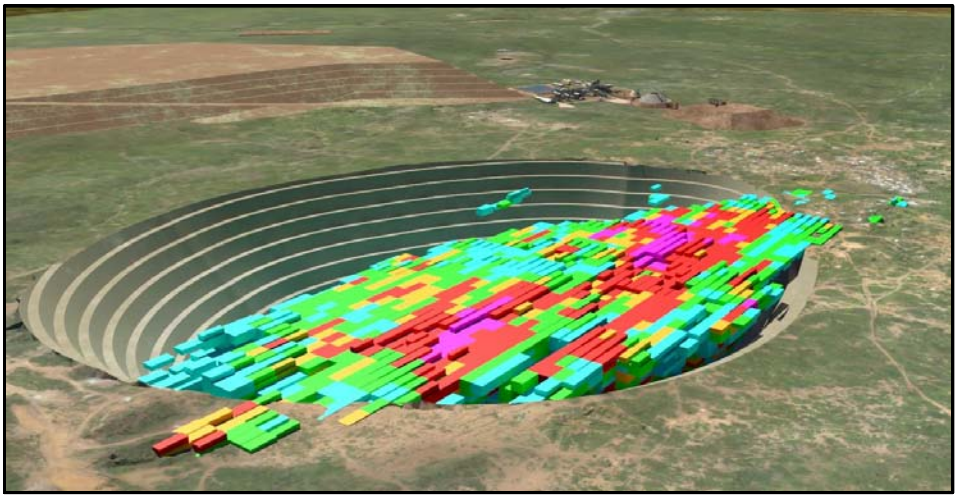
National Instrument 43-101 Preliminary Economic Assessment Technical Report

Namdini Gold Project

Ghana, West Africa



Technical Report compiled under NI43-101

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Important Notice

This notice is an integral component of the 2018 Cardinal Resources Limited Namdini Gold Project Preliminary Economic Assessment (the 2018 Namdini PEA) and should be read in its entirety and must accompany every copy made of the 2018 Namdini PEA. The 2018 Namdini PEA was prepared using the Canadian National Instrument 43-101 Standards of Disclosure for Mineral Projects.

The 2018 Namdini PEA was prepared for Cardinal Resources Limited (TSX:CDV) (Cardinal) by Golder Associates Pty Ltd (Golder). The 2018 Namdini PEA is based on information and data supplied to the authors by Cardinal. The quality of information, conclusions, and estimates contained herein are consistent with the level of effort involved in the services of the authors, based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions, and qualifications set forth in the 2018 Namdini PEA. Each portion of the report is intended for use by Cardinal subject to the terms and conditions of its contract with the authors. Except for the purposes legislated under Canadian provincial and territorial securities law, any other uses of the report, by any third party, is at that party's sole risk. The 2018 Namdini PEA is intended to be used by Cardinal, subject to the terms and conditions of its contract with the authors. Recognizing that Cardinal has legal and regulatory obligations, the authors have consented to the filing of the 2018 Namdini PEA with Canadian Securities Administrators and its System for Electronic Document Analysis and Retrieval (SEDAR).

Readers are cautioned that actual results may vary from those presented. The factors and assumptions used to develop the forward- looking information, and the risks that could cause the actual results to differ materially are presented in the body of this report under each relevant section. The conclusions and estimates stated in the 2018 Namdini PEA are to the accuracy stated in the 2018 Namdini PEA only and rely on assumptions stated in the 2018 Namdini PEA. The results of further work may indicate that the conclusions, estimates and assumptions in the 2018 Namdini PEA need to be revised or reviewed.

The authors have used their experience and industry expertise to produce the estimates and approximations in the 2018 Namdini PEA. Where the authors have made those estimates and approximations, they are subject to qualifications and assumptions and it should also be noted that all estimates and approximations contained in the 2018 Namdini PEA will be prone to fluctuations with time and changing industry circumstances. The 2018 Namdini PEA should be construed in light of the methodology, procedures and techniques used to prepare the 2018 Namdini PEA. Sections or parts of the 2018 Namdini PEA should not be read or removed from their original context.

Except for statements of historical fact relating to Cardinal, certain statements contained in the 2018 Namdini PEA constitute forward- looking information, future oriented financial information, or financial outlooks (collectively "forward-looking information") within the meaning of applicable Canadian securities legislation and "forward-looking statements" within the meaning of the "safe harbour" provisions of the United States Private Securities Litigation Reform Act of 1995. Forward-looking statements and information may be contained in this document and other public filings of Cardinal. Forward-looking information and statements relate to future events or future performance, reflect current expectations or beliefs regarding future events and are typically identified by words such as "anticipate", "could", "should", "expect", "seek", "may", "intend", "likely", "plan", "estimate", "will", "believe" and similar expressions suggesting future outcomes or statements regarding an outlook. These include, but are not limited to, statements respecting anticipated business activities; planned expenditures; corporate strategies; and other statements that are not historical facts.

Forward-looking statements and information includes statements concerning, among other things, cost reporting in the 2018 Namdini PEA, production, cost and capital expenditure guidance; development plans for processing resources; the generation of cash flow; matters relating to proposed exploration and expansion; communications with local stakeholders and community relations; negotiation and completion of transactions; commodity prices; Mineral Resources, Mineral Reserves, realisation of mineral reserves, existence or realisation of Mineral Resource estimates; the development approach, the timing and amount of future production; timing of studies, announcements and analyses, the timing of construction and development of proposed additional mines and process facilities; capital and operating expenditures; economic conditions; availability of project financing on terms reasonably acceptable to Cardinal; exploration plans and any and all other timing, exploration, development, operational, financial, budgetary, economic, legal, social, regulatory and political matters that may influence or be influenced by future events or conditions. Actual results may vary from such forward-looking information for a variety of reasons, including but not limited to risks and uncertainties disclosed in other Cardinal filings at www.sedar.com.

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Readers are further cautioned that the list of factors enumerated in the "Risk Factors" section of the AIF that may affect future results is not exhaustive. When relying on Cardinal's forward-looking information and statements to make decisions with respect to Cardinal, investors and others should carefully consider the foregoing factors and other uncertainties and potential events. Furthermore, the forward- looking information and statements herein are made as of the date hereof and Cardinal does not undertake any obligation to update or to revise any of the included forward-looking information or statements, whether as a result of new information, future events or otherwise, except as required by applicable law. The forward-looking information and statements contained herein are expressly qualified by the cautionary statement.

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1.0 SUMMARY

1.1 Purpose of this PEA Technical Report and Terms of Reference

This report was prepared by Golder Associates Pty Ltd (Golder) at the request of Cardinal Resources Limited (Cardinal). The purpose of this report is to provide Cardinal with an independent NI 43-101 compliant, Independent Technical Report and Preliminary Economic Assessment on the Namdini Gold Project in Ghana, Africa.

This Preliminary Economic Assessment (PEA) was carried out for the purpose of determining the preliminary criteria under which the Namdini Gold Project in northeast Ghana may be considered potentially economic so that a development program can be planned. This report is produced for Public Reporting under Canadian National Instrument (NI) 43-101 in Canada (NI 43-101, 2014).

The PEA on the Namdini Gold Project was commissioned by Cardinal with the purpose of defining and quantifying the technical merits of the project and for determining the conditions under which the Namdini Gold Project should be progressed to the Pre-feasibility study stage for Public Reporting of Mineral Reserves.

This PEA was prepared in accordance with the requirements of:

- Disclosure and reporting requirements of the Toronto Stock Exchange (TSX);
- Canadian National Instrument 43-101, 'Standards of Disclosure for Mineral Projects', Form 43-101F1 and Companion Policy 43-101CP (NI 43-101, 2014); and
- Canadian Institute of Mining, Metallurgy and Petroleum Definition Standards (CIM, 2014).

The Project is conceived as a large-scale open pit, mined for gold by conventional drill and blast, dug by face shovel configured excavators feeding 220 tonne trucks. The ore will be fed to a large conventional Carbon-In-Leach (CIL) process plant with a sulphide flotation circuit to enhance gold recovery. Gold bullion will be produced on site for sale into the international market.

The Namdini Gold Project will operate in a safe, responsible and technically efficient way to the benefit of all stakeholders including the government of Ghana, the owners, shareholders, employees, and local communities.

The major components of this PEA comprise: scoping for an environmental impact assessment, Mineral Resource modelling based on available data, preliminary mine design, metallurgical testwork, preliminary process design and process plant cost estimation, and preliminary financial analysis. This work tested the merits of proceeding towards a Pre-feasibility study and determined criteria to be evaluated in such a study.

1.2 Summary of risk, limitations and disclaimers

This PEA study is preliminary in nature. It includes Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorised as Mineral Reserves, and there is no certainty that the conclusions of this preliminary economic assessment will be realised.

The results of this PEA study are a guide to indicate the potential reward *versus* risk for the Namdini Gold Project and must not be regarded as a final measure of value at this stage of study.

Golder is an independent consulting company contracted by Cardinal to carry out this PEA study. Neither Golder, nor the authors of this report, has or has had previously, any material interest in Cardinal or the mineral properties in which Cardinal has an interest. Golder's relationship with Cardinal is solely one of professional association between client and independent consultant.

This report is prepared in return for professional fees based upon agreed commercial rates and the payment of these fees is not contingent on the results of this report. No member or employee of Golder is, or is intended to be, a director, officer or other direct employee of Cardinal.

In the preparation of this Independent Technical Report Golder has used information provided by Cardinal and other experts. Golder has verified this information making due enquiry of all material issues that are required in order to comply with NI 43-101 requirements.

The business of mining and mineral exploration, development and production by its nature has significant operational risks. The business depends upon, amongst other things, successful prospecting programs and competent management. Profitability and asset values can be affected by unforeseen changes in operating circumstances and by technical issues.

Factors such as political and industrial disruption, currency fluctuation and interest rates could have an impact on the proposed project's future operations, and potential revenue streams can also be affected by these factors. The majority of these factors are, and will be, beyond the control of Cardinal or any other operating entity.

This Independent Technical Report contains forward-looking statements. These forward-looking statements are based on the opinions and estimates of Cardinal, Golder and other specialist consultants at the date the statements were made. The statements are subject to a number of known and unknown risks, uncertainties and other factors that may cause actual results to differ materially from those anticipated in the forward-looking statements. Factors that could cause such differences include changes in world gold markets, equity markets, costs and supply of materials relevant to the projects, and changes to regulations affecting them.

Although Golder believes the expectations reflected in its forward-looking statements to be reasonable, Golder does not guarantee future results, levels of activity, performance or achievements.

This report was prepared by Golder for Cardinal as a PEA for Public Reporting. The information, conclusions, opinions, and estimates contained herein are based on:

- Information available to Golder at the time of preparation of this report
- Assumptions, conditions, and qualifications discussed in this report
- Data, reports, and other information supplied by Cardinal and other third parties, as documented and referenced in this PEA study report.

For the purpose of this report Golder has relied on ownership information and other local knowledge provided by Cardinal.

Golder has reviewed the mining lease and concludes that it appears in order and is current.

The report author is not aware of any specific environmental liabilities on the property. Cardinal has all required permits to conduct the proposed work on the property. The report author is not aware of any other significant factors and risks that may affect access, title, or the right or ability to perform on-going work programs on the property.

Except for the purposes legislated under Canadian or other securities laws, any use of this report by any third party is at that party's sole risk

1.3 Summary of authorship, QPs and experts relied upon

This PEA is based on the specialist consultant studies summarised in Table 1 and information from studies conducted on behalf of the project owner, by independent specialist consultants. Golder has reviewed these reports, and having made due enquiry, considers that these reports are based on accepted international industry practice and fairly represent the Namdini Gold Project.

Table 1: Scoping Study components for the Namdini PEA study

PEA Component	Specialist Study	Consulting Company
Environmental	Environmental Impact Assessment Study	Nemas Consult Ltd (NEMAS, 2017)
Mineral Resource	Creation of updated Mineral Resource Model for Namdini Deposit	MPR Geological Consultants Pty Ltd (MPR, 2017)
Mine Design	Geotechnical review	Golder Associates Ghana Ltd (Hammah, 2017)
Mine Design	Pit Optimization and Scheduling	Golder Associates Pty Ltd
Comminution Design	Comminution data analysis and design	Ore Mineral Consultants Pty Ltd (OMC)
Process Design	Review laboratory metallurgical programme and estimates. Process plant design for 3 process plant throughput options. Project Infrastructure requirements and costing. Capital and operating cost estimates.	Lycopodium Minerals Pty Ltd, (Lycopodium, 2017) and Knight Piésold Consulting
Metallurgical Testwork	Metallurgical testwork to support the process design and criteria.	Suntech Geometallurgical Laboratories
High Voltage Power Study	High voltage power supply options	Cardinal and Cardno BEC Pty Ltd

The Qualified Person(s) (QPs) identified as the authors responsible for this PEA Technical Report have specifically relied on other experts as referred to in NI 43-101 Item 3. These other experts, and their individual reports, together with the Sections to which their work applies, are identified in the Table below.

Table 2: Qualified Persons and experts relied upon for this PEA study

Company	PEA Component	Name	Role
Cardinal Resources Limited	Geology and Mineral Resource Estimate	Mr Richard Bray	Expert (not independent)
Cardinal Resources Limited	Geology and Mineral Resource Estimate	Mr Ekow Taylor	Expert (not independent)
MPR Geological Consultants Pty Ltd (MPR, 2017)	Geology Mineral Resource Model	Mr Nicolas Johnson	QP
Golder Associates Pty Ltd	Mine Design	Mr Glenn Turnbull	QP
K. Marc LeVier & Associates, Inc	Process Design	Mr Marc LeVier	QP
Nemas Consult Ltd (NEMAS, 2017)	Environmental	Dr Frank Anim	Expert

1.4 Summary of property description, ownership and royalties

Namdini is approximately 50 km southeast of Bolgatanga, the capital of the Bolgatanga Municipal District, within the Tallensi District in the Upper East Region of northern Ghana. This District is close to the southern border of Burkina Faso. The property is readily accessible from Bolgatanga along paved highway followed by 15 km of well-travelled gravel roads. Access during the rainy season is slower due to waterlogged roads, but the main access roads are passable all year round.

The Namdini Mining License is for an initial period of 15 years and is renewable. It covers an area of 19.54 Sq. Km in the Upper East Region of Ghana. Savannah Mining Ghana Limited (Savannah) completed an EIS for Namdini and has filed the EIS with the Environmental Protection Agency (EPA). Following completion of a PEA, Cardinal will submit to the Minerals Commission an updated EIS and an application for an Operating Permit for the project scale envisioned in the PEA.

The application by Savannah for a Large-Scale Mining Licence over an area of approximately 19.54 Sq Km in the Upper East Region of Ghana covering Cardinal's Namdini Project has been granted by the Minister of Lands and Natural Resources of Ghana.

Savannah applied for an assignment of this Large-Scale Mining Licence to Cardinal Namdini Mining Limited (Cardinal Namdini), a wholly owned subsidiary of Cardinal. The assignment was granted during December 2017 by the Minister of Lands and Natural Resources of Ghana.

The assignment of the Large-Scale Mining Licence to Cardinal Namdini was completed during the December 2017 quarter.

An assumption of 5% was made to account for all royalties in the Mineral Resource estimation (Section 14.1.8), the Mining cost estimates (Section 16.10) and the Economic Analysis (Section 22.0).

1.5 Summary of geology and mineralization

The Namdini Gold Project lies within the Paleo-Proterozoic Nangodi Greenstone Belt, one of a series of southwest–northeast trending granite-greenstone belts which host significant gold mineralization in Ghana and Burkina Faso. These belts are interpreted to be fault bounded, both during their development and post-deposition. Much of northern Ghana is covered by post-Birimian Voltaian Basin sediments, and at Namdini this forms the southern limit of exposure of Birimian rocks.

Key units of the metamorphosed greenstone belts include greywackes and phyllites of the Tarkwaian Formation, which are overlain by volcanic and sediment sequences of Birimian age (2.2 to 2.1 Ga), characterized by interbedded mafic to intermediate volcanic flows, felsic to intermediate tuffs and fine-grained sediments. The greenstone belts are intruded by belt-type and basin-type granitic rocks and late stage diorites. Belt-type granites are metaluminous and commonly tonalitic. Basin-types are peraluminous with higher potassium and rubidium than the belt-type granites and are generally granodiorites.

The granite–greenstone terrain that hosts the Namdini Gold Project is in the North Eastern District of Ghana, close to the border with Burkina Faso. The region contains several producing mines both on the Ghana side of the border (the Shaanxi underground gold mine) and in Burkina Faso (the Youga open pit gold mine).

Locally the Nangodi Greenstone Belt trends north-northeast to south-southwest over a distance of 30 km and turns to an east-northeast to south-southwest trend in the south of the area around Namdini. Much of the area to the south of the tenements is covered by later Voltaian Basin sediments. The belts continue underneath this cover.

Structurally the north eastern region of Ghana is characterized by steep isoclinal folding with near vertical axial planes. The greenstone belts contain locally developed open symmetric folds with axial planar cleavages parallel to bedding in the steeply inclined sediments.

The Namdini gold mineralization is located in the Nangodi Greenstone Belt within a host sequence of meta-volcaniclastics, granitoids (tonalite), and diorites. The deposit is bounded on the hangingwall and footwall sides by metasediments.

The meta-sedimentary and volcaniclastic rocks have been intensely altered with a pyrite-carbonate-muscovite-chlorite-quartz. Alteration is prevalent in the volcaniclastic rocks.

Drilling has outlined mineralization with three-dimensional continuity, with a size of approximately 1,500 m long, 550 m wide, and 600 m in depth.

In all rock types, the mineralization is accompanied by visible disseminated sulphides of pyrite in both the veins and wall rocks. In diamond drill core, the mineralized zones are visually distinctive due to the presence of millimeter to centimeter wide quartz-carbonate veins that are commonly folded and possess yellow-brown sericite-carbonate selvedges. Petrological work by trace mineral search (TMS) showed that gold is primarily associated with sulphides, in particular pyrite, where it commonly occurs as inclusions and on the crystal margins. Gold was also noted in phyllite matrix and, to a much lesser extent, in association with ilmenite.

Mineragraphic analysis by TMS has shown that very fine-grained gold less than 5 µm (microns) is dominantly associated with, and as inclusions within, disseminated sulphides and less commonly silicate minerals.

1.6 Summary of the status of exploration

Driven by activity elsewhere in Ghana and Burkina Faso during the mid-1990s, numerous Canadian and Australian junior explorers started to explore the north of Ghana, where the discovery of Youga deposit in Burkina Faso by International Gold Resources (IGR) is significant.

BHP was the first to conduct a major reconnaissance exploration program in the mid-1990s, covering most of the Nangodi area. BHP's work was directed towards developing both gold and base metal prospects. After an initial regional program which identified promising geochemical and geophysical anomalies, the project was largely abandoned as a result of BHP's decision to cease exploration activity in Ghana. Renewed interest in the area began around 2004, with an increase in the gold price, and as a result of the development of mines on the Burkina Faso side of the border. In 2006 Etruscan Resources Inc., a Canadian mining company, carried out soil sampling, rock chip sampling, limited trenching, and reverse circulation (RC) and rotary air blast (RAB) drilling (139 holes) in the Zupliga, Fulani and Dumorlugu prospects. The best drill intercept was 18 m at 3.35 g/t Au.

Randgold also explored the Nangodi-Bole belts from 2004 to 2009 with soil geochemistry, stream sediment sampling and rock chip sampling. The company identified eight areas but left when these failed to meet their economic criteria. Red Back Mining commenced exploration work over the Nangodi Belt and adjacent areas in 2005. This included a desktop study of satellite imagery, data compilation, mapping and rock chip sampling.

All exploration work on the Namdini Gold Project was executed by Cardinal. A field office with core logging and storage facilities is located near to the Namdini Gold Project site in Bolgatanga.

The primary objectives of Cardinal's exploration strategy are to:

- Improve understanding of the extent and style of mineralization in order to successfully increase the size and confidence of the Mineral Resources for Namdini.
- Develop deposit models and use grassroots exploration methods to search for gold (and pathfinder elements) to potentially locate other deposits throughout Northern Ghana.

The Namdini Gold Project was first discovered in September 2013 by prospecting. A small-scale mining licence was approved in 2014 and Reverse Circulation (RC) drilling began shortly thereafter. Cardinal drilled additional RC holes in the same licence area after reviewing initial RC results. At the conclusion of approximately 88 RC holes Cardinal had sufficient confidence in the potential size of the Namdini Gold Project to step out 600 m north along strike and drill a surface diamond drill hole (NMDD002) that intersected 87 m at 1.1 g/t Au and numerous other significant intersections.

Cardinal has built a team of site-based field geologists led by an experienced Exploration Manager. A Global Positioning System (GPS) on site is the most common navigation and survey tool in the field to locate and update geographic information.

1.7 Summary of sampling and assaying validation

No Mineral Reserve, or Ore Reserve under the JORC Code (2012), was defined for the Namdini Gold Project at this PEA level of study.

The Mineral Resource estimate is based on RC and diamond information available on the 11 September 2017, totalling 275 holes for 67,122 meters of drilling. RC and HQ diamond drilling provides around one third and two thirds of the estimation dataset respectively. Relative to the drilling information available at December 2, 2016 for the previous Mineral Resource estimate (RPA, 2017), the current estimate includes an additional 33,406 meters of drilling.

The Mineral Resource drilling comprises east-west trending traverses of easterly inclined holes. Hole spacing varies from approximately 12.5 by 25 meters in the shallow portions of southern part of the deposit to approximately 50 by 50 meters and broader in the north and at depth.

Most diamond drill holes and deeper RC holes were surveyed by electronic single-shot tools with an initial survey at 6, or rarely around 30 meters depth, and subsequent surveys at generally 30 metre intervals to drill hole end. The drill holes with comprehensive down-hole surveying contribute around three quarters of mineralized domain composites.

Core recovery measurements are available for around 58% of the Namdini HQ diamond drilling. The combined dataset of fresh rock core recoveries averages 99.9% with only approximately 4% of composites showing recoveries of less than 99%. These recoveries are consistent with high quality HQ diamond drilling. Although lower than for fresh rock, average core recoveries for weathered and transitional intervals are within the range shown by high quality HQ diamond drilling.

Sample condition is an important factor in the reliability of RC sampling, as wet samples can be associated with unrepresentative, potentially biased samples. Of the total of 19,775 RC samples, 36 were logged as 'moist' and 7 were logged as 'wet'. This indicates that the reliability of moist or wet samples does not affect the overall confidence in the Mineral Resource.

Investigation of RC sample recovery by down-hole depth showed typical cyclic trends with lower values at six meter increments representing the first sample of each six-meter drill rod, but no consistent variability in average gold grade with rod position, suggesting the variability in sample recovery does not significantly affect RC sample representativeness.

Sample preparation and assaying were undertaken by independent commercial laboratories. Most primary samples were submitted to SGS Ouagadougou in Burkina Faso or SGS Tarkwa in Ghana, for gold fire assay. A small proportion were analysed by Intertek in Tarkwa, Ghana.

Selected samples from the Mineral Resource drilling were assayed for additional attributes including sulphur and arsenic. These data were not included in the current estimates.

The sampling and assaying Quality Assurance procedures and the Quality Control results for the Namdini drilling demonstrate that the data used for the Mineral Resource estimate is appropriate at the Preliminary Economic Assessment level of study.

Available density information totals 5,955 immersion measurements by Cardinal (4,561), SGS Tarkwa (1,129) and SGS Ouagadougou (265). Weathered and porous samples were wax-coated prior to density measurement. Lengths specified for these samples range from 0.1 to 1.4 meters and average 0.3 meters. Cardinal data comprises 77% of the density samples.

1.8 Summary of the Mineral Resource estimate

Mineral Resources are not Mineral Reserves and have not demonstrated economic validity. The extent to which mining, metallurgical, marketing, infrastructure, permitting, marketing and other financial factors may affect the eventual Mineral Resource estimate is not precisely defined. The declared Mineral Resource estimate was constrained by notional economic assumption to demonstrate reasonable prospects of eventual economic extraction as required by CIM (2014).

No Mineral Reserve, or Ore Reserve under the JORC Code (2012), was defined for the Namdini Gold Project at this PEA level of study.

The Namdini Mineral Resource forming the basis of this PEA study was estimated by Mr Nicolas Johnson of MPR Geological Consultants Pty Ltd as documented in (MPR, 2017), a Qualified Person for the purpose of Mineral Resource reporting under NI 43-101.

The compiled Mineral Resource dataset comprises 31,126 composites with gold grades from 0.001 to 242.1 g/t Au and averaging 0.6 g/t Au. Holes completed during 2017 provide around 52% of the resource dataset.

In general, the transition from gold mineralization to barren host rock is characterized by diffuse grade boundaries.

The current estimates are based on a mineralized domain interpreted on the basis of composited gold grades. Domain boundaries were digitized on cross-sections, snapped to drill hole traces where appropriate, then wire-framed into a three-dimensional solid designated Domain 2. Domain 1 represents a background domain capturing generally unmineralized composites outside the mineralized domain wire-frame.

The mineralized domain trends north-northeast over a strike length of approximately 1,270 m with horizontal widths ranging from around 80 to 390 m and averaging approximately 260 m. The domain dips to the west at around 70 degrees and is interpreted to a constant elevation of -500 m RL, which represents an average depth of 710 m, which is 25 m below the base of drilling.

Cardinal supplied interpreted surfaces representing the base of oxidation and the top of fresh rock interpreted from drill hole logging. These surfaces were used for: flagging of the Mineral Resource composites into oxide, transition and fresh subdomains; density assignment; and reporting final Mineral Resources by oxidation type. Depth to the interpreted base of complete oxidation ranges from locally one to two meters to around 20 meters and averages approximately 10 meters. Interpreted depth to fresh rock ranges from around 8 to 30 meters depth and averages approximately 18 meters.

For each dataset formed from each Domain and weathering combination, indicator thresholds were defined using a consistent set of percentiles representing probability thresholds of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 0.97 and 0.99 for data in each data subset.

All class average grades were determined from bin mean grades with the exception of the upper bins, which were reviewed on a case by case basis and bin grades selected on the basis of bin mean, or median, with or without exclusion of high grade composites. This approach was adopted to reduce the impact of a small number of outlier composites. In the author's experience this approach is appropriate for Multiple Indicator Kriging (MIK) modelling of highly variable mineralization such as Namdini.

Micromine™ software was used by MPR (2017) for data compilation, domain wire-framing and coding of composite values and the specialist software GS3M™ was used for Mineral Resource estimation. The resulting estimates were then imported into Micromine™ for reporting.

The block model framework used for MIK modelling covers the full extent of the composite dataset. It comprises blocks with dimensions of 12.5 meters east-west by 25 meters north-south by 5 meters vertical. The horizontal dimensions are consistent with the drill hole spacing in the more closely drilled portion of the deposit.

Lithologies were modelled broadly, and bulk densities were then assigned to the block model by rock type and weathering domain. CIM (2014) requires that publicly reported Mineral Resource estimates only include material for which it can be demonstrated that there is 'reasonable prospect for eventual economic extraction' (RPEEE). One way to do this is to constrain the Mineral Resource within a notional optimized pit shell using assumed parameters.

The optimization parameters used by MPR (2017) reflect a large scale conventional open pit operation. The Mineral Resource model blocks were classified as Indicated or Inferred on the basis of search pass and a wire-frame outlining the more closely drilled portions of the mineralization.

Blocks within the classification wire-frame and estimated by pass 1 were classified as Indicated Mineral Resource. All remaining blocks estimated by pass 2 and 3 were assigned to the Inferred Mineral Resource class. The reported Indicated and Inferred material was then constrained to within the RPEEE notional optimized pit.

Block model reviews included comparing estimated block grades with their informing composites. These checks included inspection of sectional plots of the model and drill data, and review of swath plots. They showed no significant issues.

The Mineral Resources were reported within the resource pit shell and extend from natural surface to around 580 meters depth with around 92% of the Indicated Mineral Resources, and 44% of the Inferred Mineral Resources occurring at depths of less than 300 meters. Oxidised and transitional material hosts respectively around 2% and 2% of the estimated Mineral Resource, with the remainder (96%) in fresh rock.

Table 3 summarises the tonnes, grade and contained metal in the RPEEE limiting notional open pit of US$1500/oz and a cut-off grade of 0.5g/t Au.

Table 3: Namdini Mineral Resource Estimates at cut-off grade of 0.5 g/t Au (MPR, Sept 2017)

Category	Tonnage Mt	Grade (g/t Au)	Contained Metal (Moz Au)
Indicated	120	1.1	4.3
Inferred	84	1.2	3.1

As part of the PEA study Golder has undertaken a review of the Mineral Resource estimate that forms the basis of this study, prior to carrying out the mining studies. The review focused on geology and domain definition, the grade estimation approach, and Mineral Resource classification. The purpose of the review was to check for any significant risks associated with the Mineral Resources.

Golder carried out a series of statistical checks to validate the block model grades against the composite database using the average grade resulting from the MIK method (the e-type estimator). The statistical comparison, using declustered weighted composites and considering the lithological differences, indicates the estimation shows acceptable results. Swath plots calculated by Golder for individual domains show acceptable results.

Golder carried out an independent Mineral Resource estimation using the nominated cut-off of 0.5 g/t Au with appropriate variance adjustments. The results were similar to those presented in the Table above.

Golder considers the use of the pit shell appropriate for the purpose of limiting the reporting of Mineral Resources.

In Golders opinion, the 2017 Mineral Resource estimate for the Namdini Gold Project fairly reflects the input data.

1.9 Summary of metallurgical testwork

In July 2016, 332 kg of material was submitted to Suntech Geomet Laboratories (SGL) in Johannesburg South Africa for a range of metallurgical tests, focusing on milling, flotation, concentrate regrind and carbon- in-leach processing. The metallurgical sample was produced from quarter core from a single drill hole NMDD005 in the center of the deposit, containing gold mineralization in all three key rock units (granite, metavolcanics and diorite). The density of the metallurgical sample was determined to be 2.73 t/m^3 using SGL standard procedures.

For each lithology, the material was stage crushed to 100% passing 12 mm, following which it was blended and split by cone and quartering to remove a 10 kg sub sample for SAG Mill Power Index (SPI) and Modified Bond Work Index testwork. The remaining sample was stage-crushed to 100% passing 3.35 mm, blended and split to form a Master Composite.

A multi-element ICP analysis was conducted on each of the individual lithology samples, and the Master Composite sample. The total sulphur and carbon content of the samples was determined by Leco combustion. Gold distribution by size, for the three individual lithologies and Master Composite sample, was determined by wet screening of the -53 µm size fraction and dry screening of the +53 µm size fractions. The majority of the gold was contained within the coarse +850 µm size fraction (51.3%) and the fine -53 µm (15.2%) size fraction.

The volcanoclastic, granitic and dioritic materials all showed broadly similar results. The sulphur distribution followed a similar trend indicating a strong gold-sulphur association.

Mineralogical characterisation on the Master Composite feed sample, rougher concentrate and cyanidation tailings was conducted using XRD and QEMScan analyses. The investigations were conducted to establish the mode of occurrence of the gold bearing minerals, mineral associations, liberation and mineral grain size distribution.

Comminution testwork was conducted on the three lithological samples and a composite made up of 16% diorite, 44% granite and 40% metavolcanic. The testwork was limited to generate an understanding of the comminution characteristics of the ore body using a series of paired SPI and Bond ball mill work index testing. BBWI testing was conducted with a 106 µm closing screen. Diagnostic leach testwork was conducted to assess gold deportment within the various mineral phases, on a single Master Composite feed and flotation concentrate sample.

Direct cyanide leach testwork was conducted on the Master Composite, individual lithology and flotation concentrate samples. The direct cyanide leaching testwork focused on evaluating the impact on leach extraction of grind size, residence time, oxidative pre-treatment and activated carbon.

Given the lower direct cyanidation leach results achieved, flotation testwork was conducted to assess the amenability of the Master Composite sample to flotation. Fifteen flotation scouting test were conducted to assess the impact of various reagent combinations on gold recovery to the flotation concentrate. All flotation testwork was conducted at a primary grind P_{80} of 75 µm. The testwork was completed on 1 kg samples in a 2.5 L flotation cell which is equivalent to 40% solids w/w.

Oreway Mineral Consultants (OMC) used the testwork results for circuit selection and mill sizing. A primary crushing and “SABC comminution circuit” (an open circuit SAG mill followed by closed circuit ball mill and recycle pebble crushing) was selected by OMC based on the available comminution parameters.

Grind sensitivity testwork indicated gold recovery to flotation cleaner concentrate was similar and consistent at a P_{80} 150µm, 106 µm and 75µm. It was agreed with Cardinal that a grind size of P_{80} 106 µm should be used for the PEA study.

The mineral liberation analysis indicated that 4% of the gold present in the feed was liberated. It was agreed with Cardinal that a gravity circuit should be included in the flowsheet and that 5% gravity gold was recoverable. The gravity circuit will enable any spikes of high grade material that may be fed to the process plant to be smoothed out prior to the flotation, allowing the gravity gold to be recovered and allowing more consistent operation of the CIL and elution circuits.

Industry typical design parameters were assumed for the PEA study where testwork has not yet been completed. Metallurgical testwork is continuing for the Namdini Gold Project under the direction of K. Marc LeVier & Associates, Inc.

The comminution and metallurgical testwork has provided preliminary information about the physical characteristics and metallurgical response of the three Namdini lithologies. The process design criteria were developed based on the available testwork and industry-based assumptions. The processing route selected for the Namdini ores was rougher flotation followed by regrind and CIL of flotation concentrate.

1.10 Summary of proposed mining

In the weathered and transitional zones, a mixture of free digging, ripping, drilling and blasting methods can be employed. In the fresh, competent material at depth conventional drill and blasting methods will be used to extract the ore.

The mining style assumed is a conventional shovel operation typically using 600 t class excavators in a backhoe configuration and 220 t (Cat 793) rigid body dump trucks hauling on designed access roads. An auxiliary mining fleet of dozers, graders, water carts and utility vehicles will support the mining operation. No consideration was made for underground extensions of the operation in this PEA study.

An initial high-level assessment using Whittle 4X™ software showed that the project appears to offer a maximum 'return on capital employed' (ROCE), as a ratio of a pre-tax Net Present Value (NPV) divided by CAPEX, for a process plant feed throughput of 6 to 7 Mtpa.

The Whittle 4X™ NPV was taken as the average of the Whittle 4X™ 'best case' and Whittle 4X™ 'worst case' options at a Revenue Factor (RF) of 0.8 in each case. This RF value was selected as it represents the approximate maximum discounted cash flow point for the pit optimizations. Nine scenarios were compared for mine planning. For this preliminary mining study, a strip ratio of up to 2:1 was allowed for so that the initial optimizations were not 'mining-limited'.

The initial high level capital cost estimates (provided prior to the completion of the estimating process undertaken by Lycopodium) for the purposes of initial mine modelling and were compared against similar gold projects with which Golder is familiar and are in line with the expected total capital cost. The capital cost for varying the process plant throughputs were initially estimated by scaling. For this PEA level of study preliminary geotechnical assumptions were used in the pit optimization and pit design. Consequently the mine designs are considered conceptual in nature.

As an initial optimization exercise the 'mineable resource' was tested across a large range of process plant throughput limits from 4 Mtpa through to 10 Mtpa in 1 Mtpa increments. The optimization results were then compared in each case for the RF 0.8 pit shell to provide an equivalent basis for comparison.

Conceptual pit designs were analysed using Whittle 4X™, which generates optimized pit shapes (nested pit shells) using the Lerchs-Grossmann algorithm considering physical characteristics of the mineral deposit (resource block model), cost/price scenarios, geotechnical constraints (maximum pit slope angles) and other operational constraints.

The block model was exported to Whittle 4X™ as a parcelled model retaining the 'ore and waste fractions' (i.e. material above and below the 0.5 g/t Au cut-off grade) defined in the MIK resource model. A validation comparison of the parcelled model was carried out using the Surpac™ MIK export to Whittle 4X™ function. The MIK Whittle 4X™ model produced identical results to the parcelled model and as a result, the parcelled model was retained for further design work and mine planning options.

At this PEA study level, no specific geotechnical slope data was available and hence conservative overall wall angles of 38° and 45.5° for Geotechnical Zones 1 and 2 respectively were selected. These wall angles were replicated in the design by employing 60° sloped batter angles with 10 m and 20 m bench heights in Zone 1 and Zone 2 respectively. These angles are relatively shallow and reflect a conservative approach given the lack of available data.

The proposed mine operational tonnages appear suited to a 220-t class truck (e.g. Cat 793). All roads on site will be designed with a width of 25 m to provide a minimum width greater than or equal to 2.5 times the expected maximum size truck width. Roads will be designed with a maximum grade of 10% (1:10).

All pit designs completed as part of this PEA should be considered conceptual until specific geotechnical data determines the optimal slope design parameters.

Three throughput options were provided by Cardinal for consideration, 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa. These were selected on a basis of process comminution design criteria discussed more in detail in the process section of this report.

High-level mine production schedules were evaluated for the three scenarios considered (for the 4.5, 7.0 and 9.5 Mtpa process plant throughputs) using an initial starter pit with a subsequent pushback to the target pit size.

The schedules allowed for an initial ramp-up of the process plant in each case before full process plant production was assumed.

To gain maximum value from the 9.5 Mtpa option an estimated total peak rock movement of some 30 Mtpa is required in year 7 of that schedule, whereas for the 7.0 Mtpa option this was some 17 Mtpa and for the 4.5 Mtpa option it was some 15 Mtpa. The mining schedule has specifically allowed for the limited processing of oxide ore to less than 10% of the total mill feed on an annual basis.

Using the three process plant throughput options, an estimate of the annual truck requirements assuming a 220 t capacity haul truck was undertaken. The schedules indicated that the 9.5 Mtpa option needs approximately 19 haul trucks (the total peak truck requirement after smoothing the schedules, assuming an average Life Of Mine (LOM) of 1.3 Mtpa for each haul truck), with the 7.0 Mtpa option needing about 13 trucks and the 4.5 Mtpa option needing about 8 haul trucks.

It is proposed that the Namdini Gold Project will be mined on a contract (outsourced) mining basis with capital equipment costs amortised for the mining infrastructure and mining fleet, and charged back to Cardinal as a $/tonne mining cost.

Electrical power requirements for the mining operations will be minimal, with most mining activities relying on diesel powered engines.

Electrical supply for the primary crusher will be sourced from the high voltage grid line located approximately 25 Km away as part of the process plant and infrastructure requirements.

Pit dewatering requirements will be identified as part of the hydrological study for the project and will be further refined once detailed mine designs and pit extents have been defined.

Golder has estimated haul requirements using the industry standard Runge TALPAC™ truck and loader productivity software. An incremental cost allowance of 6 cents per 10 m bench was allowed as a vertical cost increment. The incremental cost with depth is largely driven by the increased haulage time required for the haul trucks and the increased fuel burn of the trucks on the ramp. It is assumed that the loading equipment will remain fully trucked by the contractor with additional trucks being supplied as the average mining depth per cutback increases.

The contract mining cost for the Namdini operation will be inclusive of drill and blast, load and haul and all associated mining costs with the exception of the mine planning and scheduling components which are assumed to be retained by Cardinal.

An estimated mining cost of $3.25 per tonne of rock mined was used, with an additional allowance of $0.25 per tonne for ore mining costs reflecting the additional cost of grade control and laboratory analysis for the grade control samples.

Detailed mining cost estimates will be the subject of a formal tender process from suitably qualified mining contract companies with proven experience in the region, during the Pre-feasibility stage of the Project. The estimated contract mining cost is in line with mining cost estimates Golder is familiar with at other similar sized contract mining operations on the African continent.

Initial discussions with a mining contractor with operations in Ghana provided an initial contract mining cost similar to that used in this PEA study. Further discussions and negotiations will continue with suitable mining contractors prior to any award of the mining contract.

1.11 Summary of proposed recovery and conceptual process plant

Cardinal requested that for this PEA study Lycopodium examines a range of process plant throughputs from about 5 to 10 Mtpa and that the plant throughputs considered should be based on logical step changes for the plant equipment. This work was documented for Cardinal by Lycopodium.

Comminution circuit modelling based on these criteria was completed with three plant throughput options selected based on the minimum, maximum and midpoint. The selected process plant throughput rates for the PEA study was: 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa.

The proposed process plant design for the Namdini Gold Project is based on a metallurgical flowsheet designed for optimum recovery with minimum operating costs. The flowsheet is constructed from unit process operations that are well proven in the gold mining industry.

The process plant design incorporated the following unit process operations:

- Primary crushing to produce a coarse crushed product.
- Coarse crushed ore storage and reclaim to feed the milling circuit.

- A Semi Autogenous-Ball Mill-crushing Circuit (SABC) milling circuit comprising a Semi Autogenous Grinding (SAG) mill in closed circuit with a pebble crusher and a ball mill in closed circuit with hydrocyclones to produce an 80% passing grind size (P_{80}) of 106µm.
- Gravity concentration and treatment of gravity concentrate by intensive cyanidation and electrowinning.
- Flotation of the milled slurry to recover the majority of gold to a low mass (<10%) sulphide flotation concentrate and producing flotation tailings that will be safely discarded.
- Separate thickening of the flotation concentrate and flotation tailings to recover cyanide free flotation water and to thicken the streams prior to downstream processing.
- Grinding of the flotation concentrate in a regrind mill prior to feeding to the CIL circuit.
- A CIL circuit to leach and adsorb gold and silver values from the reground flotation concentrate onto activated carbon in seven leach tanks.
- A split AARL elution circuit, electrowinning and gold smelting to recover gold from the loaded carbon to produce doré.
- A cyanide destruction circuit to reduce the concentrate CIL tailings cyanide concentration to below the maximum International Cyanide Management Code (ICMC) weak acid dissociable cyanide (CNWAD) levels.
- Parallel pumping of the cyanide destruction discharge and the thickened flotation tailings to the separate cyanide and non-cyanide Tailings Storage Facility (TSF).

A typical footprint for a process plant of this flowsheet and capacity as developed by Lycopodium for previous projects of this scale was allowed. The location reflects the quantity and level of confidence in the available information and is suitable for visually representing the conceptual site layout and supporting the operating and capital cost estimates.

Further work will be undertaken at the Pre-feasibility and Feasibility study stages when additional topographical and geotechnical information is available to optimise both the plant location and layout.

As the estimates were derived from previous Lycopodium designs they inherently represent the cost of designs compliant with local and Australian standards.

A conceptual layout was developed based on supplied site topography and satellite images of the area. While it is expected to change as the Namdini Gold Project progresses through Pre-feasibility and Feasibility study stages it is believed that the conceptual layout is sufficiently representative of the final project development that concepts and derived costs are appropriate for this PEA level of study.

The topography of the site and surrounding land forms and uses are not such that the changes expected as the project scope develops will reveal 'fatal flaws' or significant impediments or cost imposts on the project.

The conceptual layout covers the major features of the Namdini Gold Project and its infrastructure including the process plant, tailings management facility, mine open pit, and mine waste dump for the three process plant throughput options that were considered in the PEA study.

The power consumption for the 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa throughput options was estimated at 25 MW, 38 MW and 45 MW respectively. Installed power requirements are 35 MW, 50 MW and 60 MW, respectively.

Raw water will be sourced from the Volta River to the south, approximately 7 km away, from where it will be pumped to the raw water storage facility. The raw water requirements for the process plant are 200 m^3/h, 325 m^3/h and 450 m^3/h for the 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa process plants, respectively.

A pipe branch from the main raw water pipeline will supply the potable water treatment plant located at the camp that will purify the water after which it will be reticulated across the site.

The process plant, mine services area and general administration area will be enclosed within a patrolled 2 m chain link fence line to discourage casual entry. The main point of entry will be where the main access road enters the site. This point of entry will be provided with a gate and manned security post. Access from the mine haul road through the mine services area will also be monitored by a manned security post. Entry into the fenced areas will require a mine identity card and/or proof of legitimate business beyond that point.

Access to the gold room within the plant will be restricted and strictly controlled. Extensive camera surveillance will be installed and entry points will be monitored and alarmed. All personnel allowed into the area will be accompanied and monitored by members of the security team. Persons leaving the area will be subject to a comprehensive search of themselves and any tools or equipment leaving the building.

The accommodation camp will be fenced and provided with a manned entry gate to prevent unauthorised access.

The Tailings Storage Facility will be provided with a perimeter stock fence comprising three strands of barbed wire to prevent wildlife access to the facility. Active landfill areas will be fenced to prevent wildlife and vermin access.

Workshops, warehouses and the like will be of structural steel frame and metal cladding construction on concrete slabs. Office and amenity areas associated with the main structures will generally be of transportable/prefabricated style construction although concrete blockwork construction will be considered to provide additional local content if the schedule allows. The facilities are summarised below:

- Plant gatehouse for access control to the plant security area and all security monitoring functions; the facility will include change rooms, washrooms and laundry for plant staff
- Plant offices and control room
- Plant staff mess
- Electrical switch rooms, of prefabricated construction, mounted on plinths for bottom cable entry
- Reagent stores
- Plant workshop/warehouse with offices and ablutions
- Plant gold room.

An area will be provided for the mining contractor to establish their offices, workshops and other facilities. Power, potable water and connection to the site sewerage facilities will be provided. The area will also have an office for the Owner's geology/mining technical team who may share the contractor’s facilities where appropriate to avoid duplication.

The Mine Services Area facilities are summarised below:

- Heavy vehicle workshop and warehouse
- Explosives magazine
- Mine vehicle washdown bay, with water management and oil/water separation
- Fuel storage with heavy and light vehicle refuelling areas
- Light vehicle workshop
- Mine contractor’s offices
- Shift change building with showers and ablutions
- Mine safety/emergency response building
- Mine staff mess

- Owners team offices
- Site perimeter fencing.
- Allowance for the following additional facilities was made in the capital estimate:
- Main administration building
- Medical center/clinic
- Laboratory, including sample preparation area, fire assay facilities and wet laboratory.

1.12 Summary of the environmental studies to date

An Environmental and Social Impact Assessment, or more simply an Environmental Impact Assessment (EIA), is a study that culminates in the production of an Environmental Impact Statement (EIS). Cardinal engaged Nemas Consult Ltd (NEMAS) of Ghana to provide a scoping study preceding the actual EIA to identify all potentially significant environmental, safety and socio-economic and cultural issues, that are likely to come up during the development, the survey, construction, implementation and decommissioning stages of the proposed project and which need to be considered during the EIA study. This enables the key issues to be addressed from the outset and also allows early recognition of these issues in the design and evolution of the scheme for the project. The process also facilitates the recognition of aspects that would not be expected to cause significant adverse impacts. Ultimately, it defines the scope for the EIA, and for the eventual EIS.

Section 20.0 summarises the scoping work completed to date. The main objectives of the PEA study, as part of the EIA process for the Namdini Gold Project are to:

- Provide an environmental overview of the Namdini Gold Project
- Describe the existing environmental and socio-economic baseline using secondary data only
- Identify key data gaps in environmental knowledge of the Namdini Gold Project
- Undertake a preliminary assessment of the potential environmental and socioeconomic impacts associated with the Namdini Gold Project
- Obtain early input from key stakeholders in the identification of potential impacts and mitigation measures
- Generate a detailed Terms of Reference for the main EIA study and define an appropriate programme for consultation with stakeholders.

1.13 Summary of the Preliminary Economic Analysis

Key Study Outputs Include:

- Dependent upon the eventual production scenario chosen;
  - Average annual gold production ranges from 159,000 ozpa at 4.5 Mtpa up to 330,000 ozpa at 9.5 Mtpa
  - NPV ranges from US$ 706M up to US$ 1,036M pre-tax and US$ 445M up to US$ 649M post-tax
  - IRR ranges from 42% to 62% pre-tax and 31% to 44% post-tax
  - Payback ranges from 4.0 to 3.3 years and
  - All in sustaining costs (AISC) range from US$ 701/oz to US$ 794/oz
- The current target Life of Mine pit includes 91Mt @ 1.1 g/t Au for 3.3 M oz (81%) of Indicated Mineral Resource and 22 Mt @ 1.1 g/t Au for 0.8 M oz (19%) of Inferred Mineral Resources at a 0.5 g/t cut off using the September 2017 Mineral Resource Estimate data

- Identification of a higher-grade starter pit yielding up to 1 Moz gold with a <0.9 strip ratio for which further optimization will be performed in the next study phase
- Mineral Resource categories of **81% Indicated** and **only 19% Inferred** within the current LOM pit
- A new conventional gold plant inclusive of flotation and regrind - CIL of the flotation concentrate
- Given that the PEA results in a strongly positive cashflow outcome for all three throughput scenarios considered, further evaluation and trade-offs for improved economies of scale, mine scheduling, plant design and costings which are anticipated to further enhance project economics will be performed under the Pre-Feasibility Study (**PFS**) which has commenced.

Table 4: Key Economic Results (Sept 2017 Mineral Resource Data)

Key Economic Results	UNIT	4.5 Mtpa	7.0 Mtpa	9.5 Mtpa
Development Capital Cost	US$ M	275	349	426
All in Sustaining Costs (AISC)[1]	US$ / oz	794	736	701
Total Project Payback	Years	4.0	3.5	3.3
Pre-Tax NPV USD (@ 5% discount)[2]	US$ M	706	913	1,036
Post-Tax NPV USD (@ 5% discount)[2]	US$ M	445	574	649
Pre-Tax IRR	%	42%	54%	62%
Post-Tax IRR	%	31%	39%	44%

Notes

[1] Cash Costs + Royalties + Levies + Life of Mine Sustaining Capital Costs (World Gold Council Standard)

[2] Royalties calculated at flat rate of 5% & corporate tax rate of 35% used; both subject to negotiation

Table 5: Key Estimated Production Results

Resource Data Used – September 2017				
Indicated Mineral Resource	91 Mt @ 1.1 g/t Au for 3.3 Moz (81%) within Life of Mine Pit at 0.5 g/t Au cut off			
Inferred Mineral Resource	22 Mt @ 1.1 g/t Au for 0.8 Moz (19%) within Life of Mine Pit at 0.5 g/t Au cut off			
Key Estimated Production results	**UNIT**	**4.5 Mtpa**	**7.0 Mtpa**	**9.5 Mtpa**
Gold Price	US$ / oz	1,300		
Average Annual Production – Gold[1]	(koz / yr)	159	211	333
Life of Mine Production - Gold	(koz)	3,524	3,506	3,521
Average Mine Head Grade	g/t Au	1.1		
Metallurgical Recovery (Oxide / Fresh)	%	90 / 86		
Resource Mined at 0.5 g/t cut-off grade	Tonnes (M)	113		
Life of Mine Strip Ratio (t:t)	W:O	1.2 : 1		

Resource Data Used – September 2017				
Mine Life	years	27	19	14
Development Capital Cost (including owners cost and 15% contingencies)	US$ M	275	349	426
Life of Mine Sustaining Capital Cost (including reclamation)	US$ M	172	160	154
All in Sustaining Costs (AISC)[2]	US$ / oz	794	736	701

Notes

[1] Based on full production years

[2] Cash Costs + Royalties + Levies + Life of Mine Sustaining Capital Costs (World Gold Council Standard) (Assumes flat gold price of US$1,300/oz over mine production)

1.14 Summary of the Qualified Person conclusions

No Mineral Reserve, or Ore Reserves under the JORC Code (2012), was defined for the Namdini Gold Project at this PEA level of study.

The positive result of this PEA is such that it is likely that the Namdini Gold Project will continue to progress towards development of a large open pit mine and process plant, ongoing drilling and assessment, while meeting all required permits and approvals, to add significant value to the northeast region of Ghana.

The positive results of the PEA of the Namdini Gold Project have also confirmed that progression of the Namdini Gold Project to the Pre-feasibility Study (PFS) stage is warranted.

The preliminary mining schedule was based on assessment of a range of processing throughputs to maximise value, being 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa of process plant feed from the Namdini pit. The mining plan has scheduled 112 Mt of ore and 135 Mt of waste to recover 3.5 Moz Au. The 4.5 Mtpa option would result in an anticipated mine life of some 27 years. The 7.0 Mtpa option gives a mine life of 19 years and the 9.5 Mtpa option gives a mine life of 14 years.

The economic assessment was carried out on a pre-tax and post-tax basis using a 35% corporate tax rate and has assumed a total allowance for royalties of 5% of the gross revenue.

The PEA pit design was conservative due to the lack of geotechnical slope stability data and analysis. The PFS pit design may be more aggressive when based on better geotechnical information.

Further metallurgical testwork and geometallurgical modelling may confirm anticipated optimization of recovery by weathering type to enable detailed cost estimation of power and process operating costs.

The sampling and assaying Quality Assurance procedures and the Quality Control results for the Namdini drilling demonstrate that the data used for the Mineral Resource estimate is appropriate at the Preliminary Economic Assessment level of study.

In Golder's opinion, although the results of the Mineral Resource review are acceptable, the approach of ignoring the lithological differences is likely to have introduced a slight degree of under-estimation of the high-grade domain GRA and the over-estimation of the low-grade domain MSE.

1.15 Summary of recommendations

Sampling and assaying recommendations

Golder is of the view that further Mineral Resource definition RC drilling at the Namdini Gold Project should continue to be validated by diamond drilling.

As evaluation of the deposit continues, additional quality control work such as further inter-laboratory repeat assays should be continued.

Metallurgical testwork recommendations

Further metallurgical testwork should target Master Composite grades in the range expected to be presented to the process plant.

Further assaying of metallurgical samples will be required to determine the actual silver levels as the presence of silver will impact on the design of the elution and electrowinning circuits.

Future metallurgical testwork will need to monitor mercury (Hg) deportment to the flotation concentrate and cyanide soluble mercury dissolution within the concentrate leach circuit, to determine whether mercury capture and handling systems are required.

Further metallurgical assaying for tellurium (Te) should be conducted using detection limits that are better than <10 ppm. Detailed mineralogical analysis should identify any gold tellurides present in feed or concentrate samples.

Future metallurgical testwork programs should monitor As deportment and dissolution to ensure dissolved arsenic levels do not increase to a point where arsenic stabilisation within the tailings stream is required.

Finer grinding in the mills could potentially improve gold liberation and subsequent extraction by cyanidation and should be further considered.

Further metallurgical testwork is warranted to maximise gold recovery to rougher concentrate.

Further testwork is required to assess the impact of rougher-scavenger flotation residence time on gold recovery to concentrate.

The actual maximum quantities of oxide that can be blended with fresh ore in the process plant feed should be determined by further metallurgical testwork or the process design should cater for a separate oxide processing stream.

Mineral Resource estimation recommendations

For future Mineral Resources estimates the grade differences presented by each of the lithologies should be considered and reviewed to determine if relevant, during domaining and grade estimation.

Geotechnical recommendations

Golder recommends drilling of four geotechnical boreholes, oriented to the east (into the eastern sections of the pit wall) to investigate the geotechnical properties of that domain. Golder also proposes that three geotechnical boreholes with a westerly azimuth be drilled into the west wall of the pit. These drill holes, generally orientated sub-normal to the pit walls will help uncover persistent structures that dip sub-parallel to the walls, and can thus pose the greatest stability challenges. They will also help to overcome sampling bias due to the consistent orientations of the exploration boreholes.

