IVANHOE MINES MONGOLIA INC.,

OYU TOLGOI PROJECT

SUPPLEMENTARY ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE VERTICAL SHAFT # 2 IN OYU TOLGOI HUGO NORTH DEPOSIT

(Translation)

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Contents

EXECUTIVE SUMMARY

Objective of the supplementary environmental impact assessment for the vertical shaft#2 sinking is to determine potential risks and impacts that may develop during such vertical shaft sinking process. Judging from result of supplementary EIA for the vertical shaft sinking at far north Oyu, Hugo Dammet ore body, the operation of the vertical shaft sinking process shall cover comparatively small area and intended for deep ground. It's considered that project has medium impact on environment; therefore it's considered that operation can be carried out. There are three main impacts are considered that are needed to pay attention including creation of topsoil stockpile, waste rock dump and low grade ore stockpile, dewatering of ground water and labor safety operation. The following issues have been concluded during the supplementary EIA and required to be solved:

1. Main impacts on the environment during the project implementation are creation of topsoil, waste rock and low grade ore stockpile; dewatering of ground water and operation of service buildings which are placed near vertical shaft sinking.

2. The project of the vertical shaft sinking is high risk area as human working condition, therefore labor safety operation shall be comply with high labor safety standards. It's required that fixing of underground section, ventilation, lighting, protective equipments, individual protection set and measurements are taken during the accidents, shall be arranged in detail and complied.

3. Natural risks or disasters such as earthquake, underground pressured water leakage, and emission of toxic gas, fault zone effect and collapse shall be studied in advance and included vertical shaft sinking design, but risks may develop during the operation depending on natural disasters, human activity and technological conflict. Therefore, it's suggested that mitigation measures and regulation of aid operation for risks shall be prepared in advance. Staff training shall take place regularly.

4. Safety operation measures and Environmental protection plan attached to this supplementary EIA must be complied during the vertical shaft sinking and further operation of it.

5. This vertical shaft sinking process have been using up to date technology to sink and as sinking method and sinking depth. Mountain work, especially vertical shaft sinking have been carried out by Canadian Red Path Company, which is specialized vertical shaft sinking, so it's considered, that operation carried out by specialized company shall be the guarantee of fulfillment of environmental protection and safety operation.

SECTION 1. PROPOSED SHAFT DESCRIPTION

1.1 Proposed shaft design parameters

According to excavation survey plan which taking place at Oyu Tolgoi, the vertical shaft sinking shall be based on location of diamond drill hole OTD 1259 (see location map Figure 1). This vertical shaft shall be the first part of vertical shafts which are required for the implementation of technique-economical base of a survey of northern Hugo. Diameter of the vertical shaft collar filled with concrete 300 mm shall be 10.6 m and depth shall be 1764 m. The specification of the project is represented as below:

1.2 Project name

Oyu Tolgoi shaft #2

1.3 Project goal

The goal of sinking the shaft at far north Oyu is for additional exploration.

1.4 Project location

640 km far away from UB to south, 210 km far away from DZ to east, 45 km far away from HB to west and at the Far North Oyu where drilled diamond drilling numbered OTD 1259. Location and depth details are as below:

Y 4766705.7

X 65047.5

Depth 1764 m

1.5 Geotechnical Input

Golder Pty Ltd whereas commissioned by IMM1 to undertake a geotechnical investigation of the Head Frame site and to make recommendations as to the suitability and founding capacity of the foundations for the Head Frame footing strips. In order to fulfill the task, the detailed survey was carried out by Golder and the results of the survey were given in a detail on the reports “0651-1002 OT Shaft 2 Capacity of rock bearing pressure” and “0651-1002 OT Shaft 2 Founding capacity”. Impact of the rock bearing pressure (from the Head

Frame footings) to the 10M Diameter shaft concrete lining and hitch was also considered by Golder (report 0651-1002 OT Shaft 2 FEM Stress on Shaft Collar).

Golder Pty Ltd have reported that the Head Frame footing strips will sit on rock with a capacity of 2.6MPa which is more than adequate for the actual maximum load reactions imposed by the Head Frame structure. Further settlements and different settlements were not significant.

The general ground water level is located -22M below the bottom of the footings.

1.5 Operation equipments and Technical description

The Head Frame is a functional part of Shaft 2 Hoisting system. The primary function of the Head Frame is to house the mine hoisting equipment, serve as a marshalling area for personnel, equipment and materials and as an ore handling facility. The Main Hoisting equipment is housed and supported by the Head Frame and consist of:

1. Service Cage/Counterweight Friction Hoist
2. Production Friction Hoist
3. Auxiliary Cage Single Drum Hoist
4. Sheaves.

Head Frame super-structure:- The Head Frame will be constructed as a rectangular box reinforced concrete tower. Hoisting equipment and Conveyances interior support floors (or decks) will be constructed of a combination of reinforced concrete and structural steel.

Head Frame sub-structure:- To support the upper superstructure, a 26m deep rectangular box reinforced concrete sub-structure will be constructed; called the shaft collar at ground level and sub-collar at the footing foundation / 10m diameter shaft commencement interface.

Head Frame size:- The Head Frame height from the top of collar elevation to the top of roof parapet is 92.5m and -26.0m from top of collar level to bottom of footings, while the Head Frame plan footprint is 19.0 m by 23.0 m (inside face of concrete).

Head Frame Floors / Decks: - The interior of the Head Frame consist of six (6) primary operating areas / floors.

a) Sub-Collar
b) Collar;
c) Auxiliary Hoist Deck;
d) Sheave Deck;
e) Service Cage Hoist Deck;
f) Production Hoist Deck.

Head Frame Access: - Access to the Head Frame upper levels from the collar deck will be provided by stairs and a personnel lift/elevator. Lifting well access will be provided at collar for hoist installation maintenance.

Sub-Collar (Below ground level)

The sub-collar serves a number of important functions. An ore handling system will be installed at sub-collar and will consist of:

1. Skip dump (scroll plates and chutes);
2. 400 tonne steel lined, reinforced concrete surge bin;
3. Conveyor load-out facility (chutes, apron feeder, impact idlers and skirting etc);
4. Ore belt conveyor tail end structure;

Collar to Underside of Auxiliary Hoist Deck (Above ground level)

The collar deck area of the Head Frame will serve a number of important functions including:

1. The upper deck of the service cage will be loaded from collar deck elevation. Personnel will exit and enter the cage from opposite ends of the conveyance.
2. The auxiliary cage may also be accessed from the collar deck elevations.
3. Material and equipment will be marshalled for transportation to the underground mine via the service cage.
4. The Head Frame openings and floor will be designed to permit the driving of underground gear into the service cage with minimal disassembly.

5. The service cage, counterweight, skips and auxiliary cage will be removed and serviced from the collar deck level. Swing guides and electrically operated lifting equipment (monorail hoists and trolleys) will be included for the handling of all conveyances. Pneumatic or hydraulically operated fold down maintenance doors will be installed at collar elevation in all compartments.
6. The collar deck arrangement provides access to both ends of the service cage for drive in/drive off material handling. Efficient material handling will be accomplished by moving empty material cars off the cage from one side and moving loaded cars onto cage from the other side.

Auxiliary Hoist Deck: The auxiliary hoist deck will house a single drum hoist and supplementary equipment. Supplementary equipment includes electrical gear, hydraulics and motor ventilation.

Sheave Deck: - The production hoist and service cage hoist deflection sheaves will be installed at this elevation. The sheave deck will be service by an electrically operated monorail hoist and trolley. The monorail will be used for installation and maintenance of sheaves and for lifting ropes off sheaves during rope changing.

Service Cage Hoist Deck: - The service cage hoist deck will house a multi rope friction hoist and supplementary equipment. Supplementary equipment includes electrical gear, hydraulics and motor ventilation. The service cage will be hoisted in balance with a counterweight by means of the friction hoist. The service cage provides the main access to the mine for all personnel, materials and equipment.

Production Hoist Deck: - The production hoist deck will house a multi-rope friction hoist and supplementary equipment. Supplementary equipment includes electrical gear, hydraulics and motor ventilation. The production skips will be hoisted in balance from the shaft loading pocket by the friction hoist. The skips will be discharged at the skip dump located in the sub-collar.

Over Head Bridge Crane: The production hoist and related equipment will be lifted via a lifting well from collar using a 90 Tonne overhead bridge crane. The production hoist deck

overhead crane will be used for the installation and maintenance of the major hoist components. Stairs, ladders and platforms will be installed for maintenance of overhead cranes and access to the roof.

Head Frame Design

The design of the Head Frame was undertaken in two stages, as follows:-

1) The Basic Engineering.
2) The Detailed Engineering.

The basic engineering defines the building's configuration, including size and shape, for the function that will be required of it. General shaft sinking proposal is illustrated in 01-002-1101 which is attached. As the Head Frame building configuration is critical to the functional success of the facility, Ivanhoe Mines (IMMI) choose a world leading company in the design and development of Mine Facilities, Mclntosh Engineering Inc, to undertake this fundamental design work.

MEL completed the basic engineering, defining the requirements (as above) for the head frame, including operating loads (See attached MEL drawings 215-A-1233 to 1236). The Basic Engineering design has been accomplished in accordance with the International standard for the design. The engineering basic design consisted of approx 35 No Al size AutoCAD drawings showing the proposed building configuration requirements for the effective operations of Skip, Cage and Auxiliary hoists, together with associated Sheaves and conveyances to service a 10m internal diameter mine shaft, including all operating loads.

The Chinese Design Institute (CDI) selected and contracted by IMMI to undertake the work was the 'China Nonferrous Engineering and Research Institute (ENFI) in Beijing, based on their ability and capacity to undertake such work and on previous IMMI / ENFI good working experiences, but also that within China they are considered to be the premier design institute for non-ferrous engineering project. ENFFs task was to rigorously check by modeling and engineering design the MEL basic design and to produce the necessary construction drawings, specifications and schedules.

