NALUNAQ GOLD MINE

Nanortalik
Greenland

REVISED
ENVIRONMENTAL
IMPACT ASSESSMENT

November 2009
Nalunaq Gold Mine

Revised
Environmental Impact Assessment

Issued 11th December 2009

Angel Mining (Gold) A/S
Postboks 162
3922 Nanortalik
Greenland
# Table of Contents

Non Technical Summary

1 Introduction  
   Summary of Project  
   Authors

2 Angel Mining plc  
   The Company  
   History of proposals

3 Framework of the Project  
   Legislative Framework  
   Environmental framework  
   Background to the application  
   Scope of the application

4 Consultation  
   Consulted Bodies  
   Key Issues Raised by Consultees

5 General Background to Greenland and Project  
   Location of Nalunaq Gold Mine  
   Political & Economic Background  
   Geographical  
   Climate  
   Population and Demographics

6 Geological Setting

7 History of Mining at Nalunaq  
   Timeline of Mining at Nalunaq  
   Mining and Processing History  
   Environmental and Compliance History  
   Pollution from Previous Operations  
   Other Mining in Greenland

8 Hours of Operation and Manpower

9 Background to the EIA  
   Background  
   Summary of Previous Environmental Work  
   Agreements as to work required and not required  
   Requirements for EIA
10 Consequences and Alternatives
   Objectives of the Project
   Longer Term Objectives
   Limitations of this report
   Advantages and Disadvantages
   Regional
   National
   International
   Consequences of Project not taking place
   Alternative Opportunities

11 Exploration and Feasibility of Project
   Present Position
   Historical reserves Information

12 NGM Operational Proposals
   Introduction
   Access and Infrastructure
   Mining Operations
      Mining Method
      Tailings/Backfill, Underground Water, Ventilation, and Geotechnical Design
      Equipment
   Processing
      Gravity Circuit
      Carbon in Pulp and Associated Process Route
   Waste Rock and Process Waste
   Mine and Process Water
   Provision of Power
   Nalunaq Mine Camp
   Workshops, Materials Delivery and Storage
   Mine Camp Waste, Packaging Waste and Waste Water
   Product Transport, Harbour Issues, Shipping and Ship Loading

13 Legislation

14 Environmental Background & Baseline Studies
   Introduction to Situation
   Baseline Conditions
      Dust
      Noise
      Blasting vibration
      Light Pollution
      Ecology
      Landscape, Physical and Visual Intrusion
      Pollution
Fresh Water Quality
Air Quality
Land-use, Agriculture and Soils
Materials Reception and Storage
Waste from Mine Camp
Transport Issues
Marine Environment at Harbour
Cultural Heritage & Archaeology
Public Rights of Access
Tourism
Existing Resources
Greenhouse Gases
Consequent Additional Development Potential
Cumulative Impacts
Local Social Baseline Considerations

15 Aspects, Impacts & Mitigation
Dust Emissions to Air
Emissions to Water
Noise
Blasting Vibration
Light Pollution
Ecology
Landscape, Physical and Visual Intrusion
Hydrogeology and Fresh Water
Land-use, Agriculture and Soils
Materials Reception and Storage
Waste from Mine Camp
Transport Issues
Cultural Heritage & Archaeology
Public Rights of Access
Tourism
Existing Resources
Greenhouse Gases
Consequent Additional Development Potential
Cumulative Impacts

16 Social Aspects, Impacts and Mitigation

17 Environmental Management Plan

18 Environmental Monitoring Proposals
International Cyanide Management Code Compliance Proposals

19 Mine Closure Plan and Restoration & Rehabilitation Proposals

20 Public Involvement and Comments
21 Health & Safety

22 Risk Assessment Section

23 Conclusions
Non Technical Summary

The non technical summary is set out in four sections. The purpose of this is to provide a detailed description of the project in a manner that is both consistent with international best practise and the requirements that the EIA will be made public in Greenland; hence the need for additional detailed non technical information.

Section 1

a. The Nalunaq Gold Mine in the Kirkespir Valley north of Nanortalik in southern Greenland has been acquired by Angel Mining plc (formerly Angus & Ross plc) from Crew Gold Corp who operated the mine from 2004 until February 2009. The Greenlandic company Angel Mining (Gold) A/S, which is wholly owned by Angel Mining plc, is the operating company for the mine. Angel Mining plc has commissioned the preparation of this Environmental and Social Impact Study.

b. The object of the project is to reopen, develop and operate the Nalunaq Gold Mine. The Mine will utilise underground methods to exploit the resources. Crew has operated the gold mine from mid-2004 until February 2009. Angel Mining Gold A/S intend to restart mine production in early 2010 (subject to BMP approval). The target annual production rate will be almost 35,000 ounces of contained gold giving a yearly output of just under 30,000 ounces of Au. Small amounts of silver will also be produced.

c. The intentions of the ESIA are:

- to examine the technical, environmental and economic aspects of the project;
- to identify important environmental impacts and explain the best way of mitigation; and
- to show the mine can be developed without unacceptable environmental impacts;

d. The ESIA considers both, positive (beneficial) and negative (detrimental) effects of projects, as well as the residual effects, after proposed mitigation measures have been taken into account.

e. The ESIA report has been written in accordance with the regulatory requirements in Greenland.
f. A number of impacts have been identified and analysed in detail.

g. Angel Mining plc intend to utilise a simple inclined room-and-pillar type mining method using employees rather than contractors as was the historic operational ethos. Ore processing will be carried out using a combination of gravity processing and Carbon-in-Pulp (CiP) leaching. Gold doré will be produced at the mine. Metallurgical testing has shown that a considerable amount of gold is of a size less than that which can be recovered by gravity processes alone so that the CiP leaching process will ensure maximum recovery of gold from the ore.

h. No process tailings or waste rock will be put to external dump but will, instead, all be used as backfill underground in the previously mined out areas. All process plant and activity, including the doré production, will take place within the mine itself. Engineered bulkheads of bespoke design will be installed to maintain the integrity of the impoundment caverns.

i. This report attempts to give the historical background to the project including any environmental difficulties encountered and subsequent pollution caused.

j. Baseline considerations and ambient values of potential environmental impacts are given and the potential environmental impacts of the component operations of the new proposals are investigated. Mitigation measures to minimise all adverse impacts and monitoring to analyse compliance are proposed. The mitigation measures proposed will result in no significant residual adverse impacts.

k. Frameworks for the Environment Management Plan, the Health and Safety Plan and the Environmental Risk Register are proposed.

l. The two main potential impacts were found to be:
   • Dust – raised from the site roads and hard standings by wind scour and vehicle movements; and
   • Water discharge from the mine and camp into the Kirkespir River.
   It is anticipated that the mitigation measures proposed will effectively minimise these impacts and that no residual impacts will accrue.

m. Proposals for effective monitoring of all environmental impacts are proposed.

n. A Social Impact Assessment (SIA) will be prepared separately after public participation and full consultation with all stakeholders. This SIA
will include the preparation of an Impact Benefit Plan (IBP) and Impact Benefit Agreement (IaBA). The SIA was submitted in November 2009.

o. The area disturbed by the development of Angle Mining plc’s Nalunaq Gold Mine is not close to and does not involve any of the following designated areas of special interest:
   - Areas or sites of potential great sensitivity or unique geomorphological characteristics
   - Areas of special importance to wildlife
   - Areas with valuable, sensitive or representative biotopes except for the arctic char population in the Kirkespir River which would potentially be vulnerable to pollution from the mine but which will be fully protected by the proposed mitigation measures.
   - Areas of spiritual, cultural, or other socio-economic value including areas of special importance for traditional resource use. A large Norse Farm does exist in the Kirkespir River delta but this lies outside the mines curtilage and some distance from the mine link road, and will not be affected in any way by the mine’s operations.

p. The environmental effects of the previous mining operation have been seriously noted and marked by Angel Mining plc. Good environmental practice has been taken into account and built into the operational design of the mine and effective mitigation measures will be enforced to minimise the potential adverse impacts of the development. Full environmental control will be maintained to limit all adverse impacts. The mitigation measures proposed will result in no significant residual adverse impacts.

q. The comments of the Statutory and Regulating Bodies have been taken into consideration in the formulation of this project.

r. The development will have significant economic and social benefits for the Nation of Greenland and the local community of Kommune Kujalleq, comprising the former Municipalities of Nanortalik, Qaqortoq and Narsaq, in particular. Well paid work will be provided together with the knock on indirect and induced economic benefits which will improve the individual, family and community economy and reduce unemployment.

s. It is believed that the Nalunaq Mine can successfully operate and exploit the gold resource without causing major adverse impact. It is further believed that the benefits of the project to Greenland as a
whole and the local community in particular far outweigh any potential disbenefits of the project.

Section 2

Non technical Summary of the Mining and Mineral Processing methods to be used at the mine

Mining

The extraction of the gold bearing rock will employ the same machinery that was used previously in a simpler methodology. The simplicity is that the excavation void that is created to extract the ore is the same tunnel that is used for access both laterally and in the sub vertical direction. The tunnels themselves are the means of extraction. Pillars of rock are left intact to support the overlying rock [roof].

All rock will be drilled and blasted using conventional explosives, the rock face will be scaled so that is safe post blasting and the broken rock will be transported by truck to the mineral processing plant.

Mineral Processing

The broken rock from the mine is transported by truck to a tipping point that sits some 40m above the floor level of the mineral processing plant. This tipping point connects to the gold plant by a sub vertical tunnel. In effect this tunnel acts as a silo. The material is drawn from this storage chamber into a crusher which breaks the material to a size below 50mm. The material is then conveyed along a rubber belt conveyor to another crusher, which breaks the material to less than 10mm particle size.

The material is then conveyed to a storage bin before being placed into a grinding mill. The grinding mill uses steel balls and water to grind the material to a size less than 75 microns.

The finely ground material from the ‘mill’ is pumped to a series of concentrators where the gold that is free [not bound chemically to the rock] is
removed. This area of the plant is called the gravity plant. This free gold is then pumped in water to a table which by virtue of its vibration and angle further concentrates the gold. The discharge of the table is collected in a bucket. The material in the bucket is dried and when gold pours are scheduled placed into a crucible and melted with gold from the leach circuit to for a gold dore bar.

Material from the grinding ‘mill’ that is rejected from the concentrators as not gravity [free] gold] is pumped to the Carbon in Pulp leach circuit. The leach circuit is a series of tanks where lime is added to maintain liquid PH [slightly alkaline]. The Sodium Cyanide in liquid form is added to the slurry. The cyanide breaks the chemical bond between the gold and the ‘host’ rock. The material is kept within the tanks for 24-36 hours and as such there is a series of tanks cascading the liquid slurry of rock and water plus chemicals.

Midway during this process carbon in the form of charcoal is introduced. This is where the name of the process draws its name, Carbon in pulp. The slurry of finely ground rock is called a pulp. At this stage of the process the majority of the gold has formed a bond with the cyanide. When the pulp meets the carbon, the gold bonds itself to the carbon. This is as a result of chemical attraction and the porous nature of the carbon particle.

The carbon is removed from the tanks and is pumped to a vessel which contains strong acids. The gold is ‘stripped’ from the carbon and the gold solution is pumped to a small tank where electrodes are suspended. By virtue of the electrical charge in the electrodes the gold to cling to the metallic surface. The electrodes are sacrificial and they are melted in the gold furnace crucible along with the gravity gold.

The material [with gold removed] that is discharged from the leach tanks is pumped to a detoxification tank. In this tank a chemical Sodium Metabisulphate is added which ‘kills’ the cyanide. The material that leaves the detoxification tank contains less than 0.5 ppm Cyanide which is below acceptable discharge limits.

The mineral process plant waste is then pumped to an underground chamber where the solid material is deposited. The water that sits on top of the solids
which drop out of solution by gravity is then pumped back to a chamber which sits next to the mineral processing plant. Here water from the mine is added so that the water is returned to its ‘fresh’ state. This water is then re-used in the mineral processing plant. Hence all wastes stay underground, with excess water being discharged from the mine after being passed through various settlement chambers and water testing stations.

The gold Dore is stored safely in the gold room underground. It is collected and transported to Europe for processing into bullion.

Section 3

The control of hazardous substances to health used at Nalunaq Gold Mine

This section sets out specific details of the chemicals and other substances used in the mineral processing circuit. There is specific reference to the control and use of Cyanide in its various forms. Details of usage are provided, for detailed chemical formulae and process flow diagrams, the reader is drawn to the chapters of this report titled mineral process plant.

Chemical delivery

All chemicals used at the Nalunaq Gold Mine will be purchased from responsible suppliers from factories located either in the EU[27] or China/Asia. The chemicals will be stored in sealed nylon bags within dry wooden crates or in sealed steel drums. These chemicals will be purchased in a quantity that means they will fill an entire sea going container, that is 10t or 20t. The seas container will be 10ft [1/2 sized] or a full 20ft.

The sea container will be lifted from the delivery boat and placed onto the steel barge that is the harbour jetty at Nalunaq. The onsite crane will then lift the sea container onto a trailer which will be towed to the project site [12km]. The container will remain sealed during this operation. The trailer and tractor will travel at a regulated speed of 20km per hour and will have an escort
vehicle so as to maintain speed and driver attention to duties. The use of mobile phone is prohibited whilst driving any project vehicle at Nalunaq.

The sea container of chemicals will be driven up the mountain ramp to the 300mrl and taken along the 300mrl tunnel to the mineral process plant. The sea container will then be parked next to the underground stores and unloaded [de-stuffed]. The chemicals will then be placed into the store room on wooden or steel frames so that they are not placed directly onto the ground.

The store room is designed with a backward slope and a front wall so that any spillage is contained within the store room. A small sump will be incorporated into the rear of the store room. The store room will have a lockable gate arrangement. All products contained in the store room will have safety data sheets posted.

A series of spillage containment and ‘action’ boxes will be in the store room and at either side of the store room. Specifically for cyanide there will be containers of Sodium Meta-bisulphate available which can be applied to any spillage of Sodium Cyanide. The application of this chemical effectively neutralises the cyanide chemical.

When any chemical is required for use, it will be removed from the store room by Fork Lift Truck. The area and ‘roadway from the store-room to the mixing tanks will be a clean level floor made of concrete. There will be numerous spillage handling kits in the mixing tank area. The chemical will be ‘poured’ into the handling tank system as per manufacturer instructions. All employees will be required to wear the correct personal protective equipment. The area will be well ventilated.

**Water management**

The water for the mineral process plant is to be drawn from the ingress of water via the host rock found in the southern geological block. This water is believed to arise from valley floor seepage into the rock via permeable cracks or joints in the insitu rock.
This water will be pumped to the process water chamber via a series of small sumps hewn into the rock walls along the inclined ramp from the 300mrl to the mining face. This will ensure that sediment is trapped in the sumps by settlement and not reside in the mineral process plant water supply.

The process water will be used in the plant. The water is then used after cyanide detoxification as a transport medium to transfer the solid wastes to the impoundment area which is the previously mined lower target block. The water from this impoundment is then pumped back to a holding chamber for testing [by manual means by the project metallurgical staff]. The water is then pumped to the raw water process chamber [mixed with ‘fresh’ mine water]. Hence the water is recycled internally.

If there is excess water the water from the mine is sent to a series of chambers which are constructed along the 300mrl driveway. Here the water is settled and then a water sample is taken on a daily basis to ensure it complies with discharge levels [≤0.5ppm Total Cyanide] before being discharged to the environment as permitted by BMP and NERI.

Should the raw water chamber contain excess water then this will be able to be pumped to the series of water chambers along the 300mrl. These chambers containing water will be tested daily by the project metallurgical staff. In effect the already detoxified water will be further diluted by passing through three separate chambers of ‘fresh’ water from then mine. This rigorous water management system will be controlled by a separate electrical panel linking all pumps to a central control system.

If at any time a spillage falls outside of the boundary of the physical barriers in the mineral process plant; that is the tanks, sumps, barriers, and walls; then the water chamber pumps will be stopped and an assessment will be made as to whether to instigate the project emergency procedures or that the spillage will be contained and managed by the extensive dilution available via the water sumps.

In the case of a major spillage the entire project mineral process plant will be stopped and all dewatering halted. The mining machinery will be retreated from the operation face and all water in the mine will be pumped to the lower
target block with any excess kept in the lower southern block. After approximately 18 hrs operations will resume. The 18 hrs is sufficient time for the cyanide to be neutralised and treated by additional of sodium Meta-bisulphate.

As such a system has been designed that has spillage containment and management at its core. Any spoilage can be managed in a hierarchical manner.

Section 4

The monitoring regime for environmental management at Nalunaq

The person responsible for all health, welfare, safety and environmental matters is the director of mining and Exploration, Mr Tim Daffern. The site General Manager will be assisted by the Chief Geologist, Engineering manager and the company Environmental officer.

We will institute a full site Environmental Management System that is similar to the ISO 14001 system.

The people onsite will be suitable and sufficiently trained in Safe Environmental procedures and action management.

We will conduct weekly audits of all site areas and arrange for external independent auditors to come to site quarterly and undertake full site audits as per ICMI and our ISO 14001 EMS system protocols.

All water in the mine will be tested daily; all external water will be tested in accordance with the existing NERI/BMP permissions.

We will arrange for in 2010 two [six monthly] audits and training workshops by an additional specialist in cyanide handling and management. This person is nominally Mr Alistair Cadden, Director and specialist of Golders associates.

All audits onsite WILL include a component that pertains specifically to cyanide and these will be drafted based on the protocols of the ICMI and UK
laws pertaining to the handling of chemicals and products hazardous to health.

We do not intend to become fee paying members of the ICMIO but intend to implement a self regulation system based on the ICMI protocols, with audits by independent specialists who are recognised by the code as registered experts.
1 Introduction

The Environmental and Social Impact Assessment (ESIA) is a process used to evaluate the potential impacts on the environment and the community, of proposed developments. Its overall aim as part of a feasibility study is to minimise negative impacts. The EIA is also a tool to assist the financial institutions, state authorities and the wider international community, in the evaluation of environmentally related factors.

EIA also provides an important tool to aid a feasibility study, by highlighting possible environmental problems or risks, which can then be ‘designed out’ of the project at much lower cost than remediation works, after an environmental impact or incident has occurred. The EIA provides an opportunity to demonstrate that the mine has been designed in a sustainable manner, with control and mitigation measures incorporated from the outset. As such, conducting an EIA as part of the Feasibility Study for the project enables findings from both activities to be incorporated throughout the process allowing iterative changes to be made in the design or the impact mitigation measures.

A critical component of the full EIA is consultation with the local community; this is essential to ensure that the impact assessment takes account of issues regarded as priorities by those people living around and affected by the development. The applicant will also consult with relevant statutory authorities.

EIA considers both, positive (beneficial) and negative (detrimental) effects of projects, as well as the residual effects, after proposed mitigation measures have been taken into account.

A separate Social Impact Assessment (SIA) including an Impact Benefit Plan and Impact Benefit Agreement, as now required by Greenland Home Rule Government requirements, has been produced to assess the impact of the proposals on the local communities and its general socio-economic impacts.
Summary of the Project

Angel Mining plc have acquired the assets of Nalunaq Gold Mine A/S (NGM) from Crew Gold Corporation (Crew) of Weybridge, Surrey, UK, completing the acquisition on the 2nd of July 2009. The acquisition was finally approved by the Bureau of Minerals and Petroleum of the Greenland Government in late September 2009 with Investors given formal notification on the 7th October 2009. Formal confirmation of the final payment to Crew was given to Investors on 21st October 2009. The Exploitation Licence (No. 2003/05) has now been transferred to Angel Mining (Gold) A/S.

The object of the project is to reopen, develop and operate the Nalunaq Gold Mine situated in Napasorsuak near Nanortalik in Southern Greenland. The Mine will be operated by Angel Mining (Gold) Ltd (AMG) – a Greenlandic Company wholly owned by Angel Mining plc - and will utilise underground methods to exploit the resources. Crew has operated the gold mine from mid-2004 until February 2009. During this period, it has produced about 308,000 ounces of gold. Angel Mining plc have submitted revised mining, processing and environmental plans to the Bureau of Mines and Petroleum of the Greenland Government during July 2009 and September 2009 and intend to restart mine production as soon as possible in the fourth quarter of the 2009/10 financial year ending 28th February 2010, subject to the approval of the Greenland Government and their Bureau of Minerals and Petroleum (BMP). The target annual production rate will be almost 35,000 ounces of contained gold giving a saleable output of just under 30,000 ounces of Au. Small, but not insignificant, quantities of silver will also be produced.

Angel Mining will utilise a simple inclined room-and-pillar type mining method with the aid of their own workforce. Ore processing will initially be limited to gravity processing only but a Carbon-in-Pulp (CIP) leach processing system will be put in place in early 2010. Doré will be produced at the mine using concentrated ore from a combination of the gravity and Carbon-in-Pulp processes. Metallurgical testing has shown that a considerable amount of gold is of a size less than that which can be recovered by gravity processes alone, so that utilisation of the CIP process will ensure maximum recovery of

---

gold from the ore. No tailings or waste rock will be put to external tip but will, instead, all be used as backfill underground. All process plant and activity, including the doré production, will take place within the mine itself in the previously mined out areas. Engineered bulkheads of bespoke design will be installed to maintain the integrity of the impoundment caverns. Full environmental control will be maintained to limit all adverse impacts. This report attempts to give the historical background to the project including any environmental difficulties encountered and subsequent pollution caused. Baseline considerations and ambient values of potential environmental impacts are given and the potential environmental impacts of the component operations of the new proposals are investigated. Mitigation measures to minimise all adverse impacts and monitoring to analyse compliance are proposed. The mitigation measures proposed will result in no significant residual adverse impacts. Frameworks for the Environment Management Plan, the Health and Safety Plan and the Environmental Risk Register are proposed. It is believed that the Nalunaq Mine can successfully operate and exploit the gold bearing deposit without causing major adverse impact. It is further believed that the benefits of the project to Greenland as a whole and the local communities in particular far outweigh any potential disbenefits.

**Authors**

In addition to AMG’s own resources, namely Mr Timothy Daffern, Director of Mining and Exploration, the following have directly contributed to this EIA:

- GBM: Minerals Processing
- Golder Pastec: Ventilation, Geotechnical Design, Water, Backfill
- P I Watkinson: Technical Author and Co-ordinator of the ESIA

**2 Angel Mining plc**

**The Company**

Angel Mining plc (formerly called Angus & Ross plc) is a mining company registered in England & Wales under the Companies Act. It was registered under its present name in 1997 (Registration Number 3319691, VAT number
GB-860 170643) and its shares are listed on the AIM market of the London Stock Exchange (Symbol: ANGM.L). Its main properties, assets and interests are in Greenland. The company has its headquarters in Bourne, Lincolnshire, UK. It has a core of strong and informed institutional shareholders augmented by an unusually large retail component resulting in good market liquidity. By far the majority of the value in Angel Mining plc is found within the Nalunaq Gold Mine [Angel Mining (Gold) A/S] and the Black Angel Lead/Zinc Mine in West Greenland. The Greenlandic company Black Angel Mining A/S is the operating company for the Black Angel Mine and is also wholly owned by Angel Mining plc.

**History of Proposals**

Angel Mining plc (AMG) completed the acquisition of the assets of Nalunaq Gold Mine A/S (NGM) from Crew Gold Corporation (Crew) of Weybridge, Surrey, UK on 2nd July 2009. Crew operated the gold mine from mid-2004 until February 2009. During this period, it produced approximately 308,000 ounces of gold. Crew had also previously completed more than 19,000 metres of tunnelling and over 30,000 metres of diamond drilling.

The mine started operation on 1st July 2004 but was placed on care and maintenance by Crew in February 2009. The stated reason for idling the mine was the high cost of production, with Crew unwilling to make further investment. All the mining equipment remains intact at the camp. The high production costs were reported by Crew to be due to:

- High cost of actual mining due to ramp development in waste and a relatively complicated mining method with little evidence of trying to do it differently;
- High costs due to a poorly negotiated and implemented mining contract with a third party mining contractor, which was based on hours worked rather production performance;
- High shipping costs of ore; and
- High toll processing charges by a remote third party (no ore processing apart from pre-concentration screening was carried out on site).
AMG commenced the process to acquire NGM in March 2009 and agreed non-legally binding heads of terms on 7th of April 2009. Since then, full financing has been arranged and the acquisition was completed on the 2nd of July 2009. The assets acquired include mining and exploration licences (which have been transferred to AMG by the Greenland Government in September 2009), mining equipment, a fully operational mine camp and ship loading harbour facilities located close to the town of Nanortalik at the southern tip of Greenland. NGM had a fully paid environmental bond of 16 million Danish Kroner (DKK), which remains in place and has been formally transferred to AMG. A quantity of run-of-mine gold ore in stock at the harbour will be transported back to the mine and will be among the initial ore to be treated in the gravity plant by AMG.

AMG has submitted revised mining and environmental plans to the Bureau of Mines and Petroleum Bureau of Minerals and Petroleum (BMP) of the Greenland Government and this revised EIA forms part of those submissions. Mine operations and doré production are planned to start early in 2010, approvals permitting. The target annual production rate will be approximately 35,000 ounces of contained gold per annum.

AMG believes that it can operate the mine profitably by adopting a mining method that will enable it to employ predominately local labour and by producing doré on site which will eliminate the costs of concentrate shipping and external processing.

AMG has planned for an initial minimum 4 years of mine life. AMG will carry out further proving and exploration activity as part of the mining operation and preliminary life of mine plans completed by AMG indicate that a further 350,000 ounces of gold can be recovered from the Nalunaq gold mine leading to an overall projected 10 year operational life. Exploration of the deposit during the operation may amend this expectancy. Operations are under way to excavate and provide the underground caverns where the process plant will be located.
3. **Framework of the Proposal**

**Legislative Framework**

Section 10 of the Mineral Resources Act\(^2\), which forms the main relevant piece of Legislation, requires that "Prior to the commencement of exploitation and development activities a plan for the activities...............shall have been approved by the Greenland Home Rule Government..." Further the BMP Guidelines for preparing an EIA for Mineral Exploitation in Greenland state that "An EIA must be prepared when a company prepares to exploit a mineral deposit." The recommended procedures for the preparation of the EIA are set out in the BMP Guidelines. An existing ESIA was in place relating to the previous operations run by Crew. BMP have ruled that AMG must prepare a new EIA to cover their proposals before operations can commence. AMG have submitted a draft EIA in July 2009 followed by an Addendum A to the EIA in September 2009. This revised EIA, as requested by BMP, replaces these two previous draft documents. A separate Social Impact Assessment (SIA) has been submitted in November 2009.

**Environmental framework**

The Environmental Impact Study has been prepared to comply with the requirements set out above, as agreed by discussion with BMP. The main objectives of the EIA are to provide the following:

- A general description of the location and situation of the project;
- A description of the mining and environmental history of the site;
- A description of the possible impacts arising as a consequence of the proposed development;
- A description of mitigation measures intended to avoid, reduce or remedy those impacts;
- Details of an ongoing monitoring environmental programme through the life of the project; and

---

• Proposals for reducing the carbon footprint of the proposed operation.

**Background to the application**

The Nalunaq Mine was previously operated by Nalunaq Gold Mine A/S between 2004 and its idling in February 2009. The operation caused some environmental damage, some of which has not been remediated by the previous owner. This proposal utilises modern working methods which take into account good environmental practices and are designed to minimise environmental impacts. Full environmental control will be maintained to limit all adverse impacts. Considerable consultation by Angel Mining plc has taken place with the Authorities throughout the acquisition and redesign process. Meetings with BMP during this time have agreed a number of requirements for the EIA and this report takes these requirements into consideration.

**Scope of the application**

This report covers the re-development of the Nalunaq Mine including the mining method, the mineral process route which utilises gravity separation, carbon-in-pulp leaching and doré production, and the surface infrastructure requirements. All the mineral processing requirements including the smelting of the doré will take place underground within the mine itself with the process plant located within specially designed underground chambers. No mineral process plant waste, tailings or waste rock will be placed outside the mine so that no references are required for external above ground waste rock dumps or tailings management facilities (TMF/tailings dams). Full environmental control will be proposed and maintained to limit all adverse impacts.

4 Consultation

**Consulted Bodies**

As part of the acquisition and development of Nalunaq, AMG have undertaken consultation with all the stakeholders and in particularly with the Greenland Government and the Authorities including the BMP, the Local Community representatives, local people and the environmental body involved with the
monitoring of the ecological effects of mining operations in Greenland. All the bodies consulted have given positive assistance to AMG in this consultation and full and free exchange of views, ideas, suggestions and requirements has taken place.

The main bodies consulted have included:

- Greenland Government
- Bureau of Minerals and Petroleum at Nuuk
- Department of Arctic Environment (DMU) - National Environmental Research Institute (NERI) which is part of Aarhus University located at Roskilde, Denmark
- Kommune Kujalleq
- Geological Survey of Denmark and Greenland in Copenhagen (GEUS)
- Greenland Museum at Nuuk.

Public Consultation is a key part of the EIA and SIA process. Further consultation with the Statutory Bodies is ongoing and will also refer to the findings of this EIA. As part of the separate SIA process and the SIA report and associated draft Impact Benefit Agreement (IBA) submitted in November 2009, detailed consultation has taken place with the Community Representatives of Kommune Kujalleq, local businesses and organisations and the local people themselves. The SIA contains full details of the consultations and the results of the discussions including both the positive and negative comments, the hopes and aspirations and the doubts and fears which the community have expressed about the project, together with the answering comments and any provisions or statements made by the Company.

**Key Issues Raised by Consultees**

The two key environmental issues raised by the consultees are:

- Control of dust from the operation; and
- Control and safe use of the cyanide and other chemicals required for gold extraction, particularly with regard to safeguarding the surface water and groundwater regimes.
5 General Background to Greenland and Project

Location of Nalunaq Gold Mine

Greenland, (Kalaallit Nunaat in Greenlandic, Grønland in Danish), is an internally self-governing part of Denmark, being a vast island situated between the North Atlantic and Arctic Oceans. Although geographically and ethnically an Arctic island nation associated with the continent of North America, politically and historically, Greenland is closely tied to Europe, specifically Denmark and Norway. Greenland lies mostly north of the Arctic Circle and is separated from the Canadian Arctic Archipelago, to the west, primarily by the Davis Strait and Baffin Bay, and from Iceland, to the east, by the Strait of Denmark. The largest island in the world that is not also considered a continent, Greenland has a maximum length, from its northernmost point on Cape Morris Jesup to Cape Farewell in the extreme south, of about 2,655 km. The maximum distance from east to west is about 1,290 km. The length of Greenland’s coast, which is deeply indented with fiords, is estimated at 5,800 km. The total area of Greenland is approximately 2,175,600 sq km, of which about 84 per cent, or some 1,834,000 sq km, is ice cap which can be up to 3kms in thickness. Approximately one-twentieth of the world’s ice and one-quarter of the earth’s surface ice is found in Greenland. The weight of the massive Greenlandic ice cap has depressed the central land area to form a basin lying more than 300 m below sea level. It also contains The North Greenland National Park - the world’s largest national park. The capital is Nuuk, formerly called Godthab.

The Nalunaq gold mine is located at latitude 60°21’ N, and longitude 44°50’ W situated in Napasorsuak about 32km NE of Nanortalik in southern Greenland and to the west of the permanent ice-cap. The mine lies in the Kommune Kujalleq, within the former boundaries of the old municipality of Nanortalik, in Kirkespirdalen, a broad glacial valley, about 8 km from the tidal, ice-free, Saqqaa Fjord. The Saqqaa Fjord joins the Søndre Sermilik Fjord, which together with Tasermiut Fjord form two deep 60-80 km NE trending fjords that extend from the ocean of the Davis Strait (in the southwest) to the Greenland ice cap (in the northeast).
The area lies in the former Municipality of Nanortalik in the region of South Greenland, which is now forms part of the Kommune Kujalleq under recent administrational changes. The main towns of the Kommune Kujalleq are Nanortalik itself, Qaqortoq, and Narsaq together with a number of smaller communities. A 4m wide gravel road connects the mine site with the harbour facility at Sarqa Fjord 10km distant. There are no communities situated within a 15km radius from the mine.

**Political and Economic Background**

Danish settlers [adj. Vikings] reached the island in the 10th century from Iceland. Norse Greenlanders submitted to Norwegian rule in the 13th century and in 1536 it became a Danish dependency, along with Norway under the Kalmar Union which existed until 1814. At that time, the kingdom of Denmark-Norway found itself on the losing side of the Napoleonic Wars. In gratitude to Sweden for assistance in defeating Napoleon (and as a consolation for the recent loss of Finland to Russia), mainland Norway and certain Norwegian territories were transferred to Sweden — thus, the personal union of Norway and Denmark ended. The dependencies of Greenland, Iceland and the Faroe Islands, however, remained part of the re-organised "Kingdom of Denmark" and Danish colonization began.

In the early 20th century, the United States was believed to have claims made possible by the discoveries and exploration of the Peary expeditions.

In 1933, Norway attempted to claim eastern Greenland. The Permanent Court of Arbitration decided that the entire island belonged to Denmark and Greenland was made an integral part of the Kingdom of Denmark in 1953. Greenland was granted self-government in 1978 by the Danish parliament and the law went into effect on May 1st 1979 establishing the Greenland Home Rule. Greenland joined the European Community (now the EU) with Denmark in 1973, but Greenlandic voters subsequently chose to leave the European Economic Community upon achieving self-rule and withdrew in 1985 over a dispute centred on stringent fishing quotas.
Recent Political Progress Towards Independence

Greenland is a parliamentary democracy and has an elected parliament of thirty-one members operating over 4 year terms. The head of government is the Prime Minister, who is usually the leader of the majority party in Parliament. Two representatives are elected to the Danish Parliament with last elections for these posts being on 13 November 2007 (next to be held in November 2011). Following the publication of a white paper in April 2008, and following a referendum on greater autonomy, Greenland has assumed self-rule, under the Act on Greenland Self Government, in the latest step towards independence from Denmark, which will see the nation take a greater share of revenues from its natural resources. The Greenland Government has taken control of the police and the courts and Kalaallisut (Greenlandic) is now the official language. Denmark however retains the final say in defence and foreign-policy matters but Greenland actively participates in international agreements relating to Greenland. The laws of Denmark, where applicable, apply. This new self-rule system will take the nation to full independence and Greenlanders will be treated as a separate people under international law. The new coalition government elected in the last General Election on 2 June 2009 (next to be held by 2014) hopes the anticipated increase in revenues from minerals from mines such as Nalunaq and Black Angel will help to fund a final breakaway from Copenhagen. Many political analysts, however, feel that any move towards full independence is likely to be put on the backburner by the government as the new Prime Minister Kuupik Kleist has vowed to first concentrate on tackling the major social problems, such as alcoholism, domestic violence and a high suicide rate. As noted above, Greenland currently relies heavily on subsidies from the Danish government and this subsidy system is likely to remain in the longer term. The Queen of Denmark remains Greenland’s Head of State.

Fishing, sealing, and fur trapping are the principal economic activities in Greenland, which must rely on large amounts of financial support from Denmark. The fish catch is primarily cod, shrimp, and salmon; fish processing

---

is the major manufacturing industry. Agriculture is only possible on one percent of Greenland’s total area. Cattle, sheep, and goats are raised in small numbers in some portions of the south-western coast, and hardy vegetables are grown. Denmark is Greenland’s largest trading partner, and its main exports are fish, hides and skins, and fish oil. Thule Air Base in the north supports a community of American and Danish civilian and military personnel.