Golder recommends that geotechnical investigations for the CIL plant, tailings storage facilities, and other infrastructure be taken and has outlined a program of work.

Environmental, health and safety recommendations

Detailed flora and fauna profiling of the Project site should be undertaken during the EIA studies.

The proposed EIA study should undertake monitoring of dust and gaseous emissions or pollutants, such as sulphur oxides (SOx), nitrogen oxides (NOx) and carbon oxides (COx) to confirm the levels in the ambient air at the project area. Current noise levels will also be determined for the project area as part of the baseline survey.

Site specific archaeological and cultural studies should be undertaken as part of the EIA study.

The mining company should adopt a policy to ensure that every worker is vaccinated against cerebrospinal meningitis (CSM).

Prevention of water pollution will be a priority for the Project development.

Proper handling and preservation of topsoil is required during the development, construction and operation phases of the project. Well planned contouring during project development could minimise the erosion impact during heavy rains.

A Resettlement Action Plan with a clear grievance redress mechanism will have to be developed to reduce any adverse impact of land acquisition and resettlement on local communities and the Project.

Worker safety risks will be considered in an Occupational Health and Safety (OHS) plan, applicable to all contractors and employees.

Summary recommendations

This PEA study has highlighted the following recommendations that provide focus for the planned PFS and which will provide options for further optimization and trade-off studies.

A comprehensive geotechnical study is required to support more aggressive (i.e. less conservative) future pit designs.

Improvement in the pit shell shape from smaller conical pits to larger, simple pits would be advantageous in decreasing the stripping ratios. The PFS should investigate whether improved data density in the areas rejected by the pit optimiser can improve the pit design in these areas.

The proposed process plant site, Tailings Disposal Facility and waste disposal sites should be further investigated in the PFS and sterilised by drilling, particularly where there is potential for additional mineralized material.

Trade-off studies of further process plant options should be undertaken in the PFS. Different modular sized process plants with alternative comminution sections may reduce capital costs and/or operational costs, especially for power consumption.

The PEA mine design was conservative due to the lack of geotechnical slope stability data and analysis. The PFS pit design may be more aggressive when based on better geotechnical information.

Further metallurgical testwork and geometallurgical modelling may confirm anticipated optimization of recovery by weathering type to enable detailed cost estimation of power and process operating costs.

Recommendations for further work programmes have been presented to Cardinal, with costings that have been reviewed by the QP. This work will be included in the PFS budget covering:

- Further development and exploration drilling
- Sampling studies
- Metallurgical testwork
- Geotechnical drilling and investigations
- Mining trade-off studies
- Plant options studies, etc.

The author has reviewed and concurs with Cardinal's proposed work programs for updating the PEA

Table 6: Proposed further study expenditure

Item	Cost (US)
Namdini Drilling Program	$2,500,000
Metallurgical test work	$600,000
Process and Infrastructure Design	$1,100,000
Environmental and social studies	$150,000
Mine Design	$1,000,000
Mineral resource update	$150,000
Subtotal	**$5,350,000**
Contingency	$400,000
Total	**$5,750,000**

2.0 INTRODUCTION

2.1 Company Profile

2.1.1 Company Background

Cardinal Resources Ltd (Cardinal) is a gold exploration and development company and has been a reporting issuer on the Australian Stock Exchange (ASX) since August 2011 and the Toronto Stock Exchange (TSX) since July 2017. Cardinal's assets are located in Ghana and include the Namdini, Bolgatanga, and Subranum Projects.

2.1.2 Overview of the Business

The principal activity of the Corporation (and its subsidiaries) is gold exploration in Ghana. The Corporation holds interests in five tenements prospective for gold mineralization in Ghana in two NE-SW trending Paleo-Proterozoic granite-greenstone belts: the Bolgatanga Project and the Namdini Project, which are, respectively, located within the Nangodi and Bole-Bolgatanga Greenstone Belts in northeast Ghana, and the Subranum Project, which is located within the Sefwi Greenstone Belt in southwest Ghana.

Cardinal is currently focusing on developing its Namdini Project in a doré gold producing mine. The Namdini Project is located in the north-eastern region of Ghana approximately 50 km southeast of the regional center of Bolgatanga, and close to the southern border of Burkina Faso. The Namdini Project area is located approximately six kilometers southeast of the operating Shaanxi Mining Company Limited's underground gold mine. The Universal Transverse Mercator (UTM) co-ordinates for the approximate center of the Namdini Project are 756400.0 m N, 1177050.0 m E in WGS84/UTM Zone 30 projection or 10°38' 21" N Latitude and -0°39'.23" W Longitude. The nearest airport is located in Tamale, approximately a 2.5-hour drive south of Bolgatanga via 160 km of paved road on National Highway N10. Tamale is located approximately 450 km north of the capital city of Accra, Ghana, is serviced by daily 1 hour scheduled commercial flights. Total access time from Accra to the Namdini Project is approximately 4 hours using a combination of air and road travel, and approximately 14 hours solely by road travel. Accra has direct flights to the United Kingdom, Europe, South Africa, and the Middle East via regularly scheduled international commercial carriers.

The Namdini Project area is readily accessible from Bolgatanga along paved highway followed by 15 km of well-travelled gravel roads. Access during the rainy season is slower due to waterlogged roads; however, the main access roads are passable year-round.

2.2 Scope of Work

This report was prepared by Golder Associates Pty Ltd ("Golder") at the request of Cardinal Resources Limited ("Cardinal"). The purpose of this report is to provide Cardinal with an independent NI 43-101 compliant, Independent Technical Report and Preliminary Economic Assessment on the Namdini Gold Project in Ghana, Africa.

This Preliminary Economic Assessment ("PEA") was carried out for the purpose of determining the preliminary criteria under which the Namdini Gold Project in northeast Ghana may be considered potentially economic so that a development program can be planned. This report is produced for Public Reporting under Canadian National Instrument ("NI") 43-101 in Canada (NI 43-101, 2014).

This PEA study is preliminary in nature. It includes Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorised as Mineral Reserves, and there is no certainty that the conclusions of this preliminary economic assessment will be realised.

The PEA on the Namdini Gold Project was commissioned by Cardinal with the purpose of defining and quantifying the technical merits of the project and for determining the conditions under which the Namdini Gold Project should be progressed to the Prefeasibility study stage for Public Reporting of Mineral Reserves.

This PEA was prepared in accordance with the requirements of:

- Disclosure and reporting requirements of the Toronto Stock Exchange (TSX);
- Canadian National Instrument 43-101, 'Standards of Disclosure for Mineral Projects', Form 43-101F1 and Companion Policy 43-101CP (NI 43-101, 2014); and
- Canadian Institute of Mining, Metallurgy and Petroleum Definition Standards (CIM, 2014).

2.3 Namdini Gold Project PEA concept

The Namdini Gold Project is located in the north-eastern region of Ghana approximately 50 km south-east of the regional center of Bolgatanga.

The Project is conceived as a large-scale open pit, mined for gold by conventional drill and blast, dug by face shovel configured excavators feeding 220 t trucks. The ore will be fed to a large conventional CIL process plant with a sulphide flotation circuit to enhance gold recovery. Gold bullion will be produced on site for sale into the international market.

The Namdini Gold Project will operate in a safe, responsible and technically efficient way to add benefits to all stakeholders including Ghana, the owners, shareholders, employees, and local communities.

2.4 Sources of information

Sources used in the compilation of this PEA Report include:

- Namdini Gold Project Mineral Resource Estimate Study Report. Prepared for Cardinal Resources Limited by ERGM Consulting Pty Ltd (Gossage, 2017), 17 February for which the estimate was released publicly to the ASX by Cardinal in 2016.
- Technical Report on the Namdini Gold Project, Ghana, West Africa, April 5, by Roscoe Postle Associates Inc (RPA, 2017) describing the Mineral Resource estimated at April 5 and released publicly to the TSX under NI 43-101.
- Technical Report on Mineral Resource Estimation for the Namdini Gold Project, Ghana by MPR Geological Consultants Pty Ltd, 16 October (MPR, 2017).
- Report on the Geotechnical studies by Golder (Hammah, 2017)
- Scoping study on the Namdini Gold Project, July by Lycopodium Minerals Pty Ltd (Lycopodium, 2017) describing the metallurgy and preliminary process plant design options, with appropriate capital and operating cost estimates for a PEA.
- Scoping Report Environmental Impact Assessment (EIA) Study on the Namdini Gold Project, May by Nemas Consult Ltd (NEMAS, 2017) describing preliminary analysis of the local environment and community, and outlining the steps required to obtain social licence to develop and operate the proposed gold mine.

2.5 Personal inspection

Glenn Turnbull, Principal Mining Engineer from the Golder office in Perth visited the Namdini Gold Project site from 11 to 15 December, 2017.

Dr Reginald Hammah from the Golder Associates Ghana Limited (Golder Ghana) office in Accra visited the Namdini Gold Project site to advise on a programme for geotechnical pit design criteria on 29 to 30 May 2017.

Mr Nicolas Johnson of MPR Geological Consultants Pty Ltd visited the Namdini Gold Project site between the 11th and 14th of January 2017.

Mr Marc LeVier of K. Marc & Associates Inc visited the Namdini Gold Project site between the 11th and 14th of July 2017.

Dr Frank Anim of Nemas Consult visited the Namdini Gold Project site between the 1st and 4th of May 2017.

2.6 Statement of independence

Golder is an independent consulting company contracted by Cardinal to carry out this PEA study. Neither Golder, nor the authors of this report, have or have had previously, any material interest in Cardinal or the mineral properties in which Cardinal has an interest. Golder's relationship with Cardinal is solely one of professional association between client and independent consultant.

This report is prepared in return for professional fees based upon agreed commercial rates and the payment of these fees is not contingent on the results of this report. No member or employee of Golder is, or is intended to be, a director, officer or other direct employee of Cardinal.

In the preparation of this Independent Technical Report Golder has used information provided by Cardinal and other experts. Golder has verified this information making due enquiry of all material issues that are required in order to comply with NI 43-101 requirements.

There is an ongoing consultancy agreement between Golder and Cardinal regarding Golder conducting further work for Cardinal as this project progresses to the Pre-feasibility and Feasibility study stages.

The positive result of this PEA is such that it is likely that the Namdini Gold Project will continue to progress towards development of a large open pit mine and process plant, ongoing drilling and assessment, while meeting all required permits and approvals, to add significant value to the northeast region of Ghana

2.7 Risks and forward-looking statements

The business of mining and mineral exploration, development and production by its nature has significant operational risks. The business depends upon, amongst other things, successful prospecting programmes and competent management. Profitability and asset values can be affected by unforeseen changes in operating circumstances and by technical issues.

Factors such as political and industrial disruption, currency fluctuation and interest rates could have an impact on the proposed project's future operations, and potential revenue streams can also be affected by these factors. The majority of these factors are, and will be, beyond the control of Cardinal or any other operating entity.

This Independent Technical Report contains forward-looking statements. These forward-looking statements are based on the opinions and estimates of Cardinal, Golder and other specialist consultants at the date the statements were made. The statements are subject to a number of known and unknown risks, uncertainties and other factors that may cause actual results to differ materially from those anticipated in the forward-looking statements. Factors that could cause such differences include changes in world gold markets, equity markets, costs and supply of materials relevant to the projects, and changes to regulations affecting them.

Although Golder believes the expectations reflected in its forward-looking statements to be reasonable, Golder does not guarantee future results, levels of activity, performance or achievements.

2.8 Use of the term 'ore' in this PEA

The Canadian National Instrument Companion Policy 43-101 (Section 2.3) indicates that in the context of Mineral Resource estimates, the term 'ore' implies technical feasibility and economic viability that should only be attributed to 'Mineral Reserves'. In compliance with Section 2.3 of the Companion Policy, the term ore is not used in the Mineral Resource context of this PEA.

The term ore is used in the mining and processing sections of this PEA in a generic way to describe the 'mineable' part of the Mineral Resource estimate that will be extracted from the mine and fed to the process plant. Where appropriate this is referred to as the 'mineable resource' since no Mineral Reserve was estimated yet. To do so will require investigation and application of all relevant Modifying Factors as defined in CIM (2014).

This PEA study is preliminary in nature. It includes Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorised as Mineral Reserves, and there is no certainty that the conclusions of this preliminary economic assessment will be realised.

3.0 RELIANCE ON OTHER EXPERTS

3.1 Sources of information relied upon

This report was prepared by Golder for Cardinal as a PEA for Public Reporting. The information, conclusions, opinions, and estimates contained herein are based on:

- Information available to Golder at the time of preparation of this report
- Assumptions, conditions, and qualifications discussed in this report
- Data, reports, and other information supplied by Cardinal and other third parties, as documented and referenced in this PEA study report.

For the purpose of this report Golder has relied on ownership information and other local knowledge provided by Cardinal.

Golder has not researched property title or mineral rights for the Namdini Project and expresses no opinion as to the ownership status of the property.

Except for the purposes legislated under Canadian or other securities laws, any use of this report by any third party is at that party's sole risk.

The major components of this PEA comprise: scoping for an environmental impact assessment, resource modelling based on available data, preliminary mine design, metallurgical testwork, preliminary process design and process plant cost estimation, and preliminary financial analysis. This work tested the merits of proceeding towards a Pre-feasibility study and determined criteria to be evaluated in such a study.

This PEA is based on the specialist consultant studies summarised in Table 1 and information from studies conducted on behalf of the project owner, by independent specialist consultants. Golder has reviewed these reports, and having made due enquiry, considers that these reports are based on accepted international industry practice and fairly represent the Namdini Gold Project.

Table 7: Scoping Study components for the PEA study

PEA Component	Specialist Study	Consulting Company
Environmental	Environmental Impact Assessment Study	Nemas Consult Ltd (NEMAS, 2017)
Mineral Resource	Creation of updated Mineral Resource model for Namdini deposit	MPR Geological Consultants Pty Ltd (MPR, 2017)
Mine Design	Geotechnical review	Golder Associates Ghana Ltd (Hammah, 2017)
Mine Design	Pit Optimization and Scheduling	Golder Associates Pty Ltd
Comminution Design	Comminution data analysis and design	Ore Mineral Consultants Pty Ltd (OMC)
Process Design	Review laboratory metallurgical programme and estimates. Process plant design for 3 process plant throughput options.	Lycopodium Minerals Pty Ltd, (Lycopodium, 2017) and Knight Piésold Consulting

PEA Component	Specialist Study	Consulting Company
	Project Infrastructure requirements and costing. Capital and operating cost estimates.	
Metallurgical Testwork	Metallurgical testwork to support the process design and criteria.	Suntech Geometallurgical Laboratories
High Voltage Power Study	High voltage power supply options	Cardinal and Cardno BEC Pty Ltd

3.2 QPs and experts relied upon

The Qualified Person(s) (QPs) identified as the authors responsible for this PEA Technical Report have specifically relied on other experts as referred to in NI 43-101 Item 3. These other experts, and their individual reports, together with the Sections to which their work applies, are identified in Table 8.

Table 8: Qualified Persons and experts relied upon for this PEA

Company	PEA Component	Name	Role
Cardinal Resources Limited	Geology and Mineral Resource Estimate	Mr Richard Bray	Expert (not independent)
Cardinal Resources Limited	Geology and Mineral Resource Estimate	Mr Ekow Taylor	Expert (not independent)
MPR Geological Consultants Pty Ltd (MPR, 2017)	Mineral Resource Model Estimate	Mr Nicolas Johnson	QP
Golder Associates Pty Ltd	Mine Design	Mr Glenn Turnbull	QP
K. Marc LeVier & Associates, Inc	Process Design	Mr Marc LeVier	QP
Nemas Consult Ltd (NEMAS, 2017)	Environmental	Dr Frank Anim	Expert

Organisations and their personnel involved in preparing this PEA included:

- Cardinal: Bruce Lilford, Richard Bray and Ekow Taylor
- MPR: Nicolas Johnson
- Golder: Glenn Turnbull, Dr Reginald Hammah, Henry Dillon, Jorge Peres
- K. Marc LeVier & Associates, Inc: Mr Marc LeVier
- NEMAS: Dr Frank Anim, Emmanuel Acquah, Dr Kwesi Boadi, A. Adu-Nyarko, Dr J. Adomako, Dr Samuel Nkumbaan, Dr Francis Nunoo.

4.0 PROPERTY DESCRIPTION AND LOCATION

4.1 Location of tenement

Namdini is approximately 50 kilometers southeast of the regional town of Bolgatanga in northern Ghana and around 60 kilometers south of the Burkina Faso border (Figure 1).

The Tallensi district which was part of the Tallensi-Nabdam district became a separate district in 2012, through Legislative Instrument LI 2110, with Tongo as the capital. The District, which is one of the thirteen Municipalities and Districts in the Upper East Region, is bordered to the north by the Bolgatanga Municipality, to the south by West and East Mamprusi districts (both in the Northern Region), to the west by Kassena-Nankana district, and to the east by the Bawku West and Nabdam districts. The District lies between latitude 10° 15' and 10° 60' North of the equator and longitude 0° 31' and 1° 05' West of the Greenwich meridian and covers a land area of 838.4 km^2 with a total population of 81,194 which constitute 7.8 percent of the regional population. It is made up of 96 towns and villages with a settlement pattern which is predominantly rural (NEMAS, 2017). The District context of the Lease boundary is shown in Figure 1.

The project is roughly seven kilometers southeast of the operating Shaanxi underground gold mine. Namdini lies within the Nangodi Greenstone Belt, one of a series of southwest – northeast trending granite- greenstone belts which host significant gold mineralization in Ghana and Burkina Faso.

The topographic relief within the project area is generally flat with gently undulating terrain, rising to the south where the area is overlain by sediments. Elevation varies from 175 to 250 m above sea level with average elevation at approximately 190 m. Physiography is primarily savanna grassland characterized by short scattered drought-resistant trees, scrub and grass which is seasonally burnt by bushfires or scorched by the sun during the long dry season.

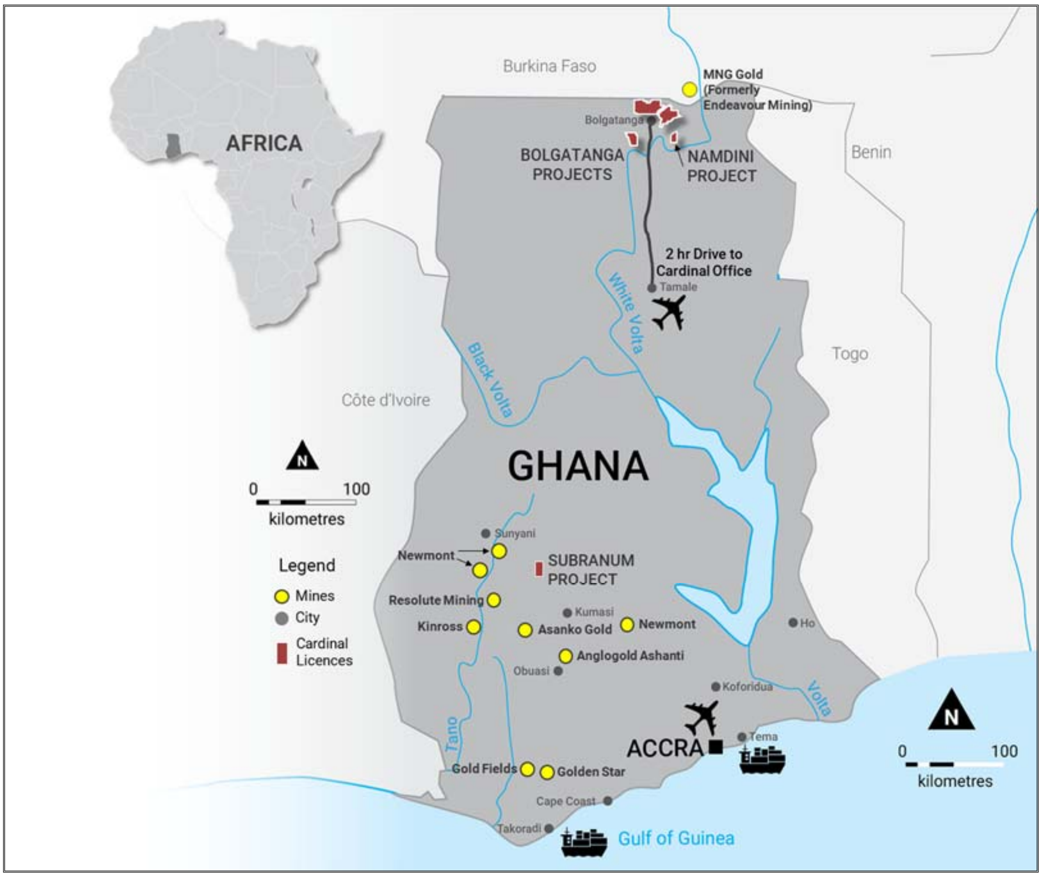

Figure 1: District context of the Lease boundary (2017)

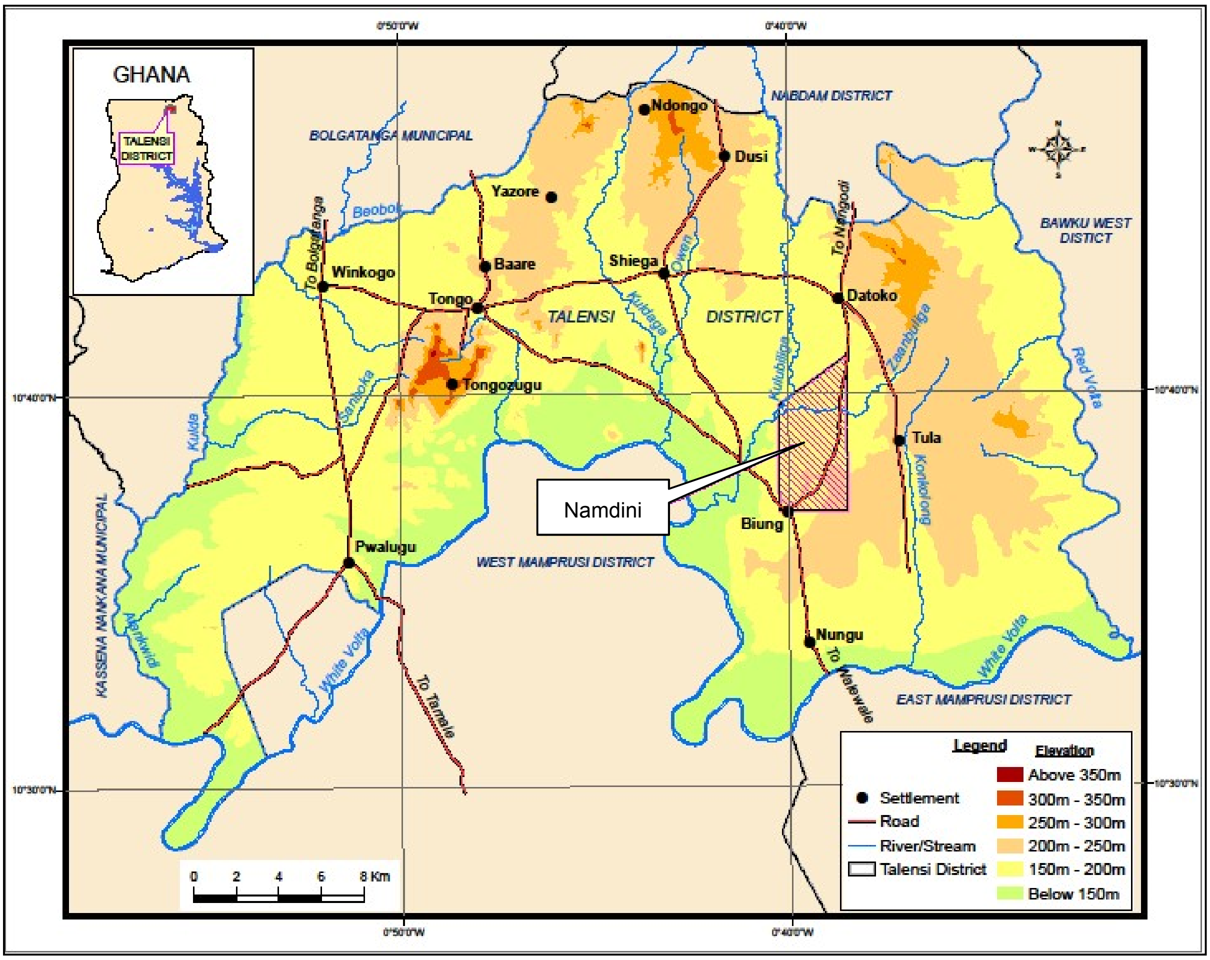

Figure 2: District Map of Tallensi showing the location of the Namdini Mining Lease (Source: NEMAS, 2017)

4.2 Tenement description

Table 9 lists the coordinate extents of the Namdini Gold Project lease. Approximate central coordinates of the deposit are 756400.0 m N, 1177050.0 m E in WGS (UTM) 84 Zone 30N projection or 10°38' 21" N Longitude and 0°39'.23" W Latitude.

Table 9: Coordinates of the Namdini Gold Project Lease

Corner	Longitude	Latitude
Top Left	10º 39' 42" N	0º 40' 15" W
Top Right	10º 40' 57" N	0º 38 30" W
Bottom Right	10º 37' 00" N	0º 38 30" W
Bottom Left	10º 36' 60" N	0º 40' 15" W

The lease covers approximately 19.54 km2. Figure 3 shows the Mining Lease boundary surveyed details and Figure 4 shows the regional physiography image.

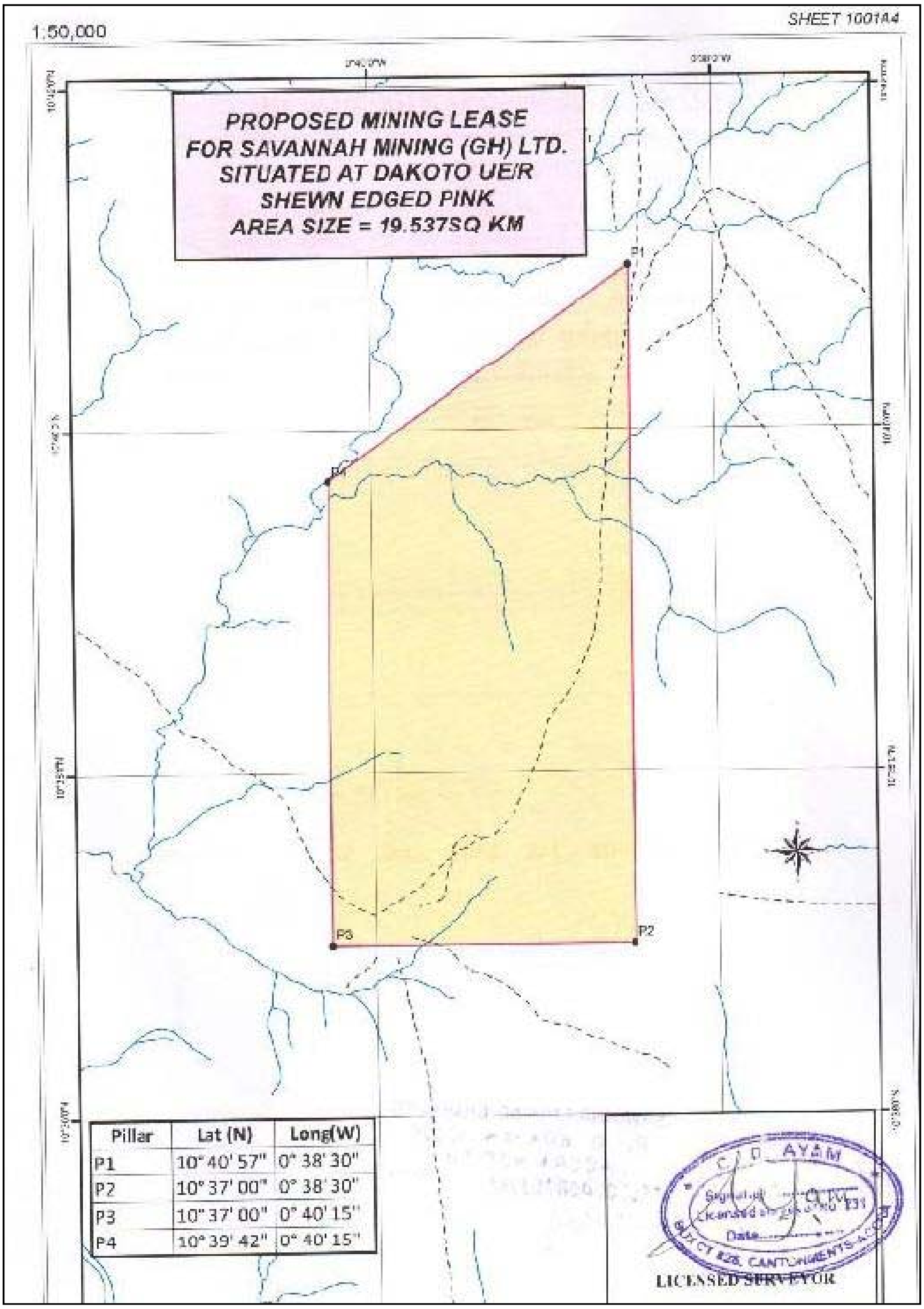

Figure 3: Namdini Gold Project surveyed lease boundary details (source: NEMAS, 2017)

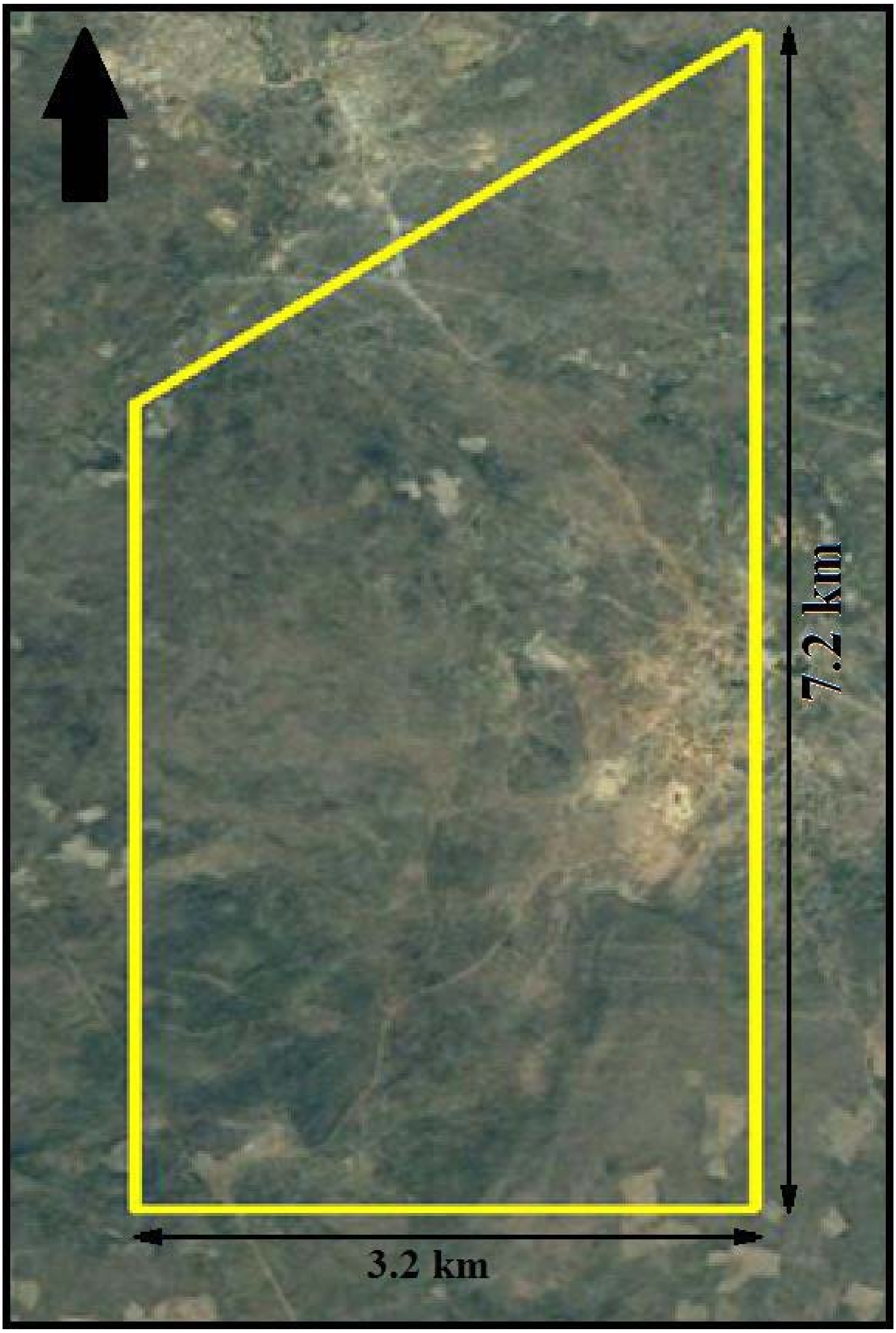

Figure 4: Location of Namdini Gold Project lease boundary (source: Cardinal 2017)

4.3 Mineral tenure and property ownership

The following description of mineral tenure and property ownership for the Namdini deposit is derived from information in RPA (2017) and Cardinal (2018).

The Namdini Mining License is for an initial period of 15 years and is renewable. It covers an area of 19.54 km^2 in the Upper East Region of Ghana. Savannah Mining Ghana Limited (Savannah) completed an EIS for Namdini and has filed the EIS with the Environmental Protection Agency (EPA). Following completion of a PEA, Cardinal will submit to the Minerals Commission an updated EIS and an application for an Operating Permit for the project scale envisioned in the PEA.

The application by Savannah for a Large-Scale Mining Licence over an area of approximately 19.54 Sq Km in the Upper East Region of Ghana covering Cardinal's Namdini Project has been granted by the Minister of Lands and Natural Resources of Ghana.

Savannah applied for an assignment of this Large-Scale Mining Licence to Cardinal Namdini Mining Limited (Cardinal Namdini), a wholly owned subsidiary of Cardinal. The assignment was granted during the December 2017 quarter by the Minister of Lands and Natural Resources of Ghana.

The assignment of the Large-Scale Mining Licence to Cardinal Namdini was completed during the December 2017 quarter.

4.4 Royalties, payments or encumbrances

An assumption of 5% was made to account for all royalties in the Mineral Resource estimation (Section 14.1.8), the Mining cost estimates (Section 16.10) and the Economic Analysis (Section 22.0).

4.5 Environmental studies

The Qualified Persons signing this report are not aware of any specific environmental liabilities on the property. Further information regarding the scoping of the Environmental Impact Assessment is provided in Section 20.0.

4.6 Permits

The Qualified Persons signing this report have been advised that Cardinal has all required permits to conduct the proposed work on the property.

Cardinal has secured the Namdini Mining License for an initial period of 15 years which is renewable. It covers an area of 19.54 km^2 in the Upper East Region of Ghana. Savannah Mining Ghana Limited (Savannah) completed an EIS for Namdini and has filed the EIS with the Environmental Protection Agency (EPA). Following completion of a PEA, Cardinal will submit to the Minerals Commission an updated EIS and an application for an Operating Permit for the project scale envisioned in the PEA.

The report author is not aware of any specific environmental liabilities on the property. Cardinal has all required permits to conduct the proposed work on the property. The report author is not aware of any other significant factors and risks that may affect access, title, or the right or ability to perform on-going work programs on the property

4.7 Other factors

The Qualified Persons signing this report are not aware of any other significant factors or risks that may affect access, title, or the right or ability to perform on-going work programs on the property.

5.0 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

5.1 Accessibility and infrastructure

The following descriptions of accessibility, local resources and infrastructure are derived from RPA (2017) and the other references cited in this section.

Namdini is approximately 50 km southeast of Bolgatanga, the capital of the Bolgatanga Municipal District, within the Tallensi District in the Upper East Region of northern Ghana. This District is close to the southern border of Burkina Faso. The property is readily accessible from Bolgatanga along paved highway followed by 15 km of well-travelled gravel roads. Access during the rainy season is slower due to waterlogged roads, but the main access roads are passable all year round.

The nearest airport is at Tamale, 160 km south of Bolgatanga by paved road on National Highway N10. Tamale is serviced by daily scheduled commercial flights from the capital Accra. Travel time from Accra to the Namdini Gold Project is approximately four hours using a combination of air and road travel or 14 hours solely by road. Accra is serviced by direct flights to the United Kingdom, Europe, South Africa, the Middle East and USA.

The Project site is located approximately 6 km southeast of the operating Shaanxi Mining Company Limited's (Shaanxi) underground gold mine (RPA, 2017).

For exploration and resource definition activities to date, personnel have generally commuted daily from Bolgatanga where Cardinal has an Exploration Office. Fuel supply for the drill rigs is provided by diesel tankers. Fresh water is taken from various boreholes located on the Namdini Gold Project site. Cardinal maintains trails on the Namdini Gold Project site to facilitate drilling and other exploration activities.

Evaluation of the project is at an early stage and infrastructure to support mining has not yet been established. For future development it may be necessary to build all-weather access roads, possibly bridges, power, water and other infrastructure.

Cardinal's surface rights cover areas sufficient for potential process plant sites, tailings storage areas, and waste disposal areas. The national Ghana power grid 161 kV above-ground transmission line runs approximately 25 km west of the Namdini Gold Project. The Namdini Gold Project is located approximately seven kilometers southeast of the operating Shaanxi underground gold mine which is supplied by grid power.

Ghana has a long mining history and has experienced technical personnel including geologists and engineers. Exploration and mining supplies are readily available within Ghana. In 2002 the Upper East Ghana region had a total population of approximately 964,500. In 2012 Bolgatanga had a population of 66,685. There are two small settlements in the vicinity of the Namdini Gold Project which generally rely on subsistence farming, artisanal mining, and harvesting of wood. There is a significant local labour pool available for recruitment for any envisioned mining operation.

Numerous historical trenches and adits, as well as organised artisanal gold mining sites, are located throughout the property and approximately 5% of the permit area was affected by these activities. Artisanal miners extract gold from the saprolite horizon, but also sink shafts as deep as 20 m to recover gold from quartz veins. These artisanal workings can result in pits and subsidence which pose hazards for people and animals.

5.2 Physiography

5.2.1 Topography

Topography of the Namdini area is generally flat to gently undulating (Figure 5) and rises to the south where the area is overlain by sediments. Elevation varies from 175 to 250 meters above sea level, averaging approximately 190 m ASL.

The topography of the district is characterized by scattered rock-outcrops and undulating gentle slopes of the upland and lowland areas. A view of the Project site looking north is provided in Figure 6.

The landscape has promoted small scale agriculture in the district.

Figure 5: Namdini Gold Project site showing terrain facing north (source: Lycopodium, 2017)

Figure 6: View of Namdini Gold Project site facing north (source: Lycopodium, 2017)

5.2.2 Drainage

The Project Area falls within the Volta River catchment and is located approximately 7 km north of the White Volta River. The main rivers that drain through the district are the White and Red Volta and their tributaries (Figure 7). The Project site drains to the west towards the White Volta River 6 km west of the site, which eventually forms part of the Volta River. A small seasonal tributary known as Zoan Buliga stream traverses the site through the north. The Project site drains to a tributary within the White Volta sub-basin. The Red Volta is east of the Project site.

There are four main sub-basins within the Volta catchment, consisting of: The Black Volta, White Volta, Oti-Pendjari and Lower Volta rivers. The sub-basins, excluding the Lower Volta system, flow to the Volta Lake which was created by the construction of Aksombo Dam in 1964.

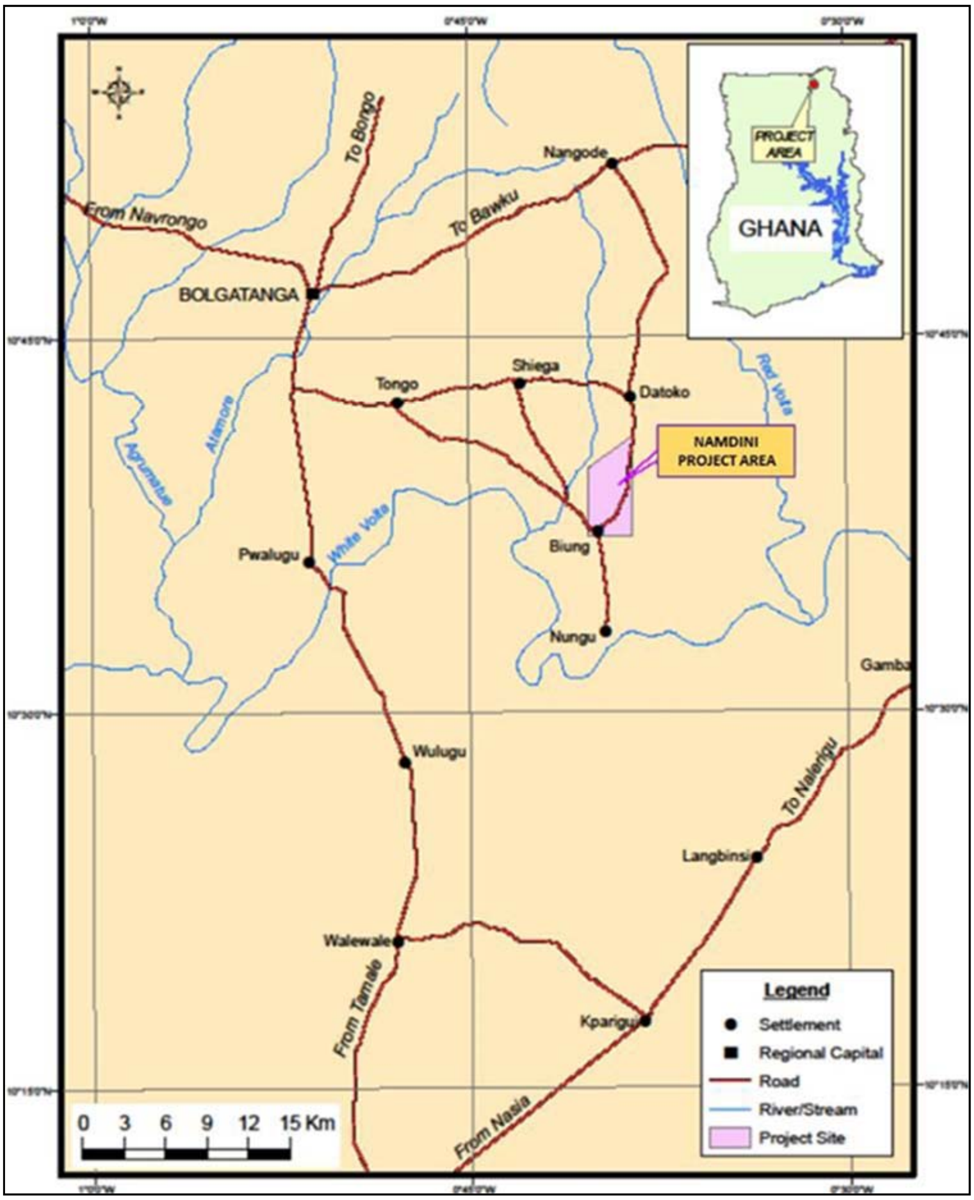

Figure 7: Drainage of the Namdini Gold Project site (source: Lycopodium, 2017)

5.3 Vegetation

The area is primarily savannah grassland characterized by short scattered drought-resistant trees, scattered scrub, and grass. The most common trees are the Sheanut, Dawadawa, and Baobab. See further details in Section 20.3.5.

5.4 Climate

Weather conditions have not significantly affected Cardinal's exploration activities, nor would they be expected to materially affect any potential mining operations.

Mean annual temperature in Bolgatanga is 28.3°C.

There is a dry season from December to late January characterized by cool, dry and dusty Harmattan winds. Temperatures during this period can be as low as 15°C at night and as high as 40°C during the day.

The rainy season is between May and October when the rainfall is erratic spatially and in duration. Mean annual rainfall varies between 800 and 1100 mm. Temperatures during this period can be as low as 20°C at night but can reach more than 35°C during the day.

Humidity is very low during the dry season but can be as high as 85% during the wet season.

6.0 HISTORY

6.1 Exploration and discovery

This section provides a brief summary of the history of exploration of the Namdini deposit and surroundings, derived from RPA (2017).

All exploration at Namdini was completed by Cardinal. Prior to Cardinal, no systematic exploration had been undertaken on the property. Small scale artisanal mining began on the property about 2013 following Cardinal's initial exploration activities.

The following summary of historical exploration in this region of north eastern Ghana is taken from RPA (2017). Golder has reviewed RPA's exploration history with Cardinal, who consider that this is still a good representation of the exploration history in the region.

> *Northern Ghana did not have extensive artisanal gold mining when compared to elsewhere in West Africa, such as southern Ghana, Côte d'Ivoire or southern Burkina Faso.*
>
> *The discovery of gold in this region occurred in late 1930s when a British businessman was shown some gold-bearing quartz veins at Nangodi by a local farmer. A small underground operation was underway by 1934, which attracted the attention of Gold Coast Selection Trust (GCST) who optioned the property in 1936 and acquired a large prospecting licence area which covered most of the belt. GCST boosted the underground production, which peaked at about 5,000 oz/year of gold in 1936-1937 but dropped thereafter as a result of lower grades (originally about 1 oz/ton and dropping to about 0.6 to 0.8 oz/ton in 1937-1939). GCST subsequently dropped the option in 1938, but mining continued on a very modest scale for a few years.*
>
> *During the early 1960s, the Ghanaian Government was trying to stimulate interest and development in northern Ghana. The Ghana Geological Survey Department carried out limited shallow drilling around prospects which had been identified by earlier work in the 1930s. In the 1970s some soil geochemistry and trenching were carried out over a 7 km stretch in the Nangodi area where most of the known prospects occur.*
>
> *Driven by activity elsewhere in Ghana and Burkina Faso during the mid-1990s, numerous Canadian and Australian junior explorers started to explore the north of Ghana, where the discovery of Youga deposit in Burkina Faso by International Gold Resources (IGR) is significant.*
>
> *During this same period small-scale miners inundated the area as the traditional small-scale mining sites in southern Ghana were closed at Tarkwa, Obuasi, Konongo, etc. Environmental problems were created when the artisanal miners encroached on forest reserve areas southwest of Bolgatanga. Eventually, the Small-Scale Mining Division of the Minerals Commission set aside a 72 km2 area south of Nangodi (Shiega-Datoko) for small-scale mining. A number of licences were taken out and up to several thousand people were living and working in the general area between 1996 and 1998.*
>
> *BHP was the first to conduct a major reconnaissance exploration program in the mid-1990s, covering most of the Nangodi area. BHP's work was directed towards developing both gold and base metal prospects. After an initial regional program which identified promising geochemical and geophysical anomalies, the project was largely abandoned as a result of BHP's decision to cease exploration activity in Ghana. Other groups acquired prospecting concessions in the mid-1990s including IGR, who picked up two areas on the margins of the belt; the western area covered a large area around Navrongo and the eastern area extended to the Bawku area. Cluff Resources held two concessions on the eastern side of the belt, adjacent to BHP's Nangodi licence area, and Teberebie Goldfields acquired a concession from just north of Nangodi to the Burkina Faso border.*
>
> *Subsequently, Ashanti Goldfields carried out extensive work on the IGR concessions after their takeover of the company, and an Australian junior, Africwest Gold, successfully applied for a reconnaissance concession in the Nangodi area in late 1996, after the BHP licence had lapsed.*

The market downturn in 1997 seriously affected Africwest's ability to raise additional equity funding and their licence in the Nangodi area lapsed.

Renewed interest in the area began around 2004, with an increase in the gold price, and as a result of the development of mines on the Burkina Faso side of the border. In 2006 Etruscan Resources Inc., a Canadian mining company, carried out soil sampling, rock chip sampling, limited trenching, and reverse circulation (RC) and rotary air blast (RAB) drilling (139 holes) in the Zupliga, Fulani and Dumorlugu prospects. The best drill intercept was 18 m at 3.35 g/t Au.

Randgold also explored the Nangodi-Bole belts from 2004 to 2009 with soil geochemistry, stream sediment sampling and rock chip sampling. The company identified eight areas but left when these failed to meet their economic criteria. Red Back Mining commenced exploration work over the Nangodi Belt and adjacent areas in 2005. This included a desktop study of satellite imagery, data compilation, mapping and rock chip sampling.

Significantly, none of the historical exploration had used a detailed airborne geophysical survey to identify structural-lithological targets to support the ground work. In 1999, the Finnish Government flew a low resolution geophysical survey over selected areas of the country for the Geological Survey of Ghana as part of a World Bank-supported project.

6.2 Historical Mineral Resource estimates

On 7 November 2016 a Mineral Resource estimate was reported by Cardinal based on drilling information available up to August 2016. This was reported in accordance with the JORC Code (2012) to the Australian Stock Exchange (ASX) as summarised in Table 10.

Table 10: Mineral Resource estimate at 07 November 2016 (Gossage, 2017; Cardinal 2016)

Mineral Resource Category	Tonnage Mt	Grade (g/t Au)	Contained Metal (Moz Au)
Indicated	6.2	1.2	0.24
Inferred	89.9	1.3	3.6

Notes

[1] Mineral Resources were reported according to the JORC Code (2012).

[2] Resources were estimated by Multiple Indicator Kriging (MIK) of 3 m down hole composites cut to 15 g/t

[3] Mineral Resources were reported at a cut-off grade of 0.5 g/t Au above a pit shell using a long-term gold price of US$1,550 per ounce.

[4] Drill holes completed at August 12, 2016 were incorporated (NMDD034).

[5] Numbers may not add due to rounding to appropriate significant figures.

In 2017, Cardinal commissioned Roscoe Postle Associates Inc (RPA) to prepare a Mineral Resource Technical Report for the Namdini Gold Project. This Mineral Resource estimate incorporated drilling information to December 2, 2016 consisting of 32,275 m of diamond (DD) and reverse circulation (RC) drilling, up to and including NMDD061, and was released by Cardinal as an NI 43-101 report on April 6, 2017.

RPA used geological wire-frames and grade shells at 0.1 g/t Au and 1.0 g/t Au to constrain grades estimated using Ordinary Kriging. High grade assays were capped separately for the four indicator domains at 1 g/t Au, 10 g/t Au, 15 g/t Au, and 25 g/t Au, then composited to three meter intervals. Densities were assigned to blocks based on lithological units and weathering horizons. Blocks were classified as Indicated and Inferred Mineral Resource based on confidence in block estimates implied by the variogram, grade continuity, and drill hole spacing. A cut-off grade of 0.5 g/t Au was used for resource reporting and Mineral Resources were constrained by a Whittle pit optimization.

The Mineral Resource estimate was documented in a technical report (RPA, 2017) dated April 5. A summary of the results is provided in Table 11

Table 11: RPA Mineral Resource estimate at 2 December 2016 (RPA, 2017)

Mineral Resource Category	Tonnage Mt	Grade (g/t Au)	Contained Metal (Moz Au)
Indicated	23.9	1.2	0.93
Inferred	100.1	1.1	3.63

Notes:

[1] Mineral Resources were reported according to the JORC Code (2012).

[2] Mineral Resources were estimated at a cut-off grade of 0.5 g/t Au, constrained by a preliminary open pit shell.

[3] Mineral Resources were estimated using a long-term gold price of US$1,500 per ounce.

[4] Drill holes completed at December 2, 2016 were incorporated (up to and including NMDD061).

[5] Numbers may not add due to rounding to appropriate significant figures.

The above publicly reported Mineral Resource estimate has since been superseded, based on a report by MPR (2017). That new estimate is fully discussed in Section 14.0 and the significant increase in tonnes and contained metal is based on additional drilling, an alternative estimation method and revised parameters to constrain the estimate within a pit shell. The MPR (2017) Mineral Resource estimate is the basis for this present PEA study.

6.3 Historical production

No commercial production has been undertaken on the site. The total gold production by artisanal miners since 1937 is unknown. During a visit in May 2017 Golder observed that a very small number of “non-mechanised” artisanal mining operations still take place on site.

7.0 GEOLOGICAL SETTING AND MINERALIZATION

7.1 Geological background

This description is based on MPR (2017):

The Namdini Gold Project lies within the Paleo-Proterozoic Nangodi Greenstone Belt, one of a series of southwest–northeast trending granite-greenstone belts which host significant gold mineralization in Ghana and Burkina Faso. These belts are interpreted to be fault bounded, both during their development and post- deposition. Much of northern Ghana is covered by post-Birimian Voltaian Basin sediments, and at Namdini this forms the southern limit of exposure of Birimian rocks (Figure 8).

Key units of the metamorphosed greenstone belts include greywackes and phyllites of the Tarkwaian Formation, which are overlain by volcanic and sediment sequences of Birimian age (2.2 to 2.1 Ga), characterized by interbedded mafic to intermediate volcanic flows, felsic to intermediate tuffs and fine-grained sediments. The greenstone belts are intruded by belt-type and basin-type granitic rocks and late stage diorites. Belt-type granites are metaluminous and commonly tonalitic. Basin-types are peraluminous with higher potassium and rubidium than the belt-type granites and are generally granodiorites.

The granite–greenstone terrain that hosts the Namdini Gold Project is in the North Eastern District of Ghana, close to the border with Burkina Faso. The region contains several producing mines both on the Ghana side of the border (the Shaanxi underground gold mine) and in Burkina Faso (the Youga open pit gold mine).

Locally the Nangodi Greenstone Belt trends north-northeast to south-southwest over a distance of 30 km and turns to an east-northeast to south-southwest trend in the south of the area around Namdini. Much of the area to the south of the tenements is covered by later Voltaian Basin sediments. The belts continue underneath this cover.

Structurally the north eastern region of Ghana is characterized by steep isoclinal folding with near vertical axial planes. The greenstone belts contain locally developed open symmetric folds with axial planar cleavages parallel to bedding in the steeply inclined sediments.

7.2 Geological setting

This description is based on RPA (2017) and MPR (2017):

The Namdini Gold Project covers the southern extension of the Nangodi Greenstone Belt (Figure 8 and Figure 9).

Namdini rock units comprise a steeply dipping sequence of Birimian inter-bedded meta-sedimentary and meta-volcanic units, which have been intruded by tonalite and diorite. The meta-sedimentary and volcaniclastic rocks have been intensely altered with a pyrite-carbonate-muscovite-chlorite-quartz assemblage. The tonalite is extensively altered and has been overprinted by silica-sericite-carbonate assemblages.

Petrography and mineralogy in the following sections is based on thin and polished section work by Townend Mineralogy Laboratory ("TMS") of Perth, Western Australia, as referenced in RPA (2017).

The regional geography for the northern Ghana region is show in Figure 8 below with the local geology shown in Figure 9.