Equipments and Floor Loads

The main equipment operating loads provided by MEL are as shown on their drawings 215-A-1234 to 1236, as attached. In addition loads and services openings sizes for hoist and equipment ventilation and exhausting has also been estimated by MEL and provided for in the design by ENF1. Operating loads for the Sinking Contractor's temporary operating floor (By Redpath at Level 33.318M) and associated service openings has also been allowed for in the design - see attached Redpath drawings 01-002-1101, 1203 and 1204. The loads from a 90 Tonne Over-Head bridge Crane (located 85.5M) has been allowed for in the design.

Design Criteria and Other Building Loads

Other building loads such as wind and seismic loads were considered in the detailed design, as per the requirement of the Fluor Design Criteria. Part of their responsibility was to produce the design criteria for all structures for the project as a whole, including the Head Frame. Dynamic forcing dynamic frequency considerations were provided by MEL. The above loadings where incorporated into the detail design by ENFI via their structural modeling (FEA) analysis

Design Standard and Environmental Condition

Survey on general environmental conditions such as a fluctuation of temperature, precipitation and humidity is conducted by Flour on the building site, and then documents were prepared. The survey result enabled to include a cyclic phenomena such as freezing and expansion of building element into the design. In addition, Mongolian Standards and Regulations for Building were included in the “Q” section of the Design Standard of Flour and used for parameter of design.

Design Codes

For processing the building design by Fluor for the Head Frame, the internationally accepted standards and Mongolian standards for building were considered. It is possible to examine the criteria of design and copy of the BS 8110 standard.

Lateral Stability, Concrete Durability, Fire Resistance, Robustness, And Movement Joints.

Lateral Stability to horizontal loads (from wind, seismic and equipment lateral loads) is derived from RC wall panels acting in two way bending to transfer loads to floors and roof

(acting as horizontal bracing diaphragms) and side walls acting as shear walls to transfer loads and forces to footings / foundations. Righting forces and moments (from dead weight of the structure) proved more than adequate to resist overturning by a significant factor of safety.

Design for Concrete Durability is a function of reinforcement cover, concrete grade (based on cube strengths) and the exposure classification that the concrete resides. Because the Head Frame tower is not protected by cladding BS 8110 would define the classification as severe and with a nominal water / cement ratio of 0.55 and a cover of 40mm; the minimum grade would be C40MPa concrete.

Fire Resistance. As this is an 'all concrete' structure the fire protection becomes a function of the concrete cover. Engineering Codes, including BS8110, advises that floors with reinforcement cover of 35mm or more will provide 3 hour fire resistance which is considered more than adequate.

Robustness relates to the need for all vertical and horizontal structural elements (floors and walls) to be tied together to enable alternative load paths to develop in the event of single element failure - and will not collapse the whole building. By inspection, the Head Frame RC box tower is very robust, being an all reinforced concrete structure.

Movement Joints are normally introduced into building structures to minimize the effects caused by shrinkage, temperature variation, creep and settlement. Fortunately the Head Frame tower is dimensionally too small in plan to warrant any movement joints, is founded on rock with relatively small settlements and no differential settlements and the structure is 'free' to move unrestrained vertically as a result of temperature change.

Structural Modelling.

This structure was modeled by ENFI using a Finite Element Analysis (FEA) software program which enable to examine/explore multiply load cases and frame configurations to obtain an optimum and cost effective structural solution. In addition, the model shall allow us to reanalyze the structure to examine the impacts imposed to the structure.

Associated Structures (Conveyor Tunnel And Plenum).

The conveyor tunnel and plenum were designed as simple box culverts.

1.6 Operation regime and technology

1.6.1 Shaft sinking

Setup

As the setup is intended to be for sinking purposes only, simple self supporting galvanized steel Quonset style structures will be used for buildings. One will house the stage winches and auxiliary hoist. The other will house the main hoist and electrical. Simple thickened slab type structures will be used for the building foundations.

The hoisting setup will involve one Nordberg 4572 mm diameter double drum, single clutch DC sinking hoist along with four (4) 30 tonne stage winches and one auxiliary hoist. The main hoist will be fitted with a 48 mm diameter 34LR 34x19 IWRC RRL Ropes will be attached to sinking buckets with a nominal capacity of 16 tonnes. The final location of the 3048 mm auxiliary hoist is the sheave deck elevation. For sinking operations it will be ground mounted with the four stage winches. It will be fitted with a 38 mm dieform 18/7 non rotating rope.

A general arrangement of the planned sinking arrangement is shown in accompanying drawings 01-002-1100. A 4 deck stage (drawing 01-002-4400) will be used as a working platform to sink the shaft. The top deck will be used to suspend the stage. The remaining decks will be used for the installation of shaft hardware and for lining operations. The four deck stage will be suspended by four 48 mm 34LR 34x19 IWRC RLL wire ropes. The four stage winches each have a line pull 38,636 kg.

The temporary sheave deck will be large enough to handle the maximum anticipated steady state and shock loads. As a result it will be a substantial structure and contain approximately 360 tonnes of steel. With the planned sinking arrangement it will mount (drawing 01-02-1203) four 4572 mm diameter sheaves for the main hoist, eight 2438 mm diameter sheaves for the stage winches and two 1715 mm diameter sheaves for the auxiliary hoist, a total of 14 sheaves and their stools.

A total of 2.8m^3/s of compressed air will be available. Four 250kW Atlas Copco GA250 compressors will be installed to supply this. In order to handle the considerable but periodic air demand, the system will be completed by the addition of a drying tank and two receivers. The air will be delivered to the face in a 200 mm line. The usual electrical, service water, pump water and compressed air reticulation systems will be installed as the shaft advances. PRV's will be installed on the service water line to control line pressure. NRV's will be used on the pump lines.

Drill/ Blast/ Muck

A remotely operated eight-boom Atlas Copco pneumatic shaft jumbo c/w COP A15 rockdrills will be used for face drilling. The drill is an independent unit designed to fit through the stage bucket wells.

Before drilling begins, the cleaned shaft bottom will be blown over with compressed air and any misfired holes and sockets will be made safe. The advance cycle is planned around a 3,000 mm effective advance per blast. 48mm blast holes will be drilled to a depth of 3,300 mm. Each round will consist of a 9 hole burn cut with 4 reamed uncharged holes. Following the cut, 8 easer and approximately 78 face holes will be used. In order to improve safety, ground support, cycle time and efficiency by minimizing the overbreak, approximately 50 reduced spacing perimeter holes will be drilled. To minimize the risk of drilling into a misfired hole the cut will be drilled off center in the shaft and with each blast will alternate from side to side.

Gassed pumped emulsion or bead sensitized emulsion primed using nonel Detonators and cartridge explosive, then will be the main explosive used. After the jumbo is removed from the shaft, the emulsion charging unit will be slung down to the stage. Alter blowing out the blast holes with compressed air, they will be charged primarily with emulsion as supplied by the existing Orica plant located on site. As the charging density of this type of emulsion can be varied to produce explosives with different characteristics, this system can be somewhat customized to varying conditions. In order to assist with wall control, a lower density charge is planned for the perimeter holes. A shock tube initiation system will be used for the face with firing being done remotely.

A Caterpillar 314C diesel tracked excavator will be used for mucking. The stage design will allow for the slinging dimensions of this unit and removal after the mucking cycle. The drill/blast/muck sequence is demonstrated in drawing 01-02-4400.

Explosive requirement is shown in the Table 1.

Table 1

No.	Main Indicators	Units	Measure
1.	Number of body holes per bench	units	91
2.	Number of perimeter holes per bench	units	50
3.	Loaded length of hole	m	2.7
4.	Diameter of hole	mm	48
5.	Charge per hole	kg	0.00489
6.	Density of explosive in perimeter hole	kg/m^3	1000
7.	Density of explosive in body hole	kg/m^3	1200
8.	Total charge per bench	kg	780
9.	Primers per bench	kg	17
10.	Nonels per bench	units	141
11.	Electric detonators per bench	units	2
12	6g/m detonating cord per bench	m	60

Total number of benches = 1450/3 = 484

Total requirement for explosives for shaft including 20% contingency for misfires, sub stations, reblasts. trim blasts and other unforeseen circumstances shown in the Table 2:

Table 2

No.	Main Indicators	Units	Measure
1.	Bulk emulsion	kg	450,000
2.	Packaged emulsion for primers	kg	10,000
3.	Nonel detonators	units	82,000
4.	Electric detonators	units	1200
5.	Detonating cord	m	30,000

Water Control

A permanent dewatering system will be installed as sinking progresses. The system is staged so it can be extended as the shaft gets deeper and pumping capacity maintained.

The maximum capacity of the system is 7 1/s. Actual water flows should be less than 1 1/s as specified in the Aquaterra report. Water will be staged up the shaft from the face using three centrifugal pumps in series. Each of the pumps will be placed at 140m apart and will be capable of staging the water to the lowest sublevel in the shaft. When a sublevel is reached these pumps are replaced with a single centrifugal unit capable of the same flow but with higher head. Sub levels will be installed at 330m intervals. In operation, the water will be staged at 140m intervals to the substation and then at 330m intervals to surface. Plans are to use Flygt B1BO2201 submersible pumps to pump from the face and Technojet centrifugal pumps on the sublevels.

If probe drilling and grouting are required, the shaft jumbo will be utilized. It is not anticipated that this will be necessary as the shaft is reported to be dry.

Ground Control/Support/Lining

In the first instance, the shaft walls will be supported with a combination of mesh and rockbolts. Hand held jacklegs will be used to drill 33mm holes and to install ground support. The flexibility exists to drill 45mm holes and bolt using the sinking jumbo. A range of 34/47mm splitsets and 19/25mm threaded rebar resin bolts will be carried on site. The option of using shotcrete or fibrecrete in addition to, or as replacement for, bolts will also be available. To maximize overall performance, lining operations will be performed concurrently with mucking and ground support operations.

