 10^{-8} m/s – 7 x 10^{-5} m/s based on test work across the site (1 x 10^{-6} m/s measured in a fractured area).

It is noted that some of the previous hydrogeological and geotechnical studies considered the saprolite and saprock to comprise one hydrogeological unit. Based on the information available, it is considered that in the area of the TMF, they comprise two distinct hydrogeological units.

Groundwater Flow

As discussed above, groundwater is encountered at relatively shallow depths in the TMF valley ranging between 0 mbgl and 16 mbgl. It is considered likely that groundwater flow within the bedrock underlying the site is likely fracture controlled, therefore localised zones of moderate permeability around isolated fracture networks are likely present.

Newfields report that a potentiometric surface map compiled by RPS Aquaterra in 2014 based on groundwater levels measured prior to construction of the TMF illustrated groundwater flow was generally parallel to topography, with groundwater flow from the north, east and south converging in the valley beneath the TMF and then flowing to the west (Newfields, 2017).

Groundwater Users

Local groundwater abstraction includes wells at the Kinjor Village for domestic use (ibid).

Groundwater will also be pumped from the open pit dewatering system, located to the north of the TMF, to control groundwater within the pit in order to allow for mining operations.

18.3.4.4 Foundation Characteristics Summary

The geotechnical and hydrogeological parameters assigned to the foundation and construction materials in design are summarised in Table 18-12.

Table 18-12: Geotechnical parameters

Material	Unit weight (kN/m³)	Undrained shear strength S_u (kPa)	Mohr-Coulomb strength parameter		Hydraulic conductivity (m/sec)
			Static, long-term conditions		
			(deg)	c' (kPa)	
Embankment (Fine)	20	BBar 0.3 with frictional properties applied	31	0	4E-08

Embankment (Transition)	20	-	38	0	1E-04
Embankment (coarse)	20	-	40	0	1E-04
Residual Soil	20	BBar 0.3 with frictional properties applied	31	0	5E-06
Foundation Alluvium	20	BBar 0.3 with frictional properties applied	20	0	1E-08
Foundation Weathered Bedrock (Saprock)	20	BBar 0.3 with frictional properties applied	32	0	5E-06
Foundation Bedrock	21	Unlimited			1E-07

18.3.4.5 Ground Models

For the assessment of the stability of the slopes three ground models were formulated from available ground investigations in the surrounding area. The main focus was on section 1 (Table 18-13) where the embankment is at its highest, with section 2 (Table 18-14) representing thick weathered zones and section 3 (Table 18-15) where the embankment is water retaining.

Table 18-13: Section 1 Ground Model

Layer	Top depth (mbgl)	Layer thickness (m)
Alluvium*	0	4
Weathered Bedrock (Saprock)	4	3.5
Bedrock	7.5	To depth

* *The alluvium encountered within the dam footprint will be excavated and replaced with compacted fine fill. Excavation will be conducted to laterally 1 m past the toe of the embankment with a 1H in 1V slope.*

** *Exploratory holes used: TP2, TP3, TP6, TP7, TP10, TP11, RC2 and RC3 (ibid).*

Table 18-14: Section2 Ground Model

Layer	Top depth (mbgl)	Layer thickness (m)
Residual Soil	0	18
Weathered Bedrock (Saprock)	18	3
Bedrock	21	To depth

**Exploratory holes used: BH16-03, BH16-07 and TP16-06.*

Table 18-15: Section 3 Ground Model

Layer	Top depth (mbgl)	Layer thickness (m)
Weathered Bedrock (Saprock)	0	4
Bedrock	4	To depth

**Exploratory holes used: BH16-01, BH16-02, TP16-08, TP16-09 and TP16-10.*

18.3.4.6 Recommendations

Geotechnical

There has currently been no laboratory strength testing for the foundation soils obtained from within the TMF area and geotechnical characteristics have been inferred from indicator tests and a small number of triaxial test carried out on remoulded soils from the plant site area. It is recommended that additional investigations and laboratory testing be carried out in the TMF area to better characterise the foundation conditions of the TMF as part of the detailed design of the facilities expansion.

Hydrogeological

It is recommended that additional site-specific data is collected for the following items which will be used to better characterise the potential for seepage from the TMF and to update the seepage impact assessment, water balance modelling and groundwater monitoring regime as necessary:

- Hydraulic conductivity of in-situ geology
- Porosity of in-situ geology.

18.3.5 Tailings Characterisation

18.3.5.1 Geotechnical

Tailings testwork was carried out by Golder (2013) as part of the TMF Phase 1 design.

Testwork included classification of index properties, asbestos identification, column settlement testing, shear strength testing and consolidation testing. The results are summarised in Table 18-16 below.

Table 18-16: Tailings geotechnical characteristics

Tests	Parameter	Value
Index properties	Specific gravity	3.01 t/m^3
	USCS	ML
	P80	80 μm
	Liquid limit	25%
	Plastic limit	24%
Settlement column test	No drainage – dry density	1.13 t/m^3
	Top drainage – dry density	1.13 t/m^3
	Bottom drainage – dry density	1.26 t/m^3
	Top and bottom drainage – dry density	1.25 t/m^3
Slurry consolidation	Coefficient of consolidation	0.09 - 4.95
	Dry density	1.10 – 1.48 t/m^3
	Hydraulic conductivity	9.7x10^{-8} – 2.6x10^{-8} m/s
Triaxial test	Internal angle of friction	33°
	Peak undrained strength ratio	0.5

Peak Strength

The peak values for the drained and undrained strength of tailings taken from the single triaxial test are considered to be too optimistic due to the samples being remoulded to initial densities greater than the design settled density predicted in column settlement tests.

Therefore, reduced values have been used in design as follows:

- ϕ' = 30°
- τ/σ'_p = 0.2

Liquefaction Resistance

The single triaxial test carried out appears to indicate that the tailings are likely to be contractant under shear loading at remoulded initial dry densities in excess of the design settled dry density of 1.25 t/m^3. It is therefore assumed, for the purposes of the prefeasibility design, that saturated in-store settled tailings may be susceptible to cyclical load induced liquefaction and static liquefaction.

Residual Strength

A review of available literature indicates that a liquefied undrained strength (τ/σ'_r) of 0.05 for gold tailings would be a reasonable estimate.

Recommendations

Additional testing to validate these findings should be carried out. Furthermore, testing to ascertain the seismic loading required to liquefy the tailings and likely liquefied strength parameters should be carried out to verify those used in design. Testing on both current tailings streams and proposed tailings should be carried out, although based on anecdotal information provided by BMMC, it is understood that the mineralogy and grind are unlikely to be significantly different such as to produce greatly differing characteristics.

18.3.5.2 Geochemical

Pre-Operational Geochemical Characterisation

Static geochemical testing of tailings from the New Liberty Gold Mine was completed by Golder as part of the initial ESIA in 2012. This testing is summarised in the 2013 ESIA prepared by Digby Wells Environmental (2013). In addition, further static testing was also carried out by Digby Wells for the 2013 ESIA. The geochemical testing reports from Digby Wells have not been provided to Golder for review and this assessment is based on summary information provided in the ESIA reports referenced.

Static testing is used to identify potential for acid generation and metal leaching that will be encountered during mining. It provides a high-level assessment of the key factors relating to environmental behaviour that could influence site water quality. From the tests carried out to support the ESIA, Golder and Digby Wells identified that the tailings were classified as non-acid generating and arsenic and Cyanide were identified as the primary contaminants of potential concern. From leach tests of tailings samples carried out by Digby Wells (leaching method not specified), arsenic levels from leach tests exceed the IFC discharge standard of 0.1 mg/L. Furthermore, mercury, nickel, lead and cobalt were elevated in some samples. Kinetic testing was conducted on the tailings samples to assess longer term drainage water quality and reaction rates. The report by DRA shows that after an initial spike, the arsenic levels in solution fall to low levels after a period of about five weeks.

Operational Geochemistry

Following the commencement of the mine's operations in 2015, monitoring programs and engineering studies have advanced the understanding of the geochemical behaviour of the tailings beyond the static characterisation work carried out as part of the ESIA, this includes work done by DRA. The TMF Design report by Newfield (2017) notes that operational issues have occurred since the mine commenced operations in 2015, resulting in processing changes being made to improve gold recoveries. This resulted in higher levels of cyanide being used for a period for processing and subsequently higher levels of weak associable dissolved cyanide were reported downstream of the TMF after discharge.

A more detailed routine environmental monitoring program commenced for the mine in 2016. The monitoring of the operating mine has identified a number of constituents of potential concern that were not identified in the high-level geochemical characterisation program carried out. In addition to arsenic and cyanide identified in preliminary testwork, the environmental monitoring has historically observed occasions of elevated concentrations of iron and nickel in surface water discharge and groundwater seepage, as well as some exceedances of copper at surface water compliance point CMP2 downgradient of the TMF. The source of the elevated copper at this compliance point was not determined. In summary, arsenic, iron, nickel, cyanide and possibly copper have occasionally been above IFC standards in surface water discharge and boreholes monitoring seepage from the TMF analysed in 2016.

Risks and Recommendations

It is understood from the 2017 Final Design Report for the TMF Expansion that further metallurgical processing changes are being evaluated by BMMC. Amongst other solutions, these include the evaluation of a three-stage counter current decantation (CCD) circuit to remove arsenic, which would then be removed by resin or reverse osmosis. Further static and kinetic testing is recommended on representative tailings samples generated by the updated processing circuit to assess geochemical changes that may inform environmental behaviour and provide an assessment of the long-term leachate conditions. The longer-term kinetic testing data from DRA on representative tailings material shows that after an early spike the arsenic levels going into solution drop to low levels after about five weeks. This should inform the groundwater impact analysis and transport modelling (see Section 20.6).

It is noted that waste rock from open pit operations is used for construction purposes, including buttressing of embankments and in the transition zone between low permeability fine fill materials. Whilst the waste rock has been assessed as non-acid generating from static testing, the geochemical behaviour of the waste rock for use as construction materials has not been assessed and metal leaching can occur under neutral pH. However, since the sulphide sulphur of the waste rock was less than the 0.3% benchmark required for acid generation (Digby Wells, 2013), the waste rock is unlikely to be acid generating and it was deemed not necessary to undertake kinetic samples.

18.3.6 Design Criteria

The complete design criteria are summarised in Table 18-17 to Table 18-23 and Figure 18-14 below.

Table 18-17: General criteria

Design Criteria	Value	Source/Comment
General		
Dam classification	High Risk	Canadian Dam Association (CDA) Regulations 2007, 2013 and 2014.

Table 18-18: Production rates

Design criteria	Value	Source/Comment
Production rates		
LOM	Oct 2018 to Oct 2028	Client
Annual tailings production rate	1.8 Mt/a	
LOM tailings production	18 Mt/a	Assumed as reasonable estimate for the purpose of this study and will be used to compare options
Current tailings deposited to Oct 2018	3.4 Mt	Client

Table 18-19: Tailings characteristics

Design criteria		Value	Source/Comment
Tailings characteristics			
Current disposal method		Thickened slurry tailings	
Average slurry solids concentration % by weight		45%	From Operations
Specific gravity		3.0	Newfields' Phase 2 Design report
Tailings average in-store dry density		1.25 t/m³	Newfields' Phase 2 Design report
Tailings beach slope	Sub-aerial	0.5%	Newfields' Phase 2 Design report

Table 18-20: Water management criteria

Design criteria		Value	Source/Comment
Water management			
Storm event	No spill	1:100-year 24-hour flood event during wet year	(Canadian Dam Association, 2014)
	Safe conveyance (inflow design flood)	1/3 between 1:1,000-year 24-hour and Probable Maximum Flood (PMF) during wet year event	(Canadian Dam Association, 2014)
Annual rainfall rates	Extremely dry year	2,248 mm	Newfields' Phase 2 Design Report
	Average year	3,307 mm	
	Extremely wet year	4,720 mm	

Stormwater runoff management	IDF	1:100-year 24-hour flood event	Newfields' Phase 2 Design Report
Rainfall	1:100-year 24-hour event	368 mm	Newfields' Phase 2 Design Report
	1:1,000-year 24-hour event	549 mm	Newfields' Phase 2 Design Report
	1:10,000-year 24-hour event Probable Maximum Precipitation (PMP)	782 mm	Newfields' Phase 2 Design Report
Total freeboard (crest to maximum operating water level (MOWL))		3.5 m	Newfields' Phase 2 Design Report to satisfy No Spill IDF
Spillway depth (at embankment crest)		1.5 m*	Newfields' Phase 2 Design Report to satisfy safe conveyance IDF + 1 m wave height
Total beach freeboard (crest to max beach level)		2.1 m	Newfields' Phase 2 Design Report

* *The spillway depth has increased since the initial Design Criteria established by Golder (2018). Following storm water capacity assessments, a deeper and narrower spillway was determined to be a more pragmatic solution. The 1.5 m allows for a safe conveyance of the 1/3rd way between a 1:1,000-year and PMF flood event with a 1 m freeboard to spillway crest as outlined in USBR (2012).*

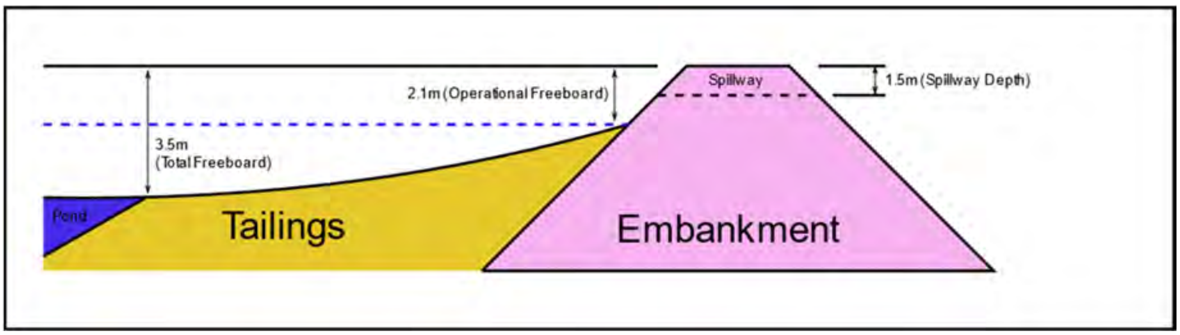


Figure 18-14: Freeboard requirements

Table 18-21: Embankment geometry

Design criteria		Value	Source/Comment
Embankment geometry			
Minimum embankment crest width		9 m	Newfields' Phase 2 Design Report/BMMC operation/construction requirements
Centerline construction	Maximum slope angles	2.5H in 1V	Newfields' Phase 2 Design Report
	Maximum raise height	3 m	
	Maximum rate of rise	2.5 m/year	Golder assessment from tailings consolidation test data

Table 18-22: Stability analysis

Loading condition	Required factor of safety	Source
Static, end of construction before reservoir filing	≥ 1.3	(Canadian Dam Association, 2014)
Static, long-term (steady-state seepage, normal reservoir level)	≥ 1.5	
Rapid drawdown	≥ 1.3	
Liquified tailings (post-seismic)	≥ 1.2	
Pseudo-static (OBE)	≥ 1.0	
Pseudo-static (MDE)	≥ 1.0	

Table 18-23: Seismic criteria

Description	Value	Comment
Dam classification	High	(Newfields, 2017)

Operational Basis Earthquake (OBE)	1,000-year recurrence interval	
	Peak horizontal ground acceleration 0.055g	
Maximum Design Event (MDE)	2,475-year recurrence interval	(Canadian Dam Association, 2014)
	Peak horizontal ground acceleration 0.11g	(Newfields, 2017)

18.3.7 Water Management

18.3.7.1 Non-Contact Water

Non-contact water primarily falls away from the TMF in the western and southern areas, however areas to the north and northwest fall towards the TMF.

As part of the Phase 2 design Newfields developed a water impoundment area to collect run-off from a 74 ha catchment to the northwest of the TMF. An embankment was constructed to 81 mRL to maintain separation between contact and non-contact water. A northern catchment area of 16 ha is conveyed, by a diversion drain, to the water impoundment area. Non-contact water is then diverted under the TMF via a penstock pipeline to the downstream toe of the TMF valley where it is attenuated, monitored, treated as necessary within a sump pond and released to the natural marsh environment via a series of charcoal filled gabion baskets. The marsh provides further attenuation prior to effluent entering the receiving environment downstream.

The proposed expansion of the TMF eventually results in the northern catchment diversion drain being inundated and as such the catchment reports to the TMF, albeit for a significantly reduced area of only 9 ha.

18.3.7.2 Contact Water

A detailed TMF water balance was developed by Newfields as part of the Phase 2 design. The pertinent conclusions of that exercise were that excess flows reporting the TMF would require discharging via the penstock system to be combined with flows from the water impoundment area for dilution and release to the environment.

For the purpose of this study the increase in throughput has been calculated to result in an estimated 67,700 m^3 additional process water being retained on the facility annually. Further to this, because of the removal of the diversion channel in latter phase of development, the accumulation of additional runoff from the northern catchment area (approximately 9 Ha) would result in a further 120,000 m^3 in an average climatic year and 170,000 m^3 in an extreme wet climatic year reporting to the supernatant pond in a given year.

In order to mitigate against operations exceeding the maximum operating pond volume, water will be released to the environment via the penstock system during the wettest months of the year while there is adequate clean water from the water impoundment area to dilute the flows (April through September). A high-level review of the Phase 2 water balance has been carried out to inform estimates of the increased excess flows to be released from the TMF on an annual basis. The changes in excess flows are summarised in Table 18-24.

Table 18-24: Estimated changes in excess flows discharged from TMF Penstock 5

Climatic conditions	Parameter	From water impoundment	Excess from TMF		Dilution factor	
			Phase 2 design	PFS design	Phase 2 design	PFS design
Extreme dry	Total flow per year	0.86 Mm^3	1.01 Mm^3	1.16 Mm^3	1.85	1.74
	Maximum discharge rate	0.11 m^3/sec	0.13 m^3/sec	0.15 m^3/sec		
Average	Total flow per year	0.93 Mm^3	1.16 Mm^3	1.51 Mm^3	1.80	1.62
	Maximum discharge rate	0.12 m^3/sec	0.15 m^3/sec	0.19 m^3/sec		

Extreme wet	Total flow per year Maximum Discharge rate	1.71 Mm³ 0.22 m³/sec	1.94 Mm³ 0.25 m³/sec	2.23 Mm³ 0.27 m³/sec	1.88	1.77

In order to provide a more accurate update of the likely excess flows, it is recommended that the full TMF water balance be updated with the revised model parameters.

Records of effluent monitoring at the sump pond for the period April through June 2018, provided by BMMC and presented in the independent auditor's report conducted by Golder (2018), indicate that effluent has been meeting the required discharge limits on total cyanide, WAD cyanide and free cyanide set by the permitting authorities. Furthermore, it has met the additional limits on dissolved arsenic set by the IFC, although not legally binding, other than on three reported occasions. Additional data provided by BMMC for the period February through November 2018 (excluding free cyanide) indicates the same general compliance under current operational conditions. It is noted that water from the natural environment often exceeds the dissolved arsenic limits due to the naturally occurring base levels of arsenic in soils. It is also noted that monitoring data was provided for samples collected prior to entering the marsh land, and as such had not benefitted from additional attenuation and dilution.

Rainfall records from site taken between 2011 and 2018 indicate that in general average climatic conditions have been observed, with the exceptions of a dryer than average year being recorded in 2014 and a slightly higher than average year recorded in 2013 and 2015, see Figure 18-15.

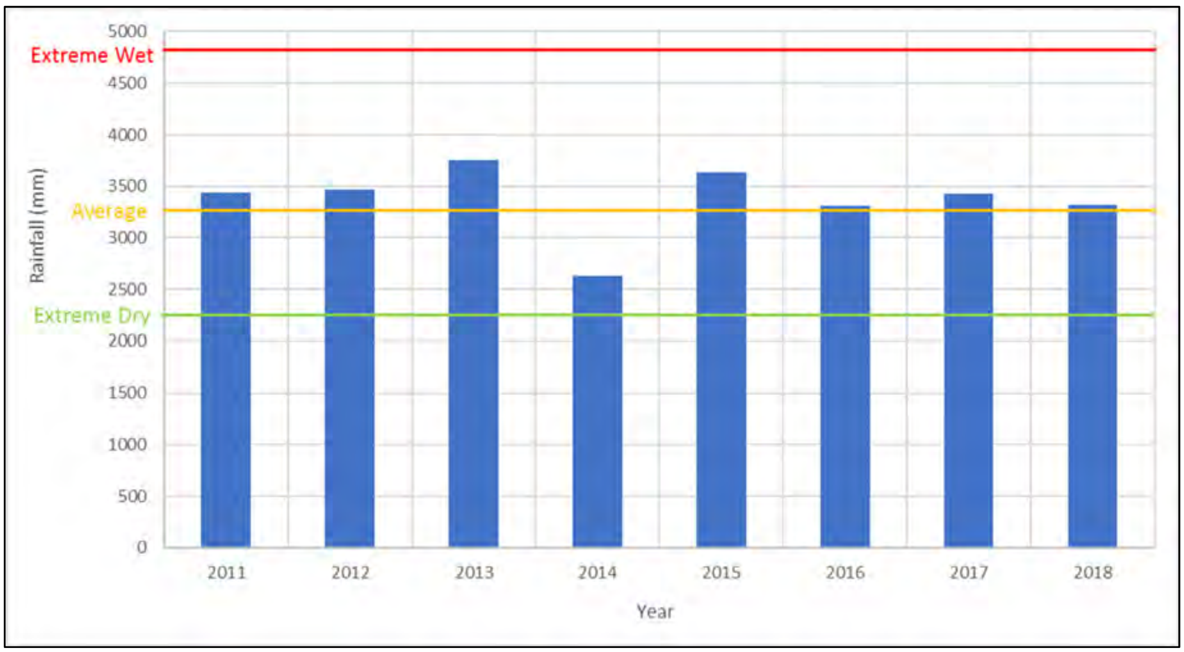


Figure 18-15: Site rainfall records

Release of water has been carried out via the penstock system which enables the effluent to be diluted by non-contact water during the wet season during April through September. Although current operational conditions indicate compliance with effluent discharge requirements set out in the operational permit, there is need for additional analyses to assess the likely impact on concentrations from the proposed levels of excess water release.

The rate at which contact water has been released from the TMF has not been recorded and as such there is no way to accurately assess what level of dilution has been occurring. However, cyanide levels recorded in the dilution pond prior to release to the marsh areas below have been consistently very low. Current WAD cyanide levels in the TMF have been recorded by BMMC at around 0.74 mg/L and the discharge limit is 0.5 mg/L, therefore it can be estimated that a dilution factor of 1.48 would be sufficient to achieve the target levels. Further to this, natural breakdown of the cyanide will occur in the marsh areas prior to entering the downstream environment to the west.

Studies will be concluded in 2019 by BMMC, to establish suitable and cost-effective technologies to remove arsenic from the supernatant water before releasing it into the Penstock and downstream wetland. This should enable water to be pumped off the dam at a higher rate and also during drier months when there is little to no fresh water available for dilution.

18.3.7.3 Emergency Spillway

Water Impoundment Area

The Phase 2 design developed by Newfields (2017) has an embankment constructed to 81 mRL to maintain separation between contact and non-contact water. The water impoundment is designed to be permanently drained, however in the situation of a probably maximum precipitation storm event the embankment would be overtopped, as a result an emergency spillway was designed and constructed to safely convey the stormwater on to the TMF and out of the TMF via the TMF emergency spillway.

For the expansion of the TMF, the water impoundment embankment will be raised initially to 86 mRL and then above this in latter stages to retain the tailings and supernatant pond within the TMF. The result of this increase in height on the water impoundment is that the design storm event no longer over tops the embankment and the spillway can be removed.

In order to mitigate against the risk of damage to the Penstock system and the potential resultant build-up of non-contact water within the water impoundment area during operations, submersible pumps will be employed to divert water around the TMF via a pipeline outfalling to the valley south of the TMF.

In the event of damage or blockage of the Penstock system in the long-term closure condition, safe conveyance of water from the area will be via a spillway constructed through the natural ground as part of the closure plan.

TMF

Operational spillways will be constructed through natural terrain to the eastern most end of the TMF out falling to the valley south of the TMF. These will be constructed through natural ground at the appropriate invert elevation for each phase of construction, moving up the hillside, with the previous spillway decommissioned as appropriate.

The closure spillway will be constructed as part of the closure plan through natural ground in the hillside just above the final operational stage spillway.

The spillway design is currently conceptual and will require further consideration through the detailed design phases.

18.3.7.4 Internal Drainage and Secondary Seepage Confinement

The starter wall formed for the southern embankment in the Phase 2 construction has an internal drainage system including an upstream toe drain and an internal column drain that drawdown the phreatic surface within the tailings and embankment. These are connected to downstream sumps which are pumped back to the surface of the facility. This drainage system will be maintained as part of the planned development of the facility.

Secondary seepage confinement drainage includes seepage cut off drains installed along the toe of the Phase 1 starter wall and the Phase 2 construction of the southern embankment. This drainage system will be maintained and extended as part of the planned development of the facility.

18.3.7.5 Tailings Deposition Strategy

Tailings will be discharged via spigots placed along the upstream crest of the Plant, South and East Embankments (Figure 18-16). By depositing from these embankments, the pond will be maintained along the northern perimeter of the facility against the natural ground. Spigots will be placed evenly along the embankment crest at approximately 25 m centres. Rotational discharge will be carried out with the development of even beaches in 0.3 m thick tailings layers in order to optimise consolidation and beach strength. Each rotation of the facility will take approximately 1.5 months.

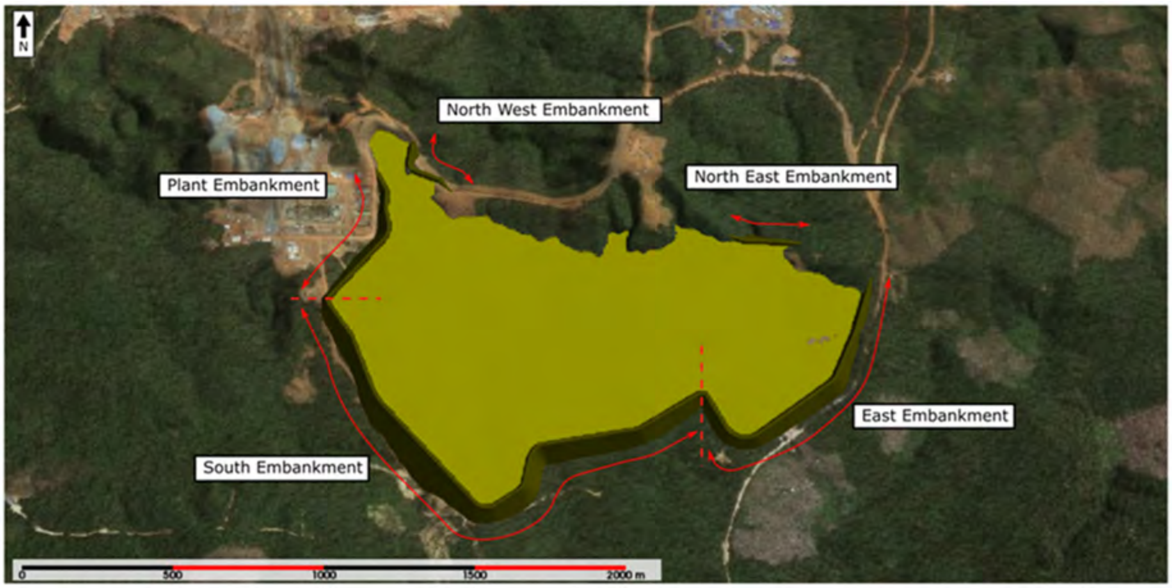


Figure 18-16:TMF embankment layout

18.3.8 Embankment Design

The embankments forming the facility up to Phase 2 at elevation 82.5 mRL are formed using the downstream method of construction. The initial Phase 1 starter wall of the southern embankment was formed as a low permeability embankment with an internal chimney drain. Phase 2 embankments were formed using a zoned earth approach with a low permeability upstream face consisting of a geomembrane, geosynthetic clay liner, clay and filter transition zone buttressed by waste rock.

The proposed expansion of the facility is based on further centreline raises using a similar zoned earth technique. The embankments will have a low permeability upstream shoulder formed from a combination of HDPE and Geosynthetic Clay Liner (GCL) sitting on a 300 mm thick layer of low permeability clay soil. A 2 m thick filter compatible transition zone will be placed between the clay and the waste rock buttress to prevent the propagation of piping erosion.

The rock buttress will sit on a 1 m thick layer of filter compatible transition material to prevent contact erosion between the rock and the natural ground.

The centreline embankments will be raised in stages, typically by 3–4 m.

18.3.9 Construction Schedule

Further to the construction of Phase 2 designed by Newfields (2017), the TMF will be constructed in phases to provide capacity to store the LOM tailings throughput. The construction phases have been developed to align with embankment designs satisfying the required factors of safety against instability and to satisfy throughput storage demands while meeting the available construction periods limited to six months per year, dictated by the annual dry season (nominally October through March).

The construction phasing is provided in Table 18-25 below and provides approximate total volumes of earthworks required to complete the construction of the associated embankments.

18.3.10 Closure Plan

Closure planning is an integral part of the general mine planning process. Closure of the TMF will involve several activities both during operations and after cessation of mining. Closure objectives outlined here will be reviewed and improved as the project progresses and more data is obtained, and the design is defined.

The closure plan requirements in the ESIA report (Golder, 2012) are outlined in the closure goals section as follows “The overall closure goal for NLGM is to progressively reinstate native forest areas that are safe, stable and non-polluting, mimicking the current land use, and taking into account the unavoidable remaining mining residue and/or disturbances towards leaving behind a positive post-mining legacy”

Some of the closure objectives at the conceptual stage will be to:

- Comply with legal requirements and the mine’s commitments to the community
- Minimise pollution to groundwater and to the atmosphere
- Establish a sustainable ecosystem similar to the natural surroundings
- Ensure the TMF is stable and safe
- Rehabilitate the TMF to be of beneficial use to the communities.

The main elements of the closure plan proposed for the TMF include:

Profiling of the tailings beach towards closure in the latter stages of development using a pre-defined deposition plan to be developed at detailed design:

- Capping the majority of the facility with a land form promoting run-off towards the closure spillway
- Capping will be designed and trialled to minimise infiltration and promote establishment of natural flora and fauna
- Capping and revegetation plans will be designed in areas close to the embankment such that damage to liner systems will be prevented
- Reduction in the size of any long-term water storage on the facility to minimise infiltration and seepage
- Permanent closure spillway will be designed to safely convey surface runoff from the facility due to design storm events.

Table 18-25: TMF phased construction schedule

Phase	Year	Plant		South		East		North East		North West	
		Earthwork volume (m^3)	Elevation (mRL)	Earthwork volume (m^3)	Elevation (mRL)	Earthwork volume (m^3)	Elevation (mRL)	Earthwork volume (m^3)	Elevation (mRL)	Earthwork volume (m^3)	Elevation (mRL)
Phase 3a	2020		82.5		82.5		82.5	24,000	86	-	-
Phase 3b	2021	58,000	85.5	258,000	85.5	81,000	85.5		86	-	-
Phase 4a	2023	63,000	88.5	309,000	88.5		85.5		86	25, 508	92.5
Phase 4b	2024		88.5		88.5	104,099	88.5	36,000	89		92.5
Phase 5	2026	68,000	90.5	377,000	90.5	132,000	90.5	58,000	92		92.5
Phase 6	2027	17,000	92.5	61,000	92.5	31,000	92.5		92		92.5
Closure	2029–2030	Closure capping									

18.3.11 Environment

18.3.11.1 Hydrogeochemical Studies

Contaminants of potential concern (COPCs) in surface water discharge and groundwater seepage from the TMF have previously been identified by Newfields (2017), from characterisation studies, monitoring programs and engineering studies; to be arsenic, cyanide (CN), iron and nickel. The studies indicate the tailings to be non-acid generating.

Hydrogeochemical Modelling – Impact assessment

The results of groundwater flow and contaminant transport modelling undertaken by RPS Aquaterra in 2013 to assess the impact of the Phase 1 TMF are reported by Newfields. The study comprised the development of a three-dimensional numerical groundwater flow model using MODFLOW-SURFACT, for the primary purpose of evaluating pit inflows and the impact of pit dewatering on groundwater which was used to develop a groundwater transport model to evaluate potential impacts from arsenic and cyanide in the Phase 1 TMF on groundwater and surface water quality in the area. The assessment is reported to have assumed 362 m^3/day seepage from the TMF with a declining source term for arsenic, falling from 2 mg/l during mining to 0.2 mg/l a year after closure, and cyanide concentrations ranging from 10 mg/l to 20 mg/l.

The results of the modelling results presented by Newfields are summarised here. The groundwater model calculated that the drawdown cone from dewatering of the open pit would draw some groundwater from beneath the northern portion of the TMF toward the plant site. The groundwater transport simulations calculated the following in relation to arsenic and Cyanide seepage.

- Arsenic
  - A contaminant plume with elevated arsenic concentrations would expand as the Phase 1 TMF expands, with the plume extending both west, north and south due to the raised piezometric level in the TMF. The northern plume was limited by dilution with background groundwater recharge and the southern plume discharging to surface water courses, with elevated arsenic concentrations following closure.
  - The WHO drinking water guideline for arsenic would be exceeded at the decommissioned plant site abstraction well within five years of operation, however groundwater quality in the open pit, and Kinjor village would not be impacted by seepage from the TMF.
  - Shallow groundwater downgradient (west) of the TMF dam would develop elevated arsenic concentrations which would discharge to local streams as baseflow.
- Cyanide:
  - Seepage from the TMF would not result in impacts to groundwater downgradient of the TMF if the assumptions made with regard to the adsorption and or destruction of cyanide are valid.
  - If the effect of destruction of cyanide in the pond or adsorption are not considered, the detectable cyanide in groundwater would be limited to less than 20 m downgradient of the TMF.

Impact Assessment – Update to Include Phase 2 TMF Raise

RPS Aquaterra updated their groundwater flow and transport model in 2017 to include the Phase 2 TMF design, as summarised in Newfields report (2017). This update took account of the increased wetted perimeter and therefore increased surface are over which seepage can occur as well as the increase in the embankment height in turn increasing the hydraulic head behind the embankment. The updated model also took account of the pit conditions as of November 2016 and was calibrated against groundwater levels recorded in January 2017.

It is reported that four scenarios were modelled by RPS: varying source concentration of arsenic and cyanide during operation and closure to update the impact assessment. The sorption conditions used in the previous Phase 1 modelling were maintained for the Phase 2 update. The modelled scenarios are summarised in Table 18-26 below.

Table 18-26: Impact analysis scenarios varying source concentration (adapted from Newfields)

Scenario	Solute	Source concentration during operation	Source concentration during closure	Sorption
1	Arsenic	2.0 mg/l	1.0 mg/l in first year following closure then 0.005 mg/l thereafter	No
2	Arsenic	0.4 mg/l	0.2 mg/l in first year following closure then 0.005 mg/l thereafter	No
3	Cyanide	20 mg/l	10 mg/l in first year following closure then 0.005 mg/l thereafter	Yes – Linear Sorption Isotherm with Kd = 3.0 L.kg
4	Cyanide	10 mg/l	5 mg/l in first year following closure then 0.005 mg/l thereafter	Yes – Linear Sorption Isotherm with Kd = 3.0 L.kg

The results of the modelling are presented in Newfields and are reported to indicate that as a result of seepage from the TMF, groundwater will mound beneath the north-eastern corner of the TMF and will then flow southwest and northwest, with the cone of depression from pit dewatering drawing groundwater to the north. The groundwater transport simulations calculated the following in relation to arsenic and cyanide seepage.

Arsenic

Based on the model results arsenic dissolved in groundwater originating from the TMF will flow beneath the TMF South Embankment and migrate to the southwest. Some of this groundwater will discharge into the surface water course downstream of the dam and some will migrate to the north west towards the dewatered pit. With source concentrations of 2.0 mg/l predicted the arsenic concentrations in monitoring borehole MB-16 (west and downgradient of the dam as shown on Figure 18-17) and downgradient of the TMF adjacent to the stream are calculated to be 0.8 mg/l and 0.33 mg/l, respectively. Both exceed WHO Drinking Water Quality Guideline of 0.01 mg/l (WHO, 2011) and the IFC arsenic effluent guideline of 0.1 mg/l (IFC, 2007). For the scenario with source arsenic concentration of 0.4 mg/l, arsenic concentrations are predicted to remain below IFC guidelines downgradient of the TMF. These results do not take the polishing effect of the downstream wetland into consideration so the actual reduction is likely to be greater.

Cyanide

Model results for the base case simulation of cyanide transport indicate no impacts to water quality outside of the TMF footprint. However, if the scenario where no sorption is included in the simulation, the model predicts a plume would develop with peak concentrations at MB-16 and a point adjacent to the stream of 4.2 mg/l and 3.5 mg/l respectively compared with the European Drinking Water Quality Standard of 0.05 mg/l EU 1998) and the EU mine waste directive limit of 10 mg/l for cyanide in tailings ponds (EU, 2006).

Model Sensitivity

It is noted that the impact calculated is sensitive to the assumed hydraulic conductivity and porosity. Using a combination of higher hydraulic conductivity and lower porosity resulted in a larger calculated arsenic plume.

Golder note that the assignment of hydraulic conductivity values was undertaken using data available for the geologic units within the valley floor; however, there is some uncertainty that these conditions (both thickness of the unit and hydraulic conductivity) will be laterally extensive across the site. The field investigations undertaken by RPS Aquaterra 2013 as reported by Newfields (2017) suggest that variations in hydraulic conductivity could vary by at least a factor of 5 within the various hydrogeologic units. The tailings hydraulic conductivity is also a source of uncertainly with laboratory test results of unconsolidated tails varying by more than an order of magnitude.

18.3.11.2 TMF Groundwater Monitoring

Groundwater Level

Nine monitoring boreholes were installed around the perimeter of the TMF in July 2013 (DTW-08, MB-06, MKB-07, MB-08, MB-12, MB-13, MB-14, and MB-17) as shown on Figure 18-17. Depth to groundwater ranges from 0 mbgl to 16 mbgl, with higher groundwater levels recorded during the wet season and lower levels during the dry season. A potentiometric surface map compiled by RPS Aquaterra in 2014 based on groundwater levels measured prior to construction of the TMF illustrated groundwater flow was generally parallel to topography. Groundwater from the north, east and south converges beneath the TDF and then flows west under natural conditions.

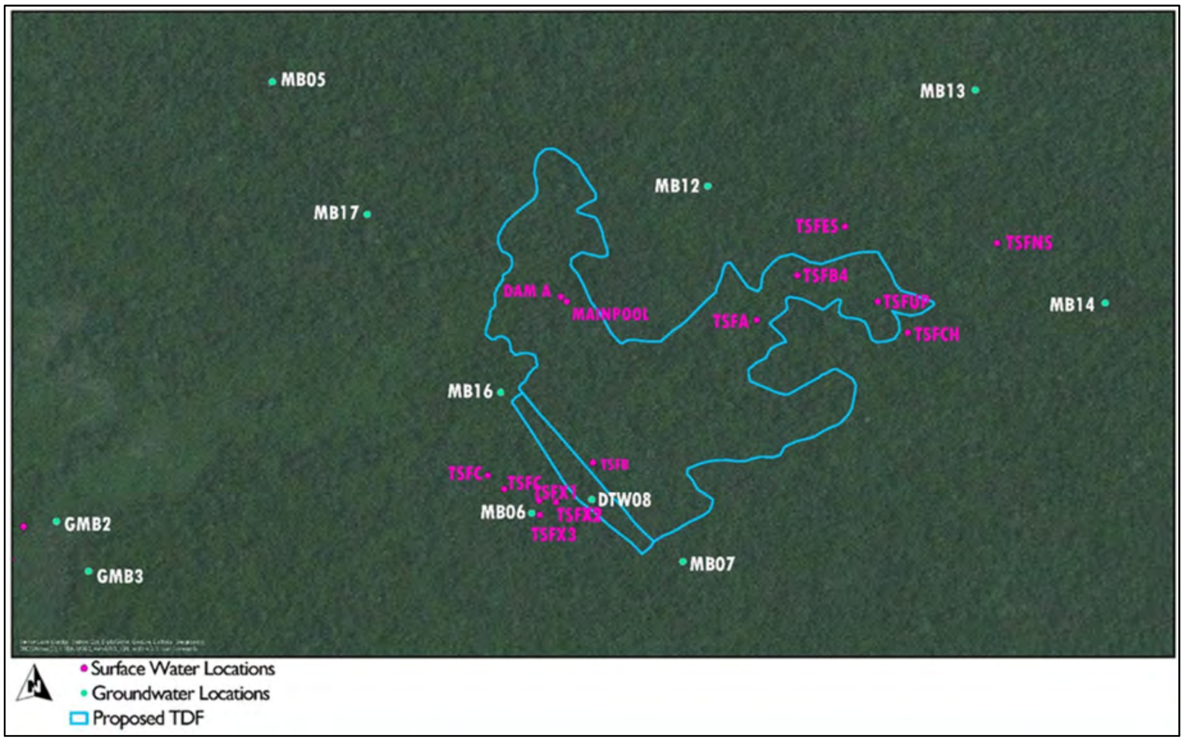


Figure 18-17: ESIA surface and groundwater sampling locations (adapted from Newfields)

Groundwater Quality

Newfields (2017) and Digby Wells (DWE, 2013) report that arsenic is present in naturally elevated concentrations at the project monitoring points and ranges from below laboratory detection limit (<0.0002 mg/l) to 0.18 mg/l which is above the WHO drinking water guideline of 0.01 mg/l (WHO, 2011).

It is reported in Newfields that groundwater samples collected from monitoring boreholes in the vicinity of the TMF (DTW-08, MB-06, MB-07, MB-08, MB-12, MB-13, MB-14, MB-16, and MB-17) were analysed for a range of metals, the majority of which, including cyanide and arsenic, were detected below the WHO drinking water quality guidelines and the IFC effluent quality standards (IFC, 2007). The background concentrations of iron in four of the boreholes (MB-05, MB-08, MB-12, and MB-14) were reported above the IFC Effluent standards (2 mg/l).

A detailed environmental monitoring program was implemented by BMMC in 2016 including surface and groundwater sampling locations around the TMF as indicated on Figure 18-19. The sampling program is reported in Newfields based on which it was concluded that surface water discharge and groundwater seepage contained elevated concentrations of COPCs, specifically arsenic, iron, nickel and cyanide above the IFC effluent guidelines. They continue to be monitored in and around the TMF 28. It is reported that groundwater samples collected from four monitoring wells near the TMF (MB-06, MB-07, MB-16, and MB-17) between July and November 2016 contained concentrations for arsenic between 0.01 mg/l and 0.071 mg/l which exceeds the WHO drinking water standard (0.01 mg/l) (note that this was immediately after the cyanide spill incident in May 2016). WHO and IFC standards for total cyanide, nickel and copper were exceeded in some samples from these wells collected in 2016 (Newfields, 2017).

Arsenic and Cyanide compliance Monitoring Points

An Arsenic Management Plan (AMP) was prepared as part of the updated ESIA (DWE, 2014) and was again updated by BMMC in 2018 specifically to:

- Note the compliance concentrations to which discharged effluent and groundwater seepage should adhere to
- Note the compliance points and monitoring programs.

The AMP defines arsenic compliance monitoring points for both surface water (TSF CMP2 and EDMP2) and groundwater (TSF GMB2 and TSF GMB3), as shown in Figure 18-18.

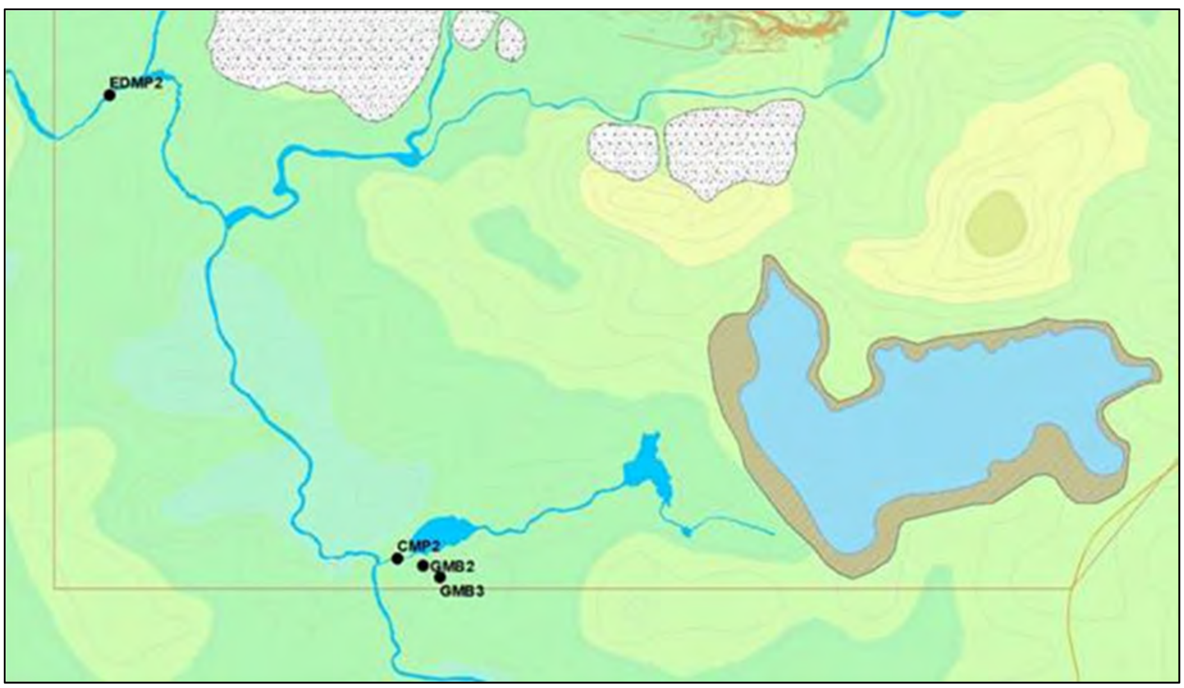


Figure 18-18: Arsenic compliance monitoring points

The program and protocol for the monitoring of arsenic in surface water and groundwater is reported as being incorporated in the wider environmental monitoring plan. The compliance concentrations to which discharged effluent and groundwater seepage should adhere to are defined as the IFC effluent quality guideline for arsenic (0.1 mg/l). The AMP sets out the requirements for the frequency of routine reporting on monitoring data (quarterly and annual).

A Cyanide Management Plan (CMP) was prepared as part of the updated ESIA (DWE, 2014) and again updated by BMMC in 2018 (to align it with the revised permitting requirements) specifically to:

- Specify WAD CN concentration in tailings discharges into the TSF

- Recommend and list possible mitigation methods to lower the CN concentration prior to discharge into the environment
- Identify compliance levels to which discharged effluent and groundwater seepage should adhere to
- Identify compliance points.

The CMP defines cyanide compliance monitoring points for both surface water (TSF CMP2 and EDMP2) and groundwater (TSF GMB2 and TSF GMB3), as shown in Figure 18-19.

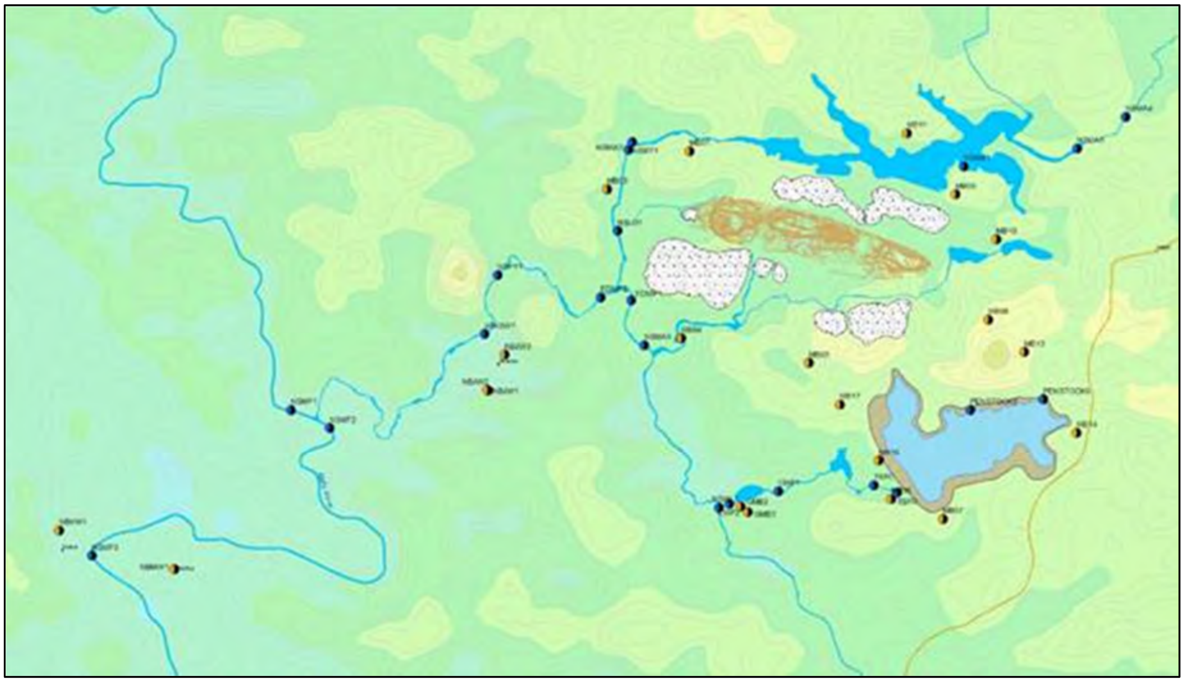


Figure 18-19: Water cyanide monitoring points

The CMP recommends international standards and concentration levels for compliance criteria based on IFC and International Cyanide Management Code (ICMC) regulations and guidelines as follows:

- Surface water discharges will be monitored at the CMP2 and EDMP2 and will comply with the EPA Discharge Permit and ICMC discharge concentration limits
- Groundwater monitoring around the processing plant will take place a at active boreholes and CN levels should be compared against background levels
- Discharge into the groundwater systems through seepage from the TSF will be monitored downstream of the wetland at active boreholes and needs to be compared against background levels.