The economy remains critically dependent on fishing and exports of fish, with the shrimp fishing industry being the largest income earner. There has been an increase of interest in hydrocarbon and mineral exploration opportunities and these sectors will provide an increasing contribution to the Greenlandic economy. A proposal for the development of a large aluminium smelter, utilising imported bauxite and new local hydropower at Maniitsoq in west Greenland is also under consideration by the Government at the present time.

The increased interest in tourism offers potential for growth but is limited by the short season and high costs. The public sector, including publicly owned enterprises and the Kommunes, plays the dominant role in the economy. Around half of Government revenue is provided by grants from the Danish Government and this forms an important supplement to the Gross Domestic Product (GDP). Greenland’s per capita GDP (at US$20K in 2001 – latest available figure) is roughly equivalent to that of the weaker economies of Europe. The GDP at the official exchange rate is estimated at $1.7 billion for 2005\(^5\) with an estimated real growth rate of 2% in that same year.

Greenland suffered economic contraction in the early 1990; but since 1993 the economy has improved. The Greenland Government has pursued a tight fiscal policy since the late 1980s which has helped create surpluses in the public budget coupled with low inflation. The present period of world economic recession is adversely affecting Greenland in common with most other world economies.

Recent Political Progress Towards Independence

In a move following a referendum on greater autonomy under the November 2008 Act on Greenland Self Government, Greenland has assumed self-rule, in

---

the latest step towards independence from Denmark, which will see the nation take a greater share of revenues from its natural resources. The Home Rule Government has taken control of the police and the courts and Kalaallisut (Greenlandic) is now the official language. Denmark however retains the final say in defence and foreign-policy matters. This new self-rule system will take the nation to full independence and Greenlanders will be treated as a separate people under international law. The new coalition government hopes the anticipated increase in revenues from minerals from mines such as Nalunaq and Black Angel will help to fund a final breakaway from Copenhagen. Many political analysts, however, feel that any move towards full independence is likely to be put on the backburner by the government as the new Prime Minister Kuupik Kleist has vowed to first concentrate on tackling the major social problems, such as alcoholism, domestic violence and a high suicide rate. As noted above, Greenland currently relies heavily on subsidies from the Danish government and this subsidy system is likely to remain in the longer term.

Greenland was formerly the world’s main source of natural cryolite, a mineral used in the manufacture of aluminium, but by the late 1980s, reserves at the Ivittuut mine were exhausted. Deposits of coal, iron ore, lead, zinc, silver, molybdenum, diamonds, gold, platinum, niobium, tantalite, olivine, graphite and uranium are known to exist and there are prospects for hydrocarbon resources. Lead, zinc, silver, gold, coal, graphite, olivine and other minerals have been exploited in the past. Olivine is presently won at the Seqi mine at Seqinnersuusaq in west Greenland which is the only other mine operating at the moment in Greenland. In addition to the Nalunaq Mine, Angel Mining plc have obtained a mining licence to exploit the Black Angel Mine at Maarmorilik in West Greenland and plan to reopen the mine in 2010. These two mining operations will make a major contribution to Greenland economy for a number of years. Apart from the obvious direct financial contributions to the country’s revenues, the project will provide direct employment together with subsequent knock-on economic opportunities for the people and country both locally and nationally.
Greenland has a favourable economic environment for mining companies which includes the following attractive features:

- No royalties to pay;
- Corporation Tax of 30%;
- Free depreciation;
- Indefinite loss carry forward;
- Dividends declared before tax;
- National Insurance charge of 0.8% of wages and salaries;
- Extendable exclusive mineral licences given for 5 year periods;
- Mining licences given for 30 years;
- Straight forward accounting rules; and
- Greenland levies no Value Added Tax (VAT).

**Geographical**

Greenland consists of an interior ice-covered plateau surrounded by a mountainous, generally ice-free, rim. The interior ice cap varies in thickness, measuring 3,000m in the centre of the island. Underneath the ice cover are the ancient rocks of the Greenland Shield, which is geologically related to the Canadian Shield. The greatest heights of land are along the eastern coast, where the extreme elevation is Gunnbjørn Fjeld. Drainage is afforded mainly by the so-called ice fjords, in which glaciers from the ice caps pass through valleys to the sea, where they form thousands of icebergs each year. The climate is extremely cold, but during the short summer in the south the mean temperature is 9°C. The mammals of Greenland are more American than European, and include the musk-ox, wolf, lemming, and reindeer.

The continental ice sheet which occupies most of the centre of Greenland retreated from the Kirkespir Valley several thousand years ago. Consequently the terrain is dominated by geologically young glacial landforms. These have been augmented by immediate postglacial processes such as the formation of talus (scree). Modification by processes of the present sub-arctic climatic regime is taking place, predominantly fluvial and mass wasting. The valley floor now contains a braided river whose alluvium gives a flat base to the
valley. There are numerous active slope processes such as debris flows and probable continued movement of rock glaciers. Frost shattering is continuing but probably at a lower rate than in the immediate post glacial period.

Climate

The Greenlandic climate is arctic to sub-arctic with cool summers and very cold winters. Mean temperatures do not exceed 10°C in the warmest summer months. In the southern part of the country and the innermost parts of the long fjords, the temperature can, however, rise to more than 20°C in June, July or August. The sea around Greenland affects the climate on the land. The stretches of coastline close to the open sea, in particular, are cooled by the sea. Therefore, during the summer months it is warmest and driest in the middle of the country, which lies closest to the ice sheet. In all parts of the country the weather is locally changeable and can vary from fjord to fjord and from one valley to the next. The air is generally very dry in Greenland in relation to many other countries, and because of this low humidity the low temperatures do not feel as cold as might be expected. Many days are completely calm with calm seas and glassy fjords and lakes. However, the wind can pick up and certain areas can experience so-called föhn winds, which are often preceded by lens-shaped clouds and are usually warm from the southeast and which can be very strong with gusts of more than 50 m/s, usually followed by precipitation. During the winter the wind can increase the effect of the cold with a high wind chill factor. Greenland is not completely devoid of rain, but heavy rain is rare. Rainfall levels are generally a little higher in the south than in the north. For example, Nanortalik has an average of 900mm of rain a year, whilst Upernavik in the north averages just 200mm of rain a year. In fact there is less rainfall in Northeast Greenland than in the Sahara, and thus the expression “the Arctic desert” has arisen. Quantities of snow also vary locally, but it is not unusual to see large amounts of snow in many towns from December to March.

Temperatures in Greenland

The temperature in Greenland is highly dependent on location and season. The mean temperature remains below +10°C in June, July and August in just about every town in Greenland, whilst all places are below freezing from
November through to April. The winter is particularly cold in the very north of Greenland, for example in Upernavik, where the thermometer shows an average of \(-20^\circ\text{C} (-4^\circ\text{F})\) in February.

**Greenlandic Mean Temperatures**

There can be large fluctuations in mean temperatures from day to day; for example in the summer months there are several places in Greenland where day temperatures can exceed 20°C. In Qaqortoq in South Greenland the winter is mild with \(-5.5^\circ\text{C}\) as the coldest mean temperature, whilst the mean temperature remains above freezing from May to October. In Kangerlussuaq on the Arctic Circle it is cold during winter with a mean temperature as low as \(-22^\circ\text{C}\), yet during the summer it is among the warmest places in Greenland with mean temperatures of around +11°C in July.

**Climate at Nalunaq**

The climate at Nalunaq tends to show an average annual temperature just above 1°C, with July the warmest month at 10°C and February the coldest at \(-9^\circ\text{C}\). Daily maxima and minima may be considerably higher or lower than this respectively. The two dominant wind directions are north and south each representing around 20 - 25% of the time. This is due to the funnelling effect of the north-south orientated Kirkespir Valley. Calm conditions occur around 20% of the time. A mountain valley phenomenon, whereby differential warming of air masses causes winds to blow down the valley sides, may give rise to strong gusts possibly originating from all directions. The dominant persistent local wind system is the katabatic system generated by the Greenland icecap, in which the density difference between cold, dense air at the top of the icecap and the warmer, lighter air at sea level drives a downward flow of air through the fjords. The temperature of this air will increase as it descends to sea level because of the greater pressure there under the Föhн effect. If the incoming air has warmed to the temperature of the air already present, then minimal outflow occurs. However, if the air coming off the icecap is still cooler and denser than that over the fjord, strong outflows can develop. The mine site is generally windier than Nanortalik, although the wind direction at Nanortalik is more variable. Precipitation at the mine is almost double that of the town, with slightly lower air temperatures.
Conditions at the Nalunaq Harbour Facility

Saqqaa Fjord is physically similar to many coastal fjords in Greenland and other parts of Northern Europe. It varies between 2.5 and 4km wide and is about 45km long, covering an area of some 160km². The average depth of the fjord is about 140m. The fjord is subject to strong winds, which originate in the open ocean or from the katabatic system associated with the Greenland ice-cap. In general, winds are strongest in the winter and are strongly directional, north and south, blowing up or down the fjord. The offshore winds can significantly affect the movement of sea ice and polar ice, carried to the mouth of the fjord by the cold East Greenland Current. This can create ice-bound conditions around the mouth of the fjord at Nanortalik and the winds can also drive larger ice-bergs up the fjord as far as the mouth of Kirkespir River. Tidal flows within the fjord are strongly diurnal and relatively large with a tidal range of about 3.6 m. The sea is usually ice free so that year-round shipment of supplies and consumables is possible.

Population and Demographics

The following information has been drawn from a number of sources including www.stat.gl, The CIA World Factbook, United Nations Statistics Division, IndexMundi and Greenland in Figures.

Nationality:
- Noun: Greenlander(s)
- Adjective: Greenlandic

Languages: Greenlandic (Kalaallisut - East Inuit language), Danish, English

Greenland has a population of 56,194 (at 1st January 2009), (53% male and 47% female) of whom 89% (January 2009 est.) are Inuit and the remaining

---

9 http://www.indexmundi.com, IndexMundi, Miguel Barrientos, New York, NY, USA. 2009
11% are mainly Danish, together with other nationals. The majority of the population is Evangelical Lutheran. Most Greenlanders live along the fjords in the south-west of the main island, which has a relatively mild climate. In 2007, 13,482 Greenlanders were living in Denmark.

Settlement and Occupations

15,105 people which represents 27% of Greenland’s total population live in the capital Nuuk. The other main Greenland towns are:

- Sisimiut Pop. 5,458
- Ilulissat Pop. 4,528
- Qaqortoq Pop. 3,304
- Aasiaat Pop. 2,948
- Maniitsoq Pop. 2,780
- Ammassalik (Tasiilaq) Pop. 1,893
- Paamiut Pop. 1,679
- Narsaq Pop. 1,627
- Nanortalik Pop. 1,430
- Uummannaq Pop. 1,296
- Qasigiannguit Pop. 1,142
- Upernavik Pop. 1,157

The age structure of the population is (at 1st January 2009):
- 0-18 years: 28% (male 7,950; female 7,700)
- 18-60 years: 61% (male 15,842; female 15,904)
- 60 years and over: 11% (male 3,207; female 2,781)

Median age (2009 est.)
- Total: 33.5 years
- Male: 34.9 years
- Female: 31.9 years

Population growth rate: 0.062% (2009 est.)
- Birth rate: 14.76 births/1,000 population (2009 est.)
- Death rate: 8.14 deaths/1,000 population (2009 est.)
- Net migration rate: -5.99 migrant(s)/1,000 population (2009 est.)
Urbanisation

- urban population: 84% of total population (2008)
- rate of urbanization: 0.9% annual rate of change (2005-10 est.)

Sex ratio (2009 est.):

- at birth: 1.05 male(s)/female
- under 15 years: 1.03 male(s)/female
- 15-64 years: 1.16 male(s)/female
- 65 years and over: 1.01 male(s)/female
- total population: 1.12 male(s)/female (2009 est.)
- Infant mortality rate: 10.72 deaths/1,000 live births

Life expectancy at birth (2009 est.):

- total population: 70.07 years
- male: 67.44 years
- female: 72.85 years

Total fertility rate: 2.19 children born/woman (2009 est.)

Employment

- Unemployment Rate 9.3% (2005 est)

Literacy

- Definition: Age 15 and over can read and write
- Total Population: 100%
- Male: 100%
- Female: 100%

Nalunaq Gold Mine is situated within the area of the former Municipality of Nanortalik which, following the recent administrative reorganisation of local government, now forms part of the Kommune Kujalleq. Kommune Kujalleq is smallest municipality in Greenland by area at 32,000 sq. km and is located at the southernmost end of the island of Greenland. It is bordered to the north by Kommuneqarfik Sermersooq which includes Nuuk. The waters of the western coast are that of the Labrador Sea, which meet the open North
Atlantic at the southern cape. The entire municipal area is highly mountainous, with numerous fjords carving deeply into the land. The three main towns of the Kommune are Qaqortoq, Narsaq and Nanortalik which contain the three major Kommune administration offices. The population of Kommune Kujalleq (at 1\textsuperscript{st} January 2009) comprised a total of 7,632 people with 3,532 in Qaqortoq, 1,953 in Narsaq and 1,777 in Nanortalik.

Nalunaq Mine lies within the old area of the Municipality of Nanortalik and Nanortalik is the nearest town. Nanortalik is the tenth largest town in Greenland and also its most southerly, being located in a scenic area consisting of picturesque fjords, small woodlands and steep mountainsides, about 100 km north of Uummannarsuaq, or Cape Farewell, the southern tip of Greenland. There are a number of smaller settlements in the Nanortalik area of which the more important are Aappilattoq, Narsaq Kujalleq (Narsarmijit), Tasiusaq, Ammassivik, and Alluitsup paa together with others with less than 20 inhabitants each. The primary occupations are fishing, service and administration. The district around Nanortalik is home to 2,200 people distributed between the town itself, five settlements and a number of sheep-holding stations.

Nanortalik has little productive trade. There are no factories and no large-scale fishing activities. Small-scale fishing, crab fishing, seal and seabird hunting and tourism provide most of the locally produced revenue. The Nalunaq Gold Mine has been a major employer since it opened. Many years ago, between 1915 – 1925, a graphite mine operated some 20 km from the town at Amitsoq. The town has extremely good harbour facilities with several industrial trade quays. The main harbour is home to a number of small fishing boats and there is a marina type harbour in the old town which provides moorings for a number of private craft which are used for transport, fishing, hunting and recreational purposes. The town exhibits a slightly run down outlook but has an attractive character and charm. Shops are limited but comprise two large and several smaller supermarkets, domestic and electrical goods, clothing and smaller general shops and cafes. A small market (Kalaaliavaq) takes place daily at the harbour side selling line-caught fish and other traditional local produce. The town’s only Hotel, the Kap Farvel, is modern and attractive and there are several other visitor accommodation options including youth hostel and apartments. Nanortalik is
served by scheduled helicopter services through Air Greenland which use the Nanortalik Heliport. These services currently link Nanortalik with the towns of Qaqortoq, Narsaq, the settlement of Alluitsup paa and the international airport at Narsarsuaq, which also lies within the Kommune Kujalleq. Narsarsuaq give connections to Nuuk and the rest of Greenland and also to Copenhagen. Other international connections to Iceland and by scheduled flights are seasonally available from Narsarsuaq and the other international airport at Kangerlussuaq north of Nuuk. No local fixed wing aircraft capability exists at Nanortalik or elsewhere in the Kommune Kujalleq, apart from Narsarsuaq, although the Kommune has plans to develop a conventional small airport at Qaqortoq. Nanortalik is not a port of call for the Arctic Umiaq Line coastal ship, which does however serve Qaqortoq all the year round and Narsaq and Narsarsuaq in the summer only.

In addition to the well-preserved old quarter, Nanortalik boasts a characteristic wooden church from 1916 and an open-air museum consisting of several buildings. The name Nanortalik means “place of polar bears”.

6 Geological Setting

The geology of SW Greenland is dominated by the Ketilidian Mobile Belt, which forms a Paleoproterozoic continental accretion to the Achaean core of south Greenland. The Julianehaab granite forms a Cordillera-type marginal batholith complex to the north, whereas the south is composed of flat-lying migmatitic metasediments termed the Psammite Zone. The gold mineralisation is hosted in the Psammite Zone, which include enclaves of epiclastic molasse sediments from the Cordilleran Mobile Belt, found in graben-like structures in the Nanortalik peninsula, and large areas of high-grade micaceous migmatites, with several generations of late and post-orogenic granites. Gold mineralisation occurred after the peak regional metamorphism (between 1850-1750 million years ago), which transformed the host metabasic rocks, mostly pillow lavas and dolerite sills, into black amphibolites with a well-developed foliation fabric. This metamorphism clearly predates the gold mineralisation as its associated alteration fabric crosscuts the amphibolite fabric. The gold mineralisation is spatially associated with a pronounced calc-silicate alteration selvage and clearly
developed in equilibrium with the calc-silicate alteration within the rest of the metabasic package. Several generations of aplite dykes, which cross cut and offset the mineralisation, provide good constraints on the timing of the gold mineralising event. The metabasic nappes in the Nanortalik district were invaded by granite batholiths towards the end of this metamorphic event, which separated the possibly once inter-connected nappe sheets. A pronounced marker horizon, consisting of a thick massive-sulphide graphite-chert sequence at the base of the metabasic package, is found at Nalunaq and also in Ippatit (Lake-410), as well as at the Kangerluluk occurrence on the SE Coast of Greenland, suggesting that this stratigraphy has a wide lateral extent.

**Geology of the Nalunaq Area**

The gold mineralisation at Nalunaq is hosted in a package of metabasic rocks including metadolerites and fine-grained amphibolites, and is often spatially related to the contact between these. The metabasic complex is underlain and partially intruded by granites to the south, whereas to the north it is underlain by meta-arkoses (molasse sediments). The granites comprise several generations of medium-grained calc-alkaline granite to porphyritic alkali feldspar granite, which intruded the metabasic rock package during the waning stages of the orogeny. Aplite dykes cross cut the metabasic rocks in several major directions. These dykes are believed to be associated with and derived from the granites.

The metabasic rock sequence consists of a lower unit of micaceous schists, presumably metapelites interbedded with calcareous units including thin marbles. The full thickness of this unit is unknown as it is tectonically bordered against the underlying meta-arkoses. This mica-schist sequence is overlain by a thick package of chemical sediments, most notably interbedded graphitic schists and thick pyritic cherts. Massive sulphide horizons up to 20-30 m thick occur at several horizons within this package.

Overlying the sulphidic graphite–chert sequence is a thick metabasic rock sequence, which forms the bulk of the Nalunaq sequence. This package is in excess of 400 m thick and includes fine-grained amphibolite, medium-grained tuffs and metadolerites. The metabasic rocks pass into a sequence of
volcanoclastics and ash tuffs. These units occur in a thin slice on the Nalunaq Mountain and in the valley floor towards the east. The top of the sequence in the Nalunaq area is a series of volcanic agglomerates and conglomerates, which show clear evidence of being water lain. The conglomerates occur in the eastern slopes of the main valley, towards the Kirkespiret Mountain.

The main lithologies associated with the gold mineralisation at Nalunaq are as follows:

- **Fine-Grained Amphibolite: Metabasalt**
  This is the predominant rock at Nalunaq, and is a dark green to black, fine-grained amphibolite with occasional relict pillow structures. It has a grain size of <0.5 mm and consists of hornblende, (clino-pyroxene) and oligoclase, with minor amounts of quartz, biotite and calcite. Sulphides are mainly pyrrhotite and pyrite with minor chalcopyrite. Biotite-rich layers within these rocks are interpreted as inter-pillow sediments and the possible products of secondary potassic alteration.

- **Medium-Grained Amphibolite: Metadolerite**
  This is a coarser grained dark green to black amphibolite with grain size varying from 1-3 mm, and is found interbedded with the fine-grained amphibolites. The major minerals are amphibole and plagioclase with minor pyroxene and sericite.

- **Aplites**
  Aplite dykes occur abundantly on the surface, criss-crossing the mountain, following both flat-lying and steep orientations. The aplites are usually fine to medium grained and composed mainly of quartz and feldspar, with subordinate biotite, which gives a ‘peppered’ appearance.

- **Pegmatites**
  These are coarser grained felsic dykes, which have a very similar mineralogy to the aplites.

**Ore Deposit**

The gold mineralisation at Nalunaq is a mesothermal vein-type gold deposit, hosted in amphibolite-facies metabasic rocks. The gold is associated with sheeted quartz veins, hosted in a large-scale shear structure, which appears to relate to regional thrusts. However, possibly due to extensive post-
mineralisation deformation there is no direct relationship between gold grade and amount of quartz. The veins consist of equigranular, white to grey quartz with stripes and bands of diopside and anorthite. Locally in the lower portion of the developed area, garnet and calcite are also found along with pink k-feldspars. Sulphides are rare and only traces of pyrite and pyrrhotite are seen. Within the contact rock minor arsenopyrite (FeAsS2) and lollingite (FeAs2) are present.

The quartz is medium to fine grained and clearly shows several generations of crystallisation and recrystallisation. Gold often forms small isolated grains measuring from 3 mm to sub-micrometre (ìm) size. The typical gold grains measure 100-200ìm and occur largely as separate grains. A particularly fine-grained gold is seen in many parts of the vein. This has a very fine spongy texture with a homogeneous distribution, and its very large surface area is amenable to leaching. Where the spongy gold appears it constitutes a significant portion of the available gold.

7 History of Mining at Nalunaq

Timeline of Mining at Nalunaq

The time-line of mining activity through the proposed restart of operations and shipment of the first doré and up to installation of the CIP process and full production from the mine is given below.

- Deposit discovered in 1992;
- Extensive geological investigations were carried out including a total of 4,600 m of tunnelling and 15 km of diamond drilling.
- Feasibility study and an Environmental Impact Assessment submitted.
- Mining commenced on July 1st 1994 by Nalunaq I/S, which was initially a joint venture between the state owned mining company Nuna Minerals and the Canadian mining company Crew Development Corporation but which became 100% owned by Crew Gold;
- Nalunaq placed on care and maintenance on September 30, 2008 on the basis of the Crew’s perception of the uneconomic nature of the resource;
• Crew concluded the sale of Nalunaq Gold Mine including all the assets, infrastructure, inventories and goodwill to Angel Mining plc, the effective date being 1\textsuperscript{st} July 2009;
• Completion of licensing and statutory requirements with BMP by Angel Mining(Gold) A/S – December 2009;
• Reopening of the mine and refurbishment of the operation – July 2010;
• Production of gold doré bullion – January 2010;
• First shipment of gold doré bullion – January 2010; and
• Provision of CIP plant process – March 2010.

Mining and Processing History of the Crew Operation

During the operations of Crew Gold, Nalunaq posed considerable challenges due to the simple, yet difficult, geometry of the Main vein. The most challenging factors included a narrow vein width of 0.7 meters and a 30° - 40° degree dip. The narrow width called for a high degree of drilling and blasting accuracy to prevent dilution and also required additional rock handling activities to ensure all the ore was successfully transferred to the bottom of the stope for mucking and cleaning. The preferred mining method was long-hole mining, which comprised drifting horizontally along the strike at 11m vertical spacing, resulting in ore blocks of about 14m - 16m length on dip. The ore drifts were either mined as a whole face or in two cuts separating the ore and the waste. This block was then subdivided into 14m wide stopes between 1.5m rib pillars. Each block was opened with a short raise along one pillar and then blasted using long blast holes drilled either from the top or the bottom. Following stoping and removal of the ore, the stope was cleaned of any residual fine ore, some of which was at high grade. Development waste from the ramp and the waste from the mining method was placed to external surface dump. Initially waste rock was used to build and expand the portal areas, as fill for laydown areas or as a base for ore stockpiles. A waste rock dump was created on the valley side from the 350 m level entry, extending up the valley.

Due to the review of resources during 2008 and because there was only a single ramp access area with limited strike length, the rate of mining was not expected to exceed 300 tonnes per day (tpd). With the cost structure and camp infrastructure in place, it was decided that the operation would not be
profitable at current gold prices. This resulted in a decision to suspend operations and move to care and maintenance with a view to seeking a suitable buyer.

The Crew Nalunaq operation had no processing facility on site. During the first years of operation, ore from Nalunaq was processed at the El Valle plant of Rio Narcea Gold Mines Ltd in Spain. In October 2006, Crew acquired the Nugget Pond processing plant in Newfoundland, Canada. Following refurbishment of the plant, ore shipments to Nugget Pond commenced in February 2007. During the Crew period of operation from mid-2004 until the end of 2008, the mine produced about 308,000 ounces of gold.

**Environmental and Compliance History of the Crew Operation**

Four main instances of non-compliance were highlighted during the various inspections taken by BMP during the period of Crew’s ownership and operation of the site. The first noted is the most serious.

- Major spillage of diesel fuel and oils at the generator and compressor station at the 350m level surface portal;
- Equipment disposed of underground was found to still contain hydraulic oil which should have been drained before equipment disposal. Two of the equipment cores found underground contained 45 to 90 litres of hydraulic oil each. This oil had to be removed. An instruction was given that more care must be taken in the future;
- BMP noted on occasion that the bunding around fuel tanks contained a quantity of water, presumably from precipitation, which compromised the capacity of the bunding to contain any extreme release of fuel from the tanks; and
- There were some instances noted of the poor operation of the sewage treatment system which may have allowed some polluted discharge into the river.

**Pollution from the Previous Operations**

The first of these above can be seen as a serious incident which was highlighted on several occasions by BMP, the latest in late 2008 and resulted
in written enforcement action being taken by BMP. However, the remaining visual evidence, at the 350m level compressor station of spilled fuel, and which has been identified in AMG’s initial surveys, shows that the necessary and appropriate clean up action was never taken by the Crew management. AMG has already begun the clean up process with the intention that this area of contaminated ground will be excavated and dealt with appropriately as part of their overall up-grade of the mine.

The NERI Environmental Monitoring Reports for the operation for 2006, 2007 and 2008\textsuperscript{11} give a comprehensive picture of the effects of the operation.

To summarise these above noted NERI reports, elevated concentrations of copper, chromium, arsenic and cobalt above natural background levels have been identified found in lichens at the waste rock dump and in the camp area. All metal concentrations showed a significant decrease with increasing distance from the road with elevated concentrations found to a distance of about 1000 m from the road. No elevated concentrations were found in mussels and sculpins in the marine environment near the harbour, while seaweed had slightly elevated concentrations locally. The impact from the mine was primarily on the Kirkespir Valley and originated from dust dispersal. The impact in the marine environment was very low and appears to have stabilised around the baseline level. Arctic char livers showed no elevation in metal concentrations.

**Other Mining in Greenland**

The following have been the major mines in Greenland with their operational periods:

<table>
<thead>
<tr>
<th>Mine</th>
<th>Minerals</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivittuut</td>
<td>Cryolite</td>
<td>1854-1987</td>
</tr>
<tr>
<td>Mestersvig</td>
<td>Lead, zinc</td>
<td>1956-1963</td>
</tr>
<tr>
<td>Maarmorilik</td>
<td>Lead, zinc, silver</td>
<td>1973-1990 (Black Angel Mine)</td>
</tr>
<tr>
<td>Nalunaq</td>
<td>Gold</td>
<td>2004-2008</td>
</tr>
</tbody>
</table>

\textsuperscript{11} NERI Reports 614, 662 and 698
There are also a number of other smaller former mining sites where various minerals including coal, marble, graphite and other materials have been mined or quarried.

The minerals sector is probably the sector that is showing the most tangible signs today of being a growth sector in the country. The present heightened interest levels in exploration for minerals in Greenland has resulted in the identification of potential economic mining opportunities at several locations.

There is currently one active mining operation in Greenland at the Seqi Olivine Mine at Maniitsoq Municipality.

Greenland might become home to up to five new mines over the next years. In addition to the re-opening of Angel Mining plc Black Angel Mine at Maarmorilik and the Nalunaq Gold Mine which is the subject of this study, these include a very large molybdenum mine in East Greenland, ruby mining at Fiskernæsset, south of Nuuk, a eudialyte mine at Narsaq, and a diamond mine in the region between Kangerlussuaq and Nuuk. In addition to these, there are potential new mining projects to extract gold, palladium, platinum, niobium, tantalum, zinc, rare earths, coal and others.

A full list of all the exploration and exploitation licences presently extant in Greenland is available from BMP.\textsuperscript{12}

8 Hours of Operation and Manpower

Manpower

It is anticipated that the mine will employ approximately 80 people. Because of the relative remoteness of the location, personnel will live at the Nalunaq mine camp base during their work period. A maximum of around 60 people will live on site at any time. The personnel will be employed on a rolling shift system including day and night shifts which will also make allowance for

rotation away from the site and travel back home. The shift pattern and working periods and the rotation periods for on and off site have not yet been fully finalised. However, the proposed on/off site rotation system is:

- Locally based personnel: 2 weeks on + 1 week off
- Expatriates: 6 weeks on + 3 weeks off

Employment at the operation, including the mine and the underground process plant, will not be gender specific. Welfare facilities for both sexes will be equally available at the Nalunaq camp.

Hours of Operation

The mine will operate on a 24 hours per day and 7 days per week basis.

9 Background to the EIA

Background to the Environmental Impact Assessment (EIA)

As noted in Chapter 1, the Environmental Impact Assessment (EIA) is used to evaluate the potential impacts on the environment and the community, of proposed developments and its overall aim as part of a feasibility study is to minimise negative impacts. The EIA can also help the financial institutions and statutory government regulatory bodies to evaluate the environmental and social effects of a project.

The ESIA can be utilised by the developer to aid a feasibility study, by highlighting possible environmental or social problems or risks, which can then taken account of in the projects design. The EIA can be used to show that the mine has been designed in a sustainable manner, with appropriate control and mitigation measures incorporated from the outset.

Consultation with the local community is a major component of the EIA and separate SIA in order to ensure that the project design and plan of operation
takes account of the views and wishes of the local community. Consultation with the relevant statutory authorities is also undertaken.

The EIA will consider both the positive and negative effects of the project, together with the residual effects, after proposed mitigation measures have been taken into account.

**Summary of Previous Environmental Work**

As noted in Chapter 9 there is a good deal of published data, analysis and research available dealing with the operations of Crew’s operations at Nalunaq and the environmental and pollution impacts and effects consequential to the methods of operation and processing. NERI have carried out a great amount of testing and analysis of environmental conditions from 1973 until the present day and considerable data from the previous operation on the effects on the local flora, particularly the lichens, together with the marine environment at the harbour site has been gathered.

**Agreements as to Work Required and not Required**

No agreements have been reached with BMP as to work specifically required or not required.

**Requirements for ESIA**

BMP has prepared guidelines setting out their requirements for the preparation of an Environmental Impact Assessment (EIA)\(^\text{13}\) which form the basis of the layout and the content of this EIA. BMP have also now published similar guidelines for the preparation of Guidelines for Social Impact Assessments for Mineral Projects in Greenland\(^\text{14}\). The SIA, produced under these guidelines forms a separate report submitted by AMG to the BMP in November 2009.


10 Consequences and Alternatives

Objectives of the Project

The main objective of the NGM project is the rehabilitation and re-opening of the existing Nalunaq mine and the profitable and environmentally sound exploitation of the remaining mineral resources available within the licence area. It is AMG’s intention that the disturbed area will be restored and left in good order following the final closure of the operation at exhaustion. It is anticipated that the first gold doré will be shipped from the mine in January 2010 (approvals permitting).

Longer Term Objectives

It is AMG’s intention to maximise the recovery of the local mineral resource and, as part of this, further exploration will be undertaken in the vicinity of the deposit within the presently licensed area in order to discover any further economic mineralisations and deposits.

Advantages and Disadvantages

Regional

Advantages:
- Continued exploitation of natural local mineral resource;
- Continued contribution to local economy;
- Continued local employment in full time, skilled, well paid, long term, non-seasonal work;
- Continued upturn in average personal economic activity;
- Continued use of an otherwise derelict brownfield site;
- Widens local economic base;
- Improvement of local skills base through training and employment;
- Lowering of local unemployment levels;
- Increase in local population;
- Consequential increases in local services;
- Improved transport links;
• Induced and indirect employment and economic opportunities;
• Heightened impact of Kommune Kujalleq in National scene;
• Opportunity for improved tourism trade; and
• Commitment of AMG to promote and maintain traditional Kalaallit Inuit way of life.

Disadvantages:
• Depletion of natural local resource;
• Possibilities of adverse environmental impacts arising from the works;
• Possible polarisation of well paid and poorly paid inhabitants;
• Possible effects of influx of workers from other parts of Greenland or overseas;

National

Advantages:
• Continued exploitation of natural mineral resource;
• Continued contribution to national economy;
• Continued contribution to GDP;
• Continued employment in full time, skilled, well paid, long term, non-seasonal work;
• Continued upturn in average personal economic activity;
• Continued use of a otherwise derelict brownfield site
• Widens national economic base;
• Improvement of national workforce skills base through training and employment;
• Lowering of national unemployment levels;
• Opportunity for improved tourism trade;
• Commitment of AMG to promote and maintain traditional Kalaallit Inuit way of life;
• Improved national transport links;
• Politically valuable project
Disadvantages:
- Depletion of natural resource;
- Possibilities of adverse environmental impacts arising from the works;
- Possible polarisation of well paid and poorly paid inhabitants;
- Possible effects of influx of workers from overseas;
- Possible perceived increase in pressure on traditional Kalaallit Inuit way of life;

International

Advantages:
- Increased awareness of Greenland as minerals source;
- Heightened profile and awareness of Greenland as a player in the international political and economic markets;
- Increase in international interest in Greenland;
- Continued use of otherwise derelict brownfield site, and commitment to eventual rehabilitation in a internationally spot-lit region;
- Opportunity for improved tourism trade;
- Highlights Greenland’s commitment to maintain traditional values and Kalaallit Inuit way of life;
- Highlights Greenland’s independence;
- Raise awareness of Greenland as good place to develop minerals interests;
- Heightened profile of Greenland in international mining scene;
- Home of a modern and innovative top-class mine project;

Disadvantages:
- May attract excessive minerals and petroleum/gas exploration;
- Possible pressure group criticism due to allowing continued development in the Arctic;
**Consequences of Project not taking place**

If the project does not go ahead under Angel Mining plc’s proposals this gold resource will not be exploited in the short to medium term. In this case the mine site and the mine workings will be abandoned and will become either derelict or restored under the terms of the rehabilitation bonding. In the latter case, very major investment will be required to redevelop and reopen the resource for exploitation in the future. In either case the economic and other benefits, which would otherwise accrue to the Nation of Greenland, and the Kommune due to its exploitation, would not become available for some considerable time or may be lost completely. Thus the national and municipal economy will not be able to accrue the advantages provided by the exploitation of a major national resource. The company’s proposals are well founded and use modern, effective, efficient and environmentally sound methods and principles. If this project does not proceed, it is possible that another company might eventually consider attempting to progress alternative proposals in due course, although as noted above this would be at a much increased cost. A further knock-on effect if Nalunaq is not approved to go ahead will be the possible delay in the establishment of the company’s Black Angel Mine at Maarmorilik near Uummannaq. If Black Angel does not go ahead in a timeous fashion, a major contribution to the Greenland economy may be withheld and potentially, fatally delayed.