Shaft forms have been sized to match the expected 3,000mm round length. Concrete lining will take place after every second face blast or each 6m of shaft advance. During lining operations, the bottom curb ring will be installed, aligned and levelled on 12 hanging rods extended from the preceding pour. Accelerated concrete will be used here to ensure the main form pour has a stable base. Once the curb poured, the main forms will be lowered, aligned and poured. The mains will be poured in 2 lifts, first the bottom 3 meters then the top 2 meters. The shaft forms will be lowered either directly with the stage or with air chain falls. Concrete for the liner will be delivered to the shaft bottom using a slick line. Two lines for this purpose will be installed as the shaft advances. Because of the large diameter of the shaft, a concrete pump will be located on the stage during the lining

operation and concrete will be pumped from the slick line receiver tank into the forms helping to ensure efficiency and quality control.

Ventilation/Heating

The design principles of the ventilation system centre are based on the requirement to ventilate for the 70 kW diesel powered mucking unit and to expediently clear blast fumes. An air volume of 47.2m^3/s is planned to accomplish this. Two 98 kW high pressure fans will supply clean surface air to the two 1,524 mm rigid vent ducts installed in the shaft. In case of emergency, and if necessary for the expedient clearing of blast fumes, the fans will be reversible. During the winter months, two 0.001 kW/h oil fired indirect heaters will be used to keep the shaft from freezing.

Man Power

The sinking phase provides 13 expatriate and 35 Mongolian direct employees (miners, deckmen, hoistmen, muckers) on site supported by 10 expatriate and 23 Mongolian employees (engineers, electricians, mechanics, welders, technical staff, clerks).

1.6.2 Box Cut and Pre-Sink Methodology

Background

The box cut and pre-sink for Shaft 2 are necessary to construct the headframe and install the galloway work stage prior to the continuation of shaft sinking. The decision was made to proceed with the pre-sink before the construction of the headframe to facilitate the installation of the galloway.

The box-cut will start at surface and will remove overburden down to the -18m elevation. Below this elevation, surface drill and blast techniques will be used to excavate for the headframe and conveyor gallery foundations down to the -24m elevation. The pre-sink will start at the -24m elevation and proceed down to the -56m elevation. Concrete lining will be completed after the installation of the sinking plant and temporary ground support will be used to control the walls until the permanent lining is installed.

For safety, a bulkhead/work platform will be installed over the pre-sink after completion. This platform will prevent men and materials from falling down the shaft and also facilitate the collar and headframe construction.

Sinking will be done with a mixed crew of national and expatriate workers. The typical crew will consist of 6 national miners and 2 expatriate miners plus one crane operator and support crew of mechanics and electricians. The support crew will be supplied using existing manpower from the Shaft 1 sinking crew.

Overburden excavation

Overburden excavation will be preformed using a combination of excavators and wheeled loaders loading into haul trucks. The excavated soil will be placed around the box cut and levelled to be used as part of the future laydown area. To ensure slope stability, the slope angle and benches will be excavated according to the criteria laid out by Golder & Associates.Overburden will be excavated down to bedrock which is estimated to be encountered between 12 and 18m below the surface. The total volume of material to be removed is estimated at 250,000 cubic meters.

Headframe Foundation Excavation

It is anticipated that the excavation for the conveyor ramp and headframe footings will need to be blasted. There may also be a requirement for blasting on the access ramp above the -18m elevation. The total volume of rock to be removed is estimated at 5500 cubic meters.

Control blasting techniques will be used to minimize over-break. This will include post shear, tight perimeter hole spacing and the installation of spilling along final walls.

Blast holes will be drilled using an Ingersol Rand track drill. Holes will be 125mm in diameter. The blast pattern will be 2.5m x 2.5m in the body of the blast and a1.5m perimeter spacing. Perimeter holes will not be blasted with the body, but will be used in a post shear to try to maintain good ground control. All holes will be laid out by a surveyor on the predetermined pattern.

There will be a total of 202 holes in the conveyor gallery with an average depth of 2.5m. Explosives calculation is as follows:

Hole diameter	125mm
Loaded depth	1.5m
ANFO per hole	15 kg
Total holes	202
ANFO required	3000 kg
Nonel detonators	202
250g PETN boosters	202
Nonel initiating system	1

There will be a total of 100 holes in the headframe foundation with an average depth of 6m. Explosives calculation is as follows:

Hole diameter	125mm
Loaded depth	1.5m
ANFO per hole	40 kg
Total holes	100
ANFO required	4000 kg
Nonel detonators	100
250g PETN boosters	100
Nonel initiating system	1

Holes will be loaded with ANFO and be initiated using 250g PETN boosters and connect-a-det nonel detonators.

Once blasting is complete, muck will be excavated in 1.5m lifts using an excavator and dump truck. After each 1.5m lift is excavated, ground control will be installed. Waste rock will be hauled to the existing Shaft 1 waste dump.

Pre-sink

To facilitate pre-sink operations, a sub-sub-collar will be poured around the perimeter of the shaft opening. This will be no more than a concrete slab with a 14m diameter hole in the middle to provide a smooth work surface around the shaft for men and equipment to

operate. The slab will be designed to support the crane and the future work platform. Once sinking has progressed far enough, the ventilation fan and duct work will also be installed. An Atlas Copco bar and arm drill mounted on an Eimco 630 overshot mucker will be used to drill the full bottom. The blast holes will be 48mm dia and 100mm dia reamed cut holes will also be drilled for each blast. To control dust, water will be sprayed down the drill steel as is standard practice in most underground mining.

Prior to drilling, the surveyor will layout the location and depth of each blast hole. The bench will be cleaned thoroughly and all holes from the previous blast will be cleaned and marked. All holes will be vertical. A spirit level will be used to ensure that holes are drilled accurately.

There are 3 sections to the pre-sink, the first 2.0m section is 13.2m in diameter. The overall pattern will be 1m x 1m. The pattern for this section is the same as for sinking but will have 2 extra rings of holes. There will be 13 cut holes, 4 reamed holes for relief, 152 body holes and 68 perimeter holes for a total of 237 holes. Perimeter holes will be spaced at 0.6m and will be light loaded to control over-break. The total number of loaded holes will be 233. The first 2 meters will be blasted in 1.2m lifts. The following is a list of explosives required for the first section

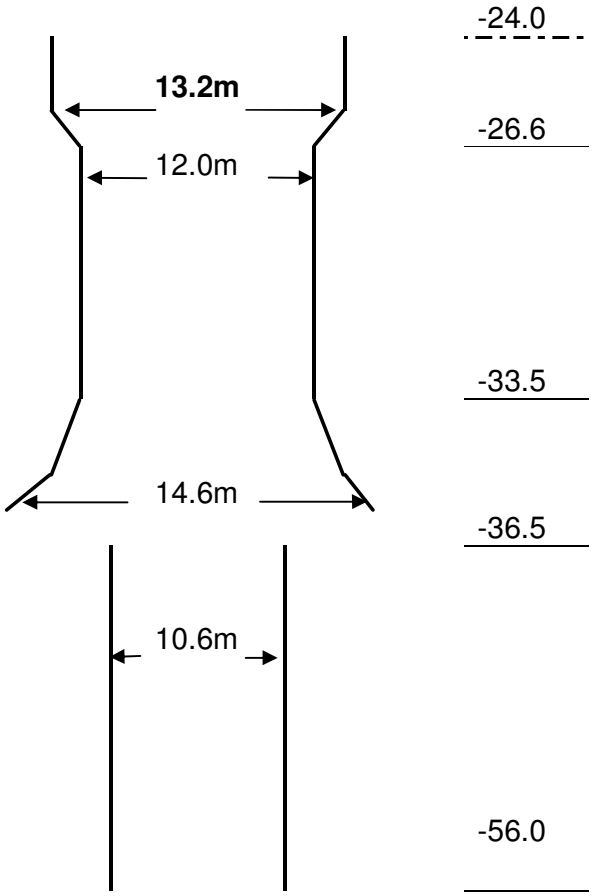
- 800 kg of emulsion
- 466 nonel detonators of various numbers
- 4 electric detonators
- 120m of 5g/m detonating cord

The next 10.6 meters will be sunk at 12m diameter. The pattern for this section is the same as for sinking but will have 1 extra ring of holes. There will be 13 cut holes, 4 reamed holes for relief, 112 body holes and 62 perimeter holes for a total of 191 holes. The total number of loaded holes will be 187. This section will be blasted in 2.4m lifts. The following is a list of explosives required for the second section:

- 2900 kg of emulsion
- 953 nonel detonators of various numbers
- 10 electric detonators
- 300m of 5g/m detonating cord

Below this, the shaft is reduced to 10.6m diameter. The pattern for this section is the same as described in section 5.2 of this report, and drawing 01-002-4501. There will be 13 cut holes, 4 reamed holes, 78 body holes and 50 perimeter holes. The total number of holes is 145 with 141 loaded holes. The following is a list of explosives required for this section:

- 4400 kg of emulsion
- 1410 nonel detonators of various numbers
- 20 electric detonators
- 600m of 5g/m detonating cord



Cross Section of Shaft 2 Pre-Sink

Prior to blasting, all men and equipment will be evacuated to a safe distance. Once blasting is complete and the smoke is cleared, mucking can proceed. A Cat 315C excavator will be lowered into the shaft using a Hitachi KH180 50tonne crawler crane. The excavator will fill 5.5 tonne sinking buckets. The buckets will also be lowered using the crawler crane.

When full the buckets will be raised and dumped on surface. From the surface dump the muck will be moved using a front end loader and dump trucks to the existing waste dump for shaft #1. The total volume of rock removed from the pre-sink is estimated at 3000 cubic meters including overbreak.

Water control

Water should not be a concern during the pre-sinking. There is currently less than 1 l/sec of inflow in the box cut and this will be pumped clear before it approaches the shaft collar. Any water encountered in the shaft will be pumped using Wilden P8 air pumps. These have a capacity of over 2.5 l/sec at 60m total dynamic head and should be adequate for the pre-sink.

Should excessive water be encountered, the option of installing either 40 hp or 150 hp Tsurumi pumps is available. Pumping capacity could then be increased to as much as 35 l/sec. No pipe will be installed during the pre-sink and all air, water and discharge water will be handled in mine hose.