The CMP also defines the following locations shown on Figure 18-19 to serve as monitoring points for CN discharged water:

- Plant and tailings stream monitoring:
  - Online monitoring will be in place to monitor the plant and tailings stream CN levels.
- TSF open water monitoring:
  - The open water stream and pool that will be contained on the TSF needs to be monitored for CN on a once weekly basis.
  - The sample needs to be taken as a composite sample comprising at least four representative sampling points within the TSF. These representative points can be changed in time considering TSF operational conditions.
- Groundwater monitoring:

- Monitoring for CN seepage into the groundwater system from the TSF will be monitored at active boreholes on monthly basis.
- Discharge point monitoring:
  - Discharge monitoring for CN will take place at CMP2 and EDMP2 on a twice weekly frequency (as per the EPA Discharge Permit) to monitor the discharged water quality and CN levels.
- Downstream surface water monitoring:
  - Surface water monitoring for CN fractions at JAKSW1 (Marvoe creek at Jikando), NSMF1 (Mafa river upstream), NSMF2 (Mafa after confluence), NSMF3 (Mafa downstream near Madina) will be done on a monthly basis.

The program and protocol for the monitoring of cyanide in surface water and groundwater at these locations is incorporated in the wider environmental monitoring plan. The CMP sets out the requirements for the frequency of routine reporting on monitoring data (quarterly and annual).

Recommendations

Based on the flow and transport groundwater modelling and impact assessment performed by RPS Aquaterra in 2013 and 2017 it is concluded that seepage from the TMF could result in COPC entering groundwater and surface water in excess of WHO guidelines and IFC effluent standards. While it is noted that the modelling and impact assessment is sensitive to the assumptions made in the model, the conclusions appear to be supported by the water quality monitoring undertaken to date. It is recommended that additional site-specific data be collected with respect to:

- Hydraulic conductivity (of tailings and in-situ geology)
- Porosity (of the tailings and in-situ geology)
- Soil water characteristic curve analysis for the tailings
- Tailings chemistry (including the pond water chemistry)
- Seepage rates from internal embankment drainage structures
- Groundwater level and quality monitoring data (for model calibration).

Based on the additional data, it is recommended that the seepage modelling and impact assessment is updated based on the currently proposed design of the TMF, and that the water balance for the TMF be updated taking in to account seepage modelling results.

18.3.11.3 Environmental Compliance

The mine currently operates the TMF under a permit valid until 8th December 2020. This requires that the mine continue to operate the TMF in accordance with permit conditions and the environmental management plans developed to address the recommendations of the environmental and social impact studies carried out as part of the initial mine development (DWE, 2013).

The permit requires on going monitoring of surface water and groundwater downstream of the facility, and this should continue with the cognisance that increased discharge flow rates from the TMF may influence the effluent contamination levels.

The permit also requires the mine to have a suitable emergency response plan for the TMF in place which will require the development of a dam breach assessment.

18.3.12 Cost Estimation

This chapter and the associated appendix outlines the capital expenditure (CAPEX) costs associated with implementing the centreline design approach for the LOM of the NLGM TMF. The operating costs of the facility have not been included as these are covered elsewhere.

The operating costs include but are not limited to; power supply, maintenance costs and labour costs.

18.3.12.1 Basis of Costing

The costing is based on an AACEI Class 4 deterministic assessment of capital expenditure only, to approximately ±25% accuracy. No contingency has been added to the costing as is to be covered by the over-arching cost assessment.

The rates have been determined through a combination of rates received from the NLGM site team and Golder experience on mine sites in Western Africa. The costs have been inflated to a 2019 rate but do not account for inflation throughout the LoM.

Preliminary and general costs associated with construction, including mobilisation of plant and people as well as associated overheads have been excluded from this assessment as construction works will be carried out by the BMMC on site construction team. The costs associated with this team, their plant and equipment are covered elsewhere.

18.3.12.2 Costing Summary

The costs have been split into phases of construction associated with different embankment raises set out in Section 16.10.

The annual and cumulative costs are summarised in Table 18-27.

Table 18-27: Annual CAPEX costs

Phase	Year	Annual cost	Cumulative cost
Studies, Design and Water Impoundment Area Preparation	2019	$594,000	$594,000
Phase 3a	2020	$593,558	$1,187,558
Phase 3b	2021	$2,350,756	$3,538,314
Phase 4a	2023	$1,921,276	$5,459,590
Phase 4b	2024	$1,116,386	$6,575,976
Phase 5	2026	$2,514,897	$9,090,873
Phase 6	2027	$1,823,128	$10,914,001
Closure		$4,838,793	$15,752,794
Total (US$ exc. VAT)		**$15,752,794**	

18.3.13 Risk Management

An assessment of the key project risks has been carried out. The risks are separated into the following categories:

- Safety and environment
- Construction and operational risks
- Infrastructure
- Storage
- Foundation
- Closure.

The assessment defines the likelihood and the impact of each risk to the project. These ratings relate to an overall rating for the risk which has approximate cost implications associated, these are:

- Low Risk (<$100k)
- Medium Risk (>$100k <$500k)
- High Risk (>$500k <$2m)
- Very High Risk (>$2m).

Mitigation measures for each of the risks are outlined with associated residual risk ratings.

It is recommended that a hazard and opportunities (HAZOP) workshop be conducted to further refine the project risk register in order that the risks have been communicated and mitigation measures are agreed upon and put in to place.

The most significant risks identified under each category are summarised below.

Safety and environment:

- Mine waste spillage in to downstream environment and water course causing contamination
- Leakage through embankment face impermeable liner system allowing contaminated contact water into the environment
- Seepage of contaminated contact water beneath facility into natural water system.

Construction and operational:

- Construction standards are not adequately controlled leading to some form of failure of the dam to safely contain solids and water
- Insufficient foundation and embankment fill geotechnical data and reliance on the use of published shear strength data
- Prolonged wet season
- Extreme rainfall event (above PMP event) or successive events which could flood and overtop the TMF embankments.

Infrastructure:

- Failure of the Penstock structure through the weight of the tailings or other issue causing the penstock system to become blocked
- Failure of the decant pumping system resulting in water not being returned to the process
- Failure of pumping system at Water Impoundment Area.

Storage:

- No significant risks identified.

Foundations:

- The ground conditions are found to be worse or more areas of concern more extensive than anticipated from the available ground investigations.

Closure:

- Long-term seepage from the facility
- Inappropriate deposition planning resulting in the pond being located in the wrong place at closure
- Insufficient construction material for capping system (waste rock, fine fill and topsoil)
- Insufficient time is given for consolidation of tailings prior to construction of capping layer and consolidation characteristics are not well understood.

Majority of these risks have been shown to be adequately mitigated by proposed measures set out in the development of the TMF expansion design and associated recommendations for additional work.

Further to carrying out recommended mitigation measures the highest residual risk is associated with the adopted geotechnical properties of the foundation and embankment materials. This underlines the need for further ground investigation and specifically the requirement to have a better understanding of the ground conditions and the geotechnical behavioural characteristics.

18.3.14 Recommendations

The areas that require further studies and assessments prior to detailed design identified throughout this chapter and the appended report are summarised below:

- An update of the NLGM water balance to assess excess and deficit flows
- Assessment of the dilution requirements and maximum discharge rates to satisfy effluent discharge limits permitted
- An additional ground investigation to improve understanding of the foundation conditions (geotechnical and hydrogeological)
- The installation of vibrating wire piezometers into the tailings to assess water levels and consolidation of the tailings beach
- Additional tailings testwork for strength and liquefaction resistance (CPTU Campaign)
- Additional tailings testwork for settlement and beach slope characterisation (also considering the Ndablama resource tailings)
- Additional tailings testwork for geochemistry for assessment of long-term leachate conditions
- Additional tailings testwork for hydraulic characterisation (to inform updates to seepage impact assessments)
- Detailed stability assessment of the slopes following improved geotechnical data from additional ground investigations and testwork
- Update of the seepage impact assessment models
- Carry out HAZOP workshop for tailings management
- Updates to OMS Manuals
- Updates to Emergency Response Plans, including the need to carry out a dam breach assessment.

19 Market Studies and Contracts

19.1 Background

Bea Mountain Mining Corporation is an existing producer and seller of gold. Good historical data for realizable gold prices therefore exists, and no market study specifically for this PFS was undertaken. Avesoro typically sells gold on the spot market, with an average realised gold price in 2018 of $1,275/oz versus an average of $1,268/oz. A flat gold price of $1,300/oz for near-term and long-term future price assumptions is used. It is this price that has been used for the PFS.

19.2 Market Analysis

Analysis of market forecasts supports the price assumptions for the PFS. A recent survey of analysts forecasts by the London Bullion Market Association suggests a 1.8% gain in the gold price in 2019 over 2018 for an average of $1,290/oz in the year (Els, 2019). 66% of responding analysts forecast spot prices reaching $1,400/oz in the period, with a range over all forecasts of $325/oz. Analysis by Sumitomo in Tokyo was the most bullish, forecasting a high of $1,475 on the likelihood of a US recession. Analysis by Metals Bulletin was the most bearish, with a forecast 2019 high for gold of $1,355/oz a low of $1,199/oz and an average price forecast of $1,242/oz. By comparison, the London Bullion Market Association predicts an average gold price of $1,311, a high of $1,475 and a of $1,150 (LBMA, 2019) The average gold price to date in 2019 was $1,304.11/oz (Figure 19-1).

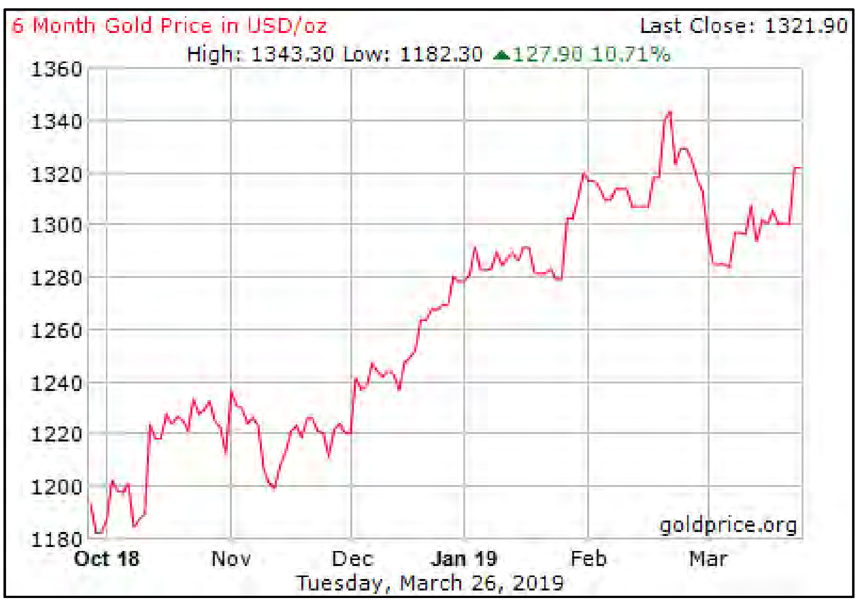


Figure 19-1: Spot gold price, 2019
Source: www.goldprice.org/spot-gold.html

19.3 Summary

A long-term gold price projection of $1,300/oz for this PFS is considered reasonable on the basis of actual gold prices realised by Avesoro in past periods, and consensus projections for the long-term gold price above this threshold across a range of analyses.

20 Environmental Studies, Permitting, and Social or Community Impact

The information presented in this section is based on a series of environmental and social impact assessment (ESIA) reports produced for BMMC (Golders 2012 and Digby Wells Environmental 2013a, 2014), government approval documents and the mine's environmental and social (E&S) management plans, monthly and annual reports, monitoring data and audit reports, plus the 2017 SRK 43-101 report for the Company.

20.1 New Liberty Gold Mine

20.1.1 Introduction

NLGM is situated in the north-western portion of Liberia within the Gola Konneh District of Grand Cape Mount County. The climate is equatorial with a wet season extending from May to November. The average annual rainfall recorded at the site during the period November 2010 to August 2017 is 3,387 mm, some 600 mm less than what is typically recorded along the coastal belt, which is over 4,000 mm. The temperatures on site are generally within the range 20ºC to 35ºC and are generally lower in the wet season than in the dry season.

The mine is 40 km from the coast and the topography is gently undulating with occasional small hills. The mine site, including the TSF is in the catchments of the Marvoe Creek and the Wilagea Creek, a tributary of Marvoe Creek, within the Mafa River basin. The Marvoe Creek has been diverted around the mine site. The confluence of the Marvoe Creek and the Mafa River, which flows to the Atlantic, is about 8 km downstream of the TSF.

Figure 20-1 below illustrates the watercourses downstream of the mine and environmental compliance points for water quality monitoring. It also shows the first two of three villages downstream of the mine.

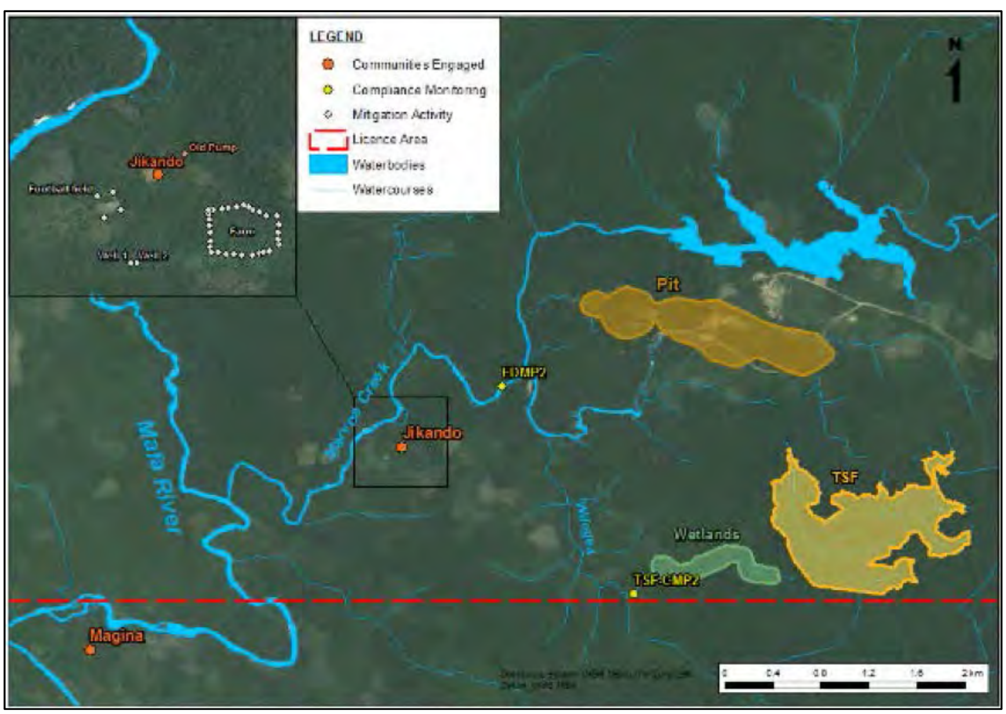


Figure 20-1: Watercourses downstream of the mine
Source: BMMC (2017)

Baseline water quality studies undertaken prior to development of the mine found that the quality of water in watercourses draining the mine site was generally good, but levels of aluminium, iron and arsenic were elevated in some samples. Historical artisanal mining was found to have had a measurable impact on aquatic habitats and ecological water quality, particularly the Marvoe Creek. However, the diversity of fish and amphibian species was found to be high. Three of the 17 fish species recorded are near threatened or vulnerable species. In February 2017, Digby Wells completed an aquatic survey around the mine site. As a result of this study, 22 species of fish and a number of aquatic invertebrates were identified. Of the 28 amphibian species recorded, more than half are Upper Guinea endemics.

Dense tall rainforest surrounds the mine site, which, prior to mining had been somewhat disturbed by past artisanal mining, prospecting, logging and bush meat hunting. Figure 20-2 presents a map of habitats in the BMMC concession that was produced in 2016. Several biodiversity studies have been completed in the vicinity of the mine. By 2015, these studies had recorded 264 plant species, which included 82 upper Guinea endemic species and two species endemic to Liberia. In terms of fauna, impacted reptiles identified included the vulnerable African Dwarf Crocodile (Osteolaemus tetraspis). Numerous bird species (139) were recorded, including vulnerable hornbill, parrot and greenbul species (specifically Ceratogymna elata, Psittacus timneh and Criniger olivaceus). Thirty mammal species were recorded including bats, rats, squirrels, antelope and primate species. Note that there is one habitat that is not mapped in detail and that is the Riverine Forest and Swamp Forest, which is associated with the rivers and streams.

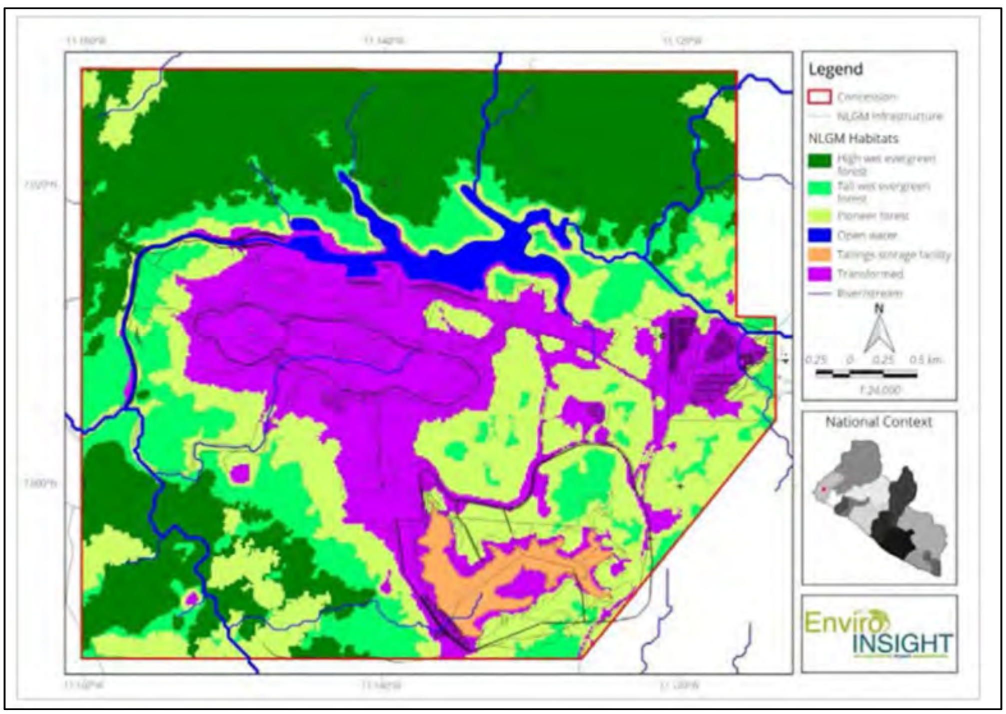


Figure 20-2: Habitat types in the BMMC Concession

The area around the mine is sparsely populated. Only six settlements were recorded within a 5 km radius of the mine site during social baseline studies in 2011 and 2012. Of these, Jawajei, Ganganma and Weagea and Jikando about 5 km downstream of the mine site and TSF (Figure 20-1) are not directly impacted. Kinjor and Larjor were situated in the mine foot print and had to be relocated. Further downstream of the TSF, near the Mafa River are the settlements Magina (also referred to as “Malina” or “Madina”), and Koma (also referred to as “Koma Djacin” and “Kohnma”), about 11 km and 12 km downstream respectively. The nearest major towns to the NLGM project site are Sinje (approximately 40 km) and Daniels Town (22 km).

Sinje is the nearest settlement with government medical facilities and education facilities beyond primary level.

The civil war in Liberia (1989–2003) claimed incalculable lives, caused population displacement, destroyed infrastructure, disrupted services and exacerbated poverty in the country. The impacts of the war were evident in the New Liberty Mine project study area at the time the 2011–2012 ESIA was undertaken. The ESIA recorded that inhabitants of the small settlements in the vicinity of the mine site were engaged in livelihood activities such as agriculture, artisanal mining and work associated with mining prospects. Kinjor and Larjor, which were located on the operation site of the mine had to be relocated to a permanent resettlement site as of 2013. Final settlement was completed in 2018 with the completion of the construction of 322 housing units and title certificates handed over to the beneficiaries.

The livelihoods of people living in Kinjor and Lajor were largely based on artisanal mining. Artisanal miners are thought to have entered the area in the 1960s, and residents of Kinjor described the settlement as being established in 1970. Lajor and Kinjor increased in size following the establishment of the New Liberty Gold Mine Project (then Mano Resources) in 1998, which offered perceived opportunities for formal and informal employment, attracted a population influx and settlement in the area.

The livelihoods of other villages in the surrounding communities of the mine are largely based on subsistence farming and fishing from streams and rivers. Unlike the agricultural villages nearby, very few of the households in Kinjor and Lajor have access to farm land and so they purchased food from surrounding farmers or from Monrovia. The ESIA recorded that structures within the project area reflected a dependence on resources in natural surroundings, because the lack of access to more durable, man-made construction materials. Energy needs were also serviced by natural available resources, primarily by wood or charcoal. Villages did not have piped bone water supply. They were mostly reliant on nearby streams and rivers to meet their needs for water supply.

By 2018, BMMC had installed water pumps in all the communities directly impacted by its operations. Among the latest beneficiaries of three hand pumps are the communities of Jikandoh, Malina and Korma. The beneficiaries are all downstream communities, where over 250 persons will have access to safe drinking water provided BMMC.

Malaria is the most common illness affecting local communities and other common illnesses are respiratory illnesses, typhoid and diarrhoeal diseases. Food shortages are experienced during the wet season. Many villages lack latrines and practice open defaecation.

Grand Cape Mount County is home to the BMMC. The County has only one major paved road, leading from Monrovia to Bo Waterside. Access to the mine site is via this road and then on another 20 km laterite road between Daniel's Town and the mine site. This laterite road was upgraded to accommodate the transport of large equipment to the site during the construction phase. About one third of Grand Cape Mount County's population is literate and the ratio of literate females to males is low. Education levels are largely are largely influenced by the proximity of households to schools.

20.1.2 Permits and Approvals

The primary approvals for NLGM take the form of:

- A Mineral Development Agreement (MDA) between the Government of Liberia and BMMC, dated 18 September 2013 and which replaced an earlier MDA dated 28 November 2001
- A Class A Mining Licence granted to BMMC on 29 July 2009
- An environmental permit for the Gold Exploitation granted to BMMC by the Liberian Environmental Protection Agency (EPA) on 4 November 2012, which was renewed as required in December 2015 and in December 2018

- A discharge permit granted to BMMC by EPA for discharges from the TSF, which is renewed on an annual basis and was recently renewed on 7 December 2018.

All the above approvals, with the exception of the Mining Licence, contain environmental and social conditions. In addition to the above approvals, BMMC has approvals for exploration, TSF Operation and importation and handling of cyanide permits. A number of the environment and social management plans produced for NLGM have been formally approved by government, are referred to in the MDA, environmental permit and/or discharge permit, and are in active use by the mine.

20.1.3 Environmental, Social, Health and Safety Management System

Significant improvements in environmental and social impact, health and safety (ESHS) management have been made. This is largely stem from top-level management's commitment to establishment of effective ESHS management systems on site.

Historically, environmental and social management performance on the site was hindered by the Ebola epidemic, which prevailed in Liberia through 2014 to mid-2015, and a lack of financial and human resources. In 2016, there was an increase in investment in environmental management, which was largely directed to addressing a cyanide incident and precautionary measures to ensure that such an incident does not occur again. In 2017 and particularly in 2018, more human and financial resources were directed into ESHS management.

In 2018, competent supervisors and officers have guided and supported the implementation of an environmental management system, a health and safety management system and a social impact management system. They have worked together to integrate these systems into an ESHS management system.

The recent SRK audit conducted in January 2019 also appreciated the good progress that has been made in addressing findings of previous reviews as follows.

- The ESHS management systems on site are functional
- Policies expressing commitment to effective ESHS management have been updated and communicated to staff and contractors
- There is evidence of management involvement in the management systems
- Stronger ESHS guidance is being provided
- Regular toolbox talks, training and site inspections are undertaken
- An environmental compliance obligations register has been established and compliance with obligations is reviewed on a regular basis
- Changes to the mine's water discharge permit, for discharges from the TSF, have been successfully negotiated, resulting in anomalous criterion for discharge to the wetland below the TSF being removed
- EHS plans have been updated and customised to the currently operation
- An extensive water quality monitoring programme continues at the mine, the monitoring data is entered in a database and is interpreted to provide useful management information
- Monitoring results obtained from the on-site laboratory are compared with those from an external laboratory and there is a good correlation between the monitoring results from both laboratories
- Monitoring of river health downstream of the mine continues, with a focus on fish and insect populations
- Monitoring programs have been expanded to include traffic speed and dust monitoring on and around the mine site

- Social impact management policies and plans have been prepared or updated, as required and are being implemented
- A social obligations register has been prepared and compliance with these obligations is reviewed regularly and the register updated accordingly
- Significant progress has been made in addressing the outstanding MDA social obligations
- Stakeholder engagements and grievances are recorded and monitored, in accordance with the revised stakeholder engagement plan and grievance mechanism
- Construction of replacement dwellings for the people physically displaced by the mine have been completed and ownership has been transferred to the respective households
- The community of Kinjor participated in the development of a livelihood restoration plan and accountability framework to reduce the community's dependency on BMMC
- A resolution between BMMC and the original land owners has been prepared with an agreed structure and process to enable finalisation of the respective social obligations
- A Memorandum of Understanding (MOU) has been drawn up, between the Government of Liberia and BMMC, defining process and procedures for government secondments to the mine
- Fish populations downstream of the mine have been increasing since the cyanide incident in 2016
- The mine's health and safety statistics reflect improvements in health and safety performance.

The only findings from previous reviews that have not been largely addressed to date are listed below.

- An updated Emergency Plan has to be developed for transport, storage and handling of explosives and has to address the elevated arsenic levels in the TSF.
- The compliance obligations register needs to include key requirements in host country legislation (including requirements under the EPA Act and the Decent Work Act)
- Some obligations in the MDA need to be addressed
- The pollution control measures for the WRDs, including sediment traps downgradient of WRD needs to be evaluated
- Sanitation in the Kinjor village needs to be included into the monitoring program of NLGM
- Biodiversity Action Plan needs to be developed as covering the proposed offset plan area
- The Closure Plan needs to be updated to reflect the current infrastructure layout on the site. A more detailed closure cost estimate should be prepared.

20.1.4 Key Environmental Issues

20.1.4.1 Compliance with Cyanide and Arsenic Criteria in Water Downstream of the TSF

BMMC manages the mineral processing operation, the tailings detoxification plant and the TSF operations such that cyanide and arsenic compliance criteria in the watercourses downstream of the mine are not exceeded. The tailings detoxification plant is equipped with two units to destroy cyanide and promote arsenic precipitation from tailings. Arsenic removal is required because the ore is rich in arsenic and arsenic is liberated during the mineral processing operation. Arsenic is removed by means of an iron co-precipitation process. Cyanide is destroyed by an INCO cyanide destruction unit. After the mineral processing operation was first commissioned, there was a suite of challenges that resulted in failure to meet cyanide compliance criteria downstream of the mine and fish deaths in the downstream watercourses were observed. The problems have been addressed and impact studies by independent specialists contracted by the Company have confirmed that the river ecosystem has largely recovered and that people living downstream of the mine have not been adversely affected.

Among the measures put in place to ensure compliance with cyanide and arsenic criteria for downstream watercourses are:

- Improvements to the control of the leaching circuit and detoxification plant
- Improvements to the design of the TSF so that the water volume and residence time of the TSF was increased so there is more time for breakdown of residual cyanide and precipitation of arsenic on the TSF
- Improvements in the process water management so to optimise the return of water from the TSF to the process
- Modification of the natural wetland below the TSF to include permeable reactive barriers (gabion baskets with iron and charcoal) and increase the reed bed density to slow down transit of water through the wetland so that arsenic, suspended solids and cyanide levels in the water flowing into the Wilagea Creek are as low as possible
- Improvements to the water monitoring including upgrading of equipment and procedures in the analytical laboratory on the mine site and establishment of a database that facilitates interpretation of the monitoring data
- Improvement to the ESHS management system including top management commitment ensuring there is compliance with relevant compliance criteria, daily review of management review of monitoring data and corrective action taken in response to nonconformities
- In addition to the above, further research is being undertaken to establish the most effective arsenic removal solution from water discharged into the environment from the TSF.

Use of the watercourses downstream of the mine is limited, but there are three villages between 6 km and 14 km downstream of the TSF (Jikando, Magina and Koma). BMMC has dug wells to supply drinking water to these villages and has equipped these with hand pumps. The mine's monitoring data demonstrates compliance with relevant cyanide and arsenic criteria at the environmental compliance points from May 2016 to present. This initiative was completed in December 2017 after a sustained period of monitoring during which the recovery of the fish population was confirmed.

The environmental compliance points defined in the mine's cyanide and arsenic management plans are below the TSF above the confluence with the Wilagea Creek (CMP2) and in the Marvoe Creek below the confluence with the Wilagea Creek (EDMP2), as shown in Figure 20-1. There are internal check points for cyanide and arsenic in water on the mine. These include the tailings prior to discharge to the TSF and the penstock on the TSF. Data from the internal check points suggest that the cyanide detoxification and the arsenic removal processes interfere with each other. When the cyanide detoxification performance is highly effective, the performance of the arsenic removal process is not optimal. This does not result in non-conformance with environmental compliance criteria but can result in internal check point values being exceeded. BMMC is working on this issue with the aim of optimising the performance of both detoxification processes.

The cyanide levels in the tailings discharged to the TSF between May and October 2017 were elevated on occasions, with weakly acid dissociable (WAD) cyanide levels exceeding 50 mg/l on 11 occasions. The incidents were attributed to some problems with the oxygen distribution balance between pre-ox, leach and detox; blockages in the reagent tanks; and issues with the acid pumps. These problems were attended to, respectively, by means of flow meters and regulators on oxygen delivery points, clearing of blockages, and replacement of acid pumps. BMMC reports that the average WAD cyanide levels on the TSF remain well below environmental permit and discharge permit conditions.

20.1.4.2 Interpretation of Water Quality Impacts and Implementation of Pollution Control Measures

BMMC has an extensive water monitoring programme, and interpretation of the data for parameters other than cyanide and arsenic has improved. The last detailed review of monitoring data was undertaken by SRK in early 2019.

Water samples are taken upstream and downstream of the mine, on the mine site and in the resettlement village. They are taken from streams and boreholes, on a monthly basis and are sent to ALS in Prague for analysis. The range of parameters determined is wide. BMMC's environmental permit requires comparison of water monitoring results with baseline water quality, and BMMC has started to formally define what constitutes baseline water quality in its management plans and procedures. The data available in the ESIA reports is limited. BMMC is entering all monitoring data into a database to facilitate comprehensive interpretation of water quality results. SRK has seen evidence that cyanide and arsenic monitoring data and other water monitoring parameters are entered into the database and interpreted on an ongoing basis. Sediment studies undertaken in watercourses downstream of the mine indicate that there is moderate natural metal enrichment of sediments in these watercourses. There is no evidence that the mine is contributing to the load of metals in the sediments, but there is evidence of metal enrichment in sediments on the mine site – specifically in the relic channel of the Marvoe Creek (the creek has been diverted around the mine workings). This area of the creek is immediately downstream of the artisanal washing sites and was heavily silted as a result of this activity. Arsenic, chromium and nickel enrichment were recorded in this location. This needs to be monitored and action may need to be taken to ensure this does not impact on downstream watercourses in future. NLGM has implemented most of the pollution control measures that it committed to implement in its permitting documentation. The outstanding pollution control measures are sediment traps downgradient of waste rock dumps.

20.1.4.3 Biodiversity Impacts

The mine's environmental permit contains the following condition (Condition 7): *"Design, and operate a biodiversity offset program based on the no net loss principle that demonstrates compensation for environmental damage equivalent to or better than the loss of habitat ecosystems services and structure given in ESIA."* Biodiversity studies were undertaken at the mine site to provide input the ESIA for the development and a draft biodiversity management plan was produced in 2014. Further work has been undertaken to produce an offset plan and comprehensive biodiversity monitoring plan for the mine:

- Higher resolution habitat mapping to define the different types of forest in the area
- Surveys to confirm the absence/presence of critical habitat triggers and to provide more precise information about populations in the area
- More comprehensive assessment of indirect effects such as forest degradation associated with population influx
- Advice for the closure plan restoration strategy, including more clarity on vegetation types and objectives
- Preparation of action plans to achieve net gains in critical habitat biodiversity values
- Development of procedures for preventing the spread of alien invasive species on the site.

A Biodiversity Offset Plan has been produced by Enviro Insight and submitted to NLGM. An extensive biodiversity monitoring program has been recommended by Enviro Insight that includes:

- Water quality monitoring, including continuous monitoring of certain parameters using automated real-time logging probes linked via satellite to a web-accessible user interface or downloaded manually on a daily basis from probes, archived in a database and immediately inspected/evaluated
- Aquatic assessment
- Vegetation change monitoring

- Sediment analysis
- Roadkill monitoring
- Diatom, macro-invertebrate and fish monitoring
- Forest mammal community monitoring
- Alien and invasive fauna monitoring.

During the last audit, SRK recommended that:

- A biodiversity action plan is developed for the mine. This should not just cover the offset but also include measure to prevent future losses of biodiversity and ecosystem services. This action plan should also cover prevention of the spread of alien species and the mine closure.
- The biodiversity offset proposal is reviewed taking account of the external reviewer FFMES' recommendations.
- The biodiversity monitoring program is refined taking the comments of FFMES.

These action items are in progress at New Liberty.

20.1.5 Social Commitments

The RAP was originally structured around four key elements linked to the legal framework and in accordance with the IFC Performance Standard 5. These were:

- Approach to land access and management
- Establishing rates of compensation
- Determining eligibility for compensation and resettlement assistance, including livelihood initiatives
- Establishing mechanisms to resolve grievances among affected persons related to compensation and eligibility.

BMMC faced a challenging start up with the construction phase being completed during the Ebola outbreak and a series of subsequent cash flow issues during initial operation phase. Even though these challenges had contributed to delays to implementation of the social management plans, construction of replacement dwellings for the people physically displaced by the mine have been completed and ownership has been transferred to the respective households. The community of Kinjor have also participated in the development of a livelihood restoration plan and accountability framework to reduce the community's dependency on BMMC. Whilst significant progress on social obligations and commitments to the host community have been made, there are a few that remain outstanding. These issues and their current status are expanded on in this section.

20.1.6 Stakeholder Engagement Planning and Management

A new stakeholder engagement plan (SEP) and a grievance mechanism has been issued in 2018 and a recording and tracking system for all engagements and grievances has been implemented. Both the SEP and grievance mechanism have been operationalised and regular planned engagements are taking place. Four quarterly newsletters and two large community billboards are now prepared for disseminating information regarding project progress to the affected communities. The approach to stakeholder and community relations is currently being restructured. The recent appointment of a Corporate Director of Social Management and Communications increases organisational competency. The new organisation chart including new appointments to increase the capacity has already been approved by the Management and recruitment process has been started. A Community Development Supervisor and a Social Data Analyst joined the team on 1 February 2019, and also the recruitment process of four more community liaison assistants is underway. Engagement with the Government of Liberia and related ministerial departments and agencies is managed from Monrovia by the BMMC Country Manager.

20.1.7 Implementation of the Resettlement Process

Duplexes have been constructed and signed over to the 322 households physically displaced by NLGM. Land tenure has been secured and each household has a certificate of ownership. Despite the sale of the land, the original Marvoh landowners are struggling with internal disunity and are also disputing the rights of the resettlers on this land. The compensation obligations in the land sale agreement have not all been met because of perceived misappropriation and mismanagement of sums paid to date, by the Marvoh administration. The Ministry of Internal Affairs through the Grand Cape Mount County Superintendent's office has begun a Focus Group Dialogue with community members, including Marvoh landowners and the resettlers to resolve the conflict over the 150 acres of land purchased for resettlement. The Minister of Internal Affairs is again assisting a peaceful resolution through an election process to create a township council and appoint an elected town chief. BMMC has drilled 21 boreholes and 216 toilet blocks have been installed for community use.

The Company has constructed a community health centre and provides financial support for the employment of community health professionals. Until the New Kinjor community is registered as an official township, community health and service provision are perceived by the Government of Liberia to be the responsibility of BMMC. The population increase in New Kinjor is putting pressure on available sanitation and increasing potential risk to water borne communicable diseases. Many of the owners of the newly constructed RAP duplexes have dug septic pits for domestic sewage, these are upstream of some of the boreholes and pose a risk to exposure to disease. BMMC is to install a water supply upstream of the RAP duplexes to enable access to clean water.

20.1.8 Livelihood Restoration and Community Development

At the time of the RAP, livelihoods were defined as being dependent on the natural resource base, with men and women engaged in a combination of subsistence agriculture and artisanal mining. Compensation payments were made related to structures not being replaced, crops and trees lost. BMMC set up a number of cooperatives and community-based initiatives as alternative livelihood activities. To date the community-based enterprises, have either failed or increased dependency on NLGM, the exception is a small microcredit scheme that provided start up seed funding of US$3,000 to five groups, four of the groups are still functioning. Community focussed participatory planning/visioning was undertaken by external consultants in September 2018 to determine a series of livelihood restoration/development activities and influx management process tailored to and owned by the community. The resettlers as well as the wider community have been included in the RAP livelihood restoration and development plan currently prepared in draft format based on the outputs from the visioning process. This plan, once finalised, will incorporate the community development programme.

20.1.9 Social Obligations

A social obligations register has been prepared and compliance with these obligations is reviewed regularly and the register updated accordingly. Significant progress has been made in addressing the outstanding MDA social obligations. Also, a Social Monitoring and Reporting Plan that is aligned with a Social Objectives Action Plan and the Social Obligations Register has been prepared and implemented. However, there are a number of unfulfilled obligations related to the agreement of lease and the real estate sale agreement. Avesoro and NLGM/BMMC attribute this to a persistent disunity amongst the Marvoh landowner (also known as the Darbo Clan) and their 10 court-appointed administrators. Further to a resolution drawn up in September 2018 between BMMC and the Darblo Clan, a schedule is being negotiated with the Marvoh Administrators for delivery on outstanding commitments.

20.1.10 Provision for Closure

A closure plan was produced for the mine in 2013 by Digby Wells Environmental (2013b). The plan was presented in the ESMP within the 2013 ESIA and has, therefore, effectively been approved by the EPA.

The closure cost estimate based on the 2013 closure plan is US$10.0 million. SRK's comments on the 2013 closure plan are listed below:

- The closure plan is highly conceptual. In terms of good international industry practice, it is appropriate to start developing a detailed plan for closure of the mine now.
- The closure design involves construction of a closure spillway and cover of the entire TSF with saprolite layer and topsoil. The capping method will be revised on the completion of the Phase 3 TSF design.
- Regarding the transfer of assets to the government, the plan states "an agreement with the Liberian Government has been reached, whereby liability for all permanent and immovable mine infrastructure, and its future maintenance, will be formally transferred to the Liberian government upon cessation of the mining operation". Section 29.1 of the 2013 MDA references transfer of immovable assets but does not include comment on liability and maintenance of the assets. There is a risk demolition may still be required and additional costs will be incurred.
- Modelling of post-closure water quality impacts from the TSF is a data gap and will need to be evaluated to inform closure planning and closure costing in future plan revisions. The exclusion of a provision for post-closure water treatment represents a risk of insufficient financial provisioning for closure. SRK recommends that the closure plan is updated, and the closure cost estimate is revised.

20.2 Environmental Baseline Conditions in the Project Area

20.2.1 Geology and Topography

The BMMC property contains a sequence of highly-deformed discrete lenses of ultramafics and amphibolites, which represent relict Archean greenstone belts, surrounded by granites and granodiorites. These rocks have been subjected to lower amphibolite grade metamorphism resulting in gneissose or schistose textures, depending on the rock competency.

The Ndablama gold target is underlain by Archean greenstone comprised of amphibolite gneisses and ultramafic rocks. Geologically, Ndablama is subdivided into three entities, designated the Northern, Central and South Eastern zones. The general geology of Ndablama consists of mafics and ultramafic rocks. The mafic package consists of amphibolite schists and gneisses which envelope a series of ultramafic schists. The ultramafic rocks have been subdivided into magnetite-rich and magnetite-poor zones. The ultramafic and mafic rocks are located close to the contact with a large granitic batholith to the east. The metavolcanic sequence has been intruded by granitic sills.

The general geology of Ndablama consists of mafics and ultramafic rocks. the topography ranges from around 50 mamsl to a maximum of 600 mamsl, with the majority of the licence area being composed of gently undulating plains at less than 200 mamsl, with two prominent east-west ridges of resistant rock units (the Bea Mountain and Tokani ranges). The Ndablama and surrounding area is dominated by low ridges. Elevations range between 150 mamsl to 350 mamsl.

20.2.2 Climate

The equatorial climate is hot year-round, with heavy rainfall from May to October. During the winter months of November to March, dry dust-laden Harmattan winds blow inland. Average annual rainfall along the coastal belt is over 4,000 mm and declines to 1,300 mm at the forest-savannah boundary in the north. Temperatures range from the low 20ºC during the rainy season to low 30ºC during the dry season.

20.2.3 Meteorological Parameters

The mean annual rainfall for New Liberty Mine is calculated as 3,372 mm and 3,173 mm for Ndablama. The monthly rainfall for the following scenarios was calculated, a normal year, an average wet and an average dry year. The normal year is taken as the statistical average year, the dry year as the 30 percentile values and the wet year as the 70 percentile values.

The tables below summarise the mean monthly and annual values for the three scenarios.

Table 20-1: Mean monthly and annual rainfall for a normal year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
mm	23	40	69	139	335	345	512	570	644	262	196	38	3 173

Table 20-2: Mean monthly and annual rainfall for a dry year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
mm	6	23	61	138	251	330	427	515	551	252	153	22	2 79

Table 20-3: Mean monthly and annual rainfall for a wet year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
mm	35	42	72	153	382	376	599	687	707	265	231	42	3 592

20.2.3.1 Monthly Evaporation

It is evident that evaporation does not vary significantly over large areas as is the case with rainfall. Hence it would be reasonable to assume that the potential evaporation at Ndablama Mine, New Liberty Mine and Monrovia will not vary significantly. The recommended values adopted are the averages between Monrovia and New Liberty Mine weather stations and is summarised in Table 20-4 below.

Table 20-4: Recommended mean annual and monthly evaporation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
mm	86	80	90	92	85	72	64	63	68	76	80	86	942
%	9.1	8.5	9.6	9.8	9.0	7.6	6.8	6.7	7.2	8.1	8.5	9.1	100

Dominant wind directions in West Africa are the northeast and southwest Monsoons as well as the Harmattan, which is a dust laden wind from the Sahara Desert. Total wind speed is greatest in the rainy season and lowest in the dry season. MM5 data for the study area indicates a wind field dominated by winds from the southwestern sector during the day and night, with very little wind from the northeast. Day and night-time average wind speeds are 1.98 m/s and 1.68 m/s respectively. Calm conditions occur 24.6% of time during the day 25.3% during the night. The average temperature in the study area over the three-year period was 26.4°C the average humidity 81.6%. Noise impacts are expected to be slightly more notable to the north of the project activities.

Mean annual temperatures in Liberia range between 18°C in the northern highlands and 27°C along the coast. The climate is characterised by the constant high temperatures and abundant rainfall. Annual average temperature for New Liberty area is given as 26.3°C. The average daily maximum temperatures for the general project area range from 25.6°C in August and September to 28.2°C in April and May, with daily minima ranging from 24.8°C in July and August to 26.8°C in May.

20.2.4 Ambient Air Quality

No ambient air quality monitoring information is currently available for the Ndablama deposit site and no national air quality monitoring data is available.

Pre-development monitoring was undertaken at NLGM, located some 46km to the west of Ndablama was undertaken as part of the baseline assessment for the NLGM project. The assessment found the following:

- The existing air quality in the region is influenced by existing artisanal mining activities, mine exploration and associated BMMC workers accommodation (from generators and wood burners), local villages (Gold Camp) and the local road network.

- The baseline air quality in the area is generally good,
- Annual and 24-hour NO_2 concentrations are less than 5% of the relevant World Health Organisation (WHO) standards as is 24-hour SO_2. 10/ 15-minute SO_2 is slightly higher but still only 6.3% of the relevant WHO standard.
- The O^3 background concentration is higher, but this is still only 53.9% of the WHO standard.
- Baseline monitoring also indicates that deposited dust is much lower than the recommended levels in both the South African and International guidelines.
- The baseline monitoring identifies that background air quality is good and concentrations are well below the relevant standards.

20.2.5 Noise

Day and night-time noise measurements were conducted from 8 November 2018 to 11 November 2018 at five locations in the general project area.

The acoustic climate at Noise Receptors (NR) is currently affected by community activities, generators, artisanal mining activities, logging activities, vehicle traffic, domesticated animals as well as natural noises such as birds and insects.

Recorded $LA_{eq,d}$ at the sampling locations away from community activity (Ndablama Camp, Ndablama Pit and Ndablama Forest) are following the Liberian noise limits for mixed residential areas. During the day, $LA_{eq,d}$ levels were between the limits for residential/commercial areas and industrial areas at the Than Town and Gold Camp sampling locations, mostly due to community activity. During the night however levels were lower, below the Liberian limit for residential/small scale production/commercial areas.

Logging with chainsaws is the main contributing source at the Ndablama Forest sampling location during the day as well as the night.

20.2.6 Soil and Land Capability

The soils identified and mapped can be broadly categorised into four dominant Soil Groups or variations of these four groups, and four Land Form Units.

The Soil Groups have similar physical and chemical characteristics and will react in a similar manner to being disturbed or impacted/worked on, while the Land Form Units have similar topographic character, erosion indices, ground roughness characteristics and sensitivity/vulnerability ratings.

The Soil Groups identified are presented and discussed in Table 20-5.

Table 20-5: Soil Groups of the project area

Name	Description
Lithic Leptosols rudic phase	Soils of the lithic Leptosols and Rudic form are characterised by shallow to very shallow rooting depths (<20 cm to 40 cm), with significant gravel to cobble size fragments of rock and rock shards, and a ground roughness that exhibits 20% to 60% cover of rocky scree. These soils are mainly associated with the steeper land forms and steeply dipping lithologies that form the mountainous terrain (25% to 60% slopes) that host the mineralised zone. The soil physical properties are characterised by very shallow to shallow, dark brown, sandy loams and sandy clay loams, single grain to apedel structure, better than average drainage, and are generally loose to friable when dry, and non-sticky and non-plastic in the wetted state.
Chromic Cambisols – rudic phase	These soils occur on the moderately steep to hilly topography that form the midslopes and upper midslopes, reflecting a change in geomorphology and geology. These soils are characterized by the presence of stones and gravels on the surface and in the profile and are more often than not underlain by a ferruginous sub-base. The land cover is densely wood bush land, with a topographic/surface gradient ranging from 12% to >25%. Generally, their depth is categorised from moderately deep to deep, generally well drained, dark brown to red and red/orange over dark brown to red subsoil with a sandy clay to sandy clay loam texture. The top soil structure is apedel to single grain, consistency is loose to very friable.
Haplic Alisols	The soils of the Alisol form are associated with the flat to rolling plain land forms and are by definition soils associated with the lower lying areas and alluvial/colluvial deposits of transported materials. The soils are

	variable in both depth as well as texture, varying from deep to shallow rooting depths with a sandy clay texture to well washed and sorted medium and course grained sands in the river channels. Physically, these soils are well drained, light brown to white on a rocky river bed. In contrast, but part of a similar topographic environment comprises colluvial derived materials that are more commonly associated with the wetland river banks and river tributaries comprise fine to medium grained sandy clay loams over clay loam, the clay content increasing with depth. The top soil structure is granular over sub-angular moderate blocky structure, and is hard when dry and friable, moist, sticky and plastic when wet. Most Alisols have a higher clay content in the subsoil than in the top soil as a result of pedogenetic process particularly clay migration leading to an argic subsoil horizon.