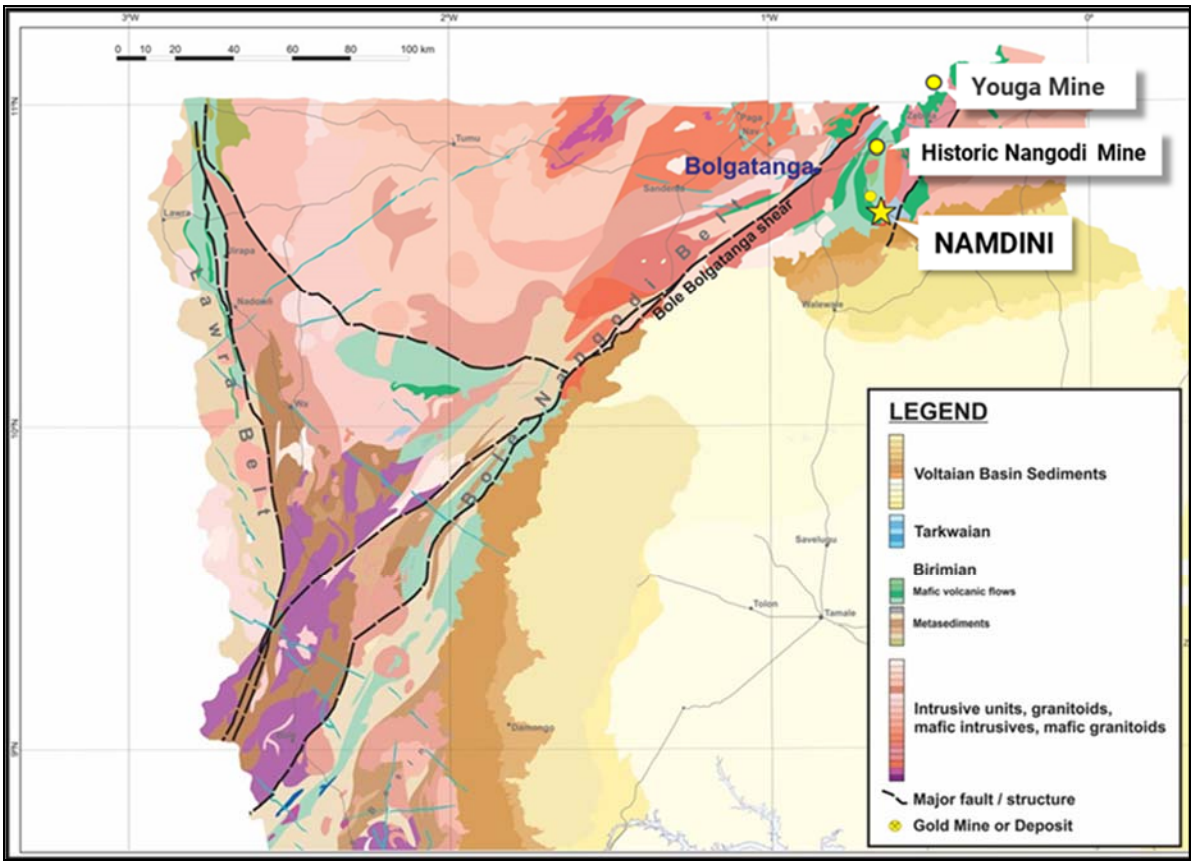

Figure 8: Regional geology of northern Ghana (source: Cardinal 2017)

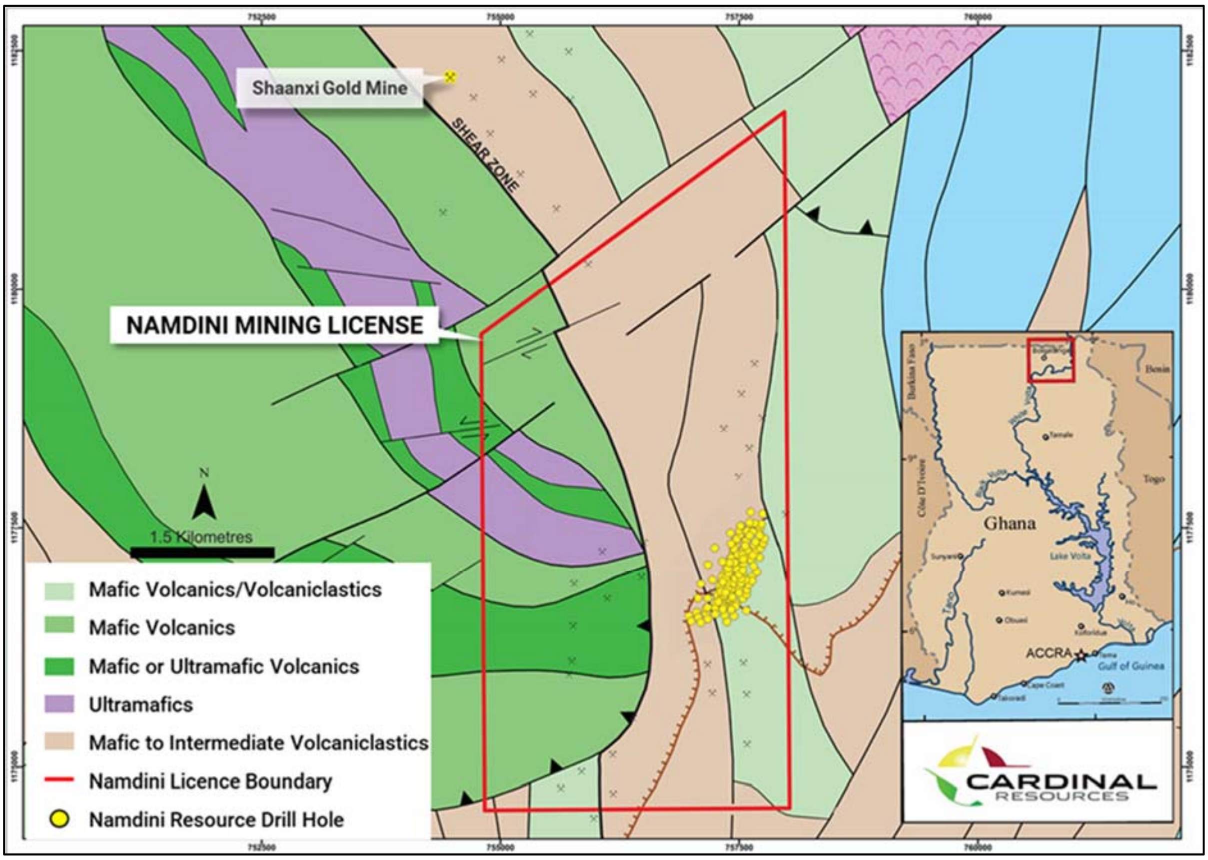

Figure 9: Local geology of the Namdini Gold Project (source: Cardinal 2017)

7.3 Structural geology

In 2016, geological consultants from Orefind Pty Ltd ("Orefind") conducted an on-site structural study and then developed a structural framework with controls on, and geometry of, the gold mineralization comprising the Namdini deposit.

Orefind's review of diamond drill core and outcrops suggested two discrete stages of gold deposition and emplacement of vein minerals and associated alteration. Currently, the structural overprinting, geometries, and kinematics are thought to be consistent with deposition of mineralization in both D1 and D2 foliation- forming events. It is likely that this represents two stages of gold deposition punctuated by a deformation hiatus between D1 and D2, i.e., the emplacement of successive mineralization-associated vein stages does not represent a single evolving event. The formation of intense D2 structures, in particular the penetrative S1-S2 composite foliation, have strongly modified or destroyed D1 overprinting and geometric relationships.

The Namdini mineralized system is located in a zone of oblique, sinistral, east side-up shearing that developed during D2. S1 is also an intense foliation and much of the foliation development is represented by a penetrative, composite S1-S2. This suggests a formation of the host shear zone during D1, with intense reactivation of the system in D2. Overall, the intensity of D2 has resulted in a strong preferred orientation of mineralized zones controlled by S2 and mesoscale F2 folds, with any D1 controls being preserved in local D2 low strain zones. Alternatively, the deposit may be located on the limb of a fold of a larger scale than the deposit.

S1 is a pervasive foliation and commonly occurs in the hinges of D2 differentiated crenulations. S2 manifests variably as an intense foliation, a spaced cleavage, a differentiated crenulation cleavage, and as a contributor to a composite S1-S2 produced by transposition of S1. Intense deformation during D2 has commonly resulted in rotation of the S1 into the S2 orientation, resulting in transposition of S1 with S2 and the formation of a pervasive composite S1-S2 foliation.

Orefind's traverses across the mineralized sequence determined that the S1-S2 asymmetry is consistent across the deposit. S1 strikes acutely clockwise of strike of S2. This asymmetry is consistent with D2 kinematic indicators, which indicate a constant sinistral sense of shear in plan. In section, the kinematics during D2 appear to have been E-side-up. Overall, Orefind noted that the mineralized package has accommodated sinistral, E-side-up, oblique shear.

Foliations are less well developed in the tonalite, with most structures represented by quartz ± carbonate vein arrays and silica-sericite fractures or veinlets. Faults are uncommon in general. In the tonalite, faults tend to manifest as zones of enhanced quartz veining or local fracturing.

Parasitic folds are common in the core but were not observed in the field. This is interpreted as a function of exposure, rather than lack of development.

The majority of textural relationships are indicative of mineralization in D2, and this likely represents the period of greatest deposition. Structural orientation controls on the geometry of mineralized zones will be overwhelmingly along the north-northeast to south-southwest D2 trends of S2 and L12 intersection lines. Lesser orientation controls are likely to have a north- south trend indicative of vein orientations in D2 extensional jogs, especially for quartz veins in the tonalite.

7.4 Host rocks

The Namdini gold mineralization is located in the Nangodi Greenstone Belt within a host sequence of meta- volcaniclastics, granitoids (tonalite), and diorites. The deposit is bounded on the hangingwall and footwall sides by metasediments.

The meta-sedimentary rocks are fine- grained chlorite-muscovite schists.

The meta-volcaniclastic rocks are very fine-grained, chlorite-muscovite phyllites.

Granitoid samples are classified as altered, sheared, sulphide-bearing tonalite. A tectonic foliation is developed in the intrusive rocks but is not pervasive in the granitoid.

The diorite rocks are assumed to be late stage intermediate diorite stock and dykes. They occur as altered (shearing, silicification, chlorite, and sericites) or unaltered diorite, as well as Quartz Diorite speckled with quartz and feldspar.

7.4.1 Weathering profile

In the mineralized area, the tropical weathering profile extends to a maximum depth of around 30 meters, comprising the following material types:

- **Strongly Oxidised (SOX)**: total oxidation off all primary minerals with little or no primary rock texture. This zone ranges from 1.0 m to 7.5 m in thickness.
- **Moderately Oxidised (MOX)**: some primary rock texture, total oxidation of feldspar to clay, and total oxidation of sulphides. This zone ranges from 0.5 m to 13.0 m in thickness.
- **Transition (TRANS)**: strong primary rock textures with partial oxidation of feldspars and sulphides. The transition zone ranges from 2.0 m to 14.5 m in thickness.

7.4.2 Alteration

The meta-sedimentary and volcaniclastic rocks have been intensely altered with a pyrite-carbonate-muscovite-chlorite-quartz. Alteration is prevalent in the volcaniclastic rocks.

Similarly, the tonalite is extensively altered and has been overprinted by silica-sericite-carbonate assemblages. The identity of carbonate alteration is difficult and is best described as iron-carbonate in the absence of petrological or geochemical characterisation. Fe-dolomite and ankerite units have been noted by TMS, although these can be difficult to unequivocally identify.

7.4.3 Mineralization and gold particle size

Drilling has outlined mineralization with three-dimensional continuity, with a size of approximately 1,500 m long, 550 m wide, and 450 m in depth.

In all rock types, the mineralization is accompanied by visible disseminated sulphides of pyrite and arsenopyrite in both the veins and wall rocks. In diamond drill core, the mineralized zones are visually distinctive due to the presence of millimeter to centimeter wide quartz-carbonate veins that are commonly folded and possess yellow-brown sericite-carbonate selvedges (Figure 10).

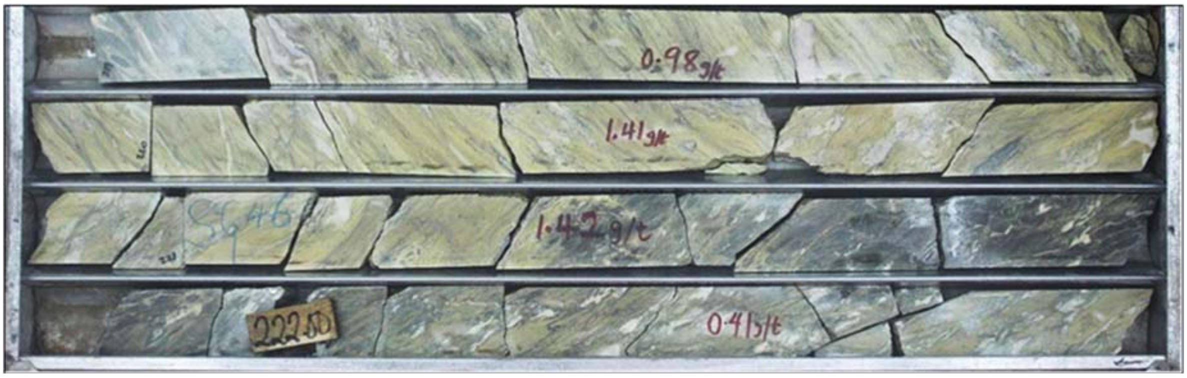

Figure 10: Alteration in drill hole NMDD007 at 227.33 m to 231.95 m (source: RPA, 2017)

Visible gold was identified by Cardinal, Orefind, and RPA. Its instances occurred in strongly altered granite and were associated with silica-sericite shears that had sub-millimeter widths, as well as in the diorite.

Petrological work by TMS showed that gold is primarily associated with sulphides, in particular pyrite, where it commonly occurs as inclusions and on the crystal margins. Gold was also noted in phyllite matrix and, to a much lesser extent, in association with ilmenite.

Mineragraphic analysis by TMS has shown that very fine-grained gold less than 5 µm (microns) is dominantly associated with, and as inclusions within, disseminated sulphides and less commonly silicate minerals (Figure 11).

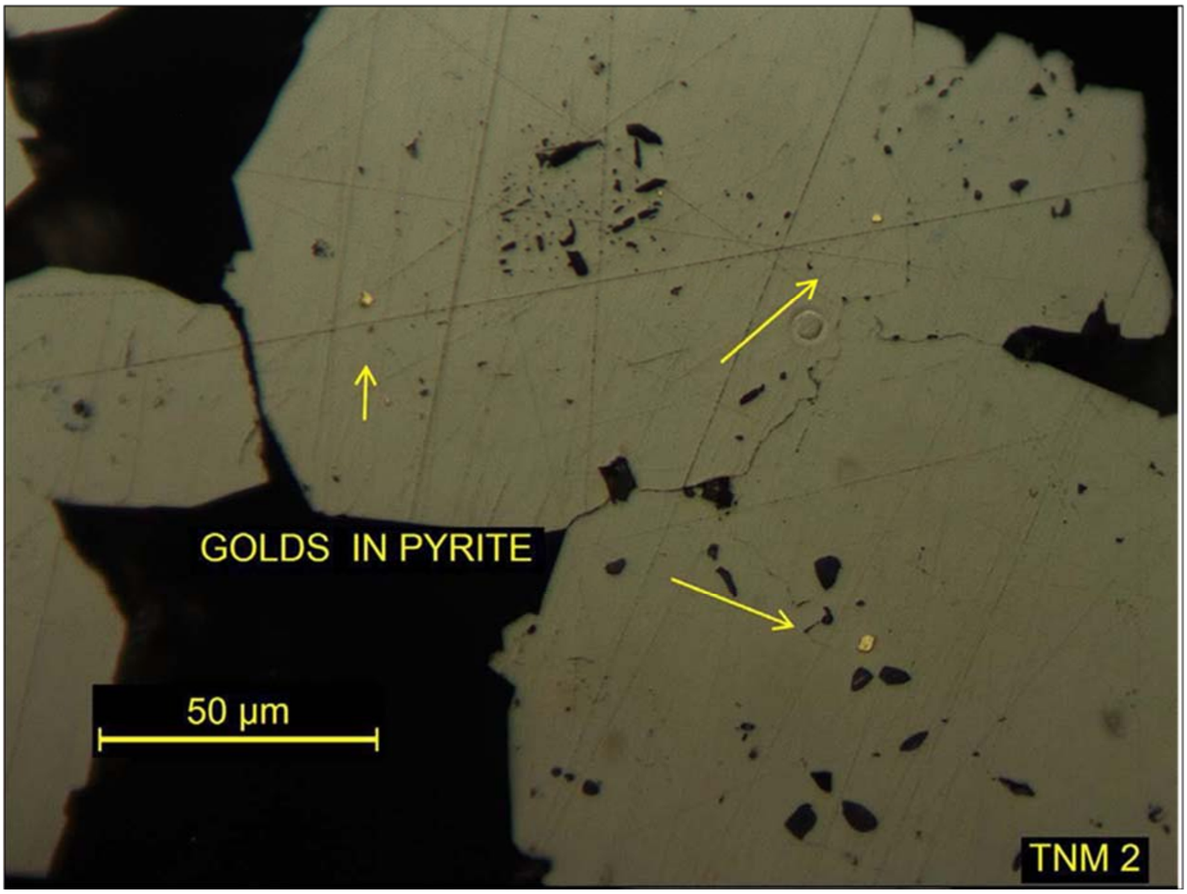

Figure 11: Gold associated with pyrite in sample TNM2 (source: TMS in RPA, 2017)

Notes on Figure 11:

The primary rock is a muscovite rich phyllite that shows extensive carbonate replacement. The phyllite hosts a major sulphide content and significant gold. The fine-grained muscovite shows a moderate preferred orientation and is heavily impregnated with ankerite carbonate.

The dominant ore minerals are pyrite and arsenopyrite that occur relatively commonly through much of the phyllite matrix. Tennantite, chalcopyrite, pyrrhotite, galena, and sphalerite all occur as fines within some pyrites. Magnetite was also detected once.

About twenty-five occurrences of gold were detected optically. The vast majority occur as inclusions in pyrite. The gold appeared low in silver. These included golds in pyrites that were predominantly under 5 µm, with the exceptions of a linear nature, reaching 25 µm. Most were single particles plus a rare trio.

The host pyrites had a wide range of grainsizes from 50 µm to 600 µm. Two occurrences of gold were single fine grains of 2 µm within silicate.

7.4.4 Cardinal logging codes

Table 12 presents a summary of the revised lithological codes and descriptions used by Cardinal geologists for geological logging purposes.

Table 12: Summary of Cardinal geological logging codes and descriptions

Code	Description
LAT	Laterite, ferruginous duricrust developed *in situ*
SPR	Saprock (<20% weatherable minerals altered)
SAP	Saprolite (>20% weatherable minerals altered)
GRA	Granodiorite or tonalite, altered Felsic rocks (sericites, muscovite, carbonate and K-feldspar)
DIO	Intermediate rocks, altered (shearing, silicification, chlorite and sericites) and unaltered diorite, Quartz Diorite speckled with quartz and feldspar
MVO	Mafic rocks, volcaniclastics, altered (sericites, chlorites + silicification)
MSE	Metasedimentary rocks, dominated by quartz-carbonate veining + haematite and chlorite
LTF	Pyroclastic rocks and tuffs
BX	Breccia
QTZ	Quartz

8.0 DEPOSIT TYPES

The important types of gold mineralization in Ghana occur in three types:

- Steeply dipping quartz veins with native gold in shear zones at Birimian belt/basin boundaries.
- Disseminated sulphide bodies, spatially (though not necessarily genetically) related with the shear zones and quartz veins, with auriferous arsenopyrite as major host of gold.
- Disseminated and stock work mineralization in late-kinematic 'basin type' granitoids.

The Birimian gold deposit types can be summarised as follows:

> *The majority of the gold occurs in two styles of mineralization: (1) mesothermal quartz vein-hosted and associated gold in metavolcanics and metasediments, and (2) modified palaeoplacer gold in conglomerates. These styles of mineralization occur in the Palaeoproterozoic Birimian Supergroup and Tarkwaian Group that make up Ghana's mainly southwest to northeast trending Birimian belts:*
>
> *Significant gold resources also occur as hydrothermal mineralization in basement-type granitoids which show some geological association with the Birimian Supergroup-hosted mesothermal mineralization. The majority of the gold mineralization is believed to have formed between approximately 2.15 and 2.6 Ga during the Eburnean orogeny.*
>
> *The mesothermal quartz vein gold mineralization is usually confined to tectonic corridors within the Birimian belts and is strongly associated with shear zones and fault systems. The quartz veins show multiple stages of formation and are steeply dipping, with the gold mineralization occurring either as free gold within fractures in the veins or as invisible gold within disseminated sulphides in the host rocks surrounding the veins. The vein- and sulphide-hosted gold is strongly associated with deformational fabrics formed by the Eburnean extensional and compressional events respectively, suggesting that disseminated sulphide mineralization predates quartz vein-hosted mineralization.*
>
> *The fluid from which the gold precipitated is believed to have been of metamorphic origin and carbon dioxide (CO2) dominated, with lesser water (H2O) and nitrogen (N2) and minor methane (CH4). Gold precipitation was probably caused by decrease in pressure, temperature and CO2-H2O immiscibility, at depths of between 7 and 11 km.*
>
> *Hydrothermal gold mineralization occurs in the Palaeoproterozoic belts and basin granitoids that intrude the Birimian belts, as well as in the sedimentary basins occurring between the belts. Gold mineralization within the granitoids occurs as micro-inclusions in sulphides in small, steeply dipping stockworks and as sulphide disseminations concordant with regional faults and shears. A gold- bearing fluid similar to that for the Birimian Supergroup-hosted quartz vein gold mineralization, but with a larger H2O component, is proposed to have formed the granitoid-hosted gold mineralization.*

The Namdini Gold Project appears to be a typical Birimian gold deposit and is hosted in a mixture of meta- sediments, volcaniclastics, and intrusives. Birimian rocks are composed of granitic-gneiss terranes separated by linear greenstone belts of meta-sedimentary and meta-volcanic rocks.

Current exploration drilling has outlined mineralization with three-dimensional continuity, a size of approximately 1,500 m long, 550 m wide and 600 m in depth, and hosted within defined Birimian gold deposit lithologies. The Cardinal exploration plan is based on defining mineralization in a size and grade that can potentially be extracted economically.

9.0 EXPLORATION

9.1 Summary of relevant work

All exploration work on the Namdini Gold Project was completed by Cardinal. A field office with core logging and storage facilities is located near to the Namdini Gold Project site in Bolgatanga.

The primary objectives of Cardinal's exploration strategy are to:

- Improve understanding of the extent and style of mineralization in order to successfully increase the size and confidence level of the Mineral Resources for Namdini.
- Develop deposit models and use grassroots exploration methods to search for gold (and pathfinder elements) to potentially locate other deposits throughout Northern Ghana.

The Namdini Gold Project was first discovered in September 2013 by prospecting. A small-scale mining licence was approved in 2014 and Reverse Circulation (RC) drilling began shortly thereafter. Cardinal drilled additional RC holes in the same licence area after reviewing initial RC results. At the conclusion of approximately 88 RC holes Cardinal had sufficient confidence in the potential size of the Namdini Gold Project to step out 600 m north along strike and drill a surface diamond drill hole (NMDD002) that intersected 87 m at 1.08 g/t Au and numerous other significant intersections.

Cardinal has built a team of site-based field geologists led by an experienced Exploration Manager. A Global Positioning System (GPS) on site is the most common navigation and survey tool in the field to locate and update geographic information.

9.2 Exploration Procedures

Cardinal's grassroots exploration procedures are generally focused on staged exploration in order to achieve quick and effective means of sampling vast areas of land for the purpose of generating targets for further detailed work.

All field sampling activities are carried out by a team of geologists, which is headed by Cardinal's experienced Exploration Manager. A Global Positioning System (GPS) is the most common navigation tool used by the exploration crew in the field in order to locate and update geographic information.

Cardinal's regional exploration activities outside the Namdini deposit area are of little relevance to the current Mineral Resource estimates and are not detailed in this report Sections 10.0, 11.0 and 12.0 describe drilling, sampling and assaying procedures in more detail for the Namdini Resource.

9.3 Geophysical surveying

A high-resolution, 100 m line-spaced airborne magnetic-radiometric survey was carried out by Terrascan Airborne from August to December 2013 over all of Cardinal's properties in north eastern Ghana.

During 2016, Terratec Geophysical Services completed a ground magnetic survey and induced polarisation (IP) survey over the Namdini deposit. The data was processed and interpreted by Southern Geoscience Consultants who generated a suite of digital images and contours, and a litho-structural interpretation at 1:50,000 scale over the area of the survey. This interpretation provided Cardinal with a detailed Project-wide geological and structural map for exploration target development and assessment activities.

9.4 Local grid

Consistent with supplied sampling information, the current study was undertaken in a local grid developed by Sahara. Unless specified, all coordinate references, and orientations in this report reflect the local grid.

The local grid transformation comprises an eight-degree rotation from WGS coordinates (Table 13), with no elevation change. The transformation rotates the obliquely (WGS) trending drill traverses to east-west (local) grid.

Table 13: Local grid translation details

Translation Point	UTM: WGS 84 Zone 30 N		Local	
	East (mE)	North (mN)	East (mE)	North (mN)
1	757,032.992	1,175,611.678	15,000.000	51,800.000
2	757,380.925	1,178,087.348	15,000.000	54,300.000
3	758,569.247	1,177,920.341	16,200.000	54,300.000
4	758,221.314	1,175,444.671	16,200.000	51,800.000

10.0 DRILLING

The Mineral Resource estimate forming the basis for this PEA was carried out by MPR (2017) and a comprehensive report, "Technical Report Mineral Resource Estimation for the Namdini Gold Project, Ghana 19 Oct 2017" is provided on Sedar (https://www.sedar.com).The information in Sections 10.0, 11.0, 12.0 and 14.1 is derived from MPR (2017).

10.1 Drill holes used for the Mineral Resource estimate

10.1.1 Summary

The Mineral Resource estimate is based on RC and diamond information available on the 11 September 2017 as summarised in Table 8 and shown in Figure 12, totalling 275 holes for 67,122 meters of drilling. RC and HQ diamond drilling provides around one third and two thirds of the estimation dataset respectively. Relative to drilling information available at December 2, 2016 for the previous Mineral Resource estimate (RPA, 2017), the current estimate includes an additional 33,406 meters of drilling.

The Mineral Resource estimates include only RC and HQ diamond drilling shown in Table 8 in Figure 12, and exclude non-resource drilling, comprising:

- A single metallurgical hole without routine down-hole assays,
- 71 Sterilisation RC holes from outside the resource area, and
- 172 closely spaced holes, drilled as part of a current grade control trial program.

The resource drilling comprises east-west trending traverses of easterly inclined holes. Hole spacing varies from around 12.5 by 25 meters in the shallow portions of southern part of the deposit to around 50 by 50 meters and broader in the north and at depth.

Table 14 summarises the number and proportion of composites from the main mineralized domain by drilling group. This table provides an indication of the relative contribution of each group to resource estimates which is an important consideration for review of sampling quality information. Key features of this summary include the following:

- HQ Diamond drilling provides around two thirds of the dataset with RC sampling contributing around one third.
- Half and quarter core samples represent approximately equal proportions of the diamond core data.

Most mineralized domain RC composites are from drill holes completed by the Cardinal (55%) and AMS rigs (28%) with the Minerex and Toomahit rigs contributing comparatively minor amounts. Table 14 and

Table 15 presents a summary of the drilling completed to September, 2017.

Table 14: Namdini RC and HQ diamond drilling

Group	Year	Number of Holes			Drill Meters		
		RC	Diamond	Total	RC	Diamond	Total
Resource	2014	44	1	45	4,749	66.00	4,815
	2015	42	9	51	4,939	2,128	7,068
	2016	19	71	90	3,991	16,400	20,391
	2017	36	53	89	8,209	26,639	34,848
	Subtotal	**141**	**134**	**275**	**21,888**	**45,234**	**67,122**
Grade control	2017	172	-	172	7,224	-	7,224
Metallurgical	2017	-	1	1	-	236.10	236
Sterilisation	2017	71	-	71	7,107	-	7,107
	Subtotal	**243**	**1**	**244**	**14,331**	**236**	**14,567**

Group	Year	Number of Holes			Drill Meters		
		RC	Diamond	Total	RC	Diamond	Total
Total		**384**	**135**	**519**	**36,219**	**45,470**	**81,689**

Table 15: Mineralized domain estimation dataset by sampling type

Drilling Type	Group		Number of Composites	Proportion of Drill Type	Proportion of Total
RC	Drill Rig	Cardinal	4,293	55%	19%
		AMS	2,188	28%	10%
		Minerex	964	12%	4%
		Toomahit	409	5%	2%
		Subtotal	**7,854**	**100%**	**35%**
Diamond	Sample Type	Half core	6,618	47%	30%
		Quarter core	7,593	53%	34%
		Subtotal	**14,211**	**100%**	**64%**
Total			**22,065**		**100%**

At completion of drilling, the drill hole collars were encased in concrete and hole details inscribed into the concrete and written on the collar pipe. The collar locations were surveyed by qualified independent surveyors from Sahara Mining Services using high accuracy differential GPS (DGPS) techniques.

During a site visit in 2016 RPA (2017) validated the 3D coordinates of 8 drill hole collars using a hand-held GPS which were found to be consistent with the Cardinal DGPS measurements.

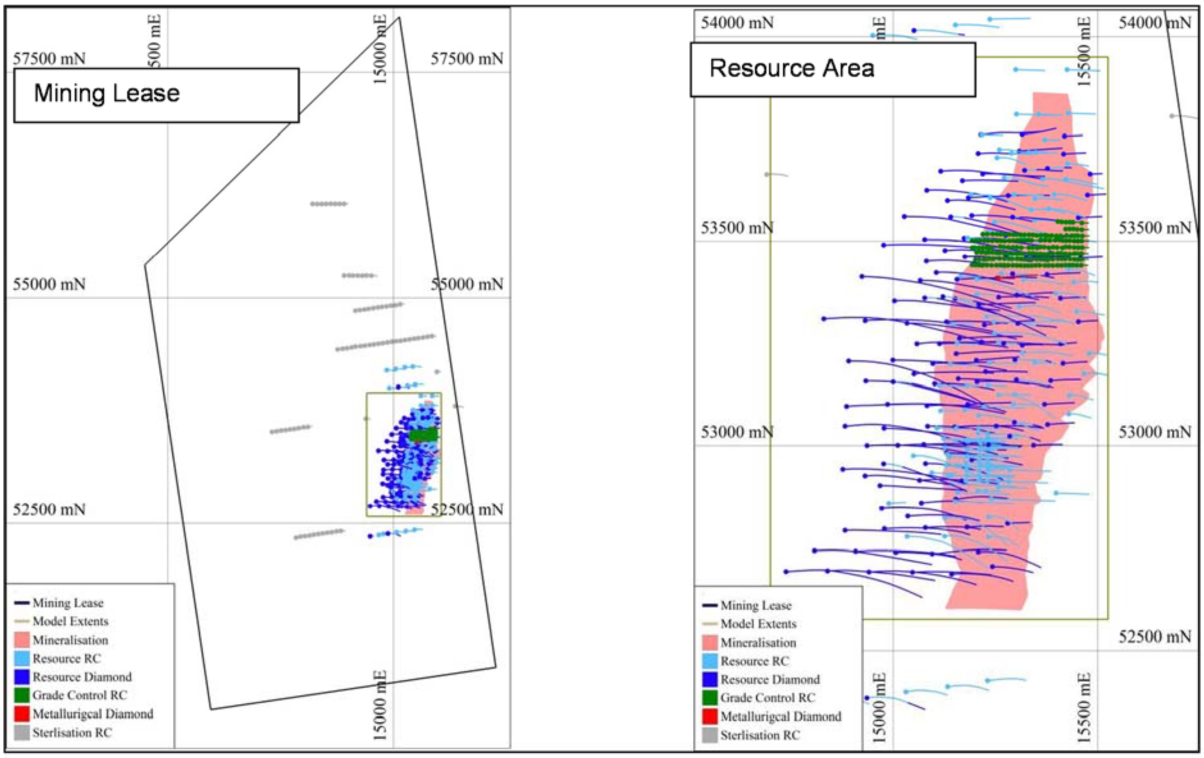

Figure 12: Namdini drilling, mineralized domain, model extents and tenement.

10.2 Down-hole surveys

Table 16 and Figure 13 show the number and proportion of mineralized domain composites in the estimation dataset by down-hole survey availability.

Most diamond holes and deeper RC holes were surveyed by electronic single-shot tools with an initial survey at six, or rarely around 30 meters depth, and subsequent surveys at generally 30 meter intervals to hole end. The holes with comprehensive down-hole surveying contribute around three quarters of mineralized domain composites. The remaining holes have variable down-hole survey coverage including the following:

- No down-hole surveys are available for drill holes providing around half of the mineralized domain RC estimation dataset.
- Rare RC drill holes, which provide 6% of the RC composites, were surveyed within the drill rods giving only inclinations and not azimuths. Locations of these hole paths have not been accurately defined.
- RC portions of pre-collared diamond holes were surveyed within the drill rods giving only inclinations and not azimuths (6%). Without accurately located pre-collars, diamond tails of these holes are less accurately defined than for comprehensively surveyed holes.

The proportion of mineralized domain composites with incomplete or no down-hole surveying reduces with depth. To depths of around 100 meters, less than half of the composites have comprehensive down-hole surveys. Below 200 meters depth, around 90% have full down-hole survey information, and below approximately 380 meters, all composites are from comprehensively down-hole surveyed holes.

Table 16: Down-hole surveying for mineralized domain composites

Down-Hole Survey	Number of Composites			Proportion of Composites		
Availability	**RC**	**DDH**	**Total**	**RC**	**DDH**	**Total**
Un-surveyed	3,804	-	3,804	48.4%	-	17.2%
Dip Only	445	-	445	5.7%	-	2.0%
Dip Only. Limited Survey	32	45	77	0.4%	0.3%	0.3%
Pre-collar un-surveyed or limited	401	1,015	1,416	5.1%	7.1%	6.4%
Comprehensive 30m or closer	3,172	13,151	16,323	40.4%	92.5%	74.0%
Total	**7,854**	**14,211**	**22,065**	**100%**	**100%**	**100%**

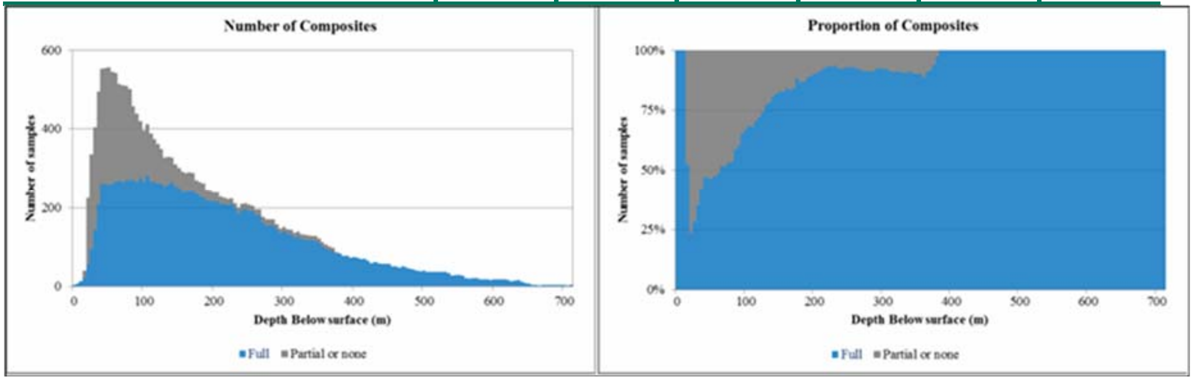

Figure 13: Down-hole surveying for mineralized domain composites

10.3 Diamond drilling

10.3.1 Procedures

The following procedures are in place for HQ Diamond drilling:

- Cardinal core technicians are at the rig site at all times while drilling.
- Core orientation of every core run.
- Geotechnical logging at the rig prior to core being put in core boxes, including recording recovery for every core run.
- Core photography (wet and dry).
- Geological logging using tablet-based software.
- All diamond drilling was at HQ diameter, with soft near surface materials drilled with a triple tube core barrel to reduce core losses.
- Early HQ Diamond Drilling was longitudinally quartered for sub-sampling with a diamond saw. For later drilling, the core was halved for assaying. Sample intervals range from 0.2 to 1.8 meters in length, with most samples assayed over one meter intervals

10.3.2 Core recovery

Core recovery measurements are available for around 58% of the Namdini diamond drilling.

Core recoveries are recovered lengths for core runs which range from 0.1 to 8.5 m and are dominated by three meter intervals. These data were composited to three meter intervals to provide a consistent basis for analysis. Table 17 summarises core recoveries for the three meter composites by modelling domain.

The combined dataset of fresh rock core recoveries averages 99.9% with only approximately 4% of composites showing recoveries of less than 99%. These recoveries are consistent with high quality diamond drilling. Although lower than for fresh rock, average core recoveries for weathered and transitional intervals are within the range shown by high quality diamond drilling.

Table 17: HQ Core Recovery by Domain

Weathering	Background		Mineralized		Total	
Domain	Number	Average Recovery	Number	Average Recovery	Number	Average Recovery
Weathered	95	95.88%	167	94.32%	262	94.89%
Transition	177	98.14%	176	96.66%	353	97.40%
Fresh	2,598	99.80%	5,528	99.89%	8,126	99.86%
Total	**2,870**	**99.56%**	**5,871**	**99.63%**	**8,741**	**99.61%**

10.4 Reverse Circulation drilling

The following procedures are in place for Reverse Circulation (RC) drilling:

- A Cardinal project geologist is at the rig site at all times while drilling.
- All holes are collared with six meters of PVC casing
- Samples are collected over one meter down-hole intervals using a cyclone, with sub-sampling by a three tier-riffle splitter. Some intervals without mineralization were composited over four meter intervals for analysis but the proportion of these is not significant.
- The riffle splitter is routinely cleaned with a rubber mallet and compressed air.
- Hole clearance and stabilisation on every rod change and compressed air 'blow-back' on each meter of sampling through the cyclone to avoid any smearing.
- Recovered sample material is routinely weighed for each interval.
- Cessation of the hole if wet samples are encountered with completion by diamond drilling.
- Collection of sieved samples for geological logging in plastic chip trays, with geological logging at the drill site and follow up logging at the Bolgatanga office. The chip trays are securely stored for future reference.

10.4.1 RC sample quality

Sample condition is an important factor in the reliability of RC sampling, as wet samples can be associated with unrepresentative, potentially biased samples. Of the total of 19,775 RC samples, 36 were logged as 'moist' and 7 were logged as 'wet'. This indicates that the reliability of moist or wet samples does not affect general confidence in the Mineral Resource.

10.4.2 RC sample recovery

Recovered RC sample weights are available for sample intervals representing around 55% of the RC drilling.

In conjunction with bit diameters, density measurements and moisture content estimates, recovered sample weights provide an indication of sample recovery for RC drilling which is an important factor for assessment of the reliability of the sampling. Sample recovery for high quality RC drilling typically averages around 80%. Experience also suggests that sample recoveries consistently less than approximately 70% can be associated with unrepresentative samples and significantly biased assay grades.

For each weighed RC sample, after allowing for hole diameter, density and an assumption for bit wear, recoveries were estimated (Table 18). Average recoveries above 86% for transition and fresh material is consistent with good RC sampling. At 74%, average recovery estimated for oxide material is somewhat lower, but still supports reasonable quality RC sampling.

Investigation of RC sample recovery by down-hole depth showed typical cyclic trends with lower values at six meter increments representing the first sample of each six-meter drill rod, but no consistent variability in average gold grade with rod position, suggesting the variability in sample recovery does not significantly affect representivity of RC samples.

Golder is of the view that further resource definition RC drilling at the Namdini Gold Project should continue to be comprehensively validated by HQ Diamond drilling.

Table 18: Average RC sample recovery by domain

	Oxide		**Transition**		**Fresh**		**Total**	
	No.	Avg.	No.	Avg.	No.	Avg.	No.	Avg.
AMS	197	78%	268	90%	4,557	85%	5,022	85%
Cardinal	478	74%	459	86%	2,598	86%	3,535	84%
Minerex	346	73%	208	90%	1,976	88%	2,530	86%
Toomahit	82	74%	78	84%	784	81%	944	81%
Combined	**1,103**	**74%**	**1,013**	**87%**	**9,915**	**86%**	**12,031**	**85%**

10.4.3 RC field duplicate samples

RC field duplicates were collected at an average frequency of around one duplicate per 20 primary samples. The duplicates were collected consistently with, and assayed in the same batch as, original samples to define the repeatability of field sampling.

Table 19 shows averages for original and field duplicate samples, by drilling rig. The field duplicate assays show reasonable repeatability, consistent with good quality RC sampling for gold.

Table 19: RC field duplicates

Au g/t	**Cardinal**		**AMS**		**Minerex**		**Toomahit**	
	Full Range		**Full Range**		**Full Range**		**Full Range**	
	Orig.	**Dup.**	**Orig.**	**Dup.**	**Orig.**	**Dup.**	**Orig.**	**Dup.**
Number	507		305		153		70	
Mean	**0.72**	**0.67**	**0.44**	**0.44**	**0.57**	**0.62**	**0.48**	**0.55**
Mean dif.		**-7%**		**1%**		**8%**		**15%**

Scatter and QQ plots in Figure 14 show that for Cardinal's rig the field duplicates are on average lower grade than the original samples at high grades however this trend is reversed for the AMS rig. These effects are not significant being due to fewer samples at higher grades.

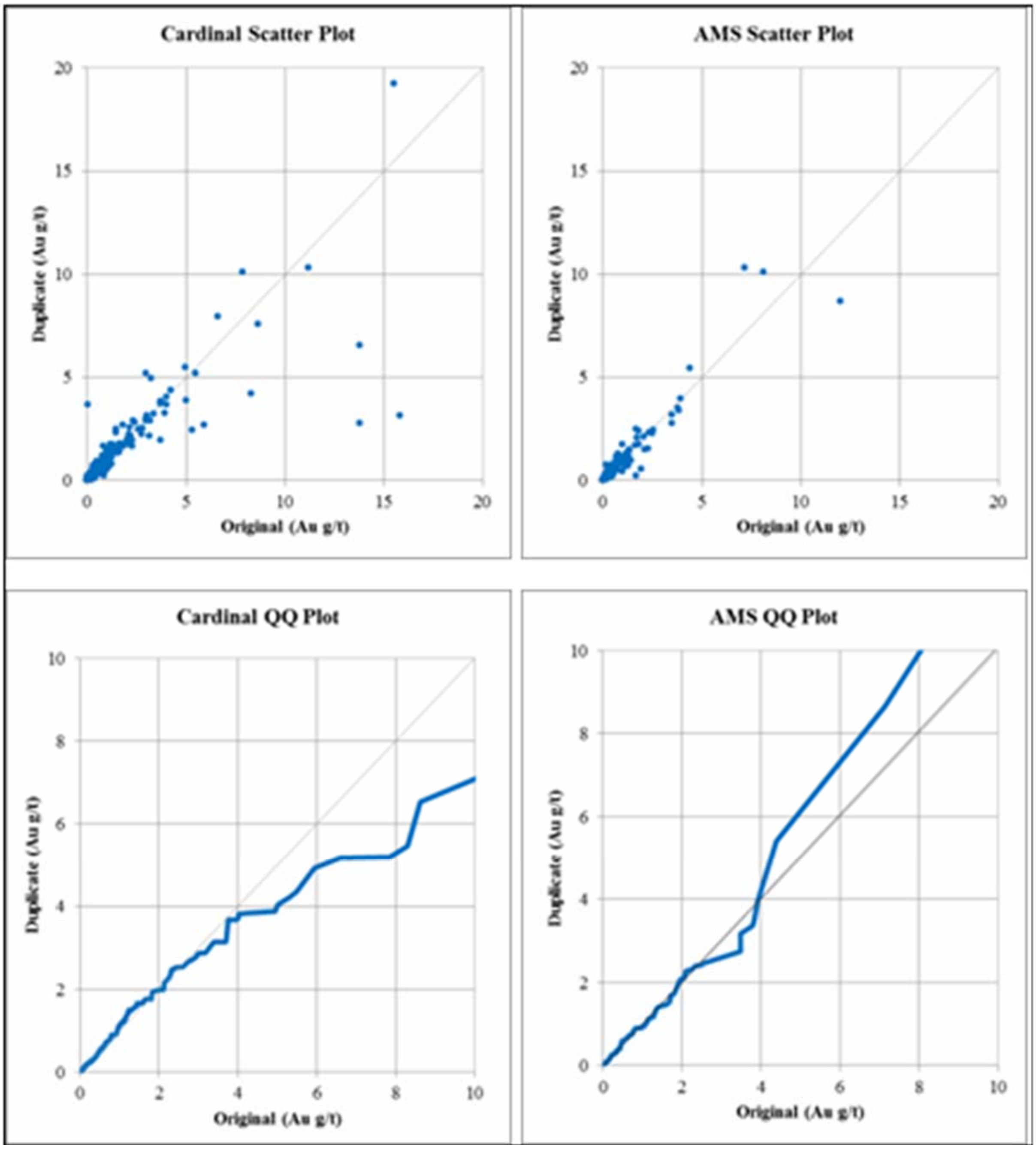

Figure 14: Scatter and QQ plots of RC field duplicates for the Cardinal and AMS drill rigs

11.0 SAMPLING PREPARATION, ANALYSES AND SECURITY

The Mineral Resource estimate forming the basis for this PEA was carried out by MPR (2017) and a comprehensive report "Technical Report Mineral Resource Estimation for the Namdini Gold Project, Ghana 19 Oct 2017" is provided in Sedar (https://www.sedar.com). The information in Sections 10.0, 11.0, 12.0 and 14.1 is derived from MPR (2017).

11.1 Laboratories

Sample preparation and assaying were undertaken by independent commercial laboratories. Most primary samples were submitted to SGS Ouagadougou in Burkina Faso or SGS Tarkwa in Ghana, for gold fire assay. A small proportion were analysed by Intertek in Tarkwa, Ghana.

SGS Tarkwa and SGS Ouagadougou are accredited by the South African National Accreditation System (SANAS) for meeting the requirements of the ISO/IEC 17025 standard for specific registered tests for the minerals industry. Intertek Tarkwa reportedly operates under ISO/IEC 17025 but has not been assessed by a standards association.

Samples analysed by SGS Ouagadougou and SGS Tarkwa contribute approximately equal proportions of the mineralized domain estimation dataset (Table 20) with Intertek providing around 1%. All original sample results in the database analysed by Intertek are from a single drill hole, and in the Inferred Mineral Resource.

Table 20: Estimation dataset by assay laboratory

Assay	Number of Composites			Proportion of Composites		
Laboratory	Background Domain 1	Mineralized Domain 2	Total	Background Domain 1	Mineralized Domain 2	Total
SGS Ouaga	2,809	9,844	12,653	31%	45%	41%
SGS Tarkwa	6,077	11,993	18,070	67%	54%	58%
Intertek Tarkwa	175	228	403	2%	1%	1%
Total	**9,061**	**22,065**	**31,126**	**100%**	**100%**	**100%**

Selected samples from the resource drilling were assayed for additional attributes including sulphur and arsenic. These data were not included in the current estimates.

Samples from sterilisation drilling were analysed by ALS in Kumasi, Ghana. These samples are not included in estimated resources and are not discussed in this report.

11.2 Sample preparation

SGS Ouagadougou and SGS Tarkwa employed consistent sample preparation and analytical procedures as follows:

- Samples were sorted and weighed before being oven dried before and crushed to 75% passing 2 mm.
- A 1.5 kg riffle split sub sample was pulverised to nominally 85% at 75 µm. Remaining coarse reject was retained.
- Samples were fire assayed for gold using a 30 or 50 g charge with an AAS finish, with a detection limit of 0.01 g/t. Assays of greater than 100 g/t were re-assayed with a gravimetric finish.

- Remaining reject and pulverised samples were returned to Cardinal's Bolgatanga Exploration Office for secure storage.

The sample preparation and assay methods used by Intertek (Tarkwa) have not been confirmed.

The reliability of the sample preparation is demonstrated by:

- Diamond core and RC samples were transported from drill sites to secure storage at Cardinals' Exploration Office by Cardinal employees before being delivered to the assay laboratory by laboratory personnel.
- A review by RPA (2017) noted that the chain of custody passes from Cardinal to the assay laboratory at the Bolgatanga sample logging facility. MPR (2017) provides photos of the core logging and secure storage sheds.
- 'Coarse blanks' of un-mineralized granite included in earlier assay batches, which contribute 11% of the mineralized domain composites, show no indication of significant contamination or sample misallocation.
- Modifications to the supplied dataset of blank assay results were limited assigning all below detection assays a value representing half the dominant detection limit (0.005 g/t).

11.3 Assay validation

Samples submitted after May 2015 included 'fine blanks' of pulverised material which did not require sample preparation. These showed no significant misallocation of assays.

11.3.1 Certified reference standards for assaying accuracy

Cardinal's monitoring of assay reliability included insertion of samples into assay batches of certified reference standards prepared by Geostats Pty Ltd, Perth, Western Australia. The standards, which were inserted at an average rate of around 1 standard per 41 primary samples, have expected gold grades of 0.27 to 6.70 g/t.

Table 21 and Figure 15 summarise reference standard assays by laboratory. Although there is some variability for individual samples, for all three laboratories average assay results generally reflect expected values, with no evidence of significant bias, supporting the overall accuracy of gold grades reported by the laboratories used for primary assaying.

For standards with expected gold grades of greater than 1.5 g/t, SGS Tarkwa reports average results around 3% higher than expected values. The magnitude of this difference is not significant at the current level of project assessment.

As evaluation of the deposit continues, additional quality control work such as further inter-laboratory repeat assays should be continued.

Table 21: Summary of Certified Reference Standards assays

Laboratory	Expected Value Range	Number Assays	Average grade g/t Au Expected	Average grade g/t Au Assay	Avg vs. Expected
SGS Ouagadougou	<1.5 g/t	354	0.50	0.50	-1%
	>1.5 g/t	264	3.67	3.70	1%
	Subtotal	**618**	**1.86**	**1.87**	**1%**
SGS Tarkwa	<1.5 g/t	460	0.50	0.50	0%
	>1.5 g/t	450	4.32	4.43	3%
	Subtotal	**910**	**2.39**	**2.44**	**2%**
Intertek Tarkwa	<1.5 g/t	7	0.34	0.32	-7%
	>1.5 g/t	13	3.29	3.31	0%

Laboratory	Expected	Number	Average grade g/t Au		Avg vs.
	Value Range	Assays	Expected	Assay	Expected
	Subtotal	20	2.26	2.26	0%

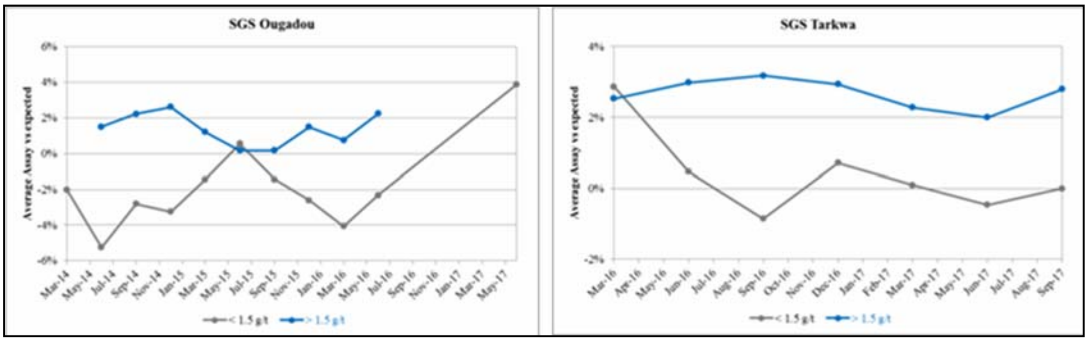

Figure 15: Deviation of assay results for Standards by date (left SGS Ouagadougou; right SGS Tarkwa)

11.3.2 Inter-laboratory repeats

Results for 746 Intertek inter-laboratory pulp repeats reasonably match the original SGS Ouagadougou results supporting the overall accuracy of SGS Ouagadougou assaying.

No inter-laboratory pulp repeats are available for SGS Tarkwa assays, although some comparative assaying on quarter core was done (see Section 12.2 for 165 duplicates also assayed at ALS Ireland). Validation of SGS Tarkwa assays by re-assaying of pulps at another laboratory is planned.

Table 22 and Figure 16 compare the Intertek repeats and original SGS assays. This table and figure demonstrate that twelve anomalous results significantly impact correlation statistics. Excluding these samples gives very close average grades for both laboratories, supporting the general accuracy of SGS Ouagadougou assaying.

Table 22: Intertek inter-laboratory repeats

Au g/t	Full Dataset		Excluding Anomalous	
	SGS Ouagadougou	Intertek	SGS Ouagadougou	Intertek
Number	746		734	
Mean	**4.23**	**3.81**	**3.81**	**3.80**
Mean difference		**-10%**		**0%**
Coef. Var.	3.38	2.97	3.17	2.99

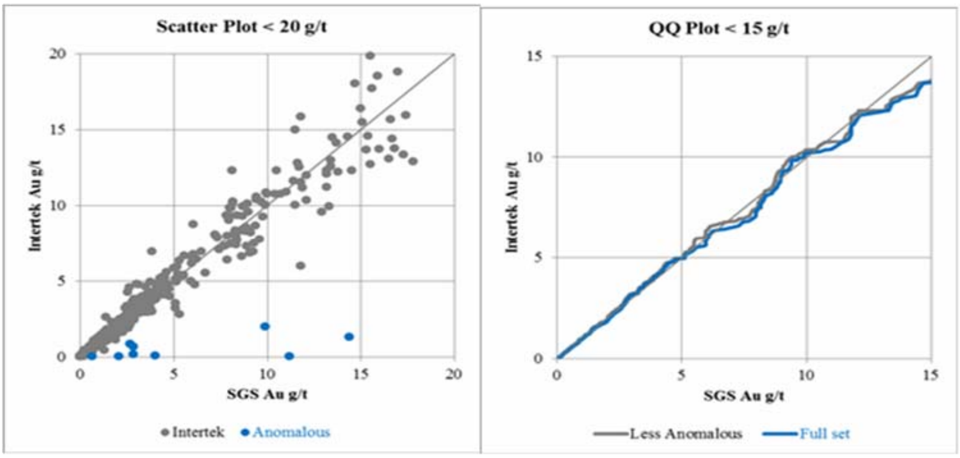

Figure 16: Intertek inter-laboratory repeats

11.4 Bulk density data validation

Available density information totals 5,955 immersion measurements by Cardinal (4,561), SGS Tarkwa (1,129) and SGS Ouagadougou (265). Weathered and porous samples were wax-coated prior to density measurement. Lengths specified for these samples range from 0.1 to 1.4 meters and average 0.3 meters. Cardinal data comprises 77% of the density samples.