**Alternative Opportunities**

Whilst Angel Mining plc have another mining interest in Greenland in the Black Angel lead and zinc mine at Maarmorilik, which is expected to start production in 2010, AMG consider that the operation and exploitation of Nalunaq gold mine, with its opportunity to resume early production in October 2009 and the financial benefits which this will provide to AMG, will be very beneficial to the start-up requirements of the large Black Angel Mine. The Black Angel Mine is Angel Mining plc’s main long term business opportunity at this time. Whilst Angel Mining have ambitions to open minerals projects elsewhere in Greenland in addition to Black Angel and Nalunaq, there is no viable alternative opportunity available to AMG at the present time.
11 Exploration and Feasibility

Present Position

The greatest risk to the project comes from the low level of resource delineation which prevails. NGM concentrated on production of ore without carrying out any work to replace resources as reserves have been mined. This has resulted in no proven reserves with the postulated resource based on good geological evidence but not by firm drilling or exploration data. By reference to the NGM Resources/Reserves Report for the end of 2008 it can be seen that 570,000 tonnes of inferred resources are present at a cut-off grade of 15g/t (rather than the 11g/t proposed by AMG) together with 45,000 tonnes of indicated resources at 10g/t some of which have been depleted by subsequent NGM operations. Due to the nuggety nature of the deposit and the form of the gold bearing reef, resource delineation by drilling is not a competent method, except to prove structure. Grade must be proved by underground development headings with regular sampling of the ore body. Grade can change markedly over short distances. The NGM geologists have identified three target areas with various pros and cons. AMG will develop the operation with reference to grades proven by their underground developments but will initially win ore from existing stopes and pillars while development drivages into fresh resources are under way. It is believed that advance development is crucial to the provision of resource delineation data and to maintain the overall resource. The greatest risk is that sufficient proven reserves are not timeously identified.

Historical Reserves Information

SRK Report 2002

The SRK report of 2002, written before initial development of the deposit, provided the following information.

The Mineral Deposit

The gold mineralization occurs in quartz veins which vary in thickness from 0.5m to 7.0m, in the Nalunaq Mountain on the north side of the Kirkespir
Valley. The host rocks are calc-silicate altered meta-volcanics. The main gold mineralisation is associated with what is known as the Main Vein, which is a remarkably consistent shear zone extending for about 2,000m on the surface, and showing a well-defined orientation and exceptional continuity. The structure constitutes a regular sheet with overall strike of 45°-50° and overall dip of 36° that appears to continue through the mountain. On the local scale, the structure undulates somewhat, and dips measured in the face of the adits vary between 22° and 45°.

The Main Vein is separated from the subsidiary South Vein by the Pegmatite Fault, a normal fault with vertical offset of 60 m. Four minor faults have been recognised, cutting the Main Vein. They vary in orientation and dip and offset the Main Vein by tens of centimetres to tens of metres. Systematic drilling and outcrop sampling has confirmed the continuation of the mineralised sheet both towards depth, below the outcrops, and up to 600 m into the mountain along strike.

The mineralisation is spatially associated with quartz, which almost universally occupies the central portion of the shear zone. The presence of quartz veins is the single most important component of the gold mineralisation and occurs principally as sheeted veins with stripes and bands of included calc-silicates and feldspars. Despite the mineralised shear-zone being a well-defined and continuous feature, the veins within it are complex. The Main Vein is a composite structure with multiple quartz veins, tectonically introduced slivers of the host rock, pinched or boudinaged veins, and internal and external folds. The veins may occupy discrete shears, which coalesce to form stacked veins or die out along strike.

**Gold distribution**

Systematic sampling of the vein underground has shown the gold grade is subject to a high nugget effect. Despite this, a grade-zonation is clearly identifiable with high-grade segments running approximately E-W throughout the mine area. The high-grade sector is characterised by a well-developed Main Vein structure, with a thick or continuous quartz vein or multiple veins, and relatively abundant visible gold. There is a general trend towards lower grades in the lower sections of the workings. Exceptionally high-grade vein
segments are found in a number of locations. The high-grade segments are characterised by abundant visible gold, often as small flakes and grains concentrated in narrow bands (of a few tens of millimetres) within the sheeted quartz vein and often, but not exclusively, associated with stripes of calc-silicates. The gold is predominantly “needle point” grains of 100-200 microns diameter, a size distribution which gives excellent recovery in gravity circuits. Studies have suggested that the gold precipitated at the solid contact of open fractures which now host the quartz veins, and that most quartz was filled in later. The sheeted appearance may have formed during subsequent contact-parallel crack-and-seal events in a discontinuous shear motion.

**Crew Corporation Report 2007**

A Crew report of 2007 provided the following information.

**Historical information**

In April 2007, Crew Gold released an updated ore reserve and resource statement for Nalunaq. The effective date for the data was December 31, 2006. The 2006 surface drilling program, combined with new underground development, provided the basis for updating of resources and the first reporting of ore reserves for this operation. The majority of resources at NGM are classified as inferred, due to the narrow vein, nuggetty nature of the deposit, where drilling on its own does not provide reliable grade estimation. Measured and indicated resources are only defined after underground drifting on structure and detailed sampling have been completed.

Total inferred resources were estimated at 1.5 million tonnes at approximately 17 g/t (diluted to 1.5 m assumed mining width and zero cut-off grade) containing approximately 823,000 ounces gold. Inferred resources are defined on the basis of a potentially mineralized area, defined by regular drilling intercepts, and excluding areas where more closely spaced sampling and underground development has allowed for classification of indicated resources. All inferred resources have been subject to reduction by assuming 40-50% payability within the areas defined by drilling intercepts and surface sampling. The grade is assumed to be similar to the average of previously
recovered ore, within a range of 16-21 g/t, as the drill intercepts appear to show a similar level of variability as the earlier resources.

Indicated resources were estimated at 535,000 tonnes at 18 g/t for approximately 315,000 of ounces gold and are based on data derived from underground drifting and systematic sampling at 1-3 m intervals. Indicated resources have a payability factor of 80% recoverable, in line with previous production performance. A total of 5,000 meters of on-vein development has been completed in strike drives and raises within the Main Vein structure. A total of 2,440 channel and chip samples were collected during the exploration stages and a further 3,400 chip samples were taken in the faces of strike drives and slot raises after production commenced in 2004.

The most significant difference to previous estimates is that Indicated Resources are now included from the Upper Block. This is due to the fact that mining development has advanced into this area and therefore activated substantial indicated resources, which are based on continuous sampling along surface outcrops. In addition, a small contribution is added from underground development near the 500 m level. The South Block is slightly expanded due to new underground development while the Target Block shows a reduction of approximately 50,000 ounces, largely due to mining depletion.

Reserves (at 31.12.2006)

Probable reserves are a subset of indicated resources and are defined where stope layouts have been completed following sublevel drift and raise development. The design of stopes is based on closely spaced sampling and assignment of actual grades from at least three sides of individual blocks, using a cap of 300 g/t Au. Current probable ore reserves total 205,000 tonnes at 18.8 g/t Au for 124,000 ounces gold. A mining recovery factor of 84% has been applied for expected losses in pillars and other unrecoverable areas.
Crew Corporation Report 2008

A Crew review of 2008 provided the following information.

Ore resources at Nalunaq underwent review during 2008. It was found that the Mountain Block was the only mining area remaining where a reasonable degree of confidence could be had in the ore resource. The Mountain Block cannot be effectively drilled from the surface because of the difficult terrain.

12 NGM Operational Proposals

Introduction

Angel Mining plc [AMG] propose to utilise a different mining method compared to that employed by Crew and outlined in Chapter 7. Additionally AGM intend to carry out a mineral process route which will initially involve a gravity process, later complemented by a carbon in pulp leaching electro-winning system. The final product from both process routes will be in the form of gold doré bullion which will be shipped directly from the site for final refining. The target annual production rate will be almost 35,000 ounces of contained gold giving a saleable output of just under 30,000 ounces of Au. All the processing will take place underground at the mine within specially designed excavated caverns. No waste rock, processed waste and reject, nor chemical residues from the processing operation will leave the mine but will be utilised in a waste impoundment operation and replaced as backfill in the worked out stopes.

The Deposit

The Nalunaq deposit is a high-grade, gold-only mineralization associated with quartz-veins in a major shear zone. As a generic type, the deposit is a mesothermal vein-type gold mineralization, hosted in Proterozoic amphibolite-facies meta-volcanic rocks. Visible gold is found in sheeted quartz veins which are located in a large-scale shear structure that appears to be related to regional thrusting. However, possibly due to extensive post-mineralization
deformation, there is no simple relationship between the gold grade and amount of quartz at Nalunaq.

The most pronounced structure at Nalunaq is a narrow zone of ductile shearing surrounded by relatively brittle margins. The Main Vein itself is hosted in a one-to-two meter wide shear zone with a remarkably constant orientation. The regular sheet has an average strike of 45°-50° and an average dip of 36° SE, varying between 22° and 55°.

The presence of quartz is the single-most important factor for the gold occurrence and is found as sheeted veins with stripes and bands of included calc-silicates. The quartz veins vary from 0.05 meters to 1.8 meters in width and often display pinch and swell structure with clear evidence of both compressive and dilatational post-mineralization deformation.

Systematic sampling of the underground exposures of the vein has shown that distribution of gold grade is erratic in nature, due to a pronounced nugget effect. Despite this variation, a regular zonation in grade can seemingly be identified in a series of high-grade segments running approximately northeast-southwest throughout the mine area.

**Access and Infrastructure**

The existing infrastructure from the previous Crew operation remains in place at the mine and harbour sites. The mining camp consists of facilities to house and maintain 120 people together with workshops, warehousing and storage. Camp infrastructure also includes water plant, sewage plant, fire fighting station, telecoms station, electricity generation facilities, laboratory, fuel storage installation, weather station and helipad. Some of these facilities require repair and upgrade which AGM will undertake in the initial phase of the reopening process. The mine offices are also situated adjacent to the main camp. Water supply and sewage services are adequate but will be refurbished. The electricity power supply requires major upgrade and relocation to satisfy the increased power demand due to the provision of a full process plant. All services will need to be reviewed against the changed requirements of the operation and upgraded as necessary. The explosives
store is situated remotely, but adjacent to the mine and camp, providing adequate and appropriate facilities.

An existing 4m wide gravel road connects the mine site with the harbour facility at Saqqaa Fjord 10km distant. The road has no drainage ditches and is prone to rain damage resulting in frequent repairs. There are 2 bridges between the mine/camp and the harbour and one of them is prone to flooding. The road’s drainage system and the two bridges on the route require attention which will be undertaken as a priority. The road is characterised by a very steep gradients and heavy trucks and tankers struggle if there is ice or snow on the inclines. The maintenance requirements of the road have been identified as an ongoing high priority issue to ensure that road safety and associated environmental exigencies are controlled.

The existing harbour facilities comprise an ore stockpile, ship loader with a grizzly and a crusher, incoming supplies handling, the main fuel depot, ammonium nitrate storage and the ANFO mixing facility. All these facilities are in reasonable order. The ore stockpile will be cleared and trucked back to the mine for treatment. The ship loading facility will not be required and will be the possible subject of disposal to a third party. The other facilities form a major part of the mine’s infrastructure, with all supplies and consumables, including fuel requirements, being delivered to the mine via the harbour and the connecting road. All the handling facilities will be upgraded as required as an early priority. The fuel farm in particular is being thoroughly investigated and brought up to modern standards as required. Emergency procedures and protocols will be put in place to deal with spillages etc. The ANFO mixing facility, in due course, will be transferred to the mine itself and set up in accord with the legal requirements. It is proposed to retain the harbour facility after closure for the benefit of the community if required. It should also be possible for others to use the harbour for other purposes such as tourism during the life of the mine.

The infrastructure is at high risk from the often severe weather conditions of the region including heavy snow, strong winds, flooding, low temperatures and the potential for avalanches. Procedures will be put in place to deal with the risks perceived due to extreme weather conditions.
Mining Operations

Mining Method

The mining method proposed by AGM is based on inclined standard room-and-pillar working up-dip on a 20% slope with final rhomboid pillars of 1.6m by 5.7m which will result in less dilution and higher recovery of gold than the previous NGM method. The initial operations of the mine over the first 12-18 months will concentrate on the winning of ore readily available in the existing stopes, mining of remnant pillars and ore from development mining headings together with treatment of the ore from the harbour stockpile. It has been identified that a considerable amount of fines (-50µm) gold remains in all the worked out stopes as ore dust. This dust will be cleaned up and won by sweeping, ditting and wash down by hydraulic methods to maximise overall gold recovery. The AMG cut-off grade of 7g/t as against the NGM cut-off grade of 15g/t releases upwards of 20K tonnes of previously out of grade ore. Ore won from the remnant pillars is expected to have a grade of 13g/t. This initial ore allows early positive operational cash flow. Full stope mining will then commence as development accesses and proves the new mining areas.

Stope development will follow the following pattern:
- Development of the stope perimeter headings (Development Mining);
- Development drilling of the stope;
- Ore production from the stope (Production Mucking); and
- Backfilling of the worked out stope using waste rock from the mining and development operations.

All waste rock produced by the mining process and indeed from the process stream, including tailings, will be utilised in the system of backfilling the stopes. No waste of any sort will be removed from the mine.
Tailings/Backfill, Underground Water, Ventilation, and Geotechnical Design

Golder Paste Technology Europe Ltd (Golder PasteTec) have produced a comprehensive study\textsuperscript{15} for NGM (The PasteTec Report), dated 15th July 2009, of the tailings/backfill system, underground water, ventilation and geotechnical considerations.

Golder Paste Technology Europe Ltd Reports

Executive Summary

Angel Mining plc (AMG) are to undertake mining and mineral processing activity within the underground Nalunaq Gold Mine (NGM). The mineral processing, ore concentration, refinement, waste management and water management follows a different basis to that previously employed at NGM. The mineral processing operations will consist of two phases undertaken in the underground mine. The first phase is gravity based mineral processing circuit and the second (additional) phase is a cyanide based mineral processing circuit.

AMG intend to commence development based mining activity during the third quarter of 2009, installing the first phase of the processing circuit in the fourth quarter 2009. The second phase of the mineral processing circuit is planned for installation and subsequent commissioning in early 2010.

The mineral processing activity generates liquid and solid materials which have been identified and are described as process water with fines (tailings) from the mineral processing and dust/fumes associated with the mining and mineral processing.

Methodologies have been identified and preliminary design work undertaken to manage these waste materials produced. The aim being to minimise

potential impact on the underground and surface environment that result from the mineral processing operations in the NGM.

All process water and fines from the mineral processing circuit (tailings) will be placed in previously mined areas in NGM. This is analogous to the conventional placement of tailings as mine backfill in underground mining operations. This application provides an effective means to fill old excavations within the mine whilst minimising materials that need to leave the mine. The tailings will be placed in old stopes with engineering controls designed and built to provide an opportunity to drain water from the material over the medium term thereby leaving the solids component in place in the mined out stopes.

Underground mine water will be managed in a controlled fashion to minimise discharge from the mine and maximise recirculation and recycling of the water in the mining and mineral processing operations. Engineered systems have been delineated to provide for appropriate means to control, clean and transport underground mine water in the operations and where necessary to discharge. These engineered controls are designed to handle the natural water flows recorded as well as those underground mine waters associated with the tailings placement, mineral processing and other mining activity.

The ventilation system at NGM has adequate capacity to manage the airborne dust and fumes associated with the mining and mineral processing activity. The ventilation system requires minor modifications to fan locations and ducting to manage ventilation flows adequately and ensure fresh air is blown in and exhaust air blown out of working areas (including the mineral processing area). A dust collection facility is recommended for the first phase of the mineral processing circuit. The second phase processing requires additional instrumentation, controls and procedures to be implemented to mitigate concentrations of the fumes associated with the electro-winning and chemicals associated with the leaching in the confined areas, ensuring these are exhausting out of the general mine environment.
Introduction

Background

Angel Mining plc (AMG) is planning to undertake mining and mineral processing activity within the underground Nalunaq Gold Mine (NGM). The mineral processing operations will consist of two phases. The first phase will be gravity based mineral processing circuit and the second phase a cyanide based mineral processing circuit.

NGM intend to commence development based mining activity during the third quarter of 2009, installing the first phase of the processing circuit in the fourth quarter 2009. The gravity mineral processing circuit will be running for approximately three months before commissioning the second phase of the mineral processing circuit in 2010.

The mineral processing phases of activity generate liquid and solid materials which have been identified during the design of the mining and mineral processing system. Specifically these waste materials are described as:

- Process water with fines from the mineral processing (tailings); and
- Dust and fumes associated with the mining and mineral processing.

Methodologies have been identified and preliminary design work undertaken to manage these waste materials produced. The aim being to minimise potential impact on the underground and surface environment that result from the mineral processing operations in the NGM.

Approach

The approach undertaken has identified effective methods to manage the process water and airborne waste materials generated by the mining and mineral processing operations. These methods suit both the gravity based and cyanide based phases of mineral processing activity.
The intent of this report is to provide descriptions of the adopted methodologies that have been incorporated into the design planning by A&R for NGM.

AMG intend to advance these methods to manage waste to an appropriate level of design. This will be done in parallel to the advancement of the mine planning requirements toward the resumption of operations at the underground mine.

A geotechnical appraisal has also been undertaken for the planned mineral processing excavation within the NGM, recognizing the importance of this planned infrastructure to the operations. The geotechnical appraisal provides for stability analysis of the new excavation that incorporates the first and second phases of the mineral processing system at NGM. This appraisal of the preliminary design is included in this report.

Objectives

The objective of this report is to provide for a description of the solutions to manage the waste materials within the NGM operations.

This report (The PasteTec Report) provides three sections addressing the management of waste from the mineral processing and mining operations. The fourth section provides for the geotechnical appraisal of the mineral processing excavation. The sections are:

- Tailings;
- Underground water;
- Ventilation; and
- Geotechnical.

Each section provides a description of the methodology to be implemented at NGM to ensure efficient, safe, sustainable and effective management of its operations and the environment. The report also provides details of the preliminary design work for each aspect of the project.
Fine Grained Process Waste ‘Tailings’

Tailings Management

Previously all ore was concentrated off site, removing any requirement to handle post concentration slurried waste material (tailings). The operation will concentrate and refine all the ore on site within the underground environment, and therefore it is necessary to manage the tailings within the underground mine. No external tailings storage facility is proposed. It is understood that development waste, i.e. material not passing through the concentration process will also be stored underground in previously excavated stope areas however this is not the focus of this study.

The overriding objective of the tailings management is the placement of material within the existing mined stopes, such that no tailings placement will be required externally from the mine. Furthermore, consideration has been given to minimising environmental, health and safety risk associated with the storage of the tailings.

Methodology Overview

The concentration process and hence tailings generation will occur on the 300 Level some 340m from the portal. The process will include the comminution of the gold bearing ore followed by gravity separation and then in 2010 additional cyanide based extraction process. To accommodate this latter addition to the process train, this report has considered two phases, namely;

- Phase 1 – Gravity based mineral processing; and
- Phase 2 – Cyanide based mineral processing.

Much of the engineering is similar between the two phases and is discussed as such, however where differences occur between the phases, these are noted. One key variation relates to production rate of the two concentration phases, such that Phase 1 has a nominal capacity of 5tph, whilst Phase 2 will operate at 10tph.
Tailings will be received from the gravity circuit (phase 1) or from a cyanide destruction process (phase 2) but in each scenario the solids concentration is likely to be similar. The relatively low rate of tailings production means it is necessary to dilute the received tailings with additional water sourced from the underground mine to enable effective pumping. This dilution will also reduce any residual cyanide concentration in the tailings following the cyanide destruction process, ensuring compliance with the International Cyanide Management Code (Cyanide Code). Further details of AMG proposals for compliance with the ICMC requirements are given in Chapter 18 – Environmental Monitoring Proposals.

The tailings will be pumped into previously mined areas where future access will not be required. Where necessary an engineered bulkhead will be employed to retain the placed tailings, ensuring their controlled separation from the operating mine. During the tailings placement water will either be displaced or released from the tailings slurry and this will be accommodated within the mine water management system.

**Preliminary Tailings Management Design**

Tailings Deposition Area Selection

An area has been identified within the mine for the placement of tailings as backfill and is indicated in Figure 1 of the PasteTec Report. The area is located at the lower end of the Target Block and extends from 280 Level through nominally to the 350 Level. The final elevation will be confirmed during later stage design work.

The area identified is considered suitable for the following reasons:

- The area below the 300 Level can be used for deposition without the need for a bulkhead;
- The area is isolated, with access along a drive at the 300 Level and via the footwall ramp only, limiting the risk from inundation;
- Once above the 300 Level the tailings can be retained with a single bulkhead on the 300 Level access drive only;
• The ground below the filled area has no prospect of future mining owing to a fault structure, therefore there is no risk of sterilizing future ore;
• The area is close to the main concentration area and at a similar elevation, therefore minimizes pumping; and
• The area has been entirely mined and therefore no ore will be sterilized within the tailings.

It is estimated that the area identified, if filled to the 350 Level, would offer 44,500 m$^3$ of storage capacity, equivalent to approximately one year of operation at the higher production rate described in the following section, and shown in Table 12.1 below.

**Table 12.1: Storage Capacities below 350 Level**

<table>
<thead>
<tr>
<th>Filling Area</th>
<th>Stope Volume (m$^3$)</th>
<th>Sill Drive Volume (m$^3$)</th>
<th>Ramp Volume (m$^3$)</th>
<th>Total Volume (m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 300 Level</td>
<td>4,700</td>
<td>4,200</td>
<td>5,100</td>
<td>14,000</td>
</tr>
<tr>
<td>300 Level to 500 Level</td>
<td>13,600</td>
<td>8,000</td>
<td>8,900</td>
<td>30,500</td>
</tr>
<tr>
<td>Total</td>
<td>18,300</td>
<td>12,200</td>
<td>14,000</td>
<td>44,500</td>
</tr>
</tbody>
</table>

In completing the above storage assessment, the following assumptions have been made:

• All void space will be filled such that no future access to the area will be possible, including filling of the footwall decline ramp;
• The average true height of the mined out stopes is 1.7m;
• The sill drives have a cross sectional area of 10 m$^2$; and
• The decline ramp has a cross sectional area of 25 m$^2$.

An important assumption is the height of the stopes. A visual inspection of some stopes indicates areas of overbreak which could increase the average stope height, therefore increasing the available storage capacity. It is recommended that a full volumetric survey of the proposed filling area be completed to determine true stope volumes for mine planning and further detailed engineering design purposes.
Design Criteria

Further to information received from AMG, the tailings production for the respective operating phases will be as shown in Table 12.2.

Table 12.2: Mineral Processing Design Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual operating hours (hrs)</td>
<td>7,884</td>
<td>7,884</td>
</tr>
<tr>
<td>Solids throughput (tph)</td>
<td>5.0</td>
<td>10.1</td>
</tr>
<tr>
<td>Solids SG</td>
<td>2.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Solids concentrations (wt%)</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Slurry volume (m$^3$/hr)</td>
<td>5.8</td>
<td>11.8</td>
</tr>
</tbody>
</table>

Tailings Transportation

As highlighted previously, the anticipated production rates are low and therefore it is necessary to increase the flow rate through the addition of water to the tailings prior to pumping. Whilst the increase in volume to be transported will increase the operating cost, this is offset by the operational benefits of running a continuous system. The alternative would require campaign pumping of perhaps 20 minutes in every hour. To achieve this a storage vessel would be required to maintain the necessary buffer capacity and after each campaign the slurry line would need to drained and potentially flushed to avoid sanding in the line.

AMG has indicated it has an extensive inventory of 100 mm ND steel piping on site and therefore wishes to consider these as the media for slurry transportation. An alternative solution could be the use of a 75mm ND HDPE pipeline, this being the smallest practical line diameter. The two options are compared in Table 12.3 below.
Table 12.3: Tailings Pipeline Selection

<table>
<thead>
<tr>
<th>Pipeline Option</th>
<th>Potential Advantages</th>
<th>Potential Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mm ND Steel</td>
<td>AMG has an existing inventory already on site</td>
<td>Potentially more labour intensive to install</td>
</tr>
<tr>
<td></td>
<td>Robust and common within the mine</td>
<td>Poorer wear characteristics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Greater water dilution required therefore greater operating cost</td>
</tr>
<tr>
<td>75 mm ND HDPE</td>
<td>Can be easier to install if laid at the edge of a drive (with sandbags)</td>
<td>Will need to bought – no inventory available</td>
</tr>
<tr>
<td></td>
<td>Flexible enough to follow the profile of the decline without requiring couplings</td>
<td>Less robust – can be damaged more easily by passing vehicles / rocks</td>
</tr>
<tr>
<td></td>
<td>Better wear characteristics</td>
<td></td>
</tr>
</tbody>
</table>

Based on the above table, either option presents worthy merits. A third alternative maybe to use both steel and HDPE. The steel can be used in areas of the mine subjected to heavy traffic use, where its robustness and the option to hang it form the drive back would be of benefit. HDPE could then be used where the piping runs through lower traffic areas, notably within the footwall decline ramp adjacent to the identified tailings backfilling area. Traffic here would likely be limited to inspection work only and thus the HDPE piping could be laid on the floor of the drive with minimal protection. In addition, the flexibility of the HDPE would enable quick installation around the curve of the decline ramp.

Regardless of the line selection AMG make, the transportation of the slurry will comprise the same components. The slurry will be received either from the thickener, or from the cyanide destruction process at a suitably sized pump box. The required water addition to achieve the necessary flow volume will be introduced along with the tailings slurry to the pump box. Drawing from the pump box will be two centrifugal slurry pumps, one duty and one standby. It is expected that the necessary mixing of the slurry and the dilution water will be achieved in the pump box and as the mixture passes through the pump impeller, ensuring homogenous slurry leaves the pump discharge.

The modification to the flow volume will ensure the flow velocity within the selected pipe will exceed the critical settling velocity, therefore mitigating the risk of sanding the line. Equally the flow velocity should not be so high as to increase the wear rate of the pipeline.
The preliminary pipeline routes are shown in Drawings 001 and 002 (Appendix A) of the PasteTec Report and are identified as Route 1 and Route 2 respectively. Table 12.4 summarises key data for the routes.

Table 12.4: Key Pipeline Data

<table>
<thead>
<tr>
<th>Key Data</th>
<th>Route 1</th>
<th>Route 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Length (m)</td>
<td>602</td>
<td>814</td>
</tr>
<tr>
<td>Start Elevation (m)</td>
<td>312</td>
<td>312</td>
</tr>
<tr>
<td>Maximum Elevation (m)</td>
<td>312</td>
<td>362</td>
</tr>
<tr>
<td>Minimum Elevation (m)</td>
<td>293</td>
<td>293</td>
</tr>
<tr>
<td>Overall Elevation Variance (m)</td>
<td>19</td>
<td>69</td>
</tr>
<tr>
<td>Borehole requirement (m)</td>
<td>0</td>
<td>29</td>
</tr>
</tbody>
</table>

Route 1 presents an option for filling the stope areas below the 300 Level and would be consider viable only before the introduction of the bulkhead. The option takes the shortest possible route through existing infrastructure with a reasonably consistent gradient.

Route 2 is designed to accommodate filling from the 300 Level up to the 350 Level. The route selected requires the installation of a single borehole to connect from the 300 Level up to the main access ramp above. From here the piping would run within the main access ramp until it reached the Target Block decline. Following the target ramp decline down the pipeline would access each sub-level from where tailings would be discharged.

Based on the pipeline route selection, Golder has completed some preliminary hydraulic modelling based on the following assumptions:

- Design case represented by Route 2;
- A flow rate 42m$^3$/hr;
- A relative slurry density range between 1.2t/m$^3$ (21 wt% solids);
- Nominal 108mm ID pipeline (steel and HDPE assumed to be similar in characteristics);
- NPSH (Net Positive Suction Head) – 1m; and
- Pipeline routes as per the Drawings 001 and 002 (Appendix A) of the PasteTec Report.
Based on these assumptions, the following pumping characteristics and duties can be reported:

- Total discharge head (TDH) – 60m;
- Maximum pump flow rate – 42 m$^3$/hr;
- Anticipated pump selection – Warman 3 x 2 or similar; and
- Estimated operating power – 10 kW per pump.

**Tailings Deposition**

The tailings deposition will be a staged process, accounting for the period of time when deposition is below the 300 Level and then above it. This process can be described in five stages, namely:

- Stage 1 – Dewater the currently flooded area beneath the 300 Level and prepare the areas for receiving backfill;
- Stage 2 – Place backfill within the area below the 300 Level;
- Stage 3 – Before completion of Stage 2 the bulkhead along the 300 Level access drive should be constructed;
- Stage 4 – Commencing filling the area above the 300 Level behind the bulkhead; and
- Stage 5 – Complete filling to the designated elevation.

The area identified below the 300 Level in the lower target block was filled with water. This has been pumped out of the mine to allow for cleanup and minor refurbishment works prior to process plant waste material [tailings] placement. The tailings in the impoundment will be fully detoxified before placement. The residual total cyanide level will be below 0.5ppm. Cyanide naturally degrades in water and sunlight and over time the residual cyanide will diminish to below detectable levels. Whilst it is recognised that in the future some water may ingress the impoundment area the tailings will have achieved a high level of densification and hence low permeability combined with the result in a low level of total cyanide and hence the risk to the environment.

Tailings deposition is then commence. It is proposed that the tailings will be discharged from a single point from the sub-level immediately above the
stope being filled. As a result of the need to dilute the tailings it is expected that there will be a brisk release of water from the deposited tailings, and this coupled with groundwater naturally occurring will result in the sub-aqueous disposal of the tailings. To optimise rapid settlement of the solids, the discharge pipeline should be extended as far into the stope (down dip) as possible. It will be necessary to review the discharge location to ensure even deposition of material across the strike length of each stope and maximise placement and backfilling of the old stopes voids. A number of discharge locations are to be considered for each sub-level.

It is anticipated that the area below the 300 Level will fill with supernatant water swiftly and as further tailings are deposited, the displaced water will be allow to travel down the 300 Level access drive where it will be intersected by the mine sedimentation system which is described further below. This operation will continue until such time as the area below the 300 Level is full and the water being displaced does not contain excessive suspended solids.

Prior to completion of filling below level 300 Level, it will be necessary to construct a bulkhead within the 300 Level access drive which will act to retain material once it is stored above the 300 Level. A description of the bulkhead is provided below. During construction it will be necessary to ensure dry working conditions within the 300 Level access drive and hence excess water within the lower levels will need to be mechanically removed with a pump rather than being allowed to simply be displaced by gravity. A submersible pump or similar may be employed to pump water via a pipe back to a suitable location where it can run back to the mine sedimentation trap whilst avoiding the bulkhead construction area. Once the bulkhead is construction is complete water can again run by gravity as the bulkhead will be design to allow the controlled passage of water through it.

Once the bulkhead is completed filling from the sub-level above the 300 Level can begin and in doing so the storage of tailings can advance above the 300 Level. The method for placement of tailings here will be similar to that described above; however the water management will vary.

Two principle options are available to manage the water. The first simply allows the water to fill up upon the placed tailings until such time as access to
the deposition sub-level becomes compromised, at which time mechanical extraction of the water is required. A second, and potential more passive solution would be the installation of a decant (penstock) type system within the inclined stopes. The design will be such that is would discharge by gravity through the bulkhead to the 300 Level access drive.

A preliminary concept for such a solution would see a large diameter pipe pass through the bulkhead and then extend to the just below the first sub-level above the 300 Level. As tailings are discharged from this sub-level and the supernatant water level rises above the tailings, excess water would be collected within the decant, thereby preventing the water level from exceeding the level of the decant.

Once the tailings level reaches a height at which the supernatant quality is compromised, then the decant is to be extended to the next sub-level and the former sub-level abandoned. Tailings deposition would then commence from the new sub-level and thus the process would be repeated. The system would also ensure that the maximum height of supernatant water would be controlled by the height between the sub-levels.

Once filling of the entire area is complete, then the decant pipe should is cut off as close to the tailings level as possible, thereby preventing the development of excessive standing water in the placed tailings in perpetuity. The design and specification for such a decant system are not within the scope of this study and therefore they should be developed in the next stage of the design.

Bulkhead Design

The bulkhead will be installed on the 300 Level drive to isolate the tailings storage from the 300 Level portal drive. The bulkhead will be installed along the 300 Level exploration drive, although the exact location of the bulkhead will be determined following examination of the ground conditions within the drive. The bulkhead is the primary engineered structure retaining the tailings based backfill with residual water in the older stoping area as previously discussed.
The design of bulkhead requires consideration of a number of elements to ensure its appropriateness as an engineered structure to control the forces acting on it and the environment in which it is constructed and in contact with. Thus, a range of factors are considered in its design.

Design Considerations

The potential failure mechanisms for bulkheads retaining the unconsolidated fill (tailings) are described below. The system of catchment chambers in the 300mrl are along with the specific design of the bulkheads mitigating engineering features to maximise the impoundment security.

- Shear failure of the bulkhead and rock interaction as a result of pore pressures resulting in shear through the rock, through the concrete, or along the rock-concrete interface;
- High hydraulic gradient near the bulkhead resulting in leakage through the rock mass;
- Stress redistribution (or induced) stresses created as a result of the excavation around the drive perimeter; within the immediate rock itself;
- Hydro-fracturing mechanisms can pose a potential problem under some circumstances if the fill pressure exceeds the minor principal stress in the rock mass away from the immediate influence of the drift (i.e. that is not subjected to consolidation grouting), and this results in the opening or creation of fractures that transmit water and tailings to the downstream side of the bulkhead; and
- Chemical attack may reduce the integrity of concrete over time.

These aspects have been reviewed during the preliminary design determined for the NGM tailings deposition.

Design Parameters

The bulkhead is planned to be located beneath a 35° inclined stope and will be constructed to retain tailings up to a vertical height of 50m.
The following design parameters have been considered for design of the bulkhead:

- The drift has a rectangular geometry 3.5m wide by 3m high (Area = 10.5m² and Perimeter = 13m);
- Nominal vertical height of fill to bulkhead = 50m;
- Tailings head (assumed saturated unit weight = 0.023MN/m³) at bulkhead location = 1.15MPa
- Vertical Rock Cover = 100m;
- The topography above the bulkhead is at a slope of approximately 20°;
- Maximum acceptable hydraulic gradient for longevity = 12 (~118kPa/m), corresponding to about 2(RMR – 5) = 2(64 - 5);
- Conservative rock-concrete interface shear strength of 0.15MPa for rock-concrete interface without grouting; and
- Overall Safety Factor of at least 3.0 required for permanent bulkhead longevity.

Rock Mass Description

The main orebody consists of quartz veining ranging up to 1m in width, located within predominant lithologies of mafic metavolcanics and dolerites. The orezone has an average plunge of 35° to the southeast, and is located beneath the east dipping face of a glaciated valley.

Based on the previous Golder report, the rock mass quality for the host mafic volcanics was assessed as having a mean RMR (Bieniawski, 1976) of 64 and values ranging from 56 (worst case) to 72 (best case), which classifies as fair to good rock mass quality. The intact rock shows an average uniaxial compressive strength (UCS) of 131MPa.

Mapping of the rock masses in the vicinity of the planned bulkhead site will be required so that the Nalunaq mine can assess the rock mass quality, rock mass fabric, and estimate the intact rock strength. The Norwegian Geotechnical Institute’s (NGI) Q-System and Bieniawski’s Rock Mass Rating
system, RMR76 (Bieniawski, 1976\textsuperscript{16}) should be used to classify the rock mass quality. Field assessment of the intact rock hardness should be made according to guidelines described in ISRM, 1981\textsuperscript{17}.

Preliminary Bulkhead Design

A parallel (monolithic and “unhitched”) type of bulkhead is considered to be most appropriate for this preliminary design at NGM.

The main bulkhead design parameter is the length of concrete that needs to be cast in the drift to ensure a stable structure. It must comply with all conditions discussed previously in this section; the selected length for the parallel bulkhead will be that which corresponds to the most critical of these five considerations.