The four Land Form Units include:

- MS – Mountains and steep slopes (25% to 60%)
- UH – Undulating to hilly slopes (12% to 25%)
- FU – Flat to undulating terrain (<12%)
- DVR – Dissected valleys and rolling terrain.

The analysis for metal content in the soils returned elevated magnesium and area of elevated aluminium, zinc, iron, manganese and mercury all returning values within or well below the values for toxicity concerns.

The land capability rating ranges from moderate to low palatable grazing lands on the lower lying gently undulating to hilly land forms Haplic Alisols and Cambisols, to rough grazing and/or wilderness land on all the steeper and shallow rooting soils associated with the Lithic Leptosols and Regosols.

In general, the soils associated with the mountainous terrain and metasediments are too steep and in some cases too shallow (<750 mm) for any form of arable cultivation. Soils with greater than 400 mm of rooting depth are for the most part restrictive to cultivation due to soil water holding capability and effective rooting depth, while any slope over 12% is considered too steep for any form of cultivation other than possibly commercial forestry. The land capability of the project area is described in Table 20-6.

Table 20-6: Land capability of the project area

Land capability	Description
Arable Land	There are no sites within the area of study that classify/rate as Arable Land. The potential for any form of commercial agriculture is restricted to the valley floodplains all of which classify as highly sensitive wetland environments and should not be impacted.
Palatable Grazing Land	The areas classified as palatable grazing land are generally associated with the deeper sandy clay loams that occur as transitional to the wetland zones in the hilly and undulating land forms downslope of more mountainous terrain and comprise for the most part the Haplic Alisols and Cambisols. However, these sites are often restricted by the terrain steepness and/or restrictions within the soil profile.
Rough Grazing or Wilderness/Conservation Land	The areas classified as rough grazing or wilderness/conservation status include all the steep land forms associated with Lithic Leptosols and some of the Haplic Alisols. The extremes of steepness of the terrain combined with the shallowness of the soil rooting render these sites to have poor grazing potential. For the majority of the area they rate as wilderness or conservation status.

20.2.7 Biological Environment

The proposed development is located within the Upper Guinean forests that extend from Senegal to Togo and are regarded as one of the biodiversity hotspots of the world. The Upper Guinean forests have a high degree of plant and animal endemism. Compared to Neotropical and Asian rainforests, African forests are characterised by much lower species richness, and contain fewer palm, epiphyte and understory species.

A wet and dry season biodiversity survey was undertaken of the general project area, with a follow-up biodiversity verification survey undertaken. The following main habitats were identified, as per Table 20-7.

Table 20-7: Habitat types of the Ndablama deposit area

Habitat type	Description
High wet evergreen forest	This habitat type most closely resembles that of 'primary' forest of all the habitats within the Ndablama Site, and could be described as mature, less disturbed forest. It is mainly limited to the crests and slopes of the inselbergs within the Ndablama Site. The canopy ranges from high (>30 m) on the lower and midslopes transitioning into tall (10–30 m) on the shallow rockier crests and is predominantly closed. Numerous emergents such as *Petersianthus macrocarpus*, *Piptadeniastrum africanum* and *Klainedoxa gabonensis* occupy the canopy, with *Pentaclethra macrophylla* representing one of the taller tree species. The understory is relatively open mainly consisting of erect treelets and tall shrubs. The tree and shrub species composition are typical of "Wet evergreen forest", with the characteristic evergreen species including *Diospyros chevalieri*, *D. sanza-minika*, *Heritiera utilis* and *Lophira alata*. This habitat type is well represented by SCC and includes the IUCN CR *Aubregrinia taiensis*, the IUCN EN *Neolemonniera clitandrifolia* and *Placodiscus pseudostipularis* as well as numerous IUCN VU, Upper Guinea Endemic (UGE) and Liberian Endemic (LE) species
Tall wet evergreen forest	This habitat type has similar aspects of the *High Wet Evergreen Forest* type; however, the canopy is slightly broken and consists of mainly tall (20–30 m) trees and a few scattered emergents and therefore slightly more degraded. It is limited to the lower (and therefore more accessible to illegal loggers) slopes and hills of the Ndablama Site and is likely an expansion of the "Degraded evergreen lowland forest". This habitat type exhibits a slightly broken canopy and could therefore be described as a functioning "buffer zone" around the *High Wet Evergreen Forest* type. The understory is more tangled, but the tree and shrub species composition remain typical of 'Wet evergreen forest' as described above. Tall trees are common and include *Heritiera utilis*, *Gilbertiodendron preussii*, *Dialium aubrevillei* and large specimens of *Uapaca guineensis*. This habitat type is moderately represented by SCC and includes (amongst others) the IUCN VU *Heritiera utilis*, *Khaya anthotheca* and *Lophira alata* as well as numerous UGE species, such as *Anthocleista nobilis, Pycnocoma angustifolia, Rinorea prasina* and *Zanthoxylum gilletii*.
Tall/ short forest mosaic	This habitat type consists of a mosaic of remnant *Tall Wet Evergreen Forest* type and older 'secondary' (10 - 20 years) forest. The canopy is very discontinuous, with a mixture of large *Zanthoxylum gilletii*, medium sized *Funtumia africana*, and smaller *Maesobotrya barteri* trees and pioneer saplings like *Musanga cecropioides.* The undergrowth is highly tangled, with a dense shrub and immature liana strata including *Cnestis corniculata,* with the tree and shrub composition representing areas of secondary growth and therefore deviating from the typical 'Wet evergreen forest'. This habitat type has a poor to moderate representation of SCC and includes the IUCN VU *Trichilia ornithothera*, *Terminalia ivorensis* and *Nauclea diderrichii* as well as a few UGE species, such as *Macaranga heterophylla, Hypselodelphys triangulare* and *Mussaenda chippii*.
Short broken forest	This habitat type represents fallow land occupied by young secondary forest most likely between two and seven years in age that has been created by shifting cultivation practises. It consists of a successional mosaic ranging from single-species *Musanga cecropioides* stands to mixed gregarious stands of *Harungana madagascariensis*; *Rauvolfia vomitoria* and *Macaranga heterophylla* in a combination of shrub and small tree forms. Early successional stands are often impenetrable due to the presence of *Scleria boivinii,* but these die out in 'older' stands due to diminishing light. This habitat type has a poor representation of SCC although it includes the IUCN VU *Trichilia ornithothera* and *Nauclea diderrichii* as well as a few UGE species, such as *Trichilia ornithothera* and *Scadoxus multiflorus* var*. longitubus*.
Low bush and thicket	This habitat type represents pioneer stands of forest likely below two years in age with *Musanga cecropioides* and low growing scrambling grasses, shrubs and lianas like *Scleria boivinii*, *Combretum comosum*, and *Rhabdophyllum affine*. These areas are usually associated with road reserves and footpaths leading to and from villages that are continuously disturbed through their close associations with human settlements and infrastructure. This habitat type has a poor representation of SCC but includes the UGE *Scadoxus multiflorus* var*. longitubus* and *Hypselodelphys triangulare* species.
Towns/ artisanal mines/ farmlands	The Ndablama Site covers a large area and is surrounded by numerous towns with large areas of permanent subsistence agricultural lands as opposed to the shifting agricultural practices described under the previous habitats. The vegetation is dominated by cultivated, alien and useful species for the local communities. There is a low diversity of woody species but a high diversity of herbaceous species.

Habitat type	Description
Azonal Riverine Forest (not mapped)	This habitat type represents forested areas along the rivers and streams found within the Ndablama Site, excluding areas flowing through *Towns/Artisanal mines/Farmlands* type. The canopy cover is mostly well developed and predominantly closed. The tree and shrub species present are typical riverine specialists intermixed with surrounding forest habitat species and include tall species of *Pterocarpus santalinoides*, *Aphanocalyx pteridophyllus*, *Gilbertiodendron splendidum*, *Parkia bicolor*, *Treculia africana, Carapa procera* and scattered emergents of *Ceiba pentandra*. This habitat type is poor to moderately represented by SCC and includes the IUCN VU *Gilbertiodendron splendidum*, *Khaya anthotheca* and *Heritiera utilis* as well as some UGE species, such as *Aphanocalyx pteridophyllus, Gilbertiodendron splendidum* and *Callichilia subsessilis*.
Azonal Swamp Forest (not mapped)	This habitat type represents all areas that are either periodically or permanently inundated. This habitat is however, mostly disturbed due to artisanal mining and the canopy cover is mostly broken and relatively open. Typical swamp forest specialist species are associated with this habitat type include *Raphia* sp, *Symphonia globulifera*, *Ficus vogelliana* and *Xylopia parviflora.* This habitat type is poorly represented by SCC and includes the IUCN VU *Gilbertiodendron splendidum* and *Heritiera utilis* as well as a few UGE species, such as *Anthocleista nobilis* and *Raphia palma-pinus*.
Rivers	This River habitat type includes the two large perennial river systems. It consists of the smaller Yambasei River flowing from East to West in the northern extent- and the larger Lofa River flowing from East to West in the southern extent of the Ndablama prospecting are. This habitat encompasses the water column and the rocky or sandy shores
Streams	This habitat type includes all smaller perennial and ephemeral streams of the Ndablama Site of which three main sub-habitat types are distinguished. The distinction is based on stream Strahler order and slope (which determines flow speed) as follows: • High velocity mountain streams, which include fast flowing and narrow (Strahler Order 1) forest streams on steep topography (Slope degrees >6), usually situated near the top of the mountains/hills and often characterised by waterfalls/cascades; • Mountain streams, which include medium velocity flowing streams with medium width (Strahler Order <2) within High Wet Evergreen Forest and Tall Wet Evergreen Forest habitat types, periodically forming deep pools and occasionally having rocky/sandy shores; and • Lowland streams, which include slow flowing, broader (Strahler Order mostly 2-3) lowland streams usually forming tributaries to the larger river habitats and usually with a well-defined stream bank.

20.2.8 Avifauna

Approximately 254 bird species are expected to occur in the Ndablama Site which equates to 41% of the approximate 615 species listed for Liberia as a whole. Of the 254-expected species in this area, 208 (82%) were confirmed through these surveys and another 46 species are predicted to be present (based on suitable habitat) but were not observed during the surveys. In addition, 78% of Guinea-Congolian forest endemics in Liberia (c. 184 species) could also be present in the Ndablama Site. Of these, 128 species were confirmed in the Ndablama Site during the surveys.

The dominant bird species in the Ndablama Site are forest species that are prominent in most of the different habitat types, irrespective of the ecological condition of the habitat. These species are typical component of foraging mixed-species bird groups (often known as "bird parties"). Typical species in the Ndablama Site of the upper canopy are slender-billed greenbul (*Stelgidillas gracilirostris*) and collared sunbird (*Hedydipna collaris*), while typical species of the forest midstrata include little greenbul (*Eurillas virens*) and grey longbill (*Macrosphenus concolor*). Those species that are prominent in the understorey include olive sunbird (*Cinnyris olivacea*), green hylia (*Hylia prasina*) and blue-billed malimbe (*Malimbus nitens*). The dominant guild composition in the Ndablama Site consists of insectivorous and frugivore passerines which facilitate important ecological processes such as pollination (facultative pollinators), seed dispersal (frugivores) and the maintenance of invertebrate prey numbers (insectivores).

20.2.9 Mammals

Based on habitat suitability and previous records within the region, an estimated 145 mammal species may be expected to occur within the Ndablama Site. During the study, a total of 39 species were observed, with 26 species recorded in the dry season(D) and 32 species recorded in the wet season (W), representing 26% (total), 22% (W) and 18% (D) of the expected species respectively.

20.2.10 Herpetofauna

20.2.10.1 Amphibians

A total of 26 species were observed in the dry season and 31 species in the wet season, representing 39% and 46% of the expected species respectively. A total number of 36 amphibian species were observed in the Ndablama Site across both of the studies representing 54% of the expected species.

A clear distinction of amphibian assemblages was evident within the Ndablama Site. The various habitat associations are as follows:

- Rivers
- Marshes, disturbed ponds, artificial impoundments and disturbed streams
- High velocity mountain streams in evergreen forest
- Mountain streams in Tall Wet Evergreen Forest
- Lowland streams in forest
- Rain-filled depressions in evergreen forest on inselbergs.

20.2.10.2 Reptiles

A total of 11 species were observed in the dry season and 18 species in the wet season, representing 11% and 18% of the expected species respectively. A total number of 22 reptile species were observed in the Ndablama Site across both of the studies representing 22% of the expected species.

For reptiles, a less clear habitat-associated assemblage was evident compared to amphibians, predominantly due to the relatively low number of species and individuals observed during the surveys. Nevertheless, four main reptile assemblages were evident as presented below.

- Rivers
- Forest streams
- Dense forest
- Broken forest, low bush and thicket.

20.2.11 Aquatic Fauna

According to the Intermediate Habitat Integrity Assessment (IHIA) results, instream habitat integrity in the Lofa River reach is considered to be a Class A, or Natural, indicating the system is in a natural state. This is largely due to the large size of the Lofa system and its capacity to deal with anthropogenic activities such as artisanal mining, which was observed at numerous sites, and is directly modifying the river bed. These modifications are impacting on habitat quality and availability; however isolated and larger areas are not influenced. Riparian habitat within the Lofa River reach is considered a Class B, or largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. However, aerial imagery reveals clearing of riparian vegetation along the Lofa River reach. This will likely increase bank and channel modifications, leading to increased sedimentation and impact on instream habitat. The clearing of riparian vegetation will likely alter vegetation community structure and increase the presence of alien and invasive vegetation.

Riparian habitat integrity in the Yambasei River reach is considered to be a Class B, or largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. The largely natural state of the riparian zone is due to the isolated clearing of indigenous vegetation along the Yambasei system. However, increased human-related activity along the banks of the Yambasei is likely to increase modifications and decrease the state of the riparian zone.

Habitat integrity of smaller systems within the Ndablama Site range from natural to seriously modified. Serious modifications were observed in numerous systems within the Ndablama Site. These modifications were associated with intensive artisanal mining activities. Modifications to instream and riparian habitats include impacts on flow, bed, channel, water quality, indigenous vegetation, bank collapse and scouring, and large-scale sedimentation of instream habitat.

Several impacts within the Ndablama Site were observed during the field surveys which impact on the biodiversity of the area. These activities include:

- Slash and burn agricultural practices
- Unregulated charcoal production
- Unregulated logging/timber production
- Artisanal mining
- Erosion and sedimentation
- Water pollution of streams
- Alien and/or invasive species
- Vehicle Traffic and road kills
- Removal of natural vegetation from mining exploration activities.

20.2.12 Habitat Sensitivity

Each of the habitats was evaluated in terms of its sensitivity and importance. A sensitivity analysis was combined by assigning sensitivity scores for the Botany, Avifauna, Mammals and Herpetofauna. All the terrestrial disciplines considered the high and tall wet evergreen forest to be of very high sensitivity. A summary is provided in Table 20-8.

Table 20-8: Habitat sensitivity assessment

Description	Flora	Avifauna	Mammals	Herpetofauna	Aquatic fauna
High wet evergreen forest	Very High Sensitivity. This habitat type is therefore considered likely to be IFC critical habitat under Criterion 1, Criterion 2, and Criterion 4.	Very High Sensitivity. These two habitat types combined provides habitat for a high richness of species endemic to the Upper Guinea forest block, and therefore is considered to be IFC critical habitat under Criterion 2 and Criterion 4.	Very High Sensitivity. The Endangered West African Chimpanzee (*Pan troglodytes verus*) occurs within this habitat type which is listed as Endangered on the IUCN Red List of Threatened Species and therefore this habitat is considered to be IFC critical habitat under Criterion 1.	Very High Sensitivity. The endangered Ringed River Frog (*Phrynobatrachus annulatus*) occurs exclusively in this habitat type and therefore this habitat is considered to be IFC critical habitat under Criterion 1, Criterion 2 and Criterion 4.	
Tall wet evergreen forest	Very High Sensitivity. This habitat type is therefore considered to be IFC critical habitat under Criterion 1, and Criterion 2	Very High Sensitivity. It is therefore considered to be IFC critical habitat under Criterion 2.	Very High Sensitivity. The Endangered West African Chimpanzee (*Pan troglodytes verus*) occurs within this habitat type which is listed as Endangered on the IUCN Red List of Threatened Species and therefore this habitat is considered to be IFC critical habitat under Criterion 1	Very High Sensitivity. The endangered Ringed River Frog (*Phrynobatrachus annulatus*) occurs exclusively in this habitat type and therefore this habitat is considered to be IFC critical habitat under Criterion 1, Criterion 2 and Criterion 4.	
Tall/short forest mosaic	Medium to High Sensitivity.	Very High Sensitivity. It is therefore considered to be IFC critical habitat under criterion 2.	Very High Sensitivity.	Very High Sensitivity.	
Short broken forest, low bush and thicket	Medium to Low Sensitivity.	Low Sensitivity.	Medium to Low Sensitivity.	Medium to Low Sensitivity.	
Azonal riverine forest	Very High to High Sensitivity.	Very High Sensitivity.	Very High Sensitivity. As IFC critical habitat under Criterion 1.	Very High Sensitivity. Due to its association with streams and rivers which harbour herpetofauna Species of Conservation Concern, and the reliance of these species on the forest surrounding the streams, this habitat type is a very high sensitivity.	
Azonal swamp forest	Medium Sensitivity.	Medium Sensitivity.	Very High Sensitivity. Qualifies as IFC critical habitat under Criterion 1.	Medium Sensitivity.	

Description	Flora	Avifauna	Mammals	Herpetofauna	Aquatic fauna
Rivers and streams		High Sensitivity.			
High velocity mountain stream			High Sensitivity.	Very High Sensitivity. The endangered Sierra Leone Water Frog (*Odontobatrachus natator*) exploits this habitat type and therefore this habitat is considered to be IFC critical habitat under Criterion 1, Criterion 2 and Criterion 4.	Very High Sensitivity. This habitat is considered to be IFC critical habitat under Criterion 1, Criterion 2 and Criterion 4
Mountain stream			High Sensitivity.	Very High Sensitivity. It is the only habitat where the endangered Ivory Coast Frog (*Amnirana occidentalis*) was observed and therefore this habitat is considered to be IFC critical habitat under Criterion 1, Criterion 2 and Criterion 4.	These systems supported populations of *Epiplatys fasciolatus spp*. (excluding *Epiplatys fasciolatus zimiensis*) and the endangered *Scriptaphyosemion brueningi*. The critically endangered *Tilapia coffea* were collected at sites ND3 and ND17. Therefore, this habitat is considered to be IFC critical habitat under Criterion 1, Criterion 2 and Criterion 4.
Lowland streams and rivers			Very High Sensitivity. The Yambasei River and all the larger linked systems is considered to be IFC critical habitat under Criterion 1	Very High Sensitivity. The critically endangered African Slender-snouted Crocodile (*Mecistops cataphractus)* is known from the Yambasei River and therefore this habitat is considered to be IFC critical habitat under Criterion 1.	The Lofa system supported critically endangered species including *Labeo cf. curriei*, *Tilapia cessiana*, and *Tilapia coffea.* Due to the high diversity of fish collected, numerous species have not been identified and further investigation is required. Therefore, this habitat is considered to be IFC critical habitat under Criterion 1, Criterion 2 and Criterion 4. Given the dependence of these lowland aquatic systems on upstream ecosystem health including that of the catchment area, these habitats may also be considered as critical

20.2.13 Protected Areas

The Lake Piso Multiple Sustainable Use Reserve is located in the Robertsport area. the Bong Mountain National Park is located to the east, with the Kpo Mountains National Park located to the northeast of the proposed development.

No protected areas are located within the immediate vicinity of the Ndablama Resource Area.

20.2.14 Integrated Assessment of Baseline Environmental Conditions

20.3 Socio-Economic Baseline Conditions

This section provides a description of the socio-economic baseline conditions and context in the study areas within the BMMC tenement area.

20.3.1 General Overview

The study area is characterised by several small agricultural villages and artisanal mining communities, with a marked distinction between those found in the north and north-eastern sections, versus those in the central and western corridor. Settlements and towns in the north and north-eastern portions of the study area, notably the villages and communities of Ndablama, Silver Hills, Weaju, and Leopard Rock were documented as predominantly artisanal mining communities. On the contrary, others encountered in the central and western sections (with the exception of the New Liberty Gold Mine (NLGM) resettled communities) were observed to be small villages and hamlets with a heavy dependence on subsistence farming and agricultural activity.

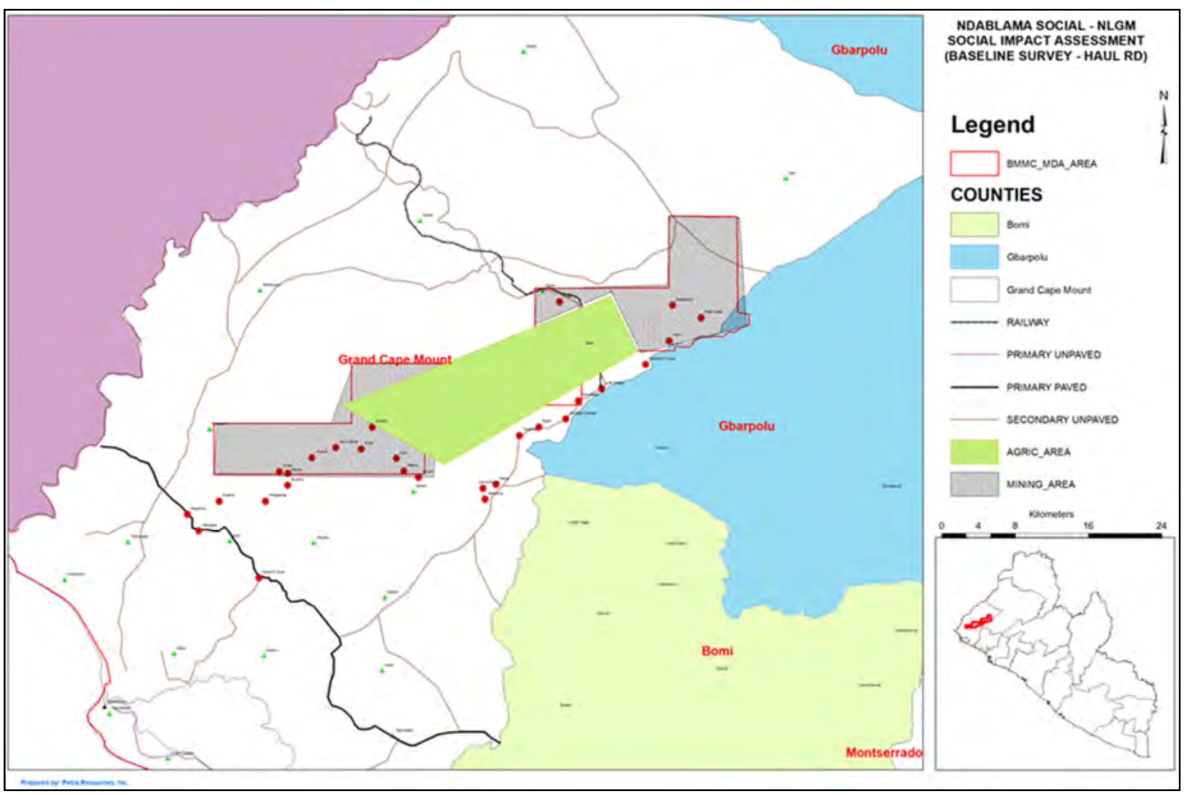


Figure 20-3: Map of study area showing mining and agricultural areas

The north and northeast areas have had a long history of artisanal mining activities which continue to this day as confirmed during the baseline survey. Some of the forest areas traversed during the exercise also reveal indications of ongoing logging and hunting activities for both domestic energy use, local construction, income-generation and household dietary consumption. Notably, the artisanal mining villages in the north and northeast were also identified to be predominantly inhabited by Sierra Leoneans from the nearby neighbouring country which forms the western border with Liberia, approximately 45 km north-west of the study area.

In the western sections of the study area, since the opening of the NLGM there has been an influx of people in search of job opportunities as many respondents in these areas were relatively recent migrants, however residents in the central portions have generally resided there for generations, maintaining their traditional farming livelihoods – often at a subsistence scale.

Mining prospects, however, have had the greatest impact on the immediate area, both artisanal mining and the exploration activities of BMMC. The area surrounding the existing New Liberty mining pit originally consisted of densely forested areas and small, rural villages supported by agricultural activities. Artisanal miners are thought to have entered the area in the 1960s and residents of New Kinjor informed the field team that the old town was established in 1970.

Consequently, the villages of Larjor and old Kinjor developed considerably in the last 10 to 12 years with the establishment of BMMC's predecessor's mine camp in 1998, attracting families with the promise of potential opportunities for formal and informal employment, and with ongoing artisanal mining prospects. New Kinjor has experienced significant growth, with many households moving in over the past six to seven years. More recently, a large proportion of households in Larjor migrated to New Kinjor, attracted by the employment opportunities of BMMC and the newly established social services and infrastructure New Kinjor has to offer.

BMMC has actively encouraged households in Larjor to voluntarily relocate to New Kinjor in line with the company's future mine plan developments. With the exception of exploration activities in the north–eastern section of the study area, no other significant private sector investments or industries were identified in the area. The central town of Tahnn, which is the district capital (Gold Konneh District), is unique for its cultural and administrative significance within the study area.

Tahnn is located relatively close to the artisanal mining town of Weaju (7.0 km), approximately 15.0 km from Ndablama, and serves as the commercial and trade hub in the study area. A rice processing mill for first-level value addition was identified in Tahnn, however not many rice farms were found nearby. Multiple traditional cultural heritage sites were also documented in and around the town, which is an indication of the town serving as the seat of the traditional – cultural leader. The town is also the seat of the Paramount Chief which is also the highest statutory and traditional administrative leadership.

The Gold Camp village is best described as a residential location for artisanal miners working in Ndablama and the immediately surrounding areas. The community was also found to host one of the two police stations found across the entire study area.

Leadership structures in the towns and communities across the study area were found to be distinct. All villages in the mostly artisanal mining areas in the northeast are headed by a Camp Master, except for Gold Camp which was reported to be headed by a town chief and assisted by a female town chief. This differs significantly from the agrarian-based villages in the central and western section, which were found to be headed by Town Chiefs.

The most common illness reported by respondents during the survey were colds and flu, malaria, and skin rashes, which were said to be common amongst children under 5 as well as adults. Only two clinics were identified within the study area, one located in the village of Tahnn and the other in New Kinjor. The services of these clinics are supported through a network of 11 Community Health Assistants (CHAs), individuals who are based in communities throughout the study area. The only traditional herbalist (Zoe[1] as known in the traditional customary and cultural norms of Liberia) was reported to be located in the town of Tahnn.

20.3.2 Population Demographics

The standardized questionnaire captured information on population demographics within the study area. Through semi-structured focus group discussions, the exercise was able to determine an estimated number of residents of each village within the study area, which were then further separated in gender demographics. The most populated towns and villages identified in descending order are New Kinjor (18,750), Gold Camp (6,000), Tahnn (4,900) and the Ndablama community (2,200). Populations of all other village were identified to be significantly smaller, with most not recording more than 200 residents.

The field data collection identified approximately 33,000 residents, with 61% being male, 30% female and 9% children – a mixture of both boys and girls.

20.3.3 Housing Infrastructure and Sanitation Services

Housing infrastructures in the study area are quite distinct, and artisanal mining sites in the north–east were found to be characterized by 'fly-camp' structures mostly constructed from tarpaulins and held together with sticks. In the more residential areas within the same region such as Gold Camp, most structures documented were constructed of mud bricks, and exterior plastering of cement for more rigidity, while covered with zinc roofing sheets.

Structures within the study area reflect this dependence on locally-sourced natural resources and the inability or lack of access to purchase more durable construction materials. Household structures were observed to have walls predominantly made of mud, crudely cut reeds and poles and roofs of thatch. Given the unprocessed and non-durable nature of these construction materials, they require frequent maintenance and upkeep, thus the majority of residential structures documented were said to be less than 10 years old.

20.3.4 Farming and Agriculture

Majority of the residents in the study area, particularly in the central and western sections are subsistence farmers, with the exception of New Kinjor and Jawaji, where many are contracted or employed by the company. The survey identified a total of 114 farms across the study area with mixed small crops and cassava accounting for the most commonly grown agricultural products. This also provides an indication of the typical nutrition intake and diet of nearby residents, which is heavily reliant on carbohydrates.

Data collected on specific farm crops being planted reflect that most are staple and supplementary food crops, with only a marginal number of cash crop farms identified. This further reinforces the agrarian and subsistence nature of much of the farming documented in the central and western regions.

Table 20-9: Planted crops encountered on these documented farms

Planted farm crops identified	114
Palm	2
Banana	4
Cassava	34
Orange	1
Pineapple	6
Plantain	14
Sugarcane	4

[1] *Zoe is the name giving to a traditional doctor or healer in Liberia – Zoes are thought to have special powers given to them by the* Gods and are often very powerful in the community leadership.

Planted farm crops identified	114
Rice	12
Mixed crops (ex: bitter-ball; pepper; corn)	35
Rubber	2

Respondents indicated that much of their crops are grown for domestic consumption, with some of the harvested crop sold to help offset the cost of production which includes land rental and labour support required for clearing and harvesting.

20.3.5 Health Services and Conditions

Access to formal health services are relatively limited within the study area, which hosts only two public clinics in New Kinjor and Tahnn, with no hospitals were identified. Patients and residents are often referred to a clinic through a network of 11 Community Health Assistants (CHAs), all stationed in various towns and villages, providing basic first-aid and first response before reaching the clinic. The survey exercise did not determine the training level, quality or capabilities of the CHAs or document the scope of services provided at the two clinics identified in the study area.

Patients that require hospital care are transported to St. Timothy's Hospital in Robertsport, approximately 60 km west of New Kinjor. The presence of a traditional healer/herbalist was also reported in the village of Tahnn. The most commonly reported ailments were colds and flu, malaria, and skin diseases (rashes) which were said to be common amongst children under five and adults. The survey exercise did not identify the potential source(s) of these reported illnesses.

20.3.6 Education

A significant majority of education facilities documented were elementary schools, both public and private, with private institutions often associated with nearby churches within the area. Only one high school was documented during the survey, located in the town of Tahnn, which also hosts the only post-secondary educational institution identified. The post–secondary institution was documented as a vocational training institute offering trade crafts and life skills to its students.

20.3.7 Livelihoods and Income

Limited educational attainment stagnates the potential for many residents of the local population to occupy semi-skilled and skilled positions within the formal sector. This further increases the competition for informal, temporary labourer opportunities with BMMC, often to support to exploration, mining and further development of camp areas. The relatively consistent availability of some casual labourer positions has had a significant impact on the livelihood activities in areas near New Kinjor and Jawaji, where contracting for BMMC is now the primary means of income. In contrast, livelihood activities in the towns and villages in the north and northeast, are almost exclusively artisanal mining or equally exclusively agriculture in the central and western villages of the study area.

In the artisanal mining communities, respondents indicated that the majority of the males work the fields as miners, while the females remain at home rearing the children or engaging in micro-scale subsistence farming to supplement household diets.

Other key livelihood activities identified included petty trading businesses which provide supplies and basic provisions to the mining areas as well as drinking bars, which double as entertainment centres. These provision shops and bars were documented to be owned and/or operated by both men and women.

20.3.8 Artisanal Mining

Artisanal miners usually work as daily hires and in groups (organised casual laborers), with mining licence owners or non-licence owners. While most of the miners identified were men, there were some women documented as directly involved in the actual mining activity. The artisanal mining process, mostly undertaken across the Ndablama area in the north, involves the digging of a pit/trench to an average depth of 20 m/65 ft. A water source is often needed to help wash the soil off the gold, a job usually assigned to the women found within the mines. Large tracts of land are degraded by these artisanal activities and often remain so as no environmental remediation or land reclamation is undertaken by the artisanal miners.

20.3.9 Small Business and Trade

In addition to artisanal mining and subsistence agriculture, half of the surveyed households run some form of micro/small business. These include the sale of farm produce including rice, vegetables, oil, and fish usually transported via motorbikes to these areas. There are cases where some of these goods are traded in value for gold – especially within the mining villages.

20.3.10 Culture, Heritage, Customs, Sacred Sites and Traditions

The population of the study area is divided between residents who practice both the Christian and Muslim faiths who live within the same communities. The exercise identified a total of 18 cultural heritage sites, which include burial grounds, traditional prayer grounds, Poro society[2] , and Sande society sites[3].

Table 20-10: Summary of sacred/cultural sites identified

Cultural/Heritage/Traditional sites	**18**
Burial grounds	8
Poro society	3
Traditional prayer site	3
Sande society	4

20.3.11 Belief Systems

Many of the inhabitants follow traditional/animist belief systems, however there is also a strong presence of both Christianity and Islamic faiths, with many respondents practicing a combination of both to varying degrees.

Most households in the agricultural villages were identified to retain more traditional, animistic values, despite the presence of both churches and mosques in the area. Many of the survey respondents indicated they practice animist forms of beliefs, however most also professed to be Muslims, likely indicating an actual practice of a combination and belief in both. The presence of a higher number of churches did not appear to genuinely reflect a reality of more Christians within the study area, rather they were explained by the approach of the proliferation of independent churches versus an increasing number of Christians.

20.4 Preliminary Assessment of the Environmental Impacts

The ESIA is currently being undertaken, with selected baseline studies completed to inform the engineering studies associated with the project. Studies are ongoing to quantify the environmental and social impacts associated with the proposed development.

20.4.1 Impact on the Geological Environment

Waste rock and ore will be drilled and blasted as part of the mining operations. The blast area and number of drillholes will determine the amount of dust emissions emanating from these activities. The deeper the

[2] Poro Society is the traditional male society it is considered a traditional heritage site totally not accessible to non-members; it dates back to before the founding of Liberia in 1847.

[3] Sande Society is the traditional female society it is considered a traditional heritage site totally not accessible to non-members; it dates back to before the founding of Liberia in 1847.

pit becomes, the lower the dust fallout rate and particulate emissions become. Air blast sound pressure is associated with mining operations where blasting is required. This is likely to be experienced by residents in the immediate proximity of the site. The impact is typically of short duration. Vibration levels experienced at surface are expected to be well below the levels at which structural damage could occur. Blasting can be controlled to some extent by using different blasting techniques that minimises the dispersion of dust.

Permanent, localised change in topography will occur due to the development of the open pit and mine residue deposits.

20.4.2 Soils and Land Use

The impact on land use will primarily happen during the construction and operational phases of the project.

Acquisition of land for the Project will cause economic displacement of local farmers and landowners. Disturbed land (including the WRDs, pit, mine services area, haul road and ancillary facilities) will be reclaimed wherever possible back to its original land use (primarily agriculture) or an agreed alternative land use.

Re-establishing farm fields in other areas will reduce the amount of other available land, potentially increase land values, and possibly increase pressure on undeveloped areas sources of agricultural land.

Local residents will be affected by temporary, and in some cases permanent, elimination of common property resources, including natural resources occurring in the Project area. Elimination of agricultural fields and subsistence produce could threaten food security and place increased pressure on vulnerable populations as well as women to fulfil their expected role within the household, while simultaneously reducing their ability to do so through reduced access to agricultural land. Conflict could arise from increased competition for productive land and common property resources.

In addition, concern has been raised over how compensation will be paid to local farmers and individuals who will lose crop-lands. There is concern this could lead to food insecurity, inadequate livelihood restoration and allegations of inadequate compensation payments.

20.4.3 Fauna and Flora

Clearing of vegetation during the construction and operational phase of the project will inevitably disturb the fauna habitat, shelter and food sources. The potential development of settlements along the major roads will result in increased crop cultivation and human-wildlife interactions due to animals raiding these food sources will also increase. The siting of infrastructure away from the natural habitat wherever possible, and progressive rehabilitation and reinstatement of disturbed areas could reduce the spatial scope and severity of the impacts.

The risk of accidents on the various access, haulage and construction roads, as well as increased human-wildlife contact due to improved access into the area, will increase. The potential development of settlements along the major roads could result in an increase in human-wildlife interactions due to animals raiding these food sources. The improved access to the Natural Habitat can also lead to increased hunting activities. Continuous environmental awareness raising, and training should aim at minimizing the impacts on fauna. This should also involve an induction training programme, where appropriate conservation principles, safety procedures, snake-bite avoidance and first-aid treatment are taught through the use of easy-to-understand study material. Designated staff must be trained to be able to safely capture and relocate potentially dangerous snake species.

Strict implementation of speed control measures, as well as warnings at animal crossings and along all access roads, could reduce the risk of incidents. All noise-generating activities should be mitigated to be within legal noise limits, and disturbance levels should be kept to a minimum and restricted to operational areas. Progressive rehabilitation and reinstatement of disturbed areas could assist in reducing the spatial scope and severity of the impacts.

General waste management on site has the potential of attracting not only scavenging indigenous fauna, but also alien species. They can furthermore also be introduced by vehicles moving in and out of the site.

The development of various mine access, construction and haul roads, the siting of containment facilities such as the WRDs, as well as the construction of the open pit, will result not only in the loss of flora species and habitat, but also the secondary impacts of fragmenting/splitting habitats and loss of biodiversity.

The impact of the loss of biodiversity and habitat fragmentation will thus be permanent in certain areas. The severity of the impact is moderately significant, the spatial scope area specific. With proper mitigation measures, the overall post-mitigation impact significance can be reduced.

The current layout affects some critical habitat to the south of the pit. A biodiversity offset will be considered as per the requirements of the Mitigation Hierarchy in Performance Standard 6 of the IFC's Performance Assessment, if the design cannot be changed to avoid affecting the critical habitat. This offset will be aligned with the current Biodiversity Management Plan that is currently in place.

20.4.4 Terrestrial Ecology

The development will require the removal of undisturbed vegetation from areas earmarked for infrastructure placement. The impact is expected to be of a moderate to high significance and limited to the project site. With careful infrastructure planning and continuous rehabilitation, the impact significance will be reduced.

20.4.5 Aquatic Environment

The impacts of sediment deposition could affect aquatic habitats downstream of the proposed development. The proposed development may lead to an influx of work-seekers into the area, and this is likely to increase the pressure on aquatic resources because of increased harvesting of aquatic resources, clearing additional land for cultivation, increased abstraction, sanitation, washing, etc.

The proposed haul road between Ndablama and NLGM will cross several aquatic ecosystems. The impacts at each crossing are expected to have a small footprint, but the cumulative impacts of multiple crossings will have a larger footprint, which was rated as "local" in terms of the scoring system used to assess impacts.

20.4.6 Ecosystem Services

The Liberian forests provide essential ecosystem services such as:

- Fertile soil for agriculture
- Flood control
- Medicinal plants
- Food and protein sources
- Stable and consistent supply of water

The local community relies on the ecosystem services available them for economic activities as well as the provision of food. The proposed development is expected to have a limited impact on the ecosystem services in the area to be affected, as the area is currently used for exploration activities as well as artisanal mining.

20.4.7 Air Quality

PM and gaseous emissions will be released during the construction, operational and decommissioning phases of the project. Only the operational phase air quality impacts were quantified since construction and decommissioning phase impacts will likely be similar or less significant than the operational phase impacts. The significance of construction-related inhalation health impacts is considered low. Since fugitive dust from construction activities is easily managed, the significance of its impact could be reduced to very low if the management and additional mitigation measures recommended in the EMP are implemented effectively.

The cumulative impacts as a result of the baseline/pre-development air quality and construction operations are likely to be low to medium.

During the operational phase, vehicle entrainment of dust from unpaved roads is expected to contribute most notably to PM emissions. Stack releases will contribute most significantly to diesel particulate matter (DPM), SO_2 and NOx emissions. Vehicles contribute the most to CO and volatile organic compounds (VOC) emissions.

The GHG emissions from the project are not likely to result in a noteworthy contribution to climate change on its own.

20.4.8 Environmental Noise

The increase in noise levels at nearby communities are expected to be limited and complaints are not expected. Noise impacts on the local wildlife is discussed in Section 2.6.6.

20.4.9 Blasting and Vibration

The estimated vibration levels are based on waste blasting, which will generate the highest ground vibration amplitudes because the holes will be deeper than those applied to ore blasting and will, therefore, contain a larger bulk of explosives per hole. Vibration amplitudes will depend on the initiation system used and the design applied by a blasting engineer. With proper mitigation measures, the blasting engineer will be able to control the vibration amplitudes so that they are lower than 7.5 mm/s at any building or structure. The project is, therefore, unlikely to impact neighbouring buildings and structures and the impact is, therefore, considered to be negligible.

People living downwind of the opencast operation will be more negatively impacted by air blast levels than other people around the mine. Very effective mitigation measures are available to contain air blast levels thus making the negative impact significance Medium-Low with these measures in place. To achieve low negative impact significance, air blast levels need to be kept below 125 dB at any point of concern for all blasting operations.

The negative impact of fly rock will be most severe for structures and people within 500 m of blasting, but with mitigating measures in place, there will be no impact at distances further than 500 m and a low impact at distances between 100 m and 500 m from blasting. The mitigation measures require special control on stemming and clearing of people in the zone closer than 500 m to blasting.

Dust and fumes from blasting will be carried downwind from the blasting areas. Fumes (mainly nitrous oxides (red in colour) and carbon monoxide) disperse very quickly into the atmosphere, and will not pose a risk to people or animals at distances greater than approximately 1,000 m. At distances closer than this, there is a risk to people's health, and this will fall into the occupational health category.

20.4.10 Archaeology and Heritage

The proposed development is not expected to directly impact any of the heritage or archaeological sites, provided that the mitigation measures are implemented effectively.

20.5 Preliminary Assessment of the Socio-Economic Impacts

20.5.1 Socio-Economic

The following potential social and economic impacts have been identified as part of the assessment and will be confirmed and assessed as part of the ESIA for the project:

- Migration and urbanisation.
- Increase in social tension/conflict.
- Loss of cultural cohesion and traditional customs and structures.
- Economic displacement. The loss of gold washing areas in the Ndablama area the impact is considered significant, especially in the areas directly affected by the mine infrastructure and associated facilities. While the artisanal miners do not have a legal right to mine in the Ndablama area, the development of the pit and associated WRD will prevent future access to the current workings. It is anticipated that the majority will relocate to nearby areas not currently earmarked for development.
- Loss of agricultural resources: Along the haul route some cultivated fields and plantations may be affected during the construction phase. The impact is considered limited, provided that mitigation measures are implemented.
- Degradation of conditions of access to natural resources.
- Inequalities in socio-economic structures.
- New economic opportunities.
- Diseases and the risk of transmission of HIV/AIDS.
- Opportunities available via the community development plant.
- Erosion of the traditional culture and loss of identity.

20.5.2 Employment and Economy

The primary socio-economic impacts associated with the Project will be positive in that residents of the study area and the region will be offered employment opportunities during the construction phase, while currently employed persons will continue to be employed at NLGM due to the extended life of the mine. This will translate into an improved standard of living for those hired and their families, which could in turn improve local health and education through increased spending on both, as well as improve the status, skill and experience for those hired.

National, regional and local businesses and contractors will benefit both directly and indirectly from Project-related construction and operational activities due to purchase of goods and services. Increased incomes and profits of local businesses and major suppliers for purchase of goods and services manufactured and supplied in Liberia will be realised. This increased revenue to local businesses will in turn contribute positively to the local economy through expanded local employment, increased disposable incomes, and growth in the local consumer base.

The Employment policy and practices by BMMC are governed by the prevailing and applicable laws and regulations of the Republic of Liberia. The focus of the employment policy and practice is to maximise the recruitment of local Liberian Nationals with the skills and capabilities that match the requirements of the positions within the approved company structure of BMMC at all levels of employment.

It is only after exhausting both avenues of sourcing Liberian skills at local, regional and national levels that BMMC will then consider the option of expatriate recruitment and employment, within legal requirements in the country, including providing details of ongoing and planned recruitment and training of Liberians to replace those expatriates who would have been employed.

20.5.3 Training and Education

Project development has the potential to provide increased availability and opportunity for a wide range of skills development and job training, particularly for women and local youth. Job opportunities made available to women could increase the health and well-being of families in general. The CDP will improve local education through direct support/improvements made to school facilities and may also positively impact school enrolment, attendance and completion due to increased household income (for school fees) and student anticipation of future employment. These impacts will continue for the construction, operational, decommissioning and post closure phases of the project.

20.5.4 Population Influx, Inflation and Increase In Crime

The social and economic pressures of population growth will continue as additional people move to the area to find employment and require accommodations and community services (particularly during construction). The influx of people in search of jobs associated with Project development is expected to be limited, provided that mitigation measures are implemented.

20.5.5 Disadvantaged and Vulnerable Groups

Within the Project area, the most marginalised or vulnerable groups will be those whose access to land has been impacted, as well as those who have to purchase a large percentage of their foodstuffs and rent accommodation (e.g. civil servants, pensioners, the poor, etc.). Some women, for whom access is dependent upon a husband or male family member owning land, could also be classified as vulnerable. In addition, where men will be lost to the family's agricultural activities because of mine employment, food security could be threatened, increasing vulnerability of this group. Youth, who will not gain compensation for loss of land but will not have future access to land that is their inheritance, will also be considered a vulnerable group.

20.5.6 Resettlement, Economic Displacement and Impact On Agricultural Resources

The development will result in the economic displacement of some artisanal miners that are currently working within the development footprint and associated safety buffer. Farmers whose agricultural assets are affected will be assisted with the obtaining of alternative land to work as well as provided with compensation for the loss of the agricultural assets and cash crops.

An asset survey identified a number of facilities and structure along the haul route corridor that need to be taken into consideration during the detail design and alignment of the haul route from Ndablama to NLGM. The following social, agricultural and heritage sites were identified along the route:

- Seven dwellings
- 32 farms
- Three sacred sites and one burial ground
- One soccer field and one town hall
- Two villages
- 11 water access points
- Two worship sites (one church and one mosque).

It is anticipated that the detailed engineering alignment will avoid all structures and dwellings, while mitigation will be required for agricultural and social facilities that cannot be avoided.

The proposed pit, WRD, mine services area and associated infrastructure is expected to primarily impact artisanal mining activities and associated infrastructure.

The main facilities identified within the development footprint area and associated buffer include:

- Pits with associated mini-crushers

- Gold washing facilities in the local drainage lines
- Temporary Shelters constructed from wood and tarpaulin
- Hand dug wells
- Cultivated fields.

Mitigation will be undertaken in terms of the relevant Liberian legislation, which includes the following key elements:

- Determining eligibility for compensation and resettlement assistance, including livelihood restoration initiatives.
- Approach to land access and management.
- Establishing rates of compensation. Standard compensation rates (set by the Government) will be used for agricultural crops and trees.
- Establishing mechanisms to resolve grievances among affected persons related to compensation and eligibility.

International best practice guidelines will also be taken into consideration during the detailed planning and implementation phases, which include the IFC's Performance Standards and the World Bank Group's Operational Policies.

20.5.7 Government Revenue and Royalties

During all phases of the project payment of dividends, tax on taxable income, royalties and surface rent will contribute to the fiscus. These contributions are expected to improve the financial capacity of the government to improve community infrastructure and service delivery in the district. The rates that apply include the royalty rate of 3% of net revenue and a corporate tax rate of 25%.

BMMC will also contribute to community development as per the Community Development Plan that will last beyond the life of the Project.

20.5.8 Community Wellbeing and Expectations

The Project area is made up of a combination of agriculturally-based rural society as well as a newly established artisanal mining community. Local social systems and structures have evolved over generations and have responded dynamically to the changing social environment.

The influence of the Project on the various intra- and inter-settlement social systems and structures will likely be experienced in a number of ways. Kinship relationships as well as economic and social sharing of resources are common, providing support (emotional and practical) between residents of the Project area.

Rapid change associated with the Project, including the potential for reduced emotional well-being and social disruption (due to direct and indirect effects of population influx) could increase local social problems including prostitution, teenage pregnancy, alcohol and drug use, domestic violence, and crime.