Table 23 summarises the density measurements by rock type and weathering domain, coded by the weathering and rock type wire-frames used for the resource modelling. For weathering and rock units with reasonable numbers of Cardinal and SGS measurements, the SGS measurements give very similar average values to Cardinal providing confidence in the repeatability of Cardinal's density measurements.

The trend plots in Figure 17 compare density and gold grade for fresh samples. The density measurements are not strongly correlated with gold grades. Granite samples show no notable association between density and grade. Metavolcanic and diorite samples demonstrate a slight general increase in average density with increasing grade. Measurements for these units show an increase in average density from around

2.80 t/bcm at low grades to 2.83 t/bcm at gold grades of around 4 g/t, an increase of around 1%. These trends are not significant at the current level of project assessment.

Table 23: Density measurements by rock type

Rock	Weath.	SGS		Cardinal		Combined		Cardinal
Unit	Zone	No.	Avg. t/bcm	No.	Avg. t/bcm	No.	Avg. t/bcm	Vs. SGS
Combined	Oxide	19	2.22	120	2.20	139	2.21	-1%
Meta-volcanic	Trans.	26	2.57	21	2.70	47	2.63	5%
	Fresh	617	2.82	1,087	2.80	1704	2.81	-1%
Granite	Trans.	23	2.52	14	2.64	37	2.57	5%
	Fresh	230	2.73	332	2.71	562	2.72	-1%
Diorite	Trans.	-	-	51	2.55	51	2.55	-
	Fresh	328	2.83	1,731	2.79	2,059	2.80	-1%
Meta-sediment	Trans.	59	2.60	66	2.56	125	2.58	-2%
	Fresh	92	2.83	1,080	2.79	1,172	2.79	-2%
Pyroclastic	Trans.	-	-	20	2.60	20	2.60	-
	Fresh	-	-	26	2.73	26	2.73	-

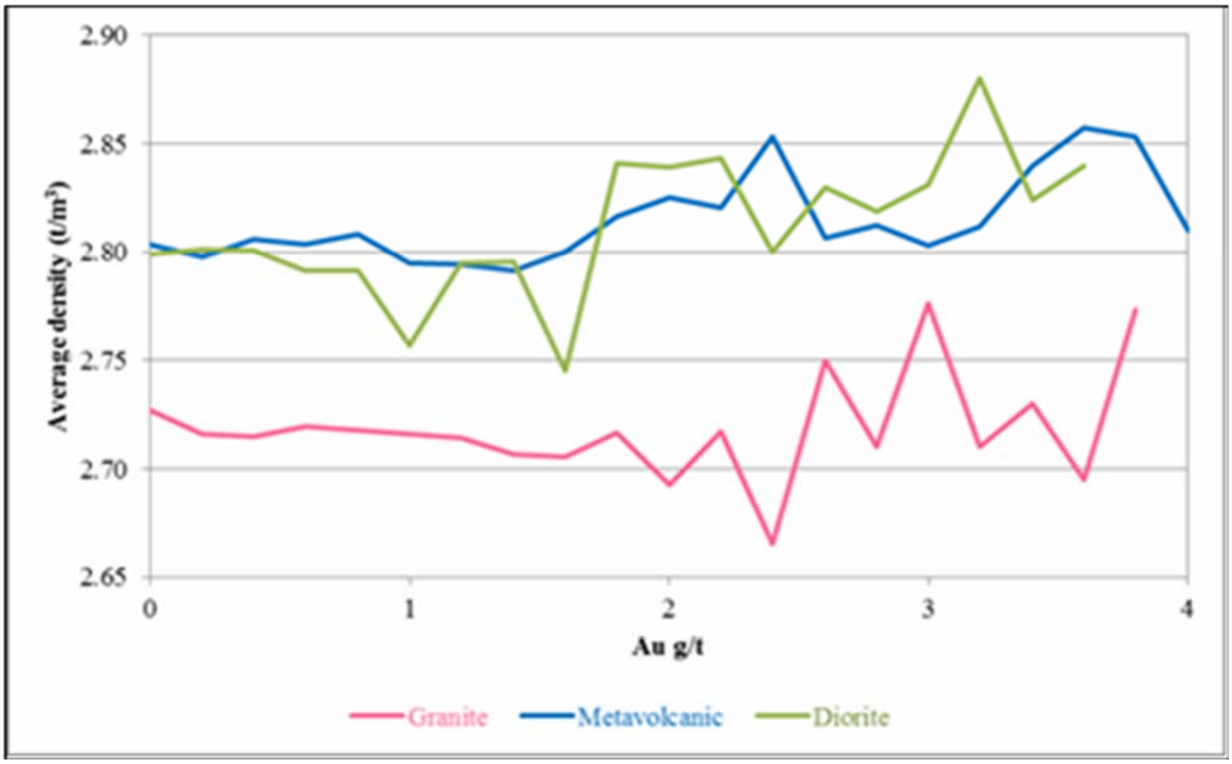

Figure 17: Density versus gold grade for fresh mineralization

11.5 Summary

The sampling and assaying Quality Assurance procedures and the Quality Control results for the Namdini drilling demonstrate that the data used for the Mineral Resource estimate is appropriate at the Preliminary Economic Assessment level of study.

12.0 DATA VERIFICATION

The Mineral Resource estimate forming the basis for this PEA was carried out by MPR (2017). The information in Sections 10.0, 11.0, 12.0 and 14.1 is derived from MPR (2017), supplemented with previous work by RPA (2017).

12.1 Procedures

Cardinal maintains strict protocols with respect to the review and validation of assay results prior to importing into the drill hole database as detailed in RPA (2017). In RPA's opinion, the HQ diamond drilling operations were being completed to industry standard. No RC drills were operating at the time of their site visit.

12.2 Duplicate core sampling

Two sets of duplicate assays from independent quarter core check sampling by consultant geologists employed by Cardinal, are available. Results are summarised in Table 24, which show as expected that there is significant scatter for quarter core duplicates, due to the erratic distribution of gold at short ranges.

Specifically, it was observed that

For the 49 quarter core duplicates collected in July 2016 and assayed by SGS Tarkwa (Figure 18, left):

- 34 had original assays by SGS Ouagadougou with the SGS Tarkwa assays 35% higher
- 15 had original assays by SGS Tarkwa which closely match the original assays.

For the 165 duplicates collected by RPA (2017) as Independent Witness Sampling in January 2017 and assayed by ALS Ireland:

- all had original assays by SGS Tarkwa and show no notable difference in mean grades and reasonable scatter for duplicate core sampling (Figure 18, right), providing confidence in the general reliability of SGS Tarkwa assaying.

Table 24: Independent core duplicates

July 2016 duplicates				
Au g/t	**Original SGS Ouagadougou**		**Original SGS Tarkwa**	
	Original	**Duplicate**	**Original**	**Duplicate**
	SGS Ouaga.	**SGS Tarkwa**	**SGS Tarkwa**	**SGS Tarkwa**
Number	34		15	
Mean	**2.26**	**3.06**	**3.15**	**3.11**
Mean dif.		**35%**		**-1%**
Coef. Var.	1.13	1.24	1.47	1.48

January 2017 duplicates (Independent Witness Sampling)				
Au g/t	Full dataset		< 15.0 g/t	
	Original	Duplicate	Original	Duplicate
Number	165	164		
Mean	1.41	1.34	1.26	1.28
Mean dif.		**-5%**		**1%**

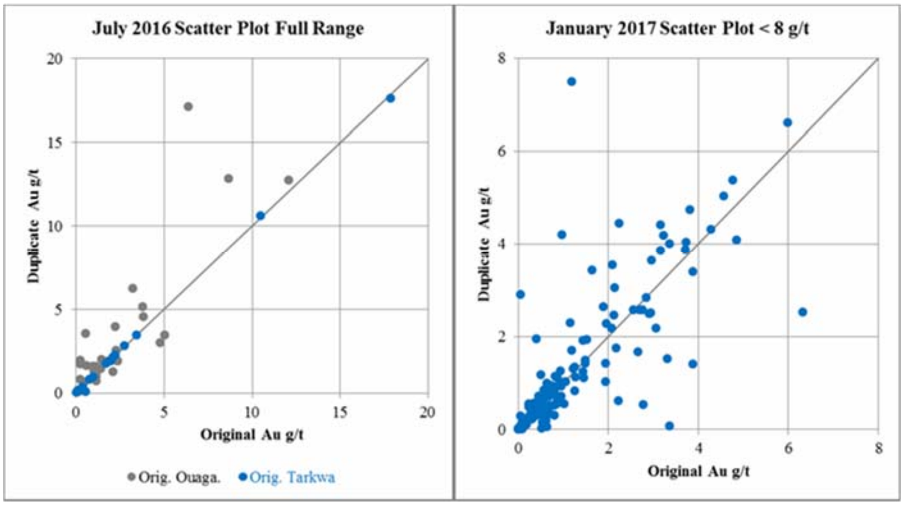

Figure 18: Scatter plots of quarter core field duplicates

Left: SGS Ouagadougou and SGS Tarkwa re-assayed at SGS Tarkwa

Right: SGS Tarkwa assays re-assayed at ALS Ireland (Independent Witness Samples)

12.3 Recent database validation checks

Verification checks undertaken to confirm the validity of the drilling database compiled for the Mineral Resource estimate used in this PEA included:

- Checking for internal consistency between, and within database tables
- Comparison of assay values between nearby holes
- Comparison of assay entries with laboratory source files supplied by Cardinal These checks showed no significant issues.

Laboratory source files supplied by Cardinal include gold assay results for 99.7% of primary assays in the compiled database (Table 25). Inconsistencies found were limited to eight samples from a single drill hole (NMRC147) for which received sample weights which average 2.6 kg were incorrectly entered as gold grades. All gold assays for these samples were reported as <0.01 g/t. These samples represent around 0.01% of the assay dataset. They lie outside the main mineralized domain and the incorrectly assigned values do not significantly impact general confidence in the current estimates.

The available information indicates that the drilling database was generally carefully compiled and validated and is an appropriately reliable basis for Mineral Resource estimation.

Table 25: Laboratory source file checks

Comment	Number of Assays	Proportion of Assays
No significant differences noted	63,699	99.69%
Sample weight entered as gold grade	8	0.01%
Subtotal checked	**63,707**	**99.7%**
Not checked	192	0.3%
Total	**63,899**	**100.0%**

13.0 MINERAL PROCESSING AND METALLURGICAL TESTING

13.1 Introduction

During 2015, metallurgical testwork focused on bottle roll analyses of RC drill cuttings and quarter core samples, and initial gravity and leaching testwork at SGS Vancouver.

In June 2016, the core sampling protocol was adjusted to include routine gold and sulphur analyses of quarter core samples with quarter core allocated for metallurgical testwork. Metallurgical testwork was conducted at the Suntech Geomet Laboratories (SGL), South Africa.

The first phase focused on developing an understanding of the mineralogy and assessing the metallurgical characteristics of the deposit with respect to comminution properties, liberation grind size, and amenability to recovery by froth flotation and cyanidation. Following completion of the first phase, a second phase of testwork aimed to optimise the metallurgical performance using representative samples carefully selected across the entire orebody.

In 2017, Lycopodium Minerals Pty Ltd (Lycopodium) were engaged by Cardinal's as their process consultants, who reviewed the two phases of metallurgical testwork completed to date for the development of the process plant design criteria and recovery flow sheet.

13.2 Phase 1 metallurgical testwork

In July 2016, 332 kg of material was submitted to Suntech Geomet Laboratories ("SGL") in Johannesburg South Africa for a range of metallurgical tests, focusing on milling, flotation, concentrate regrind and carbon- in-leach processing. The metallurgical sample was produced from HQ size quarter core from a single drill hole NMDD005 located in the center of the deposit, containing gold mineralization in all three key rock units (granite, metavolcanics and diorite) as discussed in Section 7.2.2. The sample was chosen to reflect the range of typical grades in each mineralized rock type.

The density of the metallurgical sample was determined to be 2.73 t/m³ using SGL standard procedures.

For each lithology, the material was stage crushed to 100% passing 12 mm, following which it was blended and split by cone and quartering to remove a 10 kg sub sample for SAG Mill Power Index (SPI) and Modified Bond Work Index testwork. The remaining sample was stage-crushed to 100% passing 3.35 mm, blended and split to form a proportionate Master Composite ("MC") sample Table 26.

Table 26: Phase 1 Master Composite sample

Material Type	Total Mass (kg)	Retained (kg)	Composited (kg)	Composite %
Volcanoclastic	136.1	38.3	86.8	40.0
Granitic	137.5	30.8	95.5	44.0
Diorites	58.6	12.8	34.7	16.0
Total	**332.2**	**81.9**	**217.0**	**100.0**

Source: Table 3, Suntech Geomet Laboratories, Metallurgical Test Report for Cardinal Resources, Rpt 034

13.2.1 Gold head grades

The gold grade head assays for the MC sample components were determined by triplicate fire-assay and are presented in Table 27.

- Gold head grades of the three lithologies tested ranged from 0.88 g/t to 1.88 g/t while the MC sample, used for subsequent testwork, had an average grade of 1.42 g/t Au. The MC head grade is near the reported range of 1.1 g/t to 1.2 g/t for the Indicated and Inferred Mineral Resource presented in Section 14.0. Further metallurgical testwork should target Master Composite grades in the range expected to be presented to the process plant.

- The volcanoclastic (V) lithology yielded the highest average gold grade (1.88 g/t) with minimal variation in gold grades. No 'spotty gold' affect was evidenced and gravity recoverable gold is likely to be low.
- The SGL back-calculated MC gold head grade was 1.40 g/t which correspond favourably with the assayed gold head grade of 1.42 g/t.

Table 27: Gold grade of the Master Composite sample

Sample ID	Volcanoclastic (Au g/t)	Granitic (Au g/t)	Diorite (Au g/t)	MC Suntech (Au g/t)
Aliquot 1	1.96	1.01	1.45	1.25
Aliquot 2	1.77	0.78	1.70	1.51
Aliquot 3	1.91	0.86	1.62	1.50
Average	**1.88**	**0.88**	**1.59**	**1.42**

13.2.2 Elemental analysis

A multi-element ICP analysis was conducted on each of the individual lithology samples, and the Master Composite sample. The total sulphur and carbon content of the samples was determined by Leco combustion. Results are provided in Figure 19.

Item	Sample description	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	In	K	Li	Mg	Mn	Mo	Na	Nb	Ni
		ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	%	ppm	ppm	%	ppm	ppm
1	Volcaniclastics (V)	<3	7,21	545	<20	408	<1.2	<15	5,7	<2.5	31	206	55	7,98	15,4	<10	1,42	17,7	2,57	840	9,23	1,39	<5.00	136
2	Granitic lithologies (G)	<3	8,16	225	<20	677	<1.2	<15	2,1	<2.5	11,3	78	24	2,76	17,7	<10	1,69	<10.5	0,54	346	10,6	3,12	7,28	22
3	Diorites (D)	<3	6,79	299	<20	154	<1.2	<15	5,8	<2.5	40	133	125	11,2	15,3	<10	1,37	22	2,79	1101	18,5	1,31	<5.00	101
4	Weighted mean		7,561	364,8		486			4,1		23,8	138	52,6	6,2	16,4		1,53		1,7	664	11,3	2,1		80,2
5	Master Composite (MC)	<3	7,683	388	<20	522	<1,2	<15	4,2	<2,5	20,2	131	52,3	6,3	16,2	<10	1,54	12,5	1,8	690	10,2	2,1	<5,00	79,7
6	*Variance (%)*		*1,6%*	*6,0%*		*7,0%*			*0,0*		*17,9%*	*5,3%*	*0,4%*	*2,2%*	*1,0%*		*0,6%*		*3,5%*	*3,7%*	*10,9%*	*1,8%*		*0,7%*

Item	Sample description	P	Pb	Rb	S^{2-}	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Tl	Ti	U	V	W	Y	Zn	Zr	Hg	C	S
		ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%
1	Volcaniclastics (V)	595	26	53	0,8	5,92	20	<10	<10	365	<5	<10	<4	<1	1990	0,77	148	25	10	89	70	0,35	2,4	0,9
2	Granitic lithologies (G)	569	17,8	60	0,8	8,51	<6	<10	<10	439	<5	<10	4,24	<1	954	2,3	37	45	4,93	52	71	1,2	1,0	0,9
3	Diorites (D)	236	24	75	2,1	4,03	23	<10	<10	176	<5	<10	<4	<1	1990	<0.3	173	<10	7,45	111	31	<0.2	2,8	2,3
4	Weighted mean	526	22,07	59,6	1	6,76	12			367					1534	1,32	103		7,4	76,2	64,2		1,9	1,2
5	Master Composite (MC)	543	37,33	58,33	1,1	6,77	13	<10	<10	372	<5	<10	<4	<1	1558	1,27	105	21,7	7,26	81,3	65,33	0,43	1,8	1,2
6	*Variance (%)*	*3%*	*41%*	*2%*	*4%*	*0%*	*10%*			*1%*					*2%*	*4%*	*1%*		*1%*	*6%*	*2%*		*2%*	*0%*

Figure 19: ICP and sulphur grades comprising the Master Composite sample

It was observed that:

- Silver head grade analysis failed to indicate the amount of silver present as detection limits were high at 3 g/t Ag. Further assaying of metallurgical samples will be required to determine the actual silver levels as the presence of silver will impact on the design of the elution and electrowinning circuits.
- Carbon head grades ranged from 1.0 to 2.8%. No organic carbon analysis was completed; however, testwork indicates a slight increase in gold extraction from direct cyanidation vs CIL cyanidation leach tests.
- Tellurium head assays were not completed to a detection limit commensurate with identifying this mineral as a possible candidate for the refractory nature of the ores. Further metallurgical assaying for tellurium (Te) should be conducted using detection limits that are better than <10 ppm. Detailed mineralogical analysis should identify any gold tellurides present in feed or concentrate samples.

- Sulphur levels of the samples tested ranged from 0.8% to 2.1%, potentially rendering the ore amenable to upgrading by froth flotation.
- Arsenic (As) returned grades that could possibly indicate a limitation to optimal leach performance in certain areas. The results ranged from 299 ppm to 545 ppm As. Future metallurgical testwork programs should monitor As deportment and dissolution to ensure dissolved arsenic levels do not increase to a point where arsenic stabilisation within the tailings stream is required.
- The grades of those deleterious elements which are likely to cause cyanide consumption (Cu, Zn, Pb, Ni, Sb) are low and unlikely to adversely affect cyanide consumption, carbon loading or electrowinning. However, all elements should be monitored throughout the testing.

13.2.3 Gold and sulphur distribution by particle size

Gold distribution by size, for the three individual lithologies and Master Composite sample, was determined by wet screening of the -53 µm size fraction and dry screening of the +53 µm size fractions. The majority of the gold was contained within the coarse +850 µm size fraction (51.3%) and the fine -53 µm (15.2%) size fraction.

The volcanoclastic, granitic and dioritic materials all showed broadly similar results. The sulphur distribution followed a similar trend indicating a strong gold-sulphur association.

13.2.4 Mineralogical characterisation

Mineralogical characterisation on the Master Composite feed sample, rougher concentrate and cyanidation tailings was conducted using XRD and QEMScan analyses. The investigations were conducted to establish the mode of occurrence of the gold bearing minerals, mineral associations, liberation and mineral grain size distribution. Mineralogical characterisation was completed by Mintek Laboratories with pertinent findings summarised as follows:

- Modal mineralogy of the feed and concentrate samples determined that gold occurred predominantly as electrum, with a distribution of 60.5% and 80.5% to feed and concentrate respectively. Free (native) gold distribution to feed and concentrate was 39.6% and 17.4% respectively, indicating that not all free gold was recovered to concentrate.
- Mineral liberation analysis concluded that 96% and 31.8% of the gold contained within the feed and concentrate samples respectively, was associated with sulphides. Grinding of the feed samples to 80% passing 75 µm resulted in only 40.8% of the gold in concentrate being partially exposed. Only 4% and 27.5%, respectively, of the gold present in the feed and concentrate samples were liberated.
- Mineral grainsize analyses concluded that 89% and 78% of the gold contained within the feed and concentrate samples respectively, was finer than 16 µm, while 51.3% and 72.1% respectively was finer than 10 µm.
- Mineral association analyses concluded that the majority of the gold present in the feed and concentrate samples was associated with pyrite (75.4% and 73.8%, respectively). Gold associated with arsenopyrite was also reported. Only 1.5% of the gold in concentrate was associated with arsenopyrite, indicating poor arsenopyrite recovery to the flotation concentrate.
- Free surface or liberated gold accounted for 5.6% of the gold present within the feed samples. Free surface or liberated gold accounted for 20.3% of the gold present within the concentrate samples, indicating that grinding to 80% passing 75 µm has liberated some, but not all of the gold present in the sample. Finer grinding in the mills could potentially improve gold liberation and subsequent extraction by cyanidation and should be further considered.

13.2.5 Comminution testwork

Comminution testwork was conducted on three lithological samples (D = diorites, G = granitic, V = volcanoclastic) and a composite made up of 16% D, 44% G and 40% V. The testwork was limited to generating an understanding of the comminution characteristics of the ore body using a series of paired SPI and Bond ball mill work index testing. BBWI testing was conducted with a 106 µm closing screen. Results from the comminution testwork program showed:

- The SPI testwork indicates that the ore is moderately competent and little variation in competency is evident. The D series samples are marginally more competent than the G and V series samples. The Axb (37.5) from the SPI index also indicates that the material is considered competent.
- The BBWI index indicates that the material is considered moderately hard.

13.2.6 Diagnostic leach testwork

Diagnostic leach testwork was conducted to assess gold deportment within the various mineral phases, on a single Master Composite feed and flotation concentrate sample. This work showed:

- For the MC feed sample, 61.3% of the contained gold was leached by direct cyanidation, while a further 2.8% was leached in the presence of carbon (CIL). Mildly oxidative pre-leaching rendered an additional 8% of the gold amenable to cyanidation.
- In contrast, severe oxidative pre-leaching (HNO3) rendered an additional 27% of the gold amenable to cyanidation, indicating gold locked in pyrite and/or to a smaller extent arsenopyrite. Similar results were obtained for the diagnostic leaching of the concentrate sample, albeit additional gold recovered with CIL was 1.1% and gold associated with carbon was estimated at 1.4%. Additional characterisation work is recommended in the next phase of testing to definitively determine the presence of organic carbon and any potential effects.

13.2.7 Direct cyanide leaching testwork

Direct cyanide leach testwork was conducted on the Master Composite, individual lithology and flotation concentrate samples, using the following standard leach conditions:

- Leach feed density 50% solids (w/w)
- Initial leach cyanide concentration 2,000 ppm (2 kg/t)
- 48-hour leach residence time
- pH 10.5 to 11.0, adjusted with lime
- Leach aeration, air to maintain dissolved oxygen between 6 – 8 mg/L.

The direct cyanide leaching testwork focused on evaluating the impact on leach extraction of grind size, residence time, oxidative pre-treatment and activated carbon.

It was noted that:

- Using grind sizes varying from P_{80} 212 µm to P_{80} 53 µm showed a significant relationship between grind size and residue grade, with residue grade decreasing with increasing grind fineness. The lowest gold residue grade was achieved at a primary grind size of P_{80} 75 µm. Finer grinding to a P_{80} 53 µm yielded no marked improvement in gold residue grade.
- Mineral grain size analysis by QEMScan indicated that the coarsest gold particle observed was less than 16 µm and that 40% of the gold present was smaller than 5 µm.
- Oxygen injection reduced leach residue gold grade from 0.51 g/t to 0.43 g/t. Leach extraction, from a head grade of 1.42 g/t, increased from 64.1% to 69.7%. The addition of lead nitrate (1.6 kg/t) and hydrogen peroxide also reduced gold residue grades to 0.48 g/t and 0.46 g/t respectively.
- Both leach kinetics and overall gold extraction were enhanced by the inclusion of an oxidant, such as lead nitrate. Fast leach kinetics are evident in that between 41% and 56% gold dissolution was achieved within the first hour of leaching. For the baseline series, extending the leach residence time from 24 hours to 48 hours yielded an increase in gold extraction of 1.4%, from 64.1% to 65.5%. For the lead nitrate series, extending the leach residence time from 24 hours to 48 hours yielded an increase in gold extraction of 2.8%, from 66.2% to 69.0%. Given the presence of significant electrum the slow leach kinetic tail, beyond 24 hours is not surprising.

To assess the potential variability in gold extraction between the various lithologies, each lithology was individually tested. All samples were tested under the base line conditions with a primary grind size of

P_{80} 75µm. The diorite samples yielded the highest 48-hour gold extraction at 70.4%, followed by the volcanoclastic samples at 63.8%. The granitic samples yielded the poorest 48-hour gold extraction, at 49.1%. This is possibly attributed to the significantly coarser grind size reported for this sample.

Cyanide consumption for the whole ore leaches was high, ranging from 1.35 kg/t to 1.60 kg/t. No solution analysis to identify the cyanides consumers was conducted. Copper levels in the feed were relatively low (24 to 155 ppm) and would not have contributed to this high cyanide consumption rate. Conducting leaches in the presence of carbon (CIL) is known to give artificially high cyanide consumption levels at the laboratory scale unless the carbon was pre-treated.

With the presence of sulphide (pyrite and pyrrhotite) cyanide consumption may be attributed to iron cyanide complexes and thiocyanate, CNS.

Lime consumption was low and ranged from 0.26 kg/t to 0.53 kg/t.

13.2.8 Flotation testwork

Given the low gold extractions achieved with direct cyanidation leach, flotation testwork was conducted to assess the amenability of the Master Composite sample to flotation. Fifteen flotation scouting test were conducted to assess the impact of various reagent combinations on gold recovery to the flotation concentrate. All flotation testwork was conducted at a primary grind P_{80} of 75 µm. The testwork was completed on 1 kg samples at 40% solids w/w. This showed:

- Flotation yielded good overall gold recoveries to rougher concentrate at acceptable mass pulls (at an average mass pull of 9.5%). The scouting tests achieved an average gold recovery of 93% at a concentrate grade of 16.4 g Au/t.
- Test 11, using copper sulphate, yielded comparable cleaner flotation results to Test 7, and should rougher-scavenger flotation only be considered, Test 11 rougher recovery results are superior to Test 7. Test 11 recovered 99.3% of the gold into a rougher concentrate containing 20.2 g/t at a mass yield of 6.4% while Test 7 recovered 94.2% of the gold into a rougher concentrate containing 22.7 g/t at a mass yield of 5.1%. Further metallurgical testwork is warranted to maximise gold recovery to rougher concentrate.
- All tests using Maxgold 900 (Test 5 and 6) yielded improved gold recovery to cleaner and re-cleaner concentrates.
- Flotation testwork included cleaning and re-cleaning stages to reduce the overall mass of concentrate produced. The upgrading stages reduce overall gold recovery as concentrate mass is reduced and grade increased. A trade-off study is required to determine the capital and operating costs of various downstream concentrate processing circuit sizes (i.e. regrind, thickening, concentrate leach, carbon processing circuits) to validate the use of cleaning stages (e.g. roughing and scavenging with no cleaning may be the best option for maximising project economics).
- Grind optimization testwork (at grind sizes of P_{80} 212, 150, 106, 75 and 53 µm) conducted for the flotation processing route indicated maximum gold recovery occurs at a grind P_{80} between 106µm and 75 µm.
- Flash rougher flotation testwork (7 minutes) indicated it was possible to recover 72% of the gold into a concentrate containing 24.5 g/t gold with a mass yield of 4.6%.
- A single rougher flotation rate test was conducted, on the Master Composite sample, using the optimum conditions from Test 7. Concentrates were collected at timed intervals, with a total rougher flotation time of 31 minutes. The Master Composite sample yielded fast flotation kinetics, with high gold recovery following three minutes of flotation. Further Gold recovery was apparent following seven minutes of flotation with no significant improvement evident after 15 minutes. Further work is required to assess the variability in rougher flotation response.
- Variability in flotation performance, with respect to the lithology samples, was also tested. All variability testwork was conducted using the Test 7 optimum reagent suite. Further work is required to assess the variability in rougher flotation response.

13.2.9 Cyanide leaching testwork – flotation concentrate

Direct cyanide leach testwork was conducted on the flotation concentrates using the following standard leach conditions:

- Initial leach cyanide concentration 5,000 ppm (5 kg/t) to ensure residual cyanide.
- 24-hour leach residence time.
- pH 10.5 to 11.0, adjusted with lime.
- Carbon concentration, 20 mg/L.

The concentrate direct cyanide leaching testwork again focused on evaluating the impact on leach extraction of grind size, residence time, oxidative pre-treatment and activated carbon. This work showed:

- The addition of lead nitrate reduced leach residue gold grade from 15.3 g/t to 14.7 g/t. Leach extraction, from a head grade of 47.5 g/t, increased recoveries by 1.3%.
- Grind sizes varying from P_{80} 22 µm to P_{80} 15 µm showed a significant relationship between regrind size and residue grade exists, with residue grade decreasing with increasing grind fineness. The lowest gold residue grade (9.4 g/t) was achieved at a concentrate regrind size of P_{80} 15 µm.

13.3 Phase 1b metallurgical optimization testwork

In early 2017 further testwork was carried out on the original SGL single drill-hole NMDD005 Master Composite, focusing on concentrate regrind parameters and extended leach times and pre-leach aeration. No additional samples were provided and all Phase 1b testwork was conducted on the remnant samples from the Phase 1 testwork.

13.3.1 Carbon speciation

Representative samples of the Master Composite, flotation concentrate and cyanidation tails were submitted to SGS South Africa for carbon speciation, specifically total carbon (CT), organic carbon (CORG) and graphitic carbon (CGRAPH). Indicators for possible gold losses via preg-robbing (CORG) were all low, except for the flotation concentrate samples, which reported a low organic carbon grade of 0.16%. At these low organic carbon grades, organic carbon is not considered a limitation to good leaching and adsorption performance.

13.3.2 Rougher scavenger flotation

During the Phase 1 testwork campaign, bulk rougher flotation was conducted to produce concentrate for the downstream cyanidation testwork. The bulk rougher flotation testwork, conducted under the optimum reagent regime (Phase 1 Test 7), yielded a concentrate containing 17.7 g/t at a mass yield of 7.8%.

Re-floating of the rougher tails from the Phase 1 bulk concentrate production campaign, for 20 minutes, using a smaller 2.5 L Denver flotation cell, together with the addition of similar reagents used in Phase 1 recovered 23.7% of the gold in tail into a concentrate containing 0.52 g/t Au with a mass yield of 4.9%.

Further testwork is required to assess the impact of rougher-scavenger flotation residence time on gold recovery to concentrate.

13.3.3 Rougher tails size analysis

To determine the gold deportment by size fraction reporting to rougher tails, a size by size analysis was conducted, using wet screening at 25 µm.

Of the gold lost to rougher tail, 40.5% was contained within the -25 µm size fraction whilst 36.1% was contained within the -75 µm +38 µm size fraction.

13.3.4 Bulk concentrate production

A bulk rougher-cleaner flotation campaign was conducted to produce concentrate for further downstream cyanidation testwork. The bulk rougher-cleaner flotation circuit was operated at a higher mass yield, to maximise gold recovery to concentrate. A bulk rougher flotation recovery of 94.8% was achieved, at a mass yield of 8.4%. Following a single stage of cleaner flotation, gold recovery to concentrate of 94.0% was achieved into a concentrate containing 28.8 g/t at a mass yield of 4.6%.

13.3.5 Cyanide leaching testwork

Direct cyanide leach testwork was conducted on the Master Composite feed sample, Phase 1 flotation concentrates and Phase 1b flotation concentrates. This series of direct cyanide leaching testwork focused on evaluating the impact on leach extraction of: grind size, specifically a finer primary grind size of 38 µm, residence time, pre-aeration and ultra-fine grinding of concentrates to 100% passing 7 µm. This showed:

- At a primary grind size P_{80} 38 µm there was a significant relationship between grind size and residue grade, with residue grade decreasing with increasing grind fineness. Gold extraction at a primary grind size of 38 µm, following 48 hours of leaching, was 71.1%, significantly higher than the 64.1% achieved at a primary grind P_{80} of 75µm.
- Ultra-fine grinding to 7 µm yielded no significant improvement in 48-hour leach extraction. Extending the leach to 72 hours yielded a 1.9% increase in gold dissolution.
- Ultra-fine grinding to 14 µm, followed by pre-aeration, prior to cyanidation, yielded the best overall 48-hour gold dissolution, at 86.8%, increasing to 88.3% following 72 hours of leaching. Notably, extending the leach residence time from 24 hours to 72 hours yielded an increased in gold dissolution of 5.3%.

No leach reagent consumptions were reported for this testwork

It was concluded that the best metallurgical performance was attained by flotation (with 94.8% recovery), followed by regrinding of the flotation concentrate to P_{80} 14 µm, pre-leach aeration and cyanidation (with an 88.3% leach recovery).

13.4 Phase 2 metallurgical testwork – life of mine

During 2017, metallurgical testwork was significantly expanded with the production of large scale samples of diamond core from the proposed starter pit area (785 kg), life of mine pit (1,226 kg), a dedicated comminution testwork sample, a flotation optimization testwork sample (360 kg) and a specialised oxide metallurgical sample (114 kg). These samples were selected to be representative of the range of gold and sulphur grades for each rock unit and showed overall recoveries of up to 86%. Further optimization testwork was continuing at the time of this report.

13.5 Design criteria development

The comminution and metallurgical testwork has provided preliminary information about the physical characteristics and metallurgical response of the three Namdini lithologies. The process design criteria were developed based on the available testwork, Cardinal's advice and industry-based assumptions. The processing route selected for the Namdini ores was rougher flotation followed by concentrate regrind and CIL cyanidation of flotation concentrate.

Comminution circuit selection and sizing is detailed in Section 17.1.4. Orway Mineral Consultants (OMC) used the testwork results for circuit selection and mill sizing. A primary crushing and "SABC comminution circuit" (an open circuit SAG mill followed by closed circuit ball mill and recycle pebble crushing) was selected by OMC based on the available comminution parameters.

Grind sensitivity testwork indicated that good flotation recoveries could be achieved at coarse grinds. However, it was agreed with Cardinal that a pre-flotation grind size of P_{80} 106 µm should be used for the PEA study.

A gravity circuit was included in the flowsheet and on the basis that 5% gravity gold was recoverable. The gravity circuit will enable any spikes of high grade material that may be fed to the process plant to be smoothed out prior to the flotation, allowing the gravity gold to be recovered and allowing more consistent operation of the CIL and elution circuits.

The flotation reagent scouting testwork indicated that Test 11 achieved the highest gold recovery to rougher flotation concentrate and these reagent additions were used for the PEA study. The scouting testwork was completed at 40% w/w solids; a conservative solids concentration of 35% was assumed for the PEA study.

The rougher rate flotation testwork indicated fast flotation kinetics, with 98% of the overall recovered gold occurring after seven minutes of flotation with no significant improvement evident post 15 minutes. A testwork flotation time of 14 minutes with a process plant scale-up factor of 2 was allowed for the PEA study.

The concentrate regrind and cyanidation testwork indicated regrinding of the rougher concentrate followed by oxygen aeration prior to leaching with cyanide achieved the highest gold extractions. The concentrate leach testwork was completed as a direct leach (without carbon) and hence it is expected that a CIL test may achieve higher gold extraction.

Industry typical design parameters were assumed for the PEA study where testwork has not yet been completed. Metallurgical testwork is continuing for the Namdini Gold Project under the direction of K. Marc LeVier & Associates at ALS in Perth, Western Australia.

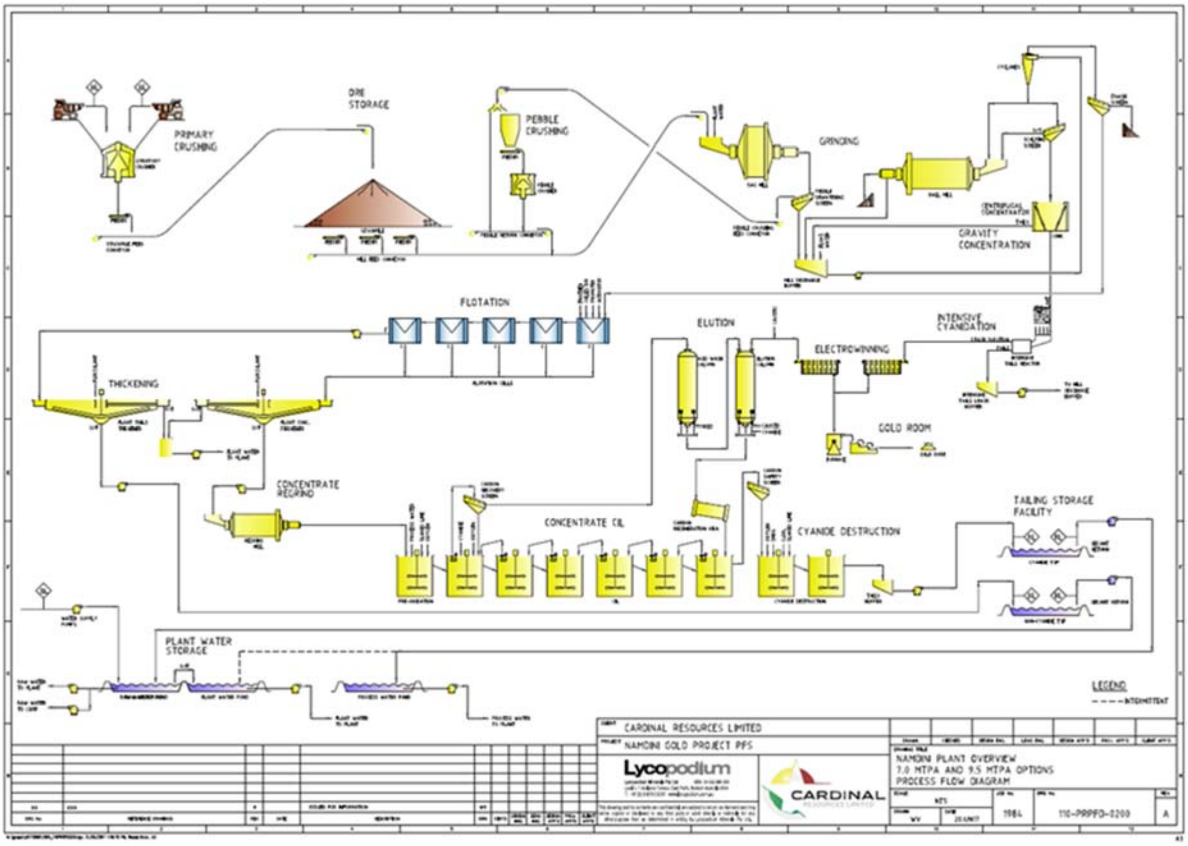

Figure 20: The selected PEA flowsheet for the Namdini project (2017):

14.0 MINERAL RESOURCE ESTIMATES

The Mineral Resource estimate forming the basis for this PEA was carried out by MPR (2017). The information in Sections 10.0, 11.0, 12.0 and 14.1 is derived from MPR (2017), supplemented with previous work by RPA (2017).

14.1 Resource estimation modelling by MPR (2017)

14.1.1 Introduction

The Namdini Mineral Resource forming the basis of this PEA study was estimated by Mr Nicolas Johnson of MPR Geological Consultants Pty Ltd as documented in (MPR, 2017), a Qualified Person for the purpose of Mineral Resource reporting under NI 43-101.

Mineral Resources were previously estimated for Namdini in November 2016 and April 2017 respectively (Section 6.2) in accordance with the JORC Code (2012). The basis, method of estimation and classification of the previous Mineral Resource estimates under the JORC Code do not materially vary from the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition Standards for Mineral Resources and Mineral Reserves. The present Mineral Resource estimates have been classified and reported in accordance with NI 43-101 guidelines and classifications adopted by CIM Council in May 2014.

Mineral Resources are not Mineral Reserves and have not demonstrated economic validity. The extent to which mining, metallurgical, marketing, infrastructure, permitting, marketing and other financial factors may affect the eventual Mineral Resource estimate is not precisely defined. The declared Mineral Resource estimate was constrained by notional economic assumption to demonstrate reasonable prospects of eventual economic extraction as required by CIM (2014).

14.1.2 Estimation dataset

The estimates are based on RC and diamond drilling data supplied by Cardinal with an effective date of 11th of September 2017. The compiled database includes an additional 33,406 meters compared to the previous estimate based on data to 2 December 2016 (RPA, 2017). The dataset available for the current Mineral Resource estimate includes 137 additional RC and diamond holes comprising the following:

- 93 holes primarily in filling the previously defined volume of gold mineralization increasing confidence in estimated resources
- 27 holes testing the down-dip extension of gold mineralization throughout the central portion of the deposit
- 17 holes drilled to the south extending the southern limit to the mineralization.

The current estimates are based on 2 m down-hole composited gold grades from RC and HQ diamond drilling with unsampled intervals generally assigned gold grades of 0.001 g/t. Peripheral, un-mineralized drill holes not relevant to the resource estimate were removed from the dataset.

The compiled resource dataset comprises 31,126 composites with gold grades from 0.001 to 242.05 g/t Au and averaging 0.59 g/t Au. Holes completed during 2017 provide around 52% of the resource dataset.

14.1.3 Mineralized domains

In general, the transition from gold mineralization to barren host rock is characterized by diffuse grade boundaries.

The current estimates are based on a mineralized domain interpreted on the basis of composited gold grades. Domain boundaries were digitised on cross-sections, snapped to drill hole traces where appropriate, then wire-framed into a three-dimensional solid designated Domain 2. Domain 1 represents a background domain capturing generally unmineralized composites outside the mineralized domain wire-frame.

The mineralized domain trends north-northeast over a strike length of approximately 1,270 m with horizontal widths ranging from around 80 to 390 m and averaging approximately 260 m. The domain dips to the west at around 70 degrees and is interpreted to a constant elevation of -500 m RL, which represents an average depth of 710 m, which is 25 m below the base of drilling.

Figure 21 presents a plan-view of the surface expression of the mineralized domain relative to drill hole traces.

Cardinal supplied interpreted surfaces representing the base of oxidation and the top of fresh rock interpreted from drill hole logging. These surfaces were used for: flagging of the resource composites into oxide, transition and fresh subdomains; density assignment; and reporting final resources by oxidation type. Depth to the interpreted base of complete oxidation ranges from locally one to two meters to around 20 meters and averages approximately 10 meters. Interpreted depth to fresh rock ranges from around 8 to 30 meters depth and averages approximately 18 meters.

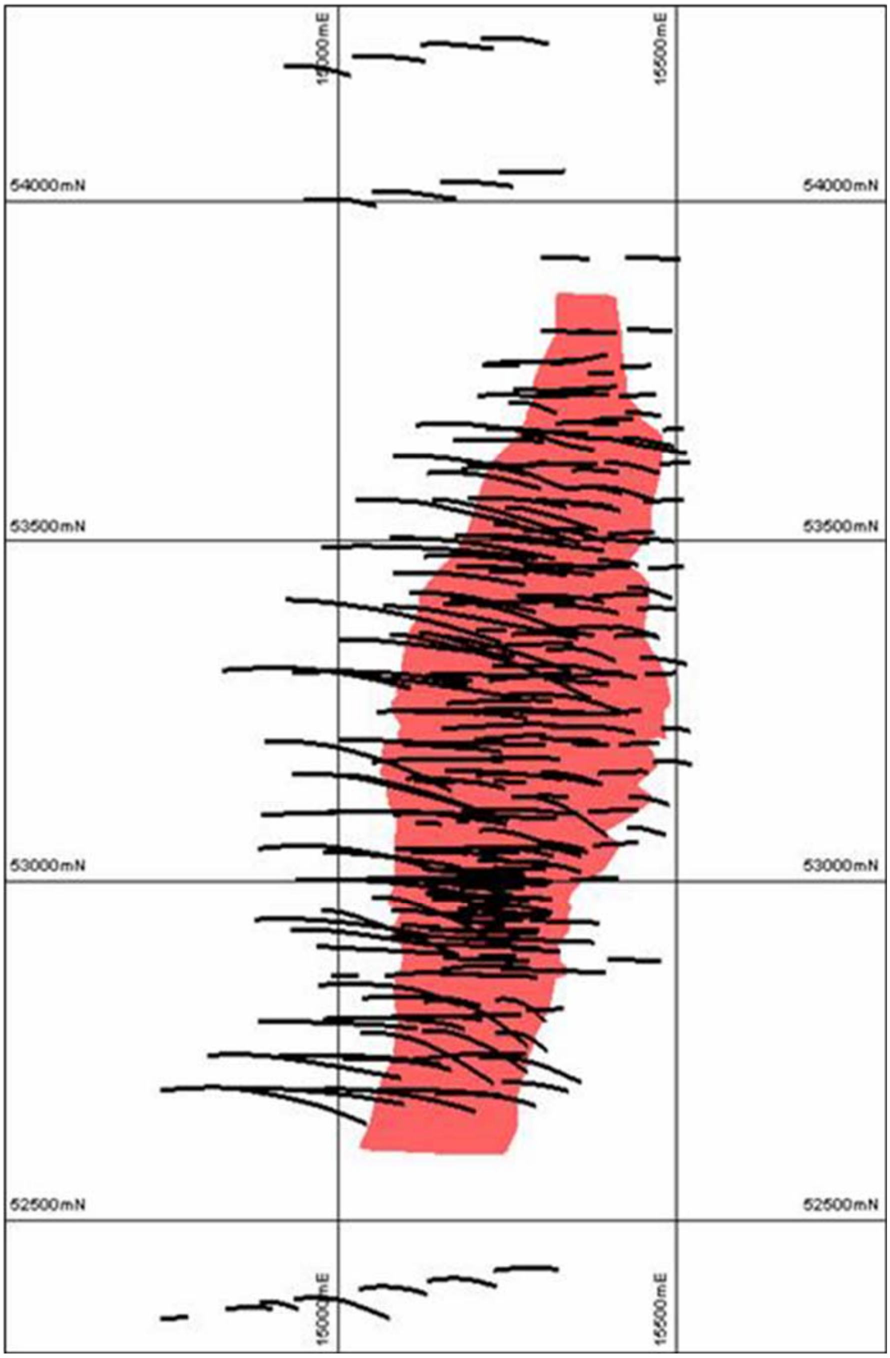

Figure 21: Mineralized domain interpretation and drill hole traces

14.1.4 Exploratory data analysis

Table 28 shows univariate statistics of composite gold grades for the resource dataset subdivided by mineralized and weathering domain. Notable features of these statistics include the following:

- At 0.05 g/t Au, the mean gold grade for Domain 1 composites is notably lower than for the mineralized domain demonstrating that the domaining was effective in assigning most mineralized composites into the mineralized domain. Some few high grades remain in Domain 1 that were not captured within the continuity of the mineralization defined for Domain 2.
- Typical of many gold deposits, all populations of gold grades show strong positive skewness with coefficients of variation generally greater than 2.0 indicating, as is often the case in gold

deposits, attention to the kriging plan, outlier grades and eventually the mining grade control will be important.

Table 28: Composite statistics

Domain 1				
Au g/t	**Oxide**	**Transition**	**Fresh**	**Combined**
Number	407	636	8,018	9,061
Mean	**0.079**	**0.044**	**0.048**	**0.049**
Variance	0.093	0.034	1.371	1.22
Coef. Var.	**3.85**	**4.23**	**24.4**	**22.5**
Minimum	0.005	0.005	0.003	0.003
1st Quartile	0.005	0.005	0.005	0.005
Median	0.018	0.013	0.008	0.008
3rd Quartile	0.05	0.025	0.018	0.020
Maximum	4.80	4.13	103.09	103.09

Domain 2				
Au g/t	**Oxide**	**Transition**	**Fresh**	**Combined**
Number	1,213	993	19,859	22,065
Mean	**0.832**	**0.767**	**0.819**	**0.817**
Variance	2.17	2.47	9.54	8.82
Coef. Var.	**1.77**	**2.05**	**3.77**	**3.63**
Minimum	0.001	0.005	0.004	0.001
1st Quartile	0.135	0.078	0.045	0.050
Median	0.385	0.305	0.270	0.275
3rd Quartile	0.930	0.795	0.800	0.810
Maximum	21.20	22.49	242.05	242.05

14.1.5 Indicator thresholds and bin average grades

For each dataset formed from each Domain and weathering combination, indicator thresholds were defined using a consistent set of percentiles representing probability thresholds of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 0.97 and 0.99 for data in each data subset.

All class average grades were determined from bin mean grades with the exception of the upper bins, which were reviewed on a case by case basis and bin grades selected on the basis of bin mean, or median, with or without exclusion of high grade composites. This approach was adopted to reduce the impact of a small number of outlier composites. In the author’s experience this approach is appropriate for Multiple Indicator Kriging (“MIK”) modelling of highly variable mineralization such as Namdini.

Table 29 summarises upper bin thresholds and bin mean grades and describes the methodology used to determine upper bin grades.

Table 29: Upper bin thresholds, class grades and approach used

Domain	Subdomain	Upper bin Au g/t			Source of Bin Grade
		Threshold	Maximum	Bin Grade	
1	Oxide	1.035	4.795	1.865	Median
	Transition	0.460	4.130	0.830	Median

Domain	Subdomain	Upper bin Au g/t			Source of Bin Grade
		Threshold	Maximum	Bin Grade	
	Fresh	0.475	103.091	0.880	Median
2	Oxide	6.340	21.200	8.770	Median
	Transition	7.800	22.490	9.865	Median
	Fresh	7.350	46.185	13.122	Mean excluding comps. >50g/t Au

14.1.6 Variogram models

Domain 2 indicator variograms were modelled for thresholds defined using a consistent set of percentiles representing probability thresholds of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 0.97 and 0.99 for the dataset of combined weathering subdomains. For determination of variance adjustment factors a variogram model of composite gold grades was also developed for the dataset. The variograms modelled for Domain 2 were used for modelling Domain 1.

As examples of the variogram orientation in Figure 20 shows the three-dimensional variogram surface for the median indicator variogram model for Domain 2, with the ranges at 90% of the sill.

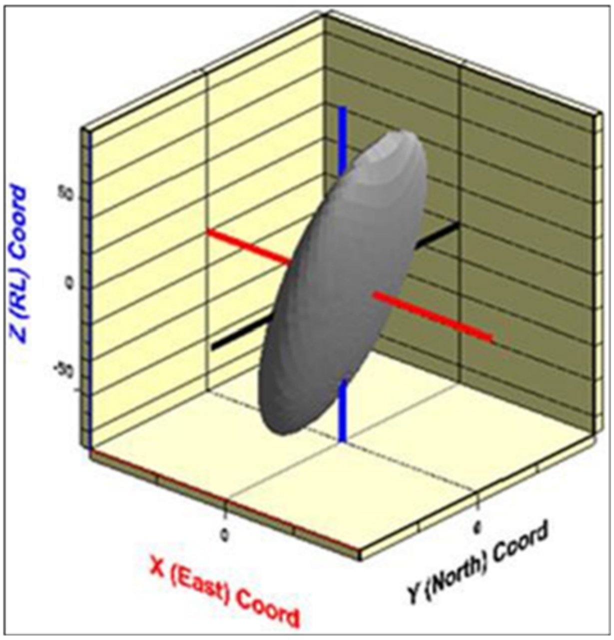

Figure 22: Three-dimensional plot showing the directions of continuity of mineralization in Domain 2

14.1.7 Estimation parameters

Micromine™ software was used by MPR (2017) for data compilation, domain wire-framing and coding of composite values and the MIK specialist software GS3M™ was used for resource estimation. The resulting estimates were then imported into Micromine™ for reporting.

The block model framework used for MIK modelling covers the full extent of the composite dataset. It comprises blocks with dimensions of 12.5 meters east-west by 25 meters north-south by 5 meters vertical. The horizontal dimensions are consistent with the drill hole spacing in the more closely drilled portion of the deposit.

Three progressively more relaxed search criteria were used for the MIK estimation as presented in Table 30. The search ellipsoids were aligned with the general mineralization orientation defined in Section 14.1.3.

Table 30: Search criteria

Search	Radii (m)	Minimum	Minimum	Maximum
	(x,y,z)	Data	Octants	Data
1	65,65,15	16	4	48
2	65,65,15	16	4	48
3	97.5,97.5,22.5	8	2	48

A variance adjustment using the direct lognormal method was used to convert the kriged estimates to a recoverable resource assuming selective mining.

The variance adjustment factors are shown in Table 31 to allow for both the block size adjustment and the information effect due to grade control.

Table 31: Variance adjustment factors

Domain	Block Effect	Information Effect	Total Adjustment
1	0.135	0.249	0.034
2	0.135	0.249	0.034

Lithologies were modelled broadly, and bulk densities were then assigned to the block model by rock type and weathering domain. The assigned values in Table 32 were derived from the average of the available measurements within the modelled domains (Table 23).

Table 32: Bulk density assignment

Rock Type	Bulk Density (t/bcm)		
	Oxide	Transition	Fresh
Metavolcanics	2.06	2.54	2.81
Granite	2.06	2.54	2.73
Diorite	2.06	2.58	2.82
Meta-Sediments	2.06	2.58	2.82

14.1.8 Pit shell constraint for RPEEE

CIM (2014) requires that publicly reported Mineral Resource estimates only include material for which it can be demonstrated that there is ‘reasonable prospect for eventual economic extraction’ (“RPEEE”). One way to do this is to constrain the Mineral Resource within a notional optimized pit shell using assumed parameters.

The optimization parameters used by MPR (2017) reflect a large scale conventional open pit operation with the cost and revenue parameters detailed in Table 33. In Golder’s view these assumptions are reasonable as a first pass.

Table 33: Assumed pit optimization parameters to define RPEEE

Description	Value
Gold price	US$ 1,500/oz
Royalty (assumed)	5%
Pit slope angle	45°

Description		Value
Ore and waste mining cost		US $2.9/t
Mill Recovery	Oxide	90%
	Transition and Fresh	86%
Mill Processing Cost	Oxide	US$ 11.6/t
	Transition and Fresh	US$ 12.1/t

14.1.9 Mineral Resource classification

The Mineral Resource model blocks were classified as Indicated or Inferred on the basis of search pass and a wire-frame outlining the more closely drilled portions of the mineralization.

Blocks within the classification wire-frame and estimated by pass 1 were classified as Indicated. All remaining blocks estimated by pass 2 and 3 were assigned to the Inferred class. The reported Indicated and Inferred material was then constrained to within the RPEEE notional optimized pit.

14.1.10 Model validation

Block model reviews included comparing estimated block grades with their informing composites. These checks included inspection of sectional plots of the model and drill data, and review of swath plots. They showed no significant issues.

Figure 21 shows a representative cross-section of the Namdini resource model. The plots in this figure show resource model blocks coloured by resource category, with the drill hole traces coloured by two meter composited gold grades.