The design details and consideration will be advanced to a detailed design requirements as further work and data is assessed for the NGM as per previous discussions regarding the commencement of operations. In this further work, full design details and considerations will be made available for review presentation. For indicative purposes only at the stage in design, Figure 2 of the Pastec Report provides some details on the design concept. Based on the previous Golder report, there are no in situ stress measurements at the Nalunaq mine. The initial in situ stresses are assumed to be represented by the ratio of horizontal stress to vertical stress (k) of 2. The vertical stress is assumed to be equal to the unit weight (0.027 MN/m\textsuperscript{3}) of the rock, multiplied by the depth below surface. In addition, simplified two dimensional numerical analyses indicated that simulation of unloading due to glacial melting and erosion might have caused a rotation of the in situ stresses, with the projected horizontal component being equal to 0.9. Additional numerical analyses will be required during the next phase of the bulkhead design to better estimate the induced stresses around the bulkhead.


\textsuperscript{17} Basic Geotechnical Description of Rock Masses. International Society for Rock Mechanics. ISRM. 1981
Re-handling of Tailings

It is understood that prior to the installation of the phase 2 mineral processing circuit, a portion of gold will be retained within the tailings and thus will need to be reintroduced to the concentration circuit once the phase 2 circuit is in operation. To facilitate this, the temporary storage of tailings will need to be achieved in such a way that it can be extracted and returned to the circuit.

The material will be stored in an existing excavated area. The location will be a slight to moderately declining drive capable of containing approximately 15,000 m$^3$ of material assuming storage for three months of operation.

Once the material has been extracted and reprocessed, the excavation could act as an intermediate and emergency sedimentation trap, and would become part of the mine water management system or if planned appropriately form any other part of the future mine development planning and operational requirements.

Long-term Life of Mine Storage

It is estimated that the currently identified storage area would offer approximate two years of capacity at the proposed extraction rate. Additional capacity will be required in the future and additional areas can be identified with similar characteristic to that of the currently proposed option and these will be incorporated in the overall life of mine planning and design.

AMG Note

There is considerable existing space available in the old open stopes to contain the expected waste materials. This space is approximately 300,000 metres cubed. As the mining continues the excavation void increases. Should there be a future waste storage imbalance, then specific voids will be created for the purpose of storing the 'tailings. At that time AMG will apply to BMP for disposal of the waste rock onto existing exterior waste dumps.
Underground Water

Mine water management at NGM focuses on managing the quantity and quality of water within the mine and exiting the mine. The inclusion of an underground concentration plant presents the opportunity to recycle ground water efficiently within the underground environment, minimising the quantity of water abstracted from other sources, and also the amount of water discharged from the mine.

The water management focuses around a central water collection and sedimentation pond, where water from within the mine can be retained and re-circulated for use either in the mine, for the process or discharge externally. The correct design and sizing of the system will minimise suspended solids, thereby leading to an improvement in the current arrangement. This controlled management of the water within the mine, including specially design sedimentation traps will be used to minimise sediment loading within water discharged from the mine.

Conceptual Water Balance

A conceptual mine water balance has been developed to determine the average flows into, within and out from the mine. Using this water balance it is possible to develop preliminary estimations of where the water will flow within the mine and necessary controls and management required.

The water balance has been developed through limited site data, information from AMG and a series of assumptions. The site data was limited to two years of monitoring of mine water outflow. The water flow was observed within the valley beneath the 300 Level portal, and recorded using a V-notch weir. The results from that monitoring are shown in Figure 3 of the PasteTec Report.

Based on the above data, an average flow from the mine equalled 64m$^3$/hr, which includes all natural groundwater inflows and operational uses such drilling water. Based on this information, the mass balance data from AMG and an understanding of the future mining method and equipment operation, the following assumptions have been developed and used in the water balance modelling:
• Natural ground water inflow (average) – 50m³/hr;
• Equipment water – 15m³/hr;
• Other mine operational use (e.g. washing faces) – 10m³/hr;
• Recycle water for processing – 36m³/hr;
• All process water will report to tailings;
• Tailings will consolidate to 80wt% solids in the stopes;
• All water will be directed to the 300 Level; and
• Excess water will be released from the mine following sedimentation.

Based on the above assumptions, the preliminary water balance has been developed and is shown in Figure 4 of the PasteTec Report.

From the model it is clear that within the mine there will be a recirculation of water, leading from the clean water pond to the concentration circuit, to the tailings and then back to the clean water pond. Within this circulation, it is assumed that only water retained within the tailings will be lost from the circuit. Additionally the model assumes that all water used within the mine for drilling etc will return to the clean water pond without loss. Consequently the mine water inflow approximately equates to the mine water outflow, less the water held within the tailings. It will be ensured that the cyanide concentration in this outflow does not exceed the guideline values for cyanide in the environment.

It should be noted that the model makes not allowance for the attenuation of water within mine between source and receptor. For example the model assumes that water used by a drill rig will immediately report to the clean water pond. This may have implications when considering short times frames of several hours where water may be extracted from the clean water pond but may not return for 24 hrs, leading to a potential for short-term draw down of the clean water pond. This issue would be mitigated by the inclusion of “top up” water which could be abstracted to cover any short-term issues that may occur infrequently in the operation.

Water Handling Systems

The water handling system is developed around a central mine water collection and sedimentation pond. The objective of this will be to retain
adequate water within the mine to avoid the need for additional water to be pump in from the existing borehole located in the valley, but also to minimise suspended solids, the latter being essential for both use with equipment underground, and the responsible release of water to the environment when discharged from the mine as may be required.

Drawing 003 in Appendix C of the PasteTec Report shows the proposed design for the water handling system. Water enters the system at the mouth of the declining ramp. Once within the large body of very slow moving water the sediments will fall from suspension and be retained at the base of the ramp. Water is then extracted from the sump at the far end of the decline, minimising disturbance to the settled solids. At times it is assumed the solids will need to be removed, and under these conditions the water level would be drawn down to allow the removal the settled material. This material would be re-handled within the processing plant, thereby ensuring its eventual storage within the tailings. This “clean up” process would likely be completed within the normal maintenance shut down period and thus would not impact on the operation of the mine. Alternative a second identical system may be installed allowing the first to be taken out of service without compromising the mining or concentration processes.

It is proposed that the water handling system be developed along the 300 Level portal drive, with all water from upper levels being directed to this level. Using the above water balance it is possible to estimate the minimum required retention time in the sump to ensure adequate removal of suspended solids. Golder has assumed an eight hour residence time as adequate for this purpose, and thus at the average inflow rate to the trap predicted by the water balance, an overall capacity of 884m$^3$ is required. The design presented provides for a capacity of 1000m$^3$.

The data and anecdotal evidence suggests that high water flows are expected during the spring thaw. In light of this the necessary capacity and / or number of water management systems installed will be reviewed during further detailed design and ongoing operation. The follow-up and action plans are a core part of the project Environmental Management System A detailed water monitoring regime and system is being established with daily water
sampling for Total Cyanide being implemented in early 2010. Such as system is described further below.

Mine Water Control and Discharge

As indicated by the preliminary water balance, it is anticipated that water will continually be discharged from the mine as is currently the case. The approached described herein is how AMG will manage the discharge of that water, which is something that is considered to be an improvement on the previous operation at NGM.

Water has been observed to exit the mine on at least two levels; however the majority discharges through the 300 Level portal. Through proper control of water flowing within the mine, water will be managed such that it is discharged through a single portal only, namely the 300 Level. The underground mine water management system is designed to collect water close to its source in small inter-level sediment traps (sumps), possibly on each sub-level. A simplified sketch of such a sump is shown in Figure 5 of the Golders PasteTec Report below for information. The location of each sump can be determined after AMG complete a comprehensive survey to identify the sources of major water course entries to the mine. Conceptually a suspended submersible pump would transfer collected water to the central water handling system on the 300 Level, however the details for achieving this not provided for in this report. The option to utilise gravity may be an option, but where possible water should be run in pipes from each sedimentation sump, allowing the mine control over the water route and eventual discharge location.

Once water enters the central water handling system, suspended solids will be removed. The water balance confirms that there will be an excess of water and thus an overflow from the central water system will be necessary. This overflow is currently predicted to be approximately 50m³/hr, a reduction on the currently estimated discharge from the mine. Water will overflow from the sump end of the central water system ensuring it passes through the sedimentation process, and will pass immediately into a culvert or closed pipe to control its flow to the portal. Once at the portal, the water flow would enter an oversized pipe to control its flow into the valley floor, where it will be
discharged in to the existing arrangements, to be upgraded, that NGM has in place.

Monitoring and Emergency Response Planning

As described previously, the current records for water entry into and out of the mine are scant. A new and robust system will be implemented to monitor where and ‘how’ water enters the mine, the flow across all seasons and finally the quality of the water as it exits the central water system. This monitoring will record the Total Cyanide, suspended solids content, pH and electrical conductivity. In addition, a regime of monitoring the cyanide levels within the chamber containing the ‘supernatant water’ [that is water rising to the top of the deposited tailings] released from the tailings. This ‘water’ which has been Detoxified will be pumped to a chamber on the 300mrl. A dual cyanide testing system will be in place at this chamber and at the final chamber before discharge to the environment. The dual system will comprise a fixed automatic detection device measuring Free Cyanide in the water. This device will be connected to a alarm in the mineral process plant so that water discharge can be stopped if discharge limits are exceeded. In addition a daily regime of collecting water samples on both operational shifts will take place. The water samples will be collected and taken to the site laboratory. The laboratory will test for Total Cyanide levels between 0.01ppm and 0.5ppm. These tests complement the normal monitoring of cyanide within the mineral process plant.

The existing emergency response plans [contingency plans] are in place at the mine. These were submitted to the BMP is May 2009 and updated in September 2009 to reflect the increased usage of chemicals onsite.. Issues to be considered in the ongoing Environmental Management System include:

- Unexpected inflows of water to the mine, inundating the central water handling system;
- Excessive sediment release from the central water system;
- High cyanide levels within the water when operating the CIL process; and
- Portions of the mine wide water system freezing.
Detailed arrangements of the mine water management system are contained in the PasteTec drawings numbers 09-1901-0012-L-005, 09-1901-0012-L-045, and 09-1901-0012-L-046.

**Ventilation**

Introduction

A review has been undertaken of the existing ventilation system at the NGM. This is based on the ventilation survey undertaken when the mine was in full scale operations in November 2008.

The following methodology is the basis of an effective underground mine ventilation system and the basis of this work. Flow through ventilation is the main ventilation circuit for the NGM. Fresh air enters the mine from surface via a shaft, ventilation raise or adit. The fresh air is distributed through the mine via internal ventilation raises and ramps, and flows are controlled by regulators and mounted ventilation fans. An auxiliary ventilation system takes air from the flow-through system and distributes it to the mine workings via ventilation fans, venturis and disposable fabric or steel ducting. The key requirements of a ventilation system is to maintain an appropriate volume and flow of fresh air to the working environment underground and thus to ensure dirty air is exhausted in a controlled fashion out of the underground mine.

This report is a technical review of the ventilation system at the underground mine. Specifically the review has included the following elements:

- To review of the status of the current ventilation system for maintaining adequate ventilation in the mine;
- To determine the required ventilation system for the proposed mining blocks; and
- To provide general considerations for future mining activity including the proposed mineral processing facility.
The ventilation review focuses on the three proposed mining blocks, referred to as:

- ‘A-B’ Southern Mining Block (SB) - down dip of general operations;
- ‘C’ Mountain Block (MB) - up dip of general mine operations; and
- ‘D’ Target Block (TB) - up dip of general mine operations.

These areas can be identified in Figure 3, Section 2.3.1 of the PasteTec Report and it is based on the data provided by AMG. A long section of the NGM with the salient points of the ventilation survey from 2008 is shown in Figure 6 of the PasteTec Report. The proposed mining plan and mining equipment to be used underground in the operations start up in 2009/2010 has also been incorporated in to the review.

For the purposes of maintaining an appropriate and recognised standard of underground mine working environment the ventilation requirements have been based on those detailed in the Canadian Ontario Mining Regulations (1990) for underground mines.

Diesel Equipment

Diesel equipment is of prime significance to generating an understanding of the ventilation demand in the NGM operation like all other mines. Table 12.5 summarises the proposed mobile equipment NGM intends to use in the operation. This data is the basis for the diesel equipment analysis in the ventilation demand assessment.

Table 12.5: Diesel equipment, power rating and air volume requirements

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Kilowatts</th>
<th>M$^3$ per second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>JS 350</td>
<td>Loader</td>
<td>136</td>
</tr>
<tr>
<td>JS 220</td>
<td>Loader</td>
<td>75</td>
</tr>
<tr>
<td>JDT 413</td>
<td>Haulage Truck</td>
<td>102</td>
</tr>
<tr>
<td>JDT 415</td>
<td>Haulage Truck</td>
<td>136</td>
</tr>
<tr>
<td>MJM 21B</td>
<td>3 Boom Jumbo</td>
<td>69</td>
</tr>
<tr>
<td>MJM 20B</td>
<td>2 Boom Jumbo</td>
<td>46</td>
</tr>
<tr>
<td>M5700DTC</td>
<td>Kubota Tractor</td>
<td>43</td>
</tr>
<tr>
<td>Longhole Drill</td>
<td>Basket</td>
<td>Drill</td>
</tr>
</tbody>
</table>
Note: Diesel equipment information received from NGM.

To obtain ventilating air volume requirements for diesel equipment, the Canadian Ontario Mining Regulations (1990) were used (i.e. 0.06 m³ per second per kilowatt).

Diesel Equipment Requirements per Mining Block

The mine plan at NGM is intending to work the three mining blocks previously discussed. A number of diesel powered mobile mining equipment is to be utilised for the mining operations. For any given mining block activity the equipment to be utilised and associated ventilation requirements are estimated in Table 12.6.

Table 12.6: Diesel equipment and airflow per mining block

<table>
<thead>
<tr>
<th>Volume Equipment Model and Type</th>
<th>Number of Units</th>
<th>Total Air Required (M³/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JS350 Loader</td>
<td>2</td>
<td>16.3</td>
</tr>
<tr>
<td>JDT 415 Haulage Truck</td>
<td>2</td>
<td>16.3</td>
</tr>
<tr>
<td>MJM 21B Drill Jumbos (3 Boom)</td>
<td>3</td>
<td>12.4</td>
</tr>
<tr>
<td><strong>Total Mining Block Air Volume</strong></td>
<td>-</td>
<td><strong>45.1</strong></td>
</tr>
</tbody>
</table>

On the basis that the equipment listed above is the maximum utilised in any mining block and a further two trucks are utilised to provide ore haulage from the mining block to the mineral processing facility an additional air flow volume is required as below:

- JDT 415 trucks x two (ramp haulage) = 16.3m³/sec

Thus a total ventilation requirement is estimated at 61.4m³/sec for the underground mine.

The mine ventilation survey data reported by NGM in November 2008 details a total air volume in to the underground mine of 87.3m³/sec. As such there is an acceptable and adequate level of air flow into the mine with the current system for the proposed mining plan.
The intent is to mine the three mining blocks consecutively as resource and mine planning indicates this to be an efficient approach. It is worthwhile to note that if future mine planning recognised a need to work the three mining areas at the same time with three times the amount of equipment in each block a total ventilation volume demand rises to $134.5m^3/\text{sec}$ plus $16.5m^3/\text{sec}$ ramp haulage giving a total demand of $151.0m^3/\text{sec}$.

The current ventilation system should be maintained efficiently to minimise energy consumption and maximise its effectiveness in the underground operations. This can be maintained by:

- Periodic ventilation surveys;
- Planned ventilation control inspections and maintenance programmes;
- Erecting ventilation brattice or regulator controls on all disused drives and stoping areas to prevent short circuiting of any components of the system; and
- Erecting controls to ensure the intake (fresh) air circuit is separated from the exhaust ventilation circuit.

If further volume requirements are recognised through refinements in mine planning or a need to operate additional development headings additional options to those described above can be implemented in the underground operations to increase capacity of the system. These include:

- Portals from 450 to 500 Level be closed for airflow, unless required for access (which should be controlled to minimise circuit losses);
- Seal all inactive levels, if there is any losses of air from the ramp; and
- Run the fans on the 600 Level and/or the 680 Level portals (turned off in the November 2008 survey), to increase the exhaust air from the mine. Then taking volume and pressure readings on these fans to incorporate in to the overall ventilation system demand and supply balance.
The following points have been considered in this preliminary design review of the system:

- The 350 Level portal to ramp is clear for airflow;
- The 400 Level portal to ramp is clear for airflow;
- The main ramp is connected to 350 Level;
- Mining will be carried out in the A-B block, C block and D block only;
- The main intake (fresh) air volume is presently supplied from 350 Level ramp portal, with a minor volume from the 400 Level ramp portal;
- The November 2008 survey data tabulated presents a discrepancy between intake and exhaust volumes in the survey; and
- The largest power rated requirements for a given piece of diesel equipment was used to determine air volume requirements.

Overall Ventilation Requirements for Mine Production Areas

**Ventilation for ‘A-B’ Southern Stopeing Block**

To provide sufficient ventilation volumes for mining the Southern stopeing block, a total of 61.4m$^3$/sec is required to be delivered by downcasting the ramp from 350 Level. There are two options discussed below to manage the ventilation requirements.

**Option 1**

To down cast 61.4m$^3$/sec on the ramp it will be necessary to exhaust the 225 Level through the 225/300 ventilation raise to the 300 Level and exhaust the ramp portal on 300 Level. This would require the installation of exhaust fans at the top of the 225/300 raise on 300 Level (fan sizes to be determined based on raise size). Level connections to the 225/300 ventilation raise between 300 and 225 Level must be sealed. Install two 1.2m diameter 113kw auxiliary ventilation fans on the ramp just above the 225 ventilation access and duct with 1.2m diameter ducting from each fan down the ramp and into the Southern stope block. This would require rigid wall duct with 1.2m diameter 113kw booster fans on each line, every 245m. These fans would supply a design air volume of 61.4m$^3$/sec to the southern stopeing block and the ramp for truck operation. This option assumes the mineral processing
area is ventilated from the Number 20 raise. The details of this option can be seen in Appendix C, Drawing 004 of the PasteTec Report.

Option 2

If the surface ramp is developed to 210 Level before mining commences, then the surface ramp from 210 Level can be used for exhaust air rather than the 225/300 raise. This would reduce the system resistance considerably and therefore lower fan horsepower requirements (i.e. install 1.2m fans at the entrance to the stoping block and therefore no fans and ducting required on the ramp). Exhaust air fans should be installed at the proposed surface ramp portal (two 1.2m diameter 113kw fans to exhaust 61.4m$^3$/sec). All connections to the 225/300 ventilation raise should be sealed with brattice work or other appropriate controls. The details of this option can be seen in the PasteTec Report at Appendix C, Drawing 005.

The following assumptions have been made regarding ventilation of this block:

- All other mining areas are idle;
- The largest power rated requirements for a given piece of diesel equipment was used to determine air volume requirements;
- The top of the 225 ventilation raise breaks into 300 Level; and
- The proposed ramp from surface will break into 210 Level.

_Ventilation for the 'C' Block (Mountain Block) Mining Area_

To provide sufficient air volumes for mining the 'C' block, a total of 61.4m$^3$/sec is required to exhaust the 720 Level. There are two options discussed below to manage the ventilation requirements.

Option 1

To provide sufficient air for mining the 'C' stoping block, install a 3m$^2$ raise from 720 Level to surface (27m perpendicular distance) and exhaust through this raise. It will be necessary to install an exhaust fan at the raise bottom on 720 Level and seal the 680 Level ramp portal. The 75kw fan on 680 Level at
the ramp portal may be sufficient for this purpose and could be relocated to
the bottom of the new raise. This fan should be started in the near future so
as to permit the collection of volume and pressure readings and thereby
enhance the ventilation data available as the bench mark for the NGM. Two
1.2m diameter 113kw fans should be installed at the ramp top on 720 Level
(MB) and run with twin 1.2m diameter ducting into the stoping area. The
details of this option can be seen in the PasteTec Report at Appendix C,
Drawing 006.

Option 2

Install two 1.2m diameter 113kw fans just below 680 Level and run 1.2m
diameter rigid wall ventilation ducting from these fans into the ‘C’ stoping
block on 720 Level. Booster fans ((113kw) will be required every 245m on
each line. Airflow is to exhaust back down the ramp to 680 portal.

In this case a design air volume of 61.4m$^3$/sec is required to ensure sufficient
air for trucks on the ramp above 680 Level. The 75kw fan presently on 680
Level may be suitable as it is currently reported as not in use.
An airtight brattice work ventilation control is also recommended to be
installed on the 610 incline (TB) to ensure sufficient air volume upcasts the
ramp from below.

As per the November 2008 ventilation survey, there is sufficient air volume on
the 730 (MB) incline to complete development of the exhaust air raise. The
details of this option can be seen in Appendix C, Drawing 007 of the PasteTec
Report.

The following assumption has been made regarding ventilation of this block:

- All other areas in the mine are idle; and
- There are presently no raise breakthroughs from 720 Level (MB) to
  surface.

General Ventilation for the ‘D’ Block (Target Block) Mining Area
To provide sufficient air volumes for mining the ‘D’ block, a total of 61.4m$^3$/sec is required. There are two options discussed below to manage the ventilation requirements.

Option 1

To provide sufficient air volumes for mining the ‘D’ block a drive to connect the 610 (TB) incline to the 540 raise (in the refuge station area) is required to be developed to draw air up the 610 (TB) incline and exhaust to the 540 raise. The 75kw fan presently on the 540 raise may be adequate for this purpose. As commented previously, it is expedient to operate this fan as soon as possible and measure fan air volumes and pressures to provide confirmation for detailed mine planning and ventilation requirements in the future. Airtight ventilation brattice work should be installed on the 550-600 east ramp just above the 610 incline connection to ensure an upcast on the main ramp from below the 610 connection. Two 113kw fans should be installed on the 610 ramp just below the proposed connection drive with twin 1.2m diameter ducting into the stoping area. The details of this option can be seen in Appendix C, Drawing 008 of the PasteTec Report.

To develop the connection drive, a 30kw fan could be installed on the 610 incline just above the proposed drive and run a 0.9m diameter ducting into the drive. This would provide sufficient air.

Option 2

Install two 1.2m diameter 113kw fans just below 610 incline, on the main ramp, and run 1.2m diameter rigid wall ventilation ducting from these fans into the ‘D’ stoping block. Booster fans (113kw) will be required every 245m on each line. In this case a design air volume of 61.4m$^3$/sec is required to ensure sufficient air for trucks on the ramp incline. The airflow (61.4m$^3$/sec) will exhaust back down the ramp and to 680 portal. The details of this option can be seen in the PasteTec Report as Appendix C, Drawing 009.
The following assumptions have been made regarding ventilation of this block:

- All other areas in the mine are idle; and
- There is no raise breakthrough at the top of the 610 ramp (incline) to surface. NGM should confirm there is no surface system connection at the top of the 610 (TB) incline;
- Surface photographs show a 670 ventilation raise breakthrough to surface. This raise may be at the top of the 610 (TB) ramp incline, in which case it may be used as an exhaust raise rather than developing a connection drive to the 540 raise. This is to be investigated further by NGM as the mine planning details develop; and
- As per the November 2008 air survey (17.9m$^3$/sec), there is sufficient air down casting the 610 (TB).

**Typical Mining Block Ventilation**

To ventilate a typical mining block 56m$^3$/sec is required. This includes a factor of 25% to account for leakage and losses. This equates to the installation of two 1.2m diameter 113kw fans in the upstream side of the mining block and running 1.2m diameter ducting from the fans. Each ventilation duct line will supply one-half the total air volume. Each 1.2m diameter ventilation duct can be split into three headings using ventilation duct laterals (i.e. routing of ducting dependent on sequence of mining).

Thereby giving the capability to ventilate six headings with fresh air. It makes intuitive sense that if fewer headings are worked at any point in time the local circuit may be made more efficient by not leaving fans on to unused headings or working areas. Conversely if more headings are worked consecutively then more fresh air intake is required in to the area.

Ventilation controlling brattice work should be installed in connection slots as required, to direct airflow through the active areas of diesel mobile equipment operations. This requires frequent inspections by appropriate personnel to ensure adequate ventilation of mining areas as is reasonable and expected in
the mining operation. The details of this option can be seen in Appendix C, Drawing 010 of the PasteTec Report.

Mineral Processing Ventilation

The development of the additions mine openings for gravity phase of the mineral processing location will require 40 horsepower (30kw) fan at the bottom of the number 20 raise on 300 Level and ducting from the fan into the crushing/mill area. The fan and ducting will supply 15.9m$^3$/sec to the crusher area as per 300 to 400 Level plan. Airflow must exhaust to the 300 Level portal.

A dust collector (bag house) will be required in the crushing area with a pickup point over the crusher. Air exhausted from the bag house can recirculate in the crusher room.

The cyanide mineral processing phase in 2010 will require exhausting the air to the 300 Level portal to mitigate the potential of minor cyanide processing associated fumes escaping into the mine atmosphere if the pH of the leaching process drops. Air monitors are to be installed in the mineral processing vicinity to ensure detection of any such conditions is promptly made and mitigated. This area must have a continuous supply of ventilating air of approximately 2.4m$^3$/sec. Procedures for remedial action are to be developed and implemented if cyanide processing associated fumes are encountered.

If measures are to be taken to control the release of HCN gas into the mine environment, the waste pass can be used to draw (fresh) air from the 300 Level portal and through the mineral processing area. This will then become exhaust air after passing through the area. An exhaust fan will be required at the top of the waste pass to exhaust 8.3m$^3$/sec. This will then require appropriate ventilation controls to ensure the exhaust air from the mineral processing chamber is then channelled through a controlled exhaust system out of the underground mine.

In the case of the waste pass being utilised as the exhaust (and drawing in fresh air from the 300 portal) the 225/300 raise must be used as an intake raise with the two 1.2m 113kw fans on the ramp at the raise bottom to be
installed in an airtight wall. These will draw fresh air down the 225/300 raise from the 300 Level portal. The air will need to be ducted with two rigid wall ventilation ducts, with booster fans every 245m on each line into the lower mining blocks. Air is to exhaust through the main ramp until such time as the planned lower mining block surface portal is installed which can then be utilised as an exhaust.

The fan sizes required will be determined for the 225/300 raise and the waste pass based on the geometry of these raises. It is likely the waste pass exhausting a small volume of air would require a fan in the size range of 0.9m diameter 5.3kw. Details of this option can be seen in the PasteTec Report as Appendix C, Drawing 010.

The limited amount of electro winning that will take place with the mineral processing activity in NGM is undertaken in a controlled environment whereby the fumes are exhausted in to a controlled and sealed conduit. This conduit should be connected to ventilation duct and an exhaust fan to ensure the electro winning fumes are force ventilated out of the mine through the exhaust ventilation circuit.

Ore Pass Ventilation

Install a 0.9m 22.5kw fan on the main ramp just west of the 450 Level breakthrough and run a 0.9m diameter duct into the orepass access drive. This will supply 14.2m$^3$/sec to the orepass drive. If the orepass dump is on 450 Level, a fan and duct are not required.

Lower Mining Block Development Ventilation

Install a 1.2m 75kw fan 9m from the ramp entrance and run 1.2m diameter ventilation ducting from the fan down the ramp for development mining. This will supply 18.9m$^3$/sec to the face, which is sufficient air for a loader and truck. Details of this option can be seen in Appendix C, Drawing 011 in the PasteTec Report.
Recommendations

The following recommendations are provided on the basis of the analysis undertaken and the discussion presented in the previous sections of this report.

**Southern ‘A-B’ Mining Block**

Develop the proposed ramp from surface and install two 1.4m 56.3kw exhaust fans at the portal to exhaust air from the south mining block to surface.

**Mountain ‘C’ Mining Block**

Develop a 3m$^2$ raise from 720 Level to surface and install two 1.4m 56.3kw fans at the bottom of the raise to exhaust air to surface.

The 75kw fan at the 680 portal may be adequate and could be relocated. This fan should be operated to permit the acquisition of volume and pressure measurements as soon as possible to support any decision on its suitability.

**Target ‘D’ Mining Block**

Develop a connection drive from the 610 ramp (beginning of the ‘D’ block mining area) to the 540 raise and install two 1.4m 56.3kw fans in the connection drive. This will up-cast the 610 incline and exhaust into the 540 raise to surface provided that there is no raise breakthrough at the top of the 610 ramp incline. Note: The 75kw fan presently at this raise may be adequate (volume and pressure measurements required to confirm suitability).

**Crusher Ventilation**

Intake air to be supplied from the fan at number 20 raise and duct in the crusher area. Air to exhaust to the 300 Level portal where 8.3m$^3$/sec is required. The fan should be started and volume and pressure readings taken to confirm suitability.
Geotechnical

Introduction

The mineral processing plant and operation requires additional excavation space in the NGM.

Based on the preliminary design of the mineral processing excavations an appropriate level of geotechnical analysis has been undertaken to assess the ground control requirements for the excavation. Preliminary confirmation is provided that excavation sizes are permissible and ground control requirements have been provided to manage risk to an acceptable level.

Mineral Processing Chamber Excavation

The mineral processing chamber consists of a range of existing and new drives to be developed in the NGM. The mineral processing area in the NGM can be seen in Figure 7 of the PasteTec Report. It is approximately 80m below the footwall of the orebody and is located on the 300 Level. Note – some mine openings and the surface contour has been excluded from the view to ensure clarity.

The existing drives form the major component of the gravity based mineral processing circuit. The new drives to be designed and excavated are predominantly for the chemical based mineral processing circuit. These form a large chamber in the new excavation measuring approximately 12m wide, 12m high and 65m long. Figure 8 of the PasteTec Report provides a plan view of the existing drives, proposed drives and an indication of the general mineral processing plant layout in the mineral processing chamber.

The current crushing chamber is approximately 845m² in plan area. The additional plan area stripped, slashed and developed under the proposed design provides an additional 1,245m². This provides a total plan area of approximately 2,090m² for the mineral processing chamber. This represents an increase in plan area of some 247% on that currently in place.
Data Input and Review

The geometric data has been supplied by AMG for the existing mine geometry and the proposed additional excavation geometry to accommodate the mineral processing plant. In addition, AMG have provided the geological description from the Kvaerner Feasibility Study (2002)\(^{18}\) and the Golder Associates Geotechnical Audit (2004)\(^{19}\) for the NGM. These were commissioned by the previous owners of the NGM.

The evaluation of the geotechnical and geological data is based on the reports and data available through a desk study nature of assessment.

The data recorded from orebody and infrastructure geological and geotechnical mapping data in 2000 and 2004 is summarised in the 2004 Golder Associates Geotechnical report and of key note is the general commentary of the rock mass classification as being in the range ‘fair’ to ‘good’ with a mean Q value of 4. Low and high Q values range from 1 to 22.

The Q system of empirical rock mass classification is not discussed in length in this report, but for a sense of context the following salient points are made (Hoek, 2007)\(^{20}\):

On the basis of an evaluation of a large number of case histories of underground excavations the Norwegian Geotechnical Institute proposed a Tunnelling Quality Index (Q) for the determination of rock mass characteristics and tunnel support requirements. The system has been used extensively in mining and civil engineering tunnels (or drives). The numerical value of the index Q varies on a logarithmic scale from 0.001 to a maximum of 1,000 and is defined by:

\[
Q = \frac{RQD \times J_r \times J_w}{J_n \times J_a \times SRF}
\]

---


Where:

- RQD is the Rock Quality Designation
- Jn is the joint set number
- Jr is the joint roughness number
- Ja is the joint alteration number
- Jw is the joint water reduction factor
- SRF is the stress reduction factor

The rock tunnelling quality Q can now be considered to be a function of only three parameters which are crude measures of:

- Block size (RQD/Jn)
- Inter-block shear strength (Jr/ Ja)
- Active stress (Jw/SRF)

The Q system goes on to evaluate and provide estimates on the ground control requirements for any given excavation based on over 1000 case histories.

Using the data reported in the 2004 Geotechnical Audit coupled to the preliminary excavation design for the mineral processing chamber, the ground control requirements are assessed. Table 12.7 provides a summary of the key points to the analysis of the excavation. Summary Q data from the 2004 reporting is included in the PasteTec report in Appendix D.

**Table 12.7 – Summary of key points from the Q system analysis for drives**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Q</td>
<td>4.37</td>
<td>Range from 1 to 22</td>
</tr>
<tr>
<td>ESR</td>
<td>1.6</td>
<td>For long term / permanent mine infrastructure</td>
</tr>
<tr>
<td>MU Span</td>
<td>5.8m</td>
<td>Maximum unsupported span estimate</td>
</tr>
<tr>
<td>Bolt Length</td>
<td>1.8m</td>
<td>Range from 1.6m to 2.8m</td>
</tr>
<tr>
<td>Bolt Spacing</td>
<td>1.5m</td>
<td>Ring and in-line spacing dimensions</td>
</tr>
</tbody>
</table>

Table Notes:
- Mean Q – is taken from the values reported in the 2004 report. This is summarized in the last page of the Appendix D of the PasteTec Report;
• ESR – the value of 1.6 is used. This is representative for permanent mine openings, water tunnels for hydro power (excluding high pressure penstocks), pilot tunnels, drives and headings for large excavations;

• ESR – the value used in the 2004 work is between 3 and 5. This is representative of temporary mine openings and not relevant to the analysis of this mine infrastructure;

• ESR – AMG may wish to review the inclusion of an ESR of 1.3 when final design details are confirmed, as this infrastructure is intended to be relatively free from ground control risk. An ESR value of 1.3 is used for storage rooms, water treatment plants, minor road and railway tunnels, surge chambers and access tunnels. The use of an ESR of 1.3 equates to a smaller maximum unsupported span and bolts of 2.1m in length;

• MU Span – the maximum unsupported span permissible is estimated based on the equation below:

\[ \text{Maximum span (unsupported)} = 2 \times \text{ESR} \times Q^{0.4} \]

• Bolt Length – the bolt length is estimated for a range of excavations width and 1.8m length is quoted for a drive size of 5.4m width. The estimation is based on the equation below:

\[ L = \frac{[2 + (0.15B)]}{\text{ESR}} \]

Where \( B = \text{excavation width} \)

Bolt spacing – the bolt spacing estimate is scaled from the chart shown at Figure 9 of the PasteTec Report. This equates to in-line and ring spacing of the bolts.