20.5.9 Socio-Economic Sustainability Post Closure

National and international experience shows that mining communities, such as that will be created by the Project, are vulnerable to socio-economic contraction after mine closure. Negative impacts include loss of employment, decreased demand for goods and services, out-migration of community residents, and potential for reduced community well-being. Many of these impacts are unavoidable, but mitigation measures can reduce the severity, such as proper planning and scheduling, skill transfer and alternative skills development projects, severance packages, and local alternative economic development.

20.5.10 Community Health and Safety Aspects

20.5.10.1 Health and Safety

Malaria

Malaria is the most frequently occurring disease in the study area. Project-related water storage features, including the pit lake and diversion structures may lead to increased malaria in the area, thereby increasing the risk of infection within local communities and Project accommodation camps. Through the implementation of the National programmes an effective malaria control programme will significantly reduce the Malaria contraction rate in the area.

Ebola

On 29 March 2016, the WHO lifted the Public Health Emergency of International Concern (PHEIC) status on West Africa’s Ebola situation. The impact this epidemic had on the world, and particularly West Africa, is significant. A total of 28,616 cases of Ebola Virus Disease (EVD) and 11,310 deaths were reported in Guinea, Liberia, and Sierra Leone. There were an additional 36 cases and 15 deaths that occurred when the outbreak spread outside of these three countries. While the spread of EVD in West Africa has been controlled, additional cases may continue to occur from time to time. However, because of ongoing surveillance and strengthened response capabilities, the affected countries now have the experience and tools to rapidly identify cases and limit the spread of the disease.

HIV/Aids

The incidence of HIV/AIDS and other Sexually Transmitted Diseases (STDs) could increase as a result of in-migration of workers seeking employment. Outbreaks of tuberculosis (TB) can be facilitated by crowded housing conditions and therefore pose a risk for both employees and community members. A similar situation is true for acute respiratory infections.

Soil, Water and Sanitation Related Diseases

The prevalence of soil-, water- and waste-related diseases depend on sanitation facilities and access to safe drinking water. In Gold Camp, water is sourced mainly from boreholes and wells within the area. The Focus Discussion Groups indicated that most residents in the area make use of traditional latrines.

Road Accidents/Spills

BMMC will transport material and equipment to and from the site via road. The route from Monrovia passes through numerous small communities along narrow, unpaved roadways; posing a potential risk to pedestrians and local traffic. Spills or accidents that may occur while transporting chemicals and hydrocarbons from either port could have an impact on human health and the environment, depending on the location and timing of the spill. Transport of cyanide to the existing NLGM to process ore from Ndablama will continue to be undertaken as per the requirements of the International Cyanide Management Code.

Social Determinants of Health

It is likely that there will be considerable in-migration as a result of the Ndablama deposit. The impact of such population influx will be felt in areas such as accommodation, overcrowding, health and social services, food-pricing and availability and other socio-economic areas.

Traffic

Traffic and congestion on local public roads will increase as Project development progresses. Placement of Project infrastructure will require some local residents to travel greater distances, less than 2 km to avoid mine operations. In addition, local residents, particularly children, lack safety awareness particularly related to road/truck traffic. In summary, safety risks to vehicles and pedestrians will be increased.

Pit Lake Hazards

The formation of a pit lake after mine closure could pose a public safety risk if not mitigated properly. A berm and warning signs will be established around the pit perimeter while the steep slopes above the final water level will be shaped to avoid dangerous slopes. The pit lake will be considered for incorporation into the community development initiatives.

20.6 Mine Water Management

20.6.1 Introduction

The key objective of the mine water management study is to develop an appropriate level of understanding of the hydrology, hydrogeology and water management aspects of the New Liberty Combined Project.

The investigations and assessments completed for this study focussed on the key hydrological and hydrogeological aspects of the project relating to:

- The prediction of inflows into the proposed open pits and underground mine for use in the development of appropriate dewatering/depressurisation strategies
- The development of appropriate surface water management strategies.

20.6.2 Site Investigations

A significant amount of information on the hydrology and hydrogeology at the New Liberty mine site was collected, collated and analysed in support of previous studies completed for the New Liberty open pits between 2011 and 2014, at which time comprehensive water monitoring programmes were established and water monitoring was initiated. Hydrological/hydrogeological investigations completed predominantly in 2013 included:

- Drilling and installation of 13 groundwater test drillholes
- Drilling and installation of 18 groundwater monitoring drillholes across the New Liberty mine site
- Drilling and installation of one groundwater drillhole intersecting the dolerite dyke in the TSF area
- Hydraulic testing of drillholes
- Groundwater quality sampling and laboratory analysis
- River level and flow monitoring
- Surface water quality sampling and laboratory analysis.

Based on a comprehensive review of the available existing hydrological and hydrogeological data, it was concluded that only limited additional field investigations were required at the New Liberty Mine for the purposes of the New Liberty Combined PFS project. A site visit to the New Liberty Mine was completed by Paul Heaney, Principal Hydrogeologist between 11 November 2018 and 19 November 2018. Additional field investigations associated with the proposed New Liberty underground mine were completed during this site visit.

The hydrogeological investigations associated with the Ndablama pit were completed by Future Flow Groundwater & Project Management Solutions as part of the ESIA for the Ndablama pit and the Ndablama haul road study. The Ndablama Gold Mine EIA/EMP Study Groundwater Study (February 2019), which details the hydrogeological investigations completed and the findings of the works, should be read in conjunction with this report.

20.6.3 Surface Water Catchments

The landscape of the New Liberty Combined Project comprises a complex network of closely spaced rivers, most of which have narrow and discontinuous floodplains. Both the New Liberty and Ndablama deposit areas ultimately drain to the Lofa River to the south of the project areas. The Lofa River flows in a south westerly direction towards the coast, with the estuary located approximately 40 km north of Monrovia. The Ndablama pit intersects a ridgeline between watersheds, the surrounding topography is steep with slopes typically between 10% and 30%.

20.6.4 Precipitation

There is a limited amount of meteorological data available for Liberia. The Liberia Hydrological Service (LHS) is responsible for the collection of meteorological statistics. There were 47 meteorological stations in Liberia before the outbreak of the civil wars (1989–1996 and 1999–2003), although the previously collected historical data has many gaps. Some of these stations had a significant historical record, for example the Ganta station records date back to 1927. The stations were operational until 1989, however, subsequent to this no new records have been compiled. All the meteorological stations were destroyed during the civil wars, except for one in western Liberia.

A weather monitoring station was installed at the New Liberty site in 2011 and at the Ndablama site in 2013, rainfall data up to November and September 2018, respectively, for each of the sites was used in this study. There are four full calendar years of data during which the rainfall records at the New Liberty and Ndablama sites overlap. In 2014, the annual rainfall recorded at Ndablama was greater than that recorded at New Liberty; however, for 2015, 2016 and 2017 the annual rainfall recorded at Ndablama was less than that recorded at New Liberty.

The monthly rainfall totals from the rainfall data available for both New Liberty and Ndablama are presented in Figure 20-4.

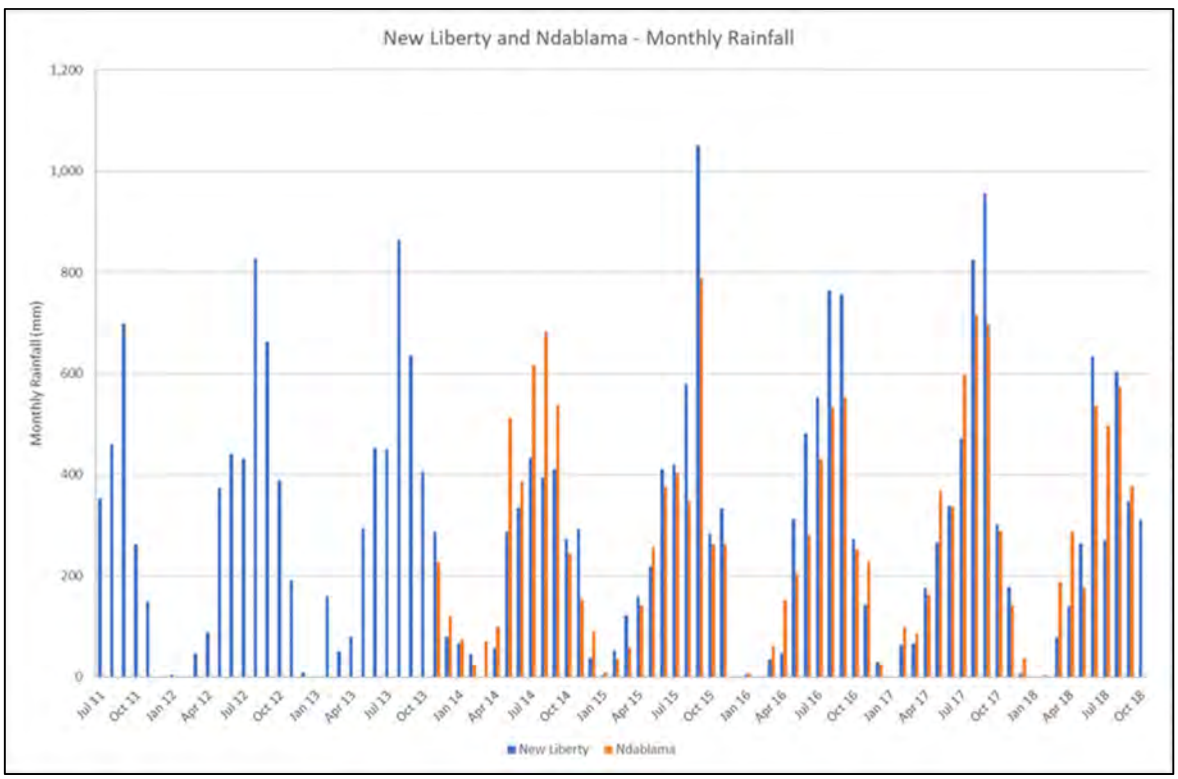


Figure 20-4: New Liberty and Ndablama – monthly rainfall
Source: CSA Global, 2018

The annual rainfall patterns are similar at the New Liberty and Ndablama sites. The rainfall totals are typically similar at the two sites, but generally lower at Ndablama than at New Liberty, except for 2014, when the recorded annual rainfall at New Liberty was lower than Ndablama and was approximately only 75% of the average annual rainfall from the other recorded years at New Liberty.

Precipitation analysis was undertaken on the available site data in order to develop representative annual precipitation for normal, wet and dry years as part of the ESIA for the Ndablama pit and haul road study and is captured within the Surface Water Quantity Assessment completed by Peens & Associates. A similar assessment was undertaken by CSA Global for the New Liberty rainfall data set.

The mean monthly and annual average rainfalls for normal, dry and wet years estimates for the New Liberty and Ndablama sites are presented in Table 20-11 and Table 20-12 respectively.

Table 20-11: New Liberty mean monthly and annual rainfall for normal, dry and wet years (mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean	19	64	66	101	292	410	444	673	739	313	225	27	**3,372**
Dry	4	46	49	69	276	374	429	555	658	273	172	8	**2,913**
Wet	11	61	69	124	303	447	454	824	796	319	287	34	**3,730**

Table 20-12: Ndablama mean monthly and annual rainfall for normal, dry and wet years (mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean	23	40	69	139	335	345	512	570	644	262	196	38	**3,173**
Dry	6	23	61	138	251	330	427	515	551	252	153	22	**2,729**
Wet	35	42	72	153	382	376	599	687	707	265	231	42	**3,592**

20.6.5 Short Duration Design Rainfall

Depth duration frequency analysis was undertaken for the Ndablama site as part of the Surface Water Quantity Assessment, and the estimated rainfall depths for a range of storm return periods and durations are presented in Table 20-13.

Table 20-13: Depth duration frequency – Ndablama

Rainfall (mm)	Return period (years)						
Duration	**2**	**5**	**10**	**20**	**50**	**100**	**200**
6 minutes	29	38	46	55	68	79	93
15 minutes	31	40	49	57	71	83	97
30 minutes	33	43	52	62	77	90	105
1 hour	38	49	60	71	88	103	120
2 hours	47	61	74	88	109	127	149
3 hours	55	72	87	104	128	150	175
4 hours	63	83	100	118	147	171	200
5 hours	70	92	111	132	163	191	223
6 hours	77	101	122	144	179	209	244
8 hours	89	116	140	166	206	240	281
10 hours	98	128	155	184	228	266	311
12 hours	105	138	167	197	245	286	334
18 hours	117	153	185	219	272	317	371
24 hours	120	157	190	225	279	326	381

Short duration storms rainfall depths were estimated for the New Liberty site by CSA Global by applying the same ratios to the 24-hour storm event rainfall depths as used for the Ndablama assessment and are presented in Table 20-14.

Table 20-14: Depth duration frequency – New Liberty

Rainfall (mm)	**Return period (years)**						
Duration	**2**	**5**	**10**	**20**	**50**	**100**	**200**
6 minutes	35	32	55	65	79	91	105
15 minutes	37	33	58	68	83	96	110
30 minutes	40	36	63	74	90	104	119
1 hour	46	41	72	84	103	118	136
2 hours	57	51	89	104	127	147	169
3 hours	67	60	105	123	150	173	199
4 hours	76	68	120	140	171	198	227
5 hours	85	76	134	156	191	220	253
6 hours	93	83	146	171	209	241	277
8 hours	107	96	168	197	240	277	319
10 hours	118	106	186	218	266	307	352
12 hours	127	114	200	234	286	330	379
18 hours	141	127	222	260	317	366	421
24 hours	145	130	228	267	326	376	432

The rainfall depths presented in the depth duration frequency tables for Ndablama and New Liberty have been adopted for mine water management design.

20.6.6 Hydrogeology

20.6.6.1 New Liberty

Hydrogeological Units

The following key hydrogeological units have been identified in the New Liberty project area:

- Saprolite/saprock: Generally, highly permeable comprising weathered bedrock and unconsolidated sediments. The thickness of this unit varies considerably over the project area which restricts the development of regional groundwater flow paths.
- Orebody/Silicified Metamorphosed Ultrabasic Suite (SMUS): Highly productive fractured bedrock.
- Hanging Wall/Footwall Complex: Predominantly low productivity fractured bedrock with localised areas of moderately higher permeability where water bearing fractures are present.
- Fractured Hanging Wall/Footwall Complex: Moderately productive fractured bedrock which is directly affected by structural deformation.

Hydraulic Parameters

Hydraulic parameters for the bedrock at New Liberty have been derived from the extensive hydraulic testing completed during the hydrogeological field investigation programme completed between February and July 2013 and additional hydraulic testing of three new hydrogeological drillholes completed in November 2018.

The hydraulic parameters derived from the 2013 hydrogeological field data were subsequently validated during subsequent groundwater model calibration and the comparison of model predicted and actual observed groundwater levels.

Hydraulic Conductivity

The range of hydraulic conductivity values derived from the hydrogeological field investigations are presented in Table 20-15 with the derived hydraulic conductivity values grouped according to the hydrogeological unit. A review of the hydraulic parameters was completed using both the 2013 and 2018 data in order to derive appropriate values to be adopted as part of New Liberty Combined PFS, the adopted hydraulic conductivity values are also presented in Table 20-15.

The hydrogeological drillholes drilled in 2018 extend significantly deeper than the previously drilled 2013 hydrogeological drillholes and thus the parameters derived from the hydraulic testing of these drillholes was deemed representative of the hydraulic units present at greater depths (i.e. those to be intersected by the proposed new underground mine).

The hydraulic conductivity values derived from the 2018 hydraulic tests are lower than those derived from the earlier hydraulic tests and this suggests that the hydraulic conductivity generally decreases with depth.

Table 20-15: New Liberty hydraulic conductivity values

Hydrogeological unit		Observed hydraulic conductivity range (m/s)	Adopted hydraulic conductivity (m/s)
Saprolite/Saprock		$7 \times 10^{-5} – 4 \times 10^{-7}$	5×10^{-6}
Orebody/SMUS	Upper Horizons (2013 testing)	$9 \times 10^{-6} – 8 \times 10^{-7}$	2×10^{-6}
	Lower Horizons (2018 testing)	$2 \times 10^{-7} – 5 \times 10^{-9}$	3×10^{-8}
Hanging Wall/Foot Wall Complex		$1 \times 10^{-8} – 9 \times 10^{-9}$	5×10^{-8}
Fractured Hanging Wall/Foot Wall Complex		$4 \times 10^{-6} – 5 \times 10^{-8}$	5×10^{-7}
Marvoe Creek Fault Zone		No direct testing	5×10^{-6}

Aquifer Storage

Aquifer storage values have previously been derived based on data from the 2013 field testing program, previous experience and literature values of similar West African formations. The derived aquifer storage values are presented in Table 20-16.

Table 20-16: Representative aquifer storage values

Hydrogeological Unit	Storage Coefficient	Specific Yield
Saprock	0.002	0.02
Orebody/SMUS	0.000012	0.002
Hanging Wall/Foot Wall Complex	0.000012	0.002
Fractured Hanging Wall/Foot Wall Complex	0.000012	0.002
Marvoe Creek Fault Zone	0.002	0.02

Groundwater Levels and Flow Direction

Approximately 12 hydrogeological drillholes were drilled in 2013 within the footprint of the current combined New Liberty pit development. The static water level in these drillholes was generally between 0.5 m and 5 mbgl, with deeper levels of 10–20 mbgl recorded in more elevated areas.

Groundwater level monitoring has been completed in 15 groundwater monitoring drillholes across the New Liberty mine site during 2013–2014 (pre-mining) and 2017–2018 (ongoing mining). The locations of the water monitoring wells are illustrated in Figure 20-5 and the measured groundwater levels are presented in Figure 20-6.

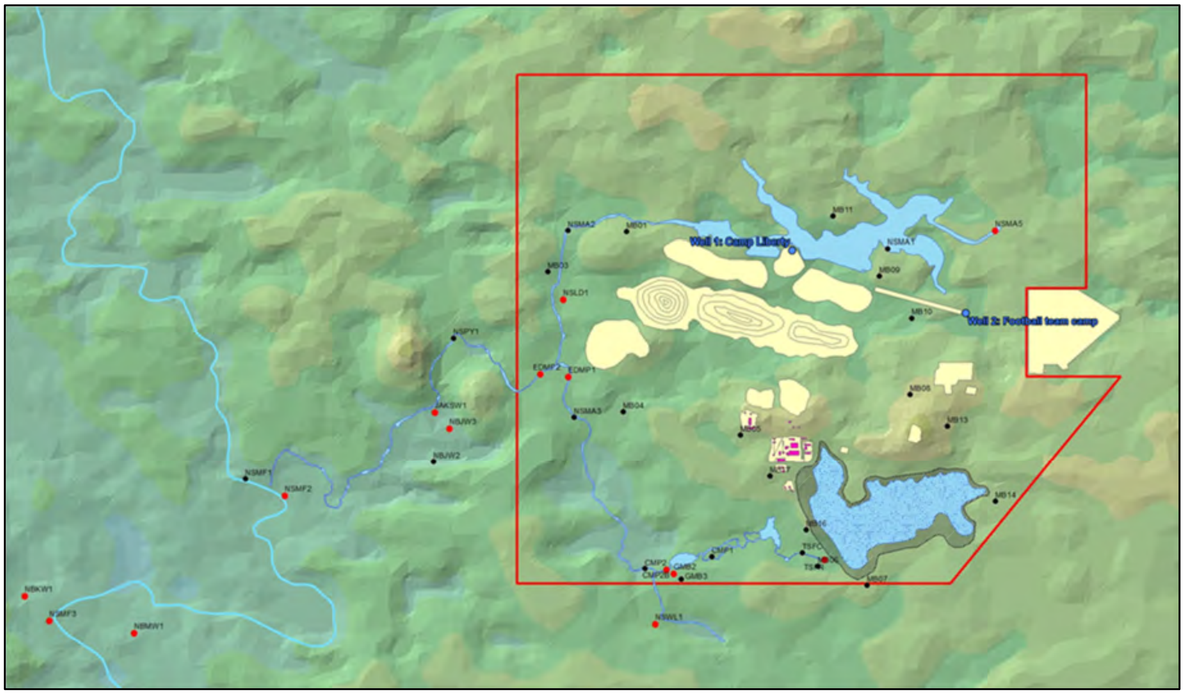


Figure 20-5: New Liberty groundwater monitoring locations

Source: CSA Global, 2018

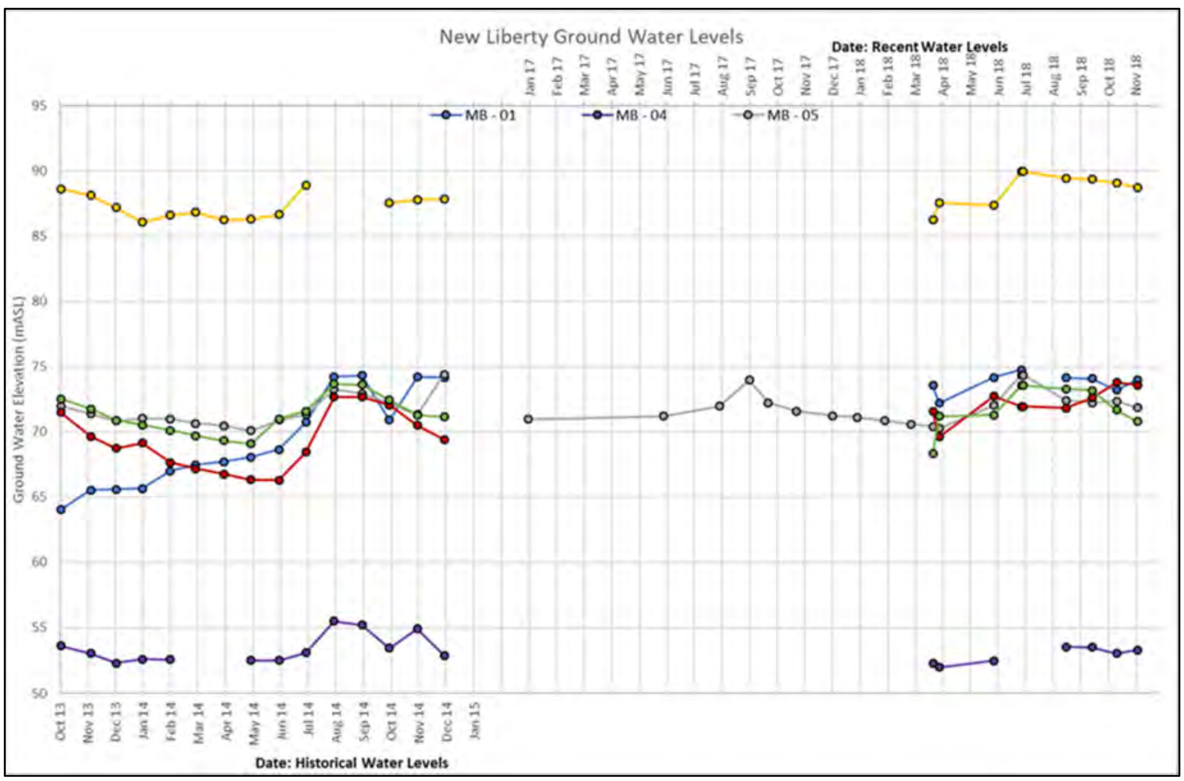


Figure 20-6: New Liberty groundwater levels

Source: CSA Global, 2018

Groundwater monitoring indicates that the groundwater level in these holes is generally less than 10 mbgl, which corresponds to relative water levels generally within the 65–75 mRL range. Two outliers occur, MB08 with water levels in the 85–90 mRL range (located within an elevated interfluve area) and MB04 with water levels in the 50–55 mRL range (located within a low-lying valley area).

The groundwater levels appear to fluctuate seasonally with higher levels recorded during the rainy season and lower levels during the dry season. The commencement of mining and associated pit dewatering does not appear to have significantly impacted groundwater levels in any of the current groundwater monitoring drillholes. However, there is currently no groundwater level monitoring within approximately 400 m of the pit.

Groundwater level measurements in the three new holes drilled within the current New Liberty pit development indicate that the groundwater level is less than 3 m below ground surface at each of the three locations. There is a large variation in the relative water levels in the three newly drilled holes:

- Larjor drillhole – groundwater level is approx. +22 mRL
- Kinjor drillhole – groundwater level is approx. -3 mRL
- Marvoe drillhole – groundwater level is approx. +28 mRL.

The groundwater levels observed in the newly drilled drillholes are significantly higher than the adjacent pit floors. This suggests that the bulk rockmass within the pit area is saturated, has poor hydraulic interconnectivity and has a low hydraulic conductivity as the saturated rock mass is not draining into the adjacent lower pit areas. It also suggests that saturated pit walls exist at some locations within the current New Liberty pit development.

The groundwater table is generally a subdued reflection of the surface topography, with the available data suggests that pit dewatering has not significantly impacted groundwater levels in any of the current groundwater monitoring drillholes. The regional groundwater flow appears to be predominantly to the west with groundwater flows generally occurring in the direction of the main surface water features (especially the Marvoe Creek), indicating that groundwater is discharging into the main river channels in the area. It is likely that there will be a localised impact on groundwater levels adjacent to the pit as a result of the ongoing pit dewatering.

Groundwater Quality

There is a significant amount of historic groundwater quality data available for the New Liberty Mine. Groundwater quality has been derived from a network of exploration and groundwater monitoring drillholes at intermittent times since commencement in 2011. Groundwater quality samples were collected and analysed from the three new drillholes drilled as part of the field investigation in November 2018.

Groundwater quality data from 2013 suggested that pre-mining the groundwater was generally of a good quality, although acidic with occasionally elevated metals concentrations (typically iron, aluminium, arsenic and lead).

The laboratory results for the groundwater samples collected from the three new drillholes drilled in 2018 were compared to the World Health Organisation (WHO) water quality guidelines and the Liberian water quality guidelines. The samples were submitted to ALS, which is an ISO17025 accredited laboratory located in the Czech Republic, for analysis. Concentrations of arsenic and mercury in exceedance of the WHO drinking water and Liberian water quality guidelines were detected in all three samples. Exceedances of WHO guidelines were also detected in at least one of the samples for aluminium, antimony, chromium, iron, nickel, sodium, nitrate and sulphate. The concentration of potassium exceeded the Liberian water quality guidelines in all three samples collected and analysed.

Groundwater Recharge and Discharge

Groundwater recharge occurs primarily as direct percolation of rainfall into the underlying bedrock. The intense nature of rainfall at the site results in a significant amount of runoff as the rainfall intensity is greater than the infiltration capacity of the bedrock. A higher recharge rate will occur through the saprolite/saprock layer than can ultimately percolate through to the lower permeability bedrock below. As result it is expected that shallow groundwater flows horizontally through the weathered rock (saprolite/saprock) layer and discharges to surface water bodies (as noted in shallow near surface inflows into the current open pits at New Liberty.

Recharge in the vicinity of the rivers can be limited due to the shallow water table, which results in potential recharge being rejected as runoff and subsequent discharge to the rivers. During the dry season it is possible that bedrock in the vicinity of the New Liberty project site is recharged by up-gradient regional aquifers and also from seepage of water from the larger rivers where the watertable drops below the river water level.

Groundwater discharge at the site is diffuse and occurs as baseflow to the rivers and streams. In general, the deeper bedrock will discharge into the weathered rock (saprolite/saprock) which in turn discharges as baseflow along the river.

Surface Water Features

The Marvoe Creek Dam is a large body of water which has the potential to act as a large water source, recharging any zones of enhanced permeability hydraulically connected between the dam and the current open pits and the proposed underground mine (e.g. alluvial sediments associated with the previous Marvoe Creek channel, large geological structures such as the Mavoe Creek Fault, etc.).

The water level in the Marvoe Creek Dam was 69.3 mRL (January 2019), which is similar to groundwater levels observed in the current groundwater monitoring drillholes but significantly higher than the groundwater levels measured in the newly drilled pit drillholes (+28 to -3 mRL) or the current pit floors, suggesting a significant hydraulic gradient exists between the Marvoe Creek Dam and the New Liberty pit.

20.6.6.2 Ndablama

The Ndablama hydrogeological investigations were completed by Future Flow Groundwater & Project Management Solutions as part of the ESIA for the Ndablama pit and haul road study. The Ndablama Gold Mine EIA/EMP Study Groundwater Study (February 2019), which details the hydrogeological investigations completed and the findings of the works, should be read in conjunction with this report.

Hydrogeological Units

The following hydrogeological units have been identified in the Ndablama deposit area:

- Saprolite and Saprock: Comprising highly weathered rock and, in areas, a transition zone consisting of saprock between the fully weathered saprolite and the underlying competent, unweathered rock. A minimum thickness of 3.21 m and a maximum thickness of 64.3 m was recorded in exploration drillholes in the Ndablama deposit area.
- Competent and Fractured Rock: Underlying competent rock with groundwater flows associated with secondary fracturing. Faults and fractures can exhibit enhanced hydraulic conductivity, but this will depend on whether the fractures have been filled with secondary mineralisation.

Hydraulic Parameters

Hydraulic parameters for the hydrogeological units present in the Ndablama area were derived from hydraulic tests performed on the five newly drilled hydrogeological drillholes around the proposed Ndablama pit in November 2018.

Aquifer transmissivity values derived for the weathered material zone, which includes the saprolite and the saprock, range between 0.01 m^2/day and 0.2 m^2/day.

Two of the new hydrogeological drillholes targeted one of the main regional structures within the bedrock. The aquifer transmissivity values derived for the fractured rock aquifer range between 0.75 m^2/day and 3.1 m^2/day. The hydraulic testing indicates that, where uncemented and where enhanced hydraulic conductivity exist, the individual regional structures associated with the fractured rock aquifer in the area have a markedly higher transmissivity than the overlying weathered material. However, regionally, the competent fresh bedrock will have a lower average hydraulic conductivity than the weathered material due to the fact there are relatively few uncemented/open enhanced hydraulic conductivity structures within the competent rock.

Groundwater Levels and Flow Direction

The depth to groundwater in the Ndablama area was obtained from two sources:

- Hydrocensus performed during the 2018 site investigation
- Depth to groundwater level reported in the August 2014 baseline groundwater and surface water monitoring report (Digby Wells Environmental, August 2014).

Water levels reported in the 2014 baseline groundwater monitoring report include four exploration drillholes, five community wells and the two drillholes at Ndablama camp. The recorded depth to groundwater ranged between artesian and 23.88 mbgl. The depth to groundwater level of 23.88 m appears to be anomalous, with the depth to groundwater generally ranging between artesian and 7 mbgl.

During the 2018 hydrocensus the depth to groundwater was measured in regional drillholes PRSB1, PRSB5, PRSB6 and PRSB7. The depth to groundwater was also measured in the five newly drilled hydrogeological drillholes (NDB1 to NDB5) around the perimeter of the proposed Ndablama pit. The results from the hydrocensus indicate that the depth to groundwater ranges between 1.25 mbgl and 7.39 mbgl.

There does not appear to be a distinction between groundwater levels measured in the newly drilled shallow hydrogeological drillholes intersecting the weathered zone and the newly drilled deep hydrogeological drillholes intersecting the fractured bedrock suggesting that there is a good hydraulic connection between the two hydrogeological units.

Groundwater levels in the Ndablama deposit area mimic topography do not appear to have been impacted by any large-scale activities in the area, as would be expected in this greenfield environment.

Groundwater flow direction is generally from the elevated hills towards the low-lying streams, with groundwater gradients generally between 1:15 and 1:40.

Groundwater Quality

Groundwater quality within the Ndablama study area was based on laboratory analysis of groundwater samples collected from the five new hydrogeological drillholes and the nine regional hydrocensus drillholes. The samples were submitted to ALS, which is an ISO17025 accredited laboratory located in the Czech Republic, for analysis. The analytical results were compared to the WHO water quality guidelines.

Exceedances of the WHO water quality guidelines were detected for chloride, nitrate and lead. In one drillhole, NDB5, both manganese and mercury concentrations also exceeded the WHO guideline values.

Groundwater Recharge and Discharge

Vertical infiltration of recharging rainfall will occur through the weathered material. The lower permeability of the underlying competent fresh bedrock will retard the infiltration of this rainfall recharge into the underlying rock. Groundwater collecting above the weathered (saprolite/saprock) and fresh rock contact will migrate laterally down gradient along the contact (transition zone) towards locations with a lower elevation. In places where the contact is near surface the groundwater may discharge as springs or seepage into the various perennial and non-perennial streams and rivers that exist in the Ndablama area.

The degree of saturation of the weathered saprolite/saprock will fluctuate seasonally depending on rainfall recharge during the wet season and it is possible that some areas of the weathered zone will be completely dry during the dry season.

For the purpose of New Liberty Combined PFS Project, it was assumed that recharge will range between 1% and 5% of the mean annual precipitation, after accounting for evapotranspiration.

20.6.7 Surface Water Management

Surface water management for the project will focus on maximising the diversion of "clean" rainfall runoff from catchments not impacted by the project development. Where rainfall runoff is originating from impacted catchment areas, this runoff is planned to be intercepted and managed in accordance with the quality of this water.

The key objectives for the project site surface water management include the following:

- Maximise the diversion of "clean" surface runoff from catchments not impacted by the Project development, thus minimising the inflow of "clean" water to the Project site and minimising the volume of water which needs to be managed (including potential treatment).
- Ensure that all surface water and groundwater flows from impacted catchments are captured and treated accordingly, in order to ensure that there are no uncontrolled releases from the project site and to ensure compliance with environmental discharge requirements.
- Maximise the reuse of water.
- Avoid the impact of flooding on project infrastructure and operations.
- Avoid the disturbance of existing surface water drainage channels and features, where possible.

As part of this study, the catchments impacted by the key project developments have been delineated, peak design flows have been estimated using the rational method based on a 50-year return period event and where within the scope of the project (i.e. Ndablama) appropriate diversion drain alignments have been designed in order to convey rainfall runoff from with the project area.

The project area is subject to high rainfall intensities and storms, and at Ndablama in particular the surrounding topography is steep with most of the terrain sloping between 10% and 30%. The topography necessitates steep diversion channels in certain areas, and will require mitigation of high flow velocities, and hence erosion potential in these channels, including consideration for drop structures, in-channel check dams and lined channels, where appropriate. The risk of erosion and sedimentation can therefore be high, particularly on disturbed or degraded lands. Surface water management to prevent erosion and control sediment requires an integrated approach, defining the discrete catchment/drainage areas, and allowing appropriate engineering solutions. Sedimentation ponds need to be considered for each disturbed catchment/drainage area in order to prevent sediment (and other contaminants) from entering drainage systems.

Where feasible, upstream surface water flows will be diverted around structures into adjacent or downstream defined surface water flow pathways. Construction on or near natural flow paths will be planned for the dry season, where practical. Temporary stabilisation measures will be used in high erosion risk zones. Areas of major erosion hazard will be identified and avoided where practical or specific management measures will be implemented in order to reduce erosion risk.

The New Liberty site is an operating mine site, with an existing surface water management plan in place, which is proposed to manage surface water associated with mining until the end of life of the open pit mine.

20.6.7.1 Site-Specific Surface Water Management – Ndablama

Non-Impacted "Clean" Surface Water Management

The surface water management of "clean" surface water catchments impacted by the Ndablama pit and waste dump was completed as part of the ESIA for the Ndablama pit and haul road project and is presented in detail within the Surface Water Quantity Assessment completed by Peens & Associates.

"Clean" surface water sub-catchments impacted by the pit and waste dump developments were delineated, and proposed channel alignments developed to divert "clean" surface water runoff around and downstream of the development, ensuring separation of the catchment runoff with runoff from disturbed catchments, such as the waste dump.

The final pit intersects a ridgeline between watersheds, which allows for the diversion of the large majority of runoff from the surrounding sub-catchments to north and south, downstream of the pit. The delineated sub-catchments, and the layout of the stormwater diversion channels around the pit and the waste dump are shown in Figure 20-7. The corresponding proposed stormwater diversion channels dimensions and proposed linings are presented in Table 20-17.

The proposed stormwater diversion channels with design flows less than 10 m^3/s have a minimum freeboard of 300 mm, while channels with larger design flows have a minimum freeboard of 500 mm. The average slope along the proposed channel route is adopted for the conceptual design as the design slope. Where mean channels velocities exceed 3.0 m/s, reinforced concrete channels are required and where flow velocities are less than 1.5 m/s, no erosion protection is required. For channels with flow velocities between 1.5 m/s and 3.0 m/s, rip-rap linings are required, which can be obtained from the waste rock if suitable.

Table 20-17: Ndablama proposed channel sizes

Channel location	Channel size – bottom width x depth x top width (m x m x m)	Channel length (m)
A-B H-I	2.5 x 0.5 x 3.7 (Concrete)	1,595
C-B D-F E-F F-G	0.5 x 0.5 x 1.5 (Concrete)	1,143
B-G G-I I-J	3.0 x 1.5 x 6.0 (Concrete)	1,297

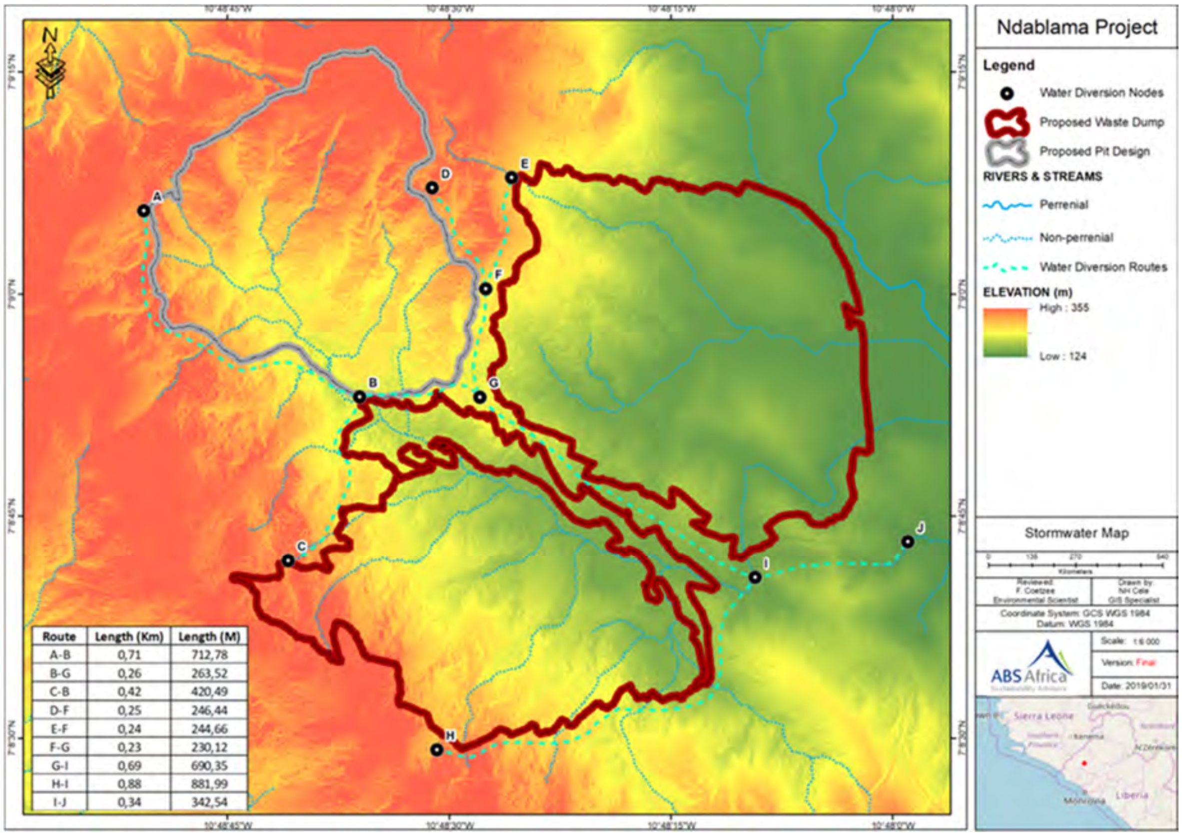


Figure 20-7: Ndablama surface water management overview
Source: CSA Global, 2018

Impacted "Dirty" Surface Water Management

The surface water management of "dirty" surface water catchments associated with the Ndablama waste dumps was completed by CSA Global.

The waste dumps are located downstream of the pit, to the east and west of the main drainage channel (G-I). Runoff from the waste dump catchments will gravity drain laterally along the benches to the periphery drainage channel around the waste dump. The periphery drainage channel collects runoff from the waste dump catchments and conveys the flow to a sedimentation pond at a low point on the perimeter of the waste dump, prior to discharge to constructed or natural drainage channels.

The periphery drainage channel alignments, and the locations of sedimentation ponds around the waste dump are shown in Figure 20-8. The corresponding proposed drainage channels dimensions and proposed linings are presented in Table 20-18.

As with the "clean" water management, the proposed stormwater diversion channels with design flows less than 10 m^3/s have a minimum freeboard of 300 mm, while channels with larger design flows have a minimum freeboard of 500 mm.

The average slope along the proposed channel route is adopted for the conceptual design as the design slope. Where mean channels velocities exceed 3.0 m/s, reinforced concrete channels are required and where flow velocities are less than 1.5 m/s, no erosion protection is required. For channels with flow velocities between 1.5 m/s and 3.0 m/s, rip-rap linings are required, which can be obtained from the waste rock if suitable.

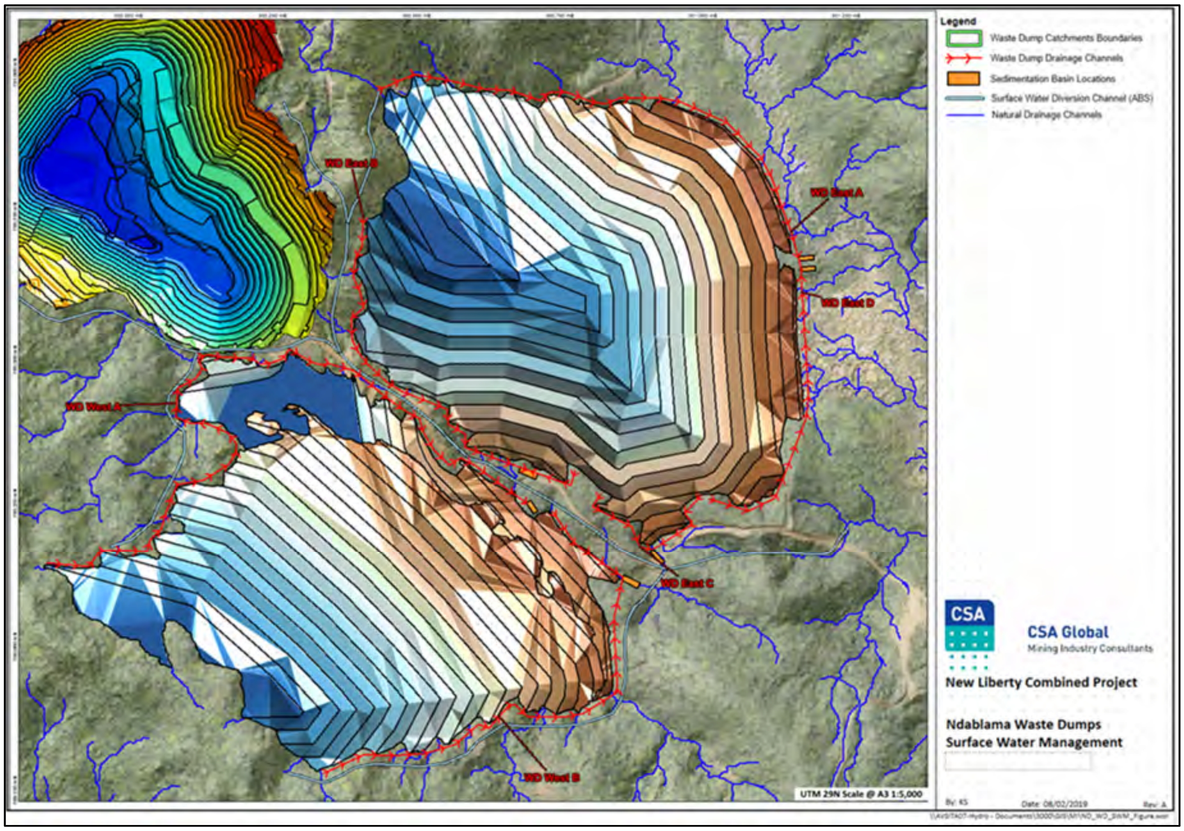


Figure 20-8: Ndablama waste dump water management
Source: CSA Global, 2018

Table 20-18: Ndablama proposed waste dump drainage channel sizes

Month	Channel shape	Channel size – bottom width x depth x top width (m x m x m)	Channel length (m)
WD East A	Trapezoid	0.5 x 1 x 2.5 (Concrete)	940
WD East B	Trapezoid	0.5 x 1 x 2.5 (Concrete)	640
WD East C	Trapezoid	1 x 0.5 x 2 (Concrete)	170
WD East D	V-shape	0 x 1 x 2 (Concrete)	530
WD West A	Trapezoid	0.5 x 1 x 2.5 (Concrete)	1,410
WD West B	Trapezoid	0.5 x 1 x 2.5 (Concrete)	780

The “dirty” water runoff from the impacted catchments such as the waste dumps is planned to be discharged to sedimentation ponds, in order to facilitate the settlement of suspended sediment, prior to discharge to the environment. To design appropriate sedimentation ponds, it is necessary to first understand the nature of the soils and sediments in the area, in order to evaluate the properties of the sediment, which will need to be settled. A minimum sedimentation pond depth of 1.2 m is recommended, incorporating a minimum settling depth of 0.6 m with an additional depth provided for the storage of settled sediment between maintenance.

Sedimentation pond design will be undertaken as part of the subsequent DFS, when there is more certainty on the project infrastructure design. It is recommended that as part of the DFS the waste dump designer and surface water management designer liaise to ensure sufficient space is allowed in the corridor between the waste dumps for surface water management infrastructure requirements, in addition to any other infrastructure requirements such as haul roads.

There is scope to reduce the external catchment area draining to the pit in the earlier stages of development and this should be optimised during the DFS as part of the surface water management design in the vicinity of the pit for each stage of development assessed.

20.6.7.2 Site-Specific Surface Water Management – New Liberty

The New Liberty site is an operating mine site, with an existing surface water management plan in place, which is managing surface water associated with mining until the end of life of the open pit.

The surface water management infrastructure surrounding the New Liberty pit was reviewed as part of the New Liberty Combined Project PFS in order to estimate potential rainfall runoff/surface water inflows to the New Liberty open pit from external catchment areas when open pit mining ceases and the underground development commences. The externals pit catchments delineated in the vicinity of the New Liberty pit are illustrated in Figure 20-9.

The two existing primary diversion drains in the vicinity of the pit capture runoff from parts of the waste dump and surrounding area and conveys the runoff to the west and south of the pit and waste dumps as illustrated in Figure 20-9.

The preliminary design of the southern waste dump appears to encroach on the drainage channel around the eastern pit perimeter. As part of the DFS it is recommended to undertake a review of the existing surface water management plan at New Liberty and incorporate any amendments required based on the final waste dump design and any future requirements for the underground expansion and associated infrastructure.