The swath plots in Figure 23 compare average estimated panel grades for Indicated Resources and average composite grades by easting, northing and elevation. The average composite grades include an upper cut of 50 g/t which is consistent with the upper limit used for generating the MIK domain statistics for Domain 2 and reduces the impact of a small number of outlier composite gold grades (up to 245 g/t Au).

The plots in Figure 23 show that although, as expected, average block grades are smoothed compared to the average composite grades, they generally closely follow the trends shown by the composite mean grades with the exception of areas of variably spaced or limited sampling.

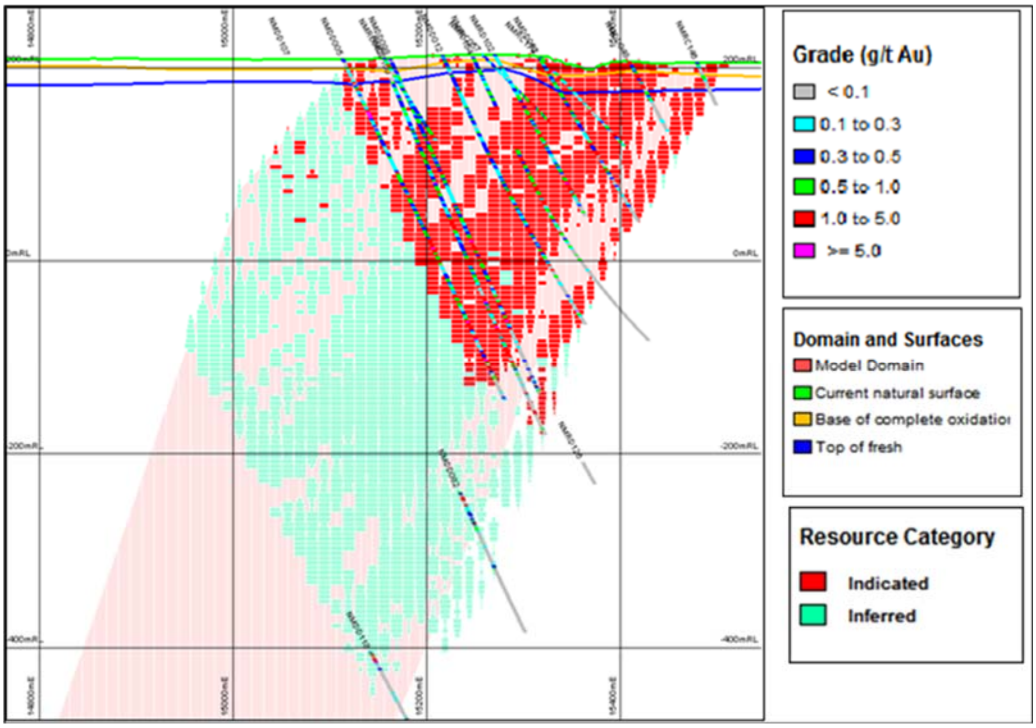

Figure 23: Mineral Resource categories, limited by the RPEEE notional pit shell

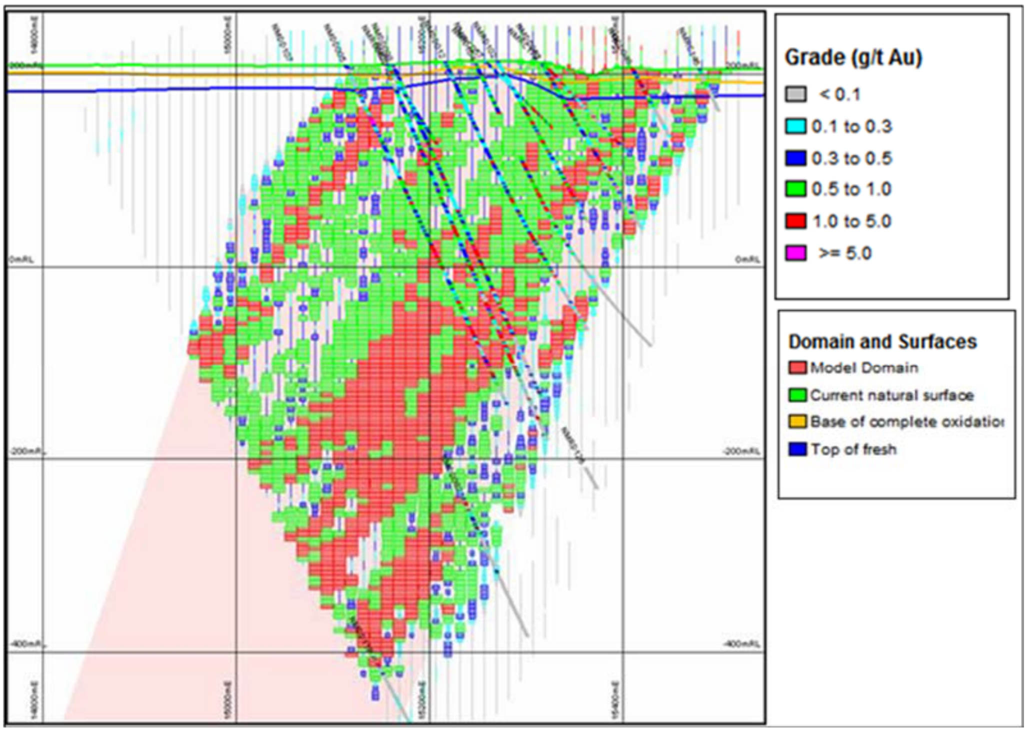

Figure 24: Average block grades

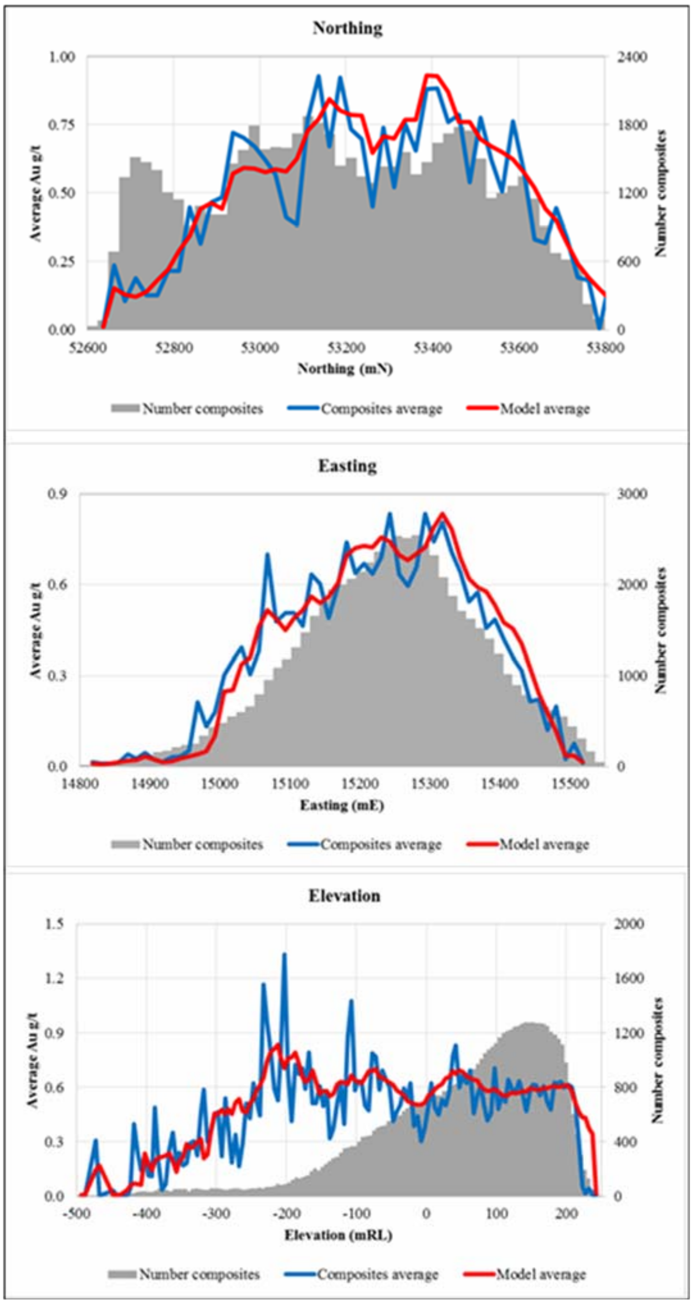

Figure 25: Average estimated grades versus composite grades in validation swaths

14.1.11 Mineral Resource estimates

Table 34 shows the Mineral Resource estimates for Namdini for a range of cut-off grades. The figures in this table are rounded to reflect the precision of the estimates.

The Mineral Resources were reported within the resource pit shell and extend from natural surface to around 600 meters depth with around 92% of the Indicated Mineral Resources, and 44% of the Inferred Mineral Resources occurring at depths of less than 300 meters.

Oxidised and transitional material hosts respectively around 2% and 2% of the estimated Mineral Resource, with the remainder (96%) in fresh rock.

Table 34: September 2017 Namdini Mineral Resource estimates (MPR, 2017)

Indicated Mineral Resource

Cut-off (g/t Au)	Tonnes (Mt)	Grade (g/t Au)	Metal (Au Moz)
0.2	175	0.9	4.90
0.3	159	0.9	4.76
0.4	140	1.0	4.55
0.5	**120**	**1.1**	**4.27**
0.6	102	1.2	3.95
0.7	86	1.3	3.61
0.8	72	1.4	3.28
0.9	60	1.5	2.96
1.0	51	1.6	2.67

Inferred Mineral Resource

Cut-off (g/t Au)	Tonnes (Mt)	Grade (g/t Au)	Metal (Au Moz)
0.2	122	0.9	3.6
0.3	111	1.0	3.5
0.4	98	1.1	3.3
0.5	**84**	**1.2**	**3.1**
0.6	72	1.3	2.9
0.7	61	1.4	2.7
0.8	52	1.5	2.4
0.9	44	1.6	2.2
1.0	37	1.7	2.0

Table 35 summarises the tonnes, grade and contained metal in the RPEEE limiting notional open pit of US$1500/oz and a cut-off grade of 0.5g/t Au.

Table 35: 2017 Namdini Mineral Resource estimates at cut-off grade of 0.5 g/t Au (MPR, 2017)

Mineral Resource Category	Tonnage Mt	Grade (g/t Au)	Contained Metal (Moz Au)
Indicated	120	1.1	4.3
Inferred	84	1.2	3.1

14.2 Independent review of the Mineral Resource estimate

14.2.1 Introduction

Golder was engaged by Cardinal to prepare the PEA and to do other works as the Namdini Gold Project progresses. As part of the PEA study Golder has undertaken a review of the Mineral Resource estimate that forms the basis of this study, prior to carrying out the mining studies documented in Section 16.0.

The Mineral Resource estimate was undertaken by MPR. Golder's review was based solely on the resource definition drill hole database, block model and wireframes provided by Cardinal.

The review focused on geology and domain definition, the grade estimation approach, and Mineral Resource classification. The purpose of the review was to check for any significant risks associated with the Mineral Resources. A summary of the key findings is presented below.

14.2.2 Data analysis and compositing

The main sampling length is 1 m, corresponding to more than 97% of all assayed results. The lithologies show differences in grade as indicated in Table 36.

Table 36: Namdini Au grades by Lithology

Lithology	No. of Samples	Average Gold Grade (g/t Au)	Variance
Diorite – DIO	12 048	0.686	32.671
Granite – GRA	7 553	1.043	23.469
Metasedimentary – MSE	5 256	0.109	0.265
Metavolcanic – MVO	21 852	0.933	7.452
Shear zone – LFT	61	0.072	0.030

The drill hole database was composited to 2 m lengths, grouping the majority of the 1 m raw samples, using a standard length-weighted averaging method.

A comparison of the raw and composites sample length and grade by lithologies showed the predominantly 1 m sample length was replaced by the 2 m composites with no apparent grade bias and maintaining the differences between lithologies.

Assessment of the grades by oxidation profile indicated that differences were not strongly evident. Analysis of the weathering by lithology indicated a slight difference related to lower-grade samples (below 0.5 g/t Au) for GRA, DIO and MVO. The metasediments (MSE) showed some evidence of supergene enrichment, with oxide material having higher grade than transition and fresh (Figure 26). On balance Golder accepted the modelling.

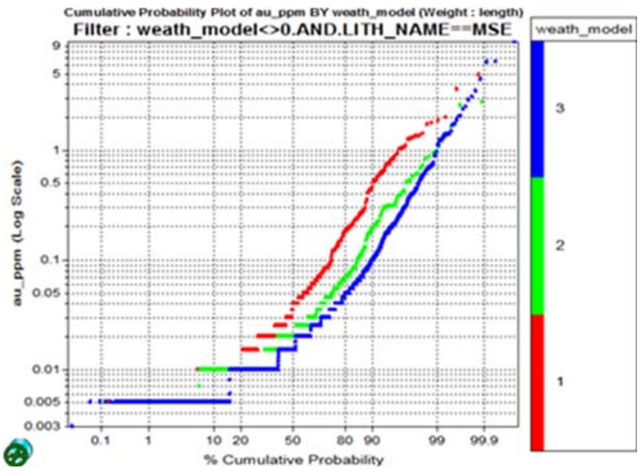

Figure 26: Probability plot of Au in 2m composite samples, by weathering type for lithological unit MSE

14.2.3 Mineralization domains

MPR constructed a mineralization shell wireframe to provide a boundary and a separation between mineralization and barren rock for grade estimation purposes, using a nominal cut-off of 0.1 g/t Au. The composite database was flagged using this mineralization shell and the grade estimation was controlled solely by this boundary, disregarding the lithology.

Golder carried out an independent grade comparison by lithologies against the mineralization boundary. Although the mineralization shell provides a satisfactory separation between mineralized and barren zones, there are still noticeable differences in grade between histograms of the main lithologies as summarised by the means in Table 37. For future Mineral Resources estimates the grade differences presented by each of the lithologies should be considered.

Table 37: Summary statistics of composite gold grades by lithology and mineralization zones

Zone	Lithology	No. of Samples	Average (g/t Au)	Variance
Mineralization	DIO	5 236	0.743	17.188
	GRA	3 822	1.046	13.484
	MSE	342	0.351	0.450
	MVO	11 444	0.889	5.173
Waste	DIO	1 792	0.139	6.737
	GRA	48	0.091	0.033
	MSE	3 254	0.053	0.067
	MVO	288	0.084	0.260

14.2.4 Block modelling

Cardinal provided the block model file Full_Model_MIK_Sept2017 in csv format for review. The block model origin and extents in the data file and are shown in Table 38.

Table 38: Namdini geological block model dimensions

Direction	Origin (m)	Extent (m)	Regular Block Size (m)
Easting (X)	14 387.5	1 450	12.5
Northing (Y)	52 450	1 675	25
RL (Z)	-550	250	5

Figure 27 shows a vertical section of the geology and mineralization, indicating the lithologies are defined in the block model.

In Golder's opinion the block dimensions are acceptable and adequately supported by the drill holes data.

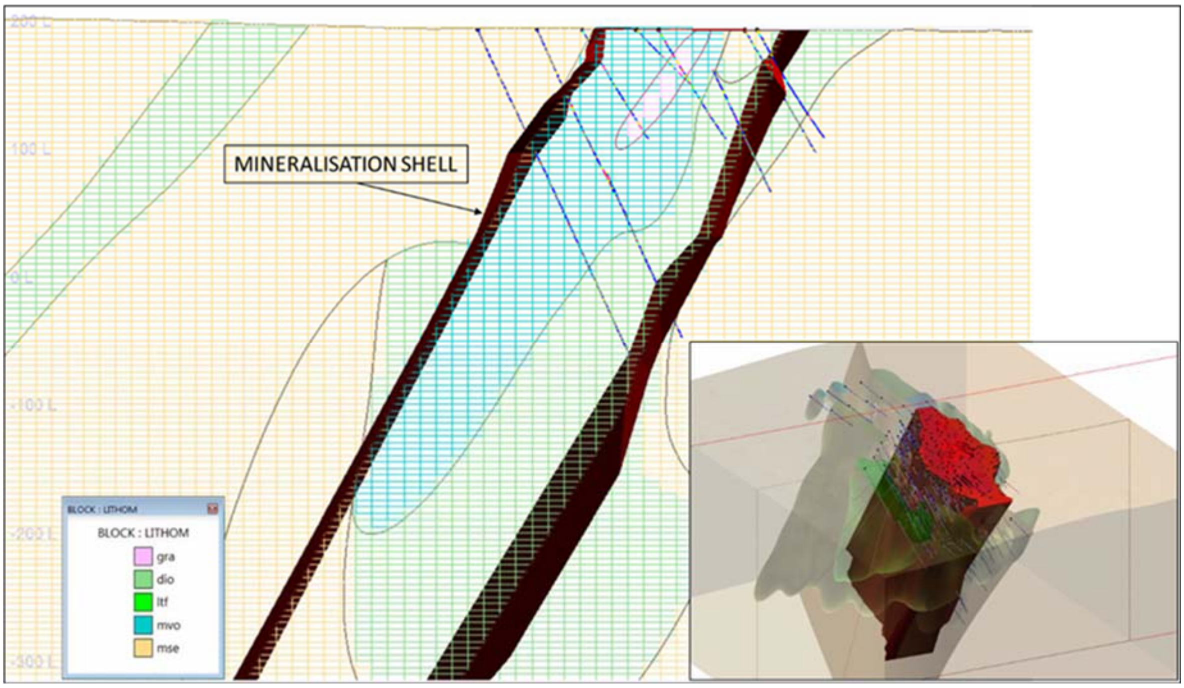

Figure 27: Section N53700 showing the geology block model and the lithology and mineralization wireframes

14.2.5 Grade estimation

The grade estimation was carried out by MPR (2017) using the MIK method. Only gold grades were modelled.

Golder carried out a series of statistical checks to validate the block model grades against the composite database using the average grade resulting from the MIK method (the e-type estimator), represented by the variable panave.

The statistical comparison, using declustered weighted composites and considering the lithological differences, indicates the estimation shows acceptable results. (Table 39)

Table 39: Statistical comparison of Au (ppm) composite versus the block model, by lithology and ore zone

Zone	Litho	DH Data (declustered)			Block Model (MIK)			MIK/DH (%)[1]	f^2
		No.	Mean	Var.	No.	Mean	Var.		
ORE	MVO	12 399	0.783	5.11	41 777	0.774	0.38	98.9	0.074
	MSE	514	0.205	0.37	4 985	0.213	0.06	103.9	0.175
	GRA	3 937	1.048	15.66	12 547	0.971	0.36	92.7	0.023
	DIO	6 253	0.591	11.62	37 888	0.590	0.30	99.7	0.025
WASTE	MVO	469	0.033	0.07	1 468	0.033	0.00	99.5	0.015
	MSE	6 475	0.021	0.02	45 166	0.027	0.00	128.8	0.050
	GRA	55	0.095	0.04	4	0.093	0.00	97.4	0.034
	DIO	3 640	0.053	2.47	17 690	0.031	0.00	58.7	0.001

Notes: [1] between DH and MIK mean values; [2] actual variance adjustment (f)

Swath plots calculated by Golder for individual domains show acceptable results as seen in Figure 28 for GRA in fresh mineralization.

Golder carried out an independent resource estimation using the nominated cut-off of 0.5 g/t Au with appropriate variance adjustments. The results were similar to those presented in Table 37.

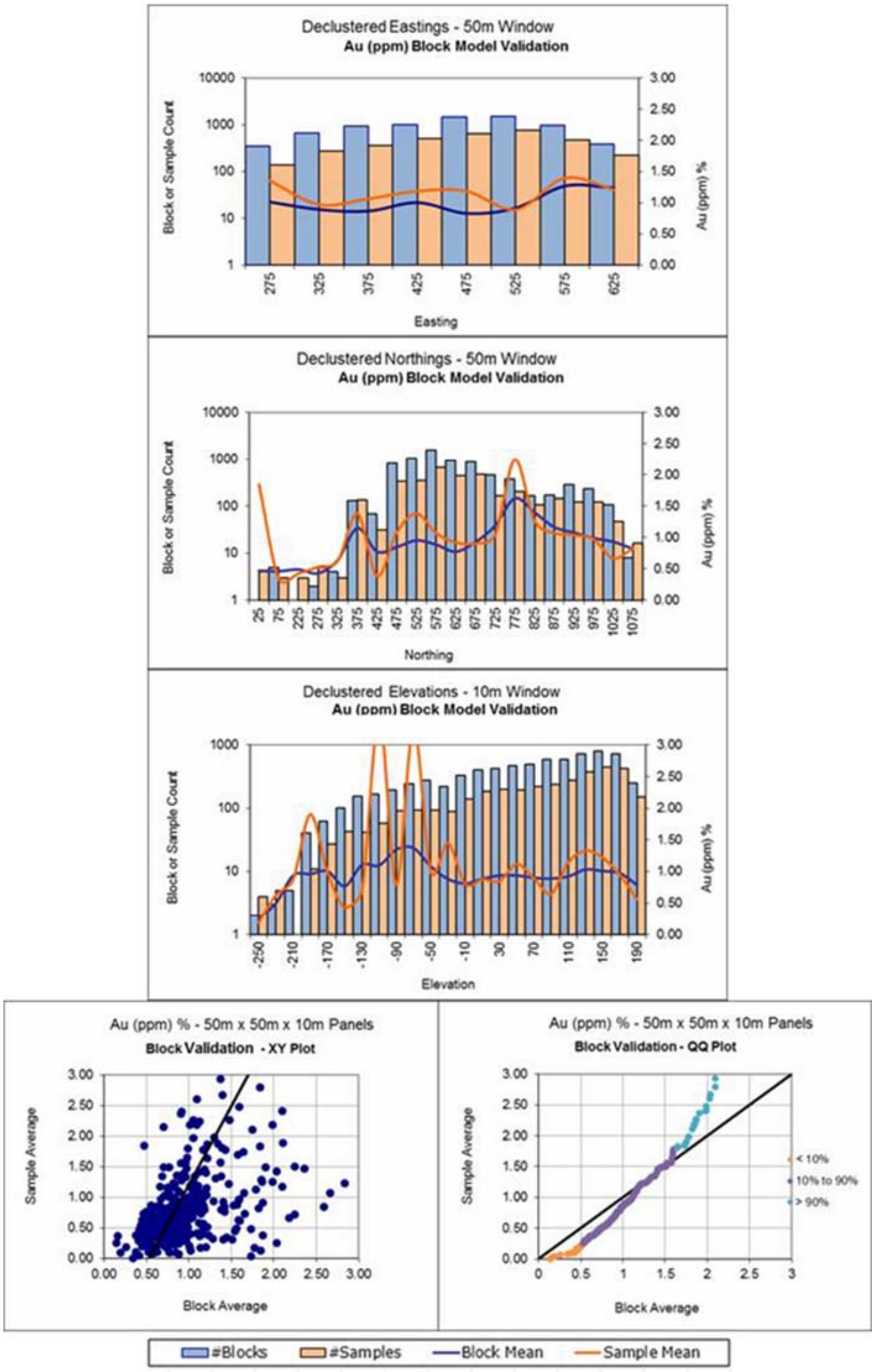

Figure 28: Swath plots of gold grade (g/t Au) for Fresh GRA, inside mineralization domain

14.2.6 Mineral Resource classification

The resource classification approach was based on 'the basis of search pass and a wire-frame outlining more closely drilled portions of the mineralization' (MPR, 2017).

To demonstrate 'reasonable prospects for eventual economic extraction' (RPEEE), Cardinal applied an open pit optimization process to the resource estimate to provide a limit to the reportable Mineral Resource.

Figure 29 shows the pit shell in the center of the deposit and the resource classification prior to constraining it by this pit shell.

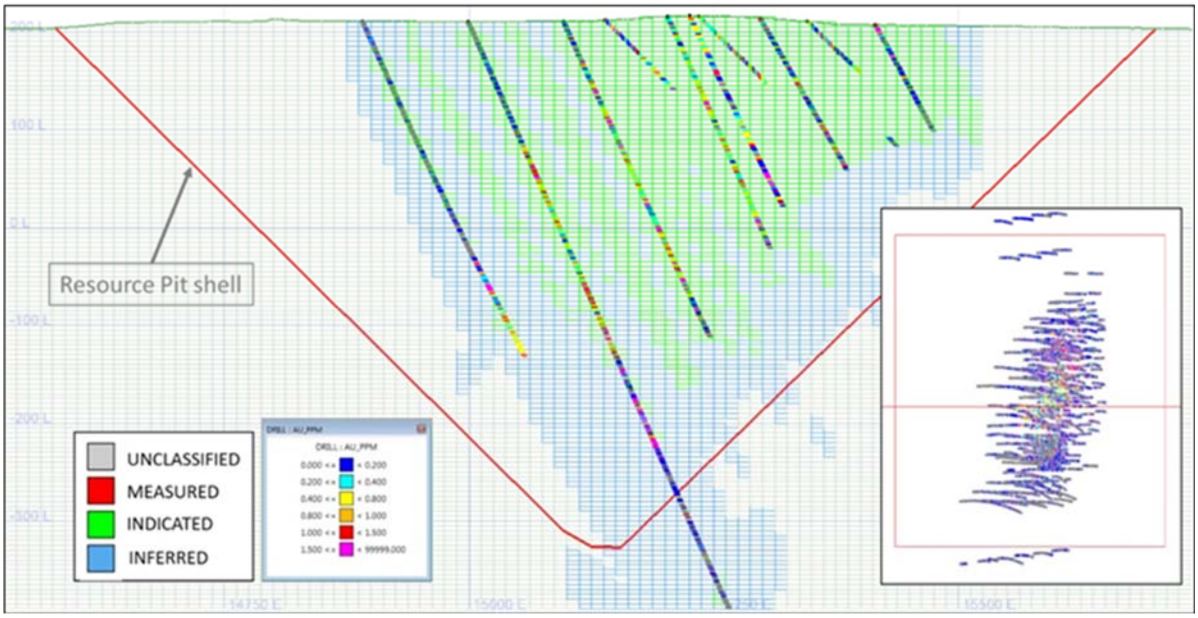

Figure 29: Vertical section N53200 showing the resource classification approach

Golder considers the use of the pit shell appropriate for the purpose of limiting the reporting of Mineral Resources.

14.2.7 Conclusion

In Golders opinion, the 2017 Mineral Resource estimate for the Namdini Gold Project fairly reflects the input data.

Overall, the Mineral Resource estimate was accepted as reasonable by Golder with no critical flaws identified.

15.0 MINERAL RESERVE ESTIMATES

No Mineral Reserve, or Ore Reserve under the JORC Code (2012), was defined for the Namdini Gold Project at this PEA level of study.

16.0 MINING METHODS

16.1 Introduction

For this mining study the mine design and costing assessment were based on the geological and Mineral Resource block model for the Namdini Gold Project supplied by MPR (2017) as discussed in Section 14.0. The Inferred and Indicated Mineral Resources were included in the assessment at a cut-off grade of 0.5 g/t Au.

The geological and block models were used as provided in the local grid system developed by Sahara Mining Services. The local grid transformation comprises an eight-degree rotation from UTM WGS coordinates (Table 40), with no elevation change. The transformation rotates the drill traverses on the obliquely trending UTM WGS grid to east-west (local) grid.

Table 40: Grid transformation from UTM (WGS84 Zone 30N) to Local Grid

Translation	UTM WGS 84 Zone 30 N		Local	
Point	East (mE)	North (mN)	East (mE)	North (mN)
1	757,032.992	1,175,611.678	15,000.000	51,800.000
2	757,380.925	1,178,087.348	15,000.000	54,300.000
3	758,569.247	1,177,920.341	16,200.000	54,300.000
4	758,221.314	1,175,444.671	16,200.000	51,800.000

16.2 Mining methodology

The mine design for the Namdini Gold Project consists of a series of nested conventional open pit layouts with access provided through a series of ramps. For mining purposes, the Namdini orebody can be considered a layered sequence consisting of (from top to bottom):

- A strongly oxidised upper weathered zone
- A moderately oxidised zone with total oxidisation of sulphides
- A transitional zone with partial oxidisation of sulphides
- A fresh non-mineralized meta-sediment sequence
- A fresh mineralized host sequence of meta-volcaniclastics, granitoids (tonalite), and diorites.

In the weathered and transitional zones, a mixture of free digging, ripping, drilling and blasting methods can be employed. In the fresh, competent material at depth conventional drill and blasting methods will be used to extract the ore.

The mining style assumed was a conventional shovel operation typically using 600 t class excavators in a backhoe configuration and 220 t (Cat 793) rigid body dump trucks hauling on designed access roads. An auxiliary mining fleet of dozers, graders, water carts and utility vehicles will support the mining operation. No consideration was made for underground extensions of the operation in this PEA study.

16.3 Mine design criteria

Mine design criteria set the basic guidelines for mine design and mine planning. These criteria are used for the generation of open pit layouts and production scheduling. The mining study is intended to determine suitable potential mining scenarios. The optimization strategy included testing a range of process plant throughputs and process feed limits to give an indication of maximum potential value versus capital outlay.

An initial high-level assessment using Whittle 4X™ showed that the project appears to offer a maximum Return on Capital Employed (ROCE), as a ratio of Net Present Value (NPV) divided by CAPEX, for a process plant feed throughput of 6 to 7 Mtpa. Note that the mining NPV calculation does not represent Cardinal's financial model calculations and are all pre-tax.

The mining NPV was taken as the average of the Whittle 4X™ 'best case' and Whittle 4X™ 'worst case' options at a Revenue Factor (RF) of 0.8 in each case. This RF value was selected as it represents the approximate maximum discounted cash flow point for the pit optimizations. For this mining study a strip ratio of up to 2:1 was allowed for so that the initial optimizations were not 'mining-limited'.

PEA level capital cost estimates have been provided by Cardinal and have been compared against similar gold projects with which Golder is familiar and are in line with the expected total capital cost.

For this PEA level of study preliminary geotechnical assumptions were used in the pit optimization and pit design. Consequently, the mine designs are considered conceptual in nature.

As an initial optimization exercise the 'mineable resource' was tested across a large range of process plant throughput limits from 4 Mtpa through to 10 Mtpa in 1 Mtpa increments. The optimization results were then compared in each case for the RF 0.8 pit shell to provide an equivalent basis for comparison.

Energy supply options have not been considered.

The 'average' discounted cash flow is the midpoint between the 'best case' and 'worst case' Whittle 4X™ options. The 'best case' represents a theoretical maximum potential value where blocks are mined honouring the defined slope angle but with no allowance for practical geometry. The 'worst case' is where the benches are completely mined sequentially prior to the next bench being accessed.

Using the high-level results, the project was compared both for absolute NPV_{10} and ROCE, which provides a useful metric to compare projects by assessing the absolute NPV_{10} against the required capital cost for the project. In the case of the Namdini Gold Project, the project appears to offer a maximum return per dollar of CAPEX at approximately 7.0 Mtpa throughput (Table 41).

The results of this PEA study are a guide to indicate the potential reward versus risk for the Namdini Gold Project and must not be regarded as a true measure of value at this stage of study.

Table 41: Namdini Gold Project – Whittle 4X™optimization results against process plant throughput

Summary	Average Discounted Cash Flow (US$ M)	CAPEX Estimate (US$ M)	Rank (1=Best)	NPV_{10} $/t Capacity
4.0 Mtpa	267	$286	9	1.356
4.5 Mtpa	309	$307	7	1.389
5.0 Mtpa	347	$327	4	1.412
6.0 Mtpa	415	$365	2	1.445
7.0 Mtpa	472	$400	1	1.446
8.0 Mtpa	518	$434	3	1.434
9.0 Mtpa	556	$465	5	1.406
9.5 Mtpa	572	$481	6	1.389
10.0 Mtpa	587	$496	8	1.371

Graphing the results of the 'average' NPV10 against the total project capital required shows that the financial return per unit of capital expenditure increases rapidly towards 5 Mtpa and decreases more slowly from 8 Mtpa. As with most large projects the absolute NPV will generally show an increase as production capacity is increased, but the 'value' for incremental spend is often not appreciated in relative terms. The use of ROCE attempts to provide a 'value' mechanism for the project scaling.

Figure 30 shows the results graphically for the Discounted Average (DAVg) NPV against the process plant throughput. The peak value for ROCE approximately corresponds to the 7.0 Mtpa throughput option.

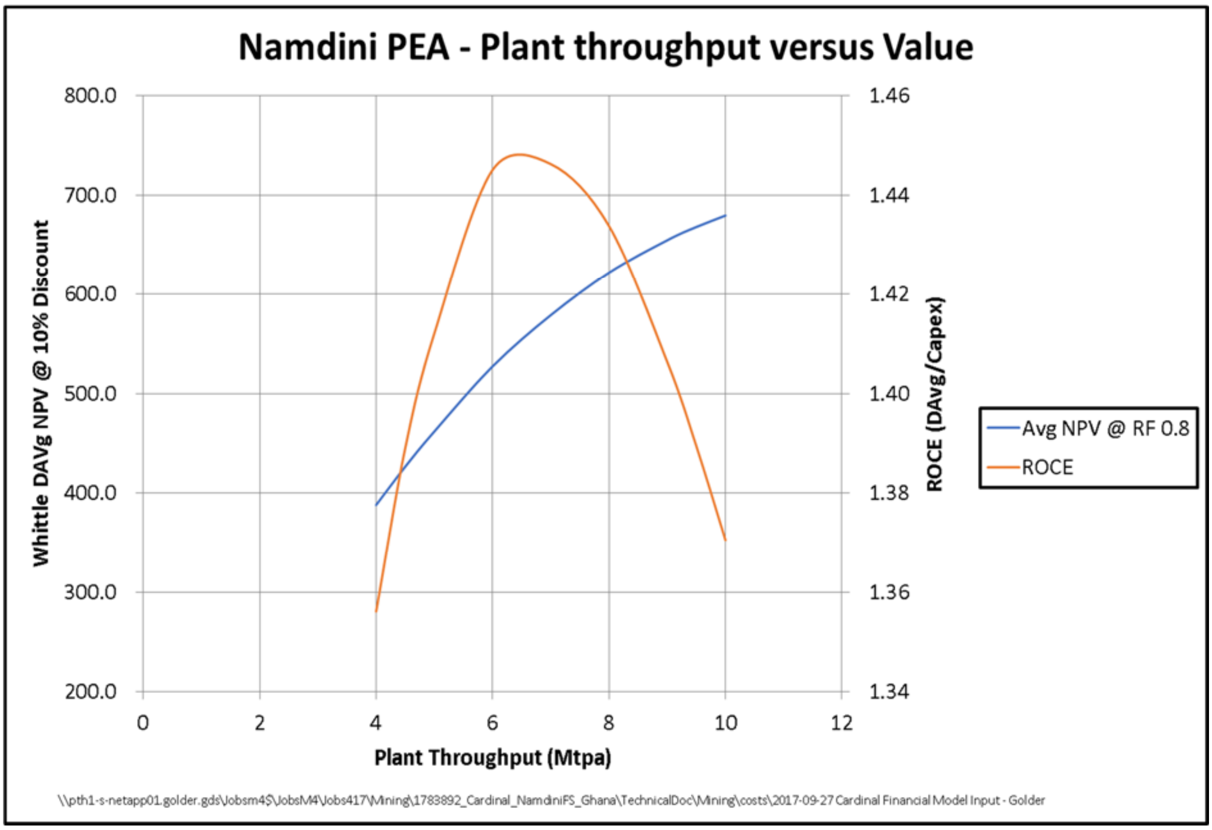

Figure 30: High-level notional project value vs proposed process plant throughput using DAVg and ROCE

Detailed project costing and further trade-off evaluations are still to be undertaken by Cardinal after completion of this initial PEA study.

The various material types to be mined and their respective dry bulk densities are presented in Table 42.

Table 42: Categories of material to be mined

Weathering Domain	Lithology	Definition	Dry Bulk Density
Strongly Oxidised0	MVO	Strongly Oxidised – Mafic rocks, volcaniclastics, altered (sericites, chlorites + silicification).	1.80
	GRANITE	Strongly Oxidised – Granodiorite/tonalite, altered felsic rocks (sericites, muscovite, carbonate and K-feldspar).	1.80
	DIORITE	Strongly Oxidised – Intermediate rocks, altered (shearing, silicification, chlorite and sericites) and unaltered diorite, quartz diorite speckled with quartz and feldspar.	1.80

Weathering Domain	Lithology	Definition	Dry Bulk Density
Moderately Oxidised	MVO	Moderately Oxidised – Mafic rocks, volcaniclastics, altered (sericites, chlorites + silicification).	2.00
	GRANITE	Moderately Oxidised – Granodiorite/tonalite, altered felsic rocks (sericites, muscovite, carbonate and K-feldspar).	2.51
	DIORITE	Moderately Oxidised – Intermediate rocks, altered (shearing, silicification, chlorite and sericites) and unaltered diorite, quartz diorite speckled with quartz and feldspar.	2.27
	MSE	Moderately Oxidised – Metasedimentary rocks, dominated by quartz-carbonate veining + haematite and chlorite	2.25
Transitional	MVO	Transitional – Mafic rocks, volcaniclastics, altered (sericites, chlorites + silicification).	2.54
	GRANITE	Transitional – Granodiorite/tonalite, altered felsic rocks (sericites, muscovite, carbonate and K-feldspar).	2.54
	DIORITE	Transitional – Intermediate rocks, altered (shearing, silicification, chlorite and sericites) and unaltered diorite, quartz diorite speckled with quartz and feldspar.	2.58
	MSE	Transitional – Metasedimentary rocks, dominated by quartz- carbonate veining + haematite and chlorite	2.58
Fresh Unweathered	MVO	Fresh – Mafic rocks, volcaniclastics, altered (sericites, chlorites + silicification).	2.81
	GRANITE	Fresh – Granodiorite/tonalite, altered felsic rocks (sericites, muscovite, carbonate and K-feldspar).	2.73
	DIORITE	Fresh – Intermediate rocks, altered (shearing, silicification, chlorite and sericites) and unaltered diorite, quartz diorite speckled with quartz and feldspar.	2.82

Weathering Domain	Lithology	Definition	Dry Bulk Density
	MSE	Fresh – Metasedimentary rocks, dominated by quartz-carbonate veining + haematite and chlorite	2.82

Source: RPA (2017)

Conceptual pit designs were analysed using Whittle 4X™, which generates optimized pit shapes (nested pit shells) using the Lerchs-Grossmann algorithm considering physical characteristics of the mineral deposit (resource block model), cost/price scenarios, geotechnical constraints (maximum pit slope angles) and other operational constraints.

The Vulcan™ export routine was used to create the Whittle 4X™ model from the mining model. Codes were then created based on weathering type and resource classification. Table 43 summarises the major parameters of the Whittle 4X™ model.

Table 43: Whittle 4X™ parameters (*NAM2017_OCTv2_RWIT_with_MCAF.mod*)

Item	X (Easting)	Y (Northing)	Z (RL)
Block size (m)	12.5	25	5
Model Origin	14387.5	52450.0	-550.0
Extent (m)	1450	1675	800
Number Parent Blocks	116	67	160

The block model was exported to Whittle 4X™ as a parcelled model retaining the 'ore and waste fractions' (i.e. material above and below the 0.5 g/t Au cut-off grade) defined in the MIK resource model. A validation comparison of the parcelled model was carried out using the Surpac™ MIK export to Whittle 4X™ function. The MIK Whittle 4X™ model produced identical results to the parcelled model and thus the parcelled model was retained for further design work and mine planning options. A check on the tonnage imported into Whittle 4X™ showed that the total material above cut-off was 225 Mt, with an identical ore tonnage being present in the Vulcan™ mining model, showing that there had been no material loss or gain during the export from Vulcan™ to Whittle 4X™.

Table 43 presents the parameters used in the Whittle 4X™ pit shell optimization analysis.

Table 44: Technical and economic parameters used in Whittle 4X™ optimization studies

Parameter	Units	Value
Gold Price	US$/oz	1 300
Ore Loss during Mining*	%	0
Dilution Added during Mining*	%	0
Mining Rate	Mtpa	Scenario
Plant Recovery – Oxidised Zone	%	90
Plant Recovery – Transitional Zone	%	86
Plant Recovery – Fresh Zone	%	86
Annual Discount Rate	%	10
Cut-off Grade**	g/t	0.5

Notes:
** Since ore loss and dilution were assumed in the variance adjustment of the MIK model, no further ore loss or dilution was considered in the pit optimization process*
*** Cut-off grade was estimated using an estimated metallurgical recovery of 86% and an input gold price of $1300/oz.*

The cut-off grade was estimated as follows: Marginal COG = Cost/Revenue

Marginal COG = (Process + Reclaim Cost) / ($1300/oz – 5% Royalties/31.1034768 g/oz) × 86% (Met Recovery) × 1.00 (Ore Recovery)

Marginal COG = ($13.7/t + $1.5/t)/$34.2 $/g Marginal COG = 0.5 g/t

Where:

- $13.7 is the process plant cost at a design throughput of 7.0 Mtpa for marginal ore per tonne processed
- $1.5 is the stockpile reclaim cost per tonne ore.
- For the purposes of the mining study, it was assumed that a ‘dry pit’ will be operated and that sufficient dewatering will allow for the geotechnical design for dry slopes.

16.4 Geotechnical investigations

Dr Reginald Hammah, Senior Rock Engineer from the Golder Accra office in Ghana, visited site in May 2017 and produced a fatal flaw analysis report and recommendations for geotechnical sampling and other work.

16.4.1 Sources of data for open pit design

To perform this work, Golder reviewed the following sources of information:

- Site walkover by Golder senior engineer and discussions with Cardinal geologists
- Mineral Resource Estimate by MPR Geological Consultants Pty Ltd. (MPR 2017)
- Geological / Lithological models (in Vulcan^{TM}) developed by Cardinal personnel
- Database of geotechnical parameters measured from core logging.
- Specific recommendations for geotechnical slope design of the pit walls have been made by Golder. The slope recommendations for the pit walls were based on the following operational assumptions:
- Vertical bench separation (production height) in the SOX material is assumed to be 5 m and total bench height equal to 10 m.
- The bench face angle(s) will be cut as steeply as possible to maximise water run-off and reduce the potential for erosion. In addition, wide berms would be used to retain any possible failure debris from the bench faces (or batters). In the event of heavy seasonal rainfall and consequently high-water run-off and the potential for erosion, this an important consideration for slope stability in the SOX material.
- Excavation will be primarily mechanical with the use of dozers or backhoes.
- An inter-ramp in the highly weathered material will not comprise more than four benches (it is highly unlikely that more than three SOX benches will be excavated at Namdini due to the thinness of the layer). SOX inter-ramps must be separated by ramps or a geotechnical berm that is 20 m or wider.

16.4.2 Preliminary open pit design

The preliminary slope design geometry for the Namdini Pit is outlined in Table 45.

Table 45: Preliminary slope geometry for open pit design

State of Rock Weathering	Bench Face Angle	Production Bench Height (m)	Vertical Bench Separation (m)	Berm Width (m)	Inter-ramp Angle
295° (Footwall) Wall Orientation					
SOX (Saprolites & Saprock)	60°	5	10	6	40.3°
Transition (Moderately Weathered Rock) – Single Benching	60°	10	10	4	45.7°
Slightly Weathered to Fresh Rock	65°	10	20	7.5	49.9°
All Other Wall Directions					
SOX (Saprolites & Saprock)	60°	5	10	6	40.3°
Transition (Moderately Weathered Rock) – Single Benching	60°	10	10	4	45.7°
Slightly Weathered to Fresh Rock	75°	10	20	8	56.3°

Bench stacks (inter-ramps) in SOX should comprise no more than four benches, i.e. they should have a vertical height of no more than 40 m. These bench stacks should be separated by a ramp or geotechnical berm with width no less than 17 m.

Inter-ramps in slightly weathered to fresh rock should consist of no more than eight benches. These should be separated by 25 m ramps or geotechnical berms.

As the Namdini pit is developed, cones of depression are likely to develop in the groundwater system, resulting in groundwater inflows to the open pit from the slopes. It is expected that the de-watering necessary to maintain reasonably dry operating conditions in the pit bottom will be adequate for slope stability purposes. However, this should be evaluated as soon as hydrogeological investigations are undertaken at Namdini.

16.4.3 Further open pit geotechnical investigations and testing

The drilling direction of exploration holes has provided good data on the hanging wall metasediments (to the west of the gold deposit), which will host significant sections of the pit walls. Since the exploration holes generally terminate after crossing through the deposit, little information exists on the footwall metasediments to the east of the Namdini gold deposit.

Golder recommends drilling of four geotechnical boreholes, oriented to the east (into the eastern sections of the pit wall) to investigate the geotechnical properties of that domain. Golder also proposes that three geotechnical boreholes with a westerly azimuth be drilled into the west wall of the pit. These drill holes, generally orientated sub-normal to the pit walls, will help uncover persistent structures that dip sub-parallel to the walls and can thus pose the greatest stability challenges. They will also help to overcome sampling bias due to the consistent orientations of the exploration boreholes.

Golder's recommended pit geotechnical investigations are summarised in Table 46.

Table 46: Recommendations for geotechnical drilling for future open pit design

Borehole No.	Northing	Easting	Dip	Azimuth	Depth (m)
1	1176628	757245	-70	280	520
2	1176979	757272	-70	295	400
3	1177236	757503	-70	310	520
4	1177294	757571	-70	100	400
5	1155057	757432	-70	115	520
6	1176787	757330	-70	115	520
7	1176522	757308	-70	130	400

16.4.4 Geotechnical investigations for plant and TSF

Golder recommends that geotechnical investigations for the CIL plant, tailings storage facilities, and other infrastructure be taken and has outlined a program of work comprising:

- Rotary drilling using diamond bit coring techniques (Geotechnical Drilling).
- SPT testing.
- Field Tests including Dynamic Cone Penetration (DCP) testing to determine the natural bearing resistance of the subsoil for the purpose of design.
- Excavation of test pits using a track mounted excavator.
- Collection of soil and rock samples for visual examination and for carrying out laboratory tests on selected samples to determine the natural, physical and relevant engineering properties of the soil on site.
- Soil and rock sampling.
- Laboratory testing.

Full information on the stratification of all soils, classification, stiffness and ultimate bearing capacity of all soils as determined on site should be provided at the end of the geotechnical investigations. The exploration program for the geotechnical investigation for the mine infrastructure is outlined in Table 47.

Table 47: Recommendations for geotechnical drilling for mine infrastructure

Infrastructure	Rotary Boreholes	Test Pits	DCPs
Plant	**2**	**16**	**16**
Preferred Plant Site	2	10	10
ROM Stockpile	0	2	2
Discard Stockpile		2	2
Product Stockpile		2	2
Tailings Storage Facility	**4**	**20**	**20**
Preferred Site	4	20	20
Total	**6**	**36**	**36**

16.4.5 Conclusions and recommendations

Golder's on-site assessment of the geological and geotechnical conditions at Namdini did not uncover any critical or fatal flaws at the Namdini Gold Project site.

16.5 Pit design concept

- For conceptual pit design analysis, two geotechnical domains were employed to define pit bench heights, berm widths, and slope angles:
- Geotechnical Zone 1 – Slightly and Moderately Oxidised Weathering Domains
- Geotechnical Zone 2 – Transitional and Fresh Weathering Domains.

Specific parameters used in the conceptual designs are presented in Table 48. At this PEA study level, no specific geotechnical slope data was available and hence conservative overall wall angles of 38° and 45.5° for Geotechnical Zones 1 and 2 respectively were selected. These wall angles were reproduced in the design by employing 60° sloped batter angles with 10 m and 20 m bench heights in Zone 1 and Zone 2 respectively. These angles are relatively shallow and reflect a conservative approach given the lack of available data.

Table 48: Geotechnical slope parameters for pit design

Parameter	Units	Geotechnical Zone 1	Geotechnical Zone 2
Face Angles	(°)	60.0	60.0
Average Slope angle	(°)	38.0	45.5
Bench Height	(m)	10.0	20.0
Berm Width	(°)	7.0	7.0
Maximum Overall Slope Angle	(m)	38.0	45.5
Ramp Width	(m)	25.0	25.0
Bench Access Width	(m)	3.5	3.5
Maximum Ramp Gradient	(%)	10.0	10.0

16.5.1 Haul roads, stockpiles and waste dumps

Haul roads on the Namdini site comprise surface roads, in-pit ramps and stockpile and waste storage access ramps. All roads are designed to the same two basic parameters, namely, the road width allowing safe passage of two haul trucks travelling in opposite directions on the road, and the gradient, being shallow enough to allow the largest of vehicles to traverse them safely.

The proposed mine operational tonnages appear suited to a 220-t class truck (Cat 793). All roads on site will be designed with a width of 25 m to provide a minimum width greater than or equal to 2.5 times the expected maximum size truck width. Roads will be designed with a maximum grade of 10% (1:10).

16.5.2 Excavation assumptions

To date no specific trials have been completed to determine the large-scale excavatability of the material types found in the Namdini deposit.

In the absence of large-scale excavation results the following assumptions were applied:

- In the weathered and transitional zones, a mixture of free digging, ripping, drilling and blasting methods are proposed.
- In the fresh, competent material at depth, conventional pre-splitting, drilling and blasting methods are proposed to extract both ore and waste.

No studies of topsoil quantities have been completed and for this PEA the volumes and costs for removal are included in those applied to removal of waste materials.

16.5.3 Pit concept summary

All pit designs completed as part of this PEA should be considered conceptual until specific geotechnical data determines the optimal slope design parameters.

Future studies may improve these conceptual designs by optimising design parameters and site layouts with respect to detailed geotechnical analysis. The results of the conceptual studies are provided in Table 49 below.

Table 49: High Level Whittle 4X™ results for Namdini optimization (Oct 2017)

Whittle Pit	Revenue Factor ($1300/oz)	Final Bench RL	Rock Tonnes Mt	Waste Tonnes Mt	Strip Ratio t:t	ROM Tonnes Mt	Diluted Feed Grade Au (g/t)	DAvg NPV @10% (US$ M)
1	0.500	40	27.5	4.4	0.2	23.1	1.40	200.1
5	0.600	-60	114.2	39.5	0.5	74.8	1.15	543.3
9	0.700	-140	194.2	90.1	0.9	104.1	1.14	618.7
13	0.800	-185	253.7	133.4	1.1	120.4	1.14	622.1
17	0.900	-255	389.6	240.3	1.6	149.4	1.14	572.8
21	1.000	-270	434.9	277.3	1.8	157.6	1.14	544.3

The optimized pit at an RF (revenue factor) of 0.8 was selected as this represented the point where some 99% of the discounted average cash flow is delivered for only 60% of the total rock mined. The graph of discounted cash flow (at NPV10 i.e. a 10% discount rate) against total rock mined is shown in Figure 29. As can be seen from the chart, the discounted value begins to diminish beyond the 0.8 RF1300 optimization shell, but the increase in total rock mined continues to grow.

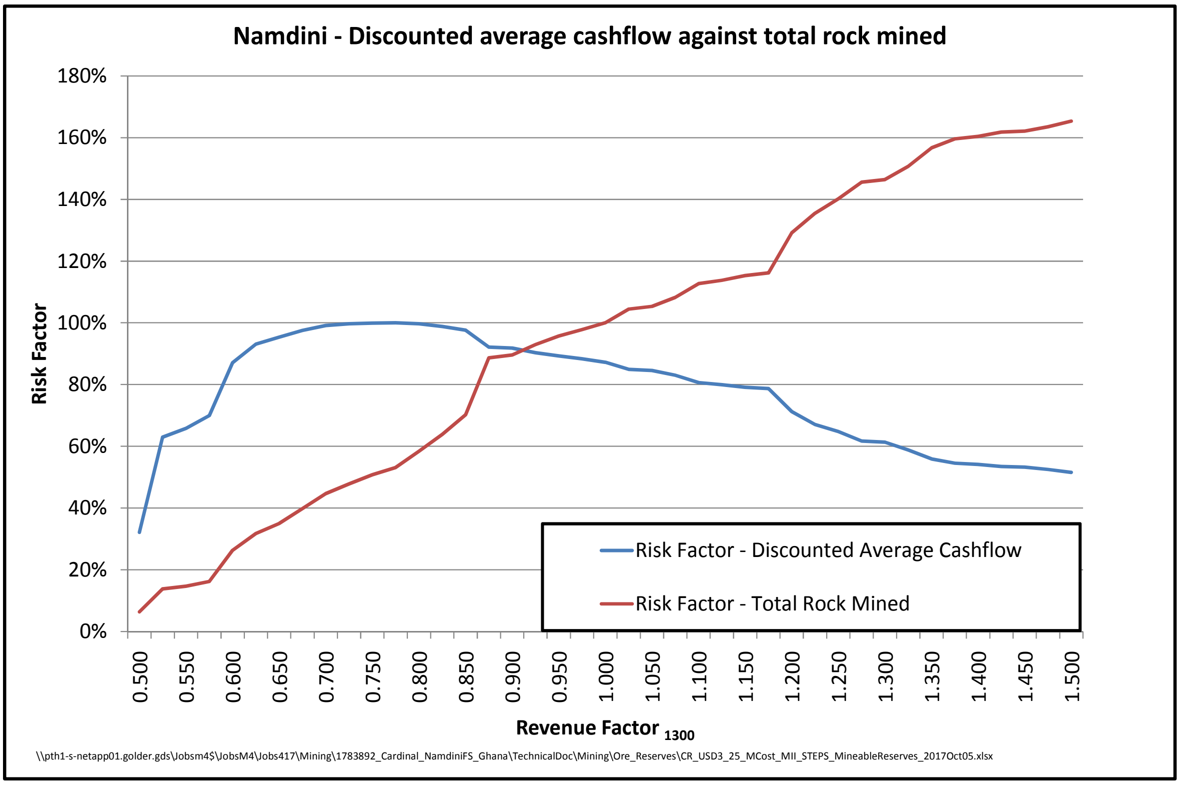

Figure 31: Whittle 4X™ optimization – risk factors for cash flow and total rock movement

16.6 Pit layout

Draft pit stages have been developed from the Whittle 4X™ optimization shells representing possible pushback regions. The whittle 4X™ pit shell results were imported into Vulcan™ as block model file Namdini_LG_MIK_V2_OCT2017_MM.bmf with mining variables added. This mining model, after some preparatory calculations, was then moved to Whittle 4X™ (version 4.5.5) for optimization. The pit optimization process developed a series of nested, largely conical, pit shells for each scenario. Figure 30 below shows the nested shells for the base case (7.0 Mtpa option).

The Whittle 4X™ pit number 13 equating to the revenue factor of 0.8 was selected as the final target pit and a specific pit design was undertaken to demonstrate how much of the mathematical Whittle 4X™ shell could be mined. Figure 31 to Figure 34 show views of the resulting design.