It should be noted that the application of the Q system is largely based on the assumption that the orientation of the excavation has been designed such that it is at its most favourable orientation towards any faults and joints that may form wedges and blocks in the excavation. This is not confirmed as the case and as such a level of risk is presented by the larger size excavations in the mineral processing chamber. As such recommendations are made for ground control requirements to be installed and further site based assessment to be undertaken to confirm ground control requirements.
Preliminary Recommendations

Based on the review of the previous geotechnical assessment data, the update of the Q assessment and the proposed mineral processing chamber geometry the following recommendations are made:

- All backs of the excavations within the mineral processing chamber are bolted with 1.8m long fully encapsulated rock bolts, with surface plates and tensioned. Spacing at 1.5m intervals;
- Bolting is to extend across the back of the excavations and into the shoulder;
- The larger excavations (over 6m in width) as shown in the Pastec report Appendix D (drawings 014 and 015) are recommended to be bolted with 6m long fully encapsulated cable bolts, with surface plates and tensioned. The cable bolt should have a capacity of 25t. Spaced at 3m. If cable bolts are installed in sequence with rock bolts, the 1.8m patterned bolting may removed where it is in the exact same location as the cable bolt. This recommendation is given in the absence of site specific data that provides clear evidence of no hazard potential being created by large wedges or blocks that may cause loosens in safe and efficient production at NGM;
- 6m cable bolts are recommended to be considered by AMG in any excavation design risk assessment to mitigate the potential for large wedges to fall/slide into the excavation. This should be at a similar spacing to the sidewalls. An excavation over 8m in height should have cable bolts installed from 5m height;
- Surface support is recommended from the Q system (as a shotcrete). In this application it is largely performing a function of managing hazard potential to the plant, equipment and personnel caused by loose rock and scats forming over time. As such 100mm steel mesh (5mm gauge) is appropriate in lieu of shotcrete. However, AMG may wish to consider the use of shotcrete as it will provide for complete scat control and provide a medium by which any deformation can be monitored (observing for any cracks). The mesh or shotcrete can then be whitewashed to improve the operating environment for the mineral processing and to aid monitoring and observation of any changes in ground stability during the life cycle of the excavation;
• AMG is recommended to risk assess whether it deems it necessary to bolt and mesh the sidewalls (down to 2m height or lower as deemed necessary) to manage risk to an acceptable level for plant and personnel as well as to manage any local defects that may warrant additional ground control measures to mitigate wedges and blocks of rocks that may become unstable;

• The new excavation maintains pillars at a 1:1 or greater width to height ratio. This permits a core of rock to exist which should enable no major issue to be experienced – unless local inspection reveals weakness in the pillars as a result of blast damage, discontinuities or stress related changes. In such cases additional pillar strengthening measures may be required; and

• Any further refinements and changes to this design geometry must undergo a review to confirm the ground control requirements as appropriate.

The general bolt lengths and spacing arrangements concur with previous work undertaken and recommended to AMG.

The recommendations provided should be reviewed by site personnel based on local data available in the excavation area and considered in the context of AMG’s risk management practices within its operations.

Further Mineral Processing Chamber Geotechnical Considerations

It is important to understand the limitations of rock mass classification systems. The use of such systems does not (and cannot) replace some of the more elaborate design procedures. However, the use of these design procedures requires access to relatively detailed information on in situ stresses, rock mass properties and planned excavation sequence, none of which may be available at an early stage in the project. As this information becomes available, the use of the rock mass classification schemes should be updated and used in conjunction with site specific analyses, such as the tasks listed below:

• Site specific discontinuity data;
• Block and wedge analysis with the discontinuity data, particularly the major fault structures in the NGM. These are the low (dip) angle faults ('Your' and 'Mosquito') and higher (dip) angle faults ('Clay' and 'Pegmatite');

• Numerical modelling should be considered for such an excavation of significance to the mine plan and operations. Such work should consider stress analysis for the proposed excavation profile over the life cycle of the NGM’s full life of operation and consider the proximity to other drives, including the surface;

• AMG should consider the mining excavation and installation of ground control sequence so as to manage risk to an acceptable level during the excavation process – including catering for any unanticipated geotechnical issues as they may arise. Such a sequence example to consider could be to develop half the heading width, bolt and cable that section. Then strip out the side to develop to the excavations full design width. This may be followed by stripping out the floor to create the full height. This example is to promote consideration of the excavation process and is not suggested as the best method or approach. AMG should determine that as a function of the equipment and personnel resources in place at the operation. In the excavation sequence – 6m cable bolts should be installed on a cut by cut basis to mitigate risk. It is not recommended they are installed after a large portion or the whole of the excavation has been mined; and

• Subject to observations during the mining, the brows into the larger excavations may require additional brow bolting to mitigate risks associated with blocks and wedges that may become potentially unstable.

Operational Geotechnical Considerations

AMG are recommended to consider the adaption of recommendations made in this report to the refinement and implementation of the following systems in the NGM operation, the identification of hazards and management of risk:

• Risk assessment of design process and operational practices for the excavation;
• Ground control standard specification be developed to ensure quality control and consistency in implementation;
• Ground control requirements for drive intersections in the mine to be risk assessed based on site specific geotechnical and geological data and to cater for the consideration of production interruption and personnel exposure risks;
• A routine check scaling and inspection program is developed and implemented at NGM for all major travel ways and areas of significant mine infrastructure; and
• Consideration is given to the development and implementation of a Ground Control Management Plan (GCMP) for the NGM operations. A GCMP will define the process, accountabilities, tools and all fundamental aspects for the NGM to operate within a framework to manager risk to an acceptable level from the hazards associated with ground control.

Other general references cited by the PasteTec Report were from the Government of Ontario\textsuperscript{21}.

**Equipment**

The underground mining equipment required for the operation comprises the following:

• 3No JS350 Scooptram;
• 2No JS250 Scooptram;
• 3No JDT413 Haulage Truck;
• 2No JDT415 Haulage Truck;
• 3No MJM20B 2-boom Jumbo Drill;
• 3No M5700DTC Tractor;
• 1No Basket Longhole Drill; and
• Ancillary Equipment.

Drillserve Ltd of Camborne, Cornwall, have assessed and reported on the condition of the mining plant and machinery left at the site by NGM.

The report\textsuperscript{22} covers trucks generators, compressors, drill rigs, scooptrams, service vehicles, workshops, stores, diesel storage and distribution system and all aspects of explosives supply and focuses on the condition of the key mining plant and its suitability for continuous mining operation, particularly in the context of the proposed new mining method.

The main conclusions and recommendations of the Drillserve Report are as follows:

- Almost every piece of diesel plant had brake cleaner (Easystart) near the engine - heater circuits on several of the machines in poor condition;
- Most things work, but have worked hard and tend to have a range of minor problems, with evidence of major repairs;
- Underground garage is good and routine maintenance certainly no worse than average;
- 350m level surface area is in poor condition. Generators and compressors have dials and valves missing, floors very slippery, fuel line randomly connected and buried in snow. Garage semi derelict.
- Stores is a good building and reasonable system but needs upgrade. Several expensive things stored outside;
- Development size will need to be related to the 3.5 Wagner scoops and 20T trucks as these are the youngest, biggest and most viable machines; and
- Air and water supply infrastructure appears intact through-out the mine.

Mineral Processing

NGM did not carry out any processing apart from pre-concentration screening of ROM on site. Consequently, considerable quantities of waste were transported to the third party toll mill at substantial cost. In the initial three months of operation, Angel Mining (Gold) A/S will utilise gravity processing techniques only to produce gold doré. The mining method should also result in less dilution of ROM also resulting in a higher grade ROM product overall. ROM ore produced during this initial period, coinciding with the initial winning of ore from remnant ore on site, existing stopes and the working of pillars, will be processed using gravity methods. The material remaining after gravity treatment will then be treated through the leach plant. During the period where there is only a gravity plant in operation this material will be temporarily stored within the mine to be treated through the leach plant in due course.

Following this initial production period, during which resource delineation by underground developments will proceed to begin to prove additional measured and indicated reserves, additional mineral processing facilities, running concurrently with the gravity process, utilising carbon-in-pulp (CIP) techniques will be installed in the mine by March 2010 (pending approval by BMP). This will allow the ROM ore to be treated to produce doré utilising crushing, screening, grinding (milling), leaching, and electro-winning techniques.

All the processing activities, together with the processing plant and facilities, will be located in specially excavated underground caverns within the mine itself. No waste material from the process stream, including tailings, will be taken outside the mine but will, instead, be utilised in the mine waste impoundment (backfill) system.
Gravity

GBM Minerals Engineering Consultants Ltd have produced a comprehensive study\(^{23}\) of the gravity processing circuit requirements for NGM dated July 2009. The general layout of the underground process area is shown in GBM Drawing 0381-G01-G-001.

**GBM Ltd Report**

**Crushing & Fine Ore Storage**

The crushing circuit is designed to run at a capacity of 11 tph, operating 12 hours per day with 85% availability. GBM Drawings 0381-G01-F-001 and 0381-G01-F-002 illustrate the flow sheet for the proposals.

There are two options open to this section of the process.

**Option 1**

Run of mine gold bearing ore is collected from the stockpile underneath the ore pass by an ore haulage truck. The ore is driven up an earth ramp and dumped onto the Locotrack LT1315. The Locotrack unit will be fitted with a jaw crusher to reduce the initial feedstock down to a p80 of 51mm. The Locotrack LT1315 will discharge using its own discharge conveyor into the feed hopper of the Locotrack LT2011E.

The LT2011E is fitted with a cone crusher to reduce the 51mm feedstock down to a p80 of 12mm, suitable to feed the ball mill. The fine ore will be transferred via belt conveyor CV005 into the fine ore bins.

**Option 2**

Run of mine (ROM) gold bearing ore is collected from the stockpile underneath the ore pass by a 5 tonne ore haulage truck. The ore is driven up

an earth ramp and dumped into the ROM bin. Apron feeders underneath the ROM bin extract and feed the ore into the jaw crusher. The jaw crusher with a closed side setting of 60 mm reduces the rock size to a p80 of 51 mm. The crushed ore discharged from the jaw crusher feeds on to conveyors CV001 and CV002 to be sent to a secondary crushing and screening station. Fines from the apron feeders will be collected on the tail end of these conveyors. Conveyor CV002 will discharge on to a vibrating screen. The oversize from the screen (> 12.5 mm) will feed into a cone crusher to reduce the ore size to a p80 of 15 mm. The crushed ore is conveyed via conveyor CV003 back on to conveyor CV002 and on to the vibrating screen for sizing.

The undersize from the vibrating screen has a p80 of 7.5 mm and is of a uniform size for feeding the ball mill. The fine ore will be transferred via belt conveyor CV005 into the fine ore bins.

A chute at the top of these two bins will evenly distribute the ore to each bin. The combined storage volume of the fine ore bins is 115 m$^3$. With a bulk density of 1.7 t/m$^3$ (a void space of 40%) this equates to a storage capacity of 200 t or 40 hours of mill operation. The noise levels around the crushing circuit will be typical of this sort of workplace and standard hearing protection will be worn by operators. The dust generated by the primary and secondary crushing plants will be collected by a central reverse jet bag filter, via ductwork running from each plant. The dust will be fed back onto the belt conveyors.

**Grinding & Sizing**

The milling circuit is designed to operate at 5 tph, operating 24 hours per day with 90% availability.

The fine ore is fed using two vibrating feeders onto a single conveyor to be transferred to the ball mill. The ore is discharged into a chute and mixed with process water. The reduction begins inside the 7’ x 9’ ball mill. The grinding of ore between the balls and the mill liners reduces the ore in size from 7.5 mm to less than 150 µm. Adjustments to the flow rate of water added, ball loading, tonnage and re-circulating load are made to maximise the mill
throughput. The ball storage area, ball bucket and ball feed chute are all designed to allow easy access and for operation and maintenance.

The mill overflow slurry discharges into the attached rotating trommel screen. This screen allows slurry to pass through at a specific size and returns coarse material to the mill. As the balls are reduced in size they are dislodged by the addition of fresh larger balls and pass out through the trommel screen and into a scats bin.

The slurry that passes through the trommel screen is collected in a chute and directed to the ball mill pump box. The pump box is designed to prevent to settling and collection of particles in the bottom that can cause the pump to stall on motor overload. A duty and standby pump will selectively pump the slurry from the pump box on to the sizing screen. All slurry pipes are designed to ensure turbulent flow that prevents settling from occurring.

The vibrating screen is installed above the height of the ball mill to allow the screen oversize to be gravity laundered back to the ball mill feed chute. The screen slot size is set to prevent all particles larger than 2 mm entering the gravity concentrator. The minus 2 mm particles passing the screen deck report to the undersize launder and on to the concentrator feed pump box. Spray bars mounted above the screen deliver process water on to the screen to further assist the undersize particles to pass through the screen deck. The undersize from the screen is collected in a pump box prior to pumping across to the concentrator/gold room plant.

The grinding and sizing area has zero emissions. The ball mill has rubber liners to reduce the noise levels in the area and therefore these are well below the acceptable limit with approved workplace hearing protection. A gantry crane is installed above the ball mill to assist with materials handling including movements of consumables such as spare liners and mill balls, as well as lifting maintenance to pumps and motors.

**Concentrator, Gold Extraction & Smelting**

The concentrator will be designed to run in time with the milling circuit and therefore operates 24 hours per day with 90% availability.
The undersize slurry from the sizing screen is pumped to the concentrator. Inside the concentrator the slurry is subject to a gravitational field, via a spinning rotor bowl. The free gold, being the densest material, is layered then trapped in the riffles of the upper zone of the rotor bowl. An automated system detects when the bed has built to a sufficient grade, when it stops the rotation momentarily to wash the concentrate from under the rotor baffles and out the concentrate launder and into the concentrate storage tank. The solids concentration out of the concentrator is approximately 80%. A small amount of process water is required to carry out this automated operation. The concentrator tails pass over the top of the rotor bowl, where they flow down the inside of the unit, out through a discharge pipe and into a pump box to be classified.

The shaking table operates for about 4 hours daily and is fed from the concentrator product storage hopper. From the hopper, the gravity concentrate is washed down a feed launder to the distribution box from which it flows on to the riffled end of concentrating table, while small streams of water from a perforated pipe flow onto the table along the whole length of the top. The tables operates at about 200 strokes per minute and, since it is set at a slight inclination toward the bottom edge, the low specific gravity particles are washed over the riffles down to the tailings launder along the bottom edge. The high specific gravity materials such as gold and sulphides are caught in the riffles and are propelled by the shaking motion of the table towards the product discharge end of the table. The riffles stop short of the discharge lip and there is plain area of the table where heavy particles continue to be gently washed and subjected to shaking and bumping motion of the table. The effect is to form bands of minerals with coarse gold uppermost then a mixed band of fine gold and coarse sulphides/metallic iron from the grinding media. Cutters are positioned to yield a gold concentrate and a middling product, which may be re-tabled. The gold collected off the end of the table is dried and mixed with fluxing material for smelting in the bullion furnace. The table tails is laundered into a pump box to be classified. On completion of the smelting process, a sample is taken for assaying before the gold bullion is poured into a series of water cooled crucibles. Any adhering slag is removed from the bullion bars, which are then numbered and
weighed before shipment to a refinery. The bars assay 90+% gold, at a theoretical rate of up to 50 oz per day.

The bullion furnace will include a vent stack to extract any moisture or fumes from the smelting process out of the gold room. The emissions from this process are typical of this operation and are not harmful to personal in close vicinity. Appropriate ear protection will be employed in the gold room during gold pouring. All mechanical equipment will have appropriate barriers to protect operations personnel.

**Classifying & Tails**

The cyclone cluster is designed to run in time with the milling circuit and therefore operates 24 hours per day with 90% availability.

The concentrate tails and shaking table tails collects in the cyclone feed pump box and is pumped to one of two 10” hydro-cyclones. The hydro-cyclone classifies the material according to size by the action of centrifugal forces. The feed slurry enters the upper end of the cyclone body at a tangential angle so that the slurry is forced to flow in a circular motion. By way of centrifugal force the heavier coarse particles are forced to the outer edge of the cyclone. The lighter fine particles rise to the centre of the cyclone slurry flow forced by the action of the heavier coarse particles. The lighter fine particles, along with the water, rise up inside the cyclone vortex finder to be collected as cyclone overflow with an estimated particle size of 80% minus 125 micron. The cyclone underflow slurry empties into a cyclone underflow diversion box where it is directed by gravity to the ball mill feed chute.

The cyclone overflow feeds to the tailings holding pond via pump box and pump to be stored until the CIP circuit is commissioned.

The operation of the classifying circuit produces zero emissions or operational hazards. The storage of tailings is dealt with independently of the processing plant.
Gold Metal Balance

The figures below show how the crushing plant operates with a throughput of 10.6 t/h and the milling plant operates with a throughput of 5.0 t/h based on an annual throughput of 39,500 tons of ore annually.

<table>
<thead>
<tr>
<th>Days/yr</th>
<th>365</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours/day</td>
<td>12</td>
</tr>
<tr>
<td>Plant availability</td>
<td>85%</td>
</tr>
<tr>
<td>Throughput t/hr</td>
<td>10.6</td>
</tr>
</tbody>
</table>

The mass balance assumes an average ore grade of 13.5 g[Au]/t, which equates to 533.25 kg[Au] (or 18,810 oz) per year or 60.9 g[Au] per day. Based on a milling plant availability of 90%, the flow rate of gold entering in stream 6 is 67.6 g[Au]/h.

The gold recovery during phase 1 of the project is 50%, which equates to 9,405 oz of the 18,810 oz of gold mined per year is sold in doré bars. If the milling plant availability was 100%, the plant could produce 10,400 oz of gold annually, but due to planned and unplanned maintenance requirements this is unrealistic. The remaining 50% of the gold is sent to a holding facility as phase 1 tailings until phase 2 of the project is complete. When phase 2 of the project is completed, the gold recovery will increase to 94% and the plant throughput capacity will increase to 80,000 tons per year. At this stage the phase 1 tailings will be recovered back into the plant and reprocessed at the higher gold recovery rate.

The GBM Drawings 0381-G01-G-002 (Elevations A-A and B-B) and 0381-G01-G-003 (Elevation C-C) illustrate in sectional view the plant associated with the Gravity Process circuit.
Leach Processing

GBM Ltd have produced a comprehensive detailed engineering study of the leach processing circuit requirements for NGM dated September 2009.

Crushing & Fine Ore Storage

The crushing circuit is designed to run at a capacity of 21 tonnes per hour, operating 12 hours per day with 85% availability. Appendix 3.2 shows the crushing and grinding circuit.

Run of mine (ROM) gold bearing ore is collected from the stockpile underneath the ore pass by a multi-tonne ore haulage truck. The ore is driven up an earth ramp and dumped into the ROM bin. An apron feeder underneath the ROM bin extracts and feeds the ore into the jaw crusher. The closed side setting on the jaw crusher is adjusted to optimise the crushed ore size profile being discharged. The crushed ore from the jaw crusher feeds conveyor 1 and conveyor 2 sequentially where the ore is transferred to the secondary crushing and screening station. A scraper is attached to the underside of the tail end of the conveyor to ensure the fines collect in the discharge chute.

Conveyor 2 discharges on to the vibrating screen. A chute collects the oversize from the screen and feeds it in to the cone crusher. Again the closed side setting on the cone crusher is adjusted to optimise the crushed ore size discharged. The feed rate is set, where possible, to choke feed the cone crusher. The crushed ore is circulated via conveyor 3 back on to conveyor 2, where is feeds on to the vibrating screen for sizing.

---


PROCESS DESCRIPTION FOR NALUNAQ EACH CIRCUIT
The deck on the vibrating screen is designed to ensure uniform feed size to the grinding circuit. The undersize from the screen is classified as fine ore. The fine ore is transferred via conveyor 5 and conveyor 6 sequentially to the fine ore storage bins. A chute at the top of these three bins evenly distributes the ore to each bin. The combined storage volume of the fine ore bins is designed to allow continuous operation of the downstream side of the plant, whilst routine maintenance is being carried out on the crushing circuit.

The noise levels around the crushing circuit are typical of this sort of workplace and standard hearing protection will be worn by operators. Dust generated by the primary and secondary crushing plants will be collected by a central reverse jet bag filter. Ductwork is run from each of the crushing plants to the bag filter. Routinely the dust collected is emptied back on to the belt conveyor and into the plant for processing.

**Grinding & Classifying**

The milling circuit is designed to operate at 10 tonnes per hour, operating 24 hours per day with 90% availability. GBM Drawing 0381-G01-F-003 illustrates the crushing and grinding circuit.

The fine ore is fed using three vibrating feeders onto a single conveyor to be transferred to the ball mill. The ore is discharged from the end of the conveyor and into a chute. The fine ore is mixed with process water, lime and recycled slurry in the ball mill feed chute. The fine ore size reduction begins inside the ball mill. The grinding of ore between the balls and the mill liners reduces the ore in size to fine slurry. Adjustments to the flow rate of water added, ball loading, tonnage and re-circulating load are made to maximise the mill throughput. The ball storage area, ball bucket and ball feed chute are all designed to allow easy access for operation and maintenance.

The mill overflow slurry discharges into the attached rotating trommel screen. This screen allows slurry to pass through at a specific size and returns coarse material to the mill. As the balls are reduced in size they are dislodged by the
addition of fresh larger balls and pass out through the trommel screen and into a scats bin.

The slurry that passes through the trommel screen is laundered to the ball mill pump box. The pump box is designed to prevent settling and collection of particles in the bottom that can cause the pump to stall on motor overload. The slurry is pumped from the pump box to the cyclones for classification. All slurry lines are designed to ensure turbulent flow to prevent settling from occurring.

The cyclones are located above the height of the ball mill to allow the cyclone underflow to gravity launder back to the ball mill feed chute. The cyclone ensures the feed to the leach circuit has the correct particle size required to efficiently leach the gold from the ore and obtain maximum gold recovery. The cyclone overflow passes through a screen deck that removes any large, low density solids that were not separated out by the cyclones. This screen oversize is classified as waste and the bin emptied when required. Spray bars mounted above the screen deliver process water on to the screen to assist the screening process. The undersize from the screen is collected in a pump box prior to pumping to the leach tanks.

The grinding and classification area has zero emissions. The ball mill has rubber liners to reduce the noise level below the acceptable limit with approved workplace hearing protection. A crane is installed above the ball mill to assist with materials handling including movements of consumables such as spare liners and mill balls, as well as maintenance requiring the lifting of pumps and motors.

**Leaching & Carbon Adsorption**

The leaching and carbon adsorption circuit is designed to operate at 10 tonne per hour, operating 24 hours per day with 90% availability. The leach circuit is designed to provide sufficient residence time to attain the target recovery rate of gold. GBM Report Drawing 0381-G01-F-004 shows the leaching, carbon-in-pulp and tailings circuit.
The slurry from the grinding and classification area is pumped into the first of three leach tanks, with the option to bypass the first tank and feed directly into the second tank if maintenance is being carried out on the first tank. The slurry enters the tank via a down-comer that reduces the chance of short circuiting. The leach tanks are individually elevated such that there is sufficient height differential between tanks to achieve a natural cascade. A launder box diametrically opposite to the feed line launders the slurry between tanks and from the third tank launder box to the leach discharge pump box.

The leach reaction requires a high pH in the leach tanks. For this reason each of the three leach tanks has a caustic feed line that can be opened if the pH falls below the target level. Cyanide is dosed in to the tank from a pre-diluted solution in the reagents area. Bags of solid sodium cyanide are delivered to the processing plant and stored in a dry environment. The bags are added to a pre-prepared solution of caustic and process water. The diluted cyanide is transferred to a holding tank, where it is control dosed to the leach circuit. The compressed air is expanded into the bottom of each tank to provide the oxygen required for the leach reaction.

\[ 4 \text{Au} + 8 \text{CN}^- + \text{O}_2 + 2 \text{H}_2\text{O} = 4 \text{Au(CN)}_2^- + 4 \text{OH}^- \]

The leach tanks are continually agitated to ensure the solids are held in suspension whilst passing through the leach circuit.

The carbon in pulp (CIP) circuit contains a total of eight tanks interconnected in a carousel configuration. The slurry from the leach discharge pump box enters the leading CIP tank via the feed launder located above the pump cell top platform. The feed launder valve arrangement directs the flow of pulp into the desired pump cell. The pulp enters the pump cell via a feed box and feed pipe and is directed to the area above the down-pumping hydrofoil, thus reducing the possibility of short circuiting. The down-pumping hydrofoil imparts sufficient energy into the pulp resulting in good mixing of the pulp and carbon, which in turn results in gold being adsorbed on to the carbon.

All the pump cells have the same horizontal elevation, and so the pump cell mechanism is used to transfer pulp between the pump cells. Pulp is drawn
through the wedge wire by virtue of the up-pumping impeller developing a head in the open volute, which is connected to the internal launder. The wedge wire screen aperture is approximately sized to allow for the flow of pulp though the screen while ensuring that the carbon remains in the pump cell as a discreet batch.

The pulp is directed through all stages in the pump cell circuit. The pulp exiting the last pump cell in the carousel sequence is directed to the carbon safety vibrating screen. When the gold on carbon in the lead pump cell reaches the set value, the lead pump cell is isolated and the feed material is directed to the second pump cell in the carousel sequence. The second pump cell effectively becomes the leading pump cell. The entire contents of the lead pump cell is drained and pumped to the loaded carbon screen. Once the contents have been drained off, the original lead pump cell is brought back on line as the new tail pump cell. The new tail pump cell is replenished with a regenerated amount of carbon.

The leach and carbon adsorption circuits have zero emissions. A pH probe in each of the cyanide dosed leach tanks will alarm if the pH level drops below a safe point for cyanide addition. Any spills from each circuit gravitate to an area sump, from where they can be collected and pumped back in to the respective tank or pump box. Monorail hoists are installed above the leach tanks and CIP tanks to assist with the maintenance of the agitators and pump cells.

**Cyanide Destruction & Tails**

GBM Report Drawing 0381-G01-F-004 shows the leaching, carbon-in-pulp and tailings circuit. The cyanide destruction area and tailings disposal system operates in conjunction with the carbon adsorption circuit. The tank has been sized to provide sufficient residence time to convert the weak acid dissociable (WAD) cyanide to cyanate prior to being transported to a tailings collection area. Processed ore from Nalunaq has been proved previously to have successfully used the Inco method to convert the WAD cyanide to cyanate when processed in Spain. The Inco method uses meta-bisulphate and aeration in the presence of a copper catalyst, already present in the ore body, to react the cyanide.
\[ \text{CN}^- + \text{SO}_2 + \text{O}_2 + \text{Cu} + \text{H}_2\text{O} = \text{CNO}^- + \text{Cu} + \text{H}_2\text{SO}_4 \]

The iron complexed cyanides are reduced during the detoxification process to the ferrous state and precipitated out of solution as insoluble metal ferrocyanide salts, where the complexes include all zinc, copper and nickel forms. In this case the cyanide is not converted to cyanate but is rendered innocuous by being fixed in a very stable complex.

The tailings enter the tank via a down-comer, which discharges as close to the bottom of the tank as practically possible. The tank is mechanically agitated to maintain a suspension and promote the reaction. Compressed air is sparged into the tank to provide the oxygen necessary for reaction. Lime is added via a hopper and screw feeder to control the pH to around 9. Sulphur dioxide by way of sodium meta-bisulphate is added at the calculated feed rate to react with the free and WAD cyanide and reduce tailings cyanide concentrations below that required to comply with environmental standards. Bags of solid sodium meta-bisulphite are delivered to the processing plant and stored in a dry environment. The bags are added to a mixing tank of process water to the correct concentration. The meta-bisulphite solution is transferred to a holding tank, where it is control dosed to the detoxification tank. The overflow from the detoxification tank feeds to a pump box, where it is pumped to the tailings handling facility. The storage and handling of tailings is dealt with independent of the processing plant.

The cyanide destruction process emits moderate levels of sulphur based odours. A ventilation system from the reagents area will direct these odours out of the enclosed processing plant.

A warning alarm panel is installed to attract the attention of an operator in the instance of a low level in the meta-bisulphite holding tank or high or low pH levels in the detoxification tank discharge. The discharge from the detoxification tank is continuously monitored for WAD cyanide and total cyanide levels to ensure the concentration being sent to tailings storage is below the maximum allowable limits [\(<0.5\text{ppm}\)]. Any spills in the area gravitate to an area sump, from where they can be collected and pumped back in to the detoxification tank.
Acid Wash, Elution & Carbon Regeneration

The acid wash, elution and carbon regeneration process is a batch process governed by the gold on carbon loading. GBM Report Drawing 0381-G01-F-005 shows the elution and gold room circuit.

Each stage of the pump cell in the adsorption circuit contains a nominal amount of carbon. Loaded carbon is recovered from the first adsorption stage by pumping the slurry and carbon from the tank over the loaded carbon screen. The slurry passes through the screen deck and returns to the feed of the adsorption circuit while the carbon is retained and washed with water sprays to remove the majority of the residual slurry adhering to the carbon. The oversize carbon from the screen falls by gravity into the loaded carbon vessel where it is retained until the acid wash process is commenced.

Loaded carbon is transferred into the acid wash column by opening the carbon inlet valves and the acid wash column drain and overflow valves. Following carbon transfer the prepared acid wash solution is pumped through the carbon bed in the column via a distribution strainer located at the bottom of the column. The spent acid overflow from the vessel is routed directly to the tails pump box.

The acid wash removes the majority of base metal salts from the carbon which would slow down the elution rate, contaminate the final gold product and reduce the carbon activity. The pump is then stopped and the carbon is left to soak in the acid. Following the acid soak period, wash water is pumped through the column to displace and wash residual acid from the carbon bed. Discharge from the column during the water wash step is also routed to the tails pump box.

At the end of the acid wash period a small volume of caustic solution is added to the acid wash tank and the dilute caustic solution is used to neutralise the residual acid on the carbon in the column. Following the neutralisation step the acid wash tank is refilled with water and a further bed volume of water is passed through the carbon bed to remove the residual caustic solution prior to carbon transfer.
Carbon is transferred from the acid wash column by applying high pressure transfer water to the column and into the carbon transfer line feeding the elution column. Following transfer, the elution column is heated to bring the carbon up to the required elution temperature. Water that has been heated using thermal oil via a heat exchanger is passed through the column until the temperature in the column reaches the set temperature. Once this temperature is achieved, the actual elution of gold can be commenced. To prevent the water in the column boiling the pressure in the column must be controlled above the vapour pressure.

Elution is achieved using a caustic cyanide pre-treatment solution followed by a hot water wash. The pre-treatment solution is mixed from measured batches of caustic solution and sodium cyanide which are added to a measured volume of dilution water. Blending of the solutions is achieved using the pre-treatment tank agitator. The pre-treatment solution is pumped into the elution column passing through the two heat exchanger units where it is heated to the set temperature. The caustic cyanide pre-treatment solution initially displaces water from the column. Once the column is completely filled with caustic cyanide solution the pre-treatment step is stopped and the column is allowed to soak to allow the solution to disperse through the carbon bed. During the pre-treatment step the cyanide solution will modify the adsorbed gold cyanide species on carbon making them amenable to subsequent elution using soft raw water in the elution step.

In the elution step, water is pumped through the column and discharged after passing through the recovery heat exchanger to the electrolyte tanks in the electro-winning area. The reduction in temperature and pressure in the column is necessary before carbon transfer from the column is undertaken. Following elution and cooling, the carbon in the column is transferred to regeneration. This is achieved by applying water pressure to the top of the elution column and also into the transfer carbon line between the column and the dewatering screen. This screen dewater the eluted carbon for regeneration.

The carbon is regenerated in a kiln which elevates the carbon temperature and reactivates it ready for adsorption. Regeneration is necessary as carbon is not selective in what it adsorbs and therefore picks up many other
substances readily. As the cyanide solution percolates through the ore mass it will pick up other elements, often organic in nature. The stripping process will leave these substances behind on the carbon, which over time restricts the carbon's ability to adsorb. To counter this, the carbon must be reactivated by having these substances removed by heating the carbon to temperatures above 700°C. To prevent the carbon from combusting at these temperatures, a negative oxygen atmosphere is maintained inside the kiln. Once the carbon has passed through the kiln the leftover ash material and fines are screened off and bagged for disposal. The carbon consists of ‘burnt’ coconut shells from Sri Lanka. The carbon is called green carbon as it does not involve any chemicals in its manufacture and is 100% pure natural product. The disposal of the carbon once it no longer useable [fine ash] in the CIP circuit will be to place it in the tailings impoundment chamber. The reactivated carbon is then ready to be reloaded with gold in the adsorption circuit.

The emissions from the carbon regeneration kiln are collected by a ventilation duct and released outside of the process plant enclosure. These emissions consist primarily of carbon and minor sulphur based oxides generated from the naturally occurring elements in the coconut shells. The fumes will be discharged by the mine ventilation system. These fumes which will be diluted along with those generated by the existing mine equipment and the fresh air drawn into the mine. All spills from drains and overflows of acid wash area gravitate to the acid floor sump, where it is collected, neutralised and pumped to the carbon safety screen. All spills from drains and overflows in the elution strip area gravitate to the elution floor sump, where it is collected and pumped to the pump cell circuit feed.

**Electro Winning & Gold Smelting**

The electro winning and gold smelting process will be designed to run on an as needs basis, which is determined by the fill status of the electrolyte tanks from the elution circuit. GBM Report Drawing 0381-G01-F-005 illustrates the elution and gold room circuit.

The electrolyte tanks area designed to each take the full volume of pregnant solution from the elution column. As soon as the electrolyte tank is full the
feed valve to this tank is closed and the feed valve to the second tank is opened ready to be filled at the next strip. Once the electrolyte tank is full of pregnant solution, the electro winning process can begin. The pregnant solution is circulated though the electro winning cell and back to the electrolyte tank. The cathodes are lowered in to the cell and the rectifier switched on. Electrons are provided to the circulating solution through the cathodes, which encourage the gold cations to precipitate out of solution and plate on to the cathodes. Once the solution is determined to be barren of gold, via a sample from the electrolyte tank, the rectifier is switched off and the circulating pumps stopped. The barren solution is pumped from the circuit back to the leach tank discharge sump. This ensures any remaining gold in the solution is not lost but retained in the circuit.

The cathodes are removed by hand and taken to the cathode wash tank where the gold is dislodged from the cathodes using a high pressure spray. The gold is collected in the tank as sludge and pumped through to the filter press. Compressed air squeezes the water from the sludge. The filter paper is taken by hand, dried in the calcine oven before it is mixed with fluxing material for smelting in the bullion furnace.

On completion of the smelting process, a sample is taken for assaying before the gold bullion is poured into a series of water cooled crucibles. Any adhering slag is removed from the bullion bars, which are then numbered and weighed before storage in the safe and onward shipment to a refinery. The bars assay +90% gold.

Fumes from the electro winning cell are extracted and passed through a scrubber before being released outside of the gold room. During the electro winning process, there is the potential to produce ammonia vapours from the reaction of cyanide and water. Small amounts of hydrogen may also be produced through the electrolysis of water. The ammonia is easily scrubbed from the vent gas with raw water and discharged to the sump. The area surrounding the gold room vent discharge point is monitored for flammable gases using a suitable flammable gas detector. A thermal conductivity meter is one option available for the detection of % LEL of hydrogen.
The calcine oven and bullion furnace includes a vent stack to extract any particulates emanating from the smelting process out of the gold room. The emissions from this process are typical of this operation and are not harmful to personal in close vicinity. Appropriate eye protection will be employed in the gold room during gold pouring. All mechanical equipment will have appropriate barriers to protect operations personnel.

**Plant Layout**

The revised drawing which illustrates the layout of the plant in the underground process factory is held as GBM Report Drawing 0381-G01-G-002.

**Mass Balance**

The detailed mass balance for the process has been analysed by GBM and is contained in Appendix GBM Report Drawing 0381-G01-F-006.

**Chemicals Utilised**

Material Safety Data Sheets (MSDS) for the following six chemicals which will be utilised in the leach process are available and held at Nalunaq by AGM:

- Sodium Cyanide;
- Activated Carbon;
- Hydrochloric Acid;
- Calcium Oxide (Lime);
- Sodium Metabisulphite; and
- Sodium Hydroxide.

It can be confirmed that Angel Mining (Gold) A/S will take all the necessary precautions and actions laid down in the various MSDS with regard to safe handling and usage so that no environmental, health or safety hazards arise.
**Waste Rock and Process Waste**

Gravity processed material (fine tailings) derived from the ROM ore in the initial stages of the project will be removed in the gravity grinding and concentration process. This waste material will be put to temporary store within the mine for later re-treatment through the CIP circuit. With the provision of the full process plant, due to the increase in ore production planned for that phase, waste tailings rock will be generated even given that the proposed new mining method will give rise to less dilution. All waste rock tailings produced will be replaced into the mine workings as a rockfill/tailings material so that no waste rock or tailings will be placed to permanent dump externally above surface. It will not be necessary to provide or operate a surface Tailings Management Facility (TMF) or tailings dam.