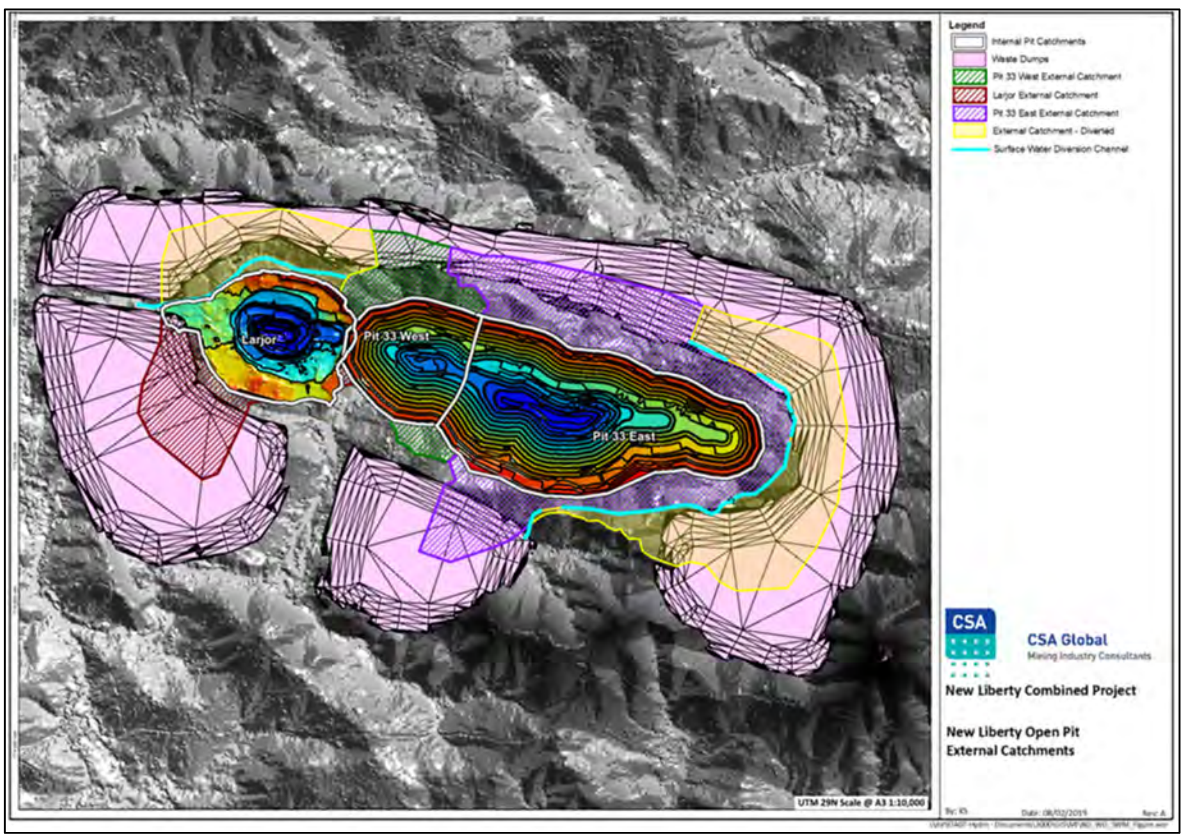


Figure 20-9: New Liberty external pit catchments
Source: CSA Global, 2018

20.6.8 Mine Inflows

20.6.8.1 Mine Plan

The following mine plans formed the basis for the assessment of surface water and groundwater inflows to the New Liberty and Ndablama mines:

- New Liberty Larjor – pit_dec2018
- New Liberty Pit 33 – NLGM_Phases_Pit33_wf - Phase_5_wf
- New Liberty Underground – NLUG Development solids_271218 & NLUG Stope solids_271218
- New Liberty Underground Mine Design Criteria Version 1_17 December 2018
- NLUG Version 1_150119
- Ndablama Stage 1 – ND_Stages_wf_dxf_19-01-29 - Stage 1
- Ndablama Stage 2 – ND_Stages_wf_dxf_19-01-29 - Stage 2
- Ndablama Stage 3 – ND_Stages_wf_dxf_19-01-29 - Stage 3
- Ndablama Stage 4 – ND_Stages_wf_dxf_19-01-29 - Stage 4.

20.6.8.2 Overview of Mine Inflows

Open Pit Inflows

Inflows into the open pits will comprise:

- Groundwater inflows – through permeable materials, structures and the bulk rock-mass
- Surface water inflows – from rainfall runoff within the pit footprint itself and the immediately adjacent surface catchments which drain towards the pit, particularly during the rainy season.

Groundwater will start to flow into the open pit as the mine excavation progresses below the water table. Groundwater inflows will generally be greatest where permeable materials (e.g. the saprock) or permeable zones (fractures zones, shears zones) are intersected, but will also be proportional to the surface area of the pit wall and the depth of the pit below the water table.

The non-fractured rock is relatively low permeability and thus will only contribute small diffuse groundwater inflows to the pits. Structurally controlled inflows will occur where the open pit intersects permeable fracture zones (or other linear features). The magnitude and length (time-wise) of the structurally controlled inflows will be dependent on the hydraulic conductivity, the head of water and the saturated volume (storage) of the fracture zone.

Rainfall runoff from the external pit catchments draining to the pits and direct rainfall falling across the pit footprint is a major contributor of pit inflows, particularly during the rainy season.

In addition, infiltrating rainfall during the rainy season is likely to result in a significant increase in pit inflows from shallow units intersected by the pit, often most significant at the weathered/fresh rock contact (transition) zone, which can become rapidly re-saturated due to rainfall recharge.

Underground Mine Inflows

Potential inflows into the proposed underground mine will comprise:

- Inflows into the underground mine from existing overlying pits – the ore-bearing shear zone and permeable structures have the potential to rapidly transmit large volumes of water from the existing overlying pits to the proposed underground mine.
- Bulk inflows into the underground mine – bulk rock mass inflows are likely to be diffuse and minor but may lead to increase pore pressures which may require depressurisation.
- Structure controlled inflows into the tunnel/drives and underground mine – any zones of enhanced permeability (e.g. contact zones, faults, shears, etc.) intersected in the underground mine have the

potential to lead to significant discrete inflows into the underground mine. Generally, these flows would be high initially but would diminish rapidly with time, however, potential links to large water sources above (e.g. The Marvoe Creek Dam, saturated waste dumps or saturated weathered sediments) could lead to these discrete inflows being more continuous in nature.

All water within the overlying open pits will need to be removed prior to the development of the underground mine and an appropriate ongoing open pit dewatering system will be required to provide effective ongoing water management of the overlying pits.

20.6.8.3 Groundwater Inflow Assessment Methodologies

Groundwater inflow predictions can be calculated using either analytical or numerical groundwater flow models. Numerical groundwater flow modelling involves the development of a 3D groundwater flow model to simulate flows to the mine and are appropriate when there is a high level of hydrogeological understanding, a large amount of hydrogeological data available and high certainty predictions is required. Analytical groundwater flow model methodologies can provide equally exact predictions as numerical models and are appropriate when less hydrogeological data is available or earlier in a project life cycle when a lower level of certainty is required. The two principal inflow mechanisms are diffuse bulk inflows and more discrete structurally controlled inflows.

Bulk Inflow Estimation

Bulk inflows are the progressive average inflows from the bulk rock-mass with time into the mine. Preliminary estimates of potential bulk inflows can be made using a lumped parameter analytical groundwater flow model with representative aquifer parameter values for the strata. The model uses a modification of the Dupuit-Forchheimer and Theim equations for flow to a well, where the mine is represented by a large diameter well (of equivalent saturated volume). Flows to the “well” are calculated for a water level in the well equivalent to, or just below the proposed mine base. This provides an estimate of the total inflows to the mine assuming there is sufficient sump or bore pumping to keep the mine dry. This method makes simplifying assumptions and is not precise. However, it does allow for order of magnitude predictions of inflows with limited hydrogeological data and/or where only preliminary mine designs exist.

Structure Controlled Inflows

Preliminary estimates of structurally controlled inflows can be made using the Goodman et al equations for estimation of inflows to tunnel (or shaft/drive) that intersects a fracture zone and representative hydraulic parameters are assigned for the intersected strata.

20.6.8.4 Groundwater Inflows – New Liberty Open Pits

Historical Inflow Predictions

Previous dewatering estimates completed (pre-mining) in 2013 based on the then proposed mine plans and available data suggested the following:

- Average groundwater inflow rates of 2.5–8.5 L/s per individual pit; total average groundwater inflows of the order 8–22 L/s; potential discrete short-term inflows related to permeable structures up to 10 L/s.
- Annual average rainfall/surface water inflow rates of 10–20 L/s per individual pit; total annual average rainfall/surface water inflows of the order 30–60 L/s.
- Recommended in-pit sump pump capacity of 210–240 L/s for each pit in order to effectively manage the dewatering requirements of large storm events.

We understand that dewatering rates and dewatering volumes are not currently recorded on-site. While information was provided regarding the dewatering pumps currently available on-site dewatering practices appear to be currently based on day to day operational requirements and that the continuity of dewatering is often impacted by removal of the pumps from the pit prior to blasting, a lack of appropriate vehicles to move the pumps around the site, pipeline restrictions and only one pump at the Kinjor pit transfer station. There is currently insufficient data to confirm current pit dewatering requirements or to validate the previous pit dewatering predictions.

Site Observations (November 2018)

The Larjor pit contained a significant volume of water in mid-November 2018 (it is understood that a depth of approximately 50 m of water was present in the Larjor pit at this time), while saturated pit floors were observed at both the Kinjor and Marvoe Pits in mid-November 2018.

Significant water volumes were observed flowing into the three pits, at numerous locations, from external pit catchments and/or shallow weathered units. This near surface water was observed to subsequently drain to the base of the pit, where it is captured in the pit sumps and then pumped out from the pit base. Near-surface inflows were particularly prevalent along the entire northern perimeter of the three pits and at the western side of the Larjor pit (where an inflow of approximately 4 L/s was measured flowing into the pit on 15 November 2018). These near surface inflows are likely to be a lot greater in magnitude during the rainy season or after large storm events.

Significant pit inflows were also observed associated with geological structures evident in the pit walls in each of the three pits. These discrete inflows appear to be associated with both the main ore bearing shear zone and also numerous other faults/fractures intersected by the pits. These inflows were observed to be significant in numerous places and flows of between 1 L/s and 2 L/s were observed inflowing from many of the structures. There appears to be a significant number of fractures in the pit walls, particularly in the Kinjor and Marvoe pits, leading to an abundance of localised seepages and inflows into the pits.

Predicted Pit Inflows

A model was run to predict potential groundwater inflows into the final New Liberty open pits (Larjor final pit and the Main Pit/Pit 33). The model adopted the following assumptions and input parameters:

- Bulk permeability of 5×10^{-3} m/d
- Unconfined aquifer with a specific yield of 0.2%
- Final pit shells as provided 18 January 2019
- Pre-mining water table level of +70 mRL (approximate average current level of Marvoe Creek Dam and average groundwater table level based on limited data available).

The model predicted groundwater inflows into the final New Liberty open pits as follows:

- Larjor pit:
    - Average bulk groundwater inflow rates of 5–10 L/s
    - Structurally controlled groundwater inflow rates of 1–2 L/s for each permeable structure intersected by the pit.
- Main pit (Pit 33):
    - Average bulk groundwater inflow rates of 10–15 L/s
    - Structurally controlled groundwater inflow rates of 1–2 L/s for each permeable structure intersected by the pit.

Generally, the structurally related inflows will reduce in magnitude rapidly, with modelling suggesting that flows would reduce by an order of magnitude within 24 hours (assuming there is not a constant supply of water to these faults, e.g. from an overlying water body like the Marvoe Creek Dam or saturated overlying shallow sediments). Long term localised inflows could potentially occur where the open pit intercepts a structure with a direct link to an overlying water body, which may be the case particularly for the larger Marvoe Creek Fault and/or Sedimentation Basin Fault.

Enhanced localised structurally related inflows may increase during the wet season, as a result of recharge/infiltration to these structures from rainfall and may reach the initially encountered higher inflow rates during prolonged wet periods.

The location of these structurally related enhanced inflows will directly correspond with where the open pit intersects significant structures. The potential long term locally enhanced mine inflows could be managed by targeted advanced dewatering of these major structures through dewatering drillholes, if possible, thus reducing the management of "contact" water within the open pits.

20.6.8.5 Groundwater Inflows – New Liberty Underground

Bulk Inflows

A model was run to predict potential groundwater inflows into the proposed underground mine at New Liberty. The model adopted the following assumptions and input parameters:

- Bulk permeability of 1 x 10^{-3} m/d
- Unconfined aquifer with a specific yield of 0.2%
- Mining schedule and underground mine areas as provided 18 January 2019
- Decline of 5 m x 5.3 m and drives of 5 m x 5 m and 4 m x 4 m
- Pre-mining water table level of +70 mRL (approximate average current level of Marvoe Creek Dam and average groundwater table level based on limited data available).

The bulk groundwater inflows into the underground mine are predicted to be generally low. The underground mine design was assessed at numerous key stages of both drive development and stoping across the full extent of the mine development, throughout the mine life, and in all cases average mine inflows were predicted to be in the order of 1–2 L/s for each stage development (into each lobe).

It should be noted that the inflow predictions are estimates based on the field data available (primarily the three new water holes drilled and tested in November 2018) and, if the bulk permeability values are in fact an order of magnitude higher, the actual bulk inflows may be twice the values quoted above. It should be noted that these are average inflow values and that inflows will be higher at times of rapid advancement (especially with respect to depth) and lower when the area has been actively mined for an extended period of time.

Structurally Controlled Inflows

The model was run to predict potential structurally controlled inflows into the proposed New Liberty underground mine using the assumptions and input parameters detailed above and a fracture permeability of 0.4 m/day (based on previous assessment of the hydraulic properties of the Marvoe Creek Fault) and specific yield of 2%.

These structurally related inflows are predicted to be in the order of 2–5 L/s. As with the open pit structurally controlled inflows, these structural controlled inflows would reduce in magnitude rapidly, although long term localised inflows could potentially occur where the underground mine intercepts a structure with a direct link to an overlying water body or saturated overlying shallow sediments. In the wet season, enhanced localised structurally related inflows into the underground mine may also occur, as a result of recharge/infiltration to these structures from rainfall, and may reach the initially encountered higher inflow rates during prolonged wet periods.

The location of these structurally related enhanced inflows will directly correspond with where the underground mine intersects significant structures, so the dewatering design should consider the location and timing of intersection in developing an appropriate dewatering system.

Cover drilling ahead of underground mining should be considered in order to provide advanced warning of potential localised structurally controlled inflows, which could be significant on first intersection, and could also be used to advance dewater these structures (areas of locally enhanced inflows) prior to mining.

The potential long term locally enhanced mine inflows could be managed through the underground mine and focussed underground dewatering; or alternatively could be managed by targeted advanced dewatering of these major structures through dewatering drillholes, if possible, thus reducing the management of “contact” water within the underground mine.

It is recommended that as part of the subsequent DFS that a program of large diameter hydrogeological drillhole drilling and test pumping be completed in order to confirm the hydraulic properties of the bulk rock mass and geological structures which will be intersected by the proposed underground mine and to evaluate any potential hydraulic connection with the Marvoe Creek Dam. If significant water yields are obtained from the hydrogeological test drillholes then these drillholes could be subsequently used as dewatering drillholes for the underground mining operation.

20.6.8.6 Groundwater Inflows – Ndablama Open Pit

A numerical 3D groundwater flow model was developed for the Ndablama deposit area in order to predict the groundwater inflows into the proposed Ndablama open pit. The groundwater model set up, input data and assumptions are detailed in the Ndablama Gold Mine EIA/EMP Study Groundwater Study (February 2019).

The model predicted groundwater inflows into the Ndablama open pit, at various stages of mine development, are detailed in Table 20-19.

Table 20-19: Ndablama predicted groundwater inflow rates

Stage	Pit groundwater inflow predictions	
	(m^3/day	Approx. (L/s)
Construction	85	1
Stage 1 – End	200	2
Stage 2 – End	395	5
Stage 3 – End	550	6
Stage 4 – End	690	8

20.6.8.7 Surface Water Inflow Assessment Methodology

Surface water inflows have been evaluated by assessing the 24-hour 50-year return period event. In addition, the wettest month and wettest three-month period from the rainfall dataset available at the project sites has also been used to calculate potential surface water inflows to the pit during a typical period of heavy rainfall.

A volumetric runoff coefficient is applied to the rainfall data in order to represent the proportion of total rainfall that actually runs off and becomes surface water flow, the remainder then either infiltrates into the ground or is lost by evaporation. Runoff coefficients vary dependent on a number of factors including the rainfall intensity, topography and ground characteristics. The runoff coefficients used for this assessment are presented in Table 20-20.

Table 20-20: Pit volumetric runoff coefficients

Volumetric runoff coefficients	Average annual rainfall	Wet period	24-hour 50-year
Pit catchment	0.65	0.70	0.90
Waste dump catchment	0.40	0.45	0.50
External catchment	0.55	0.65	0.70

Surface water inflows to the pits have been estimated by applying an appropriate Runoff Coefficient (RoC) to the relevant catchment area (Area) and multiplying it by the Rainfall (Rainfall) using the equation:

$$\text{Inflow Volume } (m^3) = \text{RoC} * \text{Area } (m^2) * \text{Rainfall } (m)$$

20.6.8.8 Surface Water Inflows – Ndablama Open Pit

Majority of catchment area external to the Ndablama pit is diverted downstream of the pit into the natural watercourse. Surface areas for the pit inflow catchments for Stages 1 to 4 of the Ndablama pit development are provided in Table 20-21.

The rainfall data provided in the Surface Water Quantity Assessment was adopted for this assessment.

Table 20-21: Pit surface water catchments

Pit stage	Internal pit catchment area (m^2)	External pit catchment area (m^2)	Total catchment area (m^2)
Stage 1	82,000	36,000	118,000
Stage 2	190,000	164,700	354,700
Stage 3	262,100	94,500	356,600
Stage 4	326,500	42,100	368,600

The surface water inflow volumes were estimated for the following rainfall scenarios, based on the rainfall data from the Ndablama site:

- Dry year
- Average year
- Wet year
- Wettest month on record
- Wettest three-month period on record
- 24-hour duration 50-year return period storm event.

The surface water inflow volumes for each of the rainfall scenarios are presented in Table 20-22.

Table 20-22: Surface water pit inflows

Pit stage	Dry year (m^3)	Average year (m^3)	Wet year (m^3)	Wet month (m^3)	Wet period (m^3)	24-hour, 50-year (m^3)
Stage 1	199,500	231,900	262,600	66,900	170,700	32,300
Stage 2	584,200	679,300	769,000	196,600	501,800	93,300
Stage 3	606,700	705,400	798,500	203,300	518,800	98,500
Stage 4	642,300	746,800	845,400	214,500	547,400	105,400

There is scope to reduce the external catchment area draining to the pit in the earlier stages of Ndablama pit development and this should be optimised during the DFS in conjunction with the surface water management in the vicinity of the pit for each stage of development assessed.

20.6.8.9 Surface Water Inflows – New Liberty Open Pit

The two primary diversion drains in the vicinity of the New Liberty pit capture runoff from parts of the waste dump and surrounding area and conveys the runoff to the west and south of the pit and waste dumps, with the remaining areas draining to the pit. Surface areas for the pit inflow sub-catchments of Larjor, Pit 33 West and Pit 33 East are provided in Table 20-23. The sub-catchments are based on the areas draining to each sump location in the end of life open pit development.

Table 20-23: Pit surface water catchments

Pit stage	Internal pit catchment area (m²)	External disturbed catchment area (m²)	External waste dump catchment area (m²)	Total catchment area (m²)
Larjor	212,600	17,500	110,200	340,300
Pit 33 West	156,400	76,100	28,500	261,000
Pit 33 East	456,600	245,300	178,800	880,700

The surface water inflow volumes were estimated for the following rainfall scenarios, based on the rainfall data from the New Liberty site:

- Dry year
- Average year
- Wet year
- Wettest month on record
- Wettest three-month period on record
- 24-hour duration 50-year return period storm event.

The surface water inflow volumes for each of the rainfall scenarios are presented in Table 20-24.

Table 20-24: Surface water pit inflows

Pit stage	Dry year (m³)	Average year (m³)	Wet year (m³)	Wet month (m³)	Wet period (m³)	24-hour, 50-year (m³)
Larjor	559,100	647,100	715,900	231,600	496,100	97,300
Pit 33 West	451,200	522,300	577,700	188,600	404,100	78,300
Pit 33 East	1,465,900	1,696,900	1,877,000	611,800	1,310,500	252,700

As part of the DFS, it is recommended to review the existing surface water management plan at New Liberty and incorporated any amendments based on the waste dump design and any future requirements for the underground expansion and associated infrastructure in the vicinity. An optimised surface water management plan may reduce the surface water inflow from external catchments to the pit.

20.6.8.10 Combined Inflows – New Liberty Mine Site

The combined groundwater and surface water pit inflows during the various rainfall scenarios assessed are presented in Table 20-25.

Table 20-25: New Liberty combined groundwater and surface water pit inflows

Pit catchment	Dry year (m³)	Average year (m³)	Wet year (m³)	Wet month (m³)	Wet period (m³)	24-hour, 50-year (m³)
Larjor	874,400	962,500	1,031,200	258,400	574,700	98,100
Pit 33 West	608,900	680,000	735,400	202,000	443,400	78,700
Pit 33 East	2,096,600	2,327,600	2,507,800	665,300	1,467,700	254,400

20.6.8.11 Combined Inflows – Ndablama Mine Site

The combined groundwater and surface water pit inflows during the various rainfall scenarios assessed are presented in Table 20-26.

Table 20-26: Ndablama combined groundwater and surface water pit inflows

Pit catchment	Dry year (m³)	Average year (m³)	Wet year (m³)	Wet month (m³)	Wet period (m³)	24-hour, 50-year (m³)
Stage 1	272,500	304,900	335,600	73,100	188,900	32,500
Stage 2	728,400	823,400	913,100	208,900	537,800	93,700

Stage 3	807,400	906,100	999,300	220,300	568,800	99,000
Stage 4	894,200	998,700	1,097,300	235,900	610,200	106,100

20.6.9 Potential Impacts of Pit Dewatering/Depressurisation

An evaluation of the impact from the predicted mine dewatering/depressurisation on the regional water table and nearby water users or groundwater dependent ecosystems was completed for the New Liberty and Ndablama mine sites.

20.6.9.1 New Liberty Mine Site

Dewatering associated with open pit development and the underground mine will lead to the water table being drawdown in the vicinity of the pits and underground mine. It is predicted that the extent of the cone of depression (water level drawdown) will be constrained to the north and west by the presence of the Marvoe Creek Dam and the Marvoe Creek Diversion Channel respectively, which act as water sources recharging the rocks in these areas. Water level drawdown will be greater in the east and south where there are no significant water/recharge sources.

Groundwater level monitoring data obtained from the groundwater monitoring network indicate that there has been no significant impact on groundwater levels as a result of the current mining operations and suggests that the cone of depression as a result of current pit dewatering is constrained to less than approximately 500 m from the current pit crests. Water levels measured in the new drillholes drilled in the 2018 site investigation suggest that the bulk rockmass has poor hydraulic interconnectivity and low permeability as the saturated rock mass is not draining into the current open pit areas. These factors all suggest that the cone of depression from the dewatering associated with the open pit and underground mine is likely to be steep and narrow.

There are two water supply wells currently operational at the New Liberty mine site, Well-1 Camp Liberty and Well-2 Football Team Camp. Water supply wells are also located outside the New Liberty mine site (wells NBJW2 and NBJW3, and NBKW1 and NBMW1).

Modelling indicates that Well-1 Camp Liberty and Well-2 Football Team Camp are located within the predicted cone of depression from the proposed future pit and underground mine dewatering and that the water levels within these water supply wells are predicted to be drawdown as a result of the dewatering. The water level in Well 1- Camp Liberty is predicted to be drawn down by up to approximately 2 m. However, this well is located adjacent to the Marvoe Creek Dam and groundwater levels at this location are likely to be impacted by recharge from the dam, therefore, it is likely that the actual drawdown in the well will be significantly less than predicted. This well is reported to be 28 m deep and therefore will not become dry (i.e. the water table is not predicted to drop below the bottom of the bore) as a result of the impacts of dewatering. However, the additional drawdown could affect the productivity of the well if the water table drops below productive zones within the upper sections of the well.

The water level in Well 2-Football Team Camp is predicted to be drawn down by up to approximately 0.5 m. This well is also located close to the Marvoe Creek Dam and groundwater levels at this location are similarly likely to be impacted by recharge from the dam. Therefore, it is likely that the actual drawdown in the well will be significantly less than predicted. There currently is no information available on the water level in this well, although water levels in the closest monitoring drillholes, MB09 and MB10, are typically between 2 mbgl and 8mbgl. This well is reported to be 13 m deep and therefore will not become dry (i.e. the water table is not predicted to drop below the bottom of the bore) as a result of the impacts of dewatering. However, the additional drawdown could affect the productivity of the well if the water table drops below productive zones within the upper sections of the well.

The water level within the village wells outside the New Liberty mine site are not predicted to be impacted as a result of the dewatering from the open pits and underground mine.

The modelling predicts that the wetland area down gradient of the TSF will not be impacted by the groundwater level drawdown as a result of dewatering.

The groundwater level drawdown as a result of dewatering will cause localised groundwater flow towards the mine area in the vicinity of the open pits and underground mine. It is predicted that this will effectively limit or prevent any potential contamination (for example spills) migrating away from the open pits and underground mine to the surrounding environment during mine operation.

The impact of the open pits and underground mine following cessation of mining and for mine closure should be evaluated once a mine closure plan has been developed for the New Liberty mine site.

20.6.9.2 Ndablama Mine Site

The potential impacts of mine dewatering have been comprehensively evaluated by Future Flow Groundwater & Project Management Solutions as part of the ESIA for the Ndablama pit and the Ndablama haul road study. The Ndablama Gold Mine EIA/EMP Study Groundwater Study (February 2019), provides details of the impact assessment completed.

Construction phase

During the construction phase of the mine, the boxcut excavations will extend below the local groundwater level and dewatering will be required to ensure a dry working environment. This will lead to localised dewatering of the sediments surrounding the excavation. The zone of influence of the groundwater level drawdown is expected to extend 80–100 m from the edge of the boxcut excavation.

There is one stream within the pit area that will be mined out. This will reduce the total length of the stream and therefore also the baseflow contribution to the overall stream flow volume. It is predicted that approximately 2.3% of the total stream will be mined out. The groundwater level drawdown is also predicted to extend under various tributaries, which will decrease the baseflow contribution to the river. It is calculated that the total reduction in stream flow volume due to the river being mined out, combined with the reduction in baseflow contribution to the river is approximately 2.5% of the discharge at the southern discharge point.

Drawdown of the groundwater level due to boxcut dewatering will cause the surrounding groundwater flow patterns to be changed so that groundwater flows towards the boxcut excavation. This will effectively limit or prevent contamination migrating away from the opencast boxcut to the surrounding environment.

Operational phase

The Ndablama open pit will extend below the local water table and thus dewatering will be required. As a result of mine dewatering local groundwater levels will be drawn down and the groundwater flow directions in the vicinity of the pit will be directed toward the pit. The zone of influence of the groundwater level drawdown in the saprolite is calculated to be approximately 100–200 m from the pit crest. The extent of the drawdown cone will be limited by the boundaries of the sub-catchment within which the pit will be located.

A portion of the river that drains the sub-catchment within which the pit will be located will be mined out. This will impact the river flow volumes due to reduced surface runoff draining into the river and also reduced baseflow contribution to the river. Using the numerical groundwater flow model results it is predicted that the average annual decrease stream flow volume in the river draining towards the southern discharge point will be a maximum of approximately 20%, although the decrease in discharge volume will vary seasonally.

It is expected that there will be an elevated water level within the WRD due to increased rainfall recharge into the material which may act as a driving head in radial directions around the WRD. The final height of the WRD is planned at 285 m amsl, which is higher than the elevation of the natural topography of the sub-catchment boundary between the pit and the WRD, therefore, it is possible that there may be seepage from the WRD into the pit. This can pose a risk to the slope stability of the pit. Numerical modelling results predict that less than 10 m^3/day of groundwater will flow from the WRD towards the pit. However, the groundwater level in the area between the WRD and the pit is not predicted to be drawn down to the level of the floor of the pit. These groundwater levels may cause a slope stability issue and could be managed through cut-off trench installed within the saprolite and saprock and/or dewatering wells installed into the fractured rock aquifer.

There are no privately-owned water supply wells that fall within the predicted zone of influence of the dewatering induced groundwater level drawdown cone.

During mine operation, the local groundwater flow patterns will be directed towards the pit due to mine dewatering, and therefore it is not expected that any contaminant plume will develop away from the pit during the life of operations.

The WRD is located outside the predicted zone of influence of the groundwater level drawdown cone that will develop due to mine dewatering. The elevated head within the WRD due to increased recharge from rainfall into the WRD may cause radial contaminant migration away from the WRD. As a result, it is likely that there will be some contaminant migration from the WRD into the pit. This contaminated water will be captured within the dewatering system along with the other pit inflows and handled within the mine water management system.

Decommissioning Phase

During the decommissioning phase the mine dewatering will stop and the water level within the pit will start to recover. Due to the relatively short duration of the decommissioning phase (assumed to be less than 6 months) there will be little recovery of the water level in the pit by the end of this phase.

The WRD will be sloped and capped, which will reduce the recharge into the WRD and lead to a lowering of the water level within the WRD area.

Long-Term Post-Operational Phase

Long term, the water level within the pit will continue to recover in conjunction with the groundwater levels within the rockmass surrounding the pit. The recovering water levels will allow the groundwater flow patterns in the area to recover to near pre-mining levels.

It is predicted that water level in the Ndablama pit will recover to approximately 195–200 m amsl within 15–20 years of the end of mine operation. At this level groundwater inflows into the pit will be minimal due to the water level within the pit being at, or even slightly above, the regional groundwater level elevations around the pit. In addition, once water levels reach these levels it is predicted that discharge from the pit will commence. It is predicted that the discharge will start where the remaining stream channel of one of the natural rivers exits the pit area. The discharge will then run along the river channel away from the mining area and spread through the area. It is predicted that the discharge volume will be in the order of 730,000 m^3 per annum (1,993 m^3 per day). It is predicted that the discharge volume entering the river from the pit is approximately 1.6% of the average daily total stream flow volume.

20.6.10 Water Monitoring Program

A long-term water monitoring program is currently in place for the New Liberty mine site. The focus of this current monitoring program is to assess any potential impact resulting from the ongoing mining when compared to the baseline dataset.

At Ndablama, the current focus of water monitoring is to establish a representative baseline monitoring dataset prior to the commencement of any mining activity. The Ndablama program will need to be refined when a more detailed mine plan becomes available. In addition, when the project moves into construction phase it will be necessary to review and rationalise the overall site water monitoring program in order to ensure that the monitoring program moves from focussing on collecting baseline data to a focus of identifying any potential impacts from the construction works and any variation in the baseline surface water and groundwater environment.

20.6.10.1 Surface Water Monitoring – Ndablama

It is recommended that a surface water monitoring program that incorporates the proposed operations, with focus on the possible sources of impact, be implemented. These sources of impacts include the open pit as well as other proposed surface infrastructure, including the WRD. It is recommended that the monitoring program should include (as a minimum) the following surface water monitoring points:

- SW1 – Immediately downstream of the open pit
- SW2 – Immediately downstream of the waste dumps
- SW3 – Downstream of catchment impacted by all mine infrastructure.

Indicative recommended surface water monitoring locations are illustrated in Figure 20-10.

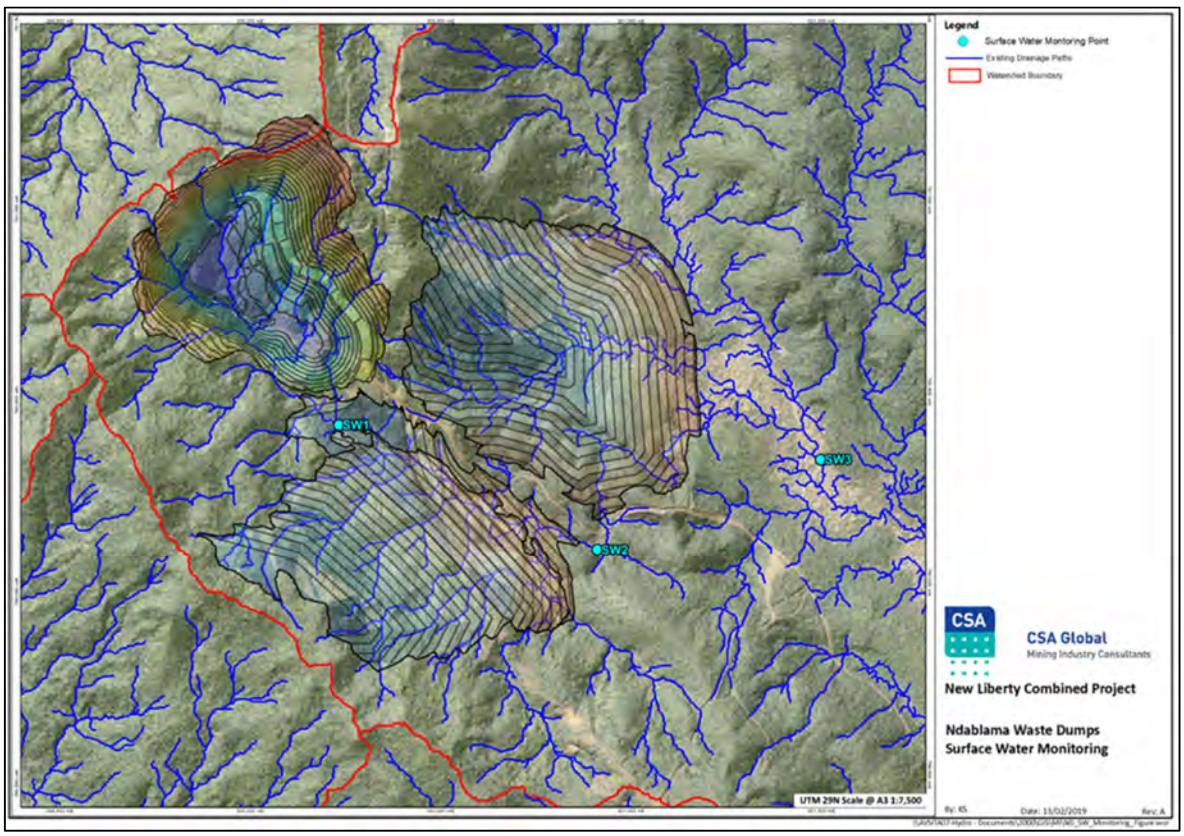


Figure 20-10: Ndabalama – notional surface water monitoring locations
Source: CSA Global, 2018

It is recommended that the monitoring program includes surface water level, flow and water quality monitoring. It is recommended that the monitoring program should start immediately, in order to establish baseline conditions prior to the commencement of mining activities. Initially, the surface water monitoring should be completed on a monthly basis. However, this should be reviewed once 12 months of data is gathered.

It is recommended that the surface water quality monitoring parameters should comply with relevant WHO, World Bank and Liberian legislation, and include the following:

- General chemistry such as pH, TDS and EC
- Major elements such as calcium, magnesium, sodium, potassium, sulphate, nitrate, fluoride, chloride, phosphate
- An ICP scan of minor elements including aluminium, arsenic, barium, boron, bismuth, cadmium, copper, chrome (total), chrome (hexavalent), cyanide, iron, manganese, mercury, molybdenum, nickel, lead, antimony, selenium, vanadium and zinc.

20.6.10.2 Surface Water Monitoring – New Liberty

A comprehensive surface water monitoring program is ongoing at the New Liberty Mine. The program comprises:

- Daily water quality sampling at five locations (TSFR, TSFA, CMP2, EDMP2 and Penstock 5), analysed at the on-site laboratory
- Weekly water quality sampling at NSWL1 and SMA1, analysed at the on-site laboratory
- Monthly batches of 15 check samples that are analysed by the accredited ALS Environmental laboratory in Prague (Czech Republic).

The existing water monitoring network is illustrated in Figure 20-11.

It is recommended that the existing comprehensive monitoring program is maintained throughout the life of the mine.

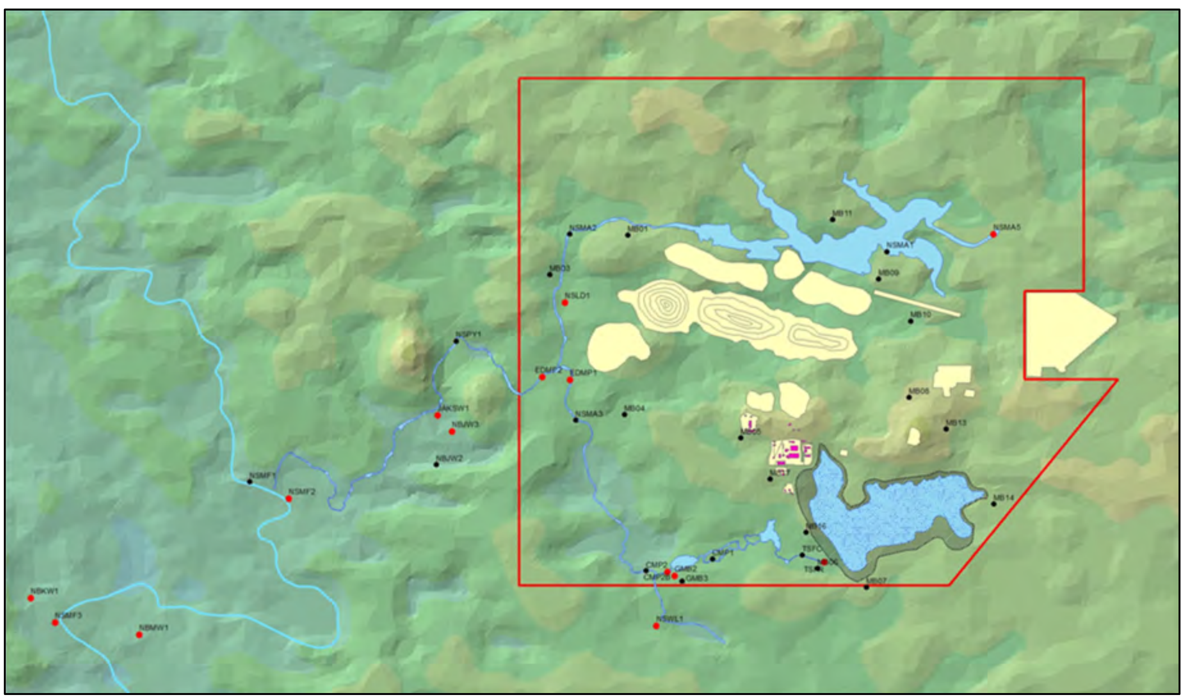


Figure 20-11: New Liberty surface water monitoring locations
Source: CSA Global, 2018

20.6.10.3 Groundwater Monitoring – Ndablama

It is recommended that a groundwater monitoring program that incorporates the proposed operations, with focus on the possible sources of impact, be implemented. These sources of impacts include the open pit as well as proposed surface infrastructure, including the WRD.

It is recommended that the monitoring program should include the following groundwater monitoring points:

- The five hydrogeological drillholes installed during the November 2018 study (NDB1 to NDB5)
- Hydrocensus points which lie close to the zones of impact and could possibly be at risk (including PRSBH8 and PRSBH9, if they can be found).

It is recommended that the monitoring program includes groundwater level and groundwater quality monitoring. It is recommended that the monitoring program should start immediately, in order to establish baseline conditions prior to the commencement of mining activities. Initially the groundwater monitoring should be completed on a monthly basis. However, this should be reviewed once twelve months of data is gathered.

Groundwater level measurements should be completed manually on a monthly basis at the seven monitoring drillholes mentioned above. In addition, a groundwater level logger should be installed in one of the new hydrogeological drillholes in order to record water levels on a six-hourly basis, with monthly download of the logger.

It is recommended that the groundwater quality monitoring parameters should comply with relevant legislation, including the following parameters:

- General chemistry such as pH, TDS and EC
- Major elements such as calcium, magnesium, sodium, potassium, sulphate, nitrate, fluoride, chloride, phosphate
- An ICP scan of minor elements including aluminium, arsenic, barium, boron, bismuth, cadmium, copper, chrome (total), chrome (hexavalent), cyanide, iron, manganese, mercury, molybdenum, nickel, lead, antimony, selenium, vanadium and zinc.

20.6.10.4 Groundwater Monitoring – New Liberty

A groundwater monitoring network exists at the New Liberty Mine and groundwater monitoring has been completed between 2013–2014 (pre-mining) and 2017–2018 (ongoing mining). The existing groundwater monitoring network is illustrated in Figure 20-11.

The existing groundwater monitoring network extends across the site and incorporates the mine operations; however, there are no groundwater monitoring drillholes within 500 m of the open pits.

It is recommended that the existing monitoring network is maintained, and new dedicated groundwater monitoring points be installed adjacent to the proposed final pit crests.

The following groundwater monitoring points are recommended to be installed as part of the monitoring programme development:

- Up to three monitoring points located along the northern edge of the open pits between the Marvoe Creek Dam and the pits, approximately 50 m from the maximum pit extent
- Two monitoring points located along the southern edge of the open pits, approximately 50 m from the maximum pit extent.

The depth of the new dedicated groundwater monitoring drillholes is recommended to extend to approximately 50 mbgl. The hydrogeological investigations completed to date suggest that the groundwater levels at the New Liberty mine site have not been significantly impacted by the operation of the mine and associated pit dewatering, and groundwater levels are typically less than 10 mbgl (even in the new drillholes drilled in November 2018 within the open pits).

Groundwater level measurements are recommended to be completed manually on a monthly basis at all sites. In addition, groundwater level loggers are recommended to be installed in one of the pit perimeter drillholes to record water levels on a six-hourly basis, downloaded on a monthly basis and calibrated to the manual level measurements.

It is recommended that groundwater quality monitoring is completed on a monthly basis at all the existing groundwater monitoring locations and two of the new pit monitoring drillholes, in accordance with best international standard (i.e. ISO-5667).

It is recommended that the groundwater quality monitoring parameters should comply with relevant legislation, and should include the following parameters:

- General chemistry such as pH, TDS and EC
- Major elements such as calcium, magnesium, sodium, potassium, sulphate, nitrate, fluoride, chloride, phosphate
- An ICP scan of minor elements including aluminium, arsenic, barium, boron, bismuth, cadmium, copper, chrome (total), chrome (hexavalent), cyanide, iron, manganese, mercury, molybdenum, nickel, lead, antimony, selenium, vanadium and zinc.

20.7 Environmental and Social Management Plan

As part of the ESIA for the Ndablama deposit an Environmental and Social Management Plan (ESMP) will be developed. The role of the ESMP is to assist BMMC in reducing potential impacts and risks and achieving its environmental objectives as well as fulfilling its commitment to the environment. The ESMP will be used to ensure compliance with environmental specifications, monitoring and management measures. The ESMP will be implemented from site preparation through to decommissioning and closure.

With the appropriate mitigation measures implemented, impacts associated with the Project can be mitigated to an acceptable level. Social impacts relating to procurement of local goods and services and access and mobility, are considered to be positive impacts. The Project, with suggested mitigation measures, will enhance the socio-economic environment of the Ndablama study area.

20.7.1 Monitoring

Environmental monitoring is intended to provide constant feedback on the effectiveness of mitigation measures identified in and implemented through the ESMP. The monitoring plan define the actions required for continuous tracking of the ESMP and will allow for the identification of any challenges and non-compliances identified, whilst providing the opportunity to adjust the ESMP and mitigate impacts that require further intervention.

BMMC will develop detailed procedures for each of these monitoring plans and will ensure that monitoring reports are prepared and reported internally, on a monthly basis, and externally, on an annual basis.

20.7.2 Stakeholder Engagement and Disclosure

A public consultation and disclosure process is currently underway as part of the Environmental and Social Impact Assessment and associated permitting process for the Ndablama deposit. The approach to consultation and disclosure is informed by IFC PS 1 (IFC, 2012) as well as the host country legislation.

The consultation process is designed to be undertaken in parallel with the socio-economic survey and is based on several participatory public meetings to be held with the local communities and authorities in each of the communities and settlements likely to be affected directly or indirectly by the proposed development.

A Stakeholder Engagement Plan (SEP) was developed as part of the EMS at NLGM by BMMC and future engagement will be undertaken within the framework already established by BMMC. BMMC A new SEP and grievance mechanism as implemented by BMMC, and by which stakeholders may communicate their concurs and comments on the project have been issued in 2018 and a recording and tracking system for all engagements and grievances have been implemented Both the SEP and grievance mechanism have been operationalised and regular planned engagements are taking place.

The SEP aims to build on an understanding of previous Stakeholder Engagement (SE) activities undertaken in the project area, identify stakeholders, concerns and interests to be engaged with, clarify the strategy for engagement with stakeholders with detailed goals and objectives and provide an Implementation Plan comprising of various components addressing existing and future BMMC requirements.

20.7.3 Community Development Plan

A Community Development Plan (CDP) was developed by BMMCAvesoro as part of its management system in support of the ongoing activities at NLGM. The CDP is being updated as a LDP considering the existing CDP is unfit for purpose. Community focussed participatory planning/visioning was undertaken by external consultants to determine a series of livelihood restoration/ development activities and influx management process tailored to and owned by the community. A livelihood restoration and development plan is being prepared based on the outputs from the visioning process. Community Development associated with the Ndablama project area will be guided by this CLDP to ensure consistency in BMMC's approach to community development across the license area.

20.7.3.1 Development Strategy

The key objectives of the LDP are:

Community Development Plan Objective 1: Supporting local economic independence whilst recognizing the mine offers opportunities for local added value.

Improved access to Technical and Vocational Training (TVET) and business development opportunities

To enable skills based economic growth

Community Development Plan Objective 2: A food secure and vibrant economy benefitting but not dependent on the mine.

To enable project affected communities to become food secure.

To link procurement opportunities at the mine with community enterprises and cooperatives

20.7.3.2 Development Opportunities Identified

Table 20-27 below summarised some of the community development opportunities identified in

Table 20-27: Community development and livelihood restoration opportunities identified

Suggested Activities:	• Sustainable/ conservation agriculture and agroforestry • Market gardens and agricultural extension training • Poultry keeping (meat and eggs) • Appropriate food processing and food hygiene • Enterprise and business development • Cooperative management skills building • Rotating savings and credit schemes • Administration and book keeping

The following CSR initiatives were identified as part of the CDP and are being considered as part of the Ndablama deposit. The proposed initiatives will either directly or indirectly contribute to the development projects at Ndablama:

- Upgrading and maintenance of the main access road to Ndablama
- Periodic maintenance of the road network in neighbouring villages
- Improving of water supply infrastructure in the nearest village

- Improvement and upgrading of the existing social infrastructure such as the school and clinic within the Gold Camp area.
- Provision of bursaries/scholarships and internships to project affected candidates.

20.7.4 Resettlement Action Plan

The project will result in the economic displacement of some members of the community and requires the development of a Resettlement Action Plan (RAP). The RAP must allow for the identification of available resources, project affected parties, an assessment of losses, determining the preferred compensation method and compensation quantification.

The Plan must include a plan for the restoration of income that allows affected people to not suffer a net economic loss due to the development.

It is essential and mandatory that before the start of the development, all assets likely to be affected need to be identified and marked, while a moratorium must be announced once the survey is completed to that prohibits further development in areas affected by the moratorium.

The major phases of the plan include:

- The identification of impacts and the zone of influence
- The identification of right holders
- The evaluation of losses
- The definition of compensation
- The execution of the compensation component
- Follow-up and closure.

As the proposed development will not result in the resettlement of communities or households, but rather impacting on existing cultivated fields and other economic activities such as artisanal mining by community members, no involuntary resettlement is associated with the proposed development. Therefore, only some community members and their economic activities may be affected by the proposed development.

Table 20-28 illustrates planning and implementation steps the Project may consider for all resettlement activities.

Table 20-28: Resettlement planning and implementation steps

Resettlement step	Main tasks
Scoping phase	General identification of affected land, people and structures. Information to present to construction and social teams to assess identification of alternatives, impact avoidance and minimization. Understanding of legal and other requirements for compensation and other displacement assistance measures.
Socio-economic census and surveys	Collection and analysis of socio-economic baseline data of people losing land and/or other assets including information from Stakeholder Identification and Land Mapping Studies. Awareness creation, notification of landowners and users. Information dissemination and consultation for assessment and census. Assets census. Identification of the significance of impacts. Preliminary identification of affected people who are particularly vulnerable to resettlement impacts. Baseline database development including health.
Consultation for resettlement	Disclosure of information and consultation prior to and throughout resettlement planning, implementation, and monitoring/evaluation phases. Consultation carried out in such a way as to promote free, prior, and informed participation of affected people in resettlement decision making.
Calculation and delivery of damage and deprivation compensation	Collection of information from Site-specific Census and Survey Report. Valuation of land, crops, buildings, and other economic assets to be affected by land acquisition, including any communal property, social and physical infrastructure, and cultural heritage items. Development of compensation measures and means of delivery.

Resettlement step	Main tasks
Resettlement planning and preparation	Define relocation, re-establishment (housing, transitional allowances, etc.), and livelihood restoration options. Define eligibility criteria for compensation and other assistance measures. Development of Resettlement Agreements defining and agreeing on assistance packages. Identification and preparation of any resettlement sites. Development and disclosure/consultation of grievance mechanism. Development of monitoring and evaluation strategy, methods, and indicators, including both internal monitoring and external evaluation and completion audit. Finalise organisational arrangements within Project Resettlement Implementation team and with external Project and non-Project entities who will be involved in a particular compensation and resettlement process. Develop comprehensive budget. Prepare compensation and resettlement schedule.
RAP implementation	Delivery of compensation payments. Implementation of physical relocation measures. Providing resettlement re-establishment assistance. Providing on-going information sharing with affected people and opportunities for participation/consultation throughout implementation of RAP measures. Implement livelihood restoration measures.
Internal monitoring	Conduct on-going input progress monitoring. Conduct monthly output monitoring. Report and respond to need for any course corrections.
External evaluation (monitoring and evaluation) and completion audit	Organise external evaluation, with particular emphasis on standard of living and livelihood restoration (bi-annually). Organise completion audit at reasonable time for RAP measures, particularly livelihood measures, to be completed.

An estimated total budget for the implementation of the RAP and associated livelihood development plans will be finalized during the ESIA process.