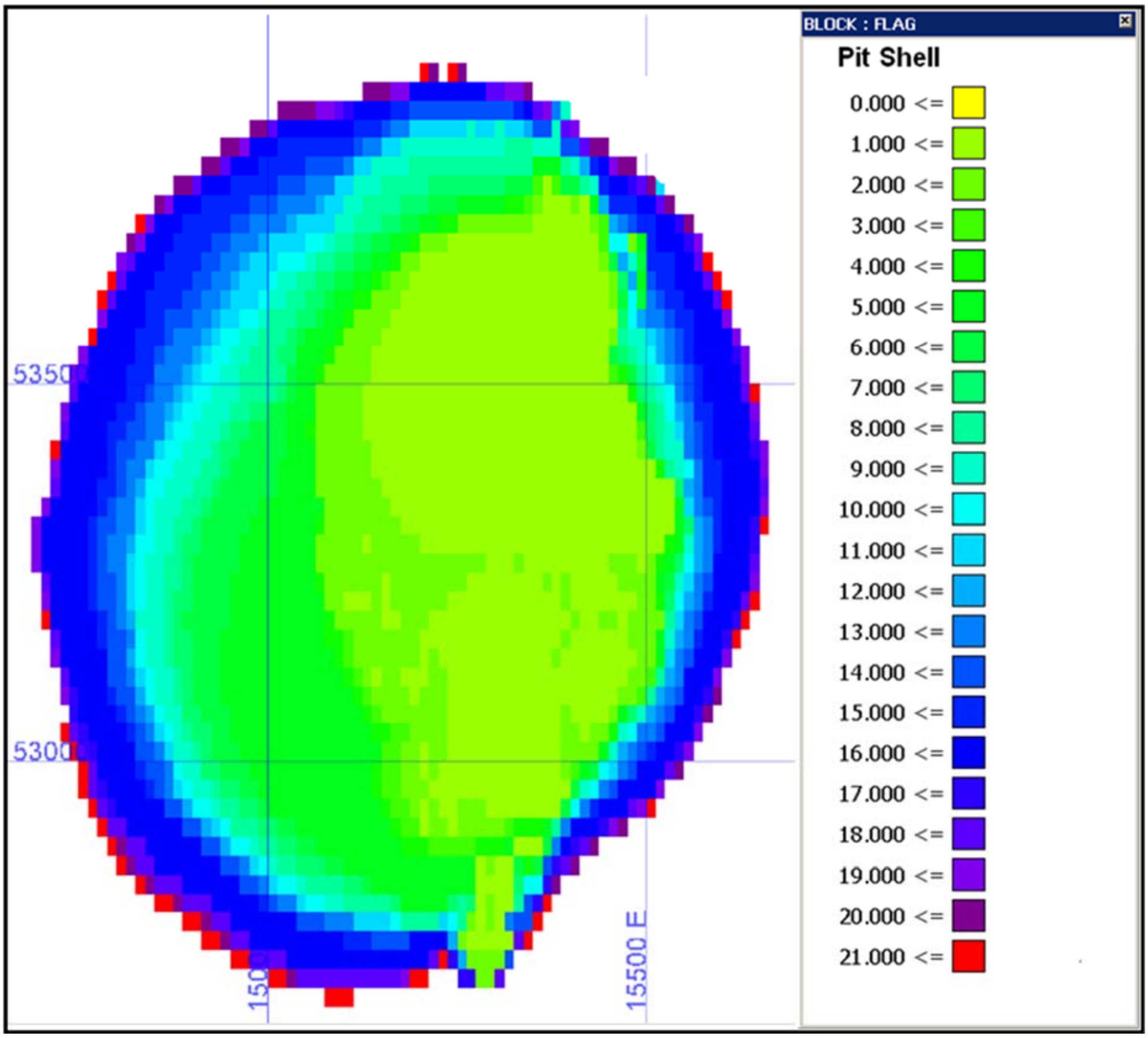

Figure 32: Nested Whittle 4X™ Pit Limits for Base Case (7.0 Mtpa option, all resources)

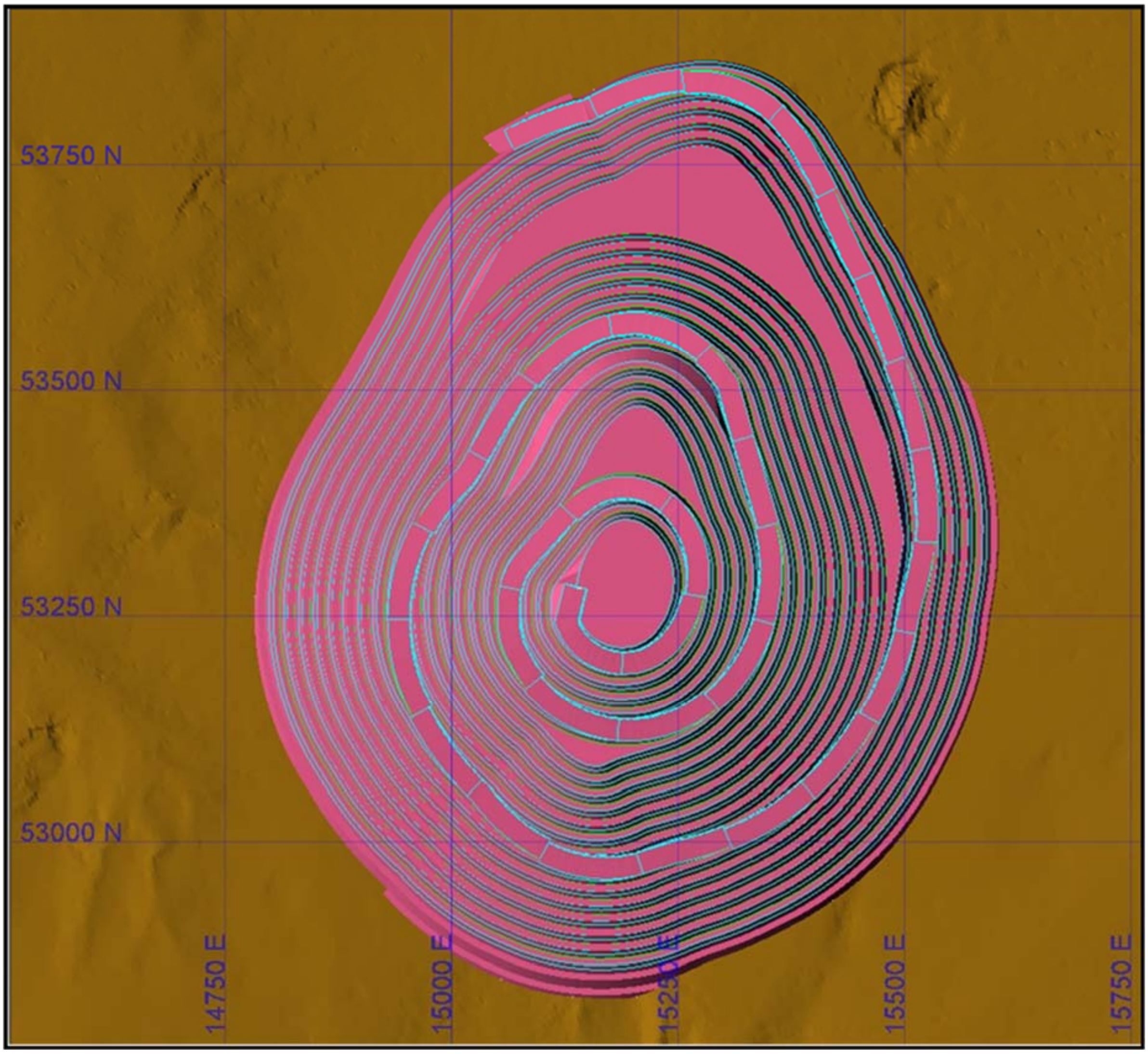

Figure 33: Pit design from Whittle 4X™ for RF 0.8 plan view

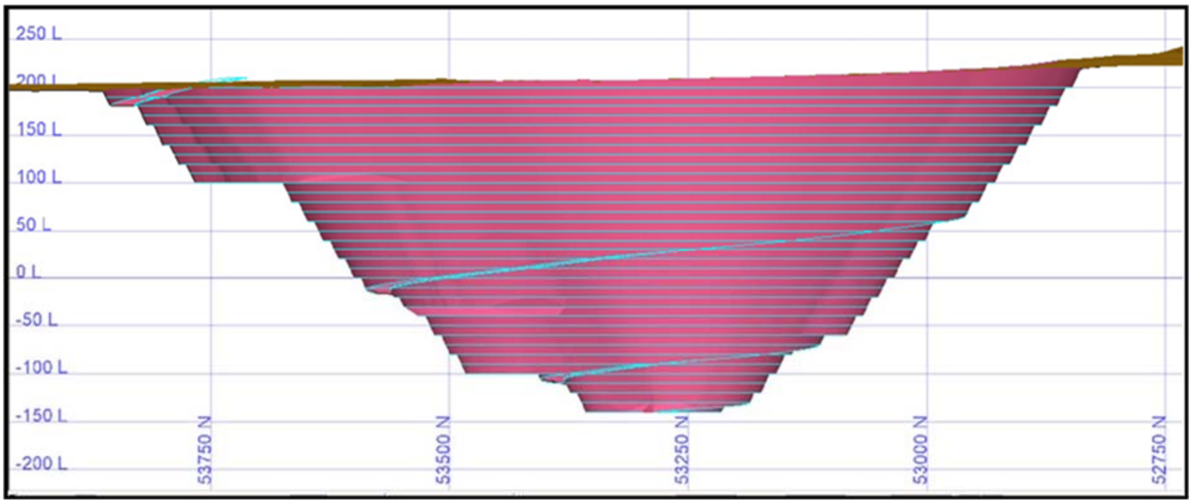

Figure 34: Pit design from Whittle 4X™ for RF 0.8 facing east

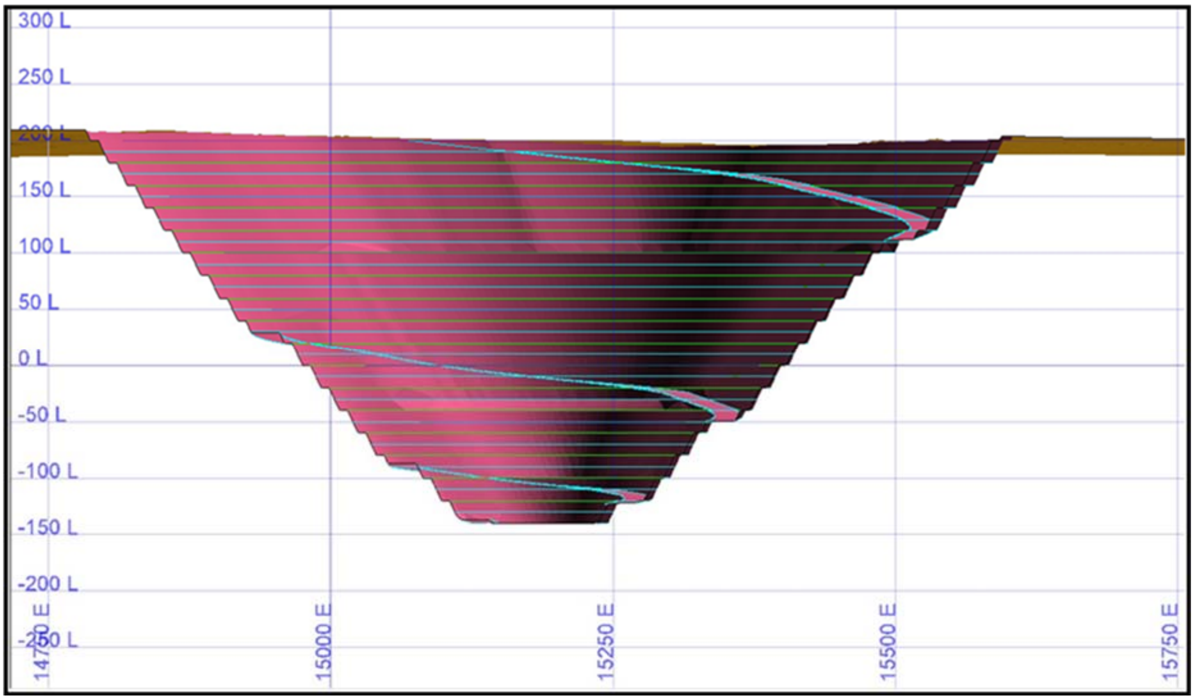

Figure 35: Pit design from Whittle 4X™ for RF 0.8 facing north

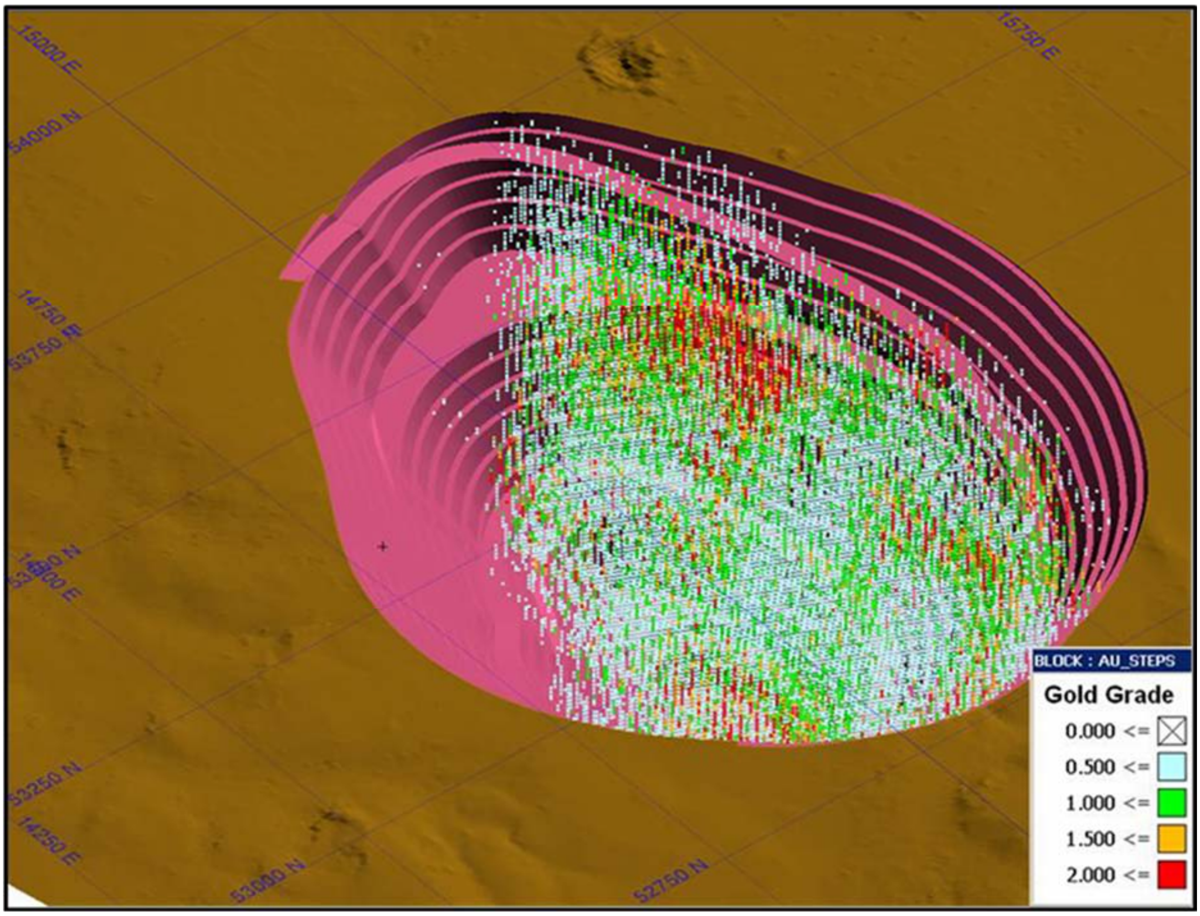

Figure 36: Pit design from Whittle 4X™ for RF 0.8 facing north-east - showing position of ore blocks

16.7 Mining production schedule

High-level mine production schedules were evaluated for the three scenarios considered (4.5, 7.0 and 9.5 Mtpa process plant throughputs) using an initial starter pit with a subsequent pushback to the target pit size.

The schedules allowed for an initial ramp-up of the process plant in each case before full process plant production was assumed.

To gain maximum value from the 9.5 Mtpa option an estimated total peak rock movement of some 30 Mtpa is required in year 7 of that schedule, whereas for the 7.0 Mtpa option this was some 17 Mtpa and for the 4.5 Mtpa option it was some 15 Mtpa. The annual total mining movement required for each scenario considered can be seen in Figure 37.

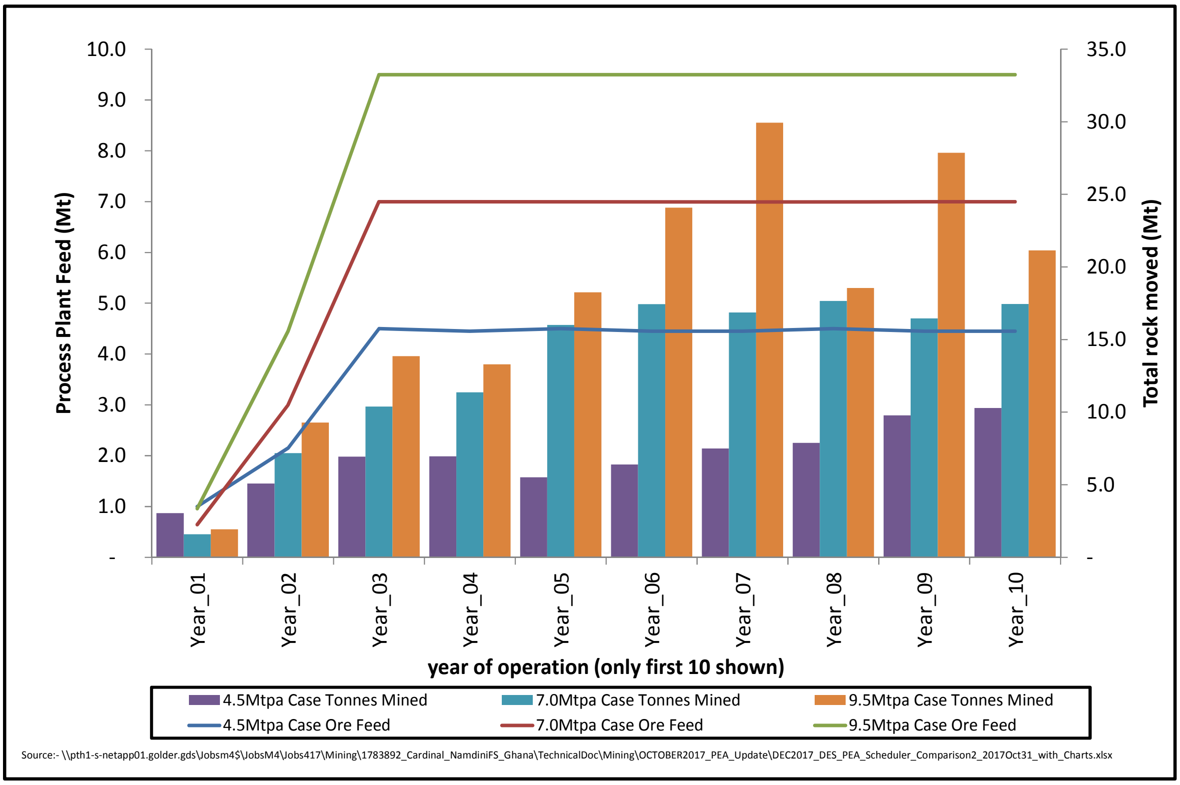

Figure 37: Scheduled total rock movement process plant feed throughput options of 4.5, 7.5 and 9.5 Mtpa only for first 10 years of production.

The mining schedule has specifically allowed for the limited processing of oxide ore to less than 10% of the total mill feed on an annual basis. The scheduled ore feed by material type is shown for the 7.0 Mtpa case in Figure 38, with the oxide ore being fed on a limited annual basis.

The actual maximum quantities of oxide that can be blended with fresh ore in the process plant feed should be determined by further metallurgical testwork.

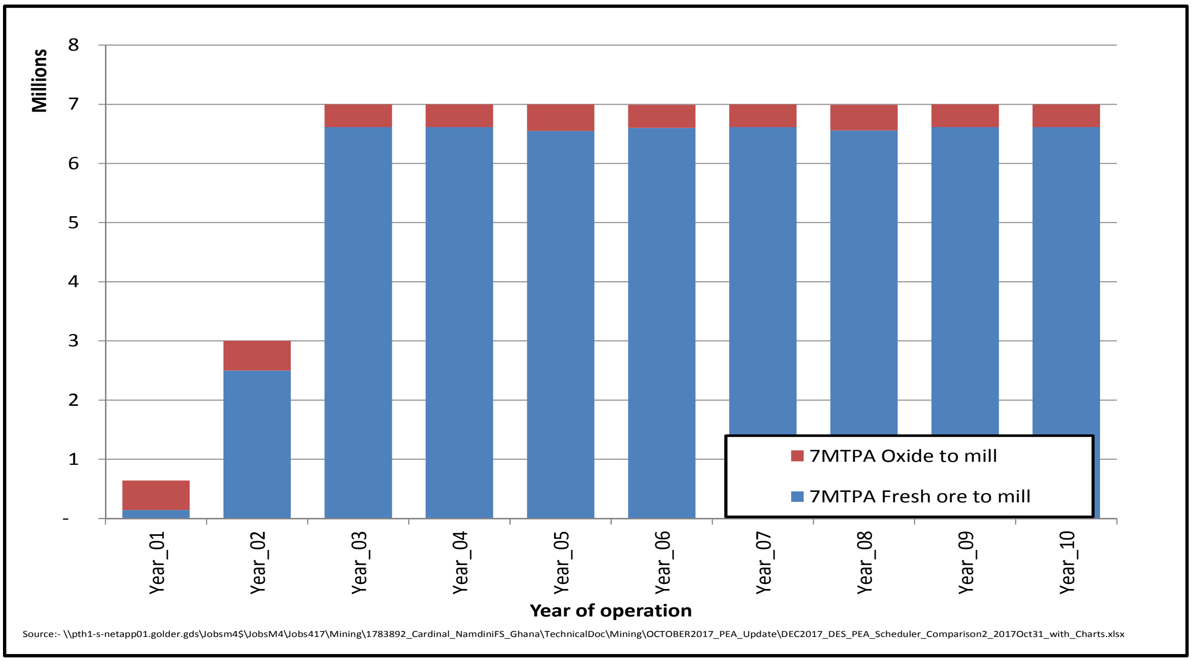

Figure 38: Mill feed by weathering type for 7.0 Mtpa case with Oxide included in main process feed (Note that this graph only shows to yr 10 out of 19 years LOM for the 7.0 Mtpa option)

16.8 Mining equipment

Using the three process plant throughput options, an estimate of the annual truck requirements assuming a 220-t capacity haul truck was undertaken. The schedules indicated that the 9.5 Mtpa option needs approximately 19 haul trucks (the total peak truck requirement after smoothing the schedules, assuming an average Life of Mine (LOM) of 1.3 Mtpa for each haul truck), with the 7.0 Mtpa option needing about 13 trucks and the 4.5 Mtpa option needing about 8 haul trucks.

An estimate of the truck profile for each of the three cases is shown in Figure 39, the tonnage movement profile was smoothed to negate single year peak requirements.

Bulk mining was assumed with limited requirement for selectivity. Only a single truck size is warranted at this PEA study stage.

The 7.0 Mtpa feed option appears to offer the best value consideration in terms of financial return over capital expenditure (Figure 28). A 220 t haul truck matched to a 600 t class excavator is appropriate for this option. Mining is expected to be carried out on 10 m benches, or two 5 m flitches within a 10 m bench.

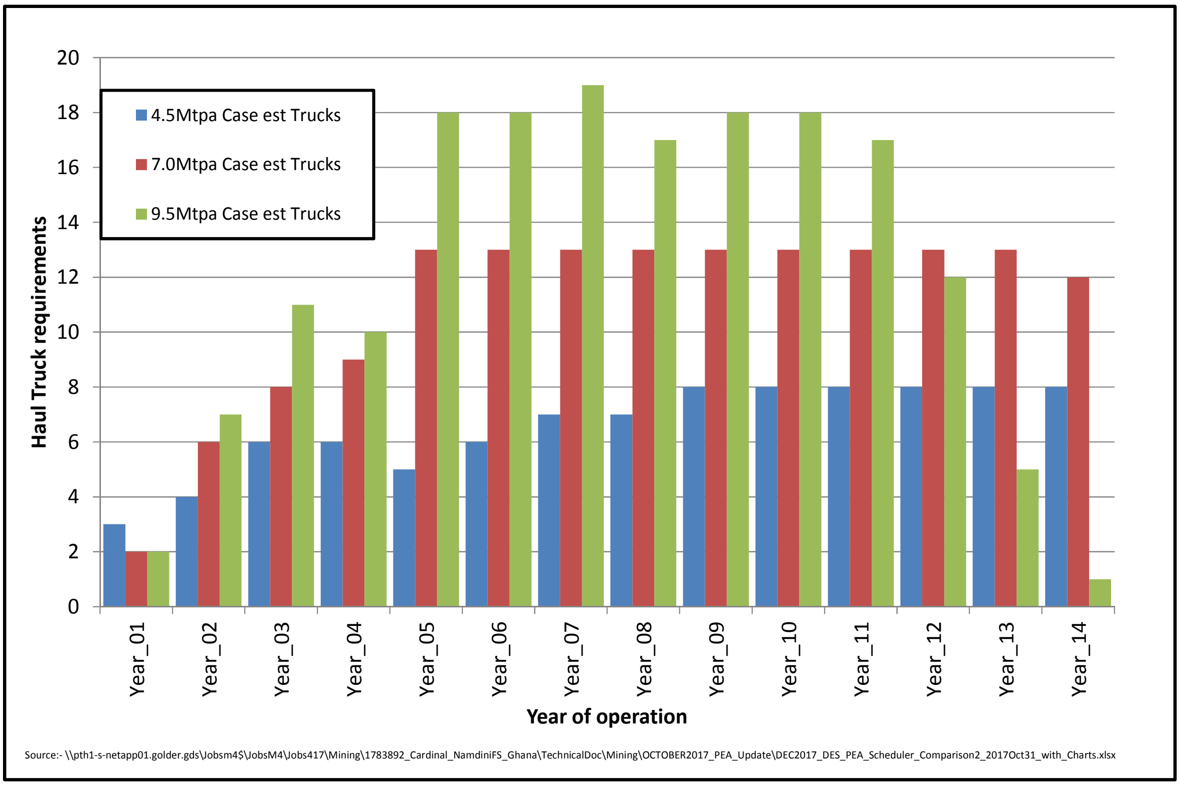

Figure 39: Estimated annual truck requirements for first 14 years of production (Full LOM for 9.5 Mtpa option)

16.9 Mining capital cost estimates

It is proposed that the Namdini Gold Project will be mined on a contract (outsourced) mining basis with capital equipment costs amortised for the mining infrastructure and mining fleet and charged back to Cardinal as a $/tonne mining cost.

16.9.1 Power supply

Electrical power requirements for the mining operations will be minimal, with most mining activities relying on diesel powered engines.

Electrical supply for the primary crusher will be sourced from the high voltage grid line located approximately 25 km away as part of the process plant and infrastructure requirements.

16.9.2 Access, roads and bridges

No specific road access or heavy-duty bridge requirements have been identified at the PEA level of study in the project infrastructure requirements proposed by Lycopodium.

16.9.3 Mining equipment

The Namdini Gold Project was evaluated by Golder based upon a conventional hard rock mining equipment fleet. There are no indicated requirements for untested or novel mining techniques.

16.9.4 Pit dewatering

Pit dewatering requirements will be identified as part of the hydrological study for the project and will be further refined once detailed mine designs and pit extents have been defined.

16.9.5 Explosive facilities

The selected mining contractor will be expected to manage and be responsible for the explosive magazine and bulk explosives production facility, with the latter generally being outsourced to a specialised explosives supplier. There are several reputed international explosives suppliers currently active in Ghana.

16.9.6 Summary capital costs

It is proposed that the total mining capital costs will be borne by the mining contractor under an outsourced mining arrangement and charged back to Cardinal under a cost per tonne mined basis. The contractor cost estimates will include an allowance for the following capital items:

- Establishment to site
- Diesel power generators (if identified in other studies)
- Diesel tank farm
- Miscellaneous site buildings
- Mining equipment
- Haulage trucks
- Light vehicles
- Pit dewatering pumps
- Explosive storage facilities
- Waste disposal infrastructure.

Additional to these, and based on the outcomes of infrastructure and process plant studies, Cardinal may be required to provide the following:

- Connection to the National Grid for power supply
- Additional roads, bridges and river crossings that have not yet been identified

16.10 Mining operating cost estimates

16.10.1 Load and haul

Golder has estimated haul requirements using the industry standard Runge TALPAC™ truck and loader productivity software. An incremental cost allowance of 6 cents per 10 m bench was allowed as a vertical cost increment. The incremental cost with depth is largely driven by the increased haulage time required for the haul trucks and the increased fuel burn of the trucks on the ramp. It is assumed that the loading equipment will remain fully trucked by the contractor with additional trucks being supplied as the average mining depth per cutback increases.

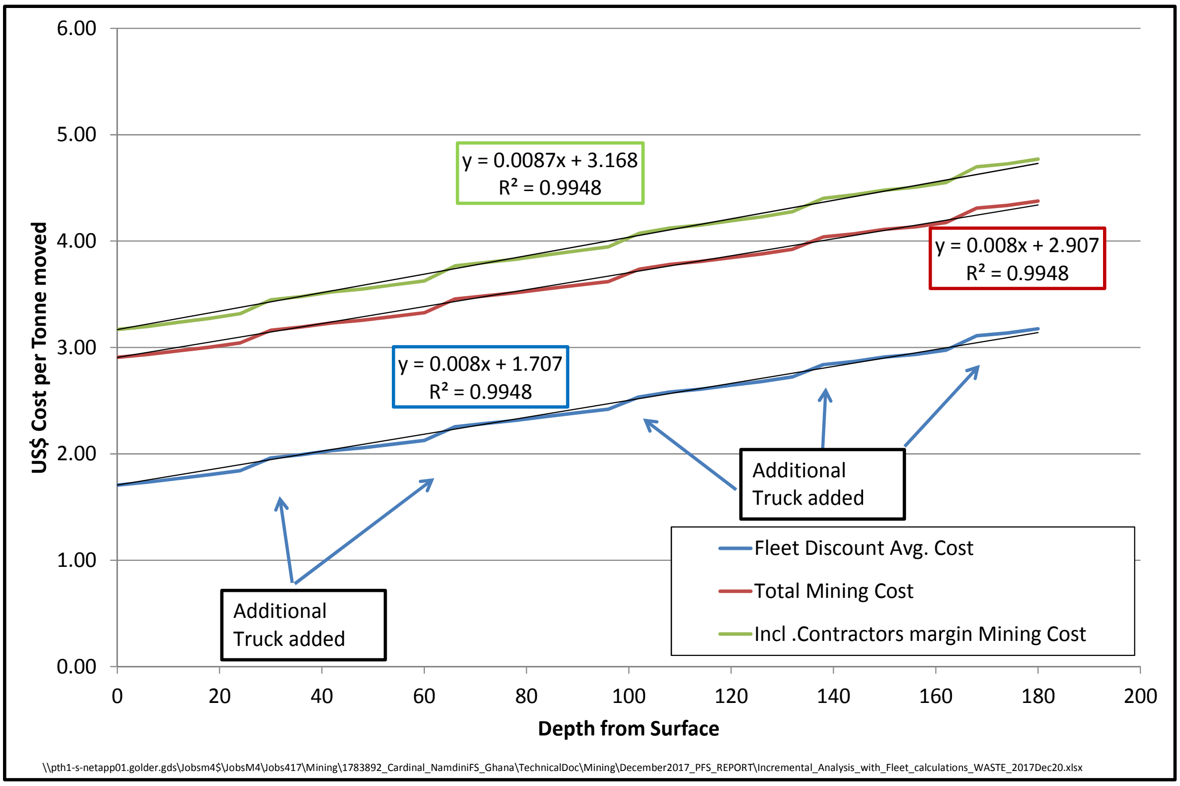

Figure 40: Talpac™ incremental cost analysis with depth with examples of when additional trucks are added

16.10.2 Drill and blast

Specific drill and blast requirements have not been established as part of this study, but it is assumed that all but the surface oxidised ore layer will require drilling and blasting prior to load and haul activities.

16.10.3 Operational mining costs

The contract mining cost for the Namdini operation will be inclusive of drill and blast, load and haul and all associated mining costs with the exception of the mine planning and scheduling components which are assumed to be retained by Cardinal.

The total mining cost will be the subject of a formal tender process from suitably qualified mining contract companies with proven experience in the region.

17.0 RECOVERY METHODS

17.1 Scale of Operation

Cardinal Resources requested that the scoping study examine a range of plant throughputs between about 5 to 10 Mtpa for the Namdini Scoping Study and that the plant throughputs considered should be based on logical step changes for the plant equipment.

Review of the comminution circuit requirements identified the lower and upper plant throughputs as follows:

- At a minimum throughput of 4 - 4.5 Mtpa, lower cost equipment types can be used such as a jaw crusher instead of a gyratory crusher, a crushed ore surge bin instead of a live stockpile and a single pinion drive on the grinding mills instead of dual pinion or gearless drives.
- A throughput of 9 - 9.5 Mtpa was indicated as the maximum based on using dual pinion drives rather than the more expensive gearless drives for the grinding mills.

Comminution circuit modelling based on these criteria was completed with three plant throughput options selected based on the minimum and maximum and a midpoint. The selected plant throughput rates for the scoping study are:

- 4.5 Mtpa
- 7.0 Mtpa
- 9.5 Mtpa

17.2 Design Philosophy

The proposed process plant design for the Namdini Project is based on a metallurgical flowsheet designed for optimum recovery with minimum operating costs. The flowsheet is constructed from unit operations that are well proven in industry.

The key project and ore specific design criteria that the plant design must meet are as follows:

- 4.5 Mtpa, 7.0 Mtpa or 9.5 Mtpa of primary ore.
- Crushing plant mechanical availability of 80% (6,988 h/y).
- Mechanical availability for the remainder of the plant of 91.3% (8,000 h/y) supported by crushed ore storage and standby equipment in critical areas.
- Sufficient automated plant control to minimise the need for continuous operator interface and allow manual override and control if and when required.

Study documents have been prepared incorporating the engineering and key metallurgical design criteria derived from the results of the metallurgical testwork.

17.3 Selected Process Flowsheet

The treatment plant design incorporates the following unit process operations:

- Primary crushing to produce a coarse crushed product.
- Coarse crushed ore storage and reclaim to feed the milling circuit.
- A SABC milling circuit comprising a SAG mill in closed circuit with a pebble crusher and a ball mill in closed circuit with hydrocyclones to produce a grind size of 80% passing (P_{80}) 106 micron.
- Gravity concentration and treatment of gravity concentrate by intensive cyanidation and electrowinning.

- Flotation of the milled slurry to recover the majority of gold to a low mass (<10%) sulphide flotation concentrate and producing 'throw away' flotation tailings.
- Separate thickening of the flotation concentrate and flotation tailings to recover cyanide free flotation water and to thicken the streams prior to downstream processing.
- Grinding of the flotation concentrate in a regrind mill to produce a grind size of P_{80} 15 micron prior to feeding to the CIL circuit.
- A CIL circuit to leach and adsorb gold and silver values from the reground flotation concentrate onto activated carbon in seven tanks providing a total of 72 hours leach time.
- A split AARL elution circuit, electrowinning and gold smelting to recover gold from the loaded carbon to produce doré.
- A SO2 / oxygen cyanide destruction circuit to reduce the concentrate CIL tailings cyanide concentration to below the maximum International Cyanide Management Code (ICMC) weak acid dissociable cyanide (CNWAD) level of 50 ppm.
- Parallel pumping of the cyanide destruction discharge and the thickened flotation tailings to the separate cyanide and non-cyanide tailings storage facilities (TSF).

17.4 Comminution Circuit Selection

A primary crush SABC circuit has been selected for the scoping study plant design. The circuit will achieve a target grind size of P_{80} 106 µm treating primary ore.

Details of the comminution testwork are included in Section 6. The comminution data was provided to Orway Mineral Consultants (OMC) for comminution circuit modelling and mill sizing. OMC completed comminution circuit modelling based on logical step changes for the size and type of comminution equipment and sized the required mills for the three plant throughput options.

The key parameters used in modelling of the comminution circuit and the selected equipment are summarised in Table 50.

Table 50: Comminution Design Parameters and Equipment

Parameters / Equipment	Units	Value	Basis	
Testwork				
BWi	kWh/t	14.9	Testwork	
SPI	min	99.42	Testwork	
Axb	-	27.5	Derived from SPI	
CWi	kWh/t	15	Assumed from OMC Database	
Ai	-	0.5	Assumed from OMC Database	
SG	-	2.70	Assumed from OMC Database	
Milling Operating Hours	h/y	8,000	Lycopodium	
Required Grind Size P_{80}	µm	106	Cardinal	
Plant Throughput	**Mtpa**	**4.5**	**7.0**	**9.5**
	t/h	563	875	1,188
Power Modeling				
SAG Mill Specific Energy	kWh/t	9.7	9.9	9.9
Pebble Crusher Specific Energy	kWh/t	0.22	0.19	0.19
Ball Mill Specific Energy	kWh/t	10.1	10.0	9.9
Total Specific Energy	kWh/t	20.0	20.1	20.1
SAG Mill Pinion Power Required	kW	5,459	8,633	11,739
Ball Mill Pinion Power Required	kW	5,669	8,707	11,799

Parameters / Equipment	Units	Value	Basis	
Equipment Selection				
Primary Crusher		Jaw Crusher	Gyratory Crusher	Gyratory Crusher
SAG Mill				
Mill Diameter x Length (EGL)	m x m	8.53 x 4.91	9.75 x 5.54	10.94 x 5.56
Installed Power	kW	7,300	11,400	15,400
Ball Mill				
Mill Diameter x Length (EGL)	m x m	6.10 x 10.21	7.00 x 11.15	7.92 x 11.16
Installed Power	kW	7,300	11,400	15,400
Pebble Crusher		Cone Crusher	Cone Crusher	Cone Crusher

17.5 Regrind Circuit Selection

An Outotec HIGmill operating in open circuit has been selected as the regrind circuit for the scoping study plant design. The regrind mill will achieve a target grind size of P_{80} 15 µm treating sulphide flotation concentrate.

The regrind mills for the three plant throughput options were initially sized by Lycopodium based on 10% mass pull to flotation concentrate and an assumed specific grinding energy of 30 kWh/t.

The regrind mill sizes were selected by the vendor based on standard HIGmill sizes as presented in Table 51

Table 51: Regrind Circuit Parameters and Equipment

Plant Throughput		4.5 Mtpa	7.0 Mtpa	9.5 Mtpa	Basis
Mass Pull to Concentrate	%	10	10	10	Cardinal
Regrind Feed	t/h	56	88	119	Calc
Regrind Feed % Solids	% w/w	50	50	50	Assume
Regrind Feed Size	P_{80} µm	106	106	106	Cardinal
Required Regrind Product Size	P_{80} µm	15	15	15	Cardinal
Selected Regrind Mill	Type	HIGmill	HIGmill	HIGmill	Lycopodium
Installed Power	kW	1,600	2,500	3,500	Outotec
	kW/t	29	28	29	Calculated

17.6 Key Process Design Criteria

The key process design criteria listed in Table 52 form the basis for the plant design.

Table 52: Key Process Design Criteria

Item	Unit	Value	Source [1,2,3,4]
Plant Throughput Options	Mt/y	4.5, 7.0, 9.5	Cardinal
Design Gold Head Grade	g Au/t	1.2	Cardinal
Gravity Gold Recovery	%	5	Cardinal
Gold Recovery to Flotation Concentrate	%	96	Cardinal
Concentrate CIL Gold Recovery	%	92	Cardinal
Overall Gold Recovery, Design	%	88	Calc
Crushing Plant Utilisation	%	80	Lycopodium
Milling / Float / CIL Plant Utilisation	%	91.3	Lycopodium
Comminution Design Parameters and Mill Power		As per Table 50	Testwork / OMC
Comminution Circuit		Primary Crush / SABC	OMC
Grind Size, P_{80}	µm	106	Cardinal
Testwork Flotation Residence Time	min	15	Testwork/Assume
Mass Recovery to Flotation Conc, Design	%	10	Cardinal
Mass Recovery to Flotation Conc, Nominal	%	5	Cardinal
Flotation Tailings Thickener Solids Loading	$t/m^2.h$	1.5	Assume
Flotation Concentrate Thickener Solids Loading	$t/m^2.h$	1.0	Assume
Concentrate Regrind Size, P_{80}	µm	15	Cardinal
Power Required for Regrind, @ design mass pull	kWh/t conc	26	Assume
Power Required for Regrind, @ nominal mass pull	kWh/t conc	30	Assume
Number of Concentrate CIL Tanks	No.	1 Pre-Ox / 6 CIL	Lycopodium
Concentrate CIL Slurry Density	% w/w	35	Assume
Concentrate CIL Residence Time	hrs	72	Cardinal
Loaded Carbon Grade	g/t Au	7,100	Assume
Cyanide Destruction Circuit		SO_2 / O_2	Lycopodium
CIL Tails Residual Cyanide	ppm	500	Assume
Plant Tails Residual Cyanide, Target	ppm	50	Cardinal
Elution Circuit Type		Split AARL	Lycopodium
Elution Circuit Capacity	t	2.5, 4.0, 5.5	Lycopodium
Frequency of Elution	strips / week	6	Lycopodium
Tailings Storage		Separate Facilities	Cardinal / Knight Piesold
Flotation Activator Copper Sulphate	g/t ore	40	Testwork/Assume

Item	Unit	Value	Source [1,2,3,4]
Flotation Promoter Aero 3148A	g/t ore	10	Testwork/Assume
Flotation Collector PAX	g/t ore	50	Testwork/Assume
Flotation Frother XP 200	g/t ore	40	Testwork/Assume
CIL Sodium Cyanide Consumption	kg/t conc	7.5	Assume
CIL Quicklime Consumption	kg/t conc	5.0	Assume
CIL Oxygen Consumption	Nm^3/t conc	10	Assume

Notes:
1 'Testwork' refers to metallurgical testwork conducted.
2 'Cardinal' refers to advice / agreement from Cardinal Resources.
3 'Lycopodium' refers to Lycopodium experience or generally accepted practice.
4 'OMC' refers to advice from Orway Mineral Consultants.

17.7 Process and Plant Description

17.7.1 Primary Crushing, Ore Storage and Reclaim - 4.5 Mtpa Plant

Mining haul trucks will deliver ore to the process plant and will tip directly into the ROM bin. If necessary, ore can be tipped onto the ROM pad and will be reclaimed to the ROM bin by a front-end loader (FEL).

ROM ore will be drawn from the ROM bin by an apron feeder and will discharge onto a vibrating grizzly. The grizzly oversize will report to the jaw crusher for primary crushing. The jaw crusher product and grizzly undersize will be conveyed to the surge bin. The surge bin will have sufficient short-term capacity (less than 30 minutes) to provide feed to the milling circuit during crushing circuit stoppages.

Crushed ore will be withdrawn from the surge bin via an apron feeder and conveyed to the milling circuit. Excess crushed ore will overflow the surge bin onto the stockpile feed conveyor and will be transferred to the dead stockpile. The stockpile will be reclaimed by FEL directly to the surge bin during longer term crushing circuit stoppages or maintenance.

Dry dust collectors and water sprays and will be installed for dust capture and suppression in the crushing and reclaim circuits.

17.7.2 Primary Crushing and Ore Storage – 7.0 Mtpa and 9.5 Mtpa Plants

Mining haul trucks will deliver ore to the process plant and will tip directly into either side of the ROM pocket. If necessary, ore can be tipped onto the ROM pad and will be reclaimed to the ROM pocket by a FEL.

ROM ore will be crushed by the gyratory crusher and then withdrawn from the ROM discharge pocket by the apron feeder. The primary crushed ore will be conveyed to the stockpile which will have sufficient storage capacity to provide feed to the milling circuit to allow for regular maintenance on the crusher.

Crushed ore will be withdrawn from the coarse ore stockpile by apron feeders and conveyed to the milling circuit.

Dry dust collectors and water sprays and will be installed for dust capture and suppression in the crushing and reclaim areas.

17.7.3 Grinding and Classification

Crushed ore will be milled to achieve the required grind size for gold and sulphide mineralization liberation. The grinding circuit will consist of a SAG mill in closed circuit with a pebble crusher and a ball mill in closed circuit with hydrocyclones. Steel balls will be added as required to the mills as grinding media.

Crushed ore will be fed directly to the SAG mill and flotation water added to achieve the correct milling density. The SAG mill will discharge via a pebble dewatering screen, and oversize consisting of pebbles and worn steel grinding media, will discharge onto the pebble crushing feed conveyor. Worn media will be removed by a magnet and pebbles will be crushed in the pebble crusher and will report back to the SAG mill conveyor, via the pebble return conveyor.

The pebble dewatering screen undersize will gravitate to the mill discharge hopper (along with the ball mill discharge) and will be diluted with flotation water prior to pumping to the classifying hydrocyclone (cyclone) cluster for size classification.

The cyclone underflow (coarse material) will report to the ball mill feed chute for further grinding. The cyclone overflow (product size material) will report to the trash screen to remove any trash material and coarse particles. Trash screen underflow will report to flotation, while oversize trash will be collected in a bin for removal and disposal.

17.7.4 Gravity Circuit

A portion of the cyclone underflow stream will feed the gravity circuit which will remove coarse gold from the milling circuit recirculating stream. The gravity circuit will consist of a scalping screen and centrifugal concentrator.

The gravity feed stream will be screened to remove coarse material which will report to ball mill feed for further processing. The screen undersize slurry will report to the centrifugal concentrator with the coarse, high specific gravity material (gravity concentrate) periodically discharged to the concentrate storage hopper for further processing (see Elution and Goldroom Operations).

The tails slurry from the centrifugal concentrator will gravitate to the mill discharge hopper for further processing.

17.7.5 Flotation

The flotation circuit will consist of a conditioning tank and five flotation tank cells and will recover a gold rich sulphide concentrate representing about 10% of the original feed tonnes.

Trash screen underflow from the grinding circuit will flow to the conditioning tank where flotation reagents promoter A3418A, activator copper sulphate and collector potassium amyl xanthate (PAX) will be added to the slurry. Conditioned slurry will report to the first flotation cell and will be dosed with frother XP200. Additional flotation reagents will be added down the flotation train as required. Flotation air will be introduced down the agitator shafts at a controlled rate.

Flotation concentrate will gravitate to the concentrate hopper and will be pumped to flotation concentrate thickening. Flotation tails will be pumped to flotation tails thickening.

17.7.6 Thickening

Flotation concentrate will be thickened to increase the slurry density prior to regrinding and to recover cyanide-free float water from the slurry. Flotation tailings will be thickened to recover cyanide-free float water from the slurry.

Each thickener feed slurry will be mixed with flocculant to facilitate effective settling. The thickened flotation concentrate (thickener underflow) will be pumped to the regrind circuit for further processing. The thickened flotation tailings (thickener underflow) will be pumped to the tails circuit for disposal.

Thickener overflows from both thickeners will gravitate to the float water tank for re-use in the cyanide free plant areas. Water shortfall will be supplemented with flotation TSF decant return water and raw water from the raw water pond to provide the balance of the milling and flotation area water.

17.7.7 Concentrate Regrind

Thickened flotation concentrate will report to a regrind mill for additional grinding. Ceramic grinding media will be added to the regrind mill as required. Ground concentrate will gravitate from the regrind mill to the CIL feed hopper and will be pumped to CIL.

17.7.8 Concentrate Leach and Adsorption Circuit

Gold will be leached from the reground flotation concentrate using sodium cyanide and oxygen. The dissolved gold will be recovered from the leach solution by adsorption onto activated carbon. The carbon will be periodically removed from the slurry and further processed to recover the gold.

The leaching and adsorption circuit will consist of a pre-leach tank and six carbon-in-leach (CIL) adsorption tanks sized to provide the required leaching residence time. The tanks will be interconnected with launders and slurry will flow by gravity through the tank train. The tanks will each be fitted with an intertank screen to retain the carbon.

The reground concentrate will be diluted with process water in the leach feed distribution box and the pre-leach tank to achieve the required leaching solids concentration. Lime slurry will be added to the leach feed distribution box and pre-leach tank to achieve the slurry pH required for cyanidation. Oxygen will be sparged down the shafts of the pre-leach tank agitator to oxygenate the slurry and to oxidise any cyanide consumers prior to leaching.

Sodium cyanide solution will be metered into the first CIL tank and into the other CIL tanks as required. Oxygen will be sparged down the shafts of the CIL tank agitators to provide oxygen to the leach.

Barren carbon will be added to the circuit in the final CIL tank and will be advanced counter current to the slurry flow allowing leached gold and silver to adsorb onto the carbon and be recovered from the CIL slurry. Carbon loaded with gold (loaded carbon) will be removed from the CIL slurry via the loaded carbon recovery screen and will report to the elution circuit to remove the contained gold and silver. After elution and regeneration in a kiln, the barren carbon will be screened and returned to the CIL circuit.

Slurry from the last CIL tank (CIL tails) will gravitate via the carbon safety screen to the cyanide destruction circuit. The carbon safety screen will recover any loaded carbon remaining in the CIL tails.

17.7.9 Elution and Goldroom Operations

The following operations will be carried out in the elution and gold room areas:

- Acid washing of carbon.
- Stripping of gold from loaded carbon back into solution using the split AARL method.
- Electrowinning of gold and silver from solution.
- Smelting of electrowinning products.
- Regeneration of barren carbon.
- Intensive cyanidation of the gravity concentrates and electrowinning of gravity gold solution.

Loaded carbon will be washed in the acid wash column with a dilute hydrochloric acid solution to remove contaminants. The loaded carbon will be transferred to the elution column and will be eluted with a hot dilute cyanide / caustic solution and water washing which will remove the gold from the carbon into the solution (pregnant solution).

Pregnant solution will be pumped through the parallel electrowinning cells and the gold will be recovered onto the cell cathodes. The gold will be removed from the cathodes by high pressure water jet washing with the gold sludge being filtered and dried prior to smelting with fluxes in a furnace to produce doré bars.

Fume extraction and gas treatment equipment will be provided to remove and scrub gases from the electrowinning cells, oven and barring furnace.

Eluted carbon (barren carbon) will be transferred to the carbon regeneration kiln for reactivation prior to re-use in the CIL circuit.

Gravity concentrate will be processed in batches through an intensive cyanidation reactor and dedicated electrowinning cell. Flocculant may be added to assist in settling of the concentrate. Gold will be leached from the gravity concentrate using sodium cyanide and oxygen with caustic solution added for pH control. Gravity leach tails will be washed and pumped back to the mill discharge hopper for retreatment.

The leach solution (pregnant solution) will be pumped through the gravity electrowinning cell to recover the contained gold. The gravity gold will be washed from the cathodes and the sludge filtered, dried and smelted.

17.7.10 Cyanide Destruction

A SO2 / oxygen cyanide destruction circuit will be utilised to meet the ICMC tailings discharge requirements of less than 50 mg/L weak acid dissociable cyanide (CNWAD) in the tailings slurry.

Screened CIL tails will gravitate to the cyanide destruction circuit consisting of two tanks interconnected with launders to allow the circuit to be run in parallel or series. Copper sulphate and sodium metabisulphite (SMBS) solutions will be added to provide the required copper and sulphur dioxide for the cyanide destruction process. Oxygen gas required for the destruction process will be sparged into the cyanide destruction tanks below the agitators. Slaked lime slurry will be added as required to maintain the slurry pH within the required range.

Cyanide destruction discharge will gravitate to the CIL tails hopper.

17.7.11 Tailings Disposal

Cyanide destruction circuit discharge will be pumped to the polymer lined CIL TSF and will be deposited using established discharge methods. Supernatant water will be recovered from the CIL TSF and returned as low cyanide decant return to the plant process water pond for re-use.

Flotation tails thickener underflow will be pumped to the flotation TSF and will be deposited into the TSF using established discharge methods. Supernatant water will be recovered from the flotation TSF and returned as cyanide free decant return water to the plant flotation water pond for re-use.

Any plant spillage that may contain cyanide will be directed to an event pond. Material in the event pond will be periodically reclaimed and returned to the process plant.

17.7.12 Reagents

Reagents will be stored on site to ensure that supply interruptions do not restrict production. The following reagents will be used in the process:

- Lime - Hydrated or quicklime will be delivered as a powder in bulk bags. Lime will be mixed with process water to achieve the required slurry density. Slaked lime slurry will be metered into the CIL feed and cyanide destruction circuits for pH control.
- Cyanide - Cyanide will be delivered as dry briquettes in bulk bags. The cyanide will be dissolved by mixing with process water to the required solution strength and transferred to a storage tank. Cyanide solution will be metered to the CIL circuit and intensive cyanidation reactor for gold leaching and to the elution circuit for stripping gold from the loaded carbon.
- Caustic - Caustic soda (sodium hydroxide) will be delivered as dry 'pearl' pellets in bulk bags. The caustic will be dissolved by mixing with raw water to the required solution strength and caustic solution will be metered into the elution circuit for stripping gold from the loaded carbon and to the intensive cyanidation reactor for pH control.
- Hydrochloric Acid - Concentrated hydrochloric acid will be delivered in drums. The acid will be diluted with raw water and metered into the elution circuit for acid washing of the loaded carbon.
- Activated Carbon - Activated carbon will be delivered in bulk bags and will be added as barren carbon make-up to the CIL circuit.
- Steel Grinding Media - Grinding media (steel balls) will be delivered in drums and will be charged to the SAG and ball mills as required to achieve the target power draws. A FEL will be used to add SAG mill balls to the mill feed conveyor as required. Ball mill balls will be loaded into a ball loading kibble and lifted to the ball mill feed chute as required.
- Ceramic Grinding Media - Grinding media (ceramic beads) will be delivered in drums and will be charged to the regrind mill as required to achieve the target power draw. Regrind mill media will be loaded into a loading kibble and lifted to the regrind mill feed chute as required.
- Promoter - Flotation promoter A3418A will be delivered as a liquid in 200 L drums. The promoter will be transferred into the promoter storage tank and will be dosed directly into the flotation circuit as required.