Ground Control/Support/Lining

Temporary ground control during the pre-sink will be weld wire mesh secured with 2.4m resin grouted rebar bolts placed on a 1.2 x 1.2m pattern. 0.9m split sets may be used to pin the screen tight to the wall where there are hollows.

Bolts will be installed after each drill-blast-muck cycle and ground support will be maintained a maximum of 1.2m from the face. Since this ground will be open for several months before the permanent lining can be installed, the walls will also be sprayed with at minimum 75mm thick layer of shotcrete.

Ventilation/heating

Ventilation must be sufficient to clear blast fumes within a reasonable period of time and enough to clear diesel smoke from the Cat 315 excavator. The excavator has an 82 kw engine. Typical ventilation requirement is for an engine this size is $5m^3$/sec.

Sufficient ventilation is also required to provide $6m^3$/min per man working. With a maximum of 8 men working, the air flow requirement is then calculated at $0.8m^3$/sec.

A Bang Bai GXF 12B 15kW van axial fan will be installed with 75 cm diameter vent duct for ventilation. This will provide at least $10m^3$/sec air flow for the pre-sink. This air will be heated using 2 Herman Nelson 14.65 kW/h artic air heating units.

7. Power supply

There are two distinct phases for power supply to Shaft 2:

Construction: Temporary supply during which power will be fed to Shaft 2 from a Diesel Power Station (DPS). Supply to Shaft 2 in this stage will be at 35 kV.

Production: Permanent supply which will come into effect following connection to the Mongolian grid. Supply to Shaft 2 in this stage will be at 220 kV

Diesel Power Station (DPS)

The DPS is a facility to be constructed 100 m to 200 m south of the Concentrator Switchyard. It will comprise an outdoor facility erected on a concrete pad and include conventional diesel generator sets, a control room, two medium voltage (MV) switchrooms, a low voltage unit, an amenities unit and a store. All above mentioned units will be containerized and fabricated suitably for the site environmental conditions. A separate fuel skid will also be provided for control and distribution of diesel fuel together with a storage area for wastes such as oil, rags, etc and an area for storage of new oil. Total initial installed capacity will be approximately 12 MW with sufficient space and switchboard ratings designed for a final installed capacity of approximately 20 MW. The facility will be designed with n-2 duty sets.

Following connection of the mine site to the Mongolian 220 kV grid, the DPS will remain in operation in a support role to the main 220 kV supply. Support will be in the form of emergency supply in the event of failure of the main 220 kV supply, dynamic support of the mine operation and black start capability. However, in this role, some of the originally installed generator sets may be removed because of the reduced demand in the production phase of the project.

Site Power Distribution

The mine site will be ringed by a 35 kV overhead power line that will provide power to many of the lower power rated facilities on site. During the construction stage of operation of the DPS, two temporary 10.5/35 kV transformers of 15 MVA capacity each will be installed on the western side of the DPS. These will step up the 10.5kV output from the DPS to the 35 kV distribution voltage.

Upon connection of the 220 kV supply from the Mongolian grid, the 35 kV supply to the overhead distribution system will come from the Concentrator Switchyard and the DPS will be connected to the Concentrator Switchyard via the 10.5/220 kV transformers at the northern end of the DPS. Thus, during construction, supply to Shaft 2 will be at 35 kV from the DPS whilst during production, Shaft 2 will be fed at 220 kV direct from the Concentrator 220 kV Switchyard.

1.8 Safety Program

The Redpath Safety Program and its underlying value, "Safety First, Last and Always", is the guiding principle under which the company continues to operate. The Redpath Safety Program consists of the following elements:

1. Indoctrination of Employees. All new and transferred employees will undergo training covering their conditions of employment, safety and health, risk management and assessments, emergency and rescue preparedness.
2. Training and Qualifications. All training records are reviewed and maintained on file, for appropriate assessments of skills and abilities. Company mandated, as well as government legislated, qualification levels are ensured prior to assignments of work.
3. 5 Point Safety System. Prior to work assignments each employee is given a 5 point workplace examination card, which outlines their workplace, assignment and any associated hazards pertaining to the assignment. Employees record the condition of entranceways and workplace and take corrective action where required.
4. Emergency Procedures. Emergency procedures are developed and a plan to handle all emergency situations are developed to be site specific. They are reviewed periodically or when site conditions warrant revisions to the procedure.
5. Safety Huddles and Meeting. Safety huddles are discussions of safety related topics reviewed with the work crews. They are most often about a specific topic relevant to the work being carried out that day.

6. Accident. Accident imaging is a safety discussion where a worker or supervisor imagines a potential accident/incident and describes the consequences, causes, and actions required to prevent such an accident/incident from occurring.

7. Planned General Inspections. Planned general inspections are formal tours of the construction/mine site, or workplace. During the inspection, identification and classification of safety hazards, risks and contravention to mining regulations policies/procedures is noted and rated accordingly.

8. Job Observations. Planned Job Observations are important to our safe and efficient production. They ensure that workers understand and comply with procedures and regulations.

9. Joint Health and Safety Committees. The committee carries out not less than monthly inspections of the workplace and records its observations. This gives the work force an opportunity to participate and make recommendations with regard to the safety of the workplace.

10. Critical Task Procedure. A critical task procedure is undertaken each time a critical task is performed. It outlines the step-by-step methods required to execute a task that has high potential for injuries, property damage or loss to process.

11. Hazard Alert. A hazard alert is a communication describing an actual or potential accident or incident.

12. Accident/Incident Reporting. Accident and Incident reporting is the detailed reporting of information pertaining to a specific accident/incident. The reporting process ensures that all accidents and incidents are reported as they occur and thoroughly investigated.

13. Positive Progressive Disciplinary Action Policy. The disciplinary policy spells out the steps in effectively disciplining employees for failing to follow rules and regulations for breaching company policy. They take the form of oral warnings, written warnings, suspensions and terminations if warranted. Every effort is taken to coach individuals in a positive disciplinary environment, progressing to increasing levels of discipline, with a view that the employee will commit to improving his/her performance. Serious safety violations are grounds for dismissal.

14. Safety Awards. Safety awards are recognition of achievements of individuals or groups in developing and maintaining exemplary safety records.

Photo 1. Preparation work for Shaft #2 on OTD 1259

Figure 1. Location of proposed Shaft #2

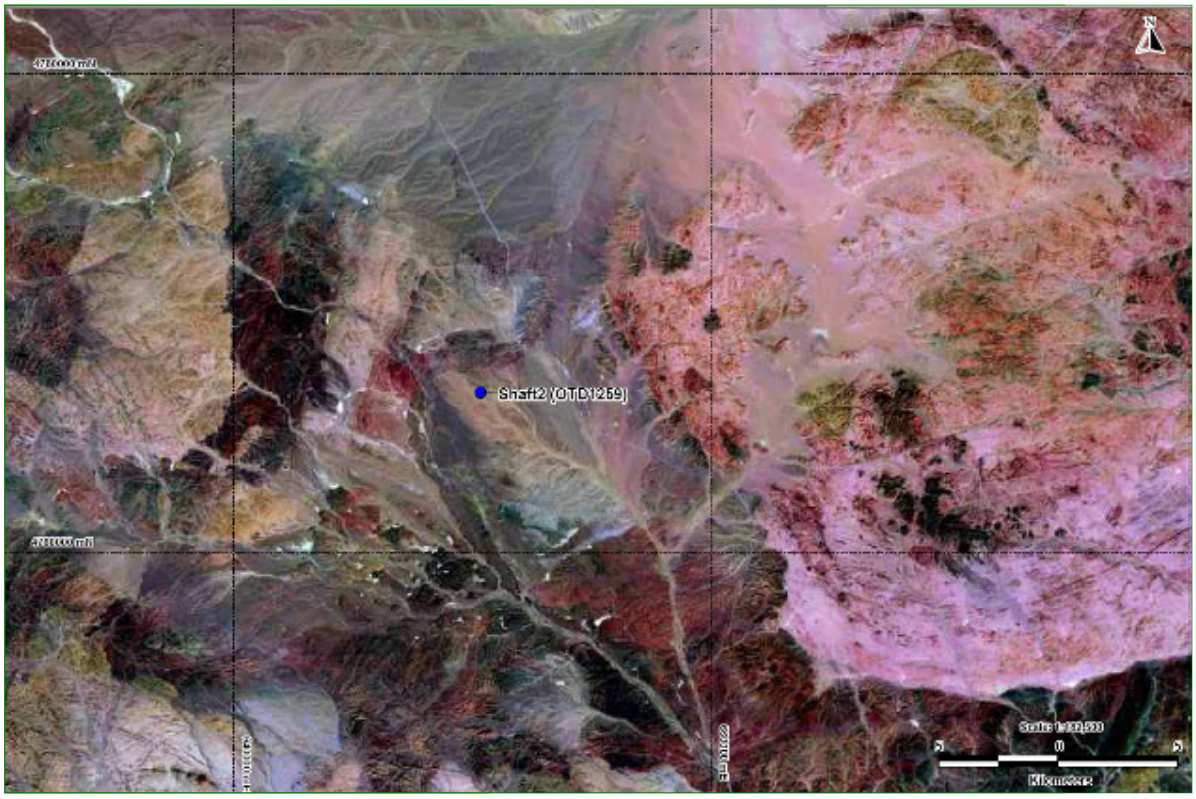
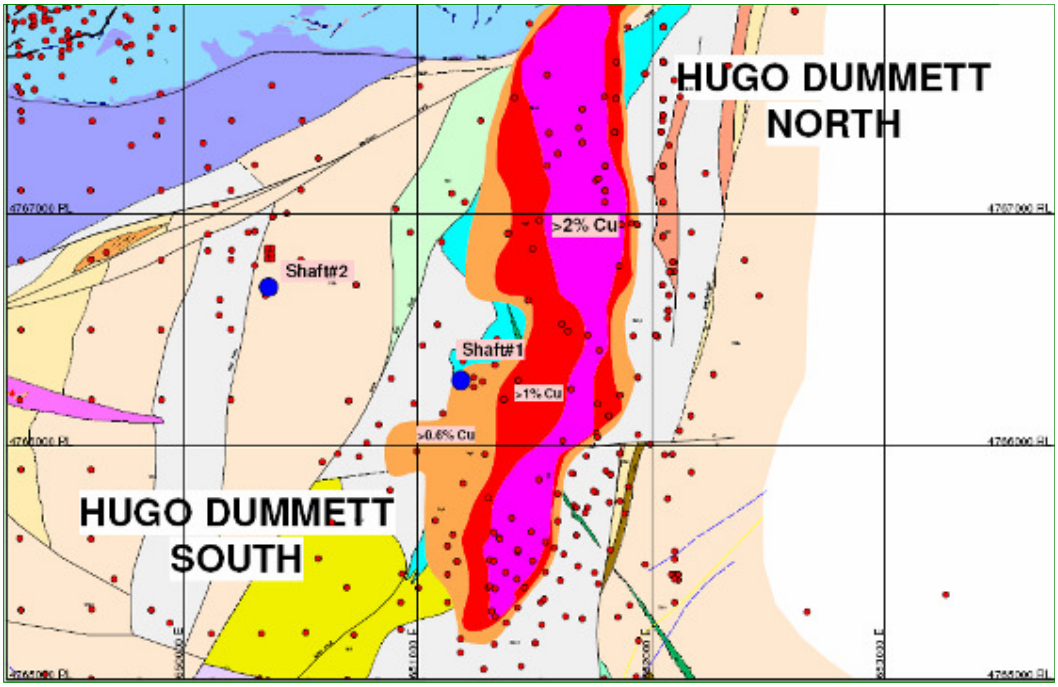