**Processing Outside the Mine**

No mineral processing will take place outside the mine. All waste rock produced by the mining process and from the process stream, including tailings, will be utilised in the system of backfilling the stopes. **No waste material of any sort will be removed from the mine.**

**Provision of Power**

All power for the mine, camp, harbour area and telecommunications station will initially be supplied by the existing diesel-powered generators. The present total installed power left by Crew amounts to about 1.7MW (1700kVA). This comparatively modest power provision will need to be increased to power the new process and doré plants. Generators are presently located at 4 places:

- mine entrance (350m level);
- mine camp;
- harbour; and
- telecommunications station (1.5km away from the camp).

The mine generators produce electricity at 60Hz, 600/115V while the generators serving the camp and the other facilities operate at 50 Hz, 400/220V.
• Mine Generators

Of the three generators at this location, normally two are operating with the third held as backup. The generators are located in sea-containers placed just outside the mine entrance at the 350m level adjacent to the mine compressors and heaters. All the generators and other plant at this place are poorly set up and poorly located. Historic and expensive fuel spillages have remained untreated during the Crew operations despite requests from BMP.

• Camp Generators

The two generators at this location stand in the open air with one generator operating and the other held as backup. These generators are poorly set up and poorly located.

• Harbour Generators

This installation comprises two generators which are only run during ship loading operations and require only minor upgrade. The generators are not needed for supplies unloading and will not be required for the continuing operations. The containerised ANFO mixing plant which is also located at the harbour at present but which will be relocated to the mine, has its own small on-board generator.

• Telecommunications Station Generators

The telecommunication station, located 1.5km away from the camp and in fair condition is powered by two generators - one operating with the other held as backup - placed in a 6m container. The station also has a battery backup which will last up to two days. The adjacent fuel tank lasts for about a month and is easy to re-fuel as the tele-station is next to the road to the harbour.
Planned Changes to the Power Generation System

- Mine and Camp

As noted above the present locations and set up of the camp and mine generators and compressors are extremely unsatisfactory and inadequate. AMG are making early changes to the generator complement and location and to clean up the oil spillage pollution which has been identified at the 350m surface level. All the mine and camp generators will be re-sited at the former mine workshop near the camp which will become the power station. The generation capacity will be increased by 1MW and at the same time all generators will be replaced. A new 20m$^3$ capacity double skinned fuel tank will be sited by the new power station with appropriate emergency bunding. As noted previously the harbour generators will no longer be required.

Nalunaq Mine Camp

The mining camp at Nalunaq is made up of permanent buildings, tents and live-in containers with a maximum sleeping capacity of up to 120 persons. In addition numerous containers are used as sheds, workshops and storage. Buildings include kitchen block, office block, miners’ block comprising emergency room, miners’ washing and changing facilities and drying room, shift boss office, and ambulance garage, recreation block containing gymnasium, common room with television etc. and an internet room, laboratory block, water plant & well, fire fighting container and generator shed. Other camp infrastructure includes sewage plant, telecoms station, workshops and storage containers and an anti-avalanche cannon.

Workshops, Materials Delivery and Storage

All supplies and consumables are delivered to the site via the harbour facility and delivered by road to the site.

The petroleum tank farm at the harbour site has a capacity of 600,000 litres and is serviced by sea-borne tanker delivery utilising an industry standard floating delivery hose system. The fuel for the generators, compressors and
heaters is delivered by road by a tanker truck. Adjacent to the camp generators there is a fuel tank of 16,000 litres, which represents about a month’s requirement. The camp’s vehicles are also fuelled from this tank. As noted above as part of the camp upgrade this fuel storage will be replaced by a new 20m$^3$ capacity double skinned fuel tank.

Ammonium nitrate for use in explosives (ANFO) manufacture is delivered to the harbour by sea in 1 tonne bags and stored in containers close to the harbour.

**Warehousing**

The spare parts warehouse is located some 500m from the main camp. It is a modern, light steel shell construction building with semi-circular corrugated steel roof. It is a main depository of all the spares and supplies for the mine and the camp, though small quantities are stored in the mine workshop and electricians’ workshops at 350m level and in the camp. Some items (drill steel, oil drums etc) are stored outside in the open on the adjacent concrete pads.

**Mine Workshops**

Located next to the warehouse the mine workshop is a large steel frame building of modern construction with steel cladding which was used as the main camp workshop and for parts storage. A second mine workshop of similar construction is situated nearby with a adjacent storage area. There are also electrician’s and handyman’s workshops. Adjacent to the workshops is a large used tyres storage area. These tyres will be used to improve the road safety and be used in the ramp construction of the underground processing plant.

**Explosives store**

The explosives store is located by the main road 2 km away from the camp and 3.4 km from the mine. It is made up of ten 6m containers in an enclosure with chain link and barbed wire fencing. The explosives storage permitted (by the BMP licence) at this place is up to 60 tonnes of explosives. The ANFO mixing plant will be brought up from the harbour and placed here, in a
separate compound and within the requirements of the legislative framework, so that ANFO will be prepared adjacent in quantities as immediately required. The bagged ammonium nitrate prills will be stored in the containers near the harbour and delivered to the ANFO mixing area at the mine as required. No made-up ANFO or other explosives will be kept at the AN storage area. Dynamite and HE, detonators, detonating cord, and small quantities of ready-mixed ANFO will be kept in the explosives store.

**Mine Camp Waste, Packaging Waste and Waste Water**

**Solid Waste Disposal**

There is no landfill site at Nalunaq. All combustible waste is burned in a makeshift incinerator 3.5km from the camp. There is no designed incinerator onsite and it has not been required by BMP. All incombustible material will be packed into the special rubbish containers located adjacent to the makeshift incinerator and periodically shipped to the landfill area at Qaqortoq via the harbour. AMG intend to institute measures to increase recycling of materials in order to minimise the amount of rubbish produced and hence decrease the amount of burning and the quantities for disposal at Qaqortoq.

Adjacent to the workshop is a large used tyres storage area. The majority of the tyres will be used to improve the road safety bunds on the road from the harbour to the mine/camp area. Upon final closure of the mine it is anticipated that BMP will permit any remaining tyres and steel scrap to be stowed in the mine. AMG intend to minimise all waste produced and stored on the site.

**Sewage disposal**

Camp sewage and waste water will continue to be treated through the existing proprietary EcoLine 2N-BFK10 biological treatment plant provided by the Danish company AEC International. Underground standard 110mm pipes with no trace heating bring all the camp sewage and waste water to the sewage well located 150m from the camp. From there it is pumped to the adjacent treatment plant. The plant is located in an open steel container with a pitched roof and consists of 3-stage sedimentation cells with bacteria
treatment. The operation of the plant is automatic and it requires little maintenance. Some instances of poor operation and management have been noted in the past but have been resolved. AMG will carry out a thorough overhaul of the system and carry out regular routine maintenance as necessary.

The treated effluent from the sewage plant is disposed by a system of fan-shaped drains going into the gravel beds by the riverbed and eventually into the river itself. The discharged water is visually clean, and the only immediately noticeable environmental impact of the plant is the increased growth of stream algae, due to increased supply of nitrates, around the disposal area. Water leaving the plant will be sampled and analysed monthly in summer and bi-monthly in winter. The monitoring programme will be designed and agreed with BMP. Historically the sewage sludge from the plant has been regularly removed by a dedicated sewage truck and driven 10km to the harbour and disposed of into the sea in a place where the water is deep and with strong currents. The sewage truck can also be used to empty the sewage well in case of the treatment plant's malfunction. This procedure is approved by the BMP but other more environmentally sound procedures will be investigated by AMG. The alternative ideas are primarily to use the waste material as a material [once dried] as a combustible fuel in a site power generation plant. This is part of the projects desire to utilise renewable energy systems at all Greenland operations.

**Product Transport, Harbour Issues, Shipping and Ship Loading**

At present, the area around the harbour on the Saqqaa Fjord contains the following facilities:

- ore stockpile
- ship loader (including grizzly and crusher) and supplies reception
- main fuel depot
- ammonium nitrate storage
- ANFO mixing facility

AMG intend to make some major changes to this facility as noted below.
The ore stockpile area is adjacent to the barge with the ship loader. There is no building, shed or any other weather protection. The ore pad, which is underlain by a geotextile membrane, can hold up to 50,000 tonnes of ore. A grizzly and crusher are in place as part of this stocking facility. An estimated quantity of around 9000 tonnes remains on the pad from previous operations and is now owned by AGM. AGM intend that this stock, as an early part of the mines opening phase, will be lifted and trucked to the mine for processing at the underground process facility. The geotextile membrane will also be removed and the stockpile area will be fully cleared of all traces of ore.

The ship loader system comprises a 200m long conveyer belt for loading the ore to the ships. The length of the conveyer can be altered to suit different types of ships, but is unable to slew sideways thus requiring that the ship has to move instead. The ship loader is powered by a 200 kVA generator that has a 400t/hr design capacity and can handle rocks up to 150mm in size. The real-life capacity is 300-350t/hr. An 8kt vessel can be loaded in 24 hours. As AMG will not be shipping any ore or material out of the harbour it is intended to fully decommission and sell the ship loading facility along with the crusher and grizzly. The decommissioned stocking area will be sympathetically re-profiled and rehabilitated to generally conform with the surrounding landform.

All materials and consumables for the mine and camp are delivered by sea. The company barge at the installation is used to receive containers and pallets with mining equipment, supplies and consumables. Apart from a mobile crane, rated at 30t, permanently residing on the barge, there is no equipment to handle containers, so they are moved using the crane. After unloading, goods are transported to the camp and mine by road on a flat bed trailer.

Adjacent to the harbour is the main fuel depot for the Nalunaq operation. It consists of 4 steel tanks, in good condition, capable of holding 150,000 litres each - total capacity 600,000 litres. The tanks are filled from tankers moored in the fjord with a 300m long hose. A tanker truck moves fuel to the mine and the camp as required.

Ammonium nitrate prills are delivered to the harbour by sea in 1000kg “Big Bags” and stored in containers close to the harbour. The ANFO mixing plant
will be moved to the mine and all ANFO mixing will be carried out there in due course. The ammonium nitrate storage containers in the harbour area will continue to be used with deliveries to the mine being undertaken as required.

## 13 Legislation

### Greenland Government Legislation

Greenland has a well-established ‘one-door’ system of administrating the country’s mineral resources. Handled by the Bureau of Minerals and Petroleum (BMP), this system simplifies application and operating conditions in the country. All land is held by the State, with no land being privately owned, which simplifies the mineral resources legislation. The BMP is in charge of licence applications and the regulatory functions related to the activities of a licensee. It can help with all aspects of mineral exploration and development projects, and is assisted by the National Environmental Research Institute (NERI) (part of the University of Aarhus in Denmark), and by the Geological Survey of Denmark and Greenland (GEUS). The previous joint minerals administration arrangements between Greenland and Denmark will shortly be superseded and are not further discussed in this report due to their forthcoming redundancy.

The main piece of legislation relating to mineral production is the Act on Minerals Resources in Greenland known as the Minerals Resources Act, Act No 335 of June 6th 1991 and amended by Act No 1074 of December 22nd 1993, Act No 303 of April 24th 1996 and Act 317 of June 3rd 1998. This is seen in English translation in Order No 368 of June 19 1998 by the Danish Energy Agency.

**Mineral Resources Act: Background:**

The Mineral Resources System for Greenland, establishes the framework for administration of mineral resources in Greenland.
The following are the principal features of the System:

- Recognition of the fundamental rights of the resident population of Greenland concerning mineral resources in Greenland;
- Conferral, on the government of Greenland of competence in major decision-making concerning mineral resources in Greenland;
- Conferral, on the government of Greenland, of public revenue from exploitation of mineral resources in Greenland; and
- Creation, under the Government of Greenland, of the Bureau of Minerals and Petroleum (BMP), as the agency charged with the central administrative, coordinating, and regulatory tasks in the development of mineral resources in Greenland.

The Mineral Resources Act provides for prospecting, exploration and production licences. The prospecting licence is non-exclusive and is normally granted for five years over large areas. Any exploration licensee who delineates a viable mineral deposit is entitled to be granted a production licence. The transition between these two licence types is described in the standard terms for exploration licences. The production licence is also exclusive, and will normally comprise a restricted area covering only the deposit. Production licences are normally granted for 30 years and can be extended to 50 years. Normally granted to public limited companies domiciled in Greenland, they are also only issued to companies that can demonstrate that they have the necessary technical and financial capabilities needed to establish a mining operation. A production licence allows the licensee to construct the facilities needed for the project, subject to the BMP's approval of the development plan, which includes an environmental impact assessment and restoration plans. Standard terms apply to the licences in each category.

Section 10 of the Mineral Resources Act requires that "Prior to the commencement of exploitation and development activities a plan for the activities.............shall have been approved by the Greenland Home Rule Government...". Further the BMP Guidelines for preparing an EIA for Mineral Exploitation in Greenland state that "An EIA must be prepared when a company prepares to exploit a mineral deposit."
Sections 10 and 19 of the Minerals Resources Act set out requirements for the operation of a project and the actions to be taken at the project's closure. Detailed requirements in the form of a Draft Model Licence were published by BMP in June 2007.

Section 25 of the Minerals Resources Act sets out in detail the requirements for the establishment of the various infrastructure required and the measures to be taken at closure for the removal of this infrastructure.

Complying with the requirements of Sections 10, 19 and 25 are integral to the approval of an exploitation licence by BMP.

Under the Greenland Income Tax Act, any company holding a production licence is subject to corporate income tax. There are no ring-fencing rules with respect to mineral activities. Tax losses can be carried forward for an unlimited period and, in certain cases, can be carried back for five years. Assets can be fully depreciated in the first year, or over time. Dividends are normally deducted from taxable income. In addition, the Government of Greenland can grant a special annual relief of up to 10% on direct investments for adding value to mineral products.

Other legislation which will apply to the project includes:

- Law on Labour and Working Environment in Greenland – Act No 1048 of 26th October 2005;
- Regulations on Explosives – Regulation No 14 of 21st August 2006;
- Greenland Building Regulations – 2006;
- Regulations on Archaeological Sites and Artefacts – Regulation No 5 of 16th October 1980; and
- Regulations for Flammable Liquids – Regulation No 9 of 6th March 1986,

or as recently amended.

Greenland participates actively in Inuit Circumpolar Conference and is a member of the Arctic Council. These intergovernmental bodies give rise to
various Codes of Practice and recommendations which apply in general to activities taking place in the Arctic.

14 Environmental Background & Baseline Studies

Introduction to Situation

The project is based on the acquisition and reopening of an existing permitted mine so that baseline conditions can be taken to be a combination of the true pre-mining baseline studies undertaken from the mid 1990s until the present day and the present existing position whereby nearly 5 years of mining operations have already taken place.

Baseline Conditions

Prior to the opening of the original mine operation in 2004, a number of environmental baseline studies were carried out. The first study was on the Arctic char population in the Kirkespir River in 1988 (Boje\textsuperscript{25}). During the exploration phase, freshwater samples from the Kirkespir River were analysed for metals and general parameters (Lakefield\textsuperscript{26}). Comprehensive baseline studies were performed during 1998-2001 and collected fish, mussels, seaweed, snow crab, sea urchin, benthic macrofauna and sediments and analysed these for different metals (NERI 384\textsuperscript{27}). The above and other NERI studies (NERI 427\textsuperscript{28} and NERI 562\textsuperscript{29}) were included in the Environmental Impact Assessment prepared for Crew by SRK Consulting in 2002\textsuperscript{30}.

Since then, during the operations of Crew between 2004 and February 2009, a number of studies Appendices (NERI 546\textsuperscript{31}, 567\textsuperscript{32}, 581\textsuperscript{33}, 614\textsuperscript{34}, 662\textsuperscript{35} and 698\textsuperscript{36}) have been carried out, including the yearly NERI environmental reports, held at Appendices so that there is a good deal of baseline data ranging from the original virgin area to what is now a brownfield site.

Conclusions Drawn by the Annual NERI Monitoring Reports

NERI Report 546 - 2004

"In general, the elements that showed elevated or slightly elevated concentrations in one or more organic tissues were Zn, Cu, Cr, As and Co. Arsenic was slightly elevated only in lichens (airborne), whereas Zn was slightly elevated only in Brown seaweed (waterborne). Elevated concentrations were on average 3-9 times higher compared to the baseline level measured in the same area prior to mine start. Except for Cr, these elevated concentrations of the above elements could be expected after the start of the mine. Drainage from ore and waste rock prior to mining activities showed elevated or slightly elevated concentrations of Al, Co, Cu, Hg, As, Cd, Pb and Zn compared to Ontario’s water quality guidelines.

In Kirkespir Bay, marine mussel and seaweed stations (M3 and M4) closer to the Kirkespir River outflow had slightly higher concentrations of some elements compared to the stations closer to the pier area (M1 and especially


This indicates that elevated concentrations in the marine organisms stem from the mining area from where elements are transported via the Kirkespir River. The pier area seems therefore not to contribute specifically to elevated concentrations in the marine environment. Resident Arctic char had 2-3 times higher concentrations of Cr and Co in their liver compared to background concentrations.

In the Kirkespir Valley and Bay area, 4-10 times higher concentrations of mainly Cu, Cr, As and Co in lichens were found in three areas. These areas are the pier area, the camp area and an intermediate area near the waterfall. Elevated concentrations in the pier and the camp area can be explained by the dispersal of dust from ore stockpiles.

Elevated concentrations in the third area could be an effect of dust carried by the wind from the stockpiles in the camp area and down the valley.

It is documented that there is an impact from the mine on the local environment. Concentrations of some of the analysed elements in some of the organisms were elevated 2-10 times compared to the baseline level found during surveys in 2000 and 2001 (Asmund 2000, 2001). Elevated concentrations were found within 5-10 km of coastline near the mouth of the Kirkespir River. This is considered a moderate impact, since only a small area is affected and increases in element concentrations are small. The impact at Nalunaq is much less than at the closed mines at Maarmorilik (Johansen et al. 2003), Ivittuut (Johansen & Asmund, 2005) and Mestersvig (Aastrup et al. 2003). At Maarmorilik and Ivittuut lead is elevated up to about 1000 times, and more than 100 km of coastline is affected at Maarmorilik and 50 km at Ivittuut. At Mestersvig lead is elevated up to 100 times and more than 40 km of coastline is affected. Because monitoring must be performed on an annual basis it is possible to follow the development of the contamination and take mitigating steps.

Prevention of dust from the two stockpile areas should be discussed with the mining company. Also, a possible explanation of the observed elevated concentrations of elements in lichens in the waterfall area should be discussed with the company.”
"In this 2005 monitoring study slightly elevated (2-5 times) average concentrations of Cu, As and Co were found in lichens only. None of the remainder average concentrations of the analysed elements in any of the organisms were elevated. An overview of the contamination of the entire area is presented by average concentrations, while contaminations of specific areas are presented by concentrations at single stations.

Compared to the monitoring study conducted in 2004, only three elements (Cu, As, Co) showed elevated average concentrations compared to five (Cu, As, Co, Zn and Cr) in 2004. Elevations were in general lower in 2005, and in 2005 there were no elevated average concentrations in the marine environment.

Elevated concentrations of Cr (9 times) were found in brown seaweed from station M3 near the mouth of Kirkespir River, and slightly elevated concentrations (2 times) of Zn and Co were found in seaweed from both station M3 and M2 close to the pier. This indicates that impacts come from both the mining area (e.g. mine water and rock crushing) and the pier area (ore stockpiling and loading). Also, slightly elevated concentrations (2 times) of Zn were found in seaweed from station M4. Dust from the road, maintained primarily by waste rock material, and from the mining area can also contribute to elevated concentrations. No elevated concentrations were found in sculpin liver. Resident Arctic char had no elevated element concentrations in their liver.

In the Kirkespir Valley and Bay area, 5-16 times higher concentrations of Cu, Cr, As and Co in lichens were found in the pier, the waterfall and the camp areas. An identical picture was found in 2004 except for As which was elevated 16 times compared to 9 times in 2004 in the camp area. Elevated concentrations of the four elements in lichens were in most of the Kirkespir Valley an effect of dust from the road, and concentrations above the background level could be found at a distance of about 1000 m from the road. An additional contribution to the concentrations came from the camp area, probably from the rock crusher, from stockpiled fine-ground rock and from mine traffic.
As in 2004, there is an impact from the mine on the local environment. Slightly elevated concentrations are found within c. 5 km of coastline near the mouth of the Kirkespir River. Compared to 2004 the impacted marine area is smaller. This could be an effect of stockpiled fine-ground ore that was removed from the area and shipped to Spain late 2003 and mid 2004. The Kirkespir Valley floor is impacted mainly from dust from the road, but also from mine activities. Element concentrations in 2005 were similar to 2004, except for arsenic in the camp area where the level was doubled.

Prevention of dust from road and camp areas should be discussed with Nalunaq Gold Mine. It is recommended that waste rock is used for road maintenance only if element analyses of fine-ground waste rock show no significant differences from fine-ground rock from existing approved quarries. Dust from the road can be reduced by watering the road during dry periods.”

NERI Report 614 - 2006

"The report describes the third year of environmental monitoring in the Nalunaq Gold Mine area. Sampling procedures in 2006 were unchanged so results are comparable to those from the two former years. No elevated concentrations were found in blue mussels and shorthorn sculpin livers, while brown seaweed had slightly elevated concentrations of Co at one sampling station. Thus, element elevations were very few in the Kirkespir Bay indicating a very low impact on the marine environment in 2006. Compared to higher concentrations in mainly seaweed, but also in blue mussel and sculpin, in 2004 and 2005 the concentrations of metals in the marine environment appear gradually to have become less from 2004 to 2006.

In resident Arctic char liver average Cd concentrations were elevated twice. Cr and Co were slightly elevated in 2004 while no elevations were found in 2005. Thus, during the three years period only minor elevations of Cr, Cd and Co have been seen.

In the lichen Cetraria nivalis elevated concentrations of Cu, Cr, As and Co between 2 and 15 times above the background concentrations were found at the waste rock depot and in the mine and the camp area. Elevations were
caused by dust dispersal from the camp area, from waste rock crushing and from driving on the roads. Elevated concentrations in the two areas were not significantly different from those found in 2005. Concentrations of the four metals in lichens from the waste rock depot were in 2006 significantly lower than concentrations in lichens from the camp area; in 2005 a significant difference was seen only in arsenic. The contamination of copper, chromium and cobalt from the road was significantly smaller in 2006 than in 2005, but concentrations above the background level can, as in 2005, be found to a distance of about 1000 m from the road.

As in the two previous years, an impact from the mining activities on the local environment could be seen in 2006, primarily in the Kirkespir Valley from dust dispersal. The impact from the road was in 2006 lower than in 2005. In the river and in the bay, element elevations were very few and the impacted area was smaller than previous years. To evaluate the rate of dust pollution from the different sources, it is recommended that the year to year variation in lichen contamination is measured by transplanting lichens from an uncontaminated area to 5-10 stations in the Nalunaq area.”

NERI Report 662 - 2007

“The report describes the results of the fourth year of environmental monitoring in the Nalunaq Gold Mine area. No elevated concentrations were found in blue mussels and shorthorn sculpin livers, while brown seaweed had slightly elevated concentrations of Co at one sampling station. Thus, element elevations were very few in the Kirkespir Bay indicating a very low impact on the marine environment in 2007. In 2004 and 2005, concentrations of especially Cr, but also concentrations of Cu, Co and Zn were elevated in seaweed. In 2004, elevations of Cr were found in sculpin livers and of Co in blue mussel. The concentrations of metals in the marine environment appear in the last two years to have stabilised around the baseline level.

In resident Arctic char livers no average concentrations were elevated in 2007 compared to baseline concentrations. Compared to the three previous years, Cr, Co and Cd were slightly elevated in 2004 and 2006, while no elevations were found in 2005. Thus, only minor elevations of Cr, Co and Cd have been seen in two of the four years.
In the lichen Cetraria nivalis concentrations of Cu, Cr, As and Co in 2007, like in the previous years, were significantly elevated compared to the background level at the depot of crushed waste rock and at the camp and mine area. Elevations in the two areas in 2007 were 5 times for Cu and Cr, 15-20 times for As and 10 times for Co. Concentrations of the four metals in the two areas were in general significantly higher in 2007 than in 2006, but this seems not to indicate a trend from 2004 where monitoring began. In all of the years 2004-2007, concentrations in lichens of Cu and As were significantly higher in the camp area than in the depot area. The relationship between metal concentrations in lichens and the distance to the gravel road did not differ significantly between the years 2005-2007 for any of the metals. All metal concentrations showed a significant decrease with increasing distance. Concentrations of Cu, Cr, As and Co above the background level could, as in previous years, be found to a distance of about 1000 m from the road. Because metals are excreted from the lichens at a low rate, a reduction in dust pollution will be difficult to detect within a few years period.

To solve this problem, lichens were in 2007 transplanted from an uncontaminated area to the Nalunaq area. By leaving the lichens for one year and then analyze them for metal concentrations, we will be able to measure the year to year variation in the lichen contamination and thereby determine the rate of dust pollution in different areas.

As in the three previous years, an impact from the mining activities on the local environment could be seen in 2007, primarily in the Kirkespir Valley from dust dispersal. The impact from the road was in 2007 higher than in 2006. In the river and in the bay, element elevations were very few and the impacted area was as small as in 2006.”

NERI Report 698 - 2008

"The report describes the results of the fifth year of environmental monitoring in the Nalunaq Gold Mine area. No elevated concentrations were found in blue mussels and shorthorn sculpin livers, while brown seaweed had slightly elevated concentrations of Co at one sampling station."
The impact from the mining activities on the marine environment was in 2008 found to be very low. During 2006-2008 the only significant elevation in the marine environment was Co concentrations in seaweed from station M3.

In resident Arctic char livers no average concentrations were elevated in 2008 compared to baseline concentrations. In 2004 and 2006, Cr, Co and Cd were slightly elevated, while no elevations were found in 2005 and 2007. In conclusion, only minor elevations of Cr, Co and Cd have been seen in two of the five years.

In the lichen Cetraria nivalis concentrations of Cu, Cr, As and Co in 2008, like in previous years, were significantly elevated compared to the background level at the depot of crushed waste rock and at the camp and mine area. Elevations in the two areas in 2008 were 4-5 times for Cu and Cr, 19 times for As and 9 times for Co. Concentrations of the four metals in the two areas during the period 2004-2008 showed differences in temporal trends. Concentrations of As and Co increased significantly during the period in both areas, whereas concentrations of Cu and Cr did not show significant temporal trends during the period. As was the only metal that showed differences between the two areas, with significantly higher levels in the camp area. We have tested the relationship between the concentrations of Cu, Cr, As and Co in lichens and the distance to the gravel road; the test included differences in levels among years. All concentrations of the four metals showed a significantly decrease with increasing distance. Metal concentrations above the background level could, as in previous years, be found to a distance of about 1000 m from the road.

It is remarkable that transplanted lichens in just one year had concentrations equal or even higher than in lichens growing naturally in the Kirkespir area. This indicates higher dust pollution in some areas in 2007-2008 than in 2006-2007. Such areas are especially the pier area and the depot of waste rock.

In 2008, the impact from the mining activities on the local environment was primarily observed in the Kirkespir Valley and originated from dust dispersal from road, mine, pier and depot. For the first time temporal trends with increasing concentrations of As and Co in lichens were demonstrated. In the
river and in the bay, element elevations were found only in seaweed from just one station.”

Dust

Prior to the start up of operations, the remoteness of the site, its physical identity and the almost total lack of roads or any activity in the wider area would have meant that the area would be almost totally dust free. Mining activity, in particular the dumping of waste rock in permanent above ground tips and the travelling of mobile plant, vehicles and lorries across often bare ground, waste rock hardstandings and site roads and over the permanent gravel access road would and did give rise to the production of fugitive dust. The strong gusty winds would also have given rise to dust blow off undressed rock slopes. The NERI Environmental Monitoring Reports for the operation for 2006, 2007 and 2008 noted that the environmental effects from the mine impacted primarily on the Kirkespir Valley and chiefly originated from dust dispersal. Elevated concentrations of copper, chromium, arsenic and cobalt above natural background levels were identified in lichens at the waste rock dump and in the camp area. All the metal concentrations showed a significant decrease with increasing distance from the road with elevated concentrations found to a distance of about 1000m from the road. These metal elements naturally occur in very low levels in the waste rock.

Noise

Apart from the existing mine operation, there are no man-made sources of noise at Nalunaq, and no noise sensitive receptors, such as schools or hospitals, in the immediate vicinity.

Pre-mining background noise levels, as LAeq90, were not measured but were held to be likely to be of the order 30-35 dB(A), or less, based on noise levels measured at other remote sites. With little or no activity on site at present, the area is extremely quiet with low ambient levels similar to those indicated above.
Blasting vibration

With no activity on site, ground vibration levels are practically non-existent, and Voss et al\textsuperscript{37} have noted that the overall seismic hazard in Greenland is low compared to the many other natural hazards. However, large destructive earthquakes can occur unexpectedly even in areas with low seismicity.

Research elsewhere in Greenland reported in March 2006 by scientists\textsuperscript{38} from Harvard University and the Lamont-Doherty Earth Observatory at Columbia University suggested that accelerating ice flow from the main ice-cap has been accompanied by a dramatic increase in seismic activity. The report asserted that this movement of the glaciers may now generate local swarms of earthquakes up to magnitude 5.0.

Light Pollution

The area is very remote from all habitation or other activity and experiences naturally high levels of normal darkness. Permanent lighting is installed for security purposes at the mine ventilation outlets on the mountain. The present low level of activity on the site at the present time is likely to give rise to very low levels of light pollution.

Ecology

Terrestrial Flora

The plant communities in the Kirkespir Valley are typical of those found throughout the Nanortalik region and southern Greenland. None are considered exceptional or worthy of designation and there are no statutorily protected habitats, communities or species recognised by the Ministry of Environment in the area. Nevertheless, each community is a fragile ecosystem, which is slow to develop in the prevailing climatic and soil conditions and hence vulnerable to physical damage.


The principal communities consist of the following:

- a lichen/moss community that is most prevalent on rock outcrops, particularly in the Upper Valley;
- a dwarf-shrub heath community, often with associated mosses and lichen, in the Lower Valley;
- a shrub willow community, especially in the river delta close to the shoreline;
- fen and marsh wetland associated with the lower reaches of the river; and
- areas of grass close to the shore on sandy ground.

In addition there is a small community of the Small White Orchid, which is the commonest Greenland orchid, in the Upper Valley, which will not be disturbed by the mine's operations.

The lichen *Cetraria nivalis* frequently grows directly on decaying organic material, either dead lichen thallus or moss carpets. As a result, there are limited opportunities for the lichen to absorb nutrients from the underlying rock or soil and a significant source of nourishment is from whatever falls upon it from the atmosphere, such as dust, snow or rain. This forms the basis of its use as an important bio-indicator.

Terrestrial Fauna

The range of animals and the numbers of individuals found in the Kirkespir Valley are limited by the types of plant communities and the low productivity of the habitats present. There are no species that are rare or threatened in the area and all are relatively common throughout southern Greenland. The Greenland government has not designated any nature conservation areas that require special protection and there are no migratory species that are particular to the area, or protected breeding birds. The shore line of Saqqqa Fjord support the greatest variety of fauna with shore birds such as wintering Brünnich’s guillemots, common eiders and long-tailed ducks. Within the valley the arctic fox, alpine hare, white-tailed eagle, gyrfalcon, snow bunting, Lapland longspur, redpoll, ptarmigan, a few wader species, and raven are present. Insects, such as butterflies, e.g. clouded yellow and arctic fritillary,
arctic bumblebees, blackflies, mosquitoes, and other flies are found during the warmer months.

Aquatic Flora

The principal fish present in the Upper Valley of the Kirkespir River are small sticklebacks and the benthic macroinvertebrates present will be restricted to groups such as the Stoneflies and Mayflies.

In the Lower Valley, below the waterfall, the predominant fish species is the Arctic char which species is widely distributed in southern Greenland and the Arctic in general and which breeds in most large rivers and lakes. In the Kirkespir, the species is present in both anadromous (migratory and sea-going) and nonanadromous (freshwater resident) forms. The migratory form enters the fjord in May-June and returns to spawn in September. It is larger than the resident type because food is more plentiful in the sea. Most fjords in the Nanortalik district are fished with pound nets at the mouths of the Char rivers. The population structure of Char in the Kirkespir River is not known, although it was electro-fished at the end of the 1980s, when the population was described as normal. The Arctic char population, however, is viable and important to local people and to tourists as a fishing resource.

The 2008 NERI Monitoring report found that the impact from the mining activities on the aquatic environment was low.

Marine Fauna and Flora

DMU/NERI scientists undertook extensive surveys of the marine biota in the Saqqaa Fjord in 1998, 2000 and 2001. These investigations related to the benthic macrofauna in the deeper zones (>200m) of the fjord, the free living fish and bottom dwelling organisms in the shallower (20-200m) parts of the fjord, and the species within the littoral and shore zones.

---

Sampling revealed the following:

- A total of 1563 benthic animals were identified from the 75 samples and separated into 70 taxa. The faunal composition (in terms of major taxonomic groups) was typical of high latitude boreal fjord basins and all collected species have been recorded from the high boreal/low arctic areas around Greenland;
- Polychaete worms accounted for some 80% of all the individual animals, but the major contributors to biomass was equally divided between three animal groups: Polychaeta, Mollusca and Echinodermata. In general, the fauna were characterised by deposit feeders, polychaete worms and protobranch bivalves;
- Conspicuous species with relatively large individual size were the bivalves *Yoldia hyperborea* and *Megayoldia thraciaeformis* and the sea star *Ctenodiscus crispatus*;
- Saqqaa Fjord was poor in bottom fish, but rich in crabs including several species of sand crabs and many large snow crabs.
- Fish surveys revealed the following main species: Shorthorn Sculpin, Atlantic Cod, Greenland Cod, Eel Pout, Skate, Spotted Wolfish, Greenland Halibut and deep sea Prawn;
- The principal species of the littoral zone that have been investigated at Nalunaq are the Blue Mussel and the brown seaweed Bladder Wrack.

The 2008 NERI Monitoring report found that the impact on the marine environment from the mining activities was very low.

Designated Wildlife Areas

There are no BMP designated wildlife areas, RAMSAR sites, National Parks, Areas of International Importance or areas with any other special ecological or landscape designation within the area of the project including areas of special importance to wildlife or areas with valuable, sensitive or representative biotopes.
Landscape, Physical and Visual Intrusion

Prior to start up of the mining operation the project area was a virtually untouched arctic wilderness with little habitation or activity of any sort apart from some subsistence sheep grazing. The majority of the licensed area remains in a similar untouched and undisturbed condition, apart from the site of the mine and camp itself, the line of the gravel road to the harbour and the harbour facility. The mine and camp area at Nalunaq can now be thought of as a brownfield site where the industrial operations which were its reason for existence will soon be resumed. The buildings and facilities provided by the previous owner and operator are still in place but requiring refurbishment or replacement.

Whilst the mine and camp represent a degraded landscape, the areal scale of the degradation, when compared with the overwhelming physical scale of the surrounding pristine landscape, is insignificant. Thus the visual intrusion of the existing mine landscape is minimal. Also because of the remoteness of the area from habitation, there are very few receptors for the visual impact, comprising occasional river fishermen and tourists.

Pollution

Prior to the mining operation the area was pristine and unpolluted. As previously noted elevated levels of some metals have been noted due to dust blow. More serious is the pollution caused by oil spillage at the 350m level generator station. No other significant pollution caused by the previous mining operations is notable.