20.7.5 Livelihood Restoration Activities

20.7.5.1 Livelihood Restoration Strategy

BMMC has recognised the need for sustainable restoration strategy. The strategy will be implemented to help the challenges that affected individuals and communities will experience through the development of the project.

The aim of the Livelihood restoration strategy is to support self-sustaining income streams for the displaced communities' members. The Livelihood restoration strategy will adopt measures that will restore the livelihoods of the affected individuals before resettlement.

A livelihood restoration plan is essential element for managing the adverse effects of economic displacement. The Project area is dominated by subsistence farming activities, artisanal mining and some commercial livelihoods. The livelihood restoration plan will include a restoration for land-based resources as well as non-land-based resources.

The land-based component of the plan will consist of extensions and supporting activities aimed at:

- Re-establishing subsistence agriculture practices
- Promoting rural enterprise through awareness creation and initiatives to generate income for individuals.

The non-land-based component will focus on the following:

- Training and collaboration of community development
- Improve social structures and support infrastructure development.

Table 20-29 outlines indicative strategies for income restoration with indicative measures. Specific measures will be considered and applied to the affected individuals and households.

Table 20-29: Livelihood restoration strategies

Classification	Affected individuals	Measures
Land-based component		

Agriculture	Farming	Increase agriculture productivity through: • Introduction of new crops • Training in new agricultural techniques • Assistance agricultural products to begin farming. • Improve marketing techniques.
Non land-based component		
Employment	Local community Members and Artisanal Miners	Skills development among unemployment. Establishment and promotion of micro enterprises. Restore and improve access to markets.
Artisanal Mining	Artisanal Miners	Continuation of artisanal mining activities outside the area earmarked for development by BMMC.

20.8 Mine Reclamation and Closure

20.8.1 Framework for Rehabilitation and Mine Closure

During the planning and implementation stages of the mining project, the focus of reclamation and closure planning is to ensure that:

- The proposed post-closure land use(s) for the site are defined and agreed with the regulatory authorities and local communities
- The nature, scale and cost of the works required to return the site to a condition consistent with the requirements of the post-closure land use(s) are defined and understood
- The necessary financial provisions are made for closure and that these are included in the assessment of the project's economic viability
- A plan is developed for the implementation of the reclamation and closure works to ensure that the process proceeds concurrently with mining operations wherever possible
- The build-up in reclamation and closure liabilities over the LOM is limited through appropriate mine planning and concurrent reclamation to mitigate as far as possible the impacts of premature or unplanned closure.

The framework within which the conceptual reclamation and closure plan has been developed is described below in terms of the following:

- LOM plan
- Policy guidelines and legislative requirements
- Post-closure land use objectives.

20.8.2 Life of Mine Plan

The study confirms the need to develop the following:

- Open pit
- WRDs
- Stormwater diversions
- Mine services area
- Internal roads and haul road to NLGM.

Existing infrastructure at NLGM that will be used include the processing plant, TSF as well as the accommodation camp, offices, workshop as well as associated structures and equipment.

20.8.2.1 Policy Guidelines and Legislative Requirements

Reclamation and closure planning are guided by the Minerals and Mining Law of 2000, the Environment Protection and Management Law of Liberia of 2002 as well as the International Mining Industry's Best Practice Guidelines and will be following the conclusions and recommendations of the ESIA and the related Management Plan.

20.8.2.2 Post-Closure Land Use Objectives

The likely land uses to be identified during this process are likely to include the following:

- Areas for agriculture
- Areas for livestock grazing
- Wildlife habitats.

For health and safety reasons, as well as the protection of specific rehabilitation works, specific areas within the mine lease may be designated as exclusion zones. Natural soil cover and vegetation will, as far as possible, be re-established over these areas but access by humans and/or livestock will be prohibited.

The following closure objectives form part of the conceptual closure plan:

- All structures not desirable or usable post-closure will be demolished and building material removed or disposed of.
- Hazardous material, equipment and contaminated soils and steel structures will be disposed of safely and in an environmentally acceptable manner.
- Areas used for the handling and storage of hazardous materials will be decontaminated.
- Disturbed areas will be rehabilitated to a final land use capability that is practical and best suited for the final landform, taking into consideration the socio-economic activities of the receiving communities.
- At the end of the mine life, the residual facilities will include open pits, WRD, diversion structures and supporting infrastructure.
- The ultimate end use of the rehabilitated areas is considered to have three major objectives:
  - Re-establishment to the greatest feasible degree of vegetation on the disturbed areas within the concession
  - Re-integration of the disturbed areas outside the project footprint into the agricultural and other prevalent economies
  - Re-development of the disturbed land by working with and involving local people to assist them in working towards a more sustainable form of livelihood.

20.8.3 Reclamation and Closure Completion Criteria

Rehabilitation and closure of areas disturbed by mining and related operations will be considered to be completed when:

- All structures, equipment and infrastructure not consistent with the post-closure land use have been decommissioned, demolished and removed from site
- Ownership of all the remaining infrastructure and services required to support the proposed post-closure land use has been formally transferred to the local authority responsible for the administration of the area
- The area has been made safe for all post-closure land users and livestock
- All surface disturbances and remaining landforms are structurally and ecologically stable and have sustainable soil and vegetation covers where applicable
- Surface water management structures are in place and are free of damage due to erosion

- All surface and groundwater discharges from the site satisfy agreed target water quality objectives.

20.8.4 General Reclamation and Closure Tasks

20.8.4.1 Protection and Harvesting of Resources for Rehabilitation

Construction activities will be undertaken with a view to ensuring the following:

- Minimise the area to be occupied by mine infrastructure
- Ensure that construction crews restrict their activities to the planned areas
- Pre-strip topsoil and overburden material from areas earmarked for development to be used during final rehabilitation, taking soil depths and soil stripping guidelines into consideration
- Establish seed banks and a nursery to be used during rehabilitation activities.

20.8.4.2 Preparation and Placement of Growth Medium

The following activities will be undertaken as part of the topsoil placement process:

- Previously disturbed areas will be graded and ripped to ensure that the area is ready for the placement of overburden and topsoil material.
- Compaction will be minimised by using appropriate equipment and replacing soils to the required thickness in single lifts, where possible.
- Soils will be moved when dry to minimise compaction. If soils must be moved when wet, shovel and truck methods should be used.
- Where multi-layer soil profiles are re-created, running over the lower layers with heavy equipment should be minimised.
- Minimise compaction during smoothing of replaced soils by using dozers rather than graders.
- Following placement, all soils should be ripped to full rooting depth.
- Where natural revegetation is not possible, the soils should be tilled to produce a seedbed suitable for the plant species selected for seeding.

20.8.4.3 Revegetation

The following considerations apply:

- Species selected for rehabilitation must meet the biodiversity objectives.
- Rehabilitation species selection must be based on practical considerations.
- Appropriate methods will be used for vegetation establishment.
- Planting should be done when climatic conditions are most likely to ensure success.
- No specialized biodiversity objectives have been set but, should these be identified during the detailed closure planning process, the necessary expertise will be acquired to ensure the successful implementation of the rehabilitation plan.
- The revegetation objectives should be set to meet the post-closure land uses that have been agreed for the site. These could be the re-establishment of the native vegetation, erosion control for the protection of water resources, establishment of high-quality grazing or the preparation of lands for arable use.

20.8.5 Specific Infrastructure Areas and Facilities

20.8.5.1 Ore Stockpiles

It is expected that ore stockpiles will be removed by the end of the mine life and that the stockpiled areas will be reclaimed by grading and revegetating to blend with the natural landscape. Where this is not possible, stockpiled ore will be reshaped and rehabilitated according to the post-closure risk posed to the receiving environment.

20.8.5.2 Contaminated Soils

Contaminated soil from solvents and lubricants and other hydrocarbon sources will be removed and placed in an approved disposal facility, most likely on the lined TSF at NLGM.

20.8.5.3 Open Pit

During the decommissioning of the pit the following will be carried out at closure:

- Decommission pipelines, pumps and electrical lines
- Remove dewatering equipment
- Block access ramps
- Evaluate the stability of the pit slopes and where required, re-shape or stabilise pit slopes
- Slope edges of the pit to the final water mark (to permit animals and people that might have fallen into the pit to get out)
- Remove water diversion channels to facilitate flooding of the open pit
- Construct a 3 m high x 4 m wide safety berm around the pit
- Continuously assess the water quality in the open pit and groundwater at the rehabilitated pit and if required, provide water treatment systems (e.g. pit lake treatment, constructed wetland) to improve water quality in the open pit.

20.8.5.4 Waste Rock Dump

The WRD will be constructed to the specified parameters of 2.50 H:1.0V with reclaimed slope with benches at vertical intervals of 15 m to provide an overall slope of approximately 3.5 H:1V.

The total footprint of the reclaimed WRDs will be approximately 80 ha. Grading will minimise potential for slope failures or rill erosion, facilitate rehabilitation activities (seeding, mulching), and provide a surface that will enhance water retention and support vegetation.

Rehabilitation of the side slopes will be carried out concurrently once each lift is completed. At closure the final slopes and crest will be rehabilitated.

The top of the WRD and remaining safety benches will be graded to promote runoff of water (free draining), prevent ponding or impounding of water and limit erosion. Angular features, including tops and edges of the WRD, will be rounded. Topsoil and growth media will be redistributed over the waste rock.

20.8.5.5 Rehabilitation Monitoring, Aftercare and Maintenance

Provision has been made for ongoing monitoring and maintenance following the completion of the final rehabilitation and closure activities. Monitoring typically includes the following aspects:

- Alignment of the actual final topography to the agreed planned landform, which is free draining
- Actual depth of topsoil placement, as well as the chemical, physical and biological status of the replaced soil
- Presence of erosion and the actual cause of the erosion
- Surface water quality, as well as the presence of ponding in low-lying areas, resulting in breeding areas for mosquitos
- Groundwater quality at agreed monitoring locations
- Vegetation basal cover

- Vegetation species diversity
- Crop growth and yield (on sites rehabilitated to agricultural end uses).

Provision has been made for the collection and analysis of environmental monitoring data (surface and ground water, air quality) and the compilation of monitoring reports for a period of:

- 18 months after closure to coincide with the decommissioning and rehabilitation phase of the project
- An additional five years after completion of the decommissioning and closure phase.

The costs associated with the post closure environmental monitoring have been based on the current and proposed project phase expenditure.

20.8.6 Financial Provision for Closure

The financial provision requirements associated with the proposed development were calculated for the concurrent, decommissioning, closure and post-closure phases of the proposed development. A closure budget provision of $10,000,000 for New Liberty with respect to the mine workings the plant and infrastructure, tailings, waste dump, roads and camp has been made. A closure budget provision of $2,500,000 for Ndablama with respect to the mine workings, waste dumps, surface infrastructure and camp has been made. The New Liberty access road and the Ndablama–New Liberty haul road will be handed over to the local municipality for community use. A total closure provision of $12,500,000 has therefore been allowed.

21 Capital and Operating Costs

21.1 Capital Costs

21.1.1 Definition of Capital Costs

Capital costs comprise Project Capital and Sustaining Capital. The costs which have been capitalised for tax purposes is the sum of two of these definitions.

Project Capital Cost includes costs incurred during the implementation of the New Liberty Underground Mine and the Ndablama satellite pit up to the point whereby the project areas are able to sustain the joint nameplate production rate of 1.8 Mt/a. Project Capital Costs include:

- The cost of surface infrastructure required for infrastructure at New Liberty to support the underground operation, such as a power generation facility and in pit sump pump stations
- The cost of underground mine development at New Liberty during the underground project ramp-up phase
- The cost of underground infrastructure at New Liberty during the underground project ramp-up phase, including but not limited to the ventilation fans, dewatering systems and other utilities
- The cost of surface infrastructure at Ndablama required to support operations at the project area, including but not limited to the cost for offices, workshops, stores and other facilities
- The cost of a haul road connecting Ndablama to the New Liberty processing facilities
- The cost related to the expansion of TSFs at New Liberty required for the storage of residues generated from the combined project
- Indirect costs related to the implementation period, such as engineering design and study costs, transport, insurance, freight and procurement costs
- Contingency during the ramp-up period outlined above.

Sustaining Capital Cost includes cost associated with Combined Project after name plate production has been achieved. This includes:

- The cost of underground mine development at New Liberty during steady state production
- The cost of underground infrastructure at New Liberty during steady state production
- The cost of maintenance of the haul road connecting Ndablama to the New Liberty processing facilities
- The cost related to further expansion of TSFs at New Liberty
- Indirect costs related transport, insurance, freight and procurement during the period of sustained production
- Closure costs related to New Liberty and Ndablama
- Contingency during the period of sustained production.

21.1.2 Base Date and Currency

The capital cost estimate is based on the engineering designs for the Combined New Liberty and Ndablama deposit, costs and information as at March 2019. The costs are presented in United States dollars (US$) in real money terms, free of escalation or inflation.

21.1.3 Estimating Strategy

The capital cost estimate has been determined through the application of historical mine costs, tenders, budget quotations, database costs and estimated costs to bills of quantities, material take-offs and estimate quantities. In terms of mine design and mine plan, the quantities applied to the unit costs were computationally modelled and scheduled in 3D space. Other costs relating to specific engineering designs were determined from drawings and associated bills of quantities. A majority of the unit capital cost estimate costs were obtained from reputable suppliers and contractors in the form of budget quotations or tenders, as well as costs from the internal company database generated from previous work. This strategy is applicable for a pre-feasibility study design.

21.1.4 Exclusions from Estimates

No specific exclusions are noted from the capital estimate.

21.1.5 Escalation and Foreign Exchange

No provisions have been allowed for escalation or variation in foreign exchange of any costs.

21.1.6 Capital Cost Summary

A work breakdown structure (WBS) was formulated for the total capital expenditure. The WBS comprises a four-tier structure. A summary of the Total Capital Cost is presented in Table 21-1. The table presents the Project Capital, Sustaining Capital and Total Capital cost against the WBS tier 2.

Table 21-1: Capital cost summary

Area	Project capital	Sustaining capital	Total
New Liberty	**12,466,650**	**40,278,875**	**52,745,524**
Site and Local Infrastructure	1,301,940	-	1,301,940
Open Pit Preparation	1,351,851	4,465,555	5,817,407
Underground Mining	9,812,859	35,813,319	45,626,178
Ndablama	**14,349,973**	**3,000,000**	**17,349,973**
Site and Local Infrastructure	14,349,973	3,000,000	17,349,973
Processing and Tailings	**3,538,314**	**7,375,687**	**10,914,001**
Tailings	3,538,314	7,375,687	10,914,001
General and Administration	**2,319,046**	**13,032,342**	**15,351,388**
Indirect Costs	2,319,046	13,032,342	15,351,388
Contingency	**3,267,398**	**6,368,690**	**9,636,089**
TOTAL	**35,941,382**	**70,055,594**	**105,996,975**

Notes: All costs presented in US$. Due to rounding, some columns or rows may not compute exactly as shown.

21.1.7 New Liberty Capital Cost

A capital cost summary for costs related to the New Liberty Project, to WBS tier 4, is presented in Table 21-2.

Table 21-2: Capital cost summary – New Liberty

Area	Project capital	Sustaining capital	Total
Site and Local Infrastructure	**1,301,940**	**-**	**1,301,940**
Utilities and Reticulation	1,301,940	-	1,301,940
Permanent Power Supply	*1,301,940*	*-*	*1,301,940*
Open Pit Preparation	**1,351,851**	**4,465,555**	**5,817,407**
Infrastructure	1,157,046	2,541,556	3,698,602
Pit Dewatering	*917,837*	*2,005,747*	*2,923,584*
Pit Electrical Reticulation	*239,209*	*535,809*	*775,018*
Pit Preparation	194,805	1,923,999	2,118,805
Cemented Crown Pillar	*194,805*	*1,599,999*	*1,794,805*
Pit Backfill	*-*	*324,000*	*324,000*
Underground Mining	**9,812,859**	**35,813,319**	**45,626,178**
Mining	8,798,161	32,541,813	41,339,973
High Wall Support	*27,975*	*27,975*	*55,950*
Level Development	*2,643,664*	*12,171,812*	*14,815,476*
Portal	*72,342*	*72,342*	*144,684*
Ramp Development	*5,482,403*	*18,398,604*	*23,881,007*
Ventilation Raise Development	*571,777*	*1,871,080*	*2,442,857*
Facilities and Services	653,511	2,059,385	2,712,896
Dewatering Pump Stations	*224,242*	*752,544*	*976,786*
Escape Ladderways	*20,239*	*67,921*	*88,160*
Lubrication Station	*15,134*	*50,788*	*65,922*
Refuge Bays	*11,508*	*38,620*	*50,128*
Ventilation Controls	*6,600*	*22,150*	*28,750*
Ventilation Fans	*375,788*	*1,127,363*	*1,503,151*
Utilities and Reticulation	361,187	1,212,121	1,573,308
Communications, Control and Instrumentation	*62,726*	*210,504*	*273,229*
Dewatering Reticulation	*78,398*	*263,098*	*341,496*
Electrical Reticulation	*10,631*	*35,676*	*46,307*
Fire Suppression	*63,444*	*212,913*	*276,357*
Potable Water Reticulation	*35,078*	*117,718*	*152,796*
Service Water Reticulation	*110,911*	*372,212*	*483,123*
TOTAL	**12,466,650**	**40,278,875**	**52,745,524**

Notes: All costs presented in US$. Due to rounding, some columns or rows may not compute exactly as shown.

Site and local infrastructure costs relate to the costs for a new power generation facility at New Liberty, required to service the demand from the underground mining activities at New Liberty. The total cost of US$1.3 million is for the implementation of a 4.5 MVA diesel generator facility.

Costs related the New Liberty Open Pit comprise pit preparation and infrastructure costs required before underground mining commences. Pit preparation costs include construction of a cemented crown pillar and backfilling the Larjor and Kinjor pits to the respective portal positions, this cost equates to US$2.1 million, with majority of the cost related to sustaining capital as works related to the larger Kinjor pit fall within the sustaining capital cost period. Similarly, infrastructure costs include the cost of collection sumps, pump stations and associated electrical infrastructure for the Larjor and Kinjor pits at a total of US$3.7 million, with majority of the cost falling within sustaining capital cost. In total, pit preparation and infrastructure cost account for US$5.8 million of capital cost.

Costs related to underground mining activities and infrastructure at New Liberty equate to a total of US$46 million. Majority of the cost is related to underground mine development of the ramps, levels and, with US$41 million attributed to these activities. The balance of the capital cost primarily relates to underground infrastructure required to support the mining operations. Underground infrastructure includes facilities such as dewatering pump stations, ventilation fans, refuge bays and equipped escape ways, totalling US$2.7 million; and utilities which include the primary backbones for electrical power, service water, potable water, compressed air, fire suppression and control and instrumentation. These utilities total US$1.5 million.

21.1.8 Ndablama Capital Cost

A capital cost summary for costs related to the Ndablama deposit, to WBS tier 4, is presented in Table 21-3.

Table 21-3: Ndablama capital cost summary

Area	Project capital	Sustaining capital	Total
Site and Local Infrastructure	**14,349,973**	**3,000,000**	**17,349,973**
Facilities and Services	1,875,245	-	1,875,245
Changehouse	*311,340*	-	*311,340*
Diesel Storage and Dispensing	*509,271*	-	*509,271*
Mine Offices	*229,322*	-	*229,322*
Mine Workshop	*215,986*	-	*215,986*
Sewage Treatment Plant	*319,797*	-	*319,797*
Stores	*289,529*	-	*289,529*
Site Preparation	12,253,170	3,000,000	15,253,170
Earthworks and Terracing	*2,253,170*	-	*2,253,170*
Haul Roads	*10,000,000*	*3,000,000*	*13,000,000*
Utilities and Reticulation	221,559	-	221,559
Site Water Reticulation	*221,559*	-	*221,559*

Notes: All costs presented in US$. Due to rounding, some columns or rows may not compute exactly as shown.

Site and local infrastructure costs account for all the capital costs at Ndablama. The costs relate to the establishment of infrastructure required to support mining operations at the satellite pit. In terms of facilities and services, provisions have been made for construction of changehouses, offices, workshops, stores, diesel storage, dispensing and power generation at a total of US$1.8 million. Significant costs relate to the preparation of the site, most notably the haul road required from Ndablama to New Liberty costing US$10 million with an additional US$3 million spread over the sustaining capital cost period for road maintenance. Additionally, due to the topographic nature of the area, significant cut and fill terracing is required for the infrastructure, equating to US$2.3 million.

21.1.9 Processing and Tailings Cost

Tailings expansion costs have been determined on and annualised bases by Golder and Associates. The costs equate to US$10.9 million over the Combined Project LOM, with US$3.5 million accounting as project capital.

Table 21-4: Processing and tailings capital cost summary

Area	Project capital	Sustaining capital	Total
Tailings	**3,538,314**	**7,375,687**	**10,914,001**
2019 Construction	594,000		594,000
Phase 3a Construction (2020)	593,558		593,558
Phase 3b Construction (2021)	2,350,756		2,350,756
Phase 4a Construction (2023)		1,921,276	1,921,276
Phase 4b Construction (2024)		1,116,386	1,116,386
Phase 5 Construction (2026)		2,514,897	2,514,897
Phase 6 Construction (2027)		1,823,128	1,823,128
Total	**3,538,314**	**7,375,687**	**10,914,001**

Notes: All costs presented in US$. Due to rounding, some columns or rows may not compute exactly as shown.

21.1.10 General and Administration Cost

General and administration (G&A) cost comprise provisions made for indirect costs associated with the project. This includes an allowance for detailed engineering design and a definitive feasibility study update, estimated at 12.5% of engineering cost at US$1.4 million, owners cost which comprises transportation, freight, insurance (7.5% of engineering cost) and procurement costs (5% of engineering cost) associated with new infrastructure. In addition, US$10 million and US$2.5 million provisions have been made for closure of New Liberty and Ndablama sites respectively.

Table 21-5: G&A capital cost summary

Area	Project capital	Sustaining capital	Total
Indirect Costs	**2,319,046**	**13,032,342**	**15,351,388**
DFS/Detailed Engineering (including ESIA)	1,425,694	-	1,425,694
Owners Costs	893,352	532,342	1,425,694
Closure Costs	-	12,500,000	12,500,000
Total	**2,319,046**	**13,032,342**	**15,351,388**

Notes: All costs presented in US$. Due to rounding, some columns or rows may not compute exactly as shown.

21.1.11 Estimate Accuracy and Contingency

A contingency has been estimated at 10% of overall capital cost. The contingency is of typical magnitude for a PFS, considering:

- A large quantity of the capital cost relates to mine development, which is affirmed by quotation from a mining contractor
- Engineering costs have been largely obtained through budget quotations and bills of quantities or material take-offs.

Contingency allowance US$3.2 million and US$6.3 million for Project Capital and Sustaining Capital Cost periods respectively.

21.1.12 Capital Expenditure and Cash-flow

Figure 21-1 presents the forecasted capital expenditure for the Combined Project. The cash flow has been generated through the respective mining schedules and infrastructure implementation schedules of the project. Project capital expenditure is incurred primarily from 2019 to 2021, with sustaining capital expenditure proceeding mainly from 2022. The greatest capital expenses are incurred in 2020 and 2021 with US$22 million per annum incurred during these years.

Figure 21-1: Capital expenditure cash flow

21.2 Project Execution

21.2.1 Introduction

The combined project will include open pit mining of the New Liberty deposit until the break-even cutoff for underground mining is reached, a transition to underground mining by long-hole open stoping methods, and open pit mining of the reserves at the Ndablama deposit with direct shipping of Ndblama ore to the New Liberty mill later in the life of the project.

At New Liberty a new, approx. 700,000 ROM t/a underground mine, will be accessed by portals developed from the old Larjor pit in 2020. An additional portal will be developed at Kinjor pit in 2022. Each portal will have constructed entry, plus support, and services including sumps/pumping and a main ventilation fan (and vent shaft) in the vicinity. Extensive facilities including sumps and pumps to maintain/control water in the final pit (Pit 33) will be provided around each portal. Additionally, an ore transfer station, with a dump for underground ore trucks, and front-end loader to load haul trucks will be provided.

Power generation will be by two new 2.25 MVA diesel generators, with reticulation at 6,000 V to the new pumps, fans and the underground. Additional workshop capacity for planned maintenance of underground fleet will be provided. New/updated roads for mobile fleet to travel from the portal(s) to the plant stockpile and workshops will be constructed.

The following buildings will be constructed:

- Mine control room
- Surface workshop
- Generator station/substation
- Ventilation stations (two).

At Ndablama a new approx. 1,200,000 ROM t/a open pit mine, operated by contractor with conventional truck/shovel fleet will be developed. The pit is to be provided with all relevant infrastructure to support conventional diesel mining fleet plus labour/supervision, including a combined workshop, fuel station and lubrication station, stores, offices, changehouse facilities, and pit dewatering infrastructure. Pit dewatering will be by Global type diesel pumps as at New Liberty, discharging into the surface stormwater diversion trenches as required. Workshops will be designed for the estimated complement of mobile fleet; offices and changehouse facilities will be designed for the estimated labour complement plus contingency. Haul trucks from the pit will dump to a ROM pad, where a front-end loader will load off-highway trucks for the transport of ore to the New Liberty ROM pad. Roads to connect the crushing station to the ND-NL haul road must be laid out. A ±46 km haul road from Ndablama mine to New Liberty mine will also be constructed prior to the development and pre-strip of the Ndablama pit. Power generation will be by a single new 400 kVA generator for small power (offices, changehouses, stores) only. Solar generation has been allowed on the changehouse roof to support power requirements.

There is an existing 1.8 Mt/a mill on site at New Liberty therefore no new milling facilities relating to Ndablama underground or Ndablama open pit are contemplated. A new road train side-tip (two 90-t cars) will be required in the ROM area to handle ROM coming from Ndablama pit from Year 5.

21.2.2 Project Management

Management of the project will be by a combination of owner's team and consultants. Overall management of the project will be by Avesoro Resources. Domain areas e.g. underground mine development, open pit mine development, the haul road project, and TSF will be managed by individual consultants specialising in these areas. All domain project managers will report to the Avesoro Project Manager. Underground mine development will be by contractor. Open pit mine development at Ndablama will also be by contractor, including initial camp setup. The provision of major infrastructure (e.g. power and pumping) is by Avesoro and will be managed by Avesoro.

21.2.3 Health, Safety, Environment and Community

Avesoro Resources is committed to:

- The provision of a risk managed workplace that is conductive to health and safety.
- The provision of expertise, appropriate resources, training and personal protective equipment to improve occupational health and safety.
- Continuously improving occupational health and safety performance through the setting of goals, and use evolving scientific knowledge and technology and best practices to achieve these goals.
- Operating in accordance with recognised industry standard, while complying with applicable legal and any other requirements.
- The application of constructive and consultative approach in interactions with stakeholders.
- Ensuring that employees and contractors are aware of their individual occupational health and safety obligations and rights.
- Ensuring that employees and contractors have the relevant skills and training to perform their work in a safe manner.
- Make this policy and its revisions available to employees, contractors, and other stakeholders.
- Ensuring that all the necessary arrangements and preparations are in place to enable the company respond promptly and effectively to any emergency that may arise in our operations.
- Reviewing this policy periodically to be consistent with any operational, legal and other requirements and available at all workplaces. Employees and contractors play a fundamental role in supporting to achieve these objectives through:
    - their right to work in an environment where health risks are reduced, and their duty to withdraw from, and report an unreasonably unhealthy or dangerous situation
    - taking ownership of occupational health and safety management programs and initiatives, and complying with all standards and procedures
    - being responsible for their safety at work and also the safety of their co-workers.

HSE responsibility will rest with Avesoro for the project. Ongoing HSE management is required for the operating New Liberty Mine. New HSE functions will be initiated in advance of developments at Ndablama, including ongoing community engagement already initiated during exploration phases.

21.2.4 Quality Control and Quality Assurance

A systematic QA/QC program for the project will be set up. For engineering and procurement activities, standards will be agreed, work will be to standard, manufacturing will be managed to standard, and procurement will be to AVS specifications. AVS will provide QA/oversight to all engineering, procurement and construction (EPC) activities under their management. Individual domain consultants will provide QA/oversight to all EPC activities under their management. Underground mine development will be by contractor, overseen by consultants acting as Avesoro's owner's engineer. Open pit mine development at Ndablama, as well as camp facilities at the mine will be by contractor, overseen by consultants acting as Avesoro's owner's engineer.

21.2.5 Risk Management

A detailed risk matrix has been developed for the project, with risk mitigation strategies for known risks developed and documented. Details can be found in Section 24.1 (Risk).

21.2.6 Project Schedule

A level 2 project schedule has been developed and is shown in Figure 21-2.

Operations at the New Liberty open pit are current and will continue until open pit mining is curtailed at Pit 33 stage in 2022.

Development of the portal at Larjor will commence in Q1 2020, with access ramp development from Q2 2020 until Q4 2021. Surface infrastructure to support underground mining at New Liberty, including new generating capacity, and surface water management facilities are developed in Q1 2020. Development of the portal at Kinjor commences at the end of open pit activity in Q3 2022, with access ramp development from Q4 2022. Footwall development is ongoing from Q4 2021 until end of LOM, with full production achieved circa Q4 2022.

Expansion of the TSF begins in March 2019, with additional phases in March 2020 and a major capital extension in March 2021. Thereafter expansion of the TSF will be incremental with ongoing mining activity.

Development of the New Liberty–Ndablama haul road begins in Q3 2021, with a duration of 6 months, with surface preparation, haul roads and surface water diversion works developed on site in Q1 2022. Camp, office and workshop facilities are constructed in Q1 2022, with mining commencing in Q2 2022. Due to the outcropping nature of the deposit, and deposit geometry, no significant pre-strip is scheduled and ore production, and waste stockpile construction start immediately.

Closure of both New Liberty mine and surface infrastructure, in line with permitting provisions, and closure of Ndablama is currently planned at the end of LOM in 2029.

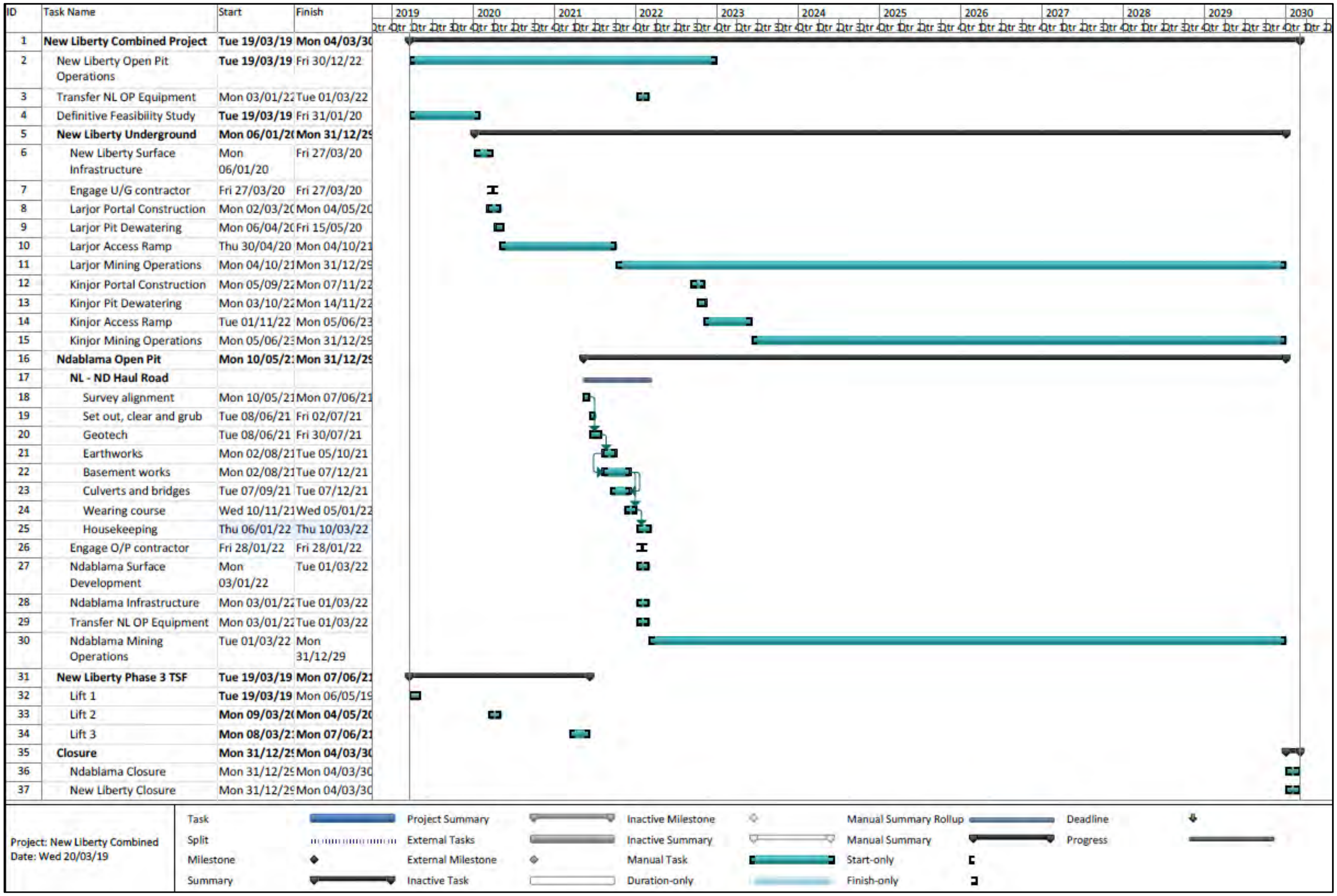


Figure 21-2: Project schedule

21.2.7 Project Controls

The project will be executed under project procedures that conform generally to ISO 9001 requirements, and embrace cost, time and resource control principles. All equipment and parts required will be purchased against established budgeted estimates that would only be exceeded with prior Avesoro approval. Subcontracts will be awarded against bills of quantity that reflect a completed detail design.

The project time control will be based on the program of works described above, which has been developed on the durations achieved on a similar sized project in which Bara has been involved. Detailed planning will be scheduled using a suitable software package and level 4 planning will be incorporated and monitored in the subcontracts awarded. Expediting will be incorporated within the procurement procedure. Planning will identify the resource requirement in all phases of the project works. This will be available at an early stage with cross reference to the similar projects completed and the resource requirement can be applied to those recognised critical paths.

21.2.8 Engineering

A Pre-feasibility level of engineering has been completed on the project. A definitive feasibility study is planned from March 2019 to March 2020. Due to the accelerated timeline on the project, early development works will proceed immediately on completion of the DFS. Other works requiring more detailed design will be thus detailed. A further five-month detail design period including incorporation of local regulations has been estimated. Where possible, licensed contractors in their specialised disciplines will be employed to undertake the detail design, under supervision.

21.2.9 Material Management and Logistics

The procurement plan for supply items currently envisaged is broken down into three groups:

- A substantial amount of equipment will be brought by the two main mining contractors from Turkey
- Additional key equipment with some proprietary engineering and design input would be imported from Europe
- Additional equipment as required can be procured South Africa, and delivered to Liberia, although it may be possible to procure from a more local source, once the detailed design and specifications are finalised and subject to commercial acceptability.

All imported items will be shipped break-bulk to the port of Monrovia for offloading. From port of Monrovia, bulk items will be loaded onto low-bed trucks or in containers as the case may be for trucking to New Liberty. All trucked loads will be escorted through Monrovia and thence via the national tar road for safety. Offloading at New Liberty will be by craneage arranged on site.

21.2.10 Contract Management

Contract management of operating contracts (New Liberty open pit, New Liberty Underground and Ndablama open pit mining contracts) will be by Avesoro. Additional contract management for the procurement of capital items (e.g. generators will also be by Avesoro, or BMMC). Management of the tailings facility expansion will be by BMMC. A specialist road development contractor will be engaged, overseen by the haul road designer in the role of owner's engineer.

21.2.11 Construction Management

No major construction, other than mining development, major capital items, and the haul road previously described, is envisaged.

21.3 Operating Costs

21.3.1 Definition of Operating Cost

Operating costs are defined as the cost of all activities related to mining and ore processing as well as general and administrative costs related to the Combined Project. Operating costs presented in this section are on-site mine only cost (C1 cash cost) and include;

- The cost of contract mining of ore and waste at the New Liberty Larjor and Kinjor open pits
- The cost of contract mining of underground stopes and ore drives at the New Liberty Underground mine
- The cost of contract mining of ore and waste at the Ndablama open pit
- The cost of transporting ore from Ndablama to the New Liberty processing facilities
- The cost of processing all ore from the Combined Project
- General and administration costs for the Combined Project.

21.3.2 Base Date and Currency

The operating cost estimate is based on the engineering designs for the Combined New Liberty and Ndablama deposit, costs and information as at March 2019. The costs are presented in United States dollars (US$) in real money terms, free of escalation or inflation.

21.3.3 Estimating Strategy

The operating cost estimate has been determined through the application of historical mine costs, tenders and estimated costs to estimated quantities. In terms of mine design and mine plan, the quantities applied to the unit costs were computationally modelled and scheduled in 3D space. Majority of the unit operating cost estimate costs were obtained from contractors in the form of budget quotations or tenders. This strategy is applicable for a PFS design.

21.3.4 Exclusions from Estimates

No specific exclusions are noted from the operating cost estimate.

21.3.5 Escalation and Foreign Exchange Rate

No provisions have been allowed for escalation or variation in foreign exchange of any costs.

21.3.6 Operating Cost Summary

The Combined Project operating cost summary is presented in Table 21-6. The operating costs have been separated by project area. Overall the Combined Project realises a C1 Cash Cost of US$56.61/t of ore milled, or US$767 per troy ounce of gold recovered. New Liberty C1 Cash Cost equates to US$36/t milled and Ndablama US$20/t milled. It is important to note the unit operating costs are derived through tonnes milled by the Combined Project and will appear lower than if the unit costs are derived by taking consideration of the tonnes milled by each project area independently.

Table 21-6: Operating cost summary

Area	LOM operating cost	Cost per tonne milled	Cost per ounce recovered
New Liberty	**615,901,031**	**36.08**	**489.03**
G&A	75,095,822	4.40	59.63
Mining	341,352,232	20.00	271.03
Processing	199,452,977	11.69	158.37
Ndablama	**350,299,177**	**20.52**	**278.14**
G&A	52,651,213	3.08	41.81
Mining	105,904,334	6.20	84.09
Processing	191,743,630	11.23	152.24
TOTAL	**966,200,209**	**56.61**	**767.16**

Notes: All costs presented in US$. Due to rounding, some columns or rows may not compute exactly as shown.

21.3.7 New Liberty Operating Costs

The most significant operating cost expense incurred at New Liberty is related to that of the open pit and underground mining contractor. Open pit mining costs have been determined from a contractor quotation whereby an all-in mining cost for US$1.70/t of rock (ore or waste) was provided. Underground contractor mining rates were also provided at US$28.50 per stope tonne and US$3,000 per ore drive metre. Additional costs were provisioned for the underground operating cost, including supply and installation of ground support and ex-pit hauling of the ore from the portal to the New Liberty processing facility.

Processing costs have been provided by Avesoro and are based on the current costs of the New Liberty processing facility. The cost equates to US$20.38/t milled.

Further, G&A costs have been factored from current operations at New Liberty to account for a production rate of 1.8 Mt/a. The overall allowance for G&A costs is US$7.23/t milled. Additions to G&A costs include provision for a Technical Services Team to oversee Avesoro's responsibilities regarding the underground operation. This cost equates to US$394,000 per year.

Table 21-7: New Liberty operating cost summary

Area	LOM operating cost	Cost per tonne milled	Cost per ounce recovered
General and Administration	**75,095,822**	**4.40**	**59.63**
Tech Services Labour Compliment	4,337,970	0.25	3.44
Open Pit G&A Cost	70,757,852	4.15	56.18
Mining	**341,352,232**	20.00	271.03
Open Pit	162,387,856	9.51	128.94
Ore Mining	*9,185,429*	*0.54*	*7.29*
Waste Mining	*153,202,427*	*8.98*	*121.64*
Underground	178,964,376	10.48	142.10
Ore Development	***63,606,133***	*3.73*	*50.50*
Stoping	*115,358,244*	*6.76*	*91.59*
Processing	**199,452,977**	11.69	158.37
Ore Processing	199,452,977	11.69	158.37
TOTAL	**615,901,031**	**36.08**	**489.03**

Notes: All costs presented in US$. Due to rounding, some columns or rows may not compute exactly as shown.

21.3.8 Ndablama Operating Costs

As per New Liberty, the most significant operating cost expense incurred at Ndablama is related to that of the open pit. Open pit mining costs have been determined from a contractor quotation whereby an all-in mining cost for US$1.70/t of rock (ore or waste) was provided.

Processing costs have been provided by Avesoro and are based on the current costs of the New Liberty processing facility. The cost equates to US$20.38/t milled. In addition, a cost of US$5.95/t milled has been included as an allowance for ore transportation cost from Ndablama to New Liberty.

Further, G&A costs have been factored from current operations at New Liberty to account for a production rate of 1.8 Mt/a. The overall allowance for G&A costs is US$7.23/t milled.

Table 21-8: Ndablama operating cost summary

Area	LOM operating cost	Cost per tonne milled	Cost per ounce recovered
General and Administration	**52,651,213**	3.08	41.81
Open Pit G&A Cost	52,651,213	3.08	41.81
Mining	**105,904,334**	6.20	84.09
Open Pit	105,904,334	6.20	84.09
Ore Mining	*19,623,492*	*1.15*	*15.58*
Waste Mining	*86,280,842*	*5.05*	*68.51*
Processing	**191,743,630**	11.23	152.24
Ore Processing	148,413,793	8.69	117.84
Ore Transportation	43,329,837	2.54	34.40
TOTAL	**350,299,177**	**20.52**	**278.14**

Notes: All costs presented in US$. Due to rounding, some columns or rows may not compute exactly as shown.

21.3.9 Estimate Accuracy and Contingency

Since a significant portion of the operating cost estimate is based on current or factored operational costs from the New Liberty operations, in addition to contractor quotations for the underground mine, it is accepted that no contingency allowance is required for the operating cost estimate.

21.3.10 Operating Expenditure and Cash Flow

Figure 21-3 presents the operating cost expenditure over the Combined Project LOM. On average, between US$90 million and US$110 million is expended per annum during the course of the Combined Project.

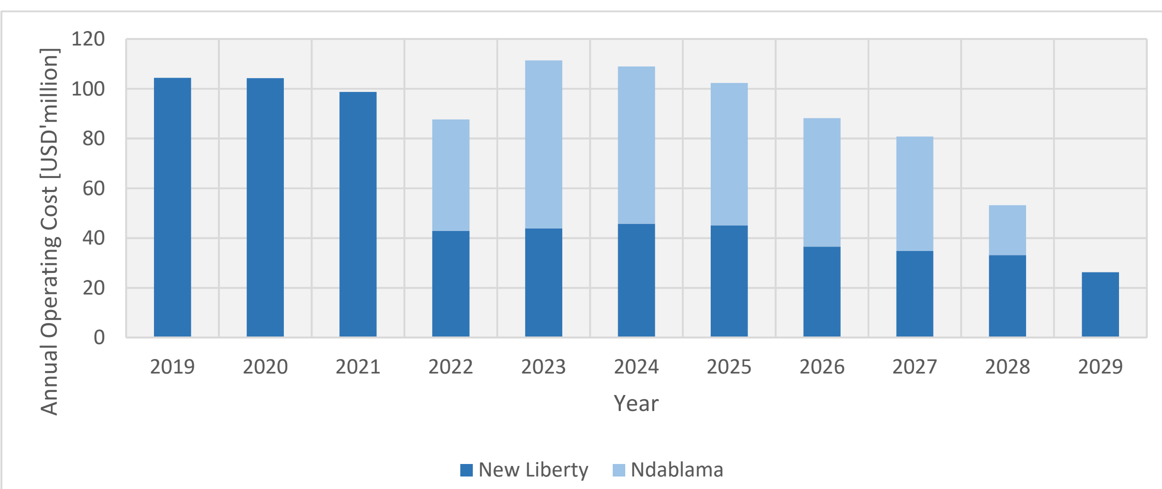


Figure 21-3: Operating expenditure cash flow

22 Economic Analysis

22.1 Basis

22.1.1 Base Date and Currency

The economic analysis is based on the capital and operating cost estimates for the Combined New Liberty and Ndablama deposit and other information as at March 2019. The analysis is presented in United States dollars (US$) in real money terms, free of escalation or inflation.

22.1.2 Analysis Methodology

The economic valuation of the project has been determined through discount cash flow analysis (DCF), whereby timeous capital and operating expenditures and revenues are discounted in time to determine a project net present value (NPV) and other key financial metrics.

22.1.3 Exclusions

No specific exclusions are noted from the analysis, the analysis takes into account revenue, royalties, operating and capital costs, debt repayments, depreciation and tax.

22.1.4 Escalation and Foreign Exchange

No provisions have been allowed for escalation or variation in foreign exchange of any costs.

22.2 Key Assumptions

22.2.1 Revenue

Revenue has been determined through application of the recovered troy ounces produced by Combined Project to the gold price. For the purposes of the analysis, a gold price of US$1,300 per troy ounce has been used.

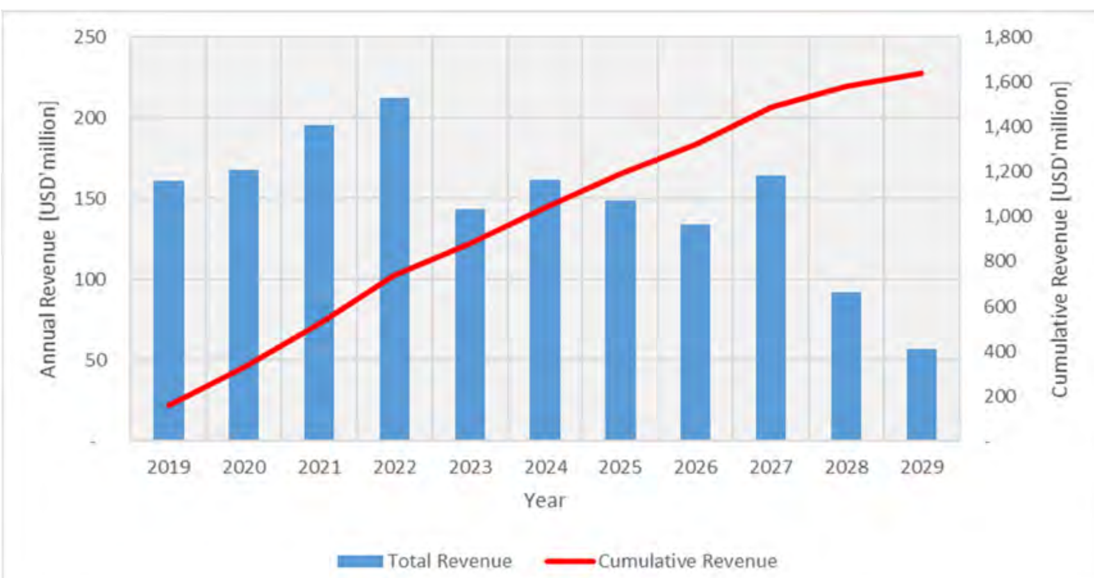


Figure 22-1: LOM revenue

During the steady-state production period of the Combined Project, approximately US$160 million in revenue is generated annually, with cumulative revenue of approximately US$1.6 billion generated over the LOM.

22.2.2 Royalties

Royalties have been determined though the legislative requirements of Liberia, with 3% of revenue applied as a royalty cost. During the steady-state production period of the Combined Project, approximately US$4.8 million in royalties are paid annually, with cumulative royalty of approximately US$49 million paid over the LOM.

22.2.3 Debt

It is intended that historical debt will be serviced through the Combined Project cash flows. Avesoro have provided a payment terms to service debt facilities to the value of US$99.7, with US$19.9 million in financing fees.

22.2.4 Depreciation

Depreciation has been calculated on the assumption of that 100% of capital expenditure may be deducted from profits in the year that they are incurred (Deductibility Rate). It is assumed that all capital expenditure is eligible for deduction.

22.2.5 Tax

A tax rate of 25% of taxable income has been used in the evaluation. Taxable income is calculated through deduction of depreciation and debt financing fees from EBITDA (Earnings before interest, tax, depreciation and amortisation). In addition, a carried forward net loss from the current operations of US$400 million was included in the evaluation.

22.2.6 Discount Rate

A discount rate of 5% has been used for the evaluation as per instruction from Avesoro.