Figure 2. Locations of vertical shafts



SECTION 2. BRIEF DESCRIPTION OF ENVIRONMENT

2.1 Physical environment of proposed shaft location

2.1.1 Geological condition of the area

Within Oyu Tolgoi Project area the geology is dominated by a siluro-devonian sequence of stratified and prophyritic andezitic and basaltic flows. Remnants of pillow structures and amygdaloidal texture (mostly augist phenocrysts) suggest a shallow aqueous environment of deposition. Inter-bedded within these flows are fine to course-grained volcanic sediments. These rocks have been intruded by a complex variety of felsic to intermediate porphyries emplaced in parallel with mineralization. Following mineralization the area has been intruded by syenitic granitoides and rhyolite and andesite dykes (Aquaterra, 2004).
Within the main Oyu Tolgoi concession area, which is 10 x 9 km^2, four separate mineralization zones have been identified with porphyry-style gold, copper and molybdenum. These zones are Central, Far North, South and Southwest Oyu, which are all contained within an area of four kilometers (N-S) by two kilometers (E-W). The main host rock types in the area are:

a. Basaltic Volcanics
b. Andesitic Tuff
c. Quartz Monzodiorite
d. Oyu Tolgoi Quartz Monzodiorite
e. Quartz Monzonite.

The Hugo North deposit occurs within a geological setting similar to that at Hugo South. Host rocks are an easterly-dipping sequence of volcanic strata correlated with the lower part of the Devonian Alagbayan Formation and quartz monzodiorite intrusive rocks. Stratigraphically lowest rocks in the sequence consist of basalt flows and minor volcaniclastic strata overlain by a dacite tuff and breccia sequence. The dacite sequence includes a lower lapilli tuff unit, with overlying coarser tuffs and breccias. Weakly-altered to unaltered sedimentary and volcanic rocks of the upper Alagbayan Formation and Sainshandhudag Formation overlie the mineralized sequence along the eastern flank of the

deposit. Farther to the east and up-section, Sainshandhudag Formation rocks unconformably overlie and are locally faulted against the Alagbayan Formation.

In the study area, cretaceous period red clay is covered with approximately 20 m thick gravel layer. As fundamental rock, there are 3 main types of rocks:

- Biotite granodiorit (BiGd),
- Dacite ashen sinter (IGN),
- Quartz moncodiorit (QMD)

Biotite granodiorit is seam of porphyry dacite which is released during shaft sinking at Hugo deposit. Biotit granodiorit is 2-3 cm in size and has pinkish brown plagioclase inlay and main brown part with 5% of biotit which changed into chlorite and sericit. Biotit granodiorit with plagioklaz distributed in Hugo Dummet with 600 m in width and suddenly gets narrower.

Quartz moncodioritian intrusives are detected as larger seam and these inlays are porphyry for too mineralized texture.

It contains small inlays of gematit therefore has red color where not changed and also contains gematit and albit in some its parts. Intrusive which are late from quartz montsodiorit (10-300 m wide) or contrary intrusives (500 x 2000 m area) are strongly affected by cericit changes and copper which is cut with smaller quartz seams are slightly mineralized (<0.3% Cu).

The highest-grade copper mineralization in the Hugo North deposit is related to a zone of intense stockwork to sheeted quartz veins (exceeding 15%, and commonly over 90%). The high-grade zone is centered on thin, east-dipping quartz monzodiorite intrusions or within the upper part of the large quartz monzodiorite body, and extends into the adjacent basalt. In addition, moderate to high-grade copper and gold values occur within quartz monzodiorite below and to the west of the intense vein zone, in the Hugo North gold zone. This zone is distinct in its high Au (ppm) to Cu (%) ratios (0.5:1). In other respects the Hugo North and Hugo South deposits have similar mineralogy and zonation patterns.

Bornite is dominant in highest-grade parts of the deposit (3% to 5% Cu) and is zoned outward to chalcopyrite (2%). At grades of <1% Cu, pyrite-chalcopyrite ± enargite, tennantite, bornite, chalcocite, and rarely covellite occur, hosted mainly by advanced argillically altered dacite tuff.

The Shaft 2 foundation is located in completely and moderately weathered Carboniferous Andesitic Lava and its geological condition is summarized below, generally based on site investigation borehole OTD1259. Before sinking the Shaft 2, five geological-geotechnical boreholes were drilled. The borehole OTD1259 is drilled at the mouth of Shaft and the others were drilled near the shaft and at distance 20-40 m of OTD1259.

Overburden Clay

To the south west of the North Boundary Fault, stiff clay (with minor sand and grit layers) overlays the Shaft Farm area and the Hugo South and North deposits. It is about 15m thick at the shaft site (OTD1259). The Shaft 2 foundations and collar will be excavated as a box-cut through the overburden clay and weathered Carboniferous rocks to a depth of about 26m.

Sub-surface Geology

Carboniferous granite outcrops to the northwest of the steep north-northwest dipping North Boundary Fault and its associated splays. The steep west-northwest dipping 1154 Fault defines the eastern boundary of a horst of up-thrown Devonian just to the west of the Shaft 2 collar. The Hugo South and North deposits lie to the east of the West Bat Fault. Carboniferous volcanoclastics sub-crop to the southeast and east of the North Boundary and 1154 faults.

Weathering

The topography of the weathered Carboniferous below the overburden clay is flat over the immediate Oyu Tolgoi area. However, foundation drilling for Shaft 2 has demonstrated that it has a local relief of a few meters. In addition, there is evidence for recent (in geologic terms) fault displacement on at least the North Boundary and 1154 faults after and during deposition of the clay. Complete weathering of the Carboniferous rocks extends to about 26m, with variable weathering to 99m.

Rock Types

The geology at the Shaft 2 site is relatively simple. A thick sequence of shallow east south east dipping Carboniferous volcanoclastics uncomfortably overlies a thick sequence of shallow south east dipping (layered/foliated) Devonian volcanoclastics. The unconformity at 883.25m is healed and tight. Thinner sedimentary inter-beds (a mixture of conglomerate, sandstones and siltstones) are present in both the thick Carboniferous and Devonian exhalative volcanic sequences. The rock types encountered in site investigation borehole OTD1259 are listed in Table 3. Despite the range of names and textures, all the volcanoclastic rocks are similar. The main feature of the sediments is that they are more bedded.

Table 3. Shaft 2 Rock Types

CARBONIFEROUS			
Volcanoclastics		Sediments	
TandL	Trachyandesitic lava	Cong	Conglomerate
DacBas	Dacite-basalt breccia	Sst- slt	Sandstone & siltstone
BasL	Basaltic lava	VSst	Volcanogenic Sandstone
Bat	Basaltic lapillic tuff		
Andlgn	Andesite ignimbrite		
AndL	Andesite lava		
DEVONIAN			
Volcanoclastics		Sediments	
L	Basaltic flow breccia	Sst-slt	Sandstone & siltstone
Vbx	Dacitic block-ash tuff		
INTRUSIVES			
BiGd	Biotite granodiorite		
Vp	Porphyritic basalt		
Rhy	Rhyolite		
Ba	Basalt		

Compared to the Carboniferous, the Devonian rocks appear to be more altered (sericitic and argillic), but they are also more lithic (slightly stiffer, stronger and less prone to deterioration, possibly due to a lower illite content). These visual impressions are not, however, substantiated by actual intact rock property testing. A wide variety of dykes

intruded both the Carboniferous and Devonian sequences during the Carboniferous. Their contacts can either be thin and tight, or thick, sheared and broken, altered and weak. Very little is known about the orientations of dykes. Unlike beds and faults, they are not necessarily regular planar features. Dykes may have preferentially intruded along faults, weaker units (sediments) and even bedding. Borehole intersection relationships cannot be trusted and correlations between widely spaced boreholes are difficult.

The shear and fault styles are often thick, continuous and weak with clay gouge fill. Numerous, similarly oriented, smaller continuity features will also locally influence the stability of the Shaft 2 walls during sinking (Hugo North Shaft #2 - Site Investigation OTD1259). More detailed information can be obtained from the report "HUGO NORTH SHAFT #2, SITE INVESTIGATION OTD1259", prepared by AMC Consultants Pty Ltd.

2.1.2 Groundwater

Aquaterra have analyzed and reported the estimated groundwater flows into proposed Shaft 2 at Oyu Tolgoi, based on seven packer tests conducted during April 2006 in the exploratory drill hole OTD 1259 which has been drilling down the route of the shaft. The drill hole was stopped at 1764 m.