Fresh Water Quality

Water sampling carried out prior to the start of mining in 2004 by Lakefield Research concluded that the water quality was generally very good, with near neutral pH conditions, odourless and without sediment or visible suspended solids.

---

Mining operations do not appear to have significantly impacted on water quality. AMG have identified and recognised that the sedimentation lagoons for water treatment, situated prior to discharge into the Kirkespir River are in poor condition and intend to completely refurbish them as a priority.

**Air Quality**

Pre mining surveys, by Lakefield as above, suggested that the concentrations of pollutant gases at the Nalunaq site were extremely low, and could be considered to be negligible. The most important sources of atmospheric pollutants are Europe and North America, through the long-range transport of gases in the upper atmosphere and their subsequent deposition with precipitation. No data are available for deposition rates at Nalunaq but river water quality and the abundance of mosses and lichens suggest acid rain deposition is not an issue.

**Land-use, Agriculture and Soils**

The land capability of the Kirkespir Valley is negligible, and there are no productive land uses, other than the Nalunaq mine operation. The area is undeveloped and has not been otherwise exploited in the past, apart from historic usage shown by its archaeological history. As will be seen in the Cultural Heritage section following, in the years 1000 CE – 1500 CE there was a large Norse farm with around 20 buildings near the Kirkespir delta with live stock grazing the entire valley. In the upper valley soil development is non-existent and the climatic conditions, severe slopes and inhospitable aspects limit plant growth severely. The instability of the valley slopes and the river flows also limit the extent to which the area could be developed. In the lower valley conditions are not very much better. Climatic conditions are equally exacting, although more amenable closer to the fjord. It is here that potential productivity is highest, and the only part of the valley where soil forming materials are present in any quantity. The natural vegetation cover consists of grasses and shrubs, together with mosses and lichens over the rockier areas. Sheep rearing is the only potentially viable commercial land use, although the area that could be used for grazing is limited and would only support a small flock of sheep. In 1997 there were eight sheep farms in the Nanortalik municipality, five on the western coastline of the Aluitsoq Fjord and three
between the settlement of Tasiusaq and Lake Tasersuaq, although the owners of 4 of these supplemented their income by fishing and hunting (Glahder 2001\textsuperscript{41}). Four other sheep farms were closed in the period 1990-1997. The mine access road could possibly be utilised to open up the area to further subsistence sheep farming. It is AMG’s intention to locally source as much of the camp food supply as possible with an emphasis on local mutton, lamb, fish and vegetables and to potentially promote local food co-operatives to help this aim.

**Materials Reception and Storage**

With little activity at the mine site, virtually no materials, apart from necessary food supplies, are being landed at present at the harbour. There is a stockpile of about 9000 tonnes of ore on the pad at the harbour which will be returned to the mine for treatment in due course. A quantity of bagged ammonium nitrate prills are held in secure store at the harbour. Substantial quantities of mechanical, electrical, plant and mining spare parts and consumables are held in the warehousing facilities and on outdoor storage areas at the mine camp. Working quantities of welfare supplies and food are also held at the camp. Quantities of diesel fuel are held in the approved storage tanks at both the harbour and the mine. Further quantities of oils, greases and out-dated helicopter fuel are held in drums at the main mine site.

**Waste from Mine Camp**

With minimal activity taking place at the mine at the moment, in practical terms, there are minimal quantities of liquid or solid waste discharged from the mine camp at the present time.

**Transport Issues**

Transport to the site is possible by helicopter to the mine helipads or by road from the harbour which is itself only accessible by ship/boat. Helicopter travel to/from the site is only likely to be undertaken for emergency purposes. No heavy bunker fuel or time-valid aviation stores are held at the harbour or on

---

site respectively at present. Quantities of diesel fuel are held in the storage tanks at both the harbour and the mine. Transport movements to and from the site are limited to visits from the AMG project teams and advisors and the specialist contractor’s personnel employed to construct and fit out the underground process chambers, together with the occasional visits of the advisory and monitoring teams from NERI, the Greenland Government and BMP. Very occasional and irregular visits are made to the area by tourist ships. There is a significant amount of local traffic by small boats involved in the fishing industry who operate in the local inshore marine waters around Saqqaa Fjord.

It is concluded that transport issues have no measurable effects on the area at the present time in normal circumstances.

**Marine Environment at Harbour**

Observations have showed that water currents within the fjord are primarily tidal, and are clearly stratified into two currents, one flowing whilst the other ebbs. Sometimes a third, wind-induced current is present at the surface. As a result, the fjord is well flushed, and prior to the start of mining, showed no significant levels of pollution.

**Cultural Heritage & Archaeology**

The Director of the Qaqortup Katersugaasivia (Qaqortoq Museum), assisted by a graduate student, surveyed the Kirkespir Valley area during July 1988, under the auspices of the Kalaallit Nunaata Katersugaasivia, the Greenlandic National Museum (Berglund & Elling, 1988). A walk-over survey that covered the exploration concession area was undertaken, which concentrated on the flatter areas. The boundaries of the search area were the lower slopes of the mountains or terrain within which settlements were not considered likely to occur. A number of earlier investigations have been carried out in the valley. The ruin complexes in Kirkespirdalen (the conservation numbers 60V2-II-566 and 567) were found and first described by Erik Holtved in 1932, who made a sketchy registration of the area north of the main stream. When

---

Ove Bak, a teacher, visited the area in 1968, he discovered a new ruin group, south of the stream. Finally, in 1981, Knud Krogh visited the area because of a proposal and plan to extend the local sheep farmers’ grazing areas.

The Kommune Kujalleq and the Nanortalik area are recognised for the Norse settlements, but there is also evidence that Inuit have used the area intensively for the last several thousands of years. There are registered traces of Thule people everywhere. The Norse settlement pattern in this part of ‘Østerbygden’ is different from elsewhere in Greenland because the exposed coastal areas have been utilised, not just the more sheltered valleys of the inner fjords, which are usually preferred.

A total of 24 ruins were identified and described. All the ruins are located on the flat plain within about 0.6 km of the shore of the fjord, and are found in a southern (3L22) and a northern (1L17) grouping. The ruins are of Norse origin and there was no evidence of Inuit or Greenlandic remains. A smaller group of Inuit ruins were located on the North side of the bay, some 500 m from the delta (high tide level). Since these were outside the concession area they have not been considered further. They will not be disturbed by the mine’s operations.

The value of the ruins as a tourist attraction is very limited since they are all very decayed and difficult to discern or identify by the casual observer. Nevertheless, this does not mean that the groups of ruins are not of value. They represent a complex of residential and commercial sites with all the ‘functions’ characteristic of a self-sufficient Norse settlement. Whilst it is not possible to date the settlement without further investigations, it is likely the area was active in the period 1000-1500 CE.

No further investigation of the ruins has been carried out since then and no disturbance of the ruins has occurred due to the Nalunaq Operations. Because the landscape in the vicinity of the mine has been degraded by its previous long history of industrial and minerals usage it is considered that there are no Cultural Heritage and Archaeological issues associated with the project area. The industrial history of the mine and its associated operations and infrastructure has been recorded and preserved by a fairly extensive photographic and documentary archive. The site does not contain any areas
of spiritual, cultural, or other socio-economic value including areas of special importance for traditional resource use.

Public Rights of Access

There are no restrictions on local public access to the area at the present time except those imposed on the immediate mine and camp area by security and health and safety requirements. This situation also applies to the harbour area.

Tourism

Occasional and irregular visits are made to the Kommune Kujalleq area by tourist cruise ships particularly to Qaqortoq, Nanortalik and Cape Farewell. The industrial nature of the site together with the stark and contrasting beauty of the surrounding wilderness can be of interest to tourist groups and with the easy access provided by the mine road occasional landings by small chartered boats have been made at the harbour with trips taken up the Kirkespir valley. Some hiking trips are also undertaken. The area as a whole is recognised as a prime mountaineering and rock climbing location. The tourist industry is, however, severely limited by the extreme weather especially in the winter and the remoteness of the area.

Existing Resources

The existing resources in and adjacent to the project area are exploited by the local people by fishing in the fjord and by limited sheep grazing on the land area. Some traditional hunting of various wild fauna will also takes place. No other resources are presently exploited.

Greenhouse Gases

With the mine operating on a limited basis only at present, the main greenhouse gases emitted from the area are confined to the limited mining operations and camp power requirements and occasional harbour usage, together with the minor vehicle movements taking place at the mine camp. Greenhouse gases were of course produced by the mine during its operational phase.
Consequent Additional Development Potential

At the present time there is no additional development potential in the area apart from the Angel Mining plc proposals for the re-opening of the Nalunaq Gold Mine set out in the present documentation.

Cumulative Impacts

There are no cumulative impacts or cumulative impact potentials relevant at the present time.

Local Social Baseline Considerations

A separate SIA has been submitted to BMP as part of this application which includes draft a Benefit and Impact Plan (BaIP) and draft Impact Benefit Agreement (IBA) prepared after consultation with the local community.

15 Aspects, Impacts & Mitigation

Emissions to Air

Emissions to air in the form of dust and gases will be generated by a number of the activities chiefly at the Mine but also at the Camp.

Underground Sources of Dust and Other Emissions:

Dust will be produced from a number of sources within the underground mine. Dust will be produced from the primary mining operations including the blasting, loading and transportation operations. The blast-hole drilling utilises water ingress into the mine from the host rock and the dust from these mining operations will be partially controlled by the damp conditions in the mine itself. All minerals processing operations will take place within the confines of the underground mine. Dust from the process operations will be intercepted by the dust collection system. The ventilation system before exhaust to the external atmosphere will incorporate dust collection methods utilising a combination of cyclones, electrostatic collection and filters. These measures will ensure that an absolute minimum of dust generated in the
underground mine will be liberated to the external environment. The internal underground environment itself will be extensively monitored to ensure that dust production does not cause a hazard to those working in the mine.

- **Crushing & Fine Ore Storage**

Dust will be generated by the primary and secondary crushing plants within the underground process plant.

**Mitigation**

Dust generated will be collected by a central reverse jet bag filter. Ductwork is run from each of the crushing plants to the bag filter. Routinely the dust collected is emptied back on to the belt conveyor and into the plant for processing. No dust will reach the outside atmosphere.

**Residual Impacts**

No residual impacts are anticipated.

- **Grinding & Classifying**

The grinding and classification area has zero emissions.

**Mitigation**

Maintenance practice and housekeeping will maintain all machinery in good order.

**Residual Impact**

No residual impact is anticipated.

- **Mine Activity**

Gas emissions in the mine will be produced by:

- Diesel powered vehicles
- Blasting operations
- Processing and gold doré production
- Maintenance operations including welding, hot cutting and brazing etc.
• “Used air”

The gases produced will include carbon dioxide, carbon monoxide, nitrous blasting fumes, and welding and hot work fumes etc. The bullion furnace will include a vent stack to extract any moisture or fumes from the smelting process out of the gold room. The emissions from this process are typical of this operation and are not harmful to personal in close vicinity. All produced gases will be exhausted to the external atmosphere through the mine ventilation system which also of course replenishes the mine’s fresh air supply.

Mitigation
The mine’s working atmosphere will be the subject of continuous monitoring by the mine ventilation officers. The mine rock itself is not gassy and will not give rise to toxic, poisonous or inflammable gases. It is suggested that the emissions content of the external ventilation exhaust is monitored.

Residual Impact
Overall it is not anticipated that significant adverse effects are going to accrue from either dust or gas emissions from the mine into the external atmosphere due to the dust suppression measures utilised as part of the underground operation.

• Leaching & Carbon Adsorption

The leach and carbon adsorption circuits have zero emissions under normal operating conditions.

Mitigation
A pH probe in each of the cyanide dosed leach tanks will alarm if the pH level drops below a safe point for cyanide addition. Any spills from each circuit gravitate to an area sump, from where they can be collected and pumped back in to the respective tank or pump box.
Residual Impact
Strict observance of the Manager’s Rules, good maintenance practice and housekeeping will maintain all machinery and warning systems in good order so that no residual impact is anticipated.

- **Cyanide Destruction & Tails**
  A number of chemicals are employed at this stage of the process. The cyanide destruction process emits moderate levels of sulphur based odours.

Mitigation
All chemicals used at this stage will be stored and utilised strictly under the requirements of the Manager’s Rules and the respective MSDS. A ventilation system from the reagents area will direct any odours out of the enclosed processing plant. A warning alarm panel is installed to attract the attention of an operator in the instance of a low level in the meta-bisulphite holding tank or high or low pH levels in the detoxification tank discharge. The discharge from the detoxification tank is continuously monitored for WAD cyanide and total cyanide levels to ensure the concentration being sent to tailings storage is below the maximum allowable limits. Any spills in the area gravitate to an area sump, from where they can be collected and pumped back in to the detoxification tank.

Residual Impact
Strict observance of the Manager’s Rules, good maintenance practice and housekeeping will maintain all machinery and warning systems in good order so that no residual impact is anticipated.

- **Acid Wash, Elution & Carbon Regeneration**
  A number of chemicals are employed at this stage of the process. The carbon regeneration kiln will give rise to emissions consist primarily of carbon and minor sulphur based oxides. The quantity is unknown as the product is 100% natural and as such is variable. It is assumed that the burnt coconut shell has minimal elemental sulphur.
Mitigation
The emissions from the carbon regeneration kiln are collected by a ventilation duct and released outside of the process plant enclosure to be dealt with by the mine’s ventilation system. A high dilution of these emissions is anticipated before emission to the outside atmosphere. All spills from drains and overflows of acid wash area gravitate to the acid floor sump, where it is collected, neutralised and pumped to the carbon safety screen. All spills from drains and overflows in the elution strip area gravitate to the elution floor sump, where it is collected and pumped to the pump cell circuit feed.

Residual Impact
Strict observance of the Manager’s Rules, good maintenance practice and housekeeping will maintain all machinery and warning systems in good order so that no residual impact is anticipated.

- Electro Winning & Gold Smelting
During the electro winning process, there is the potential to produce ammonia vapours from the reaction of cyanide and water. Small amounts of hydrogen may also be produced through the electrolysis of water.

Mitigation
Fumes from the electro winning cell are extracted and passed through a scrubber before being released outside of the gold room. The ammonia is easily scrubbed from the vent gas with raw water and discharged to the sump. The area surrounding the gold room vent discharge point is monitored for flammable gases using a suitable flammable gas detector. A thermal conductivity meter is one option available for the detection of % LEL of hydrogen.

Residual Impact
Strict observance of the Manager’s Rules, good maintenance practice and housekeeping will maintain all machinery and warning systems in good order so that no residual impact is anticipated.
Surface Sources of Dust and Other Emissions

Dust

NERI have noted that the main effects caused by the operations of the mine in the past on the external environment have been due to dust, mainly emanating from the haulage of rock from the mine to the harbour. This rock was gold ore bearing and was sent overseas for processing. With no process ore stocking at the harbour or waste dumping taking place outside the mine the main cause of fugitive dust will be from vehicle use at the mine itself. Fugitive dust may also be produced by wind scour giving rise to dust blow in windy conditions from the camp roads, hardstandings and from the previously tipped waste rock.

Mitigation
It is anticipated that the wet climate will itself regulate the production of fugitive dust. Good housekeeping including a strictly observed site speed limit will help prevent fugitive dust production form the roads. Spraying the roadways with a dust inhibitor agent may be considered during periods of very dry weather.

Residual Impact
It may be expected that small quantities of fugitive dust will be created by wind effects in dry and windy weather. It is not anticipated that these residual impacts will be significant.

- Materials, Consumables and Stores Handling

All materials, consumables and stores and indeed all other items necessary for the mine’s operation will be delivered by ship to the harbour area. The main items to be delivered will include: ammonium nitrate prills, detonators and primers for explosive manufacture and timber and steel for mine support purposes, together with all welfare supplies including food, drink, hygienic and living supplies, office supplies, etc. Also to be delivered by ships are all the liquid fuel supplies of diesel and gasoline (if required) together with all oils, greases, and lubrication products.
Ammonium nitrate prills will also be supplied in bulk bags and stored in containers until required. It will then be trucked to the mine.

All other materials and consumables are likely to be palletted and shrink wrapped so their handling should not give rise to any dust production.

Mitigation

The packaging of the delivered materials will prevent and minimise spillage but excellent and regular housekeeping and clean-up of any spillage will be carried out to minimise the possible generation of fugitive dust.

Residual Impact

Clean up procedures and excellent housekeeping will minimise any potential residual impact.

- **Transport and Vehicles**

Vehicle movements including pick-ups, forklifts and telehandlers are likely to raise dust from the roads and hardstands where they are utilised or travel. Vehicle emissions are also likely to give rise to small size particulates known as PM$_{10}$ generated from diesel exhausts. The dust monitoring proposals will also monitor these particulate emissions which are thought to be injurious to health being postulated as one of the major causes of Asthma.

Mitigation

It will not be possible to use water dust suppression methods on these areas due to the climate. Regular clean up and sweeping of the roads to minimise dust cover will be carried out. A strict site speed limit of 15 km/h will be maintained which will be obeyed by all vehicles. This will not only aid site safety but will also minimise dust mobilisation from the trafficked surfaces.

Residual Impact

Excellent housekeeping will minimise any potential residual impact.
• **Helicopter movements**

Helicopter operations may raise dust from any areas closely over-flown.

Mitigation
AMG do not plan to utilise helicopters except for emergency use only. The helipad itself will be kept free from dust and flight paths of the aircraft will be designed to avoid closely overflying the mine area to minimise air disturbance.

Residual Impact
Minimisation of helicopter usage and observation of flight paths will minimise any potential residual impact.

• **General**

A key part of the dust mitigation strategy will be the institution of a dust management plan which will not only set out the mitigation requirements but also highlight the necessities and commitment needed to institute excellent practice and house keeping. A prime part of the plan will include the training of the workforce in the hazards and consequences of not maintaining good environmental practices and the appointment of an EHS Manager to oversee and be responsible and answerable for the operation of the mitigation measures.

**Gases and Vapours**

Greenhouse gases and/or other vapours will be produced from the electricity generation plant which will utilise diesel generators, the ships visiting the port, the helicopters visiting the heliport, the vehicles in use at the mine, the maintenance procedures and operations at the workshops, any gas powered heating and cooking equipment, vented gas from the sewage treatment units, emissions from any waste incineration operation, decay products from domestic refuse and other wastes, and vapours released from spillage of hydrocarbons and solvents.
Mitigation
All diesel powered plant and other equipment which may produce emissions will be maintained in good condition to minimise emissions. Good housekeeping practice will be put in place to minimise any spillage of hydrocarbons and solvents and an emergency plan instituted to deal with any such spillage efficiently and timeously.

Residual Impact
Clean up procedures, good maintenance and excellent housekeeping will minimise any potential residual impact.

Emissions to Water

Emissions to Water from the Underground Mine

Water will be used at the underground mine in mining operations in drilling the rock face, washing the rock down prior to scaling activities and also for rock facing mapping by the geologist. The water to be used emanates from the host rock. The other main use of water is in the minerals process facility. All water produced from the mine will be treated in underground settlement areas and in the surface settlement ponds before discharge to the river.

Mitigation
All water discharged will be fully treated to comply with environmental requirements before discharge. A regular programme of monitoring and sampling will be instituted and agreed with BMP to ensure compliance. The basis of the water sampling will be a twice daily check of the water pumped from the tailings impoundment [which is recycled back into the mineral process plant]. The other water checkpoint for daily monitoring will be the water chamber located at the portal entrance to the 300mrl. This is the final water chamber before discharge to the external environment.

Residual Impact
It is not anticipated that any residual effects will accrue.
Emissions to water from the Process (Leaching) Plant

It is not anticipated that the leach process itself will allow any emissions to water. Spillages from the system could however, if untreated, find their way to the mine water treatment system.

Mitigation
As noted in the various sections of Chapter 3, all areas where possible spills could take place have provisions to ensure that any and all spillage will be caught and collected and returned back to the process system.

Residual Impact
Strict observance of the Manager’s Rules, good maintenance practice and housekeeping will maintain all machinery and warning systems in good order so that no residual impact is anticipated.

Handling of Chemicals

The reception and handling of the necessary chemicals to be used in the process is dealt with in detail later in this chapter. Extreme care will be taken to ensure that no chemicals enter the water regime either of the mine or the exterior environment.

Mitigation
The management of hazardous substances will be strictly controlled so that no adverse impacts arise from their use either to the environment or to those people involved in their use.

Residual Impact
Strict observance of the Manager’s Rules, good maintenance practice and housekeeping will maintain all machinery and warning systems in good order so that no residual impact is anticipated.

Water Emissions to the River from the Camp

All rain and runoff from the camp area will be treated in the surface settlement ponds before discharge to the river.
Mitigation
All water discharged will be fully treated to comply with environmental requirements before discharge. A regular programme of monitoring and sampling will be instituted and agreed with BMP to ensure compliance.

Residual Impact
It is not anticipated that any residual effects will accrue.

Water Emissions to Sea at the Harbour Facility

With few activities planned to take place at the harbour apart from the reception of supplies and consumable it is likely that the only source of water contamination will be from spillage.

Mitigation
Clean up procedures, good maintenance and excellent housekeeping will minimise any potential residual impact.

Residual Impact
Clean up procedures, good maintenance and excellent housekeeping will minimise any potential residual impact.

Spillages of Ore, Chemicals, Materials or Hydrocarbons etc.

All spillages of deleterious substances and materials can cause damage to water discharges and aquifers. All good practice and efforts will be utilised to minimise the risk of spillages.

Mitigation
All spillages will be immediately reported. Emergency procedures will be put in place to identify actions to be taken in the event of spillages and to take the necessary timeous remedial action.

Residual Impact
Clean up procedures, good maintenance and excellent housekeeping will minimise any potential residual impact.
Noise

Noise will be generated by many of the activities at the mine site.

**Underground Sources of Noise**

Operating mines are generally noisy places with many of the activities generating locally excessive noise which can be harmful to unprotected ears and Nalunaq will be no exception to this. Indeed, many of the activities will generate enough local noise to require the operators to wear effective ear protection as a working necessity and a health and safety imperative. Noise underground will therefore form a major health and safety feature of the operation. The noise will be produced from the actual mining operation and processing operations.

**Mitigation**
Noise generated in the underground operation will be rapidly attenuated by the underground environment itself and, in common generally with all other underground mines, it can be anticipated that practically none of this noise impact will be felt at the mine entrance and that it will not produce a significant impact to the external environment.

**Process Plant**
Process plant operators will be required to wear effective ear protection as a working necessity and a health and safety imperative. The main noise elements can be expected to arise from the crushing and ball mill operations.

**Residual Impact**
It is not anticipated that any residual effects will accrue.

**Mitigation**
Noise generated in the process operation will be rapidly attenuated by the underground environment itself and it is anticipated that practically none of this noise impact will be felt at the mine entrance and that it will not produce a significant impact to the external environment.
Residual Impact
It is not anticipated that any residual effects will accrue.

Surface Sources of Noise

Some of the surface operations will cause noise and will require operatives working at or in the vicinity to wear suitable ear protection as a working necessity and a health and safety imperative. However no extremely noisy operations such as crushing or processing will take place at the surface as all these operations are situated underground. Noise will be generated from the following operations:

- The diesel powered electricity generation system

Mitigation
The generators will operate on a 24 hour/day, 7 days/week, 365 days/year basis. They will be sited within a building which will be fully and efficiently acoustically insulated in order to baffle the noise produced within and effectively attenuate the perceived noise received outside the building.

Residual Impact
It is not anticipated that any residual effects will accrue.

- Vehicle movements including pick-ups, forklifts and telehandlers

Mitigation
A strict site speed limit of 15 km/h will be maintained which will be obeyed by all vehicles. This will not only aid site safety but also lower vehicle engine noise levels. All vehicles will be fitted with efficient silencing equipment.

Residual Impact
Clean up procedures, good maintenance and strict observation of the site speed limit will minimise any potential residual impact.
• **Helicopter movements**

**Mitigation**
AMG do not plan to utilise helicopters except for emergency use only. Helicopter traffic will give rise to non-continuous, irregular and limited periods of noise production. Flight paths of the aircraft will be designed to avoid overflying local communities wherever possible. With no local receptors it is not anticipated that helicopter movements will give rise to significant adverse impact.

**Residual Impact**
It is not anticipated that any residual effects will accrue.

**Blasting Vibration**

The underground mining operation at Nalunaq will require the use of explosives to break the rock. The main explosive utilised will be site mixed ANFO which is a standard mixture of ammonium nitrate and fuel oil. The ammonium nitrate will be in the form of prills with diesel being the fuel oil. The constituents of the explosive will be transported separately to the mine mixed at the point of use. The mixture does not become an explosive until it is mixed. A suitable electric initiation system will be utilised together with the necessary delay detonators and high explosive primers. Shotholes will be appropriately stemmed.

Even the most well designed and executed of blasts generates a certain amount of energy in the form of ground vibration and airborne vibration. When an explosive detonates within a shothole, stress waves are generated causing very localised distortion and cracking. Outside of this immediate vicinity however permanent deformation does not occur. Instead the rapidly decaying stress waves cause the ground to exhibit elastic properties whereby the rock particles are returned to their original position following the passage of the stress waves. Such vibration is always generated by blasting and will radiate away from the blast site attenuating as the distance increases. From experience of the rock mass and geology the vibration can be predicted. Airborne vibration in the form of air overpressure is generated in the mine.
atmosphere. The most effective method of control of airborne vibration is by its minimisation at source by effective stemming of the shotholes and the utilisation of electric or Nonel type detonators, avoiding the use of blasting cord.

The main effects of blasting vibration at the Nalunaq will be felt underground in the mine itself. As there is no settlement or community near the mine there will be no adverse environmental effects experienced in the local vicinity. No ecological sites of interest are situated near the project so there will also be no adverse ecological effects experienced.

Mitigation
All blasting will be carried out to international standards and will be designed to provide the optimum required rock breakage whilst minimising explosive use and hence minimising blasting vibration. Precautions will be taken in areas known to exhibit weaknesses, such as faulting, in the rock mass. Measures will be taken within the environment to ensure the safety of the personnel working within the mine during periods of blasting which will include the full or partial clearance of the mine during blasting operations and confining blasting to certain periods of the day. A full protocol and procedure will be set out to be followed in the event of misfires.

Residual Impact
It is not anticipated that any residual effects will accrue.

**Light Pollution**

The general area has no light sources apart from the mine so that there will be some general intrusion into the night skies from the lighting which will be required at the site. A high level of illumination by electric lighting will be utilised at the mine. The lighting will be used at full power during all hours of darkness between dusk and dawn. Flood-lighting will be both permanently fixed on buildings and mounted on pylons as well as mounted at lower levels to illuminate the mine site operations. Mobile lighting towers will also be utilised throughout the mine operations as required and as necessary. With no settlements or communities located in the near vicinity it is not anticipated that light pollution from the operation will cause any adverse impacts.
All lighting, both permanent and mobile, will be placed and directed so that minimum impact is experienced outwith the mine site area.

Residual Impact
In the very dark natural conditions the mine site will produce some light pollution but the overall impact in the remote setting will not be significant.

Ecology
There will be a number of activities at the mine which may have an environmental impact on the ecology established in the local vicinity of the project. Some of these activities can have an impact on the wider regional and global ecological picture. The ecology can be affected by emissions to the air such as dust and particulates and the production of gases and materials such as exhaust gases or solvents etc. It can also be affected by emissions to sea or fresh water aquifers by waste waters, contaminated runoff, leachates and chemical, gasoline or materials spillage etc. Ecology can also be affected by the other environmental health issues of noise, blasting vibration, light pollution, and by changes in land use and increased human activity. These potential impacts are dealt with generally in other parts of chapter 15 of this report. The specific effects of these impacts on the local ecology are set out here together with a specific measure to mitigate their impacts on the ecology.

Dust from the operation has been found to have affected the local land flora particularly by analysis of the reference lichen *Cetraria nivalis*. This dust has originated chiefly from wind scour producing fugitive dust from roads and undressed area. The mine is designed to specifically target environmental requirements by the proposal and employment of effective impact mitigation measures.

Mitigation
The mitigation measures proposed for the various aspects of the operation are set out under the various topic headings of this section of the report. However in order to coordinate all the various monitoring activities of the mine operation and to ensure that all environmental measures are put in
place and fully practiced with effectiveness and efficiency it is proposed that an EHS Manager will be employed. This manager with his staff will be responsible for monitoring environmental matters, ensuring that agreed mitigation measures are put in place and monitoring their efficiency and effectiveness, carrying out regular sampling and analysis of dust and water and reporting to the Mine Management on environmental matters.

Residual Impact
It is anticipated that with the environmental controls proposed and good management no residual impact will occur.

**Process Plant**

It is not anticipated that the operation of the process plant will have any impact on the flora and fauna of the local mine area or the wider regional context. However, it will be one of a number of other activities at the mine which may have an environmental impact on the ecology established in the local vicinity of the mine and possibly on the wider regional and global ecological picture. The potential impacts of the leach plant can in particular be associated with emissions to the air such as dust and particulates, the production of gases and materials such as gaseous chemicals, and emissions to the marine environment or fresh water aquifers by waste waters, contaminated runoff, leachates, chemicals, chemical residues, or materials spillage etc. These potential impacts from the leach process are dealt with more specifically in other parts of this chapter.

Mitigation
The mitigation measures proposed for the various aspects of the operation are set out under the various topic headings of this section of the report. However in order to coordinate all the various monitoring activities of the mine operation and to ensure that all environmental measures are put in place and fully practiced with effectiveness and efficiency it is proposed that a manager with responsibility for EHS will be appointed. This manager will be responsible for monitoring all environmental matters including those potentially caused by the leach process, ensuring that agreed mitigation measures are put in place and monitoring their efficiency and effectiveness,
carrying out regular sampling and analysis of dust and water and reporting to the Mine Management on environmental matters.

Residual Impact
It is anticipated that with the environmental controls proposed and good management no residual impact will occur.

Landscape, Physical and Visual Intrusion

The present landscape in the immediate vicinity of the mine is degraded by the previous operations. The project does not require a major programme of surface building works and infrastructure construction so that no further adverse impacts or visual intrusion will be created. The minerals process plant is contained entirely underground and will have no potential impact on the landscape, nor provide any physical or visual intrusion on the landscape.

There are no local settlements, communities or dwellings within sight of the development. Therefore, Zone of Visual Influence (ZVI) diagrams are considered unnecessary and have not been prepared. The surrounding, naturally imposing, landscape largely overshadows the site. The overall large scale landscape does not suffer noticeable degradation due to the mine development, which can be considered to be small scale compared with the natural surroundings. There are no areas with any special or specific landscape designation including sites of potential great sensitivity or unique geomorphological characteristics within the area of the project so that there will be no impacts on this type of site.

Mitigation
It is anticipated that the development will not cause noticeable visual impact due to its remoteness. The mine closure plan will contain proposals for the rehabilitation of the site on closure so that the final cleared site will have a minimal envelope of visual impact.

Residual Impact
It is not anticipated that any residual effects will accrue.
Energy Production

Greenland does not have a national electricity distribution grid and the Nalunaq Mine is not connected to any national electricity provision. The main source of power will be from the use of diesel generation equipment. Several large generation sets will be required to produce the amount of energy required to run all the mine’s functions. These sets will give rise to several adverse environmental impacts.

- **Noise:** The generation equipment produces considerable noise during operation.

  Mitigation: The units will be located within a dedicated which will be provided with full noise insulation and baffling so that the level of noise outside the building will be minimised to non-obtrusive and safe levels. Personnel working within the building will be required to wear suitable ear protection measures at all times.

  Residual Impact: Residual impacts are expected to be minimal but noise levels will be monitored.

- **Exhaust Gases:** The diesel engines used to power the system will produce the usual exhaust products associated with internal combustion engines. Use of diesel powered electricity generators cannot be avoided.

  Mitigation: The diesel powered generators will be maintained in good condition to minimise emissions. Good housekeeping practice will be put in place to minimise any spillage of hydrocarbons and solvents and an emergency plan instituted to deal with any such spillage efficiently and timeously.

  Residual Impact: Clean up procedures, good maintenance and excellent housekeeping will minimise any potential residual impact.
Hydrogeology and Fresh Water

Water will be discharged from the mine, from the camp as run off and from the sewage treatment system.

Mitigation
All measures necessary will be taken to manage all water prior to discharge and treat it as necessary. This will be achieved by forming settlement holding lagoons before discharge points to remove sediments together with any other chemical treatment required. Regular sampling of discharged water will be undertaken to ensure that compliance with discharge requirements is maintained. This sampling programme has been outlined in detail in this EIA and discussed with NERI staff. It will be finally agreed by NERI and BMP. This will include sampling stations and analysed parameters. Sampling stations will not only be at the outlets of discharged water, but also from stations upstream of the discharge point and also downstream e.g. near the waterfall. Thereby the impact of discharge can be compared with the natural situation (upstream station) and the dilution effect of the river and concentrations of elements and chemicals just below the Arctic char habitats (downstream station).

Residual Impact
It is anticipated that with the environmental controls proposed and good management no residual impact will occur.

Process Plant

It is not anticipated that the leach process itself will allow any emissions which could impact upon the hydrogeological or groundwater regime. Spillages from the system could however, if untreated, find their way to the mine water treatment system.

Mitigation
As noted in the various sections of Chapter 12, all areas where possible spills could take place have provisions to ensure that any and all spillage will be caught and collected and returned back to the process system.
Residual Impact
Strict observance of the Manager’s Rules, good maintenance practice and housekeeping will maintain all machinery and warning systems in good order so that no residual impact is anticipated.

Handling of Chemicals

The reception and handling of the necessary chemicals to be used in the process is dealt with in detail later in this chapter. Extreme care will be taken to ensure that no chemicals enter the hydrogeological or groundwater regime.

Mitigation
The management of hazardous substances will be strictly controlled so that no adverse impacts arise from their use either to the environment or to those people involved in their use.

Residual Impact
Strict observance of the Manager’s Rules, good maintenance practice and housekeeping will maintain all machinery and warning systems in good order so that no residual impact is anticipated.

Land-use, Agriculture and Soils

The immediate site of the Nalunaq Mine is a degraded brownfield area. The project will renew the use of the site. The land surrounding the mine development is sparsely vegetated and contains few mineral soils. Agricultural usage and potential is limited. The project will have no impact on existing land-use or soils. The process plant is contained entirely underground and will have no potential impact on the agriculture, soils or land-use of the area.

Mitigation
It is intended that after closure the Nalunaq site will not be left derelict but will be rehabilitated to a suitable, appropriate and agreed condition.
Residual Impact
No residual impact on the surrounding area is anticipated. The rehabilitation of the site following closure will return the area to its original land use.

Materials Reception and Storage

All materials, consumables and stores and indeed all other items necessary for the mine’s operation will be delivered by ship to the harbour area. The main items to be delivered will include: ammonium nitrate prills, detonators and primers for explosive manufacture, calcium chloride powder to produce brine for the drilling operation, chemicals for use in the minerals processing plant, and timber and steel for mine support purposes, together with all welfare supplies including food, drink, hygienic and living supplies, office supplies, etc. Also to be delivered by ships are all the liquid fuel supplies of diesel and gasoline (if required) together with all oils, greases, and lubrication products.

Ammonium nitrate prills will also be supplied in bulk bags and stored in containers until required and then be trucked to the mine.

All other materials and consumables are likely to be palletted and shrink wrapped so their handling should not give rise to any dust production.