22.3 Economic Evaluation

22.3.1 Discount Cash Flow Analysis

A summary of the DCF analysis is presented in Table 22-1. The economic metrics resulting from the DCF analysis is presented in Table 22-2. The analysis shows that the Combined Project is economically viable with a post-tax NPV of US$411 million, and US$286 million after servicing outstanding debts. Since the project does not incur loss during any period of the cash flow, no peak funding requirement or IRR has been calculated. Other key metrics include:

- A LOM Free Cashflow of US$370 million after repayment of outstanding debts
- A C3 Cash Cost of US$806/oz and All-In Sustaining Cost (AISC) of US$862/oz.

Table 22-1: Summary of DCF analysis

Description		Unit	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Physicals													
New Liberty Open Pit													
Waste Tonnes	89.6	Mt	33.5	33.9	22.2	0.0	-	-	-	-	-	-	-
Marginal Tonnes	0.5	Mt	0.2	0.1	0.1	0.0	-	-	-	-	-	-	-
ROM Tonnes	4.9	Mt	1.6	1.5	1.8	0.0	-	-	-	-	-	-	-
ROM Content	15.4	t	4.17	4.64	6.38	0.17	-	-	-	-	-	-	-
ROM Grade	3.12	g/t	2.53	3.16	3.64	3.69	-	-	-	-	-	-	-
Strip Ratio	16.7	waste t / ore t	18.1	21.1	11.9	0.8	-	-	-	-	-	-	-
New Liberty Underground													
Waste Tonnes	0.9	Mt	-	0.1	0.1	0.3	0.2	0.1	0.1	0.0	-	-	-
ROM Tonnes	4.7	Mt	-	0.0	0.2	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.5
ROM Content	14.3	t	-	0.11	0.75	1.28	1.86	1.70	1.83	1.87	1.80	1.65	1.47
ROM Grade	3.08	g/t	-	2.64	3.21	3.34	3.37	2.93	2.97	3.05	2.98	2.86	3.22
Ndablama Open Pit													
Waste Tonnes	50.8	Mt	-	-	-	8.3	15.9	9.6	8.4	7.1	1.4	-	-
Marginal Tonnes	4.3	Mt	-	-	-	0.8	0.6	1.4	0.4	0.3	0.7	-	-
ROM Tonnes	7.3	Mt	-	-	-	1.1	0.9	2.1	0.8	0.5	1.8	-	-
ROM Content	12.4	t	-	-	-	1.80	1.51	3.68	1.52	0.76	3.17	-	-
ROM Grade	1.71	g/t	-	-	-	1.60	1.60	1.72	1.81	1.62	1.80	-	-
Strip Ratio	4.4	waste t / ore t	-	-	-	4.3	10.0	2.7	6.8	9.2	0.6	-	-
Processing													
Milled Tonnes	17.1	Mt	1.6	1.5	1.6	1.8	1.8	1.8	1.8	1.8	1.8	1.2	0.5
Milled Content	42.4	t	4.17	4.35	5.06	5.51	3.72	4.18	3.87	3.47	4.26	2.39	1.47
Milled Grade	2.49	g/t	2.64	2.99	3.11	3.06	2.07	2.32	2.15	1.93	2.36	2.06	3.22
Recovered Content	1.26	Moz	0.12	0.13	0.15	0.16	0.11	0.12	0.11	0.10	0.13	0.07	0.04
Revenue													
Gold Price	1,300	US$/oz	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
Total Revenue	1,637	US$M	161	168	195	213	143	161	149	134	164	92	57
Cumulative Revenue		US$M	161	328	524	736	880	1,041	1,190	1,324	1,488	1,580	1,637
Royalties													
Royalty Rate	3	%	3	3	3	3	3	3	3	3	3	3	3
Total Royalty Paid	49.1	US$	4.8	5.0	5.9	6.4	4.3	4.8	4.5	4.0	4.9	2.8	1.7

Description		Unit	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Operating Cost													
C1 Cash Costs													
New Liberty	616	US$M	104.4	104.3	98.7	42.9	44.0	45.8	45.1	36.6	34.8	33.1	26.2
Ndablama	350	US$M	-	-	-	44.7	67.5	63.1	57.3	51.6	46.0	20.1	-
Total C1 Cash Cost	966	US$	104.4	104.3	98.7	87.6	111.4	108.9	102.4	88.2	80.8	53.2	26.2
Unit C1 Cash Cost	57	US$/t	66	72	61	49	62	61	57	49	45	46	57
Unit C1 Cash Cost	767	US$/oz	844	808	657	536	1,010	877	892	856	640	752	601
C3 Cash Costs													
C1 Cash Cost	966	US$M	104.4	104.3	98.7	87.6	111.4	108.9	102.4	88.2	80.8	53.2	26.2
Royalty	49	US$	4.8	5.0	5.9	6.4	4.3	4.8	4.5	4.0	4.9	2.8	1.7
Total C3 Cash Cost	1,015	US$M	109.2	109.3	104.6	94.0	115.7	113.8	106.8	92.2	85.7	56.0	28.0
Unit C3 Cash Cost	59	US$/t	69	75	64	52	64	63	59	51	48	48	61
Unit C3 Cash Cost	806	US$/oz	883	847	696	575	1,049	916	931	895	679	791	640
Capital Cost													
Project Capital Cost													
New Liberty	12.5	US$M	-	9.0	3.5	-	-	-	-	-	-	-	-
Ndablama	14.3	US$M	-	3.3	11.0	-	-	-	-	-	-	-	-
Processing and Tailings	3.5	US$M	0.6	0.6	2.4	-	-	-	-	-	-	-	-
General and Administration	2.3	US$M	1.4	0.3	0.6	-	-	-	-	-	-	-	-
Contingency	3.3	US$M	0.2	1.3	1.7	-	-	-	-	-	-	-	-
Total Project Capital Cost	35.9	US$M	2.2	14.6	19.1	-	-	-	-	-	-	-	-
Sustaining Capital Cost													
New Liberty	40.3	US$M	-	-	2.7	18.8	10.4	3.7	4.6	0.1	-	-	-
Ndablama	3.0	US$M	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5	-	-
Processing and Tailings	7.4	US$M	-	-	-	-	1.9	1.1	-	2.5	1.8	-	-
General and Administration	13.0	US$M	-	-	0.0	0.3	0.1	0.0	0.1	0.0	0.0	2.5	10.0
Contingency	6.4	US$M	-	-	0.3	2.0	1.3	0.5	0.5	0.3	0.2	0.3	1.0
Total Sustaining Capital Cost	70.1	US$M	-	-	2.9	21.5	14.2	5.9	5.7	3.5	2.6	2.8	11.0
Total Capital Cost													
Project Capital Cost	36	US$M	2.2	14.6	19.1	-	-	-	-	-	-	-	-
Sustaining Capital Cost	70	US$M	-	-	2.9	21.5	14.2	5.9	5.7	3.5	2.6	2.8	11.0
Total Capital Cost	106	US$M	2.2	14.6	22.0	21.5	14.2	5.9	5.7	3.5	2.6	2.8	11.0
Cumulative Capex		US$M	2.2	16.8	38.9	60.4	74.6	80.5	86.2	89.7	92.2	95.0	106.0

Description		Unit	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Debt													
Opening Balance		US$M	381.8	311.5	203.6	38.8	-	-	-	-	-	-	-
Principle Repayment	99.7	US$M	18.0	21.5	21.5	38.8	-	-	-	-	-	-	-
Financing Costs	20.0	US$M	7.2	7.2	4.8	0.8	-	-	-	-	-	-	-
Total Repayment	119.7	US$M	25.3	28.6	26.2	39.6	-	-	-	-	-	-	-
Closing Balance		US$M	363.7	290.0	182.2	-	-	-	-	-	-	-	-
Tax													
Depreciation													
Opening Balance			-	-	-	-	-	-	-	-	-	-	-
Additions	106.0	US$M	2.2	14.6	22.0	21.5	14.2	5.9	5.7	3.5	2.6	2.8	11.0
Deductibility Rate	100	%	100	100	100	100	100	100	100	100	100	100	100
Depreciation	106.0	US$M	2.2	14.6	22.0	21.5	14.2	5.9	5.7	3.5	2.6	2.8	11.0
Closing Balance		US$M	-	-	-	-	-	-	-	-	-	-	-
Tax													
Gross Profit/Loss	622.0	US$M	51.5	58.4	90.6	118.7	27.7	47.6	42.4	41.7	78.4	36.0	28.9
Carried Forward Net Loss		US$M	-400	-358	-321	-257	-161	-148	-106	-69	-31	-	-
Depreciation	106.0	US$M	2.2	14.6	22.0	21.5	14.2	5.9	5.7	3.5	2.6	2.8	11.0
Financing Costs	20.0	US$M	7.2	7.2	4.8	0.8	-	-	-	-	-	-	-
Net Profit/Loss		US$M	-358	-321	-257	-161	-148	-106	-69	-31	45	33	18
Taxable Income	103.8	US$M	-	-	-	-	-	-	-	-	44.9	33.3	25.6
Tax Rate	25.0	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Tax Paid	25.9	US$M	-	-	-	-	-	-	-	-	11.2	8.3	6.4
Cash-Flows													
AISC	1,085	US$M	109.2	109.3	107.5	115.6	129.9	119.6	112.5	95.7	88.3	58.8	39.0
Unit AISC	862	US$/oz	883	847	716	706	1,178	964	980	929	699	830	891
AIC	1,121	US$M	111.4	123.9	126.6	115.6	129.9	119.6	112.5	95.7	88.3	58.8	39.0
Unit AIC	890	US$/oz	901	960	843	706	1,178	964	980	929	699	830	891
EBITDA	622.0	US$M	51.5	58.4	90.6	118.7	27.7	47.6	42.4	41.7	78.4	36.0	28.9
Pre-Tax Project Cash-Flow	516.0	US$M	49.3	43.8	68.6	97.2	13.5	41.8	36.7	38.2	75.9	33.3	17.9
Post-Tax Project Cash-Flow	490.0	US$M	49.3	43.8	68.6	97.2	13.5	41.8	36.7	38.2	64.6	25.0	11.5
Post-Tax Post-Debt Cash-Flow	370.3	US$M	24.0	15.2	42.4	57.6	13.5	41.8	36.7	38.2	64.6	25.0	11.5

Table 22-2: Economic metrics

Metric	Value	Unit
Revenue (LOM)	1,637	US$M
Operating Cost (LOM)	1,015	US$M
Project Capital Cost (LOM)	36	US$M
Sustaining Capital Cost (LOM)	70	US$M
Free Cashflow (LOM)	370	US$M
C1 Cash Cost	767	US$/oz
C3 Cash Cost	806	US$/oz
AISC	862	US$/oz
AIC	890	US$/oz
Pre-Tax Project NPV_5	411	US$M
Post-Tax Project NPV_5	395	US$M
Post-Tax Post-Debt Project NPV_5	286	US$M
Operating Margin	38.0	%
Profitability Index	5.8	ul

22.3.2 Sensitivity Analysis

Sensitivity analysis has been undertaken on post-tax, post-debt project NPV. The results are summarised in Figure 22-. The analysis shows that the project is most sensitive to changes in revenue (grade, recovery, gold price) with a 25% reduction leading to a negative NPV. Improvements in operating cost may realise a greater improvement in project value as the project is more sensitive to operating cost than to capital cost.

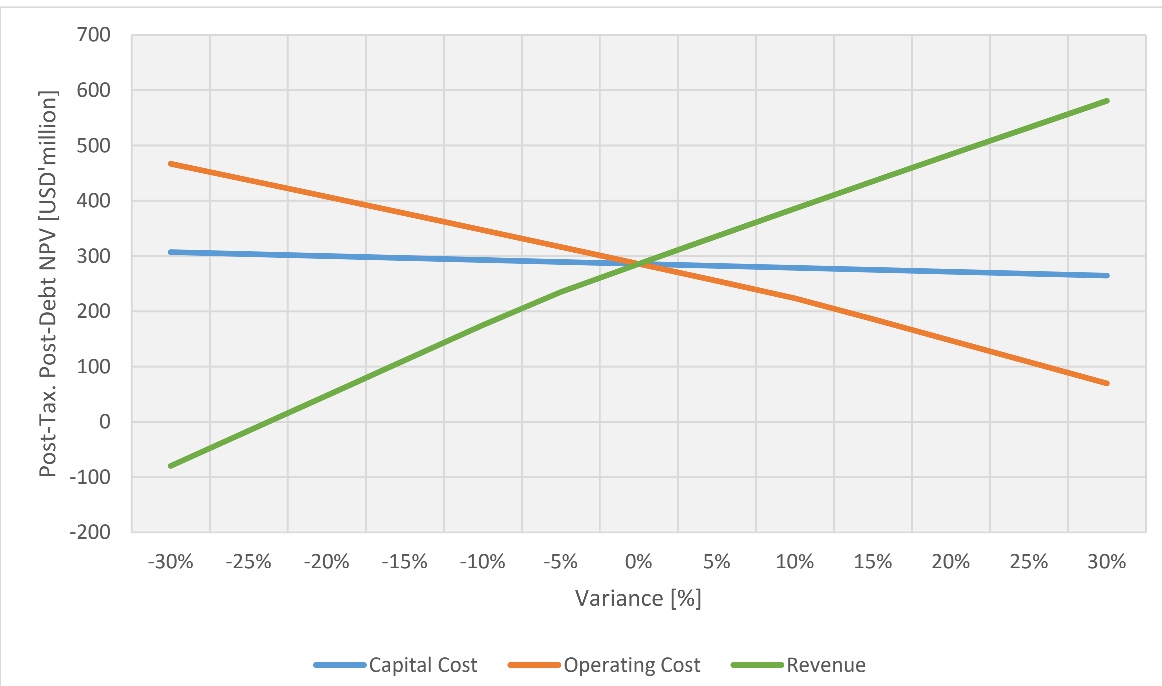


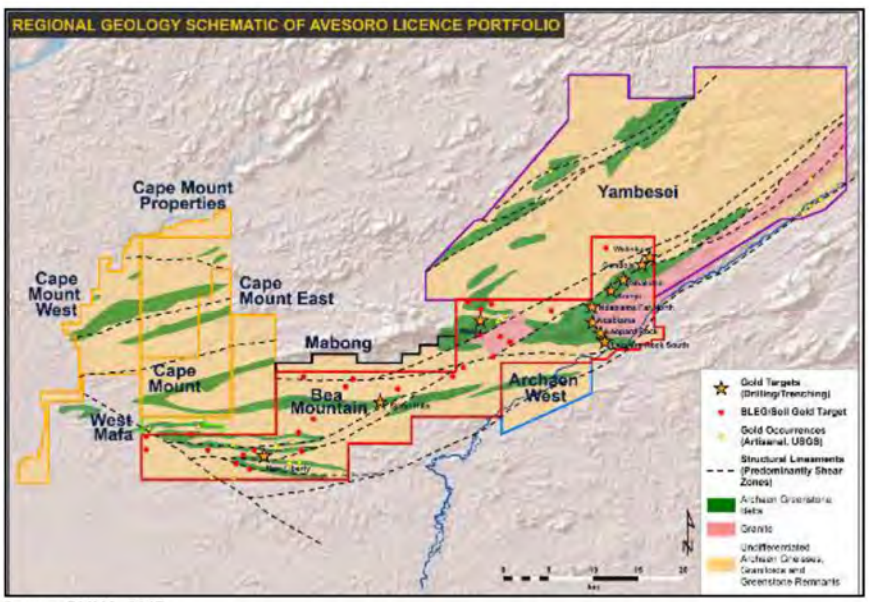
Figure 22-2: Post-tax, post-debt NPV sensitivity analysis

23 Adjacent Properties

The most recent Mineral Land Holding map update was published in February 2017 by the Ministry of Lands Mines and Energy. In addition to the Bea-MDA, BMMC acquired an exploration license known as Archaen Gold (89 km2) from Archaen Gold Ltd, as announced on 21 September 2011. After incorporating 21 km2 of the license into the Bea-MDA license (reported 11 May 2015), the Archaen Gold license was subsequently removed from BMMC's holdings.

Additionally, as reported on 19 November 2013, BMMC was been granted four new exploration licenses, contiguous to the Bea Mountain Mining license by the Ministry of Lands, Mines and Energy. The four exploration licenses are referred to as Yambesei (759 km^2), Archaen West (112.6 km^2), Mabong (36.6 km^2) and West Mafa (15.6 km^2). Following the acquisition of three exploration licenses from Sarama Investments Limited on 6 January 2016, the Yambesei and Archaean West licenses were reduced to 473 km^2 and 55.7 km^2 respectively.

In all cases, the company has 100% ownership, and these acquisitions bring the company's contiguous land holdings to an area of 1,470 km2 (Figure 23-1).



Source: BMMC, 2017

Figure 23-1: Properties Adjacent to the Bea-MDA mining license

BMMC's license portfolio hosts multiple greenstone belts and associated shear structures which to date have been the principal hosts to the gold mineralisation systems discovered in Liberia. At the time of this report, a desktop review of existing data and regional exploration activities has shown in excess of 50 gold occurrences and gold geochemical anomalies have been outlined on the Company's ground holdings. Gold mineralisation is associated with the primary shear systems or in subordinate structures related to these major breaks.

A regional BLEG campaign has been carried out to delineate prospective zones with 349 samples collected to date, including 72 in the Archaean West license. Soil sampling programmes were also undertaken in the Yambesei license, including the extension of the Yambesei structural corridor to check possible extension of the Gondoja gold corridor to the east. with 615 soil samples collected. Some 3,000 soil samples have been taken from the Yambesei license to date, with 327 soil samples from the Mabong license.

24 Other Relevant Data and Information

24.1 Risk Assessment

24.1.1 Introduction

A risk analysis for the New Liberty 'Combined' Project was carried out between March 15 and March 25 2019. A combination of CSA Global and Bara personnel collaborated on the identification and assessment of risks, facilitated by Pat Willis of Bara Consulting. This analysis summarizes the project risks based on the level of established information relating to the project as at 25 March 2019.

24.1.2 Risk Management Methodology

24.1.2.1 Background

Involved for CSA Global in the risk evaluation were:

- Dr. Belinda Van Lente, Principal Resource Geologist
- Dr. Matthew Randall, Principal Mining Engineer
- Mr. Gary Patrick, Consulting Metallurgical Engineer
- Mr. Paul Heaney, Principal Hydrogeologist

Involved for Bara were:

- Mr. Pat Willis, Principal Mining Engineer
- Mr. Clive Brown, Principal Mining Engineer
- Dr. Andrew Bamber, Study Manager

Additional risk items and mitigating actions relating to environmental and community issues were drawn in from an independent exercise by ABS Africa, the Environmental Consultant to the client on the ESIA study for the proposed Ndablama open pit and the haul road between Ndablama and New Liberty.

24.1.2.2 Approach

Objectives of the risk assessment were to identify and extant risks to the project as described in this Preliminary Feasibility Study, to assign likelihood of occurrence and consequence of occurrence to the risk and therefore assess overall level of risk to the project from Low (1) to High (5). The relevant framework for Risk likelihood is shown in Figure 24-1.

Risk Probability Descriptors

Descriptor	Description	Probability
Rare	May occur only in exceptional circumstances	1
Unlikely	Could occur at some time	2
Possible	Might occur at some time	3
Likely	Will probably occur in most circumstances	4
Almost certain	Is expected to occur in most circumstances	5

Figure 24-1: Risk Probability Descriptors

The relevant framework for Risk Consequence is shown in Figure 24-2.

Risk Consequence (Severity) Descriptors

Descriptor	Description	Severity
Insignificant	Minor injury, limited environmental impact, no impact on stakeholder confidence and company reputation	1
Minor	Medical treatment, minor site environmental impact, limited impact on stakeholder confidence and company reputation	2
Moderate	Lost time injury or illness, moderate environmental impact beyond site boundaries, medium impact on stakeholder confidence and company reputation	3
Major	Single fatality or permeant disability, serious medium term environmental impacts, high impact on stakeholder confidence and company reputation	4
Catastrophic	Multiple fatalities or multiple permeant disabilities, severe long term environmental impacts, loss of stakeholder confidence and company reputation	5

Figure 24-2: Risk Consequence Descriptors

And, the framework for the overall ranking of risk is shown in Figure 24-3.

Risk Matrix – Probability and Severity Risk Ranking Index

		PROBABILITY				
		5	4	3	2	1
CONSEQUENCE	5	25	20	15	10	5
	4	20	16	12	8	4
	3	15	12	9	6	3
	2	10	8	6	4	2
	1	5	4	3	2	1

RISK
LOW
MEDIUM LOW
MEDIUM
MEDIUM HIGH
HIGH

Figure 24-3: Probability and Severity Risk Ranking Index

Once project risks have been established and ranked in this way, a workshop discussion on risk mitigation was held. The mitigating action and residual risk post mitigation was also recorded.

24.1.3 Risks

24.1.3.1 Key Project Risks

Key risks to the project were categorized in the areas of geological/resource risk, risk relating to open pit mining (at New Liberty and Ndablama), risk to underground mining at New Liberty, metallurgical/product risk, and social/environmental risk. Market risk and management risk were identified and quantified as part of this overall process.

24.1.3.2 Geological Risk

The lack of a database increases risk due to the lack of a single point of truth as well as the absence of laboratory metadata (laboratories, assay methods and detection limits). Multiple assay techniques for Au have been used, which include an aqua regia digest with an AAS finish, fire assay and screen fire assay and bias probably exists between these techniques.

Geological/resource risks assessed included a lack of a structural model or data for the deposits, with risk of additional geological loss over those already assessed, plus additional hydrogeological risk from lack of structural knowledge as well. High levels of spatial grade variability in the Ndblama deposit was flagged as a risk, with risk to the eventual metal produced. Poor knowledge of structural controls from the prior risk item also contributes to this risk.

24.1.3.3 Mining Risk

Risk that mining dilution and loss factors are higher than those allowed in the modifying factor exists as a consequence of the combination of structure and grade variability in the deposits. Challenges in grade control, relating to the highly variable, nuggety nature of the deposits as well as the lack of visual ore zone or contact markers was also flagged. Risk of delay to the timing of the start of the underground at Kinjor due to possible delays in completing open pit mining in that pit was also identified. Pit slope stability is an identified risk at New Liberty in particular for current open pit operations, as well as relating to the reliability of underground operations in the context of rockfalls in the host pit. Crown pillar failures, relating to risk of flooding in the underground mine as well as loss of access to the underground mine was flagged as a high risk item. Over and above this risk, excessive water ingress into the open pits, as well as into the underground, on account of the high tropical rainfall intensity as well as high permeability of the laterites at the contact and large exposed pit areas post mining, was also discussed as a risk.

24.1.3.4 Metallurgical/Product Risk

Risk to both throughput and recovery were flagged in the metallurgical section as medium risks. Risk to consistently achieving gold recoveries of 92% was identified; additionally, risk to the recently upgraded plant being able to consistently achieve 1.8 Mt/a ROM throughput was flagged.

24.1.3.5 Operational Risk

Several operational risks, already identified in mining, including potential rockfalls in the open pit delaying production, as well as potentially obstructing operations in the underground mine were discussed. Excessive water ingress into New Liberty pit in particular thus disrupting either open pit or underground production was flagged as a risk. Risk of disruption of the haul route between Ndablama mine and New Liberty mill interrupting production was also discussed.

24.1.3.6 Management Risk

A proposed transition from owner-operated mining to contractor-operated mining, and achievement of combined productivity improvements and cost savings versus current owner operated performance was flagged as a management risk. Risk that the contractor performs poorly was identified as a medium risk.

24.1.3.7 Social/Environmental Risk

Several social and environmental risks had already been identified for the New Liberty operation. Additionally, risks relating to mining operations at Ndablama were freshly identified by the environmental consultant. Several vulnerable fauna species are incident on the property, where custody of these species presents a risk. Additionally, risk of exceeding other water monitoring parameters downstream of New Liberty including cyanide, iron, arsenic and water-borne sediment levels had already been identified in previous studies and audits.

Significant stakeholder/community relations risk was also identified, relating to impacted artisanal and non-artisanal communities at New Liberty and Ndablama. Additionally, as previously identified, risk of disruption due to impacted and contingent communities along the proposed Ndablama-New Liberty haul road was identified as a medium-high risk.

24.1.3.8 Market Risk

A minor market risk relating to potential weakness in commodity prices impacting marginal resources in the LOM plan was discussed.

24.1.4 Risk Mitigation

Mitigating actions to geological/resource risks identified include additional core logging, structural mapping, and modelling; in order to mitigate grade and spatial confidence in grade, a new geological model is to be developed, and the deposit remodelled to this, in combination with extensive infill drilling to improve confidence between current data points. Best practice grade control during operations as already practiced at New Liberty pit will be required to mitigate further. Low to medium residual risk is forecast due to these mitigations.

Mitigating actions to mining risk include validating contractor requirements and capacity to meet requirements for both open pit and underground operations; additionally, close owner supervision of contractors, including oversight of planned/preventative maintenance of fleet will be required to maintain production. Best practice slope control as well as advanced blast design and explosive selection to reduce overbreak and maintain slope stability will mitigate this identified risk. Mitigating actions to water inflows include improved modelling of surface flows, and groundwater flows to the pit, as well as underground workings, and additional design review of pit and mine dewatering provisions. Mitigation of stability and water ingress risks relating to the crown pillar include best practice design for artificial support of the crown pillar and appropriate sequencing of stopes to mine the crown pillar last in the LOM plan. All risks barring crown pillar risk are mitigated to medium-low risk, where risk relating to the crown pillar design remains medium-high.

Mitigating actions to metallurgical/product risk include potential for higher gravity gold recovery in Ndablama ores as well as higher overall recovery potential in New Liberty underground ore assisting recovery of gold. Additionally, lower work index parameters at New Liberty coarser grind parameters at Ndablama potentially assist ore throughput to achieve desired production levels of 1.8Mtpa. All metallurgical risk is mitigated to low risk.

Mitigating actions for social/environmental risks include improved continuing with the existing water quality monitoring and control; a well design livelihood development resettlement action plan (LDPRAP) plus best practice stakeholder community relations management mitigates the risk on risk identified relating to potential poor relations with impacted artisanal and non-artisanal communities. Continued implementation and monitoring of the Environmental, Social Health and Safety Management Plan (ESHSMS) further mitigates risk to medium-low.

24.1.5 Risk Register

The detailed risk register is presented in Figure 24-4.

RISK	RISK RATING	POSSIBLE MITIGATIONS	RESIDUAL RISK
Geology, exploration, resources			
New Liberty			
No structural model	Medium	Additional drilling required. Build structural model from pit mapping and drill core logging.	Low
Extrapolated mineralisation to depth (Inferred Mineral Resources) might not be as extensive as modelled.	Medium	Additional Infill and Exploration drilling to increase confidence.	Low
External - Weak commodity prices may materially impact marginal resources that fall within the LOM plan.	Medium		
Ndablama			
There is a very high variability in grade within the main mineralised domain, which adds risk to the eventual metal predicted. The high grade gold zones contain nuggety gold – which are irregular in occurrence, and difficult to predict. There is a risk that high grade gold continuity has been overstated in the model.	High	Improve geological model. Closely spaced grade control drilling in advance of mining.	Medium
Poorly understood structural control and influence of stratigraphic units on mineralisation. No structural or geology model.	High	Build geological and structural models from mapping and drill core logging.	Medium
External - Weak commodity prices may materially impact marginal resources that fall within the LOM plan.	Medium	No mitigation identified	
Mining			
Mining recovery & dilution factors higher than expected at NLG	High	a) Improve the blasting procedures to reduce oversize b) Improve the reconciliation procedures so as to identify opportunities for increasing ore recovery and reducing ore loss	Medium
Mining recovery & dilution factors higher than expected at Ndablama	High	Provide in-fill drilling information to enhance the confidence in the grade estimates, particularly variability. The LUC estimates of the Resource model do not lend themselves to selective mining due to the lack of spatial information.	Medium
Low mine productivity rates by the mining contractor	Medium	The stage designs for the open pit are optimised to allow the productivity rates claimed by the prospective mining contractors to be achieved. Good short term planning procedures/skill by the owner are essential.	Low
Disruption to the transport route between ND and NLG	Medium	a) Appropriate security arrangements on the private road to prevent public access b) Good road maintenance to ensure efficient operation of the transport fleet. C) Resettlement action plan for communities.	Low
Completion of the open pit at NLG is delayed	Medium	The open pit mining rate for Kinjor should be adjusted so that the open pit is completed in good time to start the underground development of Kinjor.	Low
Slope stability failure at NLG - danger to people and machinery	High	This risk needs to be reduced by improved blasting and wall control procedures.	Medium
Flooding of underground mine due to crown pillar failure	High	Sequencing of stopes to mine below crown pillar last; Concrete artificial pillar construction on pit floor; dewatering system design allows for additional inflows.	Low
Rockfall trapping people underground	Medium	Equipped escape ways provided, Refuge bays provided. Escape plan to be developed and communicated.	Medium low
Crown pillar failure resulting in loss of access to mine	High	Sequencing of stopes to mine below crown pillar last. Concrete artificial pillar construction on pit floor.	Medium high
Pit slope falure resulting in loss of access to underground	High	Continuous monitoring of pit slopes. Adequate ground support around portal. Provision of steel arch sets and armco cover over portal.	Medium
Grade control system ineffectual	Medium high	No visual grade control is possible, grade control on development by sampling, stope grade control by development sampling and infill drilling. Strict grade control practices to be implemented.	Medium low
Poor contractor performance	Medium	Effective contract management.	Medium
Excessive ground water ingression	Medium high	Dewatering system design allows for additional flows over those modelled.	Medium
Metallurgy and Processing			
Achieving the target gold recovery of 92-93%	9	Maximize GRG and inject oxygen into the leach circuit	4
Achieving the target throughput rate of 1.8Mtpa when treating the harder Ndablama ore type	9	Coarsen the grind size, or blend in with the softer ore types from the NLGM underground ore types	4
Environmental, mine closure and social			
Risk of cyanide release downstream of New Liberty plant/TSF	12	CN destruction system and management plan already in place	6
Risk of exceedence of other water monitoring parameters (basically sediments; not well managed)	9	Improve water control; improve water monitoring management	6
Quality of water in watercourses draining the mine site was generally good, but levels of aluminium, iron and arsenic were elevated in some samples	9	Implement a fully fledged ESHSMS	6
Environmental, social, health and safety management system (ESHSMS) in place but not fully fledged	9	Implement a fully fledged ESHSMS	6
Loss of endangered mammal species and other vunerable species including dwarf crocodile, hornbill, parrot and greenbul species	15	Implement a fully fledged ESHSMS. Establishment of conservation areas with local community	8
Impacted settlements Magina and Koma downstream of New Liberty	12	Appointment of community relationship manager	6
Impacted settlements along ND-NL road		Resettlement action plan + community relations	
Stakeholder/community relations risk	12	Appointment of community relationship manager at ND	6
Recurring artisanal mining activity at NL (being managed but incidents (arrests) do occur)	12	Appointment of community relationship manager	8
Impacted artisanal mining community at Ndablama	15	Implement resettlement action plan + community relations	8

Figure 24-4: Risk register

24.2 Opportunities

24.2.1 Introduction

Many strengths relating to the project have been identified during the course of the study. These include easy access and proven mineralisation with respect to current mining operations at New Liberty with geostatistical confidence in the mineralization high with visual comparisons and swath plots showing good correlation between input and output data. The narrow vein morphology of the New Liberty deposit is better suited for underground exploitation than open pit, especially at depth, and wide ore zones support lower cost mining methods such as long hole open stoping.

At Ndablama similarly geostatistical confidence in the mineralisation high with visual comparisons and swath plots showing good correlation between input and output data. Additionally, high Au grades shown both in individual composites as well as models post top cutting indicating strong periodic high-grade potential. Additionally, high confidence in volume as well as mineralisation continuity has been demonstrated. Geology, exploration and resources.

In terms of mining, these is a well-established mine at New Liberty with expensive experience of local conditions. Grade control procedures are by now well established, which additionally help to increase mining recovery. The proposed underground mining layout and method is well understood, where the use of an experienced contractor for the underground mining reduces requirement for recruitment and training by mine owner in the method. Substantial upside in terms or reduced cost in mining operations exists compared to the current owner-operated cost basis; in particular effective use of contractors for the haul between Ndablama and New Liberty can further reduce process cost.

Strong environmental opportunities also exist for the project. A vulnerable habitat and species conservation plan including suitable conservation areas has been identified. Water management and control has improved and can further improve to maintain the general good quality of water in water courses. Community relations remain good, with good potential to further improve relations with additional employment opportunity at the new mine.

24.2.2 Geology

Specific geological opportunity exists. New Liberty deposit is open at depth, as well as along strike, with substantial quantities of material currently classed as inferred which with additional infill drilling can be brought into indicated category. Ndablama deposit is also open at depth, as well as along strike, with substantial quantities of material currently classed as inferred which with additional infill drilling can be brought into indicated category. The deposits are geologically and structurally controlled, and better understanding of this will assist in future target generation and exploration.

24.2.3 Mining

Several areas of opportunity in mining have been identified. Reserves can further be increased through drilling of extensive known inferred resources at both deposits. Additionally, at New Liberty reduced pillar losses through exploration of selective use of hydraulic cemented backfill could further increase reserves. Optimization of overland haulage costs between Ndablama and New Liberty can optimise the cutoff grade, increase reserves as well as improve margins for the mining of this deposit. Further, waste haul costs can also be reduced with further optimization of waste dump designs and locations.

24.2.4 Metallurgy

Further testing of New Liberty and Ndablama ore blends to explore metallurgical synergies is required. While potential to meet and exceed the 1.8Mtpa required capacity through lower work index at New Liberty and coarser grind size at Ndablama is identified; further modifications with low capital intensity such as addition of further gravity concentration capacity, intensive leaching of gravity concentrates and oxygen addition in the leach section can further increase throughput and maintain recoveries. Significant opportunity to add value at Ndablama though potentially sorting the ore to remove waste and process high grade material only at New liberty has been identified; additionally, heap leaching of low-grade ore at Ndablama has been investigated which could add even further value.

24.2.5 Environmental

Opportunity for Bea Mountain Mining Corporation to become a leader in conservation of impacted vulnerable and endangered habitats and species has been identified. As a significant, major employer in the region, exploration of further economic upliftment and social development programs can complement this with increased stakeholder community wellbeing.

25 Interpretation and Conclusions

25.1 Conclusions

A pre-feasibility study for the Combined Project of the New Liberty Gold Mine and the Ndablama deposit in Liberia has been completed between November 2018 and March 2019. The project contemplates the transition of mining operations at New Liberty from the current open pit to underground, plus the development of a new satellite open pit at Ndablama. The study incorporated Mineral Resource modelling and reporting, mine design and scheduling work, infrastructure design, process testwork, capital cost estimation, operating cost estimation, financial modelling and reporting. Tailings facility design and Environmental studies were the responsibility of the Client. The following conclusions are relevant to this study:

25.1.1 Data

Avesoro do not have a robust data management system in place, instead they rely on Microsoft Excel spreadsheets which results in multiple versions of the "database" with no centralised point of truth. Although the lack of a database increases the time taken to review and resolve data issues, once these issues were resolved, the compiled databases are suitable for downstream work.

25.1.1.1 New Liberty

Sample security appears adequate and sample preparation and analytical techniques for both the pre-2013 drilling (prior to Avesoro's ownership) and the post 2013 drilling are mostly appropriate with no fatal flaws noted. Due to the coarse nature of the gold mineralisation, a Screen Fire Assay (SFA) technique could be used to more accurately determine the gold values.

QA/QC procedures have evolved with time, from no QC samples in 1999 and 2000 to a comprehensive program in 2018. However, the procedures do not appear to always have been diligently followed with no preparation blank being used in the most recent campaign of drilling (July – December 2018) or in the grade control drilling. Therefore, there is no adequate control on potential cross-contamination in these samples. Numerous instances of apparent misidentification of CRM and blanks are apparent which indicate issues with data management.

Precision is acceptable for the grade control and 2018 drilling, and once errors corrected, the 2018 samples indicate acceptable levels of assay accuracy. Bias is noted in many of the pre-2018 CRM results, but this is usually a negative bias, indicating that results are potentially understated (not overstated) which could be influenced by the assay method (particularly where an aqua regia digest been used).

Overall, there are issues with many of the QC results and implementation of procedures could be improved.

25.1.1.2 Ndablama

Sample security appears adequate and sample preparation and analytical techniques are appropriate with Fire Assay (FA) and Screen Fire Assay (SFA) being the industry best practice techniques for gold analysis.

Results of QC samples from drillholes NDD116 onwards were reviewed where numerous CRM identification issues were noted. However, once these were corrected, CSA Global concluded that no significant cross contamination was apparent, and that assay accuracy was acceptable with no significant bias. Assay precision was poorer than expected, indicating the coarse nature of the mineralisation.

QA/QC procedures are acceptable and when followed should provide confidence that there is no significant cross-contamination and that acceptable assay accuracy (lack of bias) and assay precision (repeatability of results) have been established.

25.1.2 Geology and Mineral Resources

CSA Global considers that data collection techniques are consistent with industry good practice and suitable for use in the preparation of an MRE to be reported in accordance with CIM (2014) guidelines. QC data supports the integrity of the analytical data which has been utilised.

25.1.2.1 New Liberty

The New Liberty deposit consists of several steeply, south dipping mineralisation zones along an east-west trend. The geology is dominated by tremolite-chlorite-actinolite-talc ± magnetite rich meta-ultramafics, sometimes with phlogopite, and flanked by migmatitic gneisses.

During December 2018, Mineral Resources were estimated for New Liberty. A 3D block model representing the mineralisation was created by CSA Global, in collaboration with Avesoro geologists, using Leapfrog™ software. High-quality RC and DD samples were used to estimate grades into blocks using OK. The block model was validated visually and statistically. The RC holes constitutes the grade control drilling and was included to interpret mineralisation wireframes, as well as used in the grade estimation. Channel sample data, where it exists, were excluded from the estimation dataset.

The total drilling used for the MRE update was 561 DD holes for a total of 98,632 m and 53,811 assays; and 1,069 RC holes, for a total of 41,417 m and 41,417 assays. The previous MRE, as documented and filed in a Technical Report in 2017 (SRK, 2017) was based on 115,984 m of drilling for a total of 1,306 drillholes and 25 channels for 1,574 m of sampling.

A total of 15,244 samples were flagged within the mineralised volume and composited downhole into 1 m lengths. The resultant 15,516 composite samples were used in the estimate. Composite length was dependent on dominant sampling length and proportion of lengths greater than the dominant sampling length.

A total of 13,884 BD measurements within the New Liberty MRE area was flagged by mineralisation domain, geology unit and the modelled weathering profile (bottom of complete oxidation) and reviewed within each of these domains. There is no significant difference in BD between the mineralisation and waste domains. However, there is a difference in BD between oxidised and fresh material, and between the SMUS and the surrounding geology. As such, an average BD was assigned per weathering profile and geological unit, as 1.58 t/m^3 for SMUS oxide, 1.40 t/m^3 for non-SMUS oxide, 2.95 t/m^3 for SMUS fresh, and 2.83 t/m^3 for non-SMUS fresh.

Hard boundaries were used between mineralisation and waste zones, and between different mineralisation domains. Following contact analysis, oxidation boundaries were soft. Variograms were modelled for larger domains using the composites, with outliers top-cut to prevent biasing the resultant model.

Grade was estimated into parent blocks using OK, controlled by dynamic anisotropy.

Grade estimates were validated against drill data. There is good correlation between the input composites and output model for the estimated Au grade. Generally, the model grade trends follow the pattern of the drill samples grades, with reasonable levels of smoothing of the higher and lower grades.

The New Liberty MRE satisfies the requirements for Measured, Indicated and Inferred Mineral Resource categories as embodied in the NI 43-101 Canadian National Instrument for the reporting of Mineral Resources and Reserves.

The MRE indicates reasonable prospects for economic extraction, where Open Pit (OP) material is reported at a cut-off grade of 0.80 g/t Au above a resource shell produced in NPV Scheduler (NPVS) using a US$1,300 Au prices and basic assumptions regarding costs, and Underground Mining (UG) is reported below the US$1,300 shell, within stope volumes based on a US$1,500 gold price optimisation at 1.90 g/t cut-off (reported at no cut-off), run to support assumptions relating to reasonable prospects of eventual economic extraction.

Compared to the previously reported MRE (SRK, 2017), the Mineral Resources have changed as follows:

- The OP Measured and Indicated Mineral Resources (M&I) have decreased by 3.93 Mt (46%) for a decrease in metal of 391.1 koz (43%). OP Inferred Mineral Resources have decreased by 3.6 Mt (99%) for a decrease in metal of 323 koz (99%).
- The UG M&I Mineral Resources have increased by 5.48 Mt (914%) for an increase in metal of 581.3 koz (894%). UG Inferred Mineral Resources have decreased by 0.1 Mt (5%) for a decrease in metal of 42 koz (14%).
- The total OP Mineral Resource has decreased by 7.50 Mt, for a decrease of 714.3 koz. The total UG Mineral Resource has increased by 5.35 Mt, for an increase of 539.2 koz.

The reasons for these changes, subject to the limitations and assumptions, are:

- The reporting cut-off for Open Pit is the same at 0.80 g/t Au. However, the reporting of Underground Mining has changed from reporting all contiguous material below the optimised pit shell at a cut-off of 2.00 g/t Au, to reporting all material within optimised stopes at no cut-off.
- The resource shells are different. The shell used to constrain the 2017 model used a gold price of US$1,500/oz, whereas the 2018 model uses a constraining shell based on a gold price of US$1,300/oz.
- The 2017 MRE reported Underground Mining as material below a US$1,500/oz gold shell, with lower-grade material within thinner (and less contiguous) zones of mineralisation removed using Deswik's Mining Stope Optimizer (SO) as a spatial guide. The 2018 MRE reported Underground Mining as material below a US$1,300/oz gold shell, within stope volumes based on a US$1,500 gold price optimisation at 1.90 g/t cut-off (reported at no cut-off).
- The 2017 MRE was depleted with mining up to 31 July 2017, compared to the 2018 MRE that was depleted with mining up to 31 December 2018.
- Additional infill drilling resulted in an increase in confidence and upgrading of Inferred Mineral Resources to Indicated Mineral Resources.
- Changes to the mineralisation and weathering models as a result of the additional drilling, led to reinterpretation below the current mined (31 December 2018) pit surface. Previously, grade shells were produced at a 0.3 g/t cut-off for Kinjor and Larjor, and 0.5 g/t cut-off for Marvoe (SRK, 2017). The current grade shells for Marvoe, Kinjor and Larjor were modelled on mineable intercepts at a cut-off of 0.5 g/t Au with a minimum true thickness of 3 m.

25.1.2.2 Ndablama

The Ndablama deposit consists of consists of three shallow westerly dipping domains along a north-south trend. The host rocks to the gold mineralisation are amphibolite schists with biotite/phlogopite, and ultramafic tremolite-chlorite schists. This sheared package of ultramafic and mafic rocks is intercalated within a gneiss sequence, overlaying a granite batholith. The mineralisation at the Ndablama deposit contains elevated gold grades, with high variability, within the identified deposit area, over reasonable strike lengths.

During December 2018, Mineral Resources were estimated for Ndablama. A 3D block model representing the mineralisation was created by CSA Global, in collaboration with Avesoro geologists, using Datamine StudioRM™ software. High-quality RC and DD samples were used to estimate grades into blocks using the top-cut model with indicator residual (TC estimate). Following the generation of the Ndablama TC estimate, recoverable resources were estimated based on a selective mining unit (SMU) of 5 m x 5 m x 5 m, completed using Uniform Conditioning (UC). The UC estimate was further post-processed to produce single cell grades for each SMU, based on Localised Uniform Conditioning (LUC) where the grade tonnage of the panel gets reconstituted in SMU sized blocks resulting in a block model with single grades. The block model was validated visually and statistically.

The total drilling used for the MRE update was 225 DD holes for a total of 47,610 m and 25,687 assays; and 33 RC holes, for a total of 4,968 m and 2,900 assays. The previous MRE, as documented and filed in a Technical Report in 2014 (AMC, 2014) was based on 27,160 m of drilling for a total of 154 drillholes.

A total of 10,761 samples were flagged within the mineralised volume and composited downhole into 1 m lengths. The resultant 10,713 composite samples were used in the estimate. Composite length was dependent on dominant sampling length and proportion of lengths greater than the dominant sampling length.

A total of 8,148 BD measurements within the Ndablama MRE area was flagged by mineralisation domain and the modelled weathering profiles (bottom of complete oxidation and top of fresh) and reviewed within each of these domains. There is no significant difference in BD between the mineralisation and waste domains. However, there is a difference in BD between oxidised and fresh material and as such, average BD was assigned per weathering profile as 1.34 t/m^3 for oxide, 1.99 t/m^3 for transitional and 2.94 t/m^3 for fresh.

Hard boundaries were used between mineralisation and waste zones, and between different mineralisation domains. Following contact analysis, oxidation boundaries were soft.

Due to the estimation methodology used (TC estimation), cross-variograms were modelled for MIN(AU,2.5) and IND(AU,2.5) for each of the three domains using 1 m top-cut composites. MIN(AU,2.5) captures the background part of the distribution and is equal to Au if Au is less than 2.5 g/t, and to 2.5 if Au is greater than 2.5 g/t; IND(AU,2.5), the indicator function at 2.5, captures the geometry of the tail of the distribution, and is equal to 1 if Au is greater than 2.5 g/t, 0 otherwise.

Grade was estimated into parent blocks of 25 m x 25 m x 5 m (X Y x Z) using the TC model method, controlled by dynamic anisotropy. This was followed by UC and LUC.

Grade estimates were validated against drill data. There is good correlation between the input composites and output model for the estimated Au grade. Generally, the model grade trends follow the pattern of the drill samples grades, with acceptable levels of smoothing of the higher and lower grades.

A campaign of infill and step-out drilling during 2018 demonstrated that even though the predicted volume and mineralisation continuity, as modelled at a 0.1 g/t Au cut-off and guided by the main shear zone, remains reasonable, there is a very high variability in grade within the main mineralised domain, which adds risk to the eventual metal predicted.

Due to the high-grade variability within the main mineralisation domain at Ndablama, Conditional Simulation (CS) testwork was completed to assist in assessing grade uncertainty and risk attached to the in-situ resource. As part of this, the CS realisations were used to build a Risk Index to characterise the level of local confidence that could be attached to the local estimates. Analysis of the distribution of the Risk Index showed that the grade estimates are marked with a substantial relative uncertainty and that locally the fluctuations between estimated and realised grades can be very important.

CSA Global notes that the Risk Index is not an absolute measure, but a relative measure of the risk of recovery of the expected value. The Risk Index, in combination with estimation statistics (slope of regression, kriging variance, number of samples used to estimate, search volume), drillholes spacing, data quality and QA/QC, potential for eventual economic extraction, volume and mineralisation continuity (as modelled at a 0.1 g/t Au cut-off and guided by the main shear zone), was used to inform classification decisions made.

The Indicated Mineral Resources for Ndablama were classified taking all of the above into account; however, CSA Global stresses that the outcome of the Risk Analysis highlights the high-grade variability nature of the deposit and that selective mining at 5 m x 5 m x 5 m, at a selected cut-off, does carry a high measure of risk.

The Ndablama MRE satisfies the requirements for Indicated and Inferred Mineral Resource categories as embodied in the NI 43-101 Canadian National Instrument for the reporting of Mineral Resources and Reserves.

The MRE indicates reasonable prospects for economic extraction, supported by a resource shell produced in NPVS using a US$1,500 Au price and basic assumptions regarding costs.

Compared to the previously reported MRE (AMC, 2014), the Mineral Resources have changed as follows:

- The Indicated Mineral Resources have increased by 2.13 Mt (28%) for an increase in metal of 202.5 koz (53%).
- Inferred Mineral Resources have decreased by 9.3 Mt (97%) for a decrease in metal of 499 koz (97%). The total Mineral Resource has decreased by 7.14 Mt (42%), for a decrease of 296.5 koz (33%).

The reasons for these changes, subject to the limitations and assumptions, are:

- The reporting cut-off has increased from 0.50 g/t to 0.85 g/t Au.
- The resource shells are different. The shell used to constrain the 2014 model used a gold price of US$1,700/oz, whereas the 2018 model uses a constraining shell based on a gold price of US$1,500/oz.
- Additional infill drilling resulted in an increase in confidence and upgrading of Inferred Mineral Resources to Indicated Mineral Resources.
- Changes to the mineralisation and weathering models are as a result of the additional drilling, leading to reinterpretation.
- No mining to date.

25.1.3 Mining and Reserves

25.1.3.1 Mining and Reserves

Mining activity for the combined project will include open pit mining of the New Liberty deposit until the break-even cutoff for underground mining is reached, a transition to underground mining by portal and ramp access followed by mining of reserves between the $1,300 pit shell (Pit 33) and the $1,500 pit shell by long hole open stoping (LHOS) methods, with open pit mining of the reserves at the Ndablama deposit and direct shipping of Ndablama ore to the New Liberty mill later in the life of the project.