The static water level in OTD1259 was 100 m below surface and flow rates were between 1 and 5 l/sec with transmissivity of over 5 m^2/day by Investigations of Aquaterra.By the investigations of Aquaterra, the shaft is located in the area of limited groundwater flow as very few areas of groundwater inflow have been encountered in the mineral exploration bores drilled below 100m. By detailed investigation of drilling, it is determined that groundwater flow is limited thanks to sealing of faults with altered clay materials and their intact nature, even though several faults were observed

Even though Shaft 2 intersects numerous structural features, the packer testing has shown that the permeability of the rock mass is low, due to sealing of faults by alteration products. As a result, groundwater inflows into the shaft will be low, less than 1 L/s.

2.1.3 Seismicity

An investigation into the seismicity at Oyu Tolgoi area is being undertaken by the Mongolian Seismological Department. The results of this work indicated that area belongs to 5 grade magnitude area.

A review of damage caused by earthquakes to underground workings was undertaken by Sharma and Judd (1991). The conclusion of this paper is that the top 50 m of an underground excavation is at most risk of being damaged by an earthquake. At the Shaft 2 the top 20 m includes the clay cover material weathered portion of gravel and the weathered biotite Granodiorite (BiGd).

In terms of the temporary ground support for the unlined section of the shaft no effect for seismic loading has been taken into account due to the short exposure time.

2.1.4 Geothermal gradient

According to the AMC Consultants Pty Ltd, stability and ground support issues were relatively rare due to high ambient temperatures. However, shock cooling of the rock masses can promote surface cracking and overbreak; e.g. when freshly exposed faces are washed down, especially when much colder water is used. The rock temperature data presently available for the Oyu Tolgoi deposit was summarised by Voulgaris and Purev: Ambient Rock Temperature (°C) = - 0.0173 x mRL + 28.574; or = 0.0173 x Depth (m) + 8.438. Geothermal temperature gradient at OTD1259 was found to be 1.73°C per 100 m The ambient rock temperature at the Shaft #2 site is therefore likely be ≈ 26 and 34°C at 1000 and 1500m, respectively.

2.1.5 Intact rock properties

Main rock types, encountered during investigation in the borehole OTD1259 were Carboniferous, Devonian and Intrusive types. As a consequence, the following generalizations applied for the shaft.

The Carboniferous and Devonian volcanoclastic rocks have similar mechanical properties:

- Compressive strength: UCS50 ≈ 110 to 150MPa. Typically the sediments have lower strengths.
- Tensile strength; UTS ≈ 9 to 13MPa
- Young's modulus; E ≈ 40 to 60GPa. Again the sediments are slightly softer, i.e. lower Young's modulus.
- Poisson's ratio; ν ≈ 0.22 to 0.34

The intrusive rocks (dykes) are stronger, but they have similar deformability (E and ν) to the volcanoclastics:

- Compressive strength; UCS50 ≈ 150 to 210MPa
- Tensile strength; UTS ≈ 10 to 15MPa

Rhyolite is a notable rock type because it is a common dyke in the Shaft Farm area. It has a high compressive (205MPa) and high tensile strength (16MPa). Lower drilling rates should be anticipated in dykes; e.g. rhyolite, dacite and hornblende biotite andersite.

2.1 6 Rock stresses

AMC Consultants Pty Ltd has executed rock stress investigations of the Shaft 2. The following recommendation is quoted from their report "HUGO NORTH SHAFT #2, SITE INVESTIGATION OTD1259"

The presently available stress and rock property data suggests that there is a chance of highly stressed ground behaviour in Shaft #2, especially below 750m. It is therefore possible that more support (e.g. fibrecrete and longer higher capacity bolts) may be required below 1000m, than has been recommended in this report. Sinking rates may also be affected. Similar to Shaft #1, AMC recommends that in situ rock stress measurement be done at several stations (levels) as Shaft #2 is progressively sunk. This data will not only assist Shaft construction (via a re-evaluation of support requirements), it will also be needed to assess the stability of associated works; level layouts, ore bins and crusher excavations etc.

Further reading of the detailed investigation into ground condition and support requirements for the Shaft 2 is available at the report "HUGO NORTH SHAFT #2, SITE INVESTIGATION OTD1259".

2.2 BIOLOGICAL FEATURES OF PROPOSED SHAFT LOCATION

2.2.1 FLORA AND VEGETATION

Generally, 4 different communities of vegetation such as, desert steppe, dry river bed, low hills and spring communities have distributed in the Oyu Tolgoi Project Area (J. Sanjid, 2003 and 2004). The shaft #2 is located within the desert steppe vegetation zone (north east side of OT license area).

The main plant community of this area consists following desert plants: *Anabasis brevifolia+Sympegma regelii and Sympegma regelii+Salsola passerina+Potanina mongolica.* In the east of shaft sinking area (1.0 km from present shaft #1) in the small area has situated semi steppe community element, involved *Stipa glareosa+Allium polyrrhizum* species.

During the summer of 2003, especially in the July was peak vegetation growth because this area has received the greatest amount of rainfall in 25 years. Results of survey within shaft sinking and near of them provided in the following table.

Table.4 Main parameters of vegetation community in the shaft sinking area

Main vegetation community	Cover, %	Average height (cm)	Dominate species within 25m x 25m sized survey field	Surveyed site
Anabasis brevifolia+Sympegma regelii+Allium polyrrhizum (desert community)	15-27	8-12	(Within 25m x 25m) *Sympegma regelii* -5 *Nitraria sphaerocarpa* -1, *Potaninia mongolica* 1, *Reamuria soongarica* 35, *Anabasis brevifolia* 237, *Allium polyrrhizum* 75, *Stipa glorecesa* 14	Near dump
Sympegma regelii+Salsola passerina+Potaninia mongolica (desert community)	25-30	15-18	(Within 25m x 25m) *Sympegma regelii* -137, *Anabasis brevifolra* -179, *Salsola passerina*- 49, *Ajania achilloides*- 136, *Potanina mongolica*- 37	Shaft sinking site

Source: J. Sanjid, Vegetation survey report, Eco-Trade, 2003

Endemic and rare plants

Only 6 species of endemic and rare plants registered in the Oyu Tolgoi license area (Eco-Trade, 2002 and 2003). But proposed shaft sinking and surrounding area (within 200 m radius) any endemic or rare plant has not registered during the field visit of botanist of Eco-Trade (J. Sanjid, April, 2005).

Present status of vegetation cover

The vegetation at cover at shaft sinking removed (40 x 60 m square) already and covered 1.0 x 1.2 km area by waste rock dump.

2.2.2 FAUNA OF SHAFT AND SURROUNDING AREA

Generally, during field survey of biological diversity in the Oyu Tolgoi license and surrounding area, 11 species of reptiles, 88 species of bird, 43 species of mammal and 92 species of insects were registered (A. Bold, D. Myagmarsuren, 2004).

But, for the shaft sinking project will operate in the small area (185 x 187 m) and waste rock will be covered 1.0 x 1.2 km area. Therefore, construction and operation of Shaft #2 hasn't significantly affect reptiles, bird, mammal and most of insects. Few soil insects can be affected during the project activity.

During last years the extensive geological explorations conducted within this area and all the animals have moved to other areas. Consequently, we can draw a conclusion that the proposed area for shaft sinking is not significant for the wild animals due to the previous exploration activities.

SECTION 3. ENVIRONMENTAL IMPACTS OF SHAFT AND MITIGATION

3.1 Environmental impacts of shaft sinking operation

General description of impacts

It is required to remove and transport soils and rocks during the construction of surface and collar section of vertical shaft and vertical shaft sinking. Dewatering of leakage shall be essential.

As long as the diameter of shaft 2 is 10 m and depth is 1764 m, a total of 138500 m^3 soil and rocks shall be excavated and stockpiled. Rocks will be transported to the south-east to the existing waste dump of the Shaft 1.Water leakage may result from shaft sinking shall be pumped out with pump and collected in previous excavation. It is determined in Australian Aquiterra company report of groundwater exploration for Oyu Tolgoi deposit that static water level at borehole OTD 1259 exists 100 m below the surface and water yield varies between 1m/sec and 5 m/sec. Consequently, it is not required to collect water until 100 m.

In the frame of geological exploration work of Oyu Tolgoi deposit which has been done until now only surface drilling had been executed but the company have commenced exploration sinking for ore technological sample, ore body capacity and detailed determination work of ore content, since 2004.

Impacts on environment that is caused by second vertical shaft sinking shall be determined and protecting measures are developed in advance.

The following impacts may develop within second vertical shaft sinking and this consideration is based on scale of the project, proposed works and time frame:

- Construction work will result in buildings and facilities which occupy 185 x 187 m^2 or 3.4 hectare
- A borehole with size of 10 m in diameter and 1764 m deep will be created within the bowels of the earth

- Approximately 140 000 m^3 stockpile of rocks will be created which resulted from foundation of building and vertical shaft sinking
- Road network will be created near vertical shaft
- Household sewage and wastes from workers' consumption

Photo 2. Main technological operation during the shaft sinking

Environmental impacts and mitigation measures

As above mentioned, main environmental impacts of shaft sinking are stockpiling of waste rock and water leakage from the shaft sinking. Considered main impacts and results of them are provided as below.

1. **Impacts** caused by stockpiling of waste rocks

Removal and stockpiling of waste rocks which taken from vertical shaft sinking is major process of such sinking works. Clay and rocks taken from vertical shaft sinking shall be stockpiled for further use of building and road construction activities.

Mitigation measures

As we judge from previous experiences, an area used for stockpiling is buried and become irrecoverable again. While choosing an area for stockpile the following criteria should be considered:

- To choose the areas which are unsuitable for household use
- To consider geography, hydrogeology and topography of deposit area
- The chosen area should be as close to mining area.

Besides, all practicable measures shall be taken in order to prevent the collapse and slide of dump during rain and flood events. Further, rehabilitation works will continually take place and surface of stockpile shall be vegetated.