- Frother - Flotation frother XP200 will be delivered as a liquid in 200 L drums. The frother will be dosed directly into the flotation circuit as required.
- Potassium Amyl Xanthate - Potassium Amyl Xanthate (PAX) will be delivered as a powder in bulk bags. PAX will be dissolved by mixing with raw water to the required solution strength and transferred to the storage tank. PAX solution will be metered to the flotation circuit as required.
- Copper Sulphate - Copper sulphate will be delivered as a powder in bulk bags and will be mixed with raw water and stored in the mixing tank. Copper sulphate solution will be metered to the flotation and cyanide destruction circuit as required.
- Sodium Metabisulphite - Sodium metabisulphite will be delivered in bulk bags and will be mixed with raw water and transferred to a storage tank. Sodium metabisulphite solution will be metered to the cyanide destruction circuit as required.
- Flocculant - Flocculant powder will be delivered in bulk bags and will be mixed with raw water and transferred to a storage tank. Flocculant will be metered to the flotation concentrate and flotation tails thickeners and intensive cyanidation reactor as required.
- Fluxes - Sodium borate (borax), silica flour, sodium nitrate (nitre) and sodium carbonate (soda ash) are used as fluxes for gold smelting. The fluxes will be delivered in 25 kg bags and mixed in small quantities with the gold sludge prior to smelting.
- Diesel - Diesel will be delivered by bulk tanker and transferred to the plant diesel day tank for storage and distribution. Diesel will be reticulated to the elution heater, carbon regeneration kiln and smelting furnace.

17.7.13 Services

The following plant services will be provided:

- Flotation Water - Flotation water will be stored in the flotation water tank (adjacent to the flotation tailings and pre-leach thickeners) and will consist of thickener overflow from the flotation tailings and pre-leach thickeners, non-cyanide flotation TSF decant return water, with raw water make-up as required. Duty / standby flotation water pumps will be provided for the flotation water supply. Separate water pumps will be provided for fluidisation water supply to the gravity concentrator and for spray water to the milling and flotation circuits.
- Raw Water - Raw water for the project will be pumped from the Volta River to the plant site raw water pond and will be pumped as required for use in the plant and the mine services area.
- Fire Water - Fire water for the process plant will be pumped from the raw water pond. The fire water suction from the pond will be at a lower level than the raw water supply suction to ensure a fire water reserve always remains in the raw water pond. A backup diesel driven fire water pump will be provided in addition to the electric fire water pump.
- Process Water - Process water will consist of the low cyanide CIL TSF decant return water, with raw water make-up as required. Process water will be stored in the process water pond and will be pumped as required for use in the plant.
- Filtered Water - Filtered water for the process plant will be produced by treating raw water in the filtered water treatment plant. Filtered water will report to the filtered water storage tank and will be used for the elution circuit, gland service water and cooling water applications.
- Potable Water - Raw water will be treated in the potable water treatment plant and will be reticulated to the plant site ablutions, safety showers and other potable water outlets.
- Flotation Air - Flotation air will be supplied by air blowers and will be reticulated to the flotation cells.
- Oxygen - Oxygen for the CIL and cyanide destruction circuits will be generated on-site in an oxygen plant and will be reticulated to the CIL and cyanide destruction tanks and the intensive cyanidation reactor.

- Plant and Instrument Air Supply - Plant and instrument air will be supplied from air compressors and will be filtered and dried before distribution to the plant.

17.8 Plant Layout and Design Considerations

A typical footprint for a plant of this flowsheet and capacity as developed by Lycopodium for previous projects of this scale has been allowed. The location reflects the quantity and level of confidence in the available information and is suitable for visually representing the conceptual site layout and supporting the operating and capital cost estimates.

Further work will be undertaken at the pre-feasibility and feasibility study stages when additional topographical and geotechnical information is available to optimise both the plant location and layout.

As the estimates were derived from previous Lycopodium designs they inherently represent the cost of designs compliant with local and Australian standards.

17.9 Electrical Design

The capital and operating cost estimates were developed based on an assumed electrical design compliant with all local standards and based on typical Australian design standards where local standards are deemed to be insufficiently prescriptive or compliant with international norms for safety and reliability.

17.9.1 Installed Load and Demand

Based on the comminution data available and Lycopodium's database of similar plant designs, the process plant and site infrastructure are expected to have the following average continuous power draw when treating primary ore with 5% mass pull to flotation concentrate:

- 4.5 Mtpa - 17.4 MW
- 7.0 Mtpa - 26.5 MW
- 9.5 Mtpa - 34.7 MW

17.10 Plant Control System

The general approach to automation and control for the plant will be one with a moderate level of complexity offering the option of local control and remote monitoring and control from a central control room. Instrumentation will be provided within the plant to measure and control key process parameters to minimise operator intervention in standard start-up functions and to provide key monitoring and control to minimise process excursions and maintain steady operation.

17.11 Metallurgical Accounting

Weightometers will be located on conveyors to determine stream tonnage in the crushing and reclaim areas. Slurry density and flow meters on selected process streams will enable calculation of stream tonnages and operating parameters.

Routine manual sampling of process streams will provide samples for metallurgical accounting purposes with shift composite samples from each of flotation feed and tails and CIL feed and tails used for plant head grade and tails grade calculation.

Flow meters will measure, as required, water and reagent usage rates to unit operations throughout the plant.

Reconciliation of the amount of reagents used over relatively long periods will be achieved by delivery receipts and stock takes.

18.0 PROJECT INFRASTRUCTURE

18.1 Site development

The Namdini Gold Project location was discussed in Section 4.1 and shown in Figure 1.

A conceptual site layout is provided in Figure 41. This layout was developed based on supplied site topography and satellite images of the area. While it is expected to change as the Namdini Gold Project progresses through Pre-feasibility and Feasibility study stages it is believed that the conceptual layout is sufficiently representative of the final project development that concepts and derived costs are appropriate for this PEA level of study.

The topography of the site and surrounding land forms and uses are not such that the changes expected as the project scope develops will reveal 'fatal flaws' or significant impediments or cost imposts on the project.

This drawing shows the major features of the Namdini Gold Project and its infrastructure including the process plant, tailings management facility, mine open pit, and mine waste dump for the three process plant throughput options that were considered in the PEA study.

The process plant, mine services area and other facilities are located outside a 500 m blast zone of the largest conceptual pit.

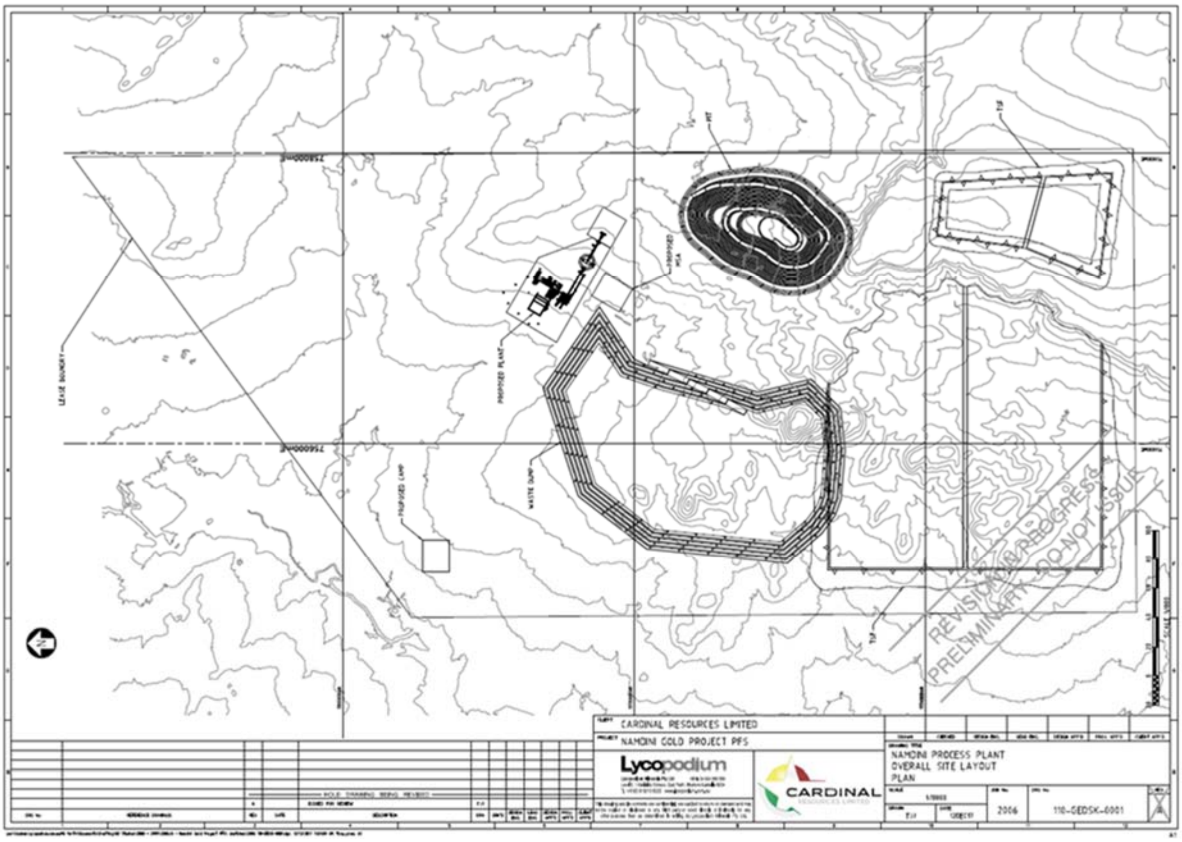

Figure 41: Conceptual site layout (source: Lycopodium, 2017)

18.2 Roads

18.2.1 Site access

The site will be accessed by road from the west with a new, approximately 30 km, gravel road linking the site to the existing national road N10 between Pwalagu and Shia. The N10 provides good access to the major cities and ports in southern Ghana and no upgrades of the N10 will be undertaken. The site access road will follow a similar route to the proposed new power line for the existing substation north of Pwalagu.

The national road N10 will be the most likely route used for transporting construction materials and operating supplies to the site from the ports in southern Ghana.

Allowance was made in the project capital for construction of 30 km of gravel access road to a standard suitable for all weather use for project development and ongoing operations.

18.2.2 Site roads

Site roads will be 'fit for purpose' and will comprise haul roads for mining use, full width gravel roads for frequent traffic by site light and heavy vehicles and basic access tracks for infrequent access by light vehicles to site infrastructure.

18.3 Power

The study is based on the assumption that a new switchyard will be constructed directly to the west of the lease area. This switchyard will include step-down transformers which will provide 11 kV power to the main HV distribution board supplying the site. Allowance was made in the estimate for static Var compensation to stabilise the HV circuit during high load events such as mill starts.

The power consumption for the 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa throughput options was estimated at 25 MW, 38 MW and 45 MW respectively. Installed power requirements are 35 MW, 50 MW and 60 MW, respectively.

The electrical system is based on 11 kV distribution and 415 V working voltage. For the process plant the 11-kV supply will be stepped down to 415 V at the switchrooms using 11 kV/415 V distribution transformers fed from the HV distribution board.

Switchrooms will house the 415 V motor control centers (“MCCs”).

The SAG, ball and regrind mill motors will operate at the 11-kV distribution voltage.

11 kV overhead power lines will distribute power across the site, stepped down at point of use with pole top transformers, kiosks or conventional transformers and MCCs.

18.3.1 Electrical buildings

The electrical equipment will be housed in prefabricated switchroom buildings. Prefabricated buildings have been selected as these can be partially fitted out at the factory reducing the need for skilled installation labour on site.

The electrical buildings will be installed with air-conditioners and suitably sealed to prevent ingress of dust.

18.4 Water supply

Raw water will be sourced from the Volta River to the south, approximately 7 km away, from where it will be pumped to the raw water storage facility. The raw water requirements for the process plant are 200 m^3/h, 325 m^3/h and 450 m^3/h for the 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa process plants, respectively.

A pipe branch from the main raw water pipeline will supply the potable water treatment plant located at the camp that will purify the water after which it will be reticulated across the site. The potable water demand for the 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa throughput options was estimated at 3 m^3/h, 6 m^3/h and 10 m^3/h respectively, with the potable water treatment plants sized accordingly.

A vendor packaged modular potable water treatment plant including filtration, ultra-violet sterilisation and chlorination will be installed at the accommodation camp with the treated water reticulated to the site buildings, ablutions, safety showers and other potable water outlets.

18.5 Sewage and waste management

18.5.1 General

Grey water and effluent from all water fixtures will drain to gravity sewerage systems at the camp and process plant site. Where gravity flow is not practicable suitable macerator pumps will be used.

Effluent will be treated in a sewage treatment plant located adjacent to the camp. The effluent treatment demand for the 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa throughput options was estimated at 45 m^3/day, 55 m^3/day and 65 m^3/day, respectively with the sewage treatment plants having been sized accordingly.

Treated effluent will be discharged into leach drains. Treatment plant sludge, following chlorination, will be suitable for direct landfill burial in unlined pits.

18.5.2 Solid wastes

Wastes will be sorted and reused or recycled as far as the limited access to recycling facilities allows. General solid wastes will be deposited into a landfill and promptly covered to deter vermin and scavengers.

Materials such as cyanide packaging will be burnt and the ashes buried, under supervision, on site beneath mine waste to prevent unauthorised use.

18.5.3 Hydrocarbon wastes

Waste lubricating oils will be returned to the supplier for recycling.

Hydrocarbon contaminated materials will be spread on volatilisation pads for decontamination before disposal in landfill sites.

18.6 Communication system infrastructure

Internal communications and IT services will use a site wide fibre optic network.

A local mobile phone provider will be contracted to upgrade existing facilities on site and provide a link into the local, national and international telecommunication network.

A radio network will be established with dedicated operational, security and emergency channels. A local ground station will be installed to provide global satellite voice and data connection.

Satellite TV and internet connection will be provided at the accommodation camp.

18.7 Fuel and lubricant supply

Several multinational fuel suppliers are established in or have agents in Ghana. It is proposed that they be approached to supply and operate site fuel and lubricant storage and dispensing facilities in exchange for long term supply contracts. Payment for the facilities will be through a small mark-up on the price of the fuel supplied.

The site fuel depot will have a storage capacity of approximately 10 days consumption of diesel to avoid supply interruptions due to inclement weather or similar events. The facility will incorporate unloading pumps, fuel filters, transfer pumps with certified flow meters and a lubricant storage facility. Fuel will be invoiced to the company upon transfer to the company's vehicle with the majority of fuel held on consignment by the supplier.

The mining contractor will be required to provide adequate site storage to meet their operational needs. Fire water and other services will be provided to the fuel depot.

18.8 Explosive storage and handling

It is anticipated that a contract will be entered into with a recognised supplier of mining explosives to establish their own facilities on site and supply emulsion explosives, initiators, detonators and other blasting consumables as needed.

18.9 Security and fencing

Site security will be based on concentric lines of fencing and control.

Areas of the lease where operations are actively taking place or where items of decentralised infrastructure are located will be patrolled by the security team.

The process plant, mine services area and general administration area will be enclosed within a patrolled 2 m chain link fence line to discourage casual entry. The main point of entry will be where the main access road enters the site. This point of entry will be provided with a gate and manned security post. Access from the mine haul road through the mine services area will also be monitored by a manned security post. Entry into the fenced areas will require a mine identity card and/or proof of legitimate business beyond that point.

The process plant itself will be enclosed by a double line of security fencing monitored by closed circuit cameras. The fence line will be provided with perimeter lighting. Entry will be by a single monitored security post and will be strictly controlled. Exit from the plant area will be subject to a search of vehicles, toolboxes and 'pat down' and/or metal detector search of all persons.

Access to the gold room within the plant will be restricted and strictly controlled. Extensive camera surveillance will be installed and entry points will be monitored and alarmed. All personnel allowed into the area will be accompanied and monitored by members of the security team. Persons leaving the area will be subject to a comprehensive search of themselves and any tools or equipment leaving the building.

The accommodation camp will be fenced and provided with a manned entry gate to prevent unauthorised access.

The Tailings Storage Facility will be provided with a perimeter stock fence comprising three strands of barbed wire to prevent wildlife access to the facility. Active landfill areas will be fenced to prevent wildlife and vermin access.

18.10 Workforce accommodation

18.10.1 Permanent accommodation camp

Where possible, employment will be offered to suitably qualified and experienced Ghanaians. All unskilled and semi-skilled positions will be filled by residents from local towns and villages. Transportation will be provided to and from local population centers for workers.

It is anticipated that a significant number of skilled Ghanaians from outside the immediate area will be allocated accommodation within the permanent accommodation camp.

Expatriate and key Ghanaian employees from outside the local area will be provided with accommodation.

It is likely that the camp will be a mix of imported, modular, prefabricated buildings and blockwork construction. Experience shows costs are similar but modular units can be brought on site and be ready to use in a shorter timeframe with a smaller site labour force required for erection. A commitment to local content will drive the use of local blockwork construction where the building is not schedule critical.

18.10.2 Construction accommodation

An area adjacent to the permanent camp and the contractor laydown areas will be made available to be used by the early earthworks and accommodation camp installation contractors. All contractors will provide their own temporary accommodation rather than be accommodated in the permanent camp.

The permanent camp will be used for the Owner, Engineering Procurement Construction & Management (“EPCM”) contractor staff and senior contractor personnel subject to availability.

18.11 Operational facilities

18.11.1 Plant area

Workshops, warehouses and the like will be of structural steel frame and metal cladding construction on concrete slabs. Office and amenity areas associated with the main structures will generally be of transportable/prefabricated style construction although concrete blockwork construction will be considered to provide additional local content if the schedule allows. The facilities are summarised below:

- Plant gatehouse for access control to the plant security area and all security monitoring functions; the facility will include change rooms, washrooms and laundry for plant staff
- Plant offices and control room
- Plant staff mess
- Electrical switch rooms, of prefabricated construction, mounted on plinths for bottom cable entry
- Reagent stores
- Plant workshop/warehouse with offices and ablutions
- Plant gold room.

18.12 Mine services area facilities

An area will be provided for the mining contractor to establish their offices, workshops and other facilities. Power, potable water and connection to the site sewerage facilities will be provided. The area will also have an office for the Owner's geology/mining technical team who may share the contractor's facilities where appropriate to avoid duplication.

The Mine Services Area facilities are summarised below:

- Heavy vehicle workshop and warehouse
- Explosives magazine
- Mine vehicle washdown bay, with water management and oil/water separation
- Fuel storage with heavy and light vehicle refuelling areas
- Light vehicle workshop
- Mine contractor's offices
- Shift change building with showers and ablutions
- Mine safety/emergency response building
- Mine staff mess
- Owners team offices
- Site perimeter fencing.

18.12.1 General and administration facilities

Allowance for the following additional facilities was made in the capital estimate:

- Main administration building
- Medical center/clinic
- Laboratory, including sample preparation area, fire assay facilities and wet laboratory.

19.0 MARKET STUDIES AND CONTRACTS

19.1 Gold Price

Gold is a readily traded commodity and no specific market study was carried out. Advice regarding the forward looking gold price was provided by Cardinal and the Project assumes US$1300/oz at the date of this PEA study.

19.2 Mined material from the conceptual economic pit

Haulage of the materials from the Namdini deposit will be on a contract basis with contract terms as per industry norms particular to the West African region where the Namdini deposit is located.

19.3 Gold Doré

For the doré produced from the proposed Namdini treatment plant, in the absence of letters of interest or letters of intent from potential smelters or buyers of gold, the following smelter terms for similar projects have been applied:

Treatment and Refining Costs ($/oz gross doré)	0.45	US$/oz	Assumed
Freight charges & Insurance ($/oz gross doré)	0.65	US$/oz	Assumed
Gold Payable (% doré gold)	99.8	%	Assumed

20.0 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT

20.1 Introduction

An Environmental and Social Impact Assessment, or more simply an Environmental Impact Assessment (EIA), is a study that culminates in the production of an Environmental Impact Statement (EIS'). Cardinal engaged Nemas Consult Ltd (NEMAS) of Ghana to provide a scoping study preceding the actual EIA to identify all potentially significant environmental, safety and socio-economic and cultural issues, that are likely to come up during the development, the survey, construction, implementation and decommissioning stages of the proposed project and which need to be considered during the EIA study. This enables the key issues to be addressed from the outset and also allows early recognition of these issues in the design and evolution of the scheme for the project. The process also facilitates the recognition of aspects that would not be expected to cause significant adverse impacts. Ultimately, it defines the scope for the EIA, and for the eventual EIS.

The discussion in this Section of this PEA was summarised from NEMAS (2017) for the proposed Namdini Gold Mining Project.

The main objectives of the PEA study, as part of the EIA process for the Namdini Gold Project are to:

- Provide an environmental overview of the Namdini Gold Project
- Describe the existing environmental and socio-economic baseline using secondary data only
- Identify key data gaps in environmental knowledge of the Namdini Gold Project
- Undertake a preliminary assessment of the potential environmental and socioeconomic impacts associated with the Namdini Gold Project
- Obtain early input from key stakeholders in the identification of potential impacts and mitigation measures
- Generate a detailed Terms of Reference for the main EIA study and define an appropriate programme for consultation with stakeholders.

20.2 Method and approach for the EIA

The method and approach for this PEA study involved preliminary field surveys, literature reviews, and examination of appropriate legal and regularity frameworks.

Preliminary field surveys were undertaken to obtain firsthand information and to confirm the project area of influence (PAI) with respect to:

- Socio-economic and cultural conditions of the local communities
- Bio-physical environment, including:
  - Flora and fauna diversity of the area
  - Present land use of the area
  - Adjacent land use trends
  - Drainage and hydrology
  - Topography and relief of the area.

Initial consultations were held with the following bodies and institutions:

- Management of Savanna Mining/Cardinal Resources
- EPA, Head office in Accra

- Minerals Commission, Head Office in Accra
- Tallensi District Assembly
- Tallensi Traditional Council
- Bongo Chief
- Leadership of Artisanal Miners
- Opinion Leaders of Host Communities.

Consultations with interest groups and stakeholders identified some important community and environmental issues and impacts that need to be addressed in the EIA.

Savanna and Cardinal also held various consultations and meetings with the following stakeholders:

- The Ghana Police Service, Regional Command-Upper East Region
- The Northern Electricity Distribution Company (NEDCo)
- Land owners.

Information gathered from various documents and reports from the NEMAS library, the proponent office, Tallensi District Assembly, Geological Survey Department, EPA, Minerals Commission's library and Internet sources were of immense help. Some of the literature examined included:

- Constitution of Ghana
- Acts and Laws of Ghana
- The World Bank Operation Manual
- Legal, Institutional and Policy Frameworks
- IFC Performance Standards on Environmental and Social Sustainability
- The Equator Principles, 2013
- Tallensi District Profile- 2014-2017
- Ghana Environmental Impact Assessment Procedures
- Namdini Mining Feasibility Study Report on the Namdini Gold Project, and
- Various topographical and google map of the project area.

The following relevant national policies were consulted and a description of the relevance of each national policy is available in NEMAS (2017):

- National Environmental Policy, 2012
- National Land Policy, 1999
- Minerals and Mining Policy, 2014
- National Water Policy, 2007
- National Buffer Zone Policy, 2014, and
- Forest and Wildlife Policy, 2012.

The regulatory framework for mining and environmental protection of relevance to the proposed mining project, was examined and a description of the relevance of each of the regulatory frameworks is available in NEMAS (2017). The following was considered:

- Minerals Commission Act 1993, Act 450

- Minerals and Mining Act 2006, Act 703
- Minerals and Mining (General) Regulations, 2012, LI 2173
- Minerals and Mining (Support Services) Regulations, 2012, LI 2174
- Minerals and Mining (Compensation and Resettlement) Regulations, 2012, LI 2175
- Minerals and Mining (Licensing) Regulations, 2012, LI 2176
- Minerals and Mining (Health, Safety and Technical) Regulations, 2012
- Minerals and Mining (Explosives) Regulations, 2012, LI 2177
- Ghana's Mining and Environmental Guidelines, May 1994
- Ghana Investment Promotion Center Act of 1994, Act 478
- The 1992 Constitution of the Republic of Ghana
- Environmental Protection Agency (EPA) Act, 1994, Act 490
- Environmental Assessment Regulations, 1999, LI 1652
- Fees and Charges (Amendment) Instrument 2015, LI 2228
- Environmental Quality Guidelines
- Lands Commission Act 2008, Act 767
- Office of the Administrator of Stool Lands Act 1994, Act 481
- Water Resources Commission Act 1996, Act 522
- Water Use Regulations 2001, LI 1692
- Ghana National Fire Service Act 1997
- Fire Precaution (Premises) Regulations, 2003, LI 1724
- The Labour Act 2003, Act 651
- Workmen's Compensation Law, 1987
- National Museums Act 387 of 1969, and
- The Local Government Act 1993, Act 462.

The relevant International Principles and Standards that will govern the preparation of the EIA study include the Equator Principles, IFC Performance Standards and the World Bank Guidelines. Again, descriptions of how each of these will guide the EIA studies are available in NEMAS (2017).

20.3 Environmental and social baseline conditions

20.3.1 Physical location and environment

The Namdini Gold Project site is located in the Upper East Region, about 50 km southeast of Bolgatanga, the regional capital as discussed in Section 4.1.

20.3.2 Climate

The climatological setting of the area is tropical with two distinct seasons; a rainy season, which is erratic and runs from May to October and a dry season that stretches from October to April. The mean annual rainfall for the district is 95 mm and ranges from 88 mm to 110 mm. The area experiences a maximum temperature of 45°C in March/April and a minimum of 12°C in December.

20.3.3 Soils

The district's soil is developed mainly from granite rocks and is shallow, with low organic matter content and is predominantly coarse in texture, making it low in soil fertility. However, valley areas have soils ranging from sandy loams to salty clays and though they have rich natural fertility, they are more difficult to till and are prone to seasonal water logging and flooding.

20.3.4 Topography and drainage

The topography of the district is characterized by scattered rock-outcrops and upland slopes. Lowlands are relatively undulating; slopes are gentle ranging from 1% to 5% gradient with some isolated rock outcrops and occasional uplands slopes at Tongo areas. The nature of the landscape is a contributory factor to the small size of land holdings of many people and has promoted the peasant nature of agriculture in the district.

Gold has resulted in small scale artisanal mining and medium scale investor activities in the district while the rocky outcrops resulted in the establishment of quarries. Some of the Project has undergone serious alteration by the illegal miners leaving dangerous pits (Figure 40).

The Red and White Volta Rivers and their tributaries drain the district. Farming activities along the Volta basin have caused the silting of the river course resulting in flooding during the rainy season, while the mining activities are a source of localised environmental degradation. The project area does not have a major river draining through or close to it. The only source of surface water through the Project site is the seasonal Zoan Buliga stream and a few stagnant ponds where rainfall is trapped in pits (Figure 42).

Figure 42: Section of the topography of the area which has undergone alteration by intensive artisanal mining (2017)

20.3.5 Terrestrial ecology

Detailed flora and fauna profiling of the Project site should be undertaken during the EIA studies.

20.3.5.1 Namdini flora

The Namdini Gold Project lies in the northern Guinea Savanna vegetation zone of Ghana. This vegetation is characterized by a continuous grassy ground layer with an open canopy tree stratum. The ground layer is annually or periodically burnt either for the generation of fresh flora for cattle grazing, farming or for gaming purposes.

The vegetation of this zone is characterized by trees such as *Parkia biglobosa, Vitellaria paradoxa, Burkea africana, Daniellia oliveri, Afzelia africana, Parinari polyandra, Hymernocardia acida, Vitex doniana, Terminalia glaucescens, Lophira lanceolata, Piliostigma thonningii and Diospyros mespiliformes. The common grasses of the Guinea Savanna-Woodland are Andropogon sp., Brachiaria brevis, Digitaria gayana, Eleusine indica, Eragrostis aspera, Hyparrhenia sp., Pennisetum pedicellatum, Schizachyrium sp., Rottboellia sp., Cymbopogon giganteus and Panicum sp.* Places that are heavily farmed and thus of low fertility usually have short wiry grass species e.g. *Aristidia kerstingii, Ctenium elegans, Schoenefeldia gracilis, Schizachyrium exile, Hyparrhenia sp.* and *Monocymbium ceresiiforme*.

The district has one gazetted forest reserve covering a total area of 261.55 km, located at Yameiriga, about 14 km from the Project site.

The structure of the vegetation is simple and has rather uniform species composition as a result of cultivation and regular annual grass burning. The trees and shrubs that occur on the Project site are fire-tolerant and are mostly left standing during cultivation. Some of the dominant trees and shrubs encountered in the study area are *Parkia biglobosa (Dawadawa), Vitellaria paradoxa* (Shea tree), *Anogeissus leiocarpos, Afzelia africana, Diospyros mespiliformes, Sarcocephallus latifolius* and *Chromolaena odorata.*

The ground flora predominantly consists of tall grasses including *Andropogon gayanus, A. tectorum, Beckeropsis unisata, Cymbopogon giganteus, Digitaria horizontalis, Elymandra androphila and Tristachya superba*. The marshy areas are dominated by grasses such as *Andropogon gayanus, Chasmopodium caudatum, Loudetia ambiens, Setaria anceps, Acroceras amplectens, Brachiaria mutica, Echinochloa stagnina, Leersia hexandra* and *Sacciolepis africana*.

A cursory study of the vegetation during a reconnaissance visit indicates that only one species, *Afzelia africana*, is of conservation concern, mostly because it is heavily exploited for its timber. Some of the tree species encountered are of economic or medicinal importance: The Shea butter tree (*Vitellaria paradoxa*), African oak (*Afzelia africana*), African copaiba balsam (*Daniellia oliveri*), the dry zone Mahogany (*Khaya senegalensis*), African locust bean (*Parkia biglobosa*), Black plum (*Vitex doniana*).

20.3.5.2 Namdini fauna

The proximity to the eastern wildlife corridor means that occasionally large mammals stray into the area. These include several primates, the Patas monkey (*Erythrocebus patas*), Green monkey (*Cercopithecus aethiops*) and Senegal galago (*Galago senegalensis*). The African elephant (*Loxodonta africana*), Warthogs (*Phacochoerus aethiopicus*) and the West African Bushbuck (*Tragelaphus scriptus*) are occasionally seen in the Project area. The Togo hare (*Lepus zechi*), Giant rat (*Cricetomys gambianus*) and the Cane rat (*Thrynomys swinderianus*) are common in the area.

Birds include species such as the Grey Heron (*Ardea cinerea*), Double-Spurred francolin (*Francolinus bicalcaratus*), and Hammerkop (*Scopus umbrett*a)

20.3.6 Air quality and noise

The Project area is generally rural with good background ambient air. Some parts have illegal mining, there is periodic burning and some few areas are under cultivation. These anthropogenic activities enhance dust emission during aggressive weather conditions. The natural cause of air pollution in the area in the dry season is the dust-laden Harmattan which affects northern Ghana from December to March.

The proposed EIA study should undertake monitoring of dust and gaseous emissions or pollutants, such as sulphur oxides (SOx), nitrogen oxides (NOx) and carbon oxides (COx) to confirm the levels in the ambient air at the project area. Current noise levels will also be determined for the project area as part of the baseline survey.

20.3.7 General archaeological and cultural setting

The Tallensi and Gurunsi are the two language communities in the District. The oral traditions of the community at Tongo Tengzuk claim that their ancestors have always been there, or alternately, sprouted from the ground or descended from heaven, as do the other indigenous Tallensi living around the base of the hill. Those Tallensi known as Namoos at Tongo, who are actually migrant Mamprusi, acknowledge the antiquity of the real Tallensi living on the hill or at the foot of it, and affirm peaceful coexistence with their neighbours. The physical setting of the district is a dramatic panorama of boulders, balancing rocks (castles) and hills upon which some of the most sacred sites in Ghana are perched.

The Tallensi have one of the most consistent patrilineal and patriarchal family systems as yet observed in Africa. It is a polygamous society and at the peak of the cycle of family development, the homestead is normally occupied by family groups consisting of an old man, his adult sons together with the wives of these men, and all their unmarried children. The people are principally agriculturalists, cultivating cereals including millet, sorghum, maize and groundnuts, as well as keeping poultry and livestock (mainly for ritual purposes).

A cursory examination of architectural variation reveals two architectural types: there are flat mud roofs, while all others have roofs of thatch or modern materials (aluminium or galvanised sheets).

There is a strong belief system associated with the African Traditional Religion. The spectacular rocky heights, caves and forest groves of the Tongo Hills are the sacred haunt of earth gods and ancestral spirits of the Tallensi. There are also intangible cultural elements involving the belief in witchcraft, evil spirits, ancestral spirits etc., culminating in a strong traditional religious system and worship which has stood to the present day. According to the Tallensi the landscape is timeless; it has existed since the beginning of time. There are lots of taboos/traditional restrictions and ritual observances that allow for the maintenance of cultural life.

There have been collaborative archaeological research projects between the University of Ghana and the University of Manchester (UK) focused on Tongo Tengzug, in the Tallensi/Nabdam District. The projects have surveyed and mapped the Tongo Tengzug archaeological/cultural landscape (settlement, other sites and shrines) and have identified several natural and cultural heritage resources.

Excavations and dating of some archaeological materials put the occupation of Tongo Tengzug beginning in the Late Stone Age era. Artefacts recovered from the excavations included lithic materials, pottery, faunal remains, metal objects, beads, etc. It is estimated that the other Tallensi settlements, which are yet to be studied archaeologically, would yield comparative data that can further the understanding of the people within the district. There is thus, potential for Stone Age, Iron Age, and Historical as well as Applied Archaeological studies within the district.

Site specific archaeological and cultural studies should be undertaken as part of the EIA study.

20.3.8 Traditions and festivals

The traditional people of the area give much reverence to their customs, norms, values and taboos. Many things are kept sacred, adored and prohibited by the community. Custodians of the traditional practices derive their livelihood from these sacred places as they serve as community-based healing and mental well- being centers and, most recently, as eco-tourism sites.

The district has cultural festivals and customary practices that are celebrated annually and are widely patronised. Some precede the planting season and others occur after the harvesting of crops They have characters that relate to the dialectic (language) areas and cover different purposes that include thanksgiving, performance review and social cohesion. Notable among these is the Tungama, in Gurunsi speaking areas, and the Tenlebgre, Golbo and Daaga festivals in the Tallensi speaking areas. There are other local festivals and cultural performances that foster close community and family ties.

20.3.9 Economy

The main economic activities in the district are crop farming, producing groundnuts, sorghum, millet, rice and maize, animal rearing and hunting. Agriculture is mainly rain fed with little irrigation and serves as the main source of employment accounting for 90% of the local economy.

Economic trees such as Shea and Dawadawa are distributed extensively in the wild. The harvesting and processing of the sheanuts and dawadawa fruit is dominantly undertaken by women. The agro-processing industry includes the production of groundnut oil, sheabutter, dawadawa (food ingredient), pito and parboiling and milling of local paddy rice

20.3.10 Industry

Industrial activity in the district is generally low. There are two main extractive activities in the district: gold mining and quarrying. There is one commercial quarry in the district operated by Granites and Marbles Company Limited, producing stone for export. The gold mining industry is not very developed. Small-scale gold mining activity, popularly known as ‘galamsey’ (gather and sell) or ‘alakpiri’ has become widespread.

20.3.11 Tourism

The district has many sites and scenes to attract tourists. These exist as customary edifices, religious craft, aesthetic scenery or geological impressions of the hills and rocks. The Tengzuk Shrine is noted as a source of good health, prosperity and spirituality which attracts people from all over the world.

The area is bounded to the south and east by beautiful mountains. The Tongo Hills to the west also provide a magnificent landscape. The whistling rocks serve as a tourist attraction.

20.3.12 Religious affiliation

The region has been reached by most major religions, however Traditionalist religion dominates (46.6%), with Christians (43.4%), an Islamic minority (3.7%) and some unaffiliated (5.6%). Among the Christians, Catholics predominate, followed by Pentecostal/Charismatics, Protestants and others.

20.3.13 Literacy and education

20.3.13.1 Education facilities

The District has a total of 123 schools most of which are in a poor state. Many are deprived of sanitation facilities, teaching materials and accessible road networks. Schooling in mud structures and under trees is not uncommon.

The District has a special school for the Deaf which runs a Pre-school, Primary and Junior High School stream. This is the only one of its kind in the Upper East Region. The nature of school infrastructure and distribution means that many pupils now cover less than 2 km to attend schools. Summary of type and number of schools in the District is presented in Table 53.

Table 53: Type and number of schools in the District

Category of School	No. of Schools
Pre-school	46
Primary Schools	46
Junior High School	28
Senior High School	1
Technical/Vocational	1
Special School for the Deaf	1
Total	**123**

School enrolments have seen gradual increases with near parity in gender.

Teacher numbers in the district are inadequate and gaps are filled by the engagement of untrained teachers. Approximately 50% of teachers are untrained at Pre-school and Primary levels and 25% untrained at Junior High School level.

20.3.14 Employment status

More than half (57.4 %) of the working population is self-employed while 32.1% are contributing family workers and 5.4% are employees.

20.3.15 Disability

The total percentage of the population with some form of disability is estimated at 5.2 % according to the 2010 Population and Housing census.

There are more persons with disability among the rural male population (5.1%) than among the urban male population (4.2%). Also, there are more persons with disability among the rural female population (5.7%) than among urban female population (4.3%).

Visual impairment is the highest recorded disability (42.8%), followed by hearing (22.3%), physical (18.4%) and speech (14.0%).

20.3.16 Water and sanitation

The water supply system in the district can be classified as rural and constitutes a large number of boreholes, hand dug wells, Small Town Water Supply System ("STWSS") and other naturally occurring water sources, such as rivers, dams, ponds and dug outs. Though these other water sources are not potable, many communities depend on them for their water needs.

Apart from a few public places (such as markets), health facilities, schools, government quarters, bungalows and offices, the District generally lacks toilets, urinals, sanitary equipment, abattoirs and waste disposal sites. The situation is acute in the mining communities, market places and at some health facilities and in some schools.

Bath houses are generally located within homes. Due to poor drainage, the surroundings of most houses have collections of wastewater pools which provide breeding grounds for vectors like mosquitoes. The incidence of malaria, which tops the ten top diseases in the District, is largely attributed to this situation.

The region contains numerous household refuse dumps and non-engineered public dumps which are relied upon by a large proportion of households for disposal of solid wastes. These household rubbish dumps are later collected and transported to farm lands to be used as manure. In the district capital and in some communities, waste is collected using refuse containers placed at vantage points with one skip loader and one tractor for waste disposal.

In most of the government establishments and schools, refuse is dumped in self-constructed pits meant for waste collection and disposal.

20.3.17 Health facilities

One of the major challenges in the District is inadequate and poorly equipped health facilities. The service providers comprise the public and private sectors which include (NGOs) and traditional practitioners. The District is served by 18 health facilities which are comprised of 2 health centers, 2 clinics and 14 Community based Health and Planning Service (CHPS) compounds run by the Ghana Health Service.

There are other health providers like chemists and traditional healers. Such facilities are the preferred first choice for many people who fall sick and self-medication is a problem.

Malaria is the leading cause of outpatient morbidity in the District. Despite numerous efforts, only a minor decline has been seen between 2012 (49.3%) and 2013 (47.2%).

Many of the diseases prevalent in the district are environmental or filth related and are preventable if the population complies with the knowledge and practices provided to them.

20.3.18 Land tenure system

The land tenure system in the Tallensi community is usufruct in nature, in that land is either owned by individuals or by families in fragments and held in trust for the dead, present and future by the Tindana (the priest and custodian of the land).

In a few communities, land ownership is vested in one person, the chief who also serves as the Tindana, and who holds the allodial title. The power to decide on the transfer of ownership is vested in the individuals or families. Where the chief holds the allodial title, (Pusu-Namogo, Tongo-Beo and Buing) he has the right to decide on ownership. Though most often inimical to physical development, the religious adherence to these conventions provides an avenue to protect and conserve land and natural resources.

20.4 Stakeholder consultations

Consultation with relevant government institutions, organisations, traditional authorities, land owners, local communities and other interested groups provides obtaining important information and raises concerns that need to be addressed in the EIA.

20.4.1 Objectives of stakeholder consultations

Consultation with stakeholders is an ongoing activity as part of the EIA process to:

- Provide information about the project and its potential impacts to those interested in or are to be affected by the project, and solicit their opinion in this regard
- Provide opportunities to stakeholders to discuss their opinions and concerns
- Manage expectations and misconceptions regarding the project
- Verify the significance of environmental and social impacts identified
- Inform the process of developing appropriate mitigation, monitoring and emergency preparedness measures.

Stakeholder concerns are summarised in Table 54 based on records of engagement with stakeholders which are available in NEMAS (2017):

Table 54: Summary of stakeholder concerns

Stakeholder	Role/Responsibility	Major Concerns/Issues and Expectations
EPA Head Office, Accra	Regulator-Environmental Protection	■ Follow Act 490 and LI 1652 ■ Register Project ■ Prepare Scoping Report ■ Prepare EIS Report ■ Prepare for Public forum if the need arises ■ Obtain environmental permit ■ Specific and not generic issues should be discussed in the report ■ Depending upon community issues/concerns, public forum may be organised by the EPA to confirm project acceptability and community concerns. ■ Community concerns should be properly captured and addressed
Tallensi District Assembly	Local Government Authority	■ The District Assembly was officially informed of the project ■ A good communication links should be established between the company and the Assembly ■ The Assembly welcomes the project ■ Concerns of host communities should be addressed ■ Agreement between landowners and the company should be honoured. ■ Local communities should first be considered for employment and where necessary trained in employable skills. ■ Should assist communities with developmental projects. ■ The company should liaise with the Assembly on key developmental projects for the community before any SCR is embarked on

Stakeholder	Role/Responsibility	Major Concerns/Issues and Expectations
Traditional Council	Landowners	■ Land-take for project are all traditional land ■ Proper and adequate compensation should be given to those who will be affected by the project ■ Alternative livelihood empowerment schemes should be designed for all Project Affected Persons ■ Affected communities should be relocated ■ The company is expected to honour the terms of agreement entered ■ Indigenes should be considered for employment ■ Royalties should be paid promptly ■ Assist them to hire tractor services to plough their land ■ Supply of fertilisers and seedlings ■ Provision of classroom blocks, clinics, boreholes, electricity scholarships and community centers
Minerals Commission, Accra	Regulator-Mineral Exploitation	■ Mining license/lease does not cover the surface right. ■ Need to secure the surface rights from land owners/traditional authorities. ■ All companies applying for mining leases are required to submit a feasibility report to the Commission for approval. ■ Mining lease will be given base upon EPA permit or proof of receipts of payments from EPA towards environmental permit acquisition. ■ A company is required to develop the mine and commence commercial production within two years from the date of granting the mining lease. ■ The layout plan should also indicate relative positions of key infrastructure/facilities. ■ Will facilitate royalty payment determination and disbursement.
Artisanal Miners	Project Affected People	■ Willing to vacate the area ■ An area should be demarcated for them ■ Should be considered for menial jobs ■ Should benefit from an alternative livelihood engagement package ■ Company is likely to renege on agreements they may sign with the communities, citing Shanghai Mining as an example
Women groups	Host community	■ Should be provided with loan facilities to augment their capital to expand trading activities ■ Company should build markets or stalls to sell their farm produce ■ To arrange with them to buy their farm produce directly without having to travel far to sell

20.5 Potential environmental or social issues and impacts

Potential environmental and social issues and impacts (positive and negative) are identified and presented here, based on analysis of Project documentation, field inspections, observations and stakeholder consultations.

20.5.1 Environmental influence

The main environmental resources to be impacted are:

- The soil resources at the Project site
- The landscape of the Project site
- The Zoan Buliga stream and a section of the White Volta, from where water may be drawn for re processing
- The groundwater resources at and around the Project site
- The flora and fauna at and around the Project site
- The ambient air environment at and around the Project site.

20.5.2 Social and community influence

The Project will have an influence on the following social resources:

- Local communities including Buing, Bingo, Wankara and Bigare
- Illegal small-scale mining operators.

20.5.3 Institutional or regulatory influence

The main institutions to be involved in supervising the project include:

- Environmental Protection Agency: to provide EPA Permit for Project implementation
- Minerals Commission: to grant the Mining Leases for the Project
- Tallensi District Assembly: to provide Development and Building Permits
- Ghana Police Service: to provide security for the Project
- Lands Commission: to certify the status of land and the right ownership
- Ghana Museum and Monument Board: to permit archaeological and cultural assessment
- Ghana National Fire Service: to provide fire permits for Project facilities
- Factories Inspectorate Department: to approve workplace safety conditions and ensure safety of workers during operation of the facility and to register the site with the Department
- Volta River Authority/Northern Electricity Distribution Company: to provide power for the Project.

20.5.4 Project activities of environmental or social concern

The main project activities of environmental and social concern are:

- Pre-Construction Phase Activities
- Construction/Development Phase Activities
- Operational/Maintenance Phase Activities
- Decommissioning/Post Mining Phase Activities.

20.5.5 Pre-construction phase activities

The major activities include:

- Field studies and exploration activities to inform project designs and planning
- Land acquisition
- Removal of illegal small-scale mining groups and galamsey workers
- Inventory of affected properties and persons.

20.5.6 Construction or development phase

The major activities include:

- Demarcation of active sites and buffer areas
- Site clearance, vegetation and topsoil removal
- Transport of materials, equipment and machinery to site
- Construction of work camp and staff housing facilities
- Construction and installation of mine infrastructure, such as process plant, tailings dam, haul roads, etc
- Construction of utility facilities (power, electricity and water).

20.5.7 Operational or maintenance phase activities

The major activities include:

- Land preparation
  - Vegetation clearing
  - Topsoil/overburden removal
- Mining and haulage activities
  - Drilling and blasting
  - Excavation, loading and haulage of ore
  - Pit dewatering and waste rock disposal
- Processing and gold recovery activities
  - Crushing
  - Milling
  - Gold recovery, and
  - Tailings disposal activities
- Support services and maintenance activities
  - Reagents, chemicals, fuels, oils supply and management
  - Explosive supply and management
  - Waste/sewage disposal and management activities
  - Concurrent rehabilitation activities

- Maintenance of tailing ponds
- Maintenance of equipment
- Disposal of worn-out equipment parts and scrap
- Disposal of waste oil
- Management of accommodation and water/power supply installations.

20.5.8 Decommissioning phase activities

The major activities will include:

- Reclamation activities
- Decommissioning of equipment and mine site facilities
- Closure activities.

20.5.9 Identification of potential environmental or social impacts

The potential environmental and social impacts identified at this PEA stage from the construction, development, operation and decommissioning phases have been categorised into positive or beneficial impacts and adverse or negative impacts as follows:

20.5.10 Positive or beneficial impacts

The positive or beneficial impacts include:

- New employment and job creation opportunities
- Creation of business opportunities for locals/Ghanaians
- Improvement in the district/regional and national revenue bases
- Improvement in the local economy of beneficiary districts
- Improvement in the local community infrastructure/facilities from corporate social responsibility agreements
- Increased in annual income and reduction of poverty in the project area
- Training and educational opportunities for the youth in the project area.

20.5.11 Adverse or negative impacts

20.5.11.1 Physical environment

The likely impacts during the development, construction and operation phases include:

- Air Pollution from blasting, loading, transport, dumping of ore, and increased vehicular movement along haul roads, operation of mine equipment, light vehicles, and diesel-powered electrical generators
- Noise, Air Blast and Vibration from blasting, crushing and milling operations, movement of haul trucks and operations of electrical generators and maintenance activities at the mechanical workshops
- Impact on soil resources from topsoil removal, erosion and soil contamination from chemical or fuel spills
- Impact on surface water resources from water pollution concerns due to chemical or fuels spills into water, transport of sediment and sewage into water, changes in surface water hydrology and flows due to the construction of mine infrastructure, and raw water abstraction for both domestic and production usage

- Impact on groundwater resources:
  - Groundwater pollution concerns from spillage of fuel/oils and chemicals, seepage of chemicals from tailings dam, and leachate of metals from exposed waste rock, and
  - Changes in the local ground water drawdown/quantity due to pit dewatering concerns
- Waste disposal:
  - Disposal of hazardous and non-hazardous wastes concerns
  - Land degradation from creation of mine pits, waste dumps, tailings dam.

20.5.11.2 Biological environment

- Impact on terrestrial flora and fauna:
  - Removal or loss of vegetation
  - Damage to or destruction of faunal habitat
  - Displacement and destruction of wildlife
- Impact on aquatic/water ecology
  - Effect of water pollution on aquatic life
  - Effect of increased pollution on water resources and usage
- Impact on birds
  - Poisoning of birds due to access to or contact with contaminated tailings pond or overflows.

20.5.11.3 Social environment

The adverse impacts likely to arise during Project implementation include:

- Land acquisition and effects on land availability for other usage
- Disruption in land use:
  - Loss of land for cattle grazing
  - Destruction of cash crops (sheanut)
  - Loss of natural resources and gathering opportunities
  - Displacement of illegal small-scale mining groups (galamsey)
- Influx of new workers, job seekers and new residents, many of whom may have different cultural expectations and values
- Increased potential of social problems such as prostitution, teen pregnancy, drugs, drunkenness, and crime
- Resource consumption concerns
- Electricity and fuel consumption concerns
  - Potential for inflation of housing costs in the local communities
- Visual intrusion
- Noise, vibration and dust nuisance
- Public and community health and safety concerns

- Increased potential for spread of infectious diseases, including HIV/AIDS
- Increased potential for spread of malaria in the local communities
- Increased potential for accidents on the public/community roads
- Worker health and safety concerns.

20.6 Potential environmental or social threats

The potential environmental or social threats to the project include illegal mining (galamsey) activities, and outbreak of cerebrospinal meningitis (CSM).

The activities of illegal small-scale mining groups or galamsey operations at the Project sites are of concern. The illegal miners are a potential source of social conflict as evidenced in some mining communities in the southern part of Ghana and also in the Upper West Region where Azumah Resources Ghana Limited has its concession. This situation is partly brought about by high unemployment in the region. The company will continue to engage relevant stakeholders, such as the District Assembly, DISEC, traditional authorities, the RCC, and the Minerals Commission to ensure a smooth and peaceful relocation of the illegal miners from the concession.

CSM disease is a deadly disease that periodically occurs in epidemic proportions especially in the Upper West and Upper East Regions during the long dry season with extreme warm weather conditions when temperatures sometimes go above 40°C. The mining company should adopt a policy to ensure that every worker is vaccinated against cerebrospinal meningitis (CSM).

20.7 Key environmental or social issues and impacts

Major key impacts associated with the project are categorised into two main groups:

- Expected Positive or Beneficial Impacts
- Negative or Adverse Impacts.

20.7.1 Expected positive or beneficial impacts

The project is expected to employ over three hundred workers during construction, one hundred direct jobs during operation and will create three hundred additional ancillary jobs. Most workers will be Ghanaians with preference given to locals. The monthly income for those employed directly and those employed indirectly will significantly improve the local economy as the District has one of the lowest incomes in the country. The economic fortunes of many homes will see a positive turnaround and with it a positive impact on the socio- economic lives of citizens in the district. This is likely to lower the migration of the youth to the cities in the southern part of the country.

Cardinal will train some of the locals through direct in-service training and will give scholarships for further education in relevant fields after which they shall be employed to their respective units. In addition, Cardinal and Savannah are committed to demonstrating social responsibility towards host communities. Such social interventions will include provision of educational and health facilities, potable water supply, and other social interventions to enhance the quality of life in their host communities.

Most of the ancillary jobs in the retail and service industry, such as cleaning, security, transport, catering, etc., will be subcontracted to locally based firms. The local hospitality industry will benefit during the planning and design phase through provision of some meal and accommodation facilities for experts and consultants involved in the Namdini Gold Project and this opportunity will continue into the construction and operational phases.

20.7.2 Negative or adverse Impacts

20.7.2.1 Air pollution

There is the potential for air pollution from dust generated during land preparation to establish the various components of mine infrastructure. These include but are not limited to:

- Pit excavation
- Process plant installation
- TSF installation
- Office and workshop establishment
- Crushing of ore
- Transportation and use of construction materials (e.g. cement, sand and gravel)
- Trafficking of light and heavy vehicles
- Noxious gases from diesel powered machines.

The exposure of bare land by the removal of vegetation and loosening of soil particles from earthmoving machines may also create dust under adverse weather conditions, such as strong wind. The effect of air pollution on ambient air is expected to be severe during the dry season (Harmattan period). These dry and windy conditions could exacerbate the pollution load in the atmosphere. Dust generation may affect sensitive local receptors, although this impact can be minimised through good site management.

People in the communities of Biung, Bingo and Wankara along with the workers at the beneficiation plant site are expected to be the largest receptors of dust impact. A school within the Bingo community and close to the area demarcated for the pit and process plant will be among the key sensitive receptors for dust pollution. High levels of air pollution may negatively impact the lives of arboreal organisms, such as birds and insects, in close proximity to the working areas.

20.7.2.2 Noise impacts

The impact of noise will vary depending on the time of day, length of impact, level of noise and type of sensitive receivers. Intermittent blasting and continuous operation of the beneficiation plant are expected to generate extensive noise which may alter the ambient baseline noise levels.

Noise is also likely to be generated during construction, typically from heavy vehicles involved in the transportation and offloading of raw materials for construction of mine infrastructure. Noise could also be generated from tractors and bulldozers used for site grading and installation of mining and other equipment. Communities close to the mining facilities notably, Bingo, Buing and Wankara will be prone to the effect of noise from such activities.

Workers in close proximity to heavy equipment or the process plant could also be affected by noise impact. Similarly, the impact of noise could interfere with terrestrial fauna.

20.7.2.3 Vibration impacts

The major source of vibration will be blasting of hard rock. Blast induced vibration could visibly shake the buildings in the host communities and cause weakening or cracking, or both, of building foundations and walls.

Fly-rock thrown by blasting will be managed to reduce the impact on buildings, communities and livestock.

20.7.3 Floral and faunal effects

The development of the Namdini Gold Project will directly result in the loss of vegetation and reduce the vegetal cover status of the project area which has already been extensively fragmented by agricultural activities, fire, and removal of timber. Secondary forest regrowth will consequently be affected.

The removal of vegetal cover and establishment of mine facilities may result in loss and migration of especially terrestrial animals whose feeding grounds or habitat will be affected in the process. Such migration could be permanent unless patches of the original vegetation and secondary forest are intentionally preserved for the survival of the local ecology.

20.7.4 Water pollution

One of the scarcest resources in the area is water. The region is generally poor due to scarcity of this import natural resource. Water, irrespective of its degree of potability and sustenance, is essential to the community.

Most surface water in the project area is seasonal. The status of both surface and groundwater quality could be compromised by the release of mine waste, oil spills or other hydrocarbon release, contaminated pit water and improper disposal of human waste. This would have dire consequences for host communities that directly depend on surface water, aquatic biodiversity and livestock farming.

Prevention of water pollution will be a priority for the Project development.

20.7.5 Topography or landscape alteration

The natural landscape aesthetic will be affected by the construction and operation of the Namdini Gold Project. The activities that will take place during the construction phase, such as clearance of vegetation, grading, creation of roads and installation of mine facilities, will change the natural landscape of the site and will affect the natural aesthetics of the area.

20.7.6 Soil erosion tendencies

The removal of vegetal cover from site and the alteration of landscape may also induce erosion from surface runoffs, during rainfall and from removal of loose soil particles during aggressive wind activities. Sensitive arboreal, terrestrial and burrow receptors could be affected.