The detailed mine design for New Liberty pit was based on the selected pit limit (Pit 33) from the optimisation work and utilised the existing interim pit stages (Stages 1, 2 and 3) that are currently being mined. An additional pit stage (Stage 4) was added to smooth out the waste stripping over the remaining life of the open pit. Initial stages are as at Kinjor and Marvoe presently. Ultimately mining will be continued until the present planned Pit 33.

A pit optimisation for the Ndablama deposit was run using Datamine's NPV Scheduler (NPVS) software. This uses the standard Lerch-Grossman (LG) algorithm. The starting surface for pit optimisation was the original surface topography as no mining has taken place in the pit area as yet. A total of four pit stages were designed based on the optimised pit shells generated by NPV Scheduler. Each pit stage was designed to have at least 1 Mt of ore and the initial stages target the blocks with the highest value.

A transition to underground mining is considered strategic for the operation in order to overcome limitations associated with the deposit geometry and dip in accessing deeper reserves. The transition to underground mining at New Liberty was determined by assessing the breakeven cut-off between current open pit mining approaches and underground methods. For that assessment, the pit increments between current Pit 33 and Pit 46 shells were studied and traded off vs. the cost and outputs of the underground approach. While an economic trade off was performed, using open pit mining costs of US$1.9/t, and underground mining cost of US$45/t, other factors were identified in the trade-off that drive the decision to go underground. The overriding factor was the practicality of increasing the mining rate for open pit mining, which becomes increasingly restricted, as well as practical limits on vertical sinking rate driven by the geometry and orientation of the New Liberty orebody.

Access to the orebody below the current open pits will be from within the pits. Separate portals will be developed in the Larjor and Kinjor pits providing access to the orebodies. Trucking ramps or declines will be developed from the portals, which will be established on the footwall side of the open pits, into the footwall of the orebody. The ramps will spiral down providing access to all main and sublevels in the mine. In order to access the ore blocks that remain outside strike of the final pit shells, but above the elevation of the portals, ramps will be developed up to the levels above.

The trucking ramp will be located in the footwall of the orebody, at a minimum of 30 m from the footwall contact, as per the recommendation in the geotechnical report.

Access to the orebody will be established every 20 m vertically, by means of a level crosscut. The dimensions of the level crosscut will be 5.0 m x 5.0 m. Between the decline and the orebody intersection two stub drives of 15 m length will be established, one left and one right. These will initially be used as muckbays. These will later be used to house infrastructure such as pump stations, dams and electrical switchgear. A set of return ventilation raises will be established between levels, which link up to an upcast vent raise, holing to surface and which will be equipped with the main fans. The level-to-level ventilation raises, which will be developed by drop raising techniques, will be located in one of the stub drives. Where required this drive will be extended to provide access to the required location of the ventilation raise. Ore drives will be established in the strike direction from the level access crosscut advancing to the limit of the orebody. Where multiple zones are present, which separated by a suitably sized pillar, minimum pillar width of 8 m, multiple drives will be established.

The average dip of the orebody is approximately 60°, with local variations in dip ranging from near vertical to around 40°. The orebody consists of a number of veins, generally parallel to each other. Mineralisation can occur in more than one of the veins, creating the potential for multiple parallel stopes in some parts of the deposit. The widths of the mineralised zones range from 2 m to 30 m, with an average width of 10 m. Rock conditions are described as generally good. The preferred mining method at New Liberty was selected as a variation of long hole open stoping. In order to reduce loss of valuable ore to pillars, consideration was given to the installation of a cemented waste rock layer on the floor of the stope to create an engineered sill pillar and thereby negate the need for sill pillars. The inclusion of this engineered, cemented, waste rock pillar reduces the pillar loss in the waste rock fill option to from 41% to 27%.

The combined annual mining schedule for New Liberty open pit, New Liberty underground and Ndablama open pit is shown in Table 25-1.

Table 25-1: Schedule of the Combined Project of New Liberty Gold Mine and Ndablama Deposit

Parameter	Unit	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	LOM Total
Mining Physicals													
New Liberty Open Pit													
Ore mined	kt	1,649.3	1,468.9	1,287.3	511.9	-	-	-	-	-	-	-	**4,917.5**
ROM grade	g/t	2.53	3.16	3.65	3.63	-	-	-	-	-	-	-	**3.12**
Waste mined	kt	33,502.2	33,876.3	22,175.0	38.6	-	-	-	-	-	-	-	**89,529.1**
Strip ratio	W:O	18.1	21.1	11.9	0.8	-	-	-	-	-	-	-	**16.7**
New Liberty Underground													
Ore mined	kt	-	41.3	233.3	382.4	552.3	579.4	617.8	613.0	605.6	577.2	456.8	**4,658.9**
ROM grade	g/t	-	2.64	3.21	3.34	3.37	2.93	2.97	3.05	2.98	2.86	3.22	**3.08**
Waste mined	kt	-	119.9	125.7	286.8	208.4	76.8	88.0	2.3				
Ndablama Open Pit													
Ore mined	Kt	-	-	-	1,123.2	873.8	1,430.4	1,484.3	906.1	1,464.5	-	-	**7,282.3**
ROM grade	g/t	-	-	-	1.60	1.60	1.67	1.81	1.66	1.83	-	-	**1,71**
Waste mined	kt	-	-	-	8,307.3	15.926.4	9,620.1	8,410.4	7,081.4	1,407.9	-	-	**50,753.4**
Strip ratio	W:O	-	-	-	4.3	10.0	2.7	6.8	9.2	0.6	-	-	**4.4**
Production													
Tonnes milled	kt	1,576.2	1,453.7	1,602.4	1,794.4	1,800.0	1,800.0	1,800.0	1,800.0	1,800.0	1,185.5	456.8	**17,069**
Milled grade	g/t	2.64	3.04	3.00	3.15	2.06	2.13	2.31	2.06	2.31	2.00	3.22	**2.49**
Recovered gold	koz	123,600	131,100	142,500	167,600	109,900	113,900	123,500	109,900	123,400	70,300	43,700	**1,259,400**

Table 25-2: Mineral Reserve statement – New Liberty Gold Mine and Ndablama Deposit, Liberia

Mineral Reserves estimated for the New Liberty "Combined" Project, Liberia, as at 31 December 2018										
Deposit	**Cut-off grade (g/t)**	**Proven**			**Probable**			**Total Ore Reserve**		
		Tonnes (Mt)	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**	**Tonnes (Mt)**	**Au grade (g/t)**	**Au metal (koz)**
New Liberty Open Pit	0.80	0.216	1.65	11	4.701	3.19	482	4.917	3.12	494
New Liberty Underground	2.00	0.084	3.36	9	4.575	3.07	452	4.659	3.08	461
Ndablama Open Pit	1.00	0.00	0.00	0.0	7.282	1.71	400	7.282	1.71	400
Total (excl. Stocks)		**0.300**	**2.13**	**21**	**16.559**	**2.51**	**1,334**	**16.859**	**2.50**	**1,355**
NL ROM Stockpiles (LG, MG, HG)					0.210	1.47	10	0.210	1.47	10
Total (incl. Stocks)		**0.300**	**2.13**	**21**	**16.769**	**2.49**	**1,344**	**17.069**	**2.49**	**1,365**

Notes:

1. *The Mineral Reserves have been depleted for mining up to 31 December 2018 and stated as of the same date.*
2. *Figures have been rounded to the appropriate level of precision for reporting.*
3. *Due to rounding, some columns or rows may not compute exactly as shown.*
4. *The Mineral Reserves are stated as in-situ dry metric tonnes.*
5. *The Mineral Reserves were prepared under the guidelines of the CIM, for reporting under NI 43-101.*
6. *The Ore Reserve is reported at a US$1,300/oz gold price.*
7. *Modifying factors applied:*
   - *New Liberty Open Pit: mining recovery of 95% and waste dilution of 10% at 0g/t Au*
   - *New Liberty Underground: pillar loss 17%, ore loss 4%, waste dilution 9%*
   - *Ndablama Open Pit: mining recovery of 95% and waste dilution of 5% at 0g/t Au.*
8. *Proven Mineral Reserves were derived from Measured Mineral Resources and Probable Mineral Reserves from Indicated Mineral Resources.*
9. *There are no known legal, political, environmental, or other risks that could materially affect the potential Mineral Reserves.*

25.1.4 Water Management

25.1.4.1 New Liberty

Site investigations indicate that the New Liberty site is underlain by a layer of moderate permeability highly weathered rock (saprolite/saprock) of varying thickness. The weathered rock is underlain by typically low permeability fractured bedrock with localised areas of enhanced permeability where water bearing fractures/faults exist. The permeability of the fractured bedrock appears to decrease with depth. Shallow groundwater flows occur through the saprolite/saprock layer and preferentially through permeable fracture zones within the fresh rock.

The groundwater level is typically less than 10 mbgl and generally 65 mRL to 75 mRL. The commencement of mining and associated pit dewatering does not appear to have significantly impacted groundwater levels in any of the current groundwater monitoring drillholes. The groundwater is generally acidic with some elevated metals concentrations.

The Marvoe Creek Dam is a large body of water which has the potential to act as a large water source, recharging any zones of enhanced permeability hydraulically connected between the dam and the current open pits and the proposed underground mine.

New Liberty Open Pit Inflows

Predicted inflows and dewatering estimates were previously completed for the New Liberty open pits in 2013 (pre-mining) based on the then proposed mine plans and available data. There is currently insufficient data to confirm the current pit dewatering rates/volumes or to validate the previous pit dewatering predictions.

In November 2018, it was observed that the Larjor Pit contained a significant volume of water, while saturated pit floors were observed at both the Kinjor and Marvoe pits. Significant water volumes were observed flowing into the three pits from external pit catchments and/or shallow weathered units. Near surface inflows were particularly prevalent along the entire northern perimeter of the three pits and at the western side of the Larjor pit. Significant discrete inflows were also observed associated with geological structures evident in the pit walls in each of the three pits (e.g. the main ore bearing shear zone, the Marvoe Creek Fault and numerous other faults/fractures).

Potential groundwater and surface water pit inflows were predicted for the proposed final New Liberty open pit as follows:

- Larjor pit:
  - Average bulk groundwater inflow rates of 5–10 L/s
  - Structurally controlled groundwater inflow rates of 1–2 L/s for each permeable structure intersected by the pit.
- Main pit (Pit 33):
  - Average bulk groundwater inflow rates of 10–15 L/s
  - Structurally controlled groundwater inflow rates of 1–2 L/s for each permeable structure intersected by the pit.

Generally, the structurally related inflows will reduce in magnitude rapidly, although long term localised inflows could potentially occur where the open pit intercepts a structure with a direct link to an overlying water body. Localised structurally related inflows may increase during the wet season and may reach the initially encountered higher inflow rates during prolonged wet periods.

Currently two primary diversion drains capture runoff from parts of the waste dump and surrounding area and convey the runoff to the west and south of the pits and waste dumps. The predicted surface water inflows from the remaining surface water catchments that drain into the proposed open pits range from approximately 560,000 m^3 to 715,000 m^3 (dry year to wet year) for Larjor pit and approximately 1,920,000 m^3 to 2,455,000 m^3 (dry year to wet year) for Pit 33.

The resulting predicted combined inflows for the proposed New Liberty pits are as follows:

- Larjor Pit: Approximately 875,000 m^3 -to 1,030,000 m^3 (dry year – wet year)
- Pit 33: Approximately 2,700,000 m^3 to 3,245,000 m^3 (dry year – wet year)
- 24-hour 50-year storm event: Approximately 98,000 m^3 for Larjor Pit and 335,000m^3 for Pit 33.

New Liberty Underground Inflows

The bulk groundwater inflows into the underground mine are predicted to be generally low with average inflows predicted to be in the order of 1–2 L/s for each stage of development (each lobe) of the underground mine. These are average bulk inflow values and inflows will be higher at times of rapid advancement (especially with respect to depth) and lower when the area has been actively mined for an extended period of time.

Structurally related inflows are predicted to be in the order of 2–5 L/s. These structurally controlled inflows are predicted to reduce in magnitude rapidly, although long term localised inflows could potentially occur where the underground mine intercepts a structure with a direct link to an overlying water body or saturated overlying shallow sediments. In the wet season, enhanced localised structurally related inflows into the underground mine may temporarily increase again. The location of these structurally related enhanced inflows will directly correspond with where the underground mine intersects significant structures. Cover drilling ahead of underground mining should be considered in order to provide advanced warning of potential localised structurally controlled inflows.

Dewatering associated with open pit development and the underground mine will result in the water table being drawn down in the vicinity of the pits and underground mine. The cone of depression is predicted to be steep and narrow with its extent constrained to the north and west by the presence of the Marvoe Creek Dam and the Marvoe Creek diversion channel respectively and greater water level drawdown to the east and south where there are no significant recharge sources.

Water levels within the two mine-site water supply wells are predicted to be drawdown as a result of the dewatering from the open pits and underground mine. However, these wells are located close to the Marvoe Creek Dam and so the actual drawdown in the wells is likely to be significantly less than predicted due to recharge from the dam. The water level within the village wells is not predicted to be impacted as a result of the dewatering from the open pits and underground mine. The wetland area down gradient of the TSF is not predicted to be impacted by the groundwater level drawdown as a result of dewatering.

The New Liberty site is an operating mine site, with an existing surface water management plan in place to manage surface water associated with the mine until the cessation of open pit mining. The current design of the southern waste dump appears to encroach on the drainage channel around the eastern pit perimeter but will be redesigned as part of the subsequent Definitive Feasibility Study (DFS).

25.1.4.2 Ndablama

Site investigations completed at Ndablama pit indicate that the site is underlain by a layer of highly weathered rock (saprolite) and in some area a transition zone consisting of saprock. This weathered zone is underlain by competent bedrock where groundwater flow is predominantly associated with secondary fracturing.

The competent fresh bedrock is considered to generally have a lower average permeability than the weathered material as there are relatively few structures with enhanced permeability within the competent rock.

Measured groundwater levels generally range between artesian and 7 mbgl. Groundwater levels in the Ndablama deposit area mimic topography with groundwater flow generally from the elevated hills towards the low-lying streams and groundwater gradients generally range between 1:15 and 1:40.

The groundwater quality of samples collected within the Ndablama study area indicates exceedances of the WHO drinking water quality guidelines for chloride, nitrate, lead, manganese and mercury.

Shallow groundwater flows will occur laterally down gradient along the weathered/unweathered contact (transition zone) and may discharge as springs or seepage into the various streams and rivers that exist in the Ndablama area. The degree of saturation of the weathered saprolite/saprock will fluctuate seasonally depending on rainfall recharge during the wet season and it is possible that some areas of the weathered zone will be completely dry during the dry season.

Groundwater inflows into the Ndablama open pit were predicted at various stages of mine development and were predicted to vary from approximately 1 L/s (construction) to 8 L/s (end of Stage 4).

Potential annual surface water inflows into the Ndablama Pit for Stage 1 range from approximately 200,000 m^3 to 260,000 m^3 (dry year – wet year) for Stage 4 from approximately 640,000 m^3 to 845,000 m^3 (dry year – wet year).

There is scope to reduce the external catchment area draining to the Ndablama pit in the earlier stages of development and this should be optimised during the DFS in conjunction with the surface water management in the vicinity of the pit.

Dewatering will also be required during the operation of the mine resulting in the draw down in local groundwater levels. The zone of influence of the groundwater level drawdown in the saprolite during the operational phase is predicted to be up to approximately 200 m from the pit crest. A portion of the river that drains the sub-catchment within which the pit will be located will be mined out. The associated average annual decrease stream flow volume in the river draining towards the southern discharge point is predicted to be a maximum of approximately 20%, although the decrease in discharge volume will vary seasonally. There are no privately-owned water supply wells that fall within the predicted zone of influence of the dewatering induced groundwater level drawdown cone.

The local groundwater flow patterns will be directed towards the pit due to mine dewatering. Seepage from the WRD into the pit may occur and will be captured within the dewatering system along with the other pit inflows and handled within the mine water management system.

During the decommissioning phase the mine dewatering will stop and the water level within the pit will start to recover. The WRD will be sloped and capped, which will reduce the recharge into the WRD and lead to a lowering of the water level within the WRD area. Long term, the water level within the pit will continue to recover. The recovering water levels will allow the groundwater flow patterns in the area to recover to near pre-mining levels. It is predicted that water level in the Ndablama pit will recover to approximately 195–200 m amsl within 15–20 years of the end of mine operation. At this level, groundwater inflows into the pit will be minimal due to the water level within the pit being at, or even slightly above, the regional groundwater level elevations around the pit. In addition, once water levels reach these levels it is predicted that water discharge from the pit will commence.

A site-specific surface water management plan was developed for the Ndablama site. Proposed channel alignments were developed to divert “clean” surface water runoff around and downstream of the development and to manage the “dirty” water runoff from the impacted catchments. Diversion channel sizing ranges from 1 m deep V-shaped channel to 1.5 m deep, 3.0 m base width trapezoidal channels. The proposed stormwater diversion channels with design flows less than 10 m^3/s have a minimum freeboard of 300 mm, while channels with larger design flows have a minimum freeboard of 500mm. Where mean channels velocities exceed 3.0 m/s, reinforced concrete channels are required and where flow velocities are less than 1.5 m/s, no erosion protection is required. For channels with flow velocities between 1.5 m/s and 3.0 m/s, rip-rap linings are required.

The runoff from the impacted catchments will be collected in channels and discharged to sedimentation ponds, in order to facilitate the settlement of suspended sediment, prior to discharge to the environment. A minimum sedimentation pond depth of 1.2 m is recommended, incorporating a minimum settling depth of 0.6 m with an additional depth provided for the storage of settled sediment between maintenance. Sedimentation pond design will be undertaken as part of the subsequent DFS, when there is more certainty on the project infrastructure design.

25.1.5 Process Technology

Testing has been carried out on representative samples from the New Liberty underground ore sources, and on samples representing the Ndablama deposit.

The testwork programs included comminution, gravity, flotation, whole ore cyanidation leaching, and gravity tails leaching.

Testing carried out on the underground ore sources from the New Liberty and Ndabalama deposits verified that the optimal process route is that of gravity-intensive cyanidation leach, followed by conventional CIL, and gold recovery on the gravity tail.

The testwork showed that both New Liberty and Ndablama ore sources have a high Gravity Recoverable Gold (GRG) component and warrants the inclusion of a gravity circuit in the flowsheet. Gold extraction on the gravity concentrate are high, and leach kinetics are rapid.

Cyanidation leaching on the gravity tails also demonstrates rapid leach kinetics.

Bond Rod Mill Work Index testing on New Liberty samples showed a Master Composite of the four zones to have a work index value of 15.21 kWh/t which would be considered ‘hard’ based on standard classification criteria. Bond Ball Mill Index testing of the New Liberty Master Composite showed it to have a work index value of 16.06 kWh/t which would again be classified as 'hard' using standard criteria.

Bond Rod and Ball Mill Work Index tests were carried out on a composite of the fresh ore types at Ndablama. The Bond Rod Mill Work Index at a product size 642 µm was 13.0 kWh/t, whilst the Bond Ball Mill Work Index at a product size P80 of 60 µm was 18.5 kWh/t which would be considered to be hard.

Overall, results for New Liberty showed that by using a combined gravity-leach methodology, gold recoveries of 92.9% and 95.2% could be achieved for the Larjor/Kinjor South and Kinjor North samples respectively.

Results for Ndablama indicate the oxide and sulphide ore types are readily processable using the gravity-leach process flowsheet, with average GRG recoveries for the oxide and sulphide ore types of 34.1% and 70.2% respectively. Gold leach extractions were on average 92.3% and 94.5% for the oxide and sulphide ore composites respectively. Recovery rates of 92% used in the study were therefore validated.

All ores generated in the project will be processed in the existing New Liberty mill. The process flowsheet is an industry-standard arrangement consisting of crushing, ore stockpiling, grinding and classification, gravity gold recovery, thickening and gold extraction by cyanidation in a carbon-in-leach (CIL) circuit. Gold is recovered from the activated carbon by acid washing, elution and electrowinning, followed by smelting to produce gold doré. The CIL tailings undergo cyanide detoxification followed by arsenic precipitation from tailings solution prior to disposal in the tailings dam.

Based on the Bond rod and ball mill work indices reported the existing grinding circuit has sufficient installed grinding capacity to process the underground ore sources from the New Liberty mine at an annual production rate of 1.8 Mt/a, targeting a grind size P80 of 75 µm.

Based on the Bond Rod and Ball Mill Work indices reported, a coarser grind size is required when processing the Ndablama ore. The existing grinding circuit has sufficient installed grinding capacity to process ore sources from the Ndablama deposit in combination with ores from New Liberty underground mine at an annual production rate of 1.8 Mt/a, targeting a grind size P_{80} of 106-125µm.

25.1.6 Infrastructure

New Liberty is to have a new, approx. 600,000 ROM t/a underground mine, accessed by portals from the old Larjor pit as well as the existing New Liberty pit (Kinjor), with a ramp accessing reserves between the current $1,300 and $1,500 New Liberty pit shell. Each portal will have constructed entry, plus support, and services including sumps/pumping and a main ventilation fan (and vent shaft) in the vicinity. Extensive facilities including sumps and pumps to maintain/control water in the final pit (Pit 33) will be provided around each portal. Additionally, an ore transfer station, with a dump for underground ore trucks, and front-end loader to load haul trucks will be provided at each portal. Water from underground will be pumped to the two in-pit sumps, where this water, plus the pit inflows will be settled, then pumped to the existing water diversion trench to the south of Kinjor pit for discharge.

The underground mine is to be designed with relevant in-mine infrastructure to support conventional diesel mining fleet plus labour/supervision, including fuel stations, lubrication stations, miner's stations, refuge stations, ventilation and pumping infrastructure. Workshops will be on surface. Operations are to be via three shifts of eight hours, plus a spare shift, operating 24/7/365. Main electrical reticulation is at 6,000 V, transformed to 500 V in working sections. Lighting and small power will be provided in stationary working places; in all other locations lighting is to be by cap lamps and lights from mobile equipment. The mine is non-methaniferous, therefore electrics are to be to IP55 and explosion protected standard only (i.e. intrinsically safe not required). Underground communications by radio, with transmission by leaky feeder is assumed. Underground communications will interface via a new digital base station on surface with existing surface radio communications/dispatch and the mine's existing control network.

Power generation by two new 2.25 MVA diesel generators is assumed, with reticulation at 6,000 V to the new pumps, fans and the underground. Additional workshop capacity for planned maintenance of underground fleet will be provided. New/updated roads for mobile fleet to travel from the portal(s) to the plant stockpile and workshops will be laid out.

There is an existing 1.8 Mt/a mill on site at New Liberty therefore no new milling facilities relating to Ndablama underground are contemplated. A new road train side-tip (two 90-t cars) will be required in the ROM area to handle ROM coming from Ndablama pit from Year 5.

Ndablama is to be an approx. 1,600,000 ROM t/a open pit mine, with conventional truck/shovel fleet and associated labour/supervision, three shifts of eight hours, plus a spare shift, operating 24/7/365. The pit is to be provided with all relevant infrastructure to support conventional diesel mining fleet plus labour/supervision, including a combined workshop, fuel station and lubrication station, stores, offices, changehouse facilities, and pit dewatering infrastructure. Pit dewatering will be by Global type diesel pumps as at New Liberty, discharging into the surface stormwater diversion trenches as required. Workshops will be designed for the estimated complement of mobile fleet; offices and changehouse facilities will be designed for the estimated labour complement plus contingency. Haul trucks from the pit will dump to a ROM pad, where a front-end loader will load off-highway trucks for the transport of ore to the New Liberty ROM pad. Roads to connect the crushing station to the Ndablama–New Liberty haul road must be laid out. Probably the single biggest item of infrastructure required is the 46 km haul road from Ndablama mine to New Liberty mine. Power generation by a single new 400 kVA generator for small power (offices, changehouses, stores) only is assumed. Solar generation has been allowed on the changehouse roof to support power requirements. Power reticulation will be at 6,000 V, transformed to 500 V in working sections. Communications/dispatch is to be by radio, with an additional 3G tower for cellular and data communications back to New Liberty.

25.1.7 Tailings

The proposed LOM is forecast to produce 18 Mt tailings in 10 years from October 2018 at an average throughput of 1.8 Mt/a. Throughput to the existing facility as of the end of October 2018 was approximately 3.4 Mt, resulting in a total storage capacity requirement of 21.4 Mt within the TMF at closure. In order to store the LOM tailings the existing TMF at the New Liberty Gold Mine will require expansion. To accommodate this requirement a vertical expansion option using the centreline method of construction was selected.

The dam is located in a basin to the south of the Plant. Presently, the dam is still in Phase 1 operation. Tailings beaches have inundated the valley up to approximately 78 RL in the western portion of the site, with the supernatant pond covering the majority of the middle and eastern portions of the basin area. Phase 2 construction to 82.5 mRL is scheduled to provide at total storage capacity of 9.35 Mt and should be completed by June 2019. A Phase 3 design, based on centreline method, to accommodate the full 21.4 Mt over LOM was designed by Golder as part of the study.

Site conditions in terms of topography, ground conditions and seismicity are generally good for impoundment. Tailings characteristics are generally good for deposition, and are not expected to change, except perhaps for a marginal coarsening of particle size in the processing of Ndablama material. Issues in the past with achieving target placed density were noted however have largely been overcome. Water management in tropical, high rainfall conditions for the location is key, however has historically been well managed within a robust dam design.

The majority of risks associated with the impoundment have been identified and have shown to be adequately mitigated by proposed measures set out in the development of the TMF expansion design and associated recommendations for additional work. The highest residual risk is associated with the adopted geotechnical properties of the foundation and embankment materials. This underlines the need for further ground investigation and specifically the requirement to have a better understanding of the ground conditions and the geotechnical behavioural characteristics.

26 Recommendations

26.1.1 Data

Avesoro would benefit from the use of an industry standard geological database programme instead of the current system of multiple Microsoft Excel spreadsheets. Version control of the Avesoro data can be an issue and there are multiple assay methods used for sample analysis. A database would have an auditable assay ranking system in place as well as containing the applicable metadata for assay results (laboratory, detection limit, method, etc.).

CSA Global recommend the following:

- That Avesoro implement an "off-the-shelf" geological database (e.g. acQuire or DataShed) which would increase confidence in the data and reduce the time taken to resolve validation issues and to understand the assay results
- QA/QC procedures should be applied diligently to ensure that adequate controls on cross-contamination, assay bias and assay precision are in place.

26.1.2 Mineral Resources

26.1.2.1 New Liberty

CSA Global recommends the following actions are completed prior to completing MRE updates in the future:

- A sound geological and structural model should form the basis of any future MREs, so that faulting and other mineralisation controls are integrated in the model.
- Additional dry BD data should be collected routinely during grade control and/or mine production and reviewed to continue building up the BD database of values that can be used to improve the confidence of the tonnage factors for the MRE.
- The current level of understanding of the Au distribution and geological controls are sufficient for mine planning purposes. CSA Global recommends that instead of additional infill drilling to upgrade Indicated Mineral Resources to Measured Mineral Resources, grade control drilling should be sufficient to delineated blast and dig lines during open cast mining.
- The resource is open down dip, as well as along strike. CSA Global recommends additional drilling for resource delineation at depth to allow current Inferred Mineral Resources to be potentially upgraded to Indicated Mineral Resources. A drill spacing along strike of 30–40 m and downdip of 20–30 m is recommended to potentially allow the classification of Indicated Mineral Resources.
- The QA/QC review showed that assay results are potentially understated, which could be influenced by the assay method (particularly where an aqua regia digest been used). Due to the coarse nature of the gold mineralisation, a Screen Fire Assay (SFA) technique could be used to more accurately determine the gold values.

26.1.2.2 Ndablama

CSA Global recommends the following actions are completed prior to completing MRE updates in the future:

- Create a geological model to support and constrain the mineralisation model, to ensure that continuity and the high-grade variability are well understood by correctly interpreting the structural and geological controls on high grades.
- Prior to any mining, conduct a grade control RC drilling program with a close spacing of at least 10 m x 10 m and estimate a grade control model to assist with short-term planning.

- Additional dry BD data should be collected routinely during grade control and/or mine production and reviewed to continue building up the BD database of values that can be used to improve the confidence of the tonnage factors for the MRE.
- CSA Global recommends that instead of additional infill drilling to upgrade Indicated Mineral Resources to Measured Mineral Resources, grade control drilling should be sufficient to delineate blast and dig lines during open pit mining.
- The resource is open down dip, as well as along strike. CSA Global recommends additional drilling for resource delineation to allow Inferred Mineral Resources to be considered for an Indicated Mineral Resources classification level. A drill spacing of 30–40 m and downdip of 20–30 m is recommended to potentially allow the classification of Indicated Mineral Resources.
- The QA/QC review showed that assay results are potentially understated, which could be influenced by the assay method (particularly where an aqua regia digest been used). Due to the coarse nature of the gold mineralisation, a Screen Fire Assay (SFA) technique could be used to more accurately determine the gold values.

26.1.3 Mining and Reserves

Further work on mining would focus on several areas:

- For the residual New Liberty pit, further optimisation of the open pit / underground transition may further curtail the life of the open pit in favour of underground mining. This should be examined in detail.
- Additional optimisation of pit slopes as well as advanced blast design to reduce overbreak and improve wall rock control would be recommended.
- For the underground mining, potential new Indicated Resources developed from additional infill drilling should be considered in an update design. Additionally, further optimisation of the footwall drive design, as well as the pillar and fill design should be undertaken.
- For mining at Ndablama, a revised geological model is expected, which should allow re-design of the pit for better ore/waste management, and optimisation of the waste dump design. Additionally, extension of Mineral Resources down dip as well as along strike should be considered in further updates to the mine design and schedule.
- Additionally, further pit geometry and pit slope optimization for Ndablama may further optimise the design and schedule.

Updated assessment of the Mineral Reserve would be a natural consequence of this work.

26.1.4 Mine Water Management

26.1.4.1 New Liberty

Recommendations for subsequent stage of project development at New Liberty include the following.

Mine inflows:

- A hydrogeological field investigation program should be completed at New Liberty including the installation and test pumping of large diameter drillholes to confirm:
  - o hydraulic properties of both the bulk rock mass.
  - o hydraulic properties of the main geological structures intersected by the final open pit and the proposed underground mine (including the Marvoe Creek Fault).
  - o hydraulic connection between large geological structures intersected by the mine and the Marvoe Creek Dam, Marvoe Creek diversion channel and overlying saturated weathered sediments.

- If significant water yields are obtained from the new hydrogeological test drillholes, then consideration should be given to commissioning these drillholes as long-term dewatering drillholes for the underground mining operation.
- Mine inflow predictions should be updated in accordance with the new hydrogeological data obtained from the site investigation, all new monitoring data available and any updated mine plans as the project progresses.
- Cover drilling ahead of underground mining should be considered in order to provide advanced warning of localised enhanced mine inflows derived from geological structures with enhanced permeability and to advance dewater/depressurise these structures prior to intersection with the main drive/shaft.

Surface water management:

- A review the existing surface water management plan at New Liberty should be competed and a subsequent update of the plan undertaken in order to incorporate any modifications required to effectively manage surface water runoff once final pit, waste dump and associated infrastructure designs are prepared and to minimise external pit catchments draining to the New Liberty pit.

Mine closure:

- Pit lake development and the potential impact of the final open pits and underground mine following cessation of mining should be evaluated once a mine closure plan has been developed for the New Liberty mine site.

Water monitoring:

- Five new groundwater monitoring drillholes should be installed adjacent to the proposed New Liberty final pit crests; including three monitoring points located along the northern side of the pits and two located along the southern edge of the pits, at a distance of approximately 50 m from the final pit crest.
- Groundwater level measurements should be completed manually on a monthly basis at all the existing monitoring drillhole sites and at the five new pit monitoring drillholes. In addition, a groundwater level logger should be installed in one of the pit monitoring drillholes in order to record water levels on a six-hourly basis, with monthly download of the logger. It is recommended that groundwater quality monitoring is completed on a monthly basis at all the existing groundwater monitoring locations and two of the new pit monitoring drillholes.

26.1.4.2 Ndablama

Recommendations for subsequent stages of project development at Ndablama include the following.

Mine inflows:

- Mine inflow predictions should be updated in accordance with any new hydrogeological data obtained from the monitoring program initiated and in accordance with any updated mine plans as the project progresses.

Surface water management:

- The surface water management plan at Ndablama should be updated in accordance with any updated pit, waste dump and associated infrastructure designs in order to ensure effective management of surface water and to minimise external pit catchments draining to the Ndablama pit.
- Sediment settlement pond designs should be undertaken once there is more certainty on pit, waste dump and associated infrastructure designs.
- Future waste dump and surface water management design should be integrated in order to ensure that sufficient space is included in the corridor, between the different waste dumps, for both surface

water management infrastructure and other mine associated infrastructure requirements such as haul roads.

Water monitoring program:

- A water monitoring program should be initiated immediately at Ndablama, in order to establish baseline conditions prior to the commencement of mining activities.
- Groundwater level measurements should be completed manually on a monthly basis at the five new hydrogeological drillholes installed in November 2018 (NDB1 to NDB5) and the Hydrocensus points PRSBH8 and PRSBH9, if they can be found. In addition, a groundwater level logger should be installed in one of the new hydrogeological drillholes in order to record water levels on a six-hourly basis, with monthly download of the logger. It is recommended that groundwater quality monitoring is completed on a monthly basis at the seven drillholes identified above.
- Surface water monitoring should include surface water levels, flow and water quality monitoring. The surface water monitoring program should include (as a minimum) the following surface water monitoring points: one point immediately downstream of the open pit, one point immediately downstream of the waste dumps; and one point downstream of entire catchment impacted by all the Ndablama mine infrastructure.
- A water monitoring review should be completed once 12 months of data is obtained.

26.1.5 Process Technology

Several recommendations in respect of process technology have been made (see below).

26.1.5.1 New Liberty

In order to achieve the study throughput rate of 1.8 Mt/a when treating the UG ore types, NLGM will have to ensure:

- Continuous ore fed from the mine
- Three-stage crushing to achieve a final product size of 100% -10 mm
- Two-stage grinding; primary ball mill, and secondary Vertimill
- Product size P80 of 75 µm reporting to the CIL circuit
- And, maintain an overall plant availability of between 95% and 96%.

To achieve this, several areas of process plant operation, including planned maintenance will need attention.

In order to achieve the desired throughput in processing harder ore from Ndablama it would be recommended to reduce the grind size to reflect the coarser liberation size for gold noted in this ore.

Additionally, in order to achieve targeted recoveries and throughputs, several other areas of optimization are recommended:

- Maximise recovery of GRG in the gravity circuit to relieve residence times in the leach section
- Consideration of an Acacia leach reactor to increase kinetics in leaching the gravity concentrate.
- Consider addition of oxygen to the CIL circuit to increase leach kinetics.

The metallurgical testwork recoveries obtained by gravity-leach tests carried out on samples representing underground ore sources from New Liberty and fresh ore from Ndablama are summarised in Section 13.2.6 and 13.3.2.

The current process plant configuration includes all the unit processes to ensure that target gold recovery is achieved including; gravity, intensive cyanidation leach, and conventional CIL/ADR circuits.

Testing showed that the New Liberty ore types have a significant GRG component and therefore it will be essential to maximise gravity recovery using the existing Falcon concentrator. It will also be important to ensure that the gold head grade to the CIL circuit does not spike in the event the Falcon concentrator is off-line for maintenance.

At an annual production rate of 1.8 Mt/a, the current CIL circuit has a calculated leach residence in the range of 19 to 20 hours. This is on the low side in the event the Falcon concentrator is offline.

To ensure that the target gold recovery of 92–93% is achieved, it is recommended to investigate the installation of a second Falcon concentrator to maximise the GRG recovery, and to ensure that the leach tanks are injected with pure dissolved oxygen to increase leach kinetics.

26.1.5.2 Ndablama

At present, no process stages are included in the design at Ndablama. However, several process stages are recommended for consideration, including:

- Ex-pit crushing of Ndablama ore in order to improve load factors in haul trucks transporting ore to Ndablama as well as improving throughput of the ore through the comminution circuit at New Liberty.
- Potential to sort Ndablama ore in order to reject waste inclusions incorporated into planned ore blocks prior to hauling the ore to New Liberty.
- Potential to sort Ndablama ore into high-grade and low-grade fractions to facilitate heap leaching of low-grade fractions, and direct shipping of high grade to New Liberty for processing.
- Further investigation of heap leach potential of low-grade ore from Ndablama and appropriate flowsheet development and circuit design.

26.1.6 Water Sources

No specific recommendations with respect to water sources are made.

26.1.7 Tailings

The areas that require further studies and assessments prior to detailed design identified throughout this chapter and the appended report are summarised below:

- An update of the NLGM water balance to assess excess and deficit flows.
- Assessment of the dilution requirements and maximum discharge rates to satisfy effluent discharge limits permitted.
- An additional ground investigation to improve understanding of the foundation conditions (geotechnical and hydrogeological).
- The installation of vibrating wire piezometers into the tailings to assess water levels and consolidation of the tailings beach.
- Additional tailings testwork for strength and liquefaction resistance (CPTU Campaign).
- Additional tailings testwork for settlement and beach slope characterisation (also considering the Ndablama Resource tailings).
- Additional tailings testwork for geochemistry for assessment of long-term leachate conditions.
- Additional tailings testwork for hydraulic characterisation (to inform updates to seepage impact assessments).
- Detailed stability assessment of the slopes following improved geotechnical data from additional ground investigations and testwork.
- Update of the seepage impact assessment models.
- Carry out HAZOP workshop for tailings management.

26.1.8 Engineering and Other Technical Studies

Additional stages of engineering study are recommended and have been included in the budget. Additional study work leading towards development of an underground mine at New Liberty and an open pit mine at Ndablama would include:

- Additional process testwork to establish the feasibility of heap leaching of Ndablama ore.
- Additional process testwork to investigate the feasibility of sorting Ndablama ore.
- Brownfield process design for additional gravity concentration capacity and intensive leach stages at New Liberty mill.
- Trade-off studies for process options at Ndablama to confirm options for the DFS.
- DFS-level engineering of the underground mine design and associated infrastructure.
- DFS-level engineering of the Ndablama pit and associated infrastructure.
- Completion of the Ndablama ESIA and implementation of environmental and community management plans at that site.
- Detailed design of underground mine development and associated infrastructure.
- Detailed design and cost estimation for the Ndablama–New Liberty road including route survey, right of way establishment and permitting.

27 References

Abzalov, M. (2008) Quality Control of Assay Data: A Review of Procedures for Measuring and Monitoring Precision and Accuracy, Exploration and Mining Geology, Vol 17, No's 3-4, p. 131–144.

ACA Howe (2000) Gold Resources and Exploration potential of the Bea Mountains Licence, Northwest Liberia, including and appendix on Diamond Exploration. Internal Report to Mano River Resources. *A.C.A Howe International Ltd*

AMC (2012) New Liberty Gold Project, Liberia, West Africa. Technical Report on Updated Mineral Resources and Mineral Reserves. AMC Project 411007 for Aureus Mining Inc. October 2012. *AMC Consultants (UK) Limited*

AMC (2013a) New Liberty Gold Project, Liberia, West Africa. Updated Technical Report. AMC Project 41303 for Aureus Mining Inc. July 2013. *AMC Consultants (UK) Limited*

AMC (2013b) Ndablama and Weaju Gold Projects Bea Mountain Mining Licence, Northern Block, Technical Report on Mineral Resources. AMC Project 413027 for Aureus Mining Inc. November 2013. *AMC Consultants (UK) Limited*

AMC (2014) Ndablama and Weaju Gold Projects Bea Mountain Mining Licence, Northern Block Liberia, West Africa. AMC Project 414013 for Aureus Mining Inc. December 2014. *AMC Consultants (UK) Limited*

Bea Mountain Mining Corp. (2018) Procedure Diamond Drilling Logging & Sampling. New Liberty Gold Mine Technical Services Department, July 2018.

Bongers, F., Poorter, L., Van Rompaey, R.S.A.R. and Parren, M.P.E. (1999) Distribution of Twelve Moist Forest Canopy Tree Species in Liberia and Cote d'Ivoire: Response Curves to a Climatic Gradient. J Veg Sci 10: 371-382.

Canadian Dam Association. (2014). Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams.

CSA Global Mining Industry Consultants 2019, "Site Visit Report - Hydrogeological Field Investigation, New Liberty Combined Project", Report No. R205.2019 1 April 2019.

Digby Wells Environmental. (2013). Environmental and Social Impact Assessment (ESIA Update fro the New Liberty Gold Mine, Liberia).

DRA (undated), Technical Assessment, New Liberty Arsenic Remediation Test Work, Report No. NLGM-TA-AS-033

EPOCH. (2013). Design Report of the New Liberty Tailings Disposal Facility DIversions Dams, Liberia. Epoch Resources (Pty) Ltd.

European Council, 1998. Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption

European Council, 2006. Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC

Future Flow 2019, "Ndablama Gold Mine EIA/EMP Study Groundwater Assessment", 6 February 2019.

Goldfarb, R.J., Groves, D.I. and Gardoll, S (2001) Orogenic Gold and Geologic Time: A Global Synthesis, Ore Geology, 18, 1-75.

Groves, D.I., Goldfarb, R.J., Robert, F. and Hart, C.J.R. (2003) Gold Deposits in Metamorphic Belts: Overview of Current Understanding, Outstanding Problems, Future Research, and Exploration Significance, Economic Geology, 98, 1-29.

Golder. (2018). New Liberty Gold Mine Tailings Facility, Liberia Expansion Concept Trade Off Study. 18110766-RPT-001.B.0.

Golder Associates (2018). Independent TSF Audit Report, June 2018, Report Number 1899537

Golder Associates (2012). New LIberty Gold Mine (NLGM) Project Environmental Impact Statement.

Golder. (2013). New LIberty Gold Mine Tailings Test Work Summary No. 137645017-001-R-Rev0.

Hagemann, S.G. and Cassidy, K.F. (2000) Archean Orogenic Lod Gold Deposits, Reviews in Economic Geology, 13, 9-68.

Hurley, P.M., Leo, G.W., White, R.W. and Fairbairn, H.W. (1971) Liberian age province (about 2700 Ma) and adjacent provinces in Liberia and Sierra Leone, Geological Society America Bulletin ,62. 3483-3490.

IFC, 2007. Environmental, Health and Safety Guidelines for Mining, dated 10 December 2007

Knight Piésold Consulting. (2013). DRA Minerals PTY LTD Geotechnical Investigation Interpretative Report (Rev 01) RI301-00429/2-01.

Lakefield Research (1999) Mineralogical and Gold Examination of Five Drill Core Samples from South Africa. Submitted by Mano River Resources Inc, Tassos Grammatikopoulos, August 20, 1999, Project No. 7777-600- LIMS:JUL7500.R99.

Lloyd, J.W. and Heathcote, J.A., (1985). Natural inorganic hydrochemistry in relation to groundwater: An introduction. Clarendon Press, Oxford.

Milési, J.P., Feybesse, J.L., Ledru, P., Dommanget, A., and Marcoux, E. (1992) Early Proterozoic Ore Deposits and Tectonics of the Birimian Orogenic Belt, West Africa, Precambrian Research, vol.58, p. 305-344.

Newfields. (2017). New Liberty Mine, Liberia - Phase 2 Tailings Disposal Facility Design No. 475.0274.000. Newfields Mining Design and Technical Services.

Preen & Associates 2018, "Avesoro Resources, Ndablama Gold Mine and Pit, Surface Water Quantity Assessment", 18 December 2018.

Richards, J.P. and Tosdal, R.M. (2001) Structural Controls on Ore Genesis, Reviews in Economic Geology, 14, 25-50.

Rivoirard, J., Demange, C., Freulon, X., Lécureuil, A. and Bellot, N. (2010) Model for top-cut with indicator residual adapted to deposits with very skewed grade distribution. IAMG 2010. Budapest 29 August – 2 September 2010.

Roberts, R.G. and Sheahan, P.A. (1989) 'Archean Lode Deposits' in Roberts, R.G. Sheahan, P.A., 1989 'Ore Deposit Models (Geoscience Canada Reprint Series 3), 1989, Geological Associated of Canada, Newfoundland Canada, 1-18.

Robb, L. (2005) Introduction to Ore Forming Processes. Blackwell Publishing, Oxford.

Snowden (2012) Advanced Resource Estimation Manual – Professional Development Courses.

SRK (2017) New Liberty Gold Mine, Bea Mountain Mining Licence Southern Block, Liberia, West Africa. NI 43-101 Report. SRK Project UK4936 for Avesoro Resources Inc, November 2017. *SRK Consulting (UK) Limited*

Stanley, C.R., and Lawie, D. (2007) Average relative error in geochemical determinations: Clarification, calculations and a plea for consistency. Exploration and Mining Geology, Vol 16, p. 267–275.

Thatcher, T (2014) Petrographic Description of Polished thin section underreflected light, Microsearch CC.

Thayer, T.P., Lill, G.G. and Coonrad, W.L. (1974) Mineral Exploration in Liberia, 1949-1950. Department of Information and Cultural Affairs, Monrovia.

US Bureau of Reclamation, (2012). Design Standards No. 13 Embankment Dams Chapter 6: Freeboard

Wesley, L. (2010). Geotechnical Engineering in Residual Soils. John Wiley & Sons.

WHO, (2011). Guidelines for drinking water quality Fourth Edition.

28 Glossary

Below are brief descriptions of some terms used in this report. For further information or for terms that are not described here, please refer to internet sources such as Wikipedia (www.wikipedia.org).

%	percent
°	degrees (in Radians)
°C	degrees Celsius
2D	two-dimensional
3D	three-dimensional
AAS	atomic absorption spectroscopy
ABA	acid-base account
AMD	acid mine drainage
ARD	acid rock drainage
ASL	above sea level
Au	gold
Avesoro	Avesoro Resources Inc.
BD	bulk density
BDL	below detection limit
CAPEX	capital expenditure
CIL	carbon-in-leach
CIM	Canadian Institute of Mining, Metallurgy and Petroleum
cm	centimetre(s)
CRM	certified reference material
CSA Global	CSA Global (UK) Ltd
CSR	Community and Social Responsibility
CSV	comma separated values
CV	coefficient of variation
DCF	discounted cash flow
DD	diamond (drillhole)
DH	drillhole
doh	direct operating hour
DTM	digital terrain model
E	east
EIA	Environmental Impact Assessment
EM	electromagnetic (survey)
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FA	fire assay
FEL	front-end loader
FS	feasibility study
g	gram

g/t	grams per tonne
G&A	General and Administration
GPS	global positioning system
ha	hectare(s)
HARD	half absolute relative difference
HR	Human Resources
HSE	Health, Safety and Environment
ICP	inductively coupled plasma
IDW	inverse distance weighting
IP	induced polarisation
IRA	inter-ramp angle
IRR	internal rate of return
JORC	Australasian Joint Mineral Reserves Committee Code
KE	kriging efficiency
kg	kilogram(s)
km	kilometre(s)
km^2	square kilometres
KNA	kriging neighbourhood analysis
kt	thousand tonnes
LDL	lower detection limit
LOM	life of mine
m	metre(s)
M	million(s)
Ma	million years
MCC	motor control centre
mE, mN, mRL	metres east, north and relative level
mm	millimetre(s)
Moz	million ounces
MRE	Mineral Resource estimate
Mt	million tonnes
Mt/a	million tonnes per annum
N	north
NI 43-101	National Instrument 43-101 for the Standards of Disclosure for Mineral Projects within Canada
NPV	net present value
NPVS	NPV Scheduler
NSR	net smelter return
OK	ordinary kriging
OREAS	Ore Research and Exploration Pty Ltd (Melbourne)
OSA	overall slope angle
oz	troy ounce, 31.1034768 g
ppb	parts per billion
PPE	personal protective equipment

ppm	parts per million
QA/QC	quality assurance/quality control
QC	quality control
Q-Q	quantile-quantile
RAB	rotary air blast (drillhole)
RAP	Resettlement Action Plan
RC	reverse circulation (drillhole)
RC-DD	reverse circulation with diamond tail (drillhole)
RCP	Rehabilitation and Closure Plan
RMS	root mean squared
ROM	run of mine
RQD	rock quality designation
S	south
SCR	solid core recovery
SD	standard deviation
SE	South East
SFA	Screen Fire Assay
SG	specific gravity
SQL	structured query language (database)
t/a	tonnes per annum
t/hr	tonnes per hour
t/m^3	tonnes per cubic metre
TMF	tailings management facility
TR	trench
TSF	tailings storage facility
US$	US dollar(s)
UTM	Universal Mercator Project
VOD	velocity of detonation
VOIP	voice over internet protocol
VSAT	very small aperture terminal
W	west
WGS1984	World Geodetic System 1984
WRD	waste rock dump

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