The area is very arid and exists under strong wind events, therefore stockpile should be covered with rocks and gravel in order to protect from wind blows that may cause dust emission into the surrounding area.

2. Impacts caused by water leakage

One of the essential impacts is water leakage from the shaft sinking. According the report of Oyu Tolgoi deposit water resource areas survey done by Australian Aquiterra Company (2006) that static level of water on borehole OTD 1259 is located at 100 m beneath the surface. Water discharge level is 1-5 l/sec.

Aquaterra Company carried out calculation of cumulative permeability for the top 850 m of the shaft due to limitation of packer test and the cumulative permeability was 3 x10-3 m/d. Even though, the permeability has calculated for the top of the Shaft, the Aquaterra

assumed that water inflow from 852 m and 1764 m will be negligible, based on their calculation that permeability and fracture occurrence decrease with depth.

Mitigation measures

To mitigate above mentioned impacts, it is required that leakage water to be pumped out permanently and kept specially prepared sump. Sump will be build not smaller than 120 000 m^3, and after 80% filling of sumps the oil pollution (if occurred pollution under ground) should be cleaned and it is needed to pour into existing box cut. Collected and cleaned water can be used for mitigating dustiness near waste rock dump and shaft sinking area, with approval of an inspector of State Professional Inspection Agency.

5. **Impacts caused by solid and liquid wastes**

During the preparation, construction and shaft sinking operation, waste and intermediate wastes will have produced. We have classified all the wastes, produced during the above mentioned activities, and provided in the following table.

Table 5.

a/ Solid waste

Types	Volume	Source
Plastic and paper packs, bottles, construction material residue	5 m^3	Food and construction material residue, containers, packs

b/ Liquid waste

Types	Volume	Source
Productional sewage	4 m^3/day	Drilling
Household sewage	2 m^3/day	Shower, laundry, bathroom
	1098 m^3/year	

c/ Waste lubricant

Types	Volume	Source
Waste lubricants (in 2006)	1.5 m^3 or 1500 l/year	Heavy duty machinery and drilling machine

d/ Intermediate wastes

No

e/ Radioactive waste

No radioactive waste

Mitigation measures

IMMI need more clear waste disposal management and monitoring and run in accordance with main waste disposal policy of the company. It is planned that sewage holes with size of (3m x 3m x 4m) 36m^3 are built near laundries, showers and bathrooms of exploration camps and collect sewage. Sewage vehicle will pump and transport it to the central waste disposal point. Proposed waste clean tactics provided as follow:

Waste clean-up and disposal methods

Table 6.

a/ Solid waste

Types	Clean-up	Disposal
Plastic and paper packs, bottles	On daily basis	Work places have been provided with rubbish bag and wastes shall be disposed to central disposal point.

b/ Liquid waste

Types	Clean-up	Disposal
Productional sewage	To pump out daily with sewage vehicle	Into the sewage disposal point within central waste disposal point
Household sewage	To pump out daily with sewage vehicle	Into the sewage disposal point, pumping from sewage vehicle.

c/ Waste lubricant

Type	Clean-up	Disposal
Waste lubricant	A barrel with capacity of 200 l shall be positioned in mechanical or repair shop	Dispose into a butt with capacity of 25 tonnes which is located in fence of mechanic shop of Major Pontil drilling company.

6. Impacts caused by breach of safety work

During the shaft sinking operation, there might be risks of entry of unauthorized bodies to the dangerous places and having any accidents. Furthermore, it will be interrupt normal regime of shaft sinking activity.

Mitigation measures:

To mitigate mentioned impact, during construction and use of buildings and facilities, fence with size of 2 m height and 7.3 km long will be built in order to ensure safety. Entrances to vertical shaft shall have doors and also security people shall work there to control workers and vehicles entering the area.

7. Impacts caused by water usage

Vertical shaft excavation project involves 50 workers in a shift during 183 days. Household water need for individual person is estimated as 50 l/day and production water demand is estimated as 14 m^3. Total amount of intended water usage is demonstrated in the following table.

Table 7. Water usage during vertical shaft sinking

Types	Volume	Resource
Household water	73000 person/day x 0.05 m^3 = 3650 m^3/year	Borehole, ground water OTRC-218
Productional water	For mitigating dustiness – 10 m^3/day For preparing concrete and mortar – 14 m^3/day Total 17520 m^3 /year (future water usage included in the total figure)	Borehole, ground water CC-01, CC-02,
Stone river	For preparing concrete and mortar - 36500 m^3/year shall be used.	Use stone river borrow pit

Also, the Shaft 2 requires hard stone and quarry site near the shaft sinking is planned to use.

3.2 Risk assessment

Risks may develop during the shaft #2 sinking and further using of the shaft for underground mining considering as follow.

Table 8. Risk assessment and general ideas for mitigation

No	Risks may develop during the shaft sinking	Risk rate (0-1)	Mitigation measures
1	Earthquake	0.5	Oyu Tolgoi area especially, the Shaft #2 area is belongs to the area with earthquake magnitude 5. All the design and protection measures should be planned against such magnitude and needed to be constructed.
2	Underground water pressure leakage	0.2	The results of hydrogeological survey completed in this area shows that water leakage will not exceed 1-5 l/sec. If this shaft is used as underground mine then it may occur such unpreventable occasions. Therefore, clear safety and protection program are needed against to such accidents
3	Underground collapse	0.7	Generally, results of geotechnical survey on the core of OTD 1259 shows that the rock mass is blocky to very blocky. Therefore, during shaft sinking process pressure gauge program should be implemented in order to adjust soil fixing design which may reduce hazard of pressure within 620 m deep section. More information is provided in below.
4	Fault zone affect	0.5	There are many faults and fault zones in the upper 600 m, 4 larger zones that may impact on stability of walls and mining rates, it may be necessary to pour the liner to the face in the following intervals: 364.7-391.5 m, 416.9-436.7 m, 444.0-451.4 m and 520.0-552.8. More information provided in below.
5	Toxic gas emission	0.1	Theoretically, there is no chance to emit toxic gases. Also, there is no information of survey. However, during the blasting may develop toxic gases. It is necessary to use safety tester and more powerful air ventilation system to be used during shaft sinking and furthermore.

Fixing design presented as below is the result of experimental or explanatory tests which took place in the core of the borehole OTD-1259. The depth considered here is the depth of drill borehole and as a shaft collar; actual depth shall be various depending on existence of geological structure of the area.

General section

- The rock mass is blocky to very blocky, and according to the Q rock quality system, 66% of the rock is classed as fair, 3% as good and 30% is as very good.
- There are many faults and fault zones in the upper 600 m, 4 larger zones that may impact on stability of walls and mining rates, it may be necessary to pour the liner to the face in the following intervals: 364.7-391.5 m, 416.9-436.7 m, 444.0-451.4 m and 520.0-552.8.
- The ground support design below 620 m is dependant upon assumed stress conditions, evidence points to a high, deviatoric stress field.
- During shaft sinking process pressure gauge program should be implemented in order to adjust soil fixing design which may reduce hazard of pressure within 620 m deep section.
- Water yield is estimated as 1-5 l/sec if such figure occurs then drilling work should be done in the front section.
- To avoid unexpected ground condition, that the shaft 2 is required to be located as close as possible to previously drilled borehole which was used for the survey.

Concrete gasket

- Concrete gasket within 620 m deep section from surface should be not more than 9 m in forms of piled.
- In the depth more than 620 m, gap between gaskets, where borehole drilled for blasting, should be not less 15-21 m.
- Gasket with 30 MPa, 300 mm shall be sufficient for 5 figures of safety which are compared with pressure of experimental and wedge fixings. Monitoring blocks for concrete gasket should also be built between regular spaces.

Soil fixing

- After putting filling agent, only professionals should check measurement.

- As fixing holders within rocks, it's essential to check their fixing standard and quality by pulling. Except for that, 1% of total rocks must be checked by special checking equipment. Sinking weight for connection is 8 tonnes and a rubber or anchor holder is 18 tonnes.
- Features of all types of elements for soil fixing must meet with Canadian and Australian standards.
- Fixing agent should have moist content and checking blocks should be built between regular spaces.
- Excavation level survey for the shaft 2 hasn't been done at all, but preparatory work of bowed pattern should be done during the proposed design. Cable bolting is required to shaft collar fixing and their length and size depend on its width.

Section of weathered biotit granidiorit (BiGd)

- Filling concrete should be not more than 9 m from front section.
- 2.4 m long resin anchored bolts shall be on 1.5 m square pattern.
- Spot bolts shall be essential to fixed within fault and sections with segments of rocks
- Fixing agent put in outer of welded net shall be 50 mm and 10 m in vertical direction Strengthening of seam fixing should be used by choices (without net).
- Limited row of net with narrow opening is done for surface fixing depending on soil condition of the area. However, it's done in accordance with the inspection of mining engineer and geo-technical engineer.

Biotit granidiorit and Ignimbrite welded tuff section within unweathered rocks

- Concrete liner must not be more than 9 m from the face.
- 2.4 m fiction bolts on 1.5 m square pattern.
- Spot bolting shall be essential to fixed within fault and sections with segments of rocks
- Concrete placed over weld mesh will be required for around 21% (37 vertical meters) of this zone and should be completed to the leveled of muck pile after every two benches. Alternatively fiber reinforced concrete can be used (with no mesh)

- Limited row of net with narrow opening is done for surface fixing depending on soil condition of the area. However, it's done in accordance with the inspection of mining engineer and geo-technical engineer.

Quartz Montsodiorit section

- The liner must not be closer than 15 m to the leveled off muck pile, where blast hole drilling is to take place
- The liner must not be further than 21 m to the leveled off muck pile, where blast hole drilling is to take place
- 3 m resin anchored bolts on a 1.5 m square pattern
- Spot bolting shall be required where faults and strong jointing is present.
- Concrete (100 mm) placed over weld mesh will be required at all times. Concrete should be completed to the leveled off muck pile after every two benches.