Proper handling and preservation of topsoil is required during the development, construction and operation phases of the project. Well planned contouring during project development could minimise the erosion impact during heavy rains.

20.7.7 Land acquisition, loss of livelihood, relocation

The tenement has an area of 19.54 km2. Digare, Bingo, Datoko, Wankara and Zanwore communities are located on the concession and have been practising illegal artisanal trade for over a decade now. In addition, the communities harvest shea butter from the wild shea butter trees while the large cattle herds use the land for grazing of their animals. The project will deprive these communities of their source of livelihood.

The host communities who are either directly located on the concession or live in close proximity to the concession, may have to be relocated either in part or in whole. The relocation could create socio-psychological disturbances if not well planned and executed.

A Resettlement Action Plan with a clear grievance redress mechanism will have to be developed to reduce any adverse impact of land acquisition and resettlement on local communities and the Project.

20.7.8 Waste generation problems

Various forms of non-mining waste will be generated during the three major phases of the project life (construction, operation and decommissioning). These will include (and may not be limited to):

- Biomass from plant debris and overburden during clearance of vegetation
- Soil waste including debris of rocks, sand and other excavated material
- Construction spoil, such as waste mortar, pieces of construction materials and fittings, packaging materials
- Liquid waste discharges from construction, hydrocarbon waste from oil and grease or lubricants from construction vehicles, equipment and machines
- Domestic waste, such as food wrappers, empty water bottles, faecal waste, generated grey water
- Faulty machinery, vehicular parts, scrap and disused machinery.

Improper management of these waste materials could impact soil fertility, both surface and ground water and the general biodiversity in the area of influence of the Project.

20.7.9 Occupational health and safety issues

Various categories of workers will be employed at different phases of the Project that may be exposed to the following (and other) risks:

- The deployment of heavy duty earth moving and construction equipment creates safety hazards.
- The site has a lot of dangerous pits created by illegal artisanal workers, some of which are concealed by debris.
- Excessive noise and vibration of machinery and inhalation of dust and gases during earthworks, construction and from hydrocarbon and fuel operating machines could affect the health of workers.
- Risks occurring in all industrial situations such as Falls, electrocution and fire.
- Bites from snakes and scorpions which are common in the Project area.
- Vector infections such as black flies (Orchocerca vovulus), the causative agent for river blindness, could affect those working close to the White Volta.
- As noted above, the area is a high risk for the occurrence of the deadly cerebrospinal meningitis ("CSM") bacterial disease, especially when temperatures exceed 40° C.

Worker safety risks will be considered in an Occupational Health and Safety (OHS) plan, applicable to all contractors and employees.

The OHS plan will:

- Provide a framework for the administration of health and safety activities
- Define health and safety responsibilities, policies and objectives
- Provide a process for performance measurement and reporting
- Establish inspection and review protocols for identification, elimination or control of potential risks, and develop compliance and communication interfaces.

20.7.10 Disturbance of cultural norms/social issues/security

The project is expected to directly employ over one hundred workers and will indirectly create jobs for more than three hundred people. The mass influx of workers into host communities (most of them without their families) could trigger vice, such as promiscuity (with its attendance effects including transmission of HIV/AIDS and other forms of sexually transmitted diseases ("STDs"), and breakdown of family system) and alcoholism.

The behaviour of workers who may not share in the culture, traditions and norms of the host communities may threaten the culture, norms and value systems of the host communities. Security of, and pressure on, existing infrastructure and social amenities (clinics, housing and schools) especially during the construction phase could also create problems for host communities.

Cultural issues and their potential effects will be studied in detail during the EIA study and mitigation measures will be proposed.

20.7.11 Public and community health and safety

The District is predominantly rural with minimal traffic and movement of vehicles. The sudden surge of vehicles and heavy-duty machines with its attendant traffic could be of public concern. The effect of noise, vibration from blasting, and dust can affect public health. Unscrupulous people may take advantage of the influx of people into the community to engage in uncivilised activities that can disturb public safety.

Indiscriminate disposal of human waste and other construction spoil during the construction phase could also affect the public.

20.8 Proposed mitigation measures

The general rules that will guide the design of mitigation measures will be:

a) **Avoidance** where impact is very significant and considered unacceptable with disastrous consequences unless prompt and adequate measures are taken

b) **Reduction** where impact is very significant or moderately significant but could be mitigated through planning, designing and controlling mitigation measures. This implies that mitigation measures will be applied until the limitations of cost effectiveness (established by best international practice) and practical application are reached

c) **Implementation** of good management practices for impacts rated as mildly significant or insignificant, to ensure that impacts are managed.

20.8.1 Classification of mitigation measures

The proposed mitigation measures for the identified impacts will be premised on the three principal methods of mitigation: Preventive, Control and Compensatory methods.

i) Preventive measures: will be adopted to include environmental and safety concerns at the design stage to ensure that certain anticipated impacts are completely avoided or reduced to insignificant levels.

ii) Control measures: sustainable environmental and good mining practices will be devised to ensure impacts are reduced to acceptable levels.

iii) Compensatory measures: will be adopted in cases of unavoidable but non-disastrous impacts that result in direct losses to communities or individuals

20.8.2 Mitigation of key impacts

20.8.2.1 Air and noise pollution

- Suppression of dust
- Regular maintenance of equipment
- Adherence to design drawing specification in vegetation clearance
- Speed ramps and speed limits
- Idling of vehicles or machines will be avoided when not in use
- Equipment selection with best technology
- Use of good quality fuels and lubricants
- Avoidance of working under aggressive weather condition
- Use of qualified operators and capacity building of machine operators
- Adoption of controlled and/or delayed blasting.

20.8.2.2 Impact on flora and fauna

- Restricted clearance, according to drawing specifications
- Preservation of patches of original vegetation as biodiversity and/or game reserves
- Avoidance of bush burning
- Authorisation before felling trees
- Afforestation of degraded lands
- Restriction of gaming and hunting and safe passage for stray animals
- Sensitisation of workers on environmental preservation.

20.8.2.3 Water pollution

- Avoidance of indiscriminate disposal of waste
- Re direction of waste water away from water courses
- Adoption of bund walls around fuel and oil depots
- Ensuring effective collection and storage of spent oil
- Stringent servicing of fuel storage facilities to avoid spillage
- Maintenance of buffer zones around streams
- Use of silt control berms and sediment control structures
- Use of lining for TSF construction to prevent seepage where required
- Re-use of tailings water for ore processing
- Treatment of tailings to meet standards before release into external environment
- Avoiding release of tailings water directly into water bodies
- Ensuring effective containment of liquid waste, and proper drainage for grey water
- Effective disposal of both liquid and solid waste.

20.8.3 Topography, landscape alteration, erosion prevention

- Practicing of good landscape engineering
- Re-contouring, pegging and terracing of areas prone to erosion
- Progressive re-vegetation or re-graveling
- Compacting of loose soil.

20.8.4 Visual effects

- Preservation of natural views by maintaining original vegetation within boundaries of active mining areas and within buffer zones
- Preservation of any natural features of interest
- Designing waste dumps and other disposal facilities to blend with surrounding topography
- Embarking on progressive rehabilitation of disturbed areas.

20.8.5 Solid and liquid waste

- Waste segregation to facilitate reuse and recycling
- Use of engineered landfill sites and incinerators
- Collection of hazardous waste material for disposal by accredited contractor
- Treatment of liquid waste before disposal
- Contained septic effluent system.

20.8.6 Compensation and resettlement

- Preparation of Resettlement Action Plan ("RAP") for compensation and relocation of affected communities
- Implementation of compensation and resettlement in accordance with RAP
- Provision of currently existing facilities (schools, potable water, and clinics) as part of resettlement
- Establishment and implementation of Alternative Livelihood Programmes for community members who lose their livelihood due to the establishment of the mine.

20.8.6.1 Occupational health and safety

The following measures are proposed to maintain OHS:

- Provisions and use of appropriate personal protective equipment (PPE)
- Adequate visibility and lighting
- Ensuring safety at the pit by appropriate designs of berms and pit walls
- Construction of structures to meet local and international building codes
- Effective signage
- Recruitment of qualified staff and operators
- Observance of traffic rules and regulations both on and off sites
- Observance of breaks within working hours
- Incentive or reward packages to boost morale of workers
- Installation of firefighting equipment
- Hoisting of caution flags and flashing lights on operating vehicles and moving machines
- Effective communication systems
- Training and refresher courses for workers
- Well-trained and effective security personnel
- Effective security connections with the Ghana Police Service
- Open-door policy of management for effective evaluation and for grievance channelling options
- Effective dust and noise abatement measures, such as regular dust suppression and routine maintenance of machines
- Periodic medical examination of workers to check fitness level for work
- Time limitation for exposure of workers to hazardous or dangerous working sites
- Proper system of identification of workers and visitors
- Working to meet local EPA Akoben and other international OHS and Environmental standards, such as ISO14001
- Vaccination of workers against CSM disease.

20.8.6.2 Public Health and Safety Concerns

The following measures are proposed to ensure that the welfare of the public and host communities is not undermined by the operations of the mine:

- Good public relations between community and the mine. A Community Relations Office in the host community can ensure access to management about community grievances
- Prompt attention by management to all community grievances received
- Observance of speed limits
- Escort of haulage trucks and other heavy equipment through townships
- Haulage trucks and heavy machinery move through townships only during daylight
- Non-involvement of mine workers in local politics and chieftaincy issues
- Periodic community and mine engagement, especially on HIV/AIDS awareness and other STDs

21.0 CAPITAL AND OPERATING COSTS

21.1 Capital cost summary

The project capital cost estimate was compiled by Lycopodium (2017). The capital cost estimate is summarised in Table 55.

It is proposed that the Namdini Project will be mined on a contract (outsourced) basis with capital equipment costs for the mining infrastructure and mining fleet amortised and charged back to Cardinal as a cost per tonne mining cost.

Table 55: Preliminary capital cost estimate summary (US$, 2Q17, ±40%)

Main Area	4.5 Mtpa US$ M	7.0 Mtpa US$ M	9.5 Mtpa US$ M
Direct Costs	187	237	290
Indirect Costs	22	28	35
Subtotal	**209**	**250**	**325**
Contingency	41	52	64
Subtotal	**250**	**318**	**389**
Owners Project Cost	25	31	37
Project Total	**275**	**349**	**426**

Process plant and infrastructure costs were estimated by Lycopodium (2017), including costs for the Tailings Storage Facility provided to them by Knight Piésold. All costs are expressed in United States dollars (“US$”) unless otherwise stated and based on 2Q2017 pricing. The estimate is deemed to have an accuracy of ±40%.

21.2 Estimate basis: process plant and infrastructure

21.2.1 Basis and methodology

The capital cost estimate was prepared in accordance with Lycopodium's standard estimating procedures and practices.

21.2.2 General estimating methodology

The process plant was broken down into unit operation areas with quantity take-offs based on similar facilities from previous projects to provide an acceptable level of confidence required for a Scoping Study estimate.

Unit rates for labour and materials were based on the Lycopodium database.

Mechanical equipment costs were taken from the Lycopodium database that includes recent market enquiries and actual project cost data.

The permanent camp pricing was based on the Lycopodium database of pricing on a cost per bed. Offices, workshops and other buildings pricing was based on the Lycopodium database of pricing. The costs for the TSF were provided by Knight Piésold.

21.2.3 Pricing basis

Pricing was identified by the following cost elements, as applicable, for the development of each estimate item.

21.2.3.1 Plant equipment

This component represents prefabricated, pre-assembled, off-the-shelf types of mechanical or electrical equipment, either fixed or mobile. Pricing is inclusive of all costs necessary to purchase the goods ex-works, generally excluding delivery to site (unless otherwise stated) but including operating and maintenance manuals. Vendor representation and commissioning spares have been allowed for separately in the estimate.

21.2.3.2 Bulk materials

This component covers all other materials, normally purchased in bulk form, for installation on the Namdini Gold Project. Costs include the purchase price ex-works, any off-site fabrication, transport to site (unless otherwise stated), and over-supply for anticipated wastage.

21.2.3.3 Installation

This component represents the cost to install the plant equipment and bulk materials on site or to perform site activities. Installation costs are further divided between direct labour, equipment and contractors' distributables.

The labour component reflects the cost of the direct workforce required to construct the Namdini Gold Project. The labour cost is the product of the estimated work hours spent on site multiplied by the cost of labour to the contractor inclusive of overtime premiums, statutory overheads, payroll burden and contractor margin.

The equipment component reflects the cost of the construction equipment and running costs required to construct the Namdini Gold Project. The equipment cost also includes cranes, vehicles, small tools, consumables, PPE and the applicable contractor's margin.

Contractors' indirect costs encompass the remaining cost of installation and include items such as offsite management, onsite staff and supervision above trade level, crane drivers, mobilisation and demobilisation, rostered breaks off site (“R&R”), and the applicable contractors' margin.

21.2.3.4 Temporary construction facilities

Facilities will be capable of servicing the owners and EPCM teams. Included in the estimate for construction facilities are the following:

- Construction offices
- Computers and computing servers, telephones, printers, etc., and office furniture
- Provision of services.

21.2.3.5 Heavy lift cranage

A heavy lift crane was allowed for in the estimate for the duration of mill installation.

21.2.3.6 Contractor distributables

Costs for mobilisation and demobilisation of labour and equipment to and from the Project site were based on projects of a similar size and adjusted to suit the Namdini Gold Project location.

21.2.3.7 Qualifications

The estimate is subject to the following qualifications:

- All labour rates, materials and equipment supply costs are 2Q17. Contingency was allowed based on the quality of the various estimate inputs, however no allowance for escalation was included.
- Construction contractor rates include mobile equipment, vehicles, fuel, construction power and consumables for the duration of construction. Potable water and raw water supply will be provided by the Client and available at site for the use by contractors.
- Flights for mobilisation, demobilisation and R&R of construction contractor personnel are incorporated in the contractor indirect labour rates on the basis of individual contractors.
- Contractor accommodation costs per day have been included in the individual contractor’s rates.
- Meals and accommodation for the EPCM team are included in the EPCM allowance.

- Project spares are a percentage allowance of the mechanical supply cost based on similar size projects.
- A commissioning assistance crew is allowed for in the EPCM allowance.
- PLC programming for the process plant was allowed for in the EPCM allowance.

21.2.3.8 Contingency

The purpose of contingency is to make specific provision for uncertain elements of cost within the Namdini Gold Project scope. Contingencies do not include allowances for scope changes, escalation or exchange rate fluctuations.

Contingency is an integral part of an estimate. It has not been applied at to all line items, resulting in an overall project contingency of approximately 15%.

21.2.3.9 Exclusions

The following is excluded from the overall project capital costs:

- Duties, taxes and fees (on the basis that the project will negotiate duty and tax-free status)
- Project sunk costs
- Project escalation
- Mining facilities, other than the mine administration building (on the basis that these will be provided by the mining contractor).

21.2.4 Escalation and foreign exchange

21.2.4.1 Escalation

Escalation is excluded from the estimate.

21.2.4.2 Exchange rates

All items in the capital estimate have been included as US$ and no allowances for exchange rate variations are included in the estimate.

21.3 Working and sustaining capital

Working capital was excluded from the estimate, other than allowance for 6 weeks operating costs which was included in the OPEX estimate.

Sustaining capital was excluded from the estimate.

21.3.1 Mining

Mining costs other than establishment costs have been excluded from the estimate.

21.4 Operating cost estimate

21.4.1 Introduction

The purpose of this operating cost estimate is to provide substantiated costs which can be used for a preliminary assessment of the viability of the Namdini Gold Project.

The operating costs have been compiled by Lycopodium (2017) based on costs developed by:

- Golder – Mining costs (Section 16.0).
- Lycopodium (2017) – Processing and General and Administration costs (Section 17.0)

Operating costs have been determined for the following three annual throughput rates operating 24 hours per day, 365 days per year at a primary grind size of P_{80} 106 µm and a flotation concentrate regrind grind size of P_{80} 15 µm:

- 4.5 Mtpa.
- 7.0 Mtpa.
- 9.5 Mtpa.

The estimate is considered to have an accuracy of ±35%, is presented in United States dollars (US$) and is based on prices obtained during the second quarter of 2017 (2Q17). Study currency exchange rates were confirmed by Cardinal Resources.

21.4.2 Overall process operating costs

The overall and summary Namdini process operating cost estimates are provided in Table 56.

Table 56: Overall operating cost estimate (US$, 2Q17, ±35%)

	4.5 Mtpa (USD / t)	7.0 Mtpa (USD / t)	9.5 Mtpa (USD / t)
Processing	**11.6**	**10.6**	**10.1**
G & A	**1.9**	**1.4**	**1.2**
TOTAL	**13.5**	**12.0**	**11.3**

21.4.3 Processing and G&A operating cost summary

The processing operating cost estimate is summarised in Table 57.

Table 57: Summary process operating cost estimate (US$, 2Q17, ±35%)

	4.5 Mtpa (USD / t)	7.0 Mtpa (USD / t)	9.5 Mtpa (USD / t)
Power	5.1	4.9	4.8
Operating Consumables	4.6	4.3	4.1
Maintenance	0.9	0.7	0.6
Laboratory	0.2	0.1	0.1
Process & Maintenance Labour	0.8	0.6	0.5
Total Processing	**11.6**	**10.6**	**10.1**
Administration Labour	0.8	0.6	0.5
General & Administration Costs	1.1	0.9	0.8
Total G&A	**1.9**	**1.4**	**1.2**
TOTAL	**13.5**	**12.0**	**11.3**

The operating costs have been compiled from a variety of sources, including the following:

- Flotation and leaching reagent consumption based on preliminary testwork on primary ore
- Assumed reagent usage regimes for cyanide detoxification
- Modelling by OMC for crushing and grinding energy and consumables, based on the preliminary comminution testwork and assumed parameters
- Typical industry data from equipment vendors
- Budget pricing or Lycopodium’s database of prices for consumables

- Lycopodium's database of costs for similar sized operations.

The LOM expected mass recovery to flotation concentrate is 5%. It is noted that during the initial years of the project, higher sulphide ores will be treated and the mass recovery to flotation concentrate may increase to 10%. This will increase the processing operating cost by approximately US$1.60/t mill feed for all process plant throughput rates.

The operating cost estimate presented in this section is exclusive of the following:

- All head office costs
- Withholding taxes and other taxes; import duty on consumable cost is included
- Any impact of foreign exchange rate fluctuations
- Any escalation from the date of the estimate
- Any contingency allowance
- Any land or crop compensation costs
- Any rehabilitation or closure costs
- Any licence fees or royalties
- Tailings storage costs, including future lifts and rehabilitation
- Government monitoring or compliance costs
- Gold refining and transport of gold from site
- All costs associated with areas beyond the battery limits of Lycopodium's scope of work.

21.4.3.1 Labour costs

The processing labour cost includes all labour costs associated with plant operations and maintenance personnel. The site laboratory is assumed to be operated on a contract basis with the personnel included in the process labour count but the labour costs included in the contract laboratory cost.

The administration labour cost includes all labour costs associated with site-based administration personnel. All head office costs are excluded, as they are included in the Owner's costs. The camp is assumed to be operated on a contract basis with the personnel included in the administration labour count but the labour costs included in the camp catering cost.

All labour costs for mining personnel are excluded, as they are included in the mining costs.

A full listing of labour positions, number of personnel and labour rates and costs was prepared by Lycopodium (2017).

The manning levels and rosters used to determine the labour operating cost estimate were based on similar operations. The estimate of the labour contingent was based on a three-shift operation (two shifts working 12 hours per day, one rotation shift), to provide continuous coverage for the plant operation with allowance for leave and absenteeism coverage. Provision was made for four weeks leave and two weeks sick leave per year per person.

Unit rates for labour have been based on information from the Lycopodium database. An overhead cost allowance was made to cover such items as payroll taxes, worker's compensation, death and disability insurance, leave provisions and superannuation contributions. Camp and bus transportation costs for the workforce are excluded from the labour cost as they are included in the G&A cost.

21.4.3.2 Power Costs

The power cost estimate was based on grid power at a unit cost of US$0.15/kWh as agreed with Cardinal. The average continuous power draw and power cost by plant area is summarised in Table 60. The power requirements and costs for the mine services area and the accommodation camp are also included.

The power consumption for the SAG and ball mills was calculated from typical ore properties, as determined by OMC. The power consumption for the regrind mill is based on the nominal mass pull of 5% to floatation concentrate and an assumed specific grinding energy of 30 kWh/t. The power consumption for the remainder of the Namdini Gold Project was estimated from typical installed power for the process plant equipment and infrastructure. Typical drive efficiency and utilisation factors were applied to the installed power to estimate the plant average continuous power draw.

21.4.3.3 Consumables costs

Costs for processing operating consumables, including reagents, liners, fuels and process supplies have been estimated. The consumables cost for mining is included in the mining operating cost.

The consumption of reagents and other consumables was calculated from laboratory testwork and comminution circuit modelling or was assumed based on experience with other operations. No additional allowance for process upset conditions and wastage of reagents was allowed. Details of consumption rates were prepared in the consumable sheet by Lycopodium (2017).

Reagent costs have been sourced from budget quotations and in-house data relating to similar projects in the region. Transport and freight to site and import duties and taxes have been added.

Cyanide destruction cost was based on the Inco Air/SO2 method, with the treatment of concentrate CIL tailings containing 500 g CNWAD/m^3 down to below 50 g CNWAD/m^3 after cyanide destruction.

A diesel price, delivered to site, of US$0.90 per litre was assumed. Diesel will be used in plant mobile equipment, for carbon elution and regeneration and for the gold room furnace. The diesel consumption for plant mobile equipment is based on industry standard vehicle consumption rates and estimated equipment utilisation. The diesel usage for carbon treatment and the gold room was calculated from first principles.

Allowances have been made for mill lubricants, water treatment reagents and operator supplies.

21.4.3.4 Maintenance materials costs

The plant maintenance cost allowance was factored from equipment supply capital costs using factors from the Lycopodium database with further detail prepared by Lycopodium (2017).

The allowance covers mechanical spares and wear parts, but excludes crushing and grinding wear components, grinding media and general consumables which are allowed for in the consumables cost.

The maintenance cost excludes site maintenance labour which is included in the labour cost. Contract labour was allowed for crusher and mill liner changes and plant shutdowns.

Allowances for plant mobile equipment, plant building maintenance and general maintenance expenses have been made. The mobile equipment allowance is based on unit costs for maintenance of the light vehicles, portable generators and other mobile equipment for the process plant. General maintenance expenses include specialist maintenance software, maintenance manuals and control system licence fees.

21.4.3.5 Laboratory costs

A laboratory building will be located on-site. A third-party contractor will be engaged to provide laboratory services and equipment typical to this type of operation.

The laboratory cost is based on assaying and analyses of periodic plant samples and 100 mining grade control samples per day.

Laboratory costs have been based on in-house data for contract laboratories of a similar size.

21.4.3.6 General and administration costs

The general and administration costs were based on information from the Lycopodium database and scaled as required to represent the three throughput options. The administration labour cost was calculated as described in Section 21.4.

The basis of costs for the accommodation contract based on camp requirements for the processing and administration personnel (but excluding contract mining personnel).

21.5 Operations preproduction and working capital costs

The costs incurred by the operations during the latter stages of construction and commissioning are included in the capital cost estimate but are derived in this estimate. The pre-production cost estimate is based on processing ore for the initial six weeks of operation. Pre-production costs associated with mining are excluded.

21.5.1 Labour costs

These costs reflect the need to recruit key operating personnel in time for them to set up and establish operating procedures and undergo training as required.

21.5.2 First fill reagents and opening stocks

Costs have been allowed to purchase the consumables and reagents required to fill the reagent tanks, charge the mills with media and provide the initial stocks of materials to sustain the operations for the first month until regular ordering of supplies can be established. Quantities allowed have been based on either consumption over a minimum period or minimum shipping quantities, considering package size.

21.5.3 Vendor representatives and training

These costs allow for specialist vendor representatives to oversee commissioning of their equipment. The training allowance covers the cost of providing training for operations maintenance staff, but not their salaries, as these are covered in the pre-production labour costs.

21.5.4 Working capital

Six weeks of processing and administration operating costs has been allowed to cover the cost of operating the plant before the first revenue is received from bullion sales.

22.0 ECONOMIC ANALYSIS

The results of the economic analysis represent forward-looking information as defined under Canadian securities law. The results depend on inputs that are subject to a number of known and unknown risks, uncertainties and other factors that may cause actual results to differ materially from those presented here. Factors that could cause such differences include, but are not limited to: changes in commodity prices (see Section 22.2.3), costs and supply of materials relevant to the mining industry, the actual extent of the mineral resources compared to those that were estimated, actual mining and metallurgical recoveries that may be achieved, technological change in the mining, processing and waste disposal, changes in government and changes in regulations affecting the ability to permit and operate a mining operation. Forward-looking information in this analysis includes statements regarding future mining and mineral processing plans, rates and amounts of metal production, tax and royalty terms, smelter and refinery terms, the ability to finance the project, and metal price forecasts.

This PEA study is preliminary in nature. It includes Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorised as Mineral Reserves, and there is no certainty that the conclusions of this preliminary economic assessment will be realised.

22.1 Financial Summary of PEA

22.1.1 Key Study Outputs

The key economic results are summarised in Table 58

Table 58: Key Economic Results

KEY ECONOMIC RESULTS	UNIT	4.5 Mtpa	7.0 Mtpa	9.5 Mtpa
Development Capital Cost	**US$ M**	275	349	426
All in Sustaining Costs (AISC)[1]	**US$ / oz**	794	736	701
Total Project Payback	**Years**	4.0	3.5	3.3
Pre-Tax NPV USD (@ 5% discount)[2]	**US$ M**	706	913	1,036
Post-Tax NPV USD (@ 5% discount)[2]	**US$ M**	445	574	649
Pre-Tax IRR	**%**	42%	54%	62%
Post-Tax IRR	**%**	31%	39%	44%

Table 1 Notes:

[1] Cash Costs + Royalties + Levies + Life of Mine Sustaining Capital Costs (World Gold Council Standard)

[2] Royalties calculated at flat rate of 5% & corporate tax rate of 35% used; both subject to negotiation.

The key production results are summarised in Table 59

Table 59: Key Estimated Production Results

RESOURCE DATA USED – SEPTEMBER 2017				
Indicated Mineral Resource	91 Mt @ 1.1 g/t for 3.3 Moz (81%) within Life of Mine Pit *at 0.5 g/t cut off*			
Inferred Mineral Resource	22 Mt @ 1.1 g/t for 0.8 Moz (19%) within Life of Mine Pit *at 0.5 g/t cut off*			
KEY ESTIMATED PRODUCTION RESULTS	**UNIT**	**4.5 Mtpa**	**7.0 Mtpa**	**9.5 Mtpa**
Gold Price	**US$ / oz**	1,300		
Average Annual Production – Gold	**(oz / yr)**	159,000	211,000	333,000
Life of Mine Production - Gold	**(oz)**	3,524,000	3,506,000	3,521,000
Average Mine Head Grade	**g/t Au**	1.1		
Metallurgical Recovery (Oxide / Fresh)	**%**	90 / 86		
Resource Mined at 0.5 g/t cut-off grade	**Tonnes**	113,000,000		
Life of Mine Strip Ratio	**W:O**	1.2 : 1		
Mine Life	**years**	27	19	14
Development Capital Cost (including owners cost and 15% contingencies)	**US$ M**	275	349	426
Life of Mine Sustaining Capital Cost (including reclamation)	**US$ M**	172	160	154
All in Sustaining Costs (AISC)[1]	**US$ / oz**	794	736	701

Notes:
[1] Cash Costs + Royalties + Levies + Life of Mine Sustaining Capital Costs (World Gold Council Standard)
(Assumes flat gold price of US$1,300/oz over mine production)

22.1.2 Investment metrics:

Based upon Life of Mine production and cost parameters, the key investment metrics of the post-tax Net Present Value cashflow forecasts are presented in Table 60. For indicative purposes only, the mid-range throughput of 7.0 Mtpa is presented.

Table 60: 7.0 Mtpa option – Post-tax NPV of Namdini's Forecast Cashflow – Gold Price Sensitivity

Post-Tax Real Discount Rate (%)	**Gold Price (US$/oz)**				
	US$1,100/oz	**US$1,200/oz**	**US$1,300/oz**	**US$1,400/oz**	**US$1,500/oz**
0	596	810	**1,023**	1,237	1,451
5	318	446	**574**	703	831
10	168	251	**334**	417	525

Note: *All NPVs are post-tax and shown in US$M*

The following four bar charts illustrate the 7.0 Mtpa option pre- and post-tax economic sensitivities.

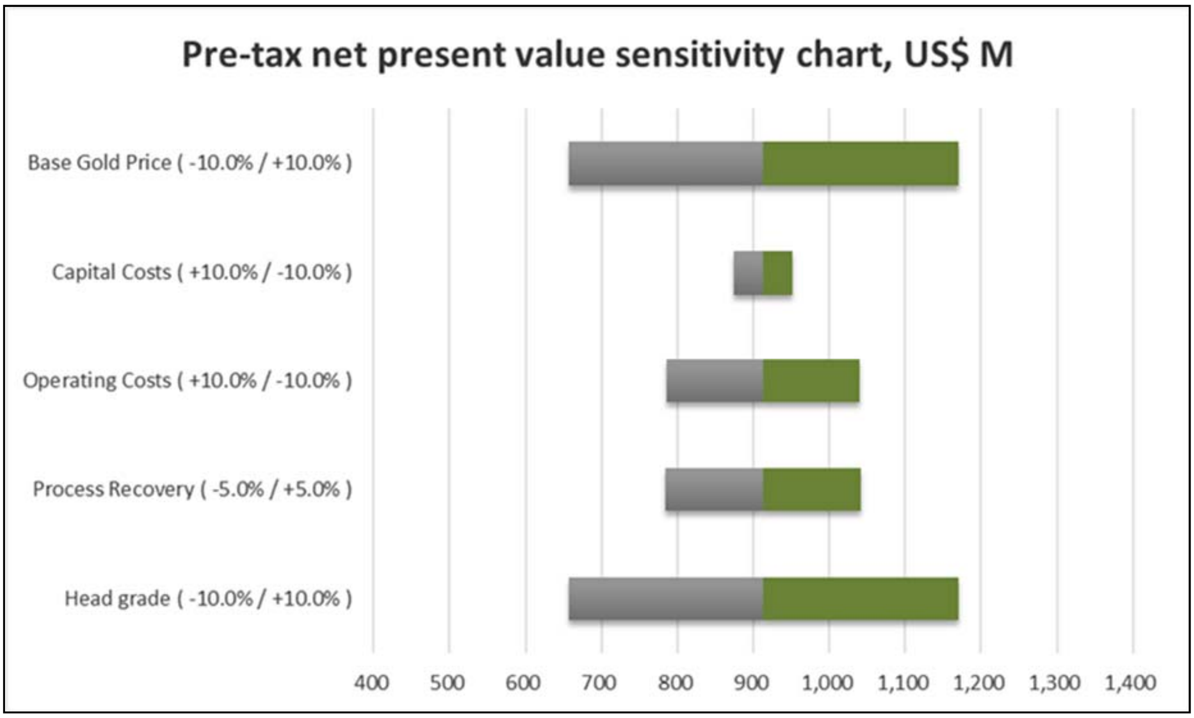

Figure 43: 7.0 Mtpa option – Pre-tax NPV sensitivity at 5% discount (US$ M)

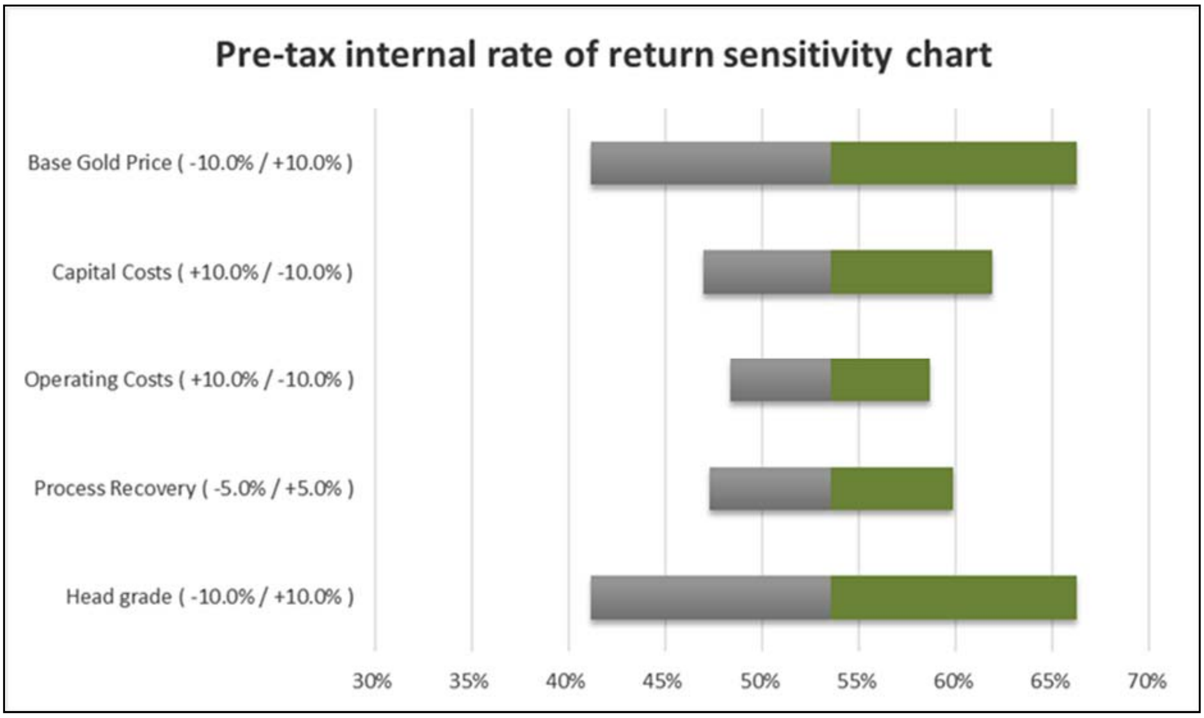

Figure 44: 7.0 Mtpa option – Pre-tax Internal Rate of Return (%)

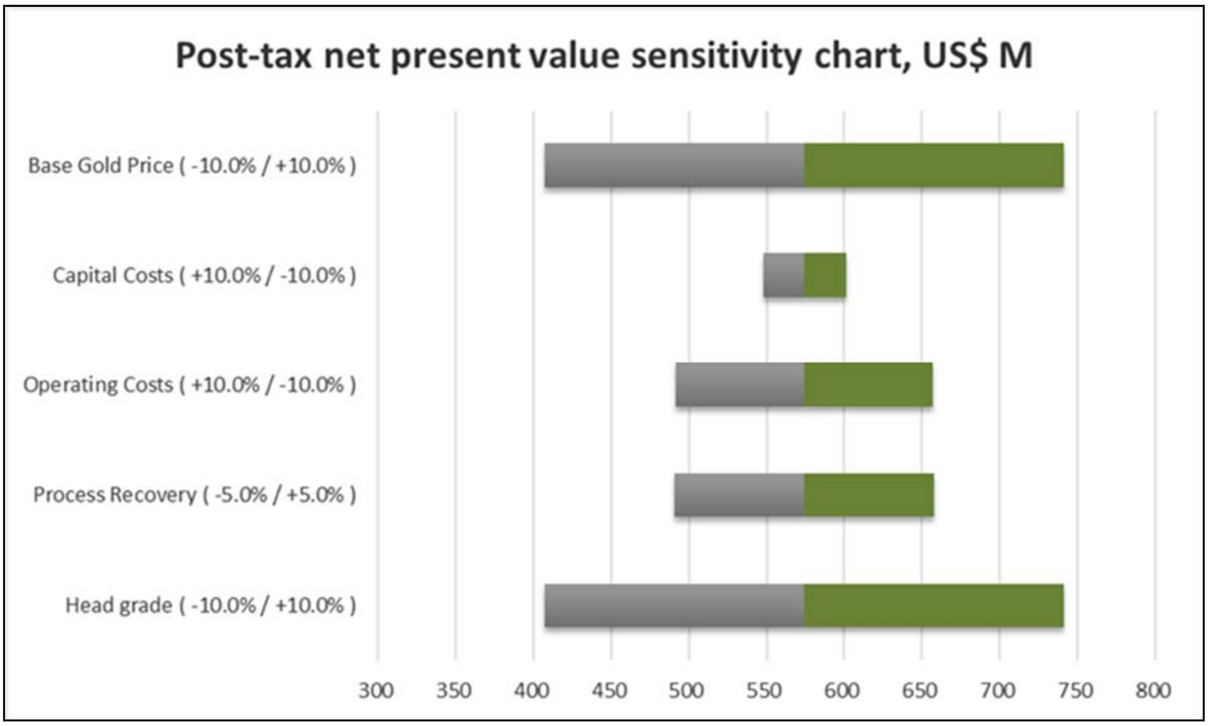

Figure 45: 7.0 Mtpa option – Post-tax NPV sensitivity at 5% discount (US$ M)

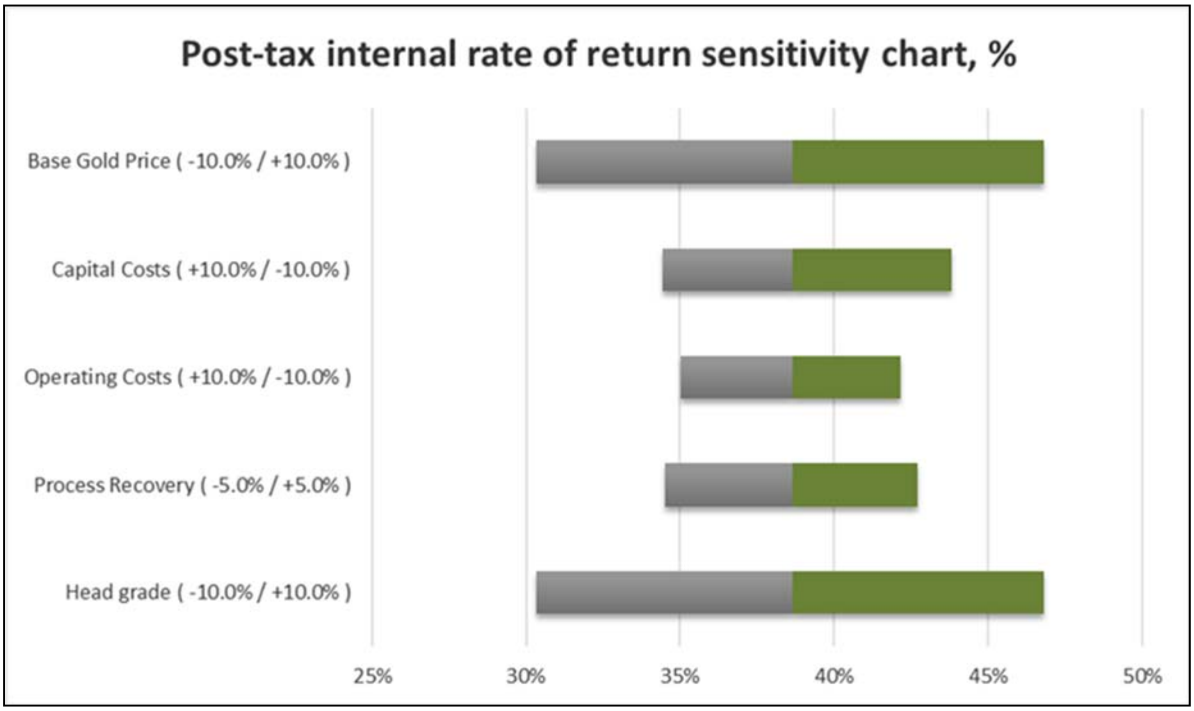

Figure 46: 7.0 Mtpa option – Post-tax Internal Rate of Return (%)

Given that the PEA results in a strongly positive cashflow outcome for all three throughput scenarios considered, further evaluation and trade-offs for improved economies of scale, mine scheduling, plant design and costings which are anticipated to further enhance project economics will be performed under the Pre-Feasibility Study ("**PFS**") which has commenced.

23.0 ADJACENT PROPERTIES

The Namdini Gold Project site is located approximately 6 km southeast of the operating Shaanxi underground gold mine.

24.0 OTHER RELEVANT DATA AND INFORMATION

The Qualified Persons signing this PEA report are not aware of any omissions or other relevant data and consider the explanations provided are not misleading.

25.0 INTERPRETATION AND CONCLUSIONS

This PEA study is preliminary in nature. It includes Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorised as Mineral Reserves, and there is no certainty that the conclusions of this preliminary economic assessment will be realised.

The positive results of the PEA of the Namdini Gold Project have confirmed that progression of the Namdini Gold Project to the Pre-feasibility Study ("PFS") stage is warranted.

The preliminary mining schedule was based on assessment of a range of processing throughputs to maximise value, being 4.5 Mtpa, 7.0 Mtpa and 9.5 Mtpa of process plant feed from the Namdini pit. The mining plan has scheduled 112 Mt of ore and 135 Mt of waste to recover 3.5 Moz Au. The 4.5 Mtpa option would result in an anticipated mine life of some 27 years. The 7.0 Mtpa option gives a mine life of 19 years and the 9.5 Mtpa option gives a mine life of 14 years.

The economic assessment was carried out pre-tax and post-tax and has assumed a total allowance for royalties of 5% of the gross revenue.

The PEA pit design was conservative due to the lack of geotechnical slope stability data and analysis. The PFS pit design may be more aggressive when based on better geotechnical information.

Further metallurgical testwork and geometallurgical modelling may confirm anticipated optimization of recovery by weathering type to enable detailed cost estimation of power and process operating costs.

26.0 RECOMMENDATIONS

This PEA study has highlighted the following recommendations that provide focus for the planned PFS, in particular, options for further optimization and trade-off studies.

A comprehensive geotechnical study is required to support more aggressive (i.e. less conservative) future pit designs.

Improvement in the pit shell shape from smaller conical pits to larger, simple pits would be advantageous in decreasing the stripping ratios. The PFS should investigate whether improved data density in the areas rejected by the pit optimiser can improve the pit design in these areas.

The proposed process plant site, Tailings Disposal Facility and waste disposal sites should be further investigated in the PFS and sterilised by drilling, particularly where there is potential for additional mineralized material.

Trade-off studies of further process plant options should be undertaken in the PFS. Different modular sized process plants with alternative comminution sections may reduce capital costs and/or operational costs, especially for power consumption.

The PEA mine design was conservative due to the lack of geotechnical slope stability data and analysis. The PFS pit design may be more aggressive when based on better geotechnical information.

Further metallurgical testwork and geometallurgical modelling may confirm anticipated optimization of recovery by weathering type to enable detailed cost estimation of power and process operating costs.

Recommendations for further work programmes have been presented to Cardinal, with costings that have been reviewed by the QP. This work will be included in the PFS budget covering:

- Further development and exploration drilling
- Sampling studies
- Metallurgical testwork
- Geotechnical drilling and investigations
- Mining trade-off studies
- Plant options studies, etc.

The author has reviewed and concurs with Cardinal's proposed work programs for updating the PEA (Table 61).

Table 61: Proposed Further Study Expenditure

Item	Cost (US)
Namdini Drilling Program	$2,500,000
Metallurgical test work	$600,000
Process and Infrastructure Design	$1,100,000
Environmental and social studies	$150,000
Mine Design Studies	$1,000,000
Mineral resource update	$150,000
Subtotal	**$5,350,000**
Contingency	$400,000
Total	**$5,750,000**

27.0 REFERENCES

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ABBREVIATIONS

AIF	Annual Information Form (company report to the TSX)
ASX	ASX Group Ltd (the Australian Securities Exchange)
BBWI	Bond ball mill work index
C.Eng	Chartered Mining Engineer
CAPEX	Capital expenditure
Cardinal	Cardinal Resources Limited
CMS	Cardinal Mining Services Limited
CNWAD	weak acid dissociable cyanide
COx	carbon oxides
CSM	cerebrospinal meningitis bacterial disease
DAVg	discounted average NPV (used in Whittle 4X™)
DGPS	differential GPS
EIA	Environmental (and Social) Impact Assessment
EIS	Environmental Impact Statement (a comprehensive public report)
EPCM	Engineering Procurement Construction & Management Eur.Ing.FEANI Registered European Mining Engineer
FEL	front end loader
GCST	Gold Coast Selection Trust
Ga	Billion years (giga annum)
Golder	Golder Associates Pty Ltd
Golder Ghana	Golder Associates Ghana Limited
HQ	Diamond Drill hole size
ICMC	International Cyanide Management Code
IRR	Internal Rate of Return
LOM	Life of Mine
Lycopodium	Lycopodium Minerals Pty Ltd
MC	Master Composite metallurgical testwork sample
MCCs	motor control centers
MIK	Multiple Indicator Kriging
MOX	moderately oxidised weathered rock
MPR	MPR Geological Consultants Pty Ltd
NEDCo	Northern Electricity Distribution Company
NEMAS	Nemas Consult Ltd
NI 43-101	National Instrument 43-101
NOx	nitrogen oxides
NPV	Net Present Value
OMC	Orway Mineral Consultants
OPEX	Operating expenditure
Orefind	Orefind Pty Ltd
PAI	project area of influence
PEA	Preliminary Economic Assessment (first stage of study under NI 43-101)
PFS	Pre-feasibility Study (second stage of study under NI 43-101)
PPE	personal protective equipment
QP(s)	Qualified Person(s) under NI 43-101

R&R	rostered breaks off site
RAP	Resettlement Action Plan
RC	reverse circulation (drilling)
RF	Revenue Factor
ROCE	Return on Capital Employed
ROM	Run of Mine (mill feed)
RPA	Roscoe Postle Associates Inc.
RPEEE	reasonable prospect for eventual economic extraction
SABC	open comminution circuit SAG mill followed by closed circuit ball mill and recycle pebble crushing
SANAS	South African National Accreditation System
Savannah	Savannah Mining Ghana Limited
SGL	Suntech Geomet Laboratories in Johannesburg
Shaanxi	Shaanxi Mining Company Limited
SML	small scale mining licenses
SPI	SAG mill power index
STDs	sexually transmitted diseases
STWSS	Small Town Water Supply System
TNM	Townend Mineralogy Laboratory
TRANS	Transition zone of partially weathered rock below MOX zone
TSX	Toronto Stock Exchange
SOX	strongly oxidised weathered rock
SOx	sulphur oxides
TSF	Tailings Storage Facility

UNITS

Many of these units are combined in measurement, e.g. kWh is thousand-Watt hours

µm	micron (millionth of mm)
bcm	banked cubic meter (volume of in situ material)
g	gram
Ga	Billion years (giga annum)
g/t Au	gold grade in grams per tonne
h	hour
ha	hectare
k	thousand
km	kilometer
km^2	square kilometer
ktpa	thousands of tonnes a year
l	litre
l/sec	litres a second (flow rate)
LG	Lerchs-Grossmann (algorithm used in pit optimization)
m	meter
M	million
m^3	cubic meter

m^3/day	cubic meters a day (flow rate)
mAHD	meters (above) average height datum
mg	milligram (thousandth of g)
mm	millimeter
Mtpa	million tonnes a year
Nm^3	normal cubic meter (unit of gas flow e.g. for oxygen consumption)
pH	measure of acidity
t	tonne
t/m^3	tonnes per cubic meter (for in situ dry bulk density)
ton	imperial ton
tph	tonnes per hour
US$	United States dollars
V	volt
W	watt
w/w	weight for weight (for slurry density)
y	year (sometimes a for annum)

Signature Page

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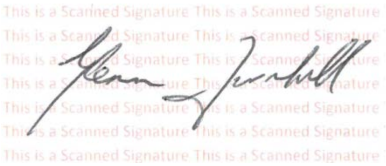

G. Turnbull	Sia Khosrowshahi (PhD, MSc, BSc)
Principal Mining Engineer	Principal Mining and Geology Group

GT/SK/hlc

A.B.N. 64 006 107 857

CERTIFICATE OF QUALIFIED PERSON

This certificate applies to the technical report prepared for Cardinal Resources. ("Cardinal") entitled: "National Instrument 43-101 Preliminary Economic Assessment Technical Report on The Namdini Gold Project, Ghana" signed on 5th February 2018 (the "Technical Report") and effective 5th February, 2018.

I, Glenn Turnbull, Eur.Ing, FIMMM, MAusIMM, C.Eng, do hereby certify that:

1. I am a Principal Mining Engineerwith Golder Associates Pty Ltd, and have been so since October 2011and am employed at: 1 Havelock Street, West Perth, Western Australia.
2. I graduated with a degree in Mining Engineering from the Nottingham University, UK in 1984. I have worked as a Mining Engineer and Management of mining operations for a total of 33 years since my graduation from university, and have worked continuously in the Mining Industry for over 40 years.
3. I am a Fellow in good standing of the Institute of Materials, Minerals and Mining (IMMM Member Number 29840).
4. I have read the definition of "qualified person" set out in the National Instrument 43-101 - Standards of Disclosure for Mineral Projects ("NI 43-101") and certify that, by reason of my education, affiliation with a professional association, and past relevant work experience, I fulfill the requirements to be an independent qualified person for the purposes of NI 43-101;
5. I am responsible for preparation of the technical report titled 'National Instrument 43-101 Preliminary Economic Assessment Technical Report on The Namdini Gold Project, Ghana' and dated 5th February, 2018 (the "Technical Report") relating to Namdini Gold deposit, Ghana. I am responsible for Sections 1.0, 2.0, 3.0, 4.0, 6.0, 14.2, 15.0, 16.0,18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0, 26.0 and 27.0 of this report for the Namdini Gold Project, Ghana. Input has been received from independent professional companies.
6. I visited the Namdini Gold Project, Ghana site between the 14-15 December 2017.
7. I am independent of the issuer as independence is described in Section 1.5 of NI 43-101.
8. I am not aware of any material fact or material change with respect to the subject matter of the Technical Report that is not reflected in the Technical Report, the omission to disclose which makes the Technical Report misleading.
9. I have read National Instrument 43-101 and Form 43-101F1 and the Technical Report has been prepared in compliance with that instrument and form.
10. I consent to the filing of the Technical Report with any stock exchange and other regulatory authority and any publication by them for regulatory purposes, including electronic publication in the public company files on their websites accessible by the public, of the Technical Report.

Dated this 5th February, 2018

Glenn Turnbull, Eur.Ing. FIMMM, MAusIMM, C.Eng. BSc Mining Engineering

MPR Geological Consultants Pty Ltd

CERTIFICATE OF QUALIFIED PERSON

This certificate applies to the technical report prepared for Cardinal Resources. ("Cardinal") entitled: "National Instrument 43-101 Preliminary Economic Assessment Technical Report on The Namdini Gold Project, Ghana" signed on 5th February 2018 (the "Technical Report") and effective 5th February, 2018.

I, Nicholas James Johnson, MAIG, do hereby certify that:

1. I am a Consulting Geologist, with the firm of MPR Geological Consultants Pty Ltd, 19/123A Colin Street, West Perth, WA 6005, Australia.
2. I graduated with an Honours degree in in Geology (1988) from the Latrobe University, Melbourne, Australia . I have worked as a Geologist for a total of 30 years since my graduation from university and have worked continuously in the Mining Industry for over 30 years.
3. I am a practicing Geologist and registered Member of the Australian Institute of Geoscientists
4. I have read the definition of "qualified person" set out in the National Instrument 43-101 - Standards of Disclosure for Mineral Projects ("NI 43-101") and certify that, by reason of my education, affiliation with a professional association, and past relevant work experience, I fulfil the requirements to be an independent qualified person for the purposes of NI 43-101;
5. I am responsible for preparation of the technical report titled 'National Instrument 43-101 Preliminary Economic Assessment Technical Report on The Namdini Gold Project, Ghana' and dated 5th February, 2018 (the "Technical Report") relating to Namdini Gold deposit, Ghana. I am responsible for Section 7.0, 8.0, 9.0, 10.0, 11.0, 12.0 and 14.1 of this report for the Namdini Gold Project, Ghana. Input has been received from independent professional companies.
6. I visited the Namdini Gold Project, Ghana site between the 11th, January, 2017 and 14th, January, 2017.
7. I am independent of the issuer as independence is described in Section 1.5 of NI 43-101.
8. I am not aware of any material fact or material change with respect to the subject matter of the Technical Report that is not reflected in the Technical Report, the omission to disclose which makes the Technical Report misleading.
9. I have read National Instrument 43-101 and Form 43-101F1 and the Technical Report has been prepared in compliance with that instrument and form.
10. I consent to the filing of the Technical Report with any stock exchange and other regulatory authority and any publication by them for regulatory purposes, including electronic publication in the public company files on their websites accessible by the public, of the Technical Report.

Dated this 5th February, 2018

Nicholas James Johnson, MAIG

CERTIFICATE OF QUALIFIED PERSON

This certificate applies to the technical report prepared for Cardinal Resources. ("Cardinal") entitled: "National Instrument 43-101 Preliminary Economic Assessment Technical Report on The Namdini Gold Project, Ghana" signed on 5th February 2018 (the "Technical Report") and effective 5th February, 2018.

I, K. Marc LeVier, MMSA, do hereby certify that:

1. I am a Consulting Metallurgist with K. Marc LeVier & Associates, Inc. and have been so since 2012 and reside in Denver, Colorado.
2. I graduated with B.S. and M. S. degrees from Michigan Technological University. I have worked as a metallurgical engineer in mineral processing, extractive metallurgy and other positions of responsibility for a total of 47 years since my graduation from university, and have worked continuously in the Mining Industry for over 42 years.
3. I am a Qualified Professional in good standing of the Mining and Metallurgical Society of America (MMSA Member Number 01225QP).
4. I have read the definition of "qualified person" set out in the National Instrument 43-101 - Standards of Disclosure for Mineral Projects ("NI 43-101") and certify that, by reason of my education, affiliation with a professional association, and past relevant work experience, I fulfill the requirements to be an independent qualified person for the purposes of NI 43-101.
5. I am responsible for preparation of the technical report titled "National Instrument 43-101 Preliminary Economic Assessment Technical Report on The Namdini Gold Project, Ghana" and dated 5th February, 2018 (the "Technical Report") relating to Namdini Gold deposit. I am responsible for Section 13.0 and 17.0 of this report for the Namdini Gold Project, Ghana. Input has been received from independent professional companies.
6. I visited the Namdini Gold Project, Ghana site in July 2017.
7. I am independent of the issuer as independence is described in Section 1.5 of NI 43-101.
8. I am not aware of any material fact or material change with respect to the subject matter of the Technical Report that is not reflected in the Technical Report, the omission to disclose which makes the Technical Report misleading.
9. I have read National Instrument 43-101 and Form 43-101F1 and the Technical Report has been prepared in compliance with that instrument and form.
10. I consent to the filing of the Technical Report with any stock exchange and other regulatory authority and any publication by them for regulatory purposes, including electronic publication in the public company files on their websites accessible by the public, of the Technical Report.

Dated this 5th February, 2018

K. Marc LeVier, QP

K. Marc LeVier & Associates, Inc.

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