Mitigation
The packaging of the delivered materials will prevent and minimise spillage but excellent and regular housekeeping and clean-up of any spillage will be carried out to minimise the possible generation of fugitive dust.

Residual Impact
Clean up procedures and excellent housekeeping will minimise any potential residual impact.

Process Plant Requirements
The processing operation will be supplied with all consumables including the chemicals and reagents necessary for the operation of the processes. All storage, use and handling of these chemicals will be strictly managed by the appropriate Manager’s Rules. Storage of the chemicals will be in a secure covered building and access to the chemicals will be strictly controlled.
Mitigation

A number of chemicals are used in the leaching process which are noted in Chapter 12 of this report. Material Safety Data Sheets (MSDS) are available at the mine for Sodium Cyanide, Activated Carbon, Hydrochloric Acid, Calcium Oxide (Lime), Sodium Metabisulphite and Sodium Hydroxide respectively which give considerable details over these substances which will be employed in the leach process regime. As may be seen from the above text and the detailed MSDS, some of these chemicals are extremely toxic and environmentally difficult. It is therefore of paramount importance that all these types of chemicals and indeed all hazardous substances are stored handled, used, managed and dealt with under rigid control. These controls and protocols are laid down in the MSDS and enforced through the Manager’s Rules on Hazardous substances. The management of hazardous substances will be strictly controlled so that no adverse impacts arise from their use either to the environment or to those people involved in their use. All the chemicals employed will be contained after use either for reuse in the process or else within the reject tailings which will be utilised as part of the CRF operation. None of these substances will be discharged or released into any part of the external environment in any form at any time. Mitigation measures will be strictly maintained as per the Manager’s Rules. It is not therefore anticipated that the use of these chemicals will give rise to any adverse environmental or occupational health impacts or issues. Full emergency clean up procedures will be put in place in the event of the spillage of any hazardous substance, again in line with the appropriate laid down protocols and procedures.

Residual Impact

Strict observation of the Manager’s Rules, clean up procedures, good maintenance and excellent housekeeping will minimise any potential residual impact.

- Fuel Delivery, Storage and Transportation

All liquid fuel chiefly diesel oil will be delivered to the harbour by sea by oil tanker. A storage facility of 600,000 litres is located at the harbour. Unloading of the fuel is achieved by means of connection to a floating
hose system through which the fuel oil will be pumped from the ship to the tanks. The fuel is then transferred to road tankers and transported to the mine where a new facility for fuel storage of 20m$^3$ capacity will be constructed.

**Mitigation**

Full operating procedures will be put in place for the operation of the tanker unloading arrangements together with emergency plans in case of oil leakage into the sea at the floating reception.

All fuel storage facilities will be surrounded by an impermeable bund able to contain 110% of the tank farm capacity to contain any spillage. The bunded areas will be kept pumped free of rain or melt water on a regular basis or by the use of an automatic pumping system.

All oil spillage will be reported and the appropriate clean-up procedure put timeously into place. Good housekeeping measures will be put in place and enforced to ensure that the chance of oil spillage is minimised.

**Residual Impact**

Clean up procedures and excellent housekeeping will minimise any potential residual impact.

**Waste from Mine Camp**

The operation will result in the generation of a good deal of waste. This will be in the form of packaging, timber waste, metal waste, paper waste, etc from the mining and materials operations; waste oils, grease, lubes, replaced mechanical parts including oil, fuel and air filters, rubber pipes, old tyres, scrap equipment, etc from the mechanical and workshop functions; food waste, domestic waste and packaging, sanitary waste, clinical waste from the health centre etc, used cooking oils, domestic cleaning waste, from the kitchens, restaurant, accommodation and welfare blocks; grey and foul water and solid sewage wastes from the various living, welfare and accommodation services. It is imperative that this waste material is dealt with in a manner to keep the site clean and tidy, to minimise chances of pollution from it and in a
generally hygienic manner. Final disposal of the waste should also be carried out in an environmentally friendly and sustainable way where possible.

There is no landfill site at Nalunaq. All combustible waste will continue to be burned in a make-shift incinerator 3.5km from the camp. There is no designed incinerator onsite and it has not been required by BMP. All incombustible material will be packed into the special rubbish containers located adjacent to the makeshift incinerator and periodically shipped to Qaqortoq for disposal via the harbour. Adjacent to the workshop is a large used tyres storage area. The majority of the tyres will be used to improve the road safety bunds on the road from the harbour to the mine/camp area. Upon final closure of the mine it is anticipated that BMP will permit any remaining tyres and steel scrap to be stowed in the mine.

All waste water, including grey water, run-off, foul drainage and solid sewage waste must be treated before disposal in a controlled way. Untreated water should not be allowed to leave the site in an uncontrolled manner. It will not be satisfactory to discharge untreated foul drainage and raw sewage even in storm flow conditions. Foul waste will be treated in the existing sewage treatment system which will produce a treated water of sufficient purity to be discharged to the river without further treatment.

Mitigation
AMG intend to institute measures to increase recycling of materials in order to minimise the amount of rubbish produced and hence decrease the amount of burning and the quantities for disposal at Qaqortoq. AMG intend to minimise all waste produced and stored on the site

Residual Impact
Excellent housekeeping will minimise any potential residual impact.

Transport Issues
Transport connections to Nalunaq will be generally by ship and up the connecting road from the harbour. Helicopters will not be utilised except in the case of emergency. There are two existing helicopter pads which will be suitable for this purpose. There are no plans to build a runway able to take
fixed wing aircraft. It will not be necessary to maintain a passport and immigration control unit or customs post at the harbour or mine as all immigration and customs requirements will be dealt with at the main Greenland port of entry.

All other requirements including stores, consumables and some personnel will be delivered by sea to the harbour and then trans-shipped by road.

There will be sea traffic in the area associated with the mine development. This traffic is crucial and integral to the successful operation of the mine. The sea traffic will not interfere with the local sea-trades which presently access passage through the inshore waters, including the fishing boats which operate there. Diesel powered light pick-up type vehicles will be utilised at Nalunaq for transportation within and around the site. Diesel powered fork lifts and telehandlers will also be used for materials handling. Diesel powered vehicles will be utilised underground on loading and haulage duties. Diesel will be stored at the mine as previously. Appropriate security and anti-spillage measures will be taken.

The marginal increase in sea traffic will result in environmental impacts but it is anticipated that with very few local receptors these impacts will not be significant and will not result in an overall adverse impact:

- Increased shipping in the local inshore waters;
- Increased noise;
- Potential pollution from fuel spills;
- Production of greenhouse gases;
- Transport operations and issues will have no significant effect on local shipping, fishing and hunting activities in either summer or winter.

Mitigation
All transportation issues will be fully planned and monitored by the mine management so that excess and unnecessary journeys are not made.

Residual Impact
No residual impacts are anticipated.
Process Plant
Chemical supplies for the leach process will, like all other consumables required by the mine, be delivered by ship to the harbour facility and then delivered from there by road transport. It is not considered that this will give rise to an increase in overall journeys.

Mitigation
All transportation issues will be fully planned and monitored by the mine management so that excess and unnecessary journeys are not made.

Residual Impact
No residual impacts are anticipated.

Cultural Heritage & Archaeology

It is considered that there are no Cultural Heritage and Archaeological issues directly associated with the reopening of the Nalunaq Mine. No ancient monuments or buildings, sites of antiquity or other sites associated with Greenland’s cultural heritage have been identified within the curtilage of the mine. The historic Norse Farm at the Kirkespir delta lies outside the mine curtilage and will not be disturbed by its operations.

Mitigation
A watching brief will be maintained by the management of the mine and if any potential items, artefacts or areas of archaeological interest are uncovered or revealed by operations then the Greenland Museum at Nuuk will be immediately notified and invited to visit the site and carry out appropriate investigations. It is intended that a full photographic progress record will be taken and maintained for a future industrial archaeology history of the operations at Nalunaq.

Residual Impact
It is considered that there will be no residual impact.
Public Rights of Access

There are no restrictions on local public access to the area at the present time apart from those imposed by safety and security issues. Operational requirements, site security and health and safety considerations will not significantly affect public access. In general, public (i.e. non-employee) access to the mine operational area itself will be restricted to pre-arranged business appointments and emergency only. It is not believed that these specific restrictions will cause any adverse impacts or inconvenience to the local people.

Mitigation
AMG will make every attempt to minimise access restrictions to those imposed by operational, security and health and safety requirements.

Residual Impact
The above restrictions are not believed to cause unnecessary impact on public rights of access which will remain unrestricted elsewhere in the vicinity.

Tourism

As noted previously, occasional tourism visits by fishermen, climbers and hikers take place to the area. The tourist industry is, however, severely limited by the extreme weather especially in the winter and the remoteness of the area.

Mitigation
AMG plan to leave the harbour area in place after closure of the mine for tourist purposes if desired by the local community and will welcome and aid where possible tourist opportunities which may arise for limited visits to the mine area where operational requirements allow.

Residual Impact
It is hoped that tourist opportunities will increase in the medium and long term.
Existing Resources

It is hoped that the additional minerals exploration programmes that will be undertaken by AMG during the life of the mine may discover other economic mineral resources in the area. In this case the life of the mine site may be extended beyond the presently expected life.

Mitigation
In view of the possible major consequences of any pollution episode and in order to ensure that no activity at the mine give rise to adverse impacts on the existing natural resources, it is imperative that all mitigation measures are fully employed and adhered to and then continually updated with the advance of knowledge, practice and environmental techniques. The appointed EHS Manager will be responsible to the Mine Management for the application of the environmental mitigation measures and their continual update.

Process Plant
Due to the higher recoveries made possible by using the leach process technology the life of the mine site may be extended beyond the presently expected life.

Mitigation
In view of the possible major consequences of any pollution episode and in order to ensure that no activity at the mine give rise to adverse impacts on the existing natural resources, it is imperative that all mitigation measures are fully employed and adhered to and then continually updated with the advance of knowledge, practice and environmental techniques. The appointed EHS Manager will be responsible to the Mine Management for the application of the environmental mitigation measures and their continual update.

Residual Impact
Extended mine life will extend the economic benefits of the mine to the local community over a longer period.
Greenhouse Gases

The mine at Nalunaq will necessarily result in an increase in emissions of greenhouse gases from the site. The site is at present not operating supporting little activity and therefore produces minimal amounts of carbon and greenhouse gas emissions.

The main greenhouse gases contributing to Global Warming and Climate Change are carbon dioxide, methane, nitrous oxide and ozone. Other gases contributing to Global Warming include sulphur hexafluoride, carbon monoxide, carbon tetrachloride, tetrafluoromethane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and chlorofluorocarbons (CFCs).

The sources of greenhouse gases in place at the Nalunaq Mine include:

- Electricity generation equipment;
- Diesel powered vehicles and engines;
- Shipping powered by bunker fuels (ie heavy oils);
- Aviation – helicopters;
- Ventilation gases from the underground mine operation including those produced by blasting operations;
- Process plant;
- Gas powered heating and cooking equipment;
- Sewage treatment plant; and
- Incineration of waste.

The major source of greenhouse gases from the above list will be the generation of electricity. It is intended that the main electricity requirement for the operation will be generated by appropriately sized large diesel powered generators. The generation system will be required to produce electricity on a 24-7 basis for 365 days per year.

Diesel powered vehicles will operate during working periods. Vehicles will include pick-up trucks, forklifts and telehandlers, and other stores and materials handling equipment.
Aviation operations may show an increase. Aviation engines are recognised as a major source of greenhouse gases.

The underground mine will produce greenhouse gases through its exhaust ventilation system. This will be a combination of exhaust gases from the diesel powered mining machinery. The forced ventilation system will also deal with gases and fumes produced from the blasting operations including nitrous oxides and carbon dioxide and monoxide as well as the normal ventilation needs of the working miners for clean air. Any fumes produced by maintenance work underground such as welding and brazing, and the fumes from the doré process will also be expelled through the ventilation system. The mine is not gaseous in itself and contains no naturally occurring flammable gas such as methane.

It is not anticipated that the leach process will produce appreciable quantities of greenhouse gases although oxides of carbon and sulphur will be produced in small quantities by the carbon regeneration kiln.

Gas powered heating and kitchen equipment etc which may be utilised on the site in the accommodation and welfare facilities for instance will produce greenhouse gases. The sewage treatment facility produces methane and carbon dioxide as part of its operation, being formed from the natural breakdown and degradation of the organic waste being treated. Final water discharge from the system is clean water. The sludge from the treatment is removed for disposal.

Mitigation

AMG intend to reduce their carbon footprint and their production of greenhouse gases in Greenland on a company wide basis by the use of various alternate energy sources. It is not yet known whether any of these alternate sources can be utilised at Nalunaq. Minor improvements which may be put into place may include turning vehicle engines off when not driving and turning down the domestic hot water supply temperature in the Camp to 60°C. AMG will attempt to estimate the amount of CO₂ being produced at Nalunaq when the mine is in full production.
Residual Impact
The production of greenhouse gases at Nalunaq is unavoidable.

Consequent Additional Development Potential

NGM will give rise to a skilled and prosperous workforce used to well paid modern employment but still steeped in and adhering to their traditional values and way of life. The additional skills provided by the operation of the process operation including the leach process will add to the local skillbase. At closure of the mine there will therefore be a large pool of workers available for onward employment in an industrial local setting. This skilled workforce will be available for employment at mines or quarries or other industrial settings.

Mitigation
As the mine reaches the end of its productive life there will be continued liaison and discussion between the Mine Management and its stakeholders and the local authorities and the Greenland Home Rule Government to facilitate the use of the workforce resource on alternate employment.

Cumulative Impacts
The mine will provide a skilled workforce able to be employed on other similar projects or in other industrial settings.

Cumulative Impacts
There are no other commercial, industrial or mining developments within a considerable distance of this project. There can therefore be no cumulative impacts due to multiple local developments.

The cumulative impact of the various singular impacts attributable to Nalunaq must however be considered. There will be a number of impacts emanating from the various aspects of the project. Some of these impacts have the potential to have an adverse effect if they are not properly managed. There are other aspects which conversely have the potential to impact positively. It is not anticipated that the process plant will appreciably add to the cumulative impact of the project.
Mitigation
The project will be professionally designed, managed and operated and all potentially adverse impacts will be fully managed and minimised. Whilst there may be the potential for the adverse impacts to have a cumulative impact it is anticipated that the first class modern management processes which will be employed will minimise this potential. Overall, it is believed that the positive economic and social benefits of exploiting the mineral resources of Nalunaq Gold Mine by far outweigh both any individual adverse impacts as well as any perceived cumulative adverse impact.

Residual Impact
No cumulative impacts are anticipated.

16 Social Aspects, Impacts and Mitigation

A separate SIA has been submitted to BMP in November 2009 as part of this application which includes a draft Benefit and Impact Plan (BaIP) and draft Impact Benefit Agreement (IBA) prepared after consultation with the local community.

17 Environmental Management Plan

The Environmental Management Plan (EMP) deals with all aspects of the mining operation including the minerals processing and production and shipment of the gold doré. The EMP will be accompanied by an Environmental Management System (EMS). Thus the EMP and EMS will together detail all the projects environmental requirements and measure compliance against those requirements.

An Environmental Management Plan (EMP) can be defined as “an environmental management tool used to ensure that undue or reasonably avoidable adverse impacts of the construction, operation and decommissioning of a project are prevented; and that the positive benefits of
The projects are enhanced (RSA DEAT 2004)\textsuperscript{43},” and is therefore an important tool for ensuring that the management actions arising from Environmental Impact Assessment (EIA) processes are clearly defined and implemented through all phases of the project life-cycle. EMPs provide an essential tool for ensuring that the mitigation of negative impacts and enhancement of positive impacts is carried out effectively during the project life-cycle utilising continual improvement.

The objectives of an EMP should include (Hill, 2000\textsuperscript{44}):

- Ensuring compliance with regulatory authority stipulations and guidelines which may be local, provincial, national and/or international;
- Ensuring that there is sufficient allocation of resources on the project budget so that the scale of EMP-related activities is consistent with the significance of project impacts;
- Verifying environmental performance through information on impacts as they occur;
- Responding to changes in project implementation not considered in the EIA;
- Responding to unforeseen events; and
- Providing feedback for continual improvement in environmental performance.

In establishing objectives and targets the following issues should be considered:

- Adverse environmental impacts;
- Positive environmental impacts;
- Legislative and other standards;
- Relevant environmental standards;
- Stakeholder concerns;
- Technical issues;


• Operational requirements; and
• Financial cost.

In order to achieve the above objectives, the scope of an EMP should include the following:

• Definition of the environmental management objectives to be realized during the life of a project (i.e. pre-construction, construction, operation and/or decommissioning phases) in order to enhance benefits and minimise adverse environmental impacts;
• Description of the detailed actions needed to achieve these objectives, including how they will be achieved, by whom, by when, with what resources, with what monitoring/verification, and to what target or performance level. Mechanisms must also be provided to address changes in the project implementation, emergencies or unexpected events, and the associated approval processes;
• Clarification of institutional structures, roles, communication and reporting processes required as part of the implementation of the EMP.
• Description of the link between the EMP and associated legislated requirements; and
• Description of requirements for record keeping, reporting, review, auditing and updating of the EMP.

The EMP should address the following headings:

• Foreword and Policy
• Location and general background to the project
• Summary of the proposed project and associated activities.
• Allocation of resources
• Summary of the Project Proponent’s existing policies, guidelines and commitments relating to health, safety and environment.
• Identification of the legislation, standards, guidelines and associated permits or licences that apply to the project and are related to management activities specified in the EMP.
• Identification of the environmental aspects of the mining operations and summary and details of the predicted negative and positive impacts associated with those aspects. Objectives
to be achieved through the EMP and the management actions that need to be implemented to mitigate the negative impacts and enhance the benefits of the project taking into account the principles of Best Available Technology Not Entailing Excessive Costs (BATNEEC). Specification of the associated responsibilities, monitoring, criteria/targets and timeframes.

- Environmental Monitoring Requirements.
- Definition of the responsibilities for management actions contained in the EMP and the arrangements for coordination among the role players involved in implementation.
- Specification of the requirements for training and environmental awareness for all site and other project personnel to ensure that the actions specified in the EMP are implemented effectively and efficiently.
- Requirements for document handling and control system to be followed for all EMP documentation.
- Requirements for reporting procedures and practices to be followed.
- Requirements for the stakeholder engagement process including management of concerns and complaints.
- Requirements for environmental audits including scheduling, competence of auditors, recording and reporting of audit findings, and corrective actions and their verification.
- Dealing with non-compliance.
- Contractor, sub-contractors and suppliers.
- Emergency Procedures
- Hazardous Substances
- Procedures and timing of management reviews during the project and the consequent revision of the EMP through a process of continuous improvement.

A senior manager will be appointed as Environmental Health and Safety (EHS) Manager responsible and accountable for all environmental and compliance aspects of the operation together with health and safety aspects. He will be responsible for the maintenance of the Environmental Management Plan (EMP) together with all monitoring and sampling requirements for environmental purposes.
AMG will put into practice, an Environmental Management System (EMS) to a standard suitable for registration under ISO 14001. This EMS then details all the projects environmental requirements and measures compliance against those requirements. It is important tool for ensuring that environmental aspects, impacts and consequences are fully taken into account in the mines operation and that the requirements are updated in the light of performance and actual practice. It is anticipated that a similar Quality Management System (QMS) to the standard of ISO 9000:2000 series would be put in place for the mines production together with an Occupational Health and Safety Management System to the standard of OHSAS 18001. These management systems all run in parallel and help to manage and maintain all mine functions in compliance with the planned requirements. The EHS Manager is responsible for the maintenance and update of these systems and for all actions required to maintain compliance.

The EHS Manager will also be responsible for the environmental services provided by the laboratory facility at the mine. The laboratory’s prime function will be ore assay for operational day to day stope grade control, the quality of ore production and quality control but will also deal with all environmental sample analysis.

As part of the ISO 14001 standard system there are a number of requirements which need to be fulfilled. A system of internal annual auditing must be put in place to consider operational aspects such as water management, waste, oil and diesel, dust, noise and all environmental compliance issues.

The EMS will contain procedures, for the following:

- Environmental Policy;
- Environmental Aspects – list of identified potential environmental impacts, risks, effects, etc.;
- Legal and other requirements – a register of all regulatory instruments relevant to the site and the specific permits, licenses, etc with the conditions, standards or limits imposed;
- Objectives, targets and programmes;
• Resources, roles, responsibilities and authority for environmental matters at corporate and site level;
• Competence, training and awareness;
• Communication;
• Documentation;
• Control of documents;
• Operational controls;
• Emergency preparedness and response;
• Monitoring, measurement and evaluation of compliance;
• Non-conformity, corrective action and preventive action;
• Control of records;
• Internal audit procedures; and
• Management review.

The Operational Controls comprise a number of important procedures:

• Compliance records;
• Requirements and restrictions;
• Written work instructions;
• Verbal work instructions; and
• Guidance and codes of practice.

A register of non compliance, complaints and incidents should be kept. Monthly environmental management meetings should be held to discuss environmental issues of concern and the meeting agenda should cover areas of operational control, objectives and targets, training needs, auditing and general monitoring, new issues/problems, site changes and any other business. If issues of concern are identified that need to be disseminated to a wider audience then ‘toolbox talks’ should be prepared by the EHS Manager to update staff on important issues.

With regard to day-to-day environmental management, and objectives, a yearly Environmental Action Plan (EAP) can be agreed with the members of the environmental team, with a series of objectives and actions throughout the year. These include goals for environmental training, general maintenance, areas for improvement, implementation of recycling programmes, changing discharge regimes.
The EHS Manager will be responsible for liaising with external parties who are affected by operations at the site. In the event of complaints, in addition to making a formal record of the complaint, the affected party should be contacted, and appropriate measures undertaken. A community liaison forum will be instituted, to provide opportunities for stakeholder dialogue about relevant issues again organised by the ESH Manager.

The ESH Manager will also be responsible for the upkeep and update of the Contingency Plans and Emergency Procedures. These protocols and procedures will cover all aspects of the mine operations and will be maintained in concert and as part of the Risk Register and the Risk Management Strategy. Knowledge and training in all emergency procedures will be given to all mine employees along with the knowledge of the potential effects and consequences of the risks covered.

A waste minimization and recycling programme should be instituted and then the results analysed and updated on a regular basis.

It is also recommended that as part of the internal and external reporting system, environmental sections are included in internal Board management reports and external company reports.

It is anticipated that the EMP will evolve during the life of the mine in line with the principles of the DMAIC circle (Design, Measure, Analyse, Improve, Control, with Continuous Improvement) taking into account the feedback provided by the monitoring and operational progress.

18 Environmental Monitoring Proposals

The mine will appoint a senior manager to be responsible for all Environmental, Health and Safety matters. Part of the duties of this EHS Manager will be to ensure that the environmental monitoring programme is carried out, that all monitoring data is recorded and that all monitoring equipment is maintained in working order. He will also be responsible for ensuring that any adverse impacts identified by the monitoring are brought to
the immediate attention of the mines management and that the appropriate remedial measures set out in the Environmental Management Plan are timeously instituted.

The following environmental monitoring programme will be instituted once approval is given by the BMP:

**General**

Weather: The existing weather station should be maintained and operated. The weather station will measure temperature including diurnal maximum and minimum, wind speed and direction, barometric pressure and precipitation. All information will be continuously measured and recorded with data download taking place on a regular daily basis. A full download of all results since the inception of the station by Crew has already been successfully carried out by AMG on 19th September 2009.

**Emissions to Air**

**Dust**: Dust could be generated at several locations within the project area at the Mine.

Underground: Due to the dust suppression measures taken within the underground workings and the process plant it is not anticipated that any fugitive dust will be emitted to the open air. It is not therefore thought necessary to carry out any dust monitoring or sampling externally at the entrance to the mine. Regular testing and sampling of the mine air and its quality, including dust control testing, will, as a matter of course, be undertaken by the Mine’s Ventilation Officers. Results will be passed to the HS&E Manager for analysis and file.

Surface: Dust could arise from the activities at the site. Appropriate measures will be taken to minimise fugitive dust. The main source of dust is likely to be caused by the vehicle movements around the site and dust blow. The climate is, however, generally likely to regulate these sources. To analyse dust
production and gauge its significance two forms of dust monitoring will be undertaken:

- Two dust monitoring stations will be established at the Camp at convenient points. Directional dust monitors of the type marketed by Dust Scan in the UK are recommended or similar.

- The dust monitoring by collection and analysis of lichens will continue in the same way as it has for many years. This will continue to be carried out by NERI.

Noise: Noise will be generated by activities in both the Mine itself and the Camp. Underground noise monitoring will be carried out as a matter of course by the EHS Manager. Noise monitoring in the camp is not considered necessary. However Noise from the new proposed replacement generator station will be estimated so that noise received at the nearest accommodation block does not exceed the recommended guideline values.

Underground: Operating mines are generally noisy places with many of the activities generating excessive noise which can be harmful to unprotected ears. All underground operatives will be required to wear ear protection as necessary and noise testing of all working places will be carried out on a regular basis, using handheld noise meters, as part of H&S analysis. The noise will be rapidly attenuated in the mine and it is not anticipated that any of the noise generated by the underground operations will be heard outwith the mine entrance. It is not therefore thought necessary to carry out any noise monitoring externally at the entrance to the mine.

Mine Camp: With no external processing taking place noise generation will be mainly confined to that produced by vehicle movement. No monitoring of this is proposed.

Emissions to Water

All discharges of water will be controlled, remediably treated as necessary and sampled on a regular basis in order to ensure that all discharged water is of a
suitable quality and will not give rise to adverse impact or pollution. This will include mine water including pumped or liberated ground water, waste and foul water, and run-off from hard-standing and paved areas. Water from these sources will be sampled immediately before discharge into the river. Water samples of the discharge from the sedimentation ponds and water samples from the river will be taken both upstream of the camp/mine area and downstream of the overflow discharge area.

The existing settlement ponds will be refurbished. The positions of sampling points will be selected with health and safety in mind to enable safe access to take the sample. This point will be at the exit to the lagoon. The EHS Manager will ensure that any unexpected points of discharge are identified and sampled. Discharges at times of storm run off will be specially sampled. All samples will be analysed and records kept. The sampling and monitoring programme will be agreed by AMG and BMP as noted earlier.

NERI will continue to undertake environmental monitoring of the marine fauna in the Saqqaa Fjord and in the area of the harbour facility.

- **Laboratory Facility**

The laboratory facility at Nalunaq will primarily carry out ore analysis for assay and grade control purposes but will also be able to carry out environmental analysis on site.

In addition to the above monitoring proposals set out in the July 2009 EIA it is proposed that additional regular monitoring of all aspects of the underground leach process will be carried out. This monitoring will include the following:

- Daily monitoring and sampling of the gaseous emissions from the plant;
- Daily monitoring and sampling of any liquid emissions from the plant;
- Monitoring of the handling and storage procedures and protocols for the chemicals utilised in the plant;
- Monitoring of the housekeeping applied to the plant area; and
- Monitoring of the provision and use of emergency clean up equipment in the plant area.
It is anticipated that the samples produced will be analysed at the mine laboratory.

**International Cyanide Management Code Compliance Proposals**

The "International Cyanide Management Code For The Manufacture, Transport and Use of Cyanide In The Production of Gold" (Cyanide Code) is a voluntary industry program for the gold mining industry to promote:

- Responsible management of cyanide used in gold mining;
- Enhance the protection of human health; and
- Reduce the potential for environmental impacts.

It was developed by a multi-stakeholder Steering Committee under the guidance of the United Nations Environmental Program (UNEP) and the then-International Council on Metals and the Environment (ICME).

The Code is an industry voluntary program for gold mining companies. It focuses exclusively on the safe management of cyanide and cyanidation mill tailings and leach solutions. AMG intends to adopt the code’s principles and will have its mining operations that use cyanide to recover gold audited to check compliance with the code’s requirements. The objective of the code is to improve the management of cyanide used in gold mining and assist in the protection of human health and the reduction of environmental impacts. AMG will utilise the available published procedures and verification protocols of the code to carry out regular auditing by an independent auditor. The verification protocols comprise:

- Gold Mining Verification Protocol;
- Pre-operational Verification Protocol;
- Cyanide Production Verification Protocol; and
- Cyanide Transportation Verification Protocol.

There are also a number of Guidance notes for use by the auditor together with standard audit summary forms for operations, production and transportation of cyanide.
The auditor, audit process and the audits themselves will be overviewed and reviewed for their compliance by an independent, fully experienced and accredited ICMI registered professional who will also carry out general awareness and technical training of the workforce prior to start up of operations. This may comprise a brief training module to enable key operational staff to be aware of the code’s requirements and particularly to understand it is not an merely an environmental initiative, but covers in depth operations, safety, training and emergency response. The training is targeted at the mine manager and procurement, warehousing, mill operations, maintenance, safety, training and environmental department heads to raise awareness of compliance requirements and issues.

Auditing will be carried out on a yearly basis in conjunction with the other general environmental audit of the NGM project.

19 Mine Closure Plan and Restoration & Rehabilitation Proposals

Planned mine closure can be expected to take place when either present reserves are exhausted and no new reserves are available, or when the economies of the mine alter because of changes in the value of the products produced due to market value fluctuations. Unplanned mine closure could be due to unexpected events such as an emergency situation forcing closure, force majeure causing temporary or full stoppage of operations, or a sudden economic crash causing economic closure. To cover all these closure exigencies, mine closure plans are required. An existing Mine Closure Programme and a security bond, in the sum of DKK16 million, exists from the previous operations by Crew which has been transferred to AMG. AMG has produced a detailed replacement MCP which was submitted to BMP in October 2009. The MCP will be regularly updated throughout the mine operations prior and up to closure. The plan allows for the requirements of planned closure and emergency unplanned closure. The MCP sets out detailed measures for closure and rehabilitation of the site, and consider long term management and monitoring requirements together with the immediate requirements to protect the environment from pollution and damage due to the effects of the closure. It is anticipated that the addition of the leach plant
and its associated processes, situated in the underground mine, will have a net zero effect on the requirements of the mine closure plan.

The detailed restoration and rehabilitation proposals will form a part of the mine closure plan. It has not yet been decided what the final post-closure land-use and form of the site will be although AMG have formulated a series of potential opportunities which have been suggested by consultation with the stakeholders and the local community. It is hoped that the Nalunaq operations will continue for many years with extended exploitation of yet to be discovered and proved additional resources. It is anticipated that the restoration strategy will evolve as the mine’s life progresses and will be finalised nearer the expected time of closure.

20 Public Involvement and Comments

A separate SIA has been submitted to BMP in November 2009 as part of this application which includes a draft Benefit and Impact Plan (BaIP) and draft Impact Benefit Agreement (IBA) prepared after consultation with the local community. Public Consultation is a key part of the EIA and SIA process. Further consultation with the Statutory Bodies is ongoing and will also refer to the findings of this EIA. As part of the separate SIA process, detailed and ongoing consultation has take place with the Community Representatives and the local people themselves. The SIA contains details of the consultations and the results of the discussions and includes both the positive and negative comments, the hopes and aspirations and the doubts and fears which the community have expressed about the project, together with the answering comments and any provisions or statements made by the Company.

21 Health & Safety

The Minerals Resources Act for Greenland requires that:

"Work in the mine must be performed in accordance with the statutes, rules and regulations applicable in Greenland. In the absence of relevant rules for mining operations, the licensee may request that the National Working Environment Authority, BMP and any other relevant authorities consent to the
work being carried out in accordance with a cohesive set of regulations for mining operations with which the licensee is conversant, e.g. “Management and Administration of Safety, Health in Mines, Health and Safety At Work Act, 1974” (UK). In that case, the provisions from time to time applicable according to such regulations must be observed. In the event that these regulations also concern matters covered by Greenland rules, the licensee must identify the most important departures from the statutes, rules and regulations applicable in Greenland with a view to discussing such departures with the competent authorities. The relevant regulations and the identified departures from the statutes, rules and regulations applicable in Greenland must be submitted to BMP as soon as possible in three copies. The licensee must submit any subsequent changes and additions as soon as possible.”

For Mining Projects in Greenland there is therefore no extant Greenland Mining Law. Therefore, failing the publication in the future of Mining Laws and Regulations by the Bureau of Minerals and Petroleum (BMP) of the Greenland Government to regulate mining operations in Greenland, then the necessary legislative processes, instructions and regulations which are required to regulate the operations of the Nalunaq Mine will be the responsibility of the Mine Owner and will be adopted and enacted by that Mine Owner. It is proposed therefore that the Nalunaq Mine will operate in general terms under the UK Mines and Quarries Act of 1954 as variously amended by Acts of the UK Parliament together with the all associated UK Legislation pertaining to the operation.

The Owner’s Procedures and Regulations will form the framework of the detailed health and safety system and include Manager’s Rules and Risk Assessment protocols. The detailed Owner’s Regulations will include Safe Systems of Work for all the various operational elements of the operation put in place.

Suitable Conditions of Employment will be included in all Employment Contracts to ensure that all employees and contractors follow the required and compulsory workplace rules and systems of work.
All Owner’s Procedures and Regulations are based on proven mining techniques, proven modern worldwide practice and experience and due knowledge of the necessary safety requirements.

The Owner’s Regulations are based on the Mining Legislation, Regulations, Codes and Rules utilised by the mining industry of the United Kingdom, and as periodically amended and updated by the Government of the UK and its administration.

### 22 Risk Assessment Section

Risk Management is now the foundation process in many countries for a successful health, safety and environment programme. Many companies utilise a formal Risk Management strategy in an effort to satisfy their “duty of care” requirements under various legislative laws.

In order for Angel Mining plc to achieve a good health, safety and environmental performance at Nalunaq Gold Mine, a formal risk management process will need to be applied at the early operation phase.

The following steps will be undertaken:

- Prepare a draft Risk Management Procedure for AMG to use when the Project starts operation;
- Prepare a template for a small risk register database to capture HSE risks associated with the Nalunaq Project;
- Undertake a ESH risk review of the Project and populate the risk database; and
- Develop risk management processes to minimise the high level risks.

### 23. Conclusions

The area disturbed by the development of Angel Mining (Gold) A/S’s Nalunaq Gold Mine is not close to and does not involve any of the following designated areas of special interest:
- Areas or sites of potential great sensitivity or unique geomorphological characteristics;
- Areas of special importance to wildlife;
- Areas with valuable, sensitive or representative biotopes - except for the Arctic char population in the Kirkespir River which would potentially be vulnerable to pollution from the mine but which will be fully protected by the proposed mitigation measures.
- Areas of spiritual, cultural, or other socio-economic value including areas of special importance for traditional resource use. A large Norse Farm does exist in the Kirkespir River delta but this lies outside the mine's curtilage and some distance from the mine link road, and will not be affected in any way by the mine’s operations.

The environmental effects of the previous mining operation have been seriously noted and marked by Angel Mining plc. Good environmental practice has been taken into account and built into the operational design of the mine, including the amendments and additions to the mine’s mineral process route set out in this document and effective mitigation measures will be enforced to minimise the potential adverse impacts of the development. Full environmental control will be maintained to limit all adverse impacts. The mitigation measures proposed will result in no significant residual adverse impacts.

The comments of the Statutory and Regulating Bodies have been taken into consideration in the formulation of this project.

The development will have significant economic and social benefits for the Nation of Greenland and the local community and Kommune Kujalleq in particular. Well paid work will be provided together with the knock-on indirect and induced economic benefits which will improve the individual, family and community economy and reduce unemployment.

**It is believed that the Nalunaq Mine can successfully operate and exploit the gold resource without causing major adverse impact. It is further believed that the benefits of the project to Greenland as a whole and the local community in particular far outweigh any potential disbenefits of the project.**