SECTION 4. LEGISLATION ENVIRONMENT OF SHAFT

The proposed shaft sinking shall be obeyed following laws; particularly Law on Environmental Protection, Law on Mineral Resources and Law on Subsoil. The relevant components of this legislation were provided in Table 9.

Table 9. Legislation relating to the shaft sinking

No	Name of laws	Articles and provisions of law	General meaning of provision	Relating articles and provisions of law
1.	Law on mineral resources	Article 16. provision 7	Rights of mining license holders	The right of entry to and transit through the mining area, use of the mining area, the right to construct necessary structures, and the right to conduct other activities related to mining and exploration;
2.	Law on subsoil	Article 18.	Rights of companies, organizations and citizens to mine common minerals and use fresh underground water	Companies, organizations and citizens may, upon authorization by Governors of soums or districts, mine common minerals and use the pure underground water without obtaining the mining area [license], for commercial and residential purposes.
		Article 21	The reasons for and the procedures to terminate the right to use subsoil	1. The right to use the subsoil shall be terminated, fully or partially, in the following circumstances: 1) [The user] does not need to use the subsoil further; 2) The period during which it was allowed to use the subsoil ended; 3) There is an inevitable need to remove the subsoil for the state or other public needs; 4) The company or organization that was using the subsoil is liquidated; 5) Circumstances dangerous to health of the [local] people arise; 2. The right to use the subsoil may be terminated if the user of the subsoil commits the following violations: 1) Does not start to use the subsoil after 3 years after receiving it; 2) Uses the subsoil for purposes other than allowed; 3) Does not meet requirements referred to in Article 20 of this law; 4) Seriously violates other regulations on use and protection of subsoil. 3. The right to use the subsoil may be terminated if [respective] companies, organizations or citizens violate regulations and conditions regarding commercial or residential use of subsoil. 4. Other reasons for terminating the rights to use the subsoil may be determined by the legislation of Mongolia. 5. Termination of the rights to use the subsoil shall come into effect when the authority that issued the document giving the mining area or the permission to use the subsoil repeals the document or the permission
		Article 37	Ensuring safety during the use of subsoil	1. Those who are building constructions and structures for purposes other than mining, or other than mining plants underground, renovating, expanding or using these structures and plants, as well as performing other geological surveys or other works related to using the subsoil shall ensure safety for [local] people and meet the requirements to protect lives and health of their employees. 2. Managers of companies and organizations using the subsoil shall have the obligation to ensure enforcement of safety rules and standards. They shall also

				appoint specific employees in all branches of their companies or organization to monitor enforcement of these rules and standards.
		Article 38	Basic requirements to ensure safety during the use of subsoil	1. The following basic requirements should be met when using subsoil: 1/ to ensure that every employee studies and conforms to safety rules and standards; 2/ to plan for prevention of hazards and for liquidation of consequences of hazards; to implement these plans; 3/ to take prompt actions in case of life-threatening hazards to employees, including discontinuing operations, evacuating employees to a safe place; to take actions necessary to eliminate hazardous conditions; 4/ to supply and ensure use of machinery, equipment, materials, working uniforms and other protecting instruments that meet requirements of safety and hygiene rules and standards; 5/ to record, store, expend and use explosives and explosive substances safely and in accordance with relevant procedures. 2. Companies and organizations doing earth works shall take complete technical and organizational actions to improve air content within mines, to improve earth work technology, operational methods and machinery, and to prevent occupational diseases and industrial accidents. They shall continuously improve living and working conditions of employees engaged in earth works, as well as the rules and standards on hygiene. 3. Earth works shall be prohibited if digging may be dangerous to lives and health of workers, or if the content of oxygen, poisonous or explosive gases and dust in the air, or air temperature inside the mine does not meet the requirements of safety and hygiene rules and standards. 4. Earth works and explosion works shall be managed by specially qualified employees; explosion works shall be carried out by people authorized to do so.
		Article 39	Duties of employees carrying out earth works with respect to implementation of safety rules and standards	Employees engaged in earth works shall have the following duties: 1/ to strictly follow requirements of safety rules and standards; 2/ to regularly check their work places and equipment, and to take actions to immediately correct any violations of the rules and standards of safety; 3/ to use uniforms and protecting instruments properly at their work places; 4/ to abstain from using methods that might cause hazards or accidents; 5/ to stop operations if potentially dangerous conditions emerge, to immediately report to supervisors, and to operate strictly in accordance with contingency plans on prevention of hazards and liquidation of consequences of hazards
		Article 41	Implementation of actions to protect the environment	1. Users of subsoil shall have a duty to implement actions to protect the environment, and shall, for this purpose, have ecological assessments and environmental impact assessments done by relevant professional authorities [specialized agencies]. They shall keep these assessments together with their drawings of the subsoil and deposits and technical documentation. 2. [They] shall take actions to eliminate negative impacts on the environment, to cover the deposit and the excavated ground, or otherwise rehabilitate them, and to rehabilitate the soil based on the environmental impact assessment. 3. Users of subsoil shall transfer a monetary pledge as a financial guarantee to carry out activities specified in paragraphs 1 and 2 of this Article, to the local government of the soum or district. 4. The amount of the pledge and the issue of appropriating it into the government budget shall be regulated by the Minerals Law.
		Article 43	Protection of parts of subsoil containing invaluable scientific, historical and cultural items	1. Parts of subsoil containing rare geological findings, rare mineral structures, and invaluable items for paleontology, science, history and culture shall be taken into protection of the state. It shall be prohibited to conduct any activities counter to wholeness and completeness of the part of subsoil taken into protection of the state. 2. Users of subsoil shall have a duty to stop their activities and inform relevant authorities if they discover any rare geological findings, rare mineral structures, and invaluable items for paleontology, science, history and culture.
3	Law on	Article 31.	Obligations	1. Comply with environmental legislation, decisions by the Government, local

	environmental protection	Provisions 1, 2 and 3	of economic entities and organization	self-Governing Organizations, Governors, and the requirements of State inspectors, and rangers; 2. Follow and conduct internal control environmental standards, limits, legislation and procedures approved by the authorized organizations; 3. Maintain records on toxic substances, adverse impacts and wastes discharged into the environment while engaged in production or services and write reports and collect data on the measures taken to reduce and remove toxic chemicals, adverse impacts and wastes, as well as on the monitoring equipment and operation and submit this to the relevant organization in a timely manner.

List of relating laws on the shaft sinking#1

- Mineral law
- Environmental protection law
- Law on subsoil

CONCLUSION

1. To judge from result of environmental impact assessment of vertical shaft sinking at far north Oyu or Hugo Dammet ore body, the operation of the vertical shaft sinking process shall cover comparatively small area (3.2 ha) and intended for deep ground. This project has medium impact on environment; therefore it's considered that operation can be carried out.

2. Main impacts on the environment during the project implementation are creation of topsoil, waste rock and low grade ore stockpile; dewatering of ground water and operation of service buildings which are placed near vertical shaft sinking.

3. The project of the vertical shaft sinking is high risk area as human working condition, therefore labor safety operation shall be comply with high labor safety standards. It's required that fixing of invisible section, ventilation, lighting, protective equipments, individual protection set and measurements are taken during the accidents, shall be arranged in detail and complied.

4. Natural risks or disasters such as earthquake, underground pressured water leakage, and elimination of toxic gas, fault zone effect and collapse shall be studied in advance and included vertical shaft sinking design, but risks may develop during the operation depending on natural disasters, human activity and technological conflict. Therefore, it's suggested that mitigation measures and regulation of aid operation for risks shall be prepared in advance, if such risks happen and also staff training shall take place regularly.

5. This vertical shaft sinking process meets with Mongolian relevant legislations including Law on subsoil, Environmental protection law and Mineral law.

SECTION 5. ENVIRONMENTAL PROTECTION PLAN FOR SHAFT # 2 SINKING

Table 10. Environmental Protection Plan

Potential Impact	Required Mitigation	Period or frequency	Predicted Expenditure (estimate) (1000 Tugrics)	Legal or Policy Obligations
Dust emissions may increase during the vertical shaft sinking	▪ To ensure whether there is temperature variation occurs and increase density of pile ▪ Do watering on dumps because of Gobian nature and climatic characteristics and if necessary to use indirect watering method	During shaft sinking (2005- 2006)	1500.0	Law on air and air pollution MNS 0017-2-3-16:1998 (at residential areas)
An area used for stockpiling may be covered with waste rock without rehabilitate again	▪ To choose the areas which are unsuitable for household use ▪ To consider geography, hydrogeology and topography of deposit area ▪ The chosen area should be as close as to mining area.		15000.0	
Sulfide in low grade ore can create acid while reacted with air and oxygen	▪ If sediments with good water transmitting capacity and rocks with many faults are distributed or ground water level is close to the surface it is suggested that base of dump should be spread with clayey soil ▪ To determine geographical location, geometric dimension of dump and slope in order to support stability of dump		20000.0	
	▪ If dump is no longer contain ore, neutralizing process shall be carried under control of relevant professional such work include rock cover and rehabilitation		15000.0	
Water leakage during the shaft sinking #2	▪ Leakage water to be pumped out permanently and kept specially prepared sump. Sump will be build not smaller		No direct cost estimated	

Potential Impact	Required Mitigation	Period or frequency	Predicted Expenditure (estimate) (1000 Tugrics)	Legal or Policy Obligations
	than 120 000 m^3, and after 80% filling of sumps clean the oil pollution (if occurred pollution under ground) and need pour into existing box cut. Collected and cleaned water can be used for mitigating dustiness near waste rock dump and shaft sinking area.			
Wastes during the operation of the shaft sinking #2	▪ To prepare more clear waste disposal management for shaft sinking #2		7000.0	
During the shaft sinking operation may have risks entry of unauthorized bodies to the dangerous places and have any accidents	▪ Fence with the size of 2 m in height and 7.3 km in length must be built in order to ensure safety. Entrances to vertical shaft shall have doors and also security people have to work there, who are responsible for controlling personnel and vehicles entering the shaft sinking area.		7000.0	

Abbreviation note: MNS – Mongolian National